JOURNAL OF COATINGS TECHNOLOGY

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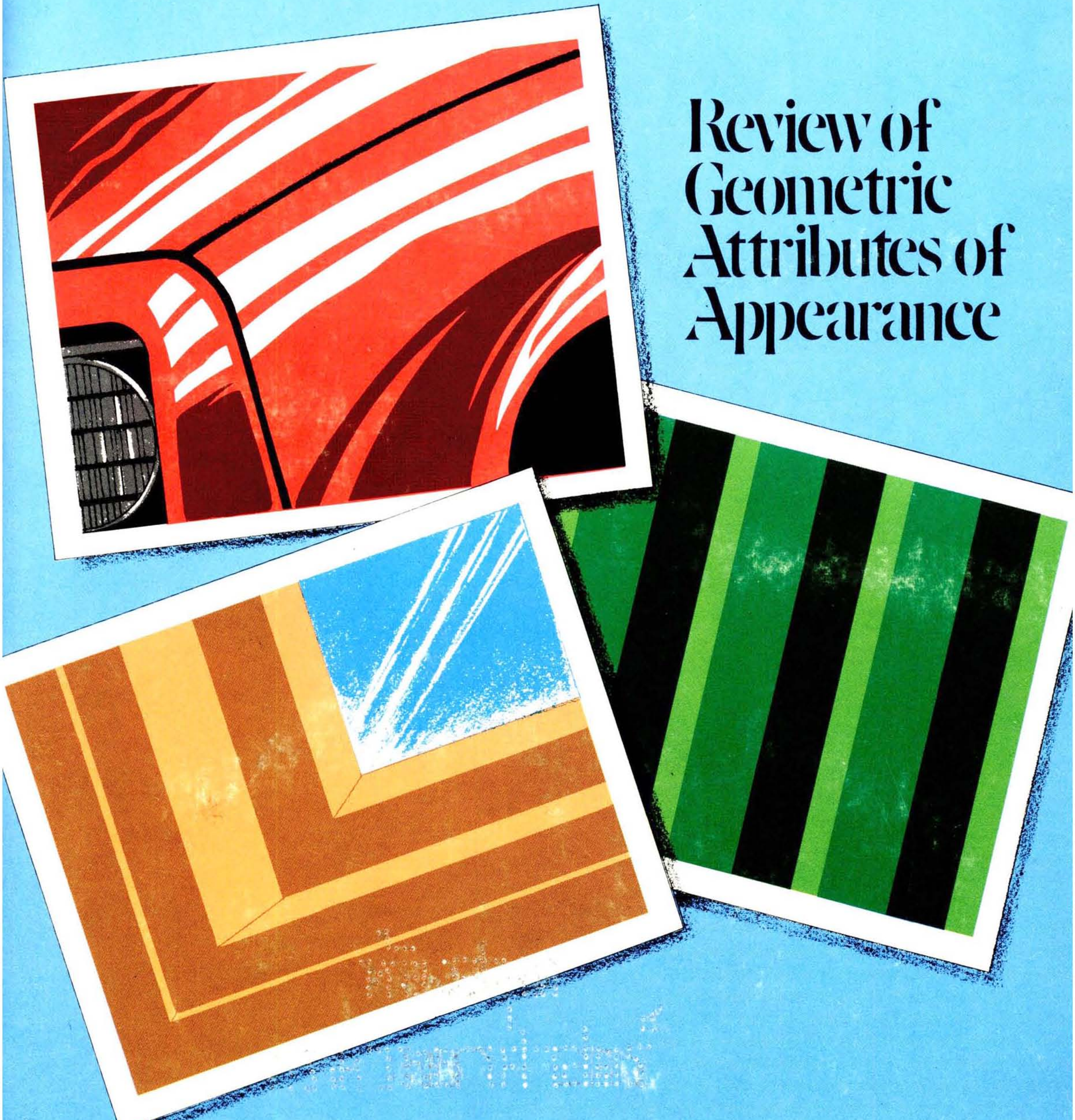
JUNE 1979

Review of Geometric Attributes of Appearance



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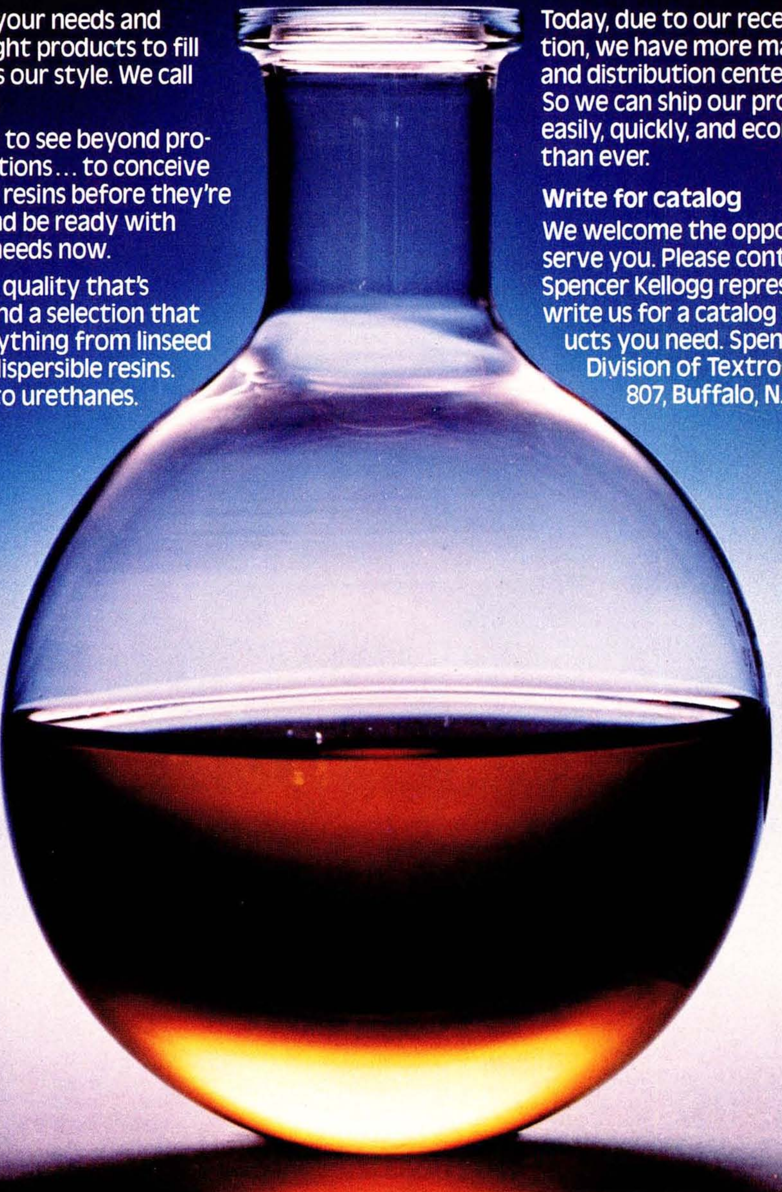

JUNE 1979

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Features

Federation Activities

Departments

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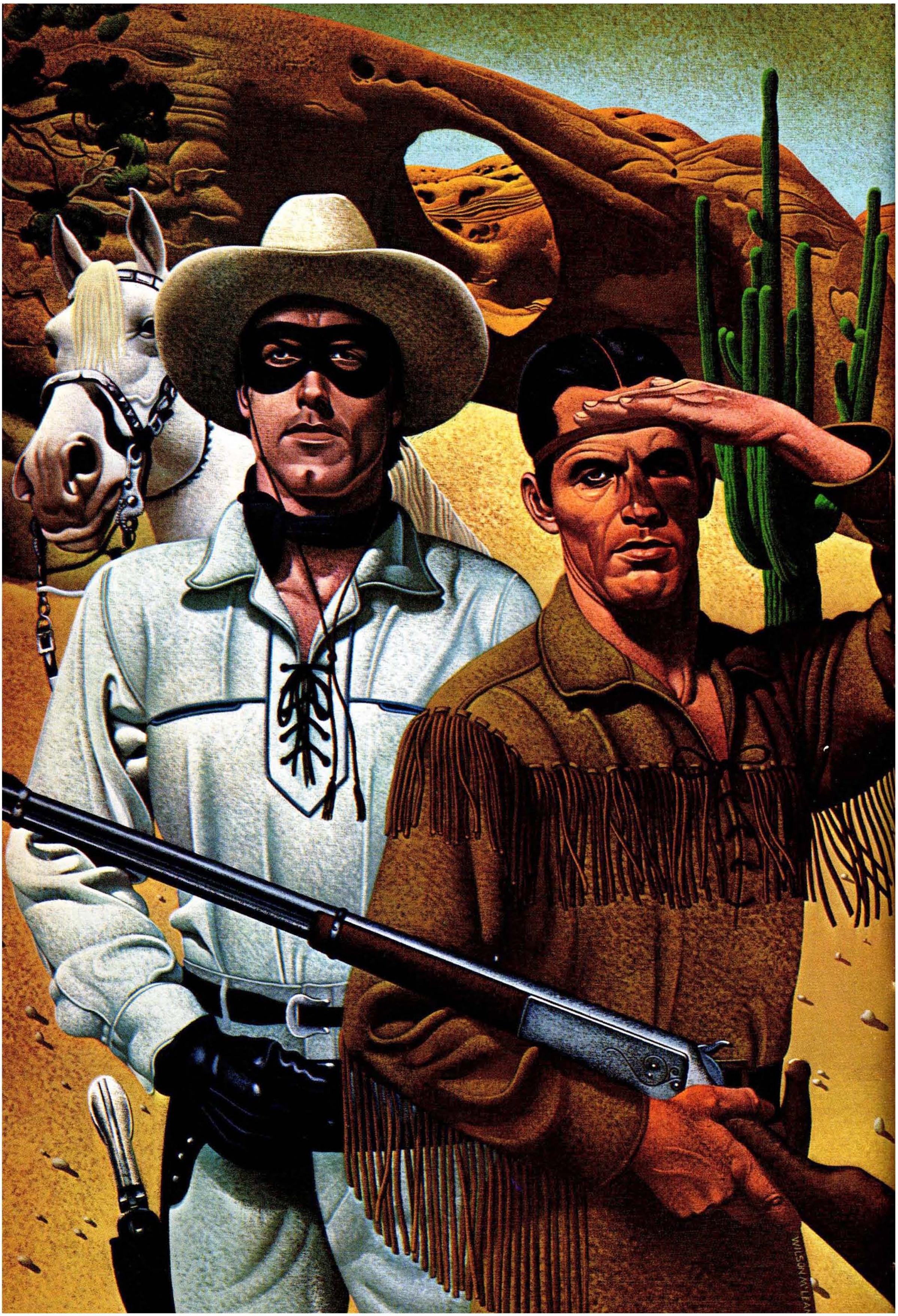
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Comment

An Industry Challenge

The current OSHA standard requires a reduction of lead exposure to 50 $\mu g/m^3$ per eight hour day. Accordingly, coatings manufacturers have been investigating substitutes for lead pigments. It is the responsibility of the paint manufacturer in developing such substitutes to market a product which has properties of lead pigments such as corrosion resistance and color compatibility with existing color systems.

Upon introduction of such new products, it is the responsibility of coatings manufacturers to warrant that such new products may be safely applied in the factory during manufacture, will not pollute the environment, may be used with safety by the consumer, and are fit for their intended use. This combination of safety requirements, in addition to the physical properties which substitute paints will be required to meet, will make the selection of lead substitutes a formidable task.

The coatings industry has a responsibility to investigate the concerns posed here and derive an answer before we spend time and resources travelling in the wrong direction.—TJM

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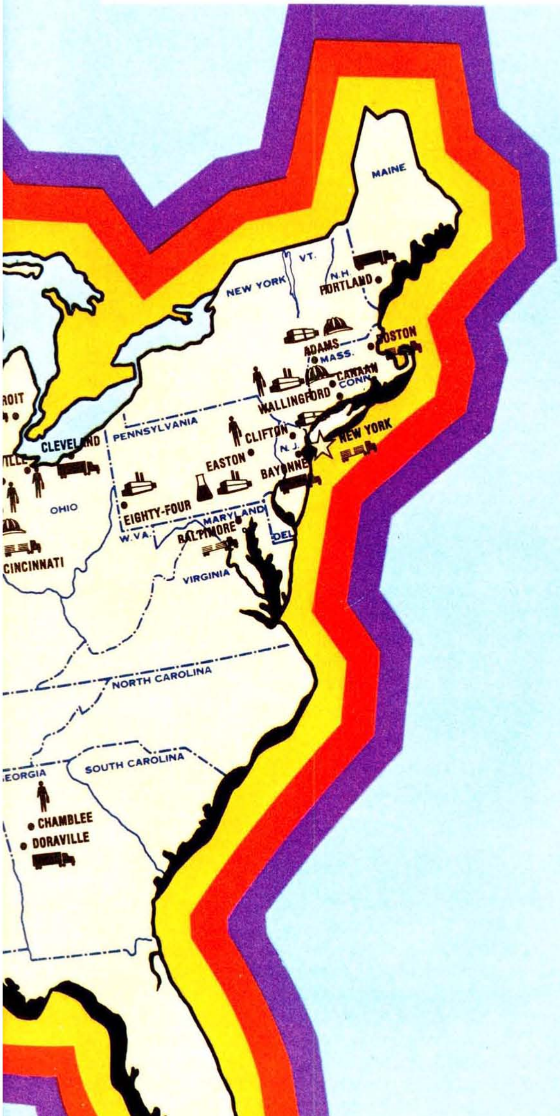

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FLEXIBILITY AND ITS RETENTION IN CLEAR COATINGS EXPOSED TO WEATHERING—H.E. Ashton

Journal of Coatings Technology, 51, No. 653, 41 (June 1979)

The influence of mechanical properties on the behavior of coatings in service is generally understood. However, the level of these properties, particularly flexibility, attributed to some binders has not reflected actual measurements.

Tensile strength and elongation of clear alkyds and phenolic varnishes have been determined using free films exposed to natural or accelerated weathering. It is shown that alkyds of intermediate oil content have higher extensibility and retain it better than those with low or high oil content, while phenolics do not remain flexible for very long in either exposure. The relation of tensile properties to exterior performance on wood is discussed.

SILANE ADHESION PROMOTERS IN ACRYLIC RESINS: PRELIMINARY RESEARCH—Cleveland Society for Coatings Technology

Journal of Coatings Technology, 51, No. 653, 53 (June 1979)

A series of silane additives were evaluated as adhesion promoters in a simple acrylic formulation. The one found to be most effective on steel substrate, namely N-beta-(Aminoethyl)-gamma-aminopropyltrimethoxysilane was studied in more detail by means of ESCA and Fourier Transform Infrared techniques to determine its relationship to the steel surface. As a result, a hypothesis is proposed to explain its mode of action.

EVALUATION AND MODIFICATION OF THE BECKMAN VARIABLE ANGLE REFLECTANCE ACCESSORY FOR CHARACTERIZATION OF METALLIC COATINGS—D.T. Roberts, Jr. and B.H. Todd

Journal of Coatings Technology, 51, No. 653, 59 (June 1979)

The Beckman 198900 double beam variable angle reflectance attachment (VAR) was evaluated on a Beckman ACTA MIV spectrophotometer to determine its usefulness in helping to characterize the appearance properties of metallic automotive coatings. After some simple modifications it was possible to produce direct spectrophotometric reflectance curves of metallic coatings which appear to be a promising aid to relative measurement of the face and flop color. With the modified attachment, full goniophotometric capabilities are not possible: the angle of viewing is restricted to 20° off the incident (illuminating) angle.

Without modification the variable angle reflectance attachment is useful for measuring the thickness of transparent thin films over reflecting substrates.

REVIEW OF GEOMETRIC ATTRIBUTES OF APPEARANCE—J.S. Christie, Jr.

Journal of Coatings Technology, 51, No. 653, 64 (June 1979)

For the sake of identification and measurement, appearance attributes can be roughly divided into two classes, those which vary in the spectral distribution of light and those which vary in light scattering or geometric distribution. This paper describes the physical characteristics of objects responsible for geometric differences, the psychological attributes (visual sensations), and the psychophysical scalar dimensions which have been developed to "quantify" gloss and other geometric attributes.

This is followed by a brief review of the historical development of the philosophy and measurement techniques applied in this area of appearance judgements. Types of instruments are described.

The CIE Committee 2.3 on Optical Properties of Materials includes a gloss subcommittee. The current work program of this subcommittee, aimed at improving correlation between visual judgements and instrumental measurements, is reviewed.

PRACTICAL ASPECTS OF INSTRUMENTAL AND COMPUTER COLOR CONTROL IN A SMALL PAINT PLANT —E.J. Lowrey

Journal of Coatings Technology, 51, No. 653, 75 (June 1979)

A tristimulus colorimeter was used for 18 years for control of production color matches in a trade sales paint plant of small to medium size. Five years ago this was replaced by an automated abridged spectrophotometer and a general purpose minicomputer equipped with color matching software. Experience over the 23 year period is summarized and some specific solutions to problems are described. Subjects discussed include: stabilizing color standards; accepting instrument decisions; sampling and sample preparation; backup systems; effects on methods, procedures, and personnel requirements; evaluation and startup of computer color matching systems.

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Tentative Schedule of Paper Presentations Announced For 1979 Federation Annual Meeting in St. Louis

Program Committee Chairman Morris Coffino has announced the tentative schedule of presentations for the 1979 Federation Annual Meeting, October 3-5 at the Convention Center in St. Louis, Mo.

The Opening Session will be held on Wednesday morning, October 3, followed by the Keynote Address by Newscaster and TV Commentator Howard K. Smith. Two afternoon sessions will be held concurrently. One will be an R&D Management Symposium (focusing on such topics as how to choose projects, strategy and experimentation, impact of government regulations, and managing research and development), the other will offer papers addressing the theme topic, "Progress Through Innovation."

On Thursday morning, October 4, the Paint Research Institute will sponsor a seminar on aqueous coatings. Concurrently, the Federation Manufacturing Committee will present a session on media mixing. In the afternoon, Roon Awards competition papers and Constituent Society papers will be presented in concurrent sessions.

On Friday morning, October 5, the Federation Educational Committee will present a session on the value of continuing education, while a concurrent session will feature papers addressing the theme topic. These will be followed by the Joseph J. Mattiello Lecture by Charles Kumins, Director of Research and Development, Tremco Incorporated, who will speak on "Physical Chemical Models for Organic Protective Coatings." The program will conclude with an afternoon panel discussion on waste disposal.

Paint Industries' Show

To be held in conjunction with the Annual Meeting, the Paint Industries' Show is the only national exhibit of raw materials and equipment used in the formulation, testing, and manufacture of coatings. Top technical representatives from participating supplier companies will be manning booths to discuss developments with personnel of the coatings manufacturing industry from around the world.

A total of 126 exhibitors will occupy 339 booth spaces in the 1979 Show, the largest in history.

Show hours will be: Noon to 5:30 pm on Wednesday, October 3; 10:00 am to 5:30 pm on Thursday, October 4; 10:00 am to 4:00 pm on Friday, October 5.

Headquarters Hotel

The Sheraton St. Louis will be headquarters hotel, and Stouffer's Riverfront Towers will be co-headquarters. Other hotels with blocks of rooms set aside for the Annual Meeting are Bel Air Hilton, Breckenridge Pavilion, Holiday Inn Riverfront, Lennox, Mayfair, Rodeway Inn, and St. Louisian.

Free shuttle bus service will be provided between participating hotels and the Convention Center.

Room Reservations

All requests for rooms and suites must be sent to the Federation Housing Bureau on the official form provided by the Federation. These have been mailed to all members. The form is included in this issue (see pages 23-24), and additional copies are available from Federation headquarters.

Registration Fees

Regular "on-site" registration fees will be $40 for Federation members and $55 for non-members. Advance registration will be available for $35 for members and $50 for non-members.

There will again be a special $15 advance registration fee each for retired Federation members and their spouses.

An advance registration form is included in this issue (see pages 26-27), and will also be mailed to Federation members in July.

Luncheon

The Federation Luncheon will be held Friday, October 5 at the Sheraton St. Louis.

Presentations will be made to recipients of the George Baugh Heckel Award (outstanding individual who has contributed to the advancement of the Federation) and the Flynn Awards (firms judged to have the best exhibit booths in the 1979 Paint Industries' Show).

Program Committee

In addition to Mr. Coffino, the following members are serving on the FSCT Program Steering Committee:

Vice-Chairman — Hugh Lowrey, of Indurall Coatings, Inc., Birmingham, Ala.; Umberto Ancona, of McCloskey Varnish Co., Philadelphia, Pa.; Thomas Ginsberg, of Union Carbide Corp., Bound Brook, N.J.; William Mirick, of Battelle Memorial Institute, Columbus, Ohio; Colin D. Penny, of Hampton Paint Mfg. Co., Inc., Hampton, Va.; and Richard E. Wolf, of DeSoto, Inc., Des Plaines, Ill.

Meetings Committee

Members of the Kansas City and St. Louis Societies are serving on the Meetings Committee under General Chairman Howard Jerome, of Vane Calvert Paint Co. Chairing the various subcommittees are: Information Services — William Fitzpatrick, of Cook Paint & Varnish Co.; Operations — John Folkerts, of Plas-Chem Coatings; Luncheon — William Smith IV, of Conchemco, Inc.; Publicity — Herman J. Lanson, of Poly Chem Resins, Inc.; Busing — Floyd Thomas, Jr., of Thomas & English, Inc.

Mrs. Howard (Gene) Jerome is in charge of the Spouses' Program.

• • •

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Advance Spouses' Registration Form – page 27
Federation Luncheon Ticket Request – page 27

NUMBER 80 JUNE 1979

FEDERATION
newsletter

Federation of Societies for Coatings Technology
YE OLDE PAINT STONE 1737

ONE HUNDRED AND FORTY-SIX EXHIBITORS TO PARTICIPATE IN LARGEST PAINT INDUSTRIES' SHOW, OCTOBER 3-5, IN ST. LOUIS

One hundred and forty-six exhibitors have signed up to participate in the record-breaking 1979 Paint Industries' Show, at the St. Louis Convention Center, October 3-5.

Among them are the following new exhibitors whom we are pleased to welcome into the Show: Automation International Corp., Custom Scientific Instruments, Inc., Enterprise Cos., C. Fricke Co., Gail Industries, Interpace Corp., Liquid Controls Corp., 3M Co., Miller Paint Equipment, Inc., Mozel Chemical Products Co., Omya, Inc., Semler Industries, Inc., Sub-Tropical Testing Service, Inc., Uniroyal Chemical, and Varian.

"Progress Through Innovation"

Running concurrently with the Paint Show will be the technical program sessions, this year geared to the theme of "Progress Through Innovation." Program Chairman Moe Coffino, of D.H. Litter Co., New York, and the members of his committee are developing several presentations which will address this theme.

Some program highlights are:

- Mattiello Lecture by Charles Kumins, of Tremco, Inc.
- Keynote Address by Howard K. Smith, noted newsman and TV commentator
- A three-hour session on "Lab Management and Innovation"
- Paint Research Institute seminar on "Aqueous Coatings"
- Manufacturing Committee sessions on "Media Mixing" and "Waste Disposal"
- Luncheon address (on Friday) by Dr. James Boren, President of the International Association of Professional Bureaucrats.

To be announced later will be Society papers, Roon competition papers, and other presentations related to the theme.

Spouses' Program

The Spouses' Program will open on Wednesday afternoon (at the Sheraton St. Louis) with a get-acquainted wine 'n cheese social. The main activity (on Thursday) will consist of a driving tour of selected St. Louis areas, a two-hour luncheon cruise on the Mississippi River, and a shopping tour.

Registration

Advance registration fees will be: Members--$35.00; Non-members--$50.00; Spouses--$20.00; Retired members and their spouses--$15.00 each. On-site fees will be: Members--$40.00; Non-members--$55.00; Spouses $25.00.

1979 Paint Industries' Show

Cervantes Convention Center

St. Louis, Missouri

October 3, 4, 5

EXHIBITORS

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Alcan Ingot & Powders, Alcan Aluminum Corp.	713-715-812-814
Alpine American Corp.	635
Aluminum Co. of America	17-19
C.M. Ambrose Co.	109-111
American Felt & Filter Co.	8-10-12
American Hoechst Corp.	227-229
American Nepheline Corp.	107
Applied Color Systems, Inc.	816-818
Ashland Chemical Co.	613-615-617-619-712-714-716-718
Atlas Electric Devices Co.	608-610
Automation International Corp.	841

B.A.G. Corp.	835
BASF Wyandotte Corp.	327-329
Bennett's Colorant Div.	330
Blackmer Pump Div., Dover Corp.	434
Brookfield Engineering Labs., Inc.	401
Brunswick/Technetics Div., Filterite Prods.	130-132
Buckman Laboratories, Inc.	408-410
Byk-Mallinckrodt Chem. Prod. GmbH	527-529-626-628

Cabot Corp., Cab-O-Sil Div.	431-433
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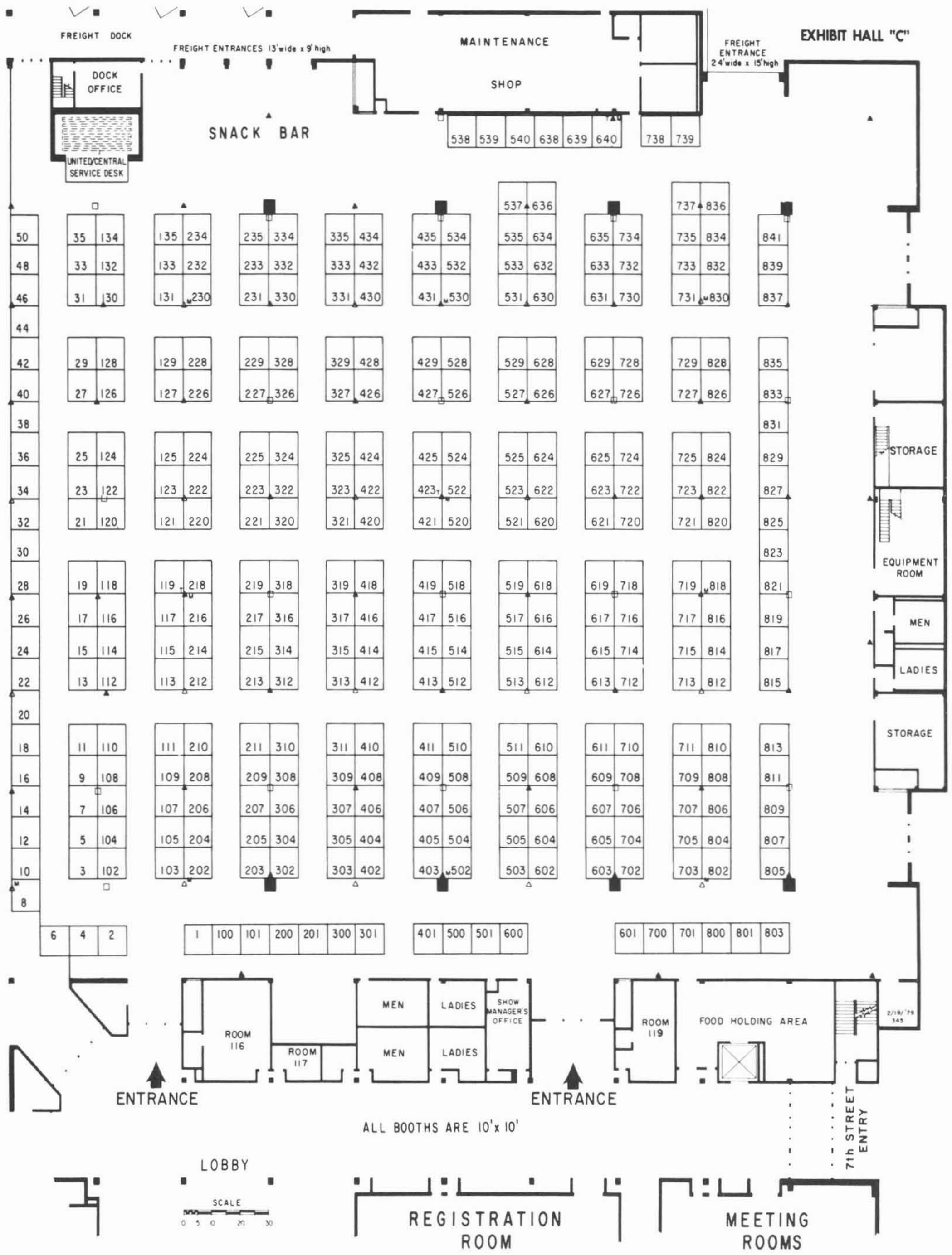

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PAINT INDUSTRIES SHOW

OCTOBER 3-5, 1979

ST. LOUIS CONVENTION CENTER - ST. LOUIS, MO.

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1979 ANNUAL MEETING AND PAINT INDUSTRIES' SHOW

CONVENTION CENTER, ST. LOUIS, MISSOURI

OCTOBER 3, 4, 5, 1979

"PROGRESS THROUGH INNOVATION"

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APPLICATION FOR ACCOMMODATIONS

Please indicate below the type of accommodations requested and your choice of hotels. Room reservations cannot be guaranteed unless this form is received by September 14, 1979. All reservation requests must be in writing and processed through the Housing Bureau: Phone requests are not accepted.

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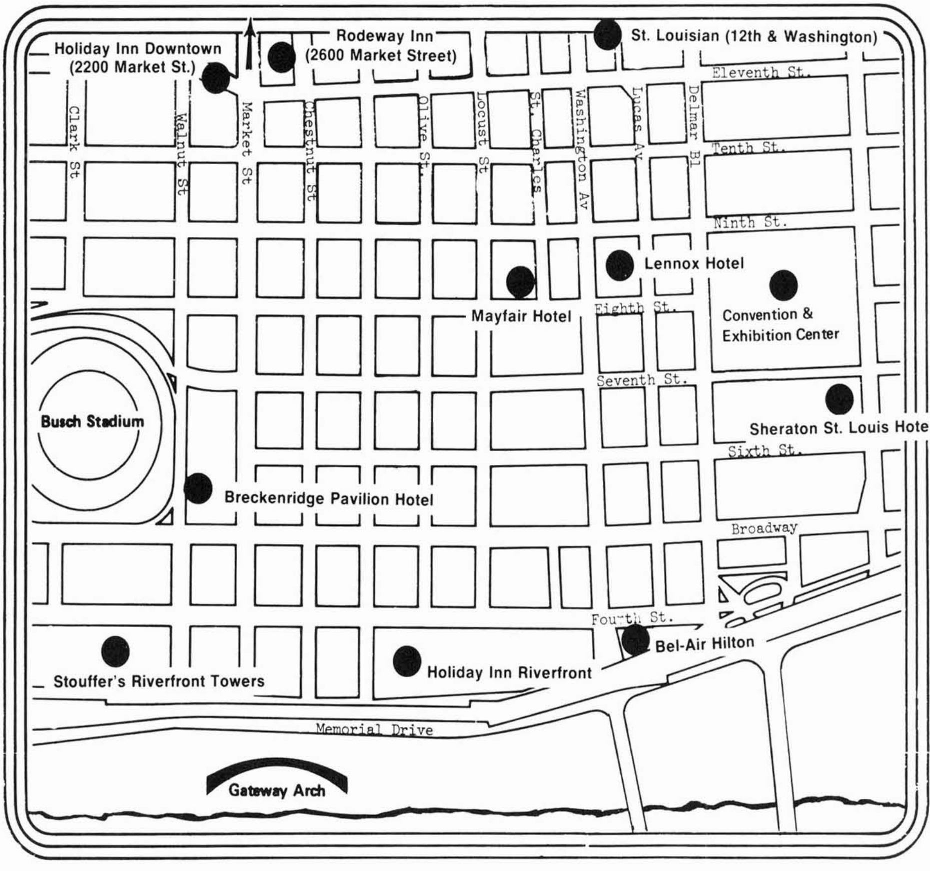

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Annual Meeting and Paint Show

October 3 - 5, 1979

St. Louis, Missouri

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Convention Center
St. Louis, Missouri
October 3 - 5

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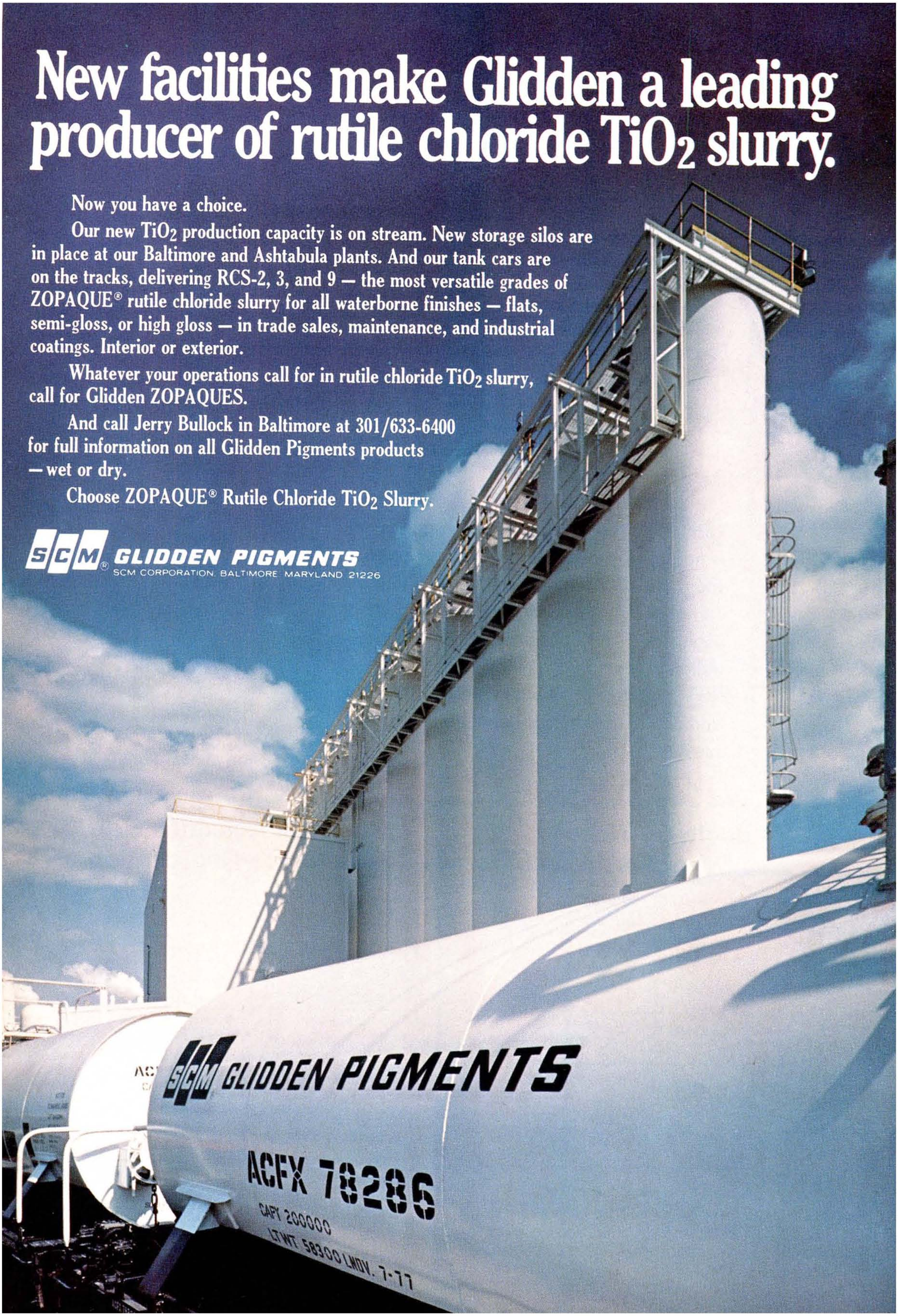
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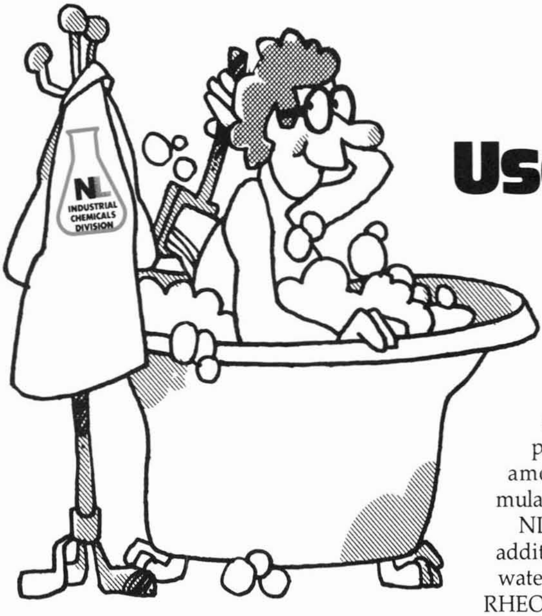
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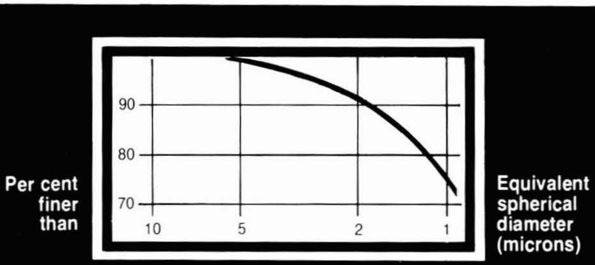

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Flexibility and Its Retention In Clear Coatings Exposed to Weathering

H. E. Ashton
National Research Council of Canada*

The influence of mechanical properties on the behavior of coatings in service is generally understood. However, the level of these properties, particularly flexibility, attributed to some binders has not reflected actual measurements.

Tensile strength and elongation of clear alkyds and phenolic varnishes have been determined using free films exposed to natural or accelerated weathering. It is shown that alkyds of intermediate oil content have higher extensibility and retain it better than those with low or high oil content, while phenolics do not remain flexible for very long in either exposure. The relation of tensile properties to exterior performance on wood is discussed.

INTRODUCTION

Because it developed from an art form with closely guarded secrets, the coatings industry seems to hold on longer than other industries to beliefs that do not stand up to scientific investigation. Long after a particular tenet has been proved false, it may continue to be repeated in the coatings industry as accepted fact.

One example of such beliefs is that "drying oils provide added flexibility to coatings films." In the field of art this was, of course, true for several centuries. Oils *are* flexible in comparison with the other binders that had previously been used: glue, casein, egg white, and egg yolk. Improved flexibility was probably one reason why oil paints superseded tempera, which was an emulsion of oil in water with egg yolk acting as the emulsifier and protective colloid. The difference between the mechanical properties of oil and those of the other binders was certainly the basis for the old artists' rule, fat on lean, but never lean on fat, i.e., do not topcoat a soft-drying material with a hard-drying material (unless the aim is to produce a wrinkle or alligator finish).

Oils are also more flexible than the hard resins used to produce the oleoresinous finishes introduced after oil paints were developed. This difference in flexibility was the basis of the old kauri test in which a hard, natural resin is added to a varnish until it cracks when bent over a narrow rod. The hypothesis was that the more hard resin that could be added, the more durable was the original varnish. This was correct when the test was first developed because the natural resins then in use were not so durable as the oils. The introduction of pure, oil-soluble phenolic resins, however, changed the relationship between oil content and durability. Exposure studies of clear finishes for exterior wood carried out at DBR/NRC showed that the durability of tung and linseed p-phenylphenolic varnishes reaches a maximum at oil contents of 58 to 66% by weight.[1] Subsequent accelerated weathering tests have confirmed these results. Despite this work, kauri reduction still appears as a requirement in exterior varnish specifications and the method is retained by ASTM.

With the invention of alkyds, the continuing belief that drying oils are more flexible than resins becomes even less tenable when studied carefully. In an alkyd, part of the polymer is formed during the cooking of the resin. Because the resin portion is tougher and not so brittle as the resins used in oleoresinous finishes, less oil or fatty acid is needed in their production. For

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Presented at the Polymer Conference, University of Detroit, June 13, 1979.

*Division of Building Research, Ottawa, Ontario, Canada K1A 0R6.

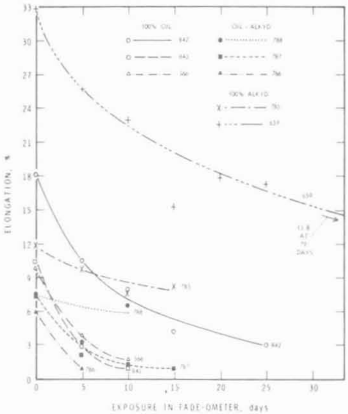

Figure 1—Elongation of pigmented coatings

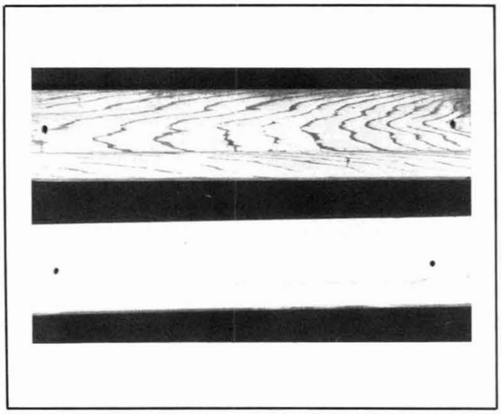

Figure 2—Test fence panels of oil paint (NRP 566), top, and alkyd (NRP 659), bottom, after 7 years' exposure

example, an alkyd containing 60% oil is considered to have a high oil content (long oil length), but an oleoresinous binder with the same oil content is said to be of medium length. Owing to the greater proportion of prepolymer in alkyds, there is less dependence upon air drying for complete film curing so that semi-drying oils can be used, yet, drying is more rapid than for a straight drying oil. Because of the lower oil content and possibly lower unsaturation, the resultant films oxidize less during aging or weathering and retain flexibility better than a binder composed completely of oil. In spite of this, some specifications for alkyd finishes for exterior wood prohibit lowering the oil content (increasing the phthalic content) because the oil is supposed to provide the flexibility needed on a wood surface.

More than 15 years ago, work carried out at DBR/NRC[2] showed that pigmented alkyd finishes had higher initial extensibility than linseed oil paints and retained their extensibility better when exposed to artificial sunlight (*Figure* 1). Part of the difference in elongation was due to lower pigment volume concentration (PVC), as shown in *Table* 1. In addition, the tensile machine then in use was not very sensitive and the rate of loading could not be controlled because the movement of the lower grip varied according to the tensile properties of the film being tested. Nevertheless, the results did indicate that alkyds should be suitable for use on exterior wood siding. Exposure tests[3] on various wood substrates confirmed the superiority of the alkyd, as illustrated in *Figure* 2. In practice, however, they only came into wide use for this purpose in North America about ten years later when the price of linseed oil increased by more than 400%.

Some of the studies on clear finishes illustrate more explicitly the relation between oil content and flexibility, especially of alkyds. The over-all objective was to determine which properties are needed to provide satisfactory performance of clear coatings. Among those considered relevant were initial tensile strength and elongation as well as changes in them with weathering. Free films of two types of clear finish were exposed to natural and accelerated weathering and their

Table 1—Composition of Pigmented Oil and Alkyd Finishes

NRP Formula Number	Binder		Pigmentation	
	Components	Total Oil Content % N-VV[a]	Type (in order of content)	PVC %[b]
842	100% Refined linseed oil	100	Basic white lead carbonate (BWLC)	31.0
843	100% Refined linseed oil	100	BWLC-ZnO-Talc	29.1
566	70% Raw linseed oil 30% Bodied linseed oil Z-3	100	Talc-BWLC-ZnO-TiO_2	33.6
786	51.6% Refined linseed oil 48.4% Extra long linseed alkyd	88.9	PbZn-Talc-TiO_2	35.4
788	25% Bodied linseed oil Q. 75% Extra long isophthalic linseed-soya alkyd	88.75	Talc-TiO_2	31.4
787	48.7% Refined linseed oil 51.3% Extra long linseed alkyd	88.2	Talc-ZnO-TiO_2	34.5
785	100% Extra long linseed alkyd	77	Talc-TiO_2	29.7
659	100% Long soya alkyd	65	TiO_2	19.6

(a) Non-Volatile Vehicle.
(b) Pigment Volume Concentration.

Table 2—Composition of Clear Finishes

NRP Formula Number	Type	Oil Content		% Volatile Content		Varnish Properties	
		Approx Length	% Solids	Aromatic Solvent	Mineral Spirits	% Solids	G - H Viscosity
Para-Phenylphenolic Varnishes							
1020	Tung	15	58.3	85.3	14.7	51	A-B
893	Tung	20	66.7	33.3	66.7	50	C
894	Tung	30	75	10.0	90.0	50	D
901	Tung	40	80	—	100.0	50	B-C
1021	Linseed	15	58.3	49.4	50.6	49.5	D
902	Linseed	20	66.7	30.6	69.4	51	B-C
903	Linseed	30	75	20.2	79.8	49.5	D
905	Linseed	40	80	10.0	90.0	50	C-D
1022	Soya	20	66.7	28.6	71.4	50	B
1023	Soya	40	80	34.7	65.3	50	C-D
1024	DH Castor	20	66.7	33.3	66.7	50	C
1025	DH Castor	40	80	2.6	97.4	49	E

NRP Formula Number	Oil Content		% Phthalic Content		Solution Characteristics	
	Type	% Solids	Isomer	% Solids	% Solids	G - H Viscosity
Alkyds						
912	Soya	59.4[a]	Ortho	25	50	A-B
913	Soya	62.5[a]	Ortho	24	50	A-B
914	Soya	56 [a]	Ortho	30	50	D-F
915	Soya	48 [a]	Ortho	35	42	E
916	Soya	39.6[a]	Ortho	39	40	G-H
1055[b]	Linseed	54	Ortho	35	50	A-B
1056[b]	Soya	56.5	Ortho	31	50	A-B
E1	Safflower	70	Ortho	17	60	A$_1$
E2	Safflower	83	Iso	9	60	A$_1$
E3	Linseed-Soya	85	Iso	13	60	A$_1$
E4	Soya	75	Iso	18	50	C-D
E5	Soya	72	Iso	20	50	C-D
E6	Soya	67	Iso	28	50	C-D

(a) Percent oil content calculated from reported fatty acid content. Other commercial alkyds are reported as oil content.

(b) Prepared in laboratory.

mechanical properties measured at intervals of exposure. This paper discusses the changes in tensile properties in relation to composition and to performance on exterior cedar panels.

EXPERIMENTAL

Materials

The clear finishes were phenolics and alkyds. There were 12 p-phenylphenolic varnishes containing from 58 to 80% of one of four different oils. The 13 alkyds, eight based on orthophthalic anhydride and five on isophthalic acid, contained from 39.5 to 85% of three different oils. The varnishes and two of the alkyds were made in the DBR laboratory. The remaining alkyds were purchased from commercial resin producers, with the soya-orthophthalic series all made by the same company. The composition of phenolics and alkyds is summarized in *Table* 2.

The coatings were applied to tinfoil using a 6-mil clearance blade and a mechanical drive equipped with a perforated suction plate.[4] These films were allowed to dry for three weeks in a room conditioned at 73.5 ±3.5°F (23 ±2°C) and 50 ±5% RH.

Accelerated Weathering

After air drying, the coatings, still on the foil, were mounted carefully on a rack so that no fold could develop in the coating during handling and weathering. To determine the effect of accelerated weathering on tensile strength and flexibility, the mounted coatings were exposed in a twin carbon-arc Weather-Ometer® operating on a cycle of 12 hours light without water and 12 hours very high relative humidity without light. The latter was substituted for the 12-hr water spray in the cycle customarily used in this laboratory to test clear finishes on wood.[5] The substitution was necessary be-

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Weather-Ometer is a registered trademark of Atlas Electric Devices Co.

Table 3—Tensile Strength of Alkyds During Accelerated Weathering
(Maximum Load at Break or Yield Point - PSI)

	Ortho-phthalic Alkyds												
	Commercial						Lab Prepared		Iso-phthalic Commercial Alkyds				
Days Exposed	**912 Soya**	**913 Soya**	**914 Soya**	**915 Soya**	**916 Soya**	**E1 Safflower**	**1055 Linseed**	**1056 Soya**	**E2 Safflower**	**E3 Linseed Soya**	**E4 Soya**	**E5 Soya**	**E6 Soya**
0	710	76	411	316	759	122	1105	121	60	66	139	200	156
6	679	55	431	618	767	97	1123	168	47	44	163	205	375
12	884	46	—	653	830	86	1166	—	110	62	181	—	—
18	—	—	823	526	914	—	1676	75	—	—	267	228	421
30	1119	78	1040	849	1673	114	2411	273	—	52	342	547	564
40	1051	—	985	719	—	—	2254	—	549	—	722	676	519

cause the force of the water spray might damage free films exposed for any length of time. Subsequent tests on clear finishes on wooden panels showed that with the light-humidity cycle it took twice as long to obtain results the same as those of the light-water spray. The ratio in this study may be closer to one because free films obtained from a single coat would absorb water more rapidly than a three-coat system applied to wood.

Natural Weathering

For outdoor exposure, thick, 8 × 12-in. glass plates were used as supports. As suggested in ASTM D2370, a thin layer of castor oil was applied to one side of the glass plate to hold the coated foil in close contact with it, taking care to avoid applying too much oil. The foil bearing the coating was then placed on the glass plate and the surface completely smoothed with tissue. Excess foil was folded over all four sides of the plate and the coating taped to the plate with waterproof plastic-coated tape, leaving a sufficiently large area for exposure.

The mounted clear finishes were exposed at an angle of 45 deg on south-facing racks 4 ft (1.2 m) above the ground at the exposure site of the National Research Council, Ottawa. Exposure of 20 sets of 12 paraphenylphenolic varnishes began in July 1968. The same number of sets of 13 alkyd coatings were exposed in August. Twenty sets allowed a total exposure time of about 16 months because of more frequent testing during the first few months of exposure.

Tensile Tests

At the end of each selected period of natural or accelerated weathering, one set of each coating was removed from the racks for testing. The other sets were left undisturbed for further exposure. The foil bearing the coating was removed from the support and examined for any damage that might have occurred during exposure. It was then placed between two waxed paper sheets and cut into one-inch (25 mm) strips using a Thwing-Albert precision sample cutter. The coating side of the strips was taped at both ends and the strips placed on a mercury bath. When the coatings floated freely after amalgamation of the tin, they were picked up with tweezers at a taped end. Each film was spread on waxed paper and the original underside carefully cleaned with a camel hair brush. To obtain a relatively clean surface and permit easy handling of the free film on mercury, it was necessary to use a large amount of mercury in a spacious amalgamation bath.

The one-inch wide strip of the unsupported coating was taped on both sides at each end to provide a 3-in. (76 mm) gauge length. The waterproof plastic-coated pressure-sensitive cloth tape also acted as a grip for the jaws of the tensile machine. The test specimens were pulled on a Tinius-Olsen U-Celtronic® tensile tester equipped with a 12,000 g cell. This machine allows the load to be decreased in steps down to 120 g for full-scale deflection. It was usually operated in the 600, 1200, or 2400 g range depending upon the strength of the coating. In most cases the coating was pulled at a strain rate

Table 4—Flexibility Properties of Alkyds During Accelerated Weathering
(Maximum Elongation at Break - Per cent)

	Ortho-phthalic Alkyds												
	Commercial						Lab Prepared		Iso-phthalic Commercial Alkyds				
Days Exposed	**912 Soya**	**913 Soya**	**914 Soya**	**915 Soya**	**916 Soya**	**E1 Safflower**	**1055 Linseed**	**1056 Soya**	**E2 Safflower**	**E3 Linseed Soya**	**E4 Soya**	**E5 Soya**	**E6 Soya**
0	100.1	71.0	106.8	111.9	164.2	55.5	91.0	88.2	42.8	40.2	51.0	55.8	84.1
6	100.0	90.8	101.9	136	137.2	62.6	86.2	123.8	52.5	56.3	67.5	57.7	137.2
12	81.2	79.3	110.2	133.5	106.6	61.0	72.0	—	49.3	60.9	70.4	58.3	111.0
18	55.6	69.0	77.5	74.3	79.7	—	42.6	80.0	—	66.0	57.8	48.7	93.1
30	57.0	40.7	32.0	58.8	17.4	71.2	7.8	41.9	55.4	55.7	72.3	58.6	100.9
40	44.3	—	50.0	87.5	—	—	8.0	—	17.4	—	32.9	46.0	93.5

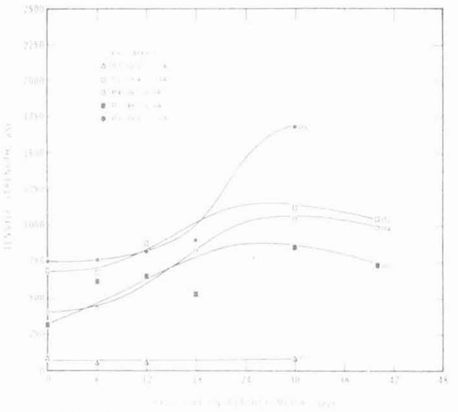


Figure 3—Tensile strength of alkyds with different oil contents

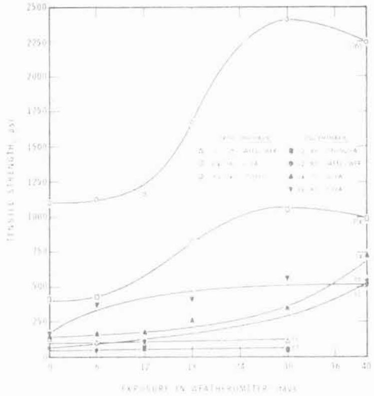


Figure 4—Tensile strength of alkyds with different acids and oil types

of 0.12 in. (3 mm) per minute, which is 4% of the gauge length per minute.

The maximum load in grams applied to the one-inch wide strip of the coating at either break or deformation (yield point) was determined directly from the recording chart on the machine. Tensile strength was calculated in terms of pounds per square inch and expressed as the maximum load at the point of break or yield.

The maximum extension in the length of the test specimen at the point of break was taken as the measure of flexibility of the coating. Extension in length was determined from the rate of strain and the time required for breaking to occur. Elongation was calculated as the per cent increase in the gauge length of the coating and reported as percent elongation.

Because of the variability encountered in tensile tests conducted on thin films of organic coatings, it had been planned to use at least ten specimens of each material for one test. With some coatings exposed to accelerated or natural weathering for fairly long periods, however, the number of test specimens was reduced because those that developed defects were discarded. For example, most phenolic coatings exposed in the Weather-Ometer for more than 12 cycles or outdoors for more than one year became so brittle that they broke either in the process of removing them from the amalgamation bath or while mounting them on the tensile tester. Because of this, the results for coatings of longer exposure time were obtained from a limited number of specimens or could not be obtained at all.

When results from an individual specimen were low for both elongation and tensile strength, compared with other specimens of the same material subjected to the same weathering period, they were rejected. The procedure described in ASTM D2370 requires that the lowest five results be discarded automatically, regardless of how they differ from the others. Some difficulty was experienced in selecting results from specimens weathered for fairly long periods. In most tests where the specimen broke in the approximate center of the gauge length, the results were taken as reliable. Specimens of coatings that were weathered for a long period, however, frequently shattered completely at the time of break. In such cases the validity of the results was considered questionable and they were not reported. Examples can be seen in the Tables where test data do not agree with those from either the preceding or following exposures. They are reported merely to illustrate the variability encountered in determining the tensile strength and flexibility of thin coatings.

RESULTS AND DISCUSSION

Because tensile strength and elongation are inversely related for most organic coatings, it is essential to consider both properties at the same time to obtain a more

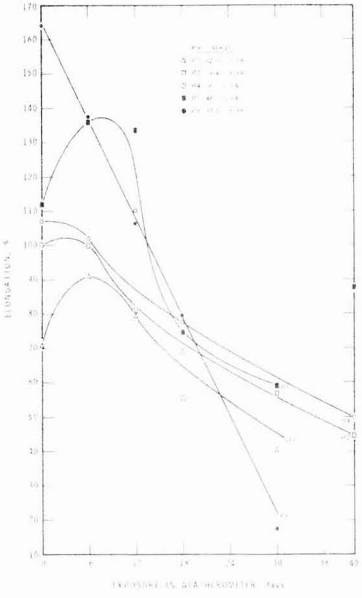


Figure 5—Flexibility of alkyds with different oil contents

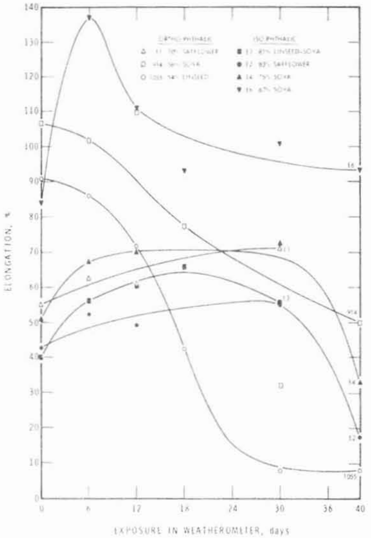


Figure 6—Flexibility of alkyds with different acids and oil types

complete picture of their mechanical properties. For example, high tensile strength is only beneficial if it is accompanied by a fair amount of elongation; otherwise the material is brittle. Conversely, high elongation requires a reasonable level of tensile strength or the coating will be weak. If a material has both high tensile strength and high elongation, it is considered tough, but this combination is the exception with organic coatings.

Because of the effect of one mechanical property upon the other, it would be preferable to combine the two in a single factor. This is sometimes done by integrating the area under the stress-strain curve and considering the result as a measure of toughness. Theoretically, the best way to treat the tensile properties of viscoelastic materials is by means of failure envelopes.[6] This, however, is not normal practice because of the large number of tests required to define the failure envelope completely. Consequently, the results obtained in this study will be presented in the usual terms of tensile strength and elongation.

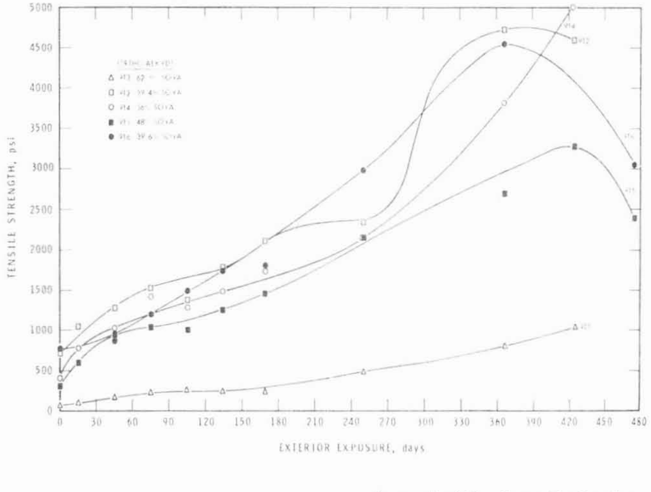
Effect of Weathering On Tensile Properties of Alkyds

ACCELERATED WEATHERING (AW): The tensile strengths and elongation results from clear alkyd films exposed to AW are given in *Tables* 3 and 4. Curves for most of these finishes are plotted in *Figures* 3 to 6. In general, alkyds have low tensile strengths that increase with longer exposure, except for the long oil ortho alkyds and very long oil iso alkyds. Flexibility changes caused by AW vary with the resin: elongation of lower oil content alkyds tends to decrease continuously, while that of higher oil content alkyds generally goes through a maximum before decreasing.

The effect of oil content on tensile strength is illustrated in *Figure* 3, where the type of oil and dibasic acid are the same, and in *Figure* 4, for different oils and acids. In the former, the tensile strengths of the alkyds with the highest and lowest oil contents are in the expected order, but the three with intermediate oil contents, although fairly similar, are reversed. The laboratory-prepared linseed ortho alkyd had the highest tensile strength of all the alkyds tested. Corresponding soya alkyds of similar (914) or lower (916) oil content show the same type of weather-induced changes in strength but at lower levels.

Tensile strengths of isophthalic alkyds are in the expected order, except after 40 days of exposure. There is a larger difference between the two longest iso alkyds than might be expected, E3 remaining weak but E2 gradually increasing in strength. There is a trend for iso alkyds to have somewhat higher tensile strengths than ortho alkyds of similar or even lower oil content (E6 vs. 913, E2 vs. E1). Both the longest ortho and iso alkyds have very little strength, but the latter contains 15% more oil.

Figure 7—Tensile strength of alkyds with different oil contents



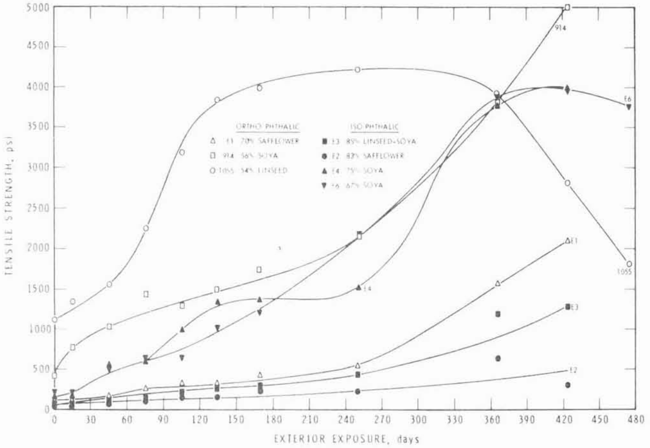


Figure 8—Tensile strength of alkyds with different acids and oil types

The elongation results are very different from those suggested by the "oil-is-flexible" hypothesis. The short oil alkyd with the highest tensile strength also has the greatest initial elongation (*Figure* 5). This eventually drops to the lowest, however, in keeping with the marked increase in strength. In this group the 62.5% soya alkyd, which has very little strength, has also the lowest flexibility during most of the exposure, while the alkyd with the second lowest oil content has the second highest flexibility. As with tensile strength, the medium soya and linseed alkyds behave similarly, with the latter having lower flexibility. This is attributed to differences in reactivity of the oils, since oil contents are nearly the same.

With the iso alkyds, that with the lowest oil content has high initial flexibility and by far the highest flexibility retention (*Figure* 6). The 75% iso alkyd also has somewhat higher extensibility than the two longest iso resins, but this was not the case with the 72% alkyd.

The increase in flexibility of many of the alkyds during the first stages of AW is attributed to toughening by crosslinking. Initially, the films were soft and relatively weak, so that they broke at lower loads and extensions. The poor mechanical properties of long and very long alkyds are consistent with the proposition[7] that in such resins some of the oil is present as a mixture only, and is not chemically bonded to the alkyd molecule. During drying some crosslinks form, but not enough to increase tensile strength appreciably. The higher strengths and good flexibility of the long oil iso alkyds suggest that the oil reacts more during preparation to become a part of the molecule. It is known that orthophthalic anhydride tends to form ring compounds, thus reducing formation of chain polymers with higher molecular weights.

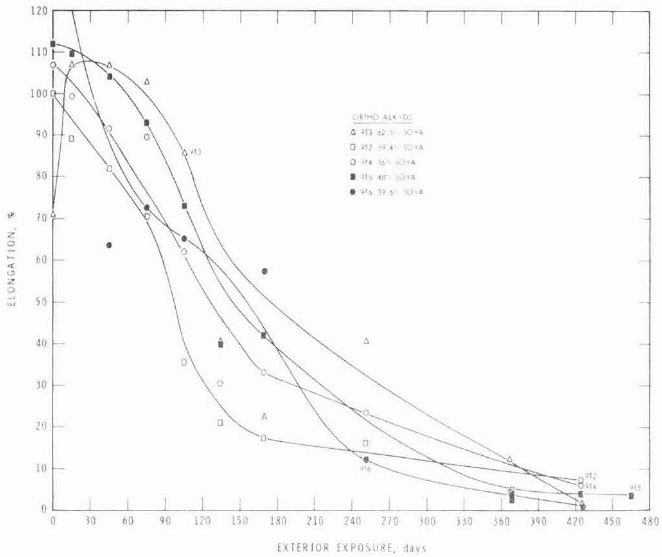


Figure 9—Flexibility of alkyds with different oil contents

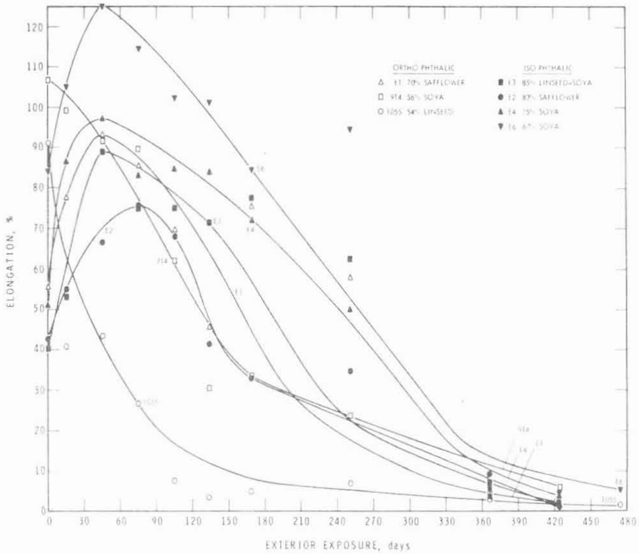


Figure 10—Flexibility of alkyds with different acids and oil types

NATURAL WEATHERING (NW): The tensile strength and elongation results for alkyds exposed to NW are shown in *Figures* 7 to 10. It is evident that the maximum tensile strength, which was much higher in NW than in AW, was not reached until after a year's exposure. In fact, most of the longer oil alkyds were still increasing in tensile strength at the end of the test when flexibility was correspondingly lower.

The order of strength of the ortho alkyds in *Figure* 7 approximates that of AW (*Figure* 3), although the shorter alkyds exhibit, after one year, a decrease in strength not evident in the brief AW exposure. Another difference is the moderate increase in strength of the long oil alkyd after six months. The three intermediate resins are in the same relative order in both NW and AW. The linseed alkyd curve in *Figure* 8 is similar to that of the short soya in *Figure* 7, i.e., there is a decrease in strength after one year. Iso alkyds E4 and E6 are comparable in strength, as they were in AW. Similarly, E1 and E3 are comparable, but in NW there is an increase in strength after eight months. Only E2 appears to have lower strength in NW, but results were not available for two of the later AW exposure intervals.

With regard to oil length and elongation, in *Figure* 9, the long and short soya ortho alkyds exhibit flexibilities comparable to those in AW, but the others are lower. In NW the long oil alkyd has the highest flexibility, but that with the second highest oil content has the lowest flexibility for the first eight months. Medium length alkyds, 914 and 915, are similar, although the latter, with less oil, is more flexible for the first six months.

In *Figure* 10, the longest ortho alkyd and all the iso alkyds reach a peak in extensibility after about 45 days' exposure. The 70% safflower ortho alkyd is slightly more flexible than the 83% safflower iso alkyd. Again, the shortest iso alkyd, E6, has the highest elongation, although its superiority to E4 is not so marked as in AW. Both are more flexible than the ortho alkyd of comparable oil content. As in AW, the ortho alkyd containing

Table 5—Tensile Strength of Phenolics During Accelerated Weathering

(Maximum Load at Break or Yield Point, psi)

	15-Gallon		20-Gallon				30-Gallon		40-Gallon			
Days Exposed	1020 Tung	1021 Linseed	893 Tung	902 Linseed	1022 Soya	1024 DH Castor	905 Tung	903 Linseed	901 Tung	905 Linseed	1023 Soya	1025 DH Castor
0	2843	2477	3069	1260	556	982	1878	910	1196	712	67	334
0.50	5108	5257	4616	3946	1718	2004	2306	1690	1781	1154	274	513
1	5444	5762	5273	4970	2948	3453	2662	2079	2324	1572	341	686
2	5596	5810	5447	5333	2877	4200	2971	2888	2854	1741	384	594
4	5815	5014	6115	5731	4241	4391	4454	4474	3069	2857	822	1230
6	5050	4494	—	4191	3004	2964	4423	4053	3501	3541	817	1228
8	4548	2379	3766	—	2732	3282	4638	3855	3195	3244	856	1187
10	—	—	3352	2666	2470	2542	4480	4539	3090	3265	854	1219
12	2888	2102	2370	—	—	—	4026	—	—	—	—	1684

Table 6—Flexibility Properties of Phenolics During Accelerated Weathering

(Maximum Elongation at Break, per cent)

	15-Gallon		20-Gallon				30-Gallon		40-Gallon			
Days Exposed	1020 Tung	1021 Linseed	893 Tung	902 Linseed	1022 Soya	1024 DH Castor	905 Tung	903 Linseed	901 Tung	905 Linseed	1023 Soya	1025 DH Castor
0	9.1	6.7	8.2	21.7	93.1	75.4	39.7	76.4	12.3	63.8	26.1	53.8
0.5	8.6	6.8	11.2	9.5	27.3	15.9	25.5	27.8	29.1	38.9	47.6	54.5
1	9.4	5.8	9.9	10.1	8.3	9.9	13.8	21.9	9.2	35.9	56.6	64.5
2	8.5	7.5	10.1	7.9	8.3	8.8	8.8	8.4	9.5	24.4	51.6	53.4
4	6.7	5.2	10.6	10.5	8.8	8.5	8.2	8.7	8.6	8.8	32.9	29.5
6	9.6	5.7	5.2	6.2	4.6	4.5	9.7	10.1	9.1	8.7	38.4	34.5
8	5.9	6.4	3.7	—	5.1	5.7	9.1	7.0	7.8	8.9	23.9	25.0
10	5.1	4.0	5.1	4.2	3.9	5.2	6.9	4.9	8.9	8.5	15.5	22.5
12	5.8	2.9	4.4	—	—	—	6.0	7.9	—	—	—	21.6

relatively fast-drying linseed oil lost all flexibility after three months' weathering, at the same time rapidly increasing in tensile strength. This is related more to oil type than to oil content because the corresponding laboratory-prepared soya (not illustrated) was similar in elongation to the other medium length soya alkyds, e.g., 914. Of the alkyds tested, iso alkyds E4, E5, and E6 have the best combination of tensile strength and elongation.

Effect of Weathering On Tensile Properties of Phenolics

ACCELERATED WEATHERING: The tensile strength and elongation of phenolic varnishes subjected to AW are listed in *Tables* 5 and 6. Compared to alkyds, phenolics have much higher tensile strength that increases much more rapidly during AW, as illustrated in *Figure* 11 (note scale difference). Regardless of oil content or oil type, all varnishes have much lower flexibility than alkyds after a few days of accelerated weathering.

Among 20-gal varnishes, that made with tung oil has the highest tensile strength throughout the exposure. The tensile strength of linseed varnish approaches that of tung varnish, but for soya and dehydrated castor varnishes it is somewhat lower. With regard to oil contents, varnishes with more oil have lower tensile strengths that peak a few days later than do the shorter oil varnishes.

Regardless of oil type, all 20-gal varnishes lose all flexibility after one day AW. Elongations, as well as tensile strengths, of the two short tung varnishes are the same within experimental error throughout the test. Evidently the additional resin did not cause the 15-gal varnish to become more brittle than the 20-gal one. Only the 40-gal soya and DH castor varnishes retain flexibility for more than eight days, which might lead one to conclude that they should perform better than all other phenolics. In fact, their performance on exterior wood is relatively poor; one factor associated with this might be their low tensile strength.

The initial high strength and low elongation of tung varnishes are attributed to the high degree of conjugated unsaturation present in tung oil. This contributes to rapid drying, so that the film is closer to its final air-dried properties than are those containing slower drying oils. During weathering radiant energy accelerates the drying process. Consequently, all varnishes decrease to low levels of elongation.

The differences in tensile strength show the differences among the oils in reactivity during varnish cooking. Tung and linseed react more with the resin, resulting in higher tensile strength at all times during exposure. The peak in strength reached after three to four days is most probably related to the processes of crosslinking and chain scission caused by ultraviolet light.[8] Crosslinking is a continuation of the drying process, so that at first tensile strength increases. After many of the available sites are used up, chain scission becomes predominant, leading to decreases in molecular size and a correspondingly lower strength.

NATURAL WEATHERING: Examples of the changes in tensile strength and elongation of phenolic varnishes during NW are given in *Figures* 12 and 14. With these finishes, the peak tensile strength of naturally weathered films is lower and the change more gradual than in

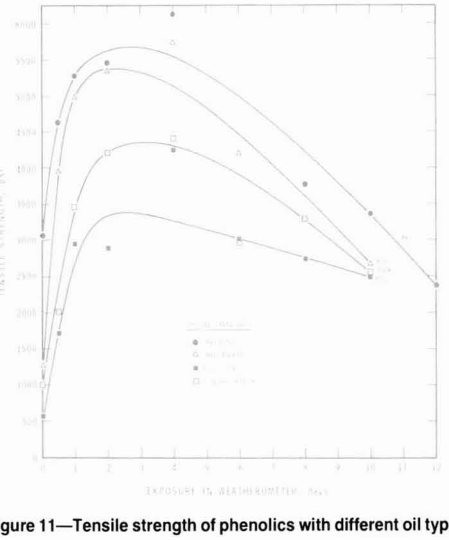


Figure 11—Tensile strength of phenolics with different oil types

Table 7—Flexibility Properties of Phenolics During Natural Weathering

(Maximum Elongation at Break, per cent)

	15-Gallon		20-Gallon				30-Gallon		40-Gallon			
Days Exposed	1020 Tung	1021 Linseed	893 Tung	902 Linseed	1022 Soya	1024 DH Castor	894 Tung	903 Linseed	901 Tung	905 Linseed	1023 Soya	1025 DH Castor
0	9.1	6.7	8.2	21.7	93.1	75.4	39.7	76.4	12.3	63.8	26.1	53.8
7	8.3	6.9	10.7	11.5	17.9	40.1	—	57.0	45.1	63.1	56.5	51.6
15	7.0	4.4	6.4	5.8	4.7	4.7	7.1	6.5	28.9	—	—	—
25	6.2	4.4	9.9	7.1	13.7	9.9	—	7.5	46.4	42.0	65.0	68.9
45	5.5	3.4	4.3	5.5	4.0	2.8	5.8	4.8	6.7	2.2	4.5	3.6
61	6.3	5.2	7.4	3.6	2.5	2.6	5.2	3.6	7.0	4.7	4.8	5.2
75	6.4	4.3	5.5	5.9	3.1	4.1	6.0	5.3	6.4	5.0	4.4	3.0
90	5.7	5.0	5.2	5.7	5.5	4.6	6.1	3.9	4.6	3.2	3.8	2.9
105	5.5	4.1	7.3	5.6	2.2	4.0	5.3	3.7	6.8	2.7	3.3	4.5
134	5.0	4.8	—	5.0	2.7	4.0	3.8	4.6	7.6	5.1	3.9	4.3
169	4.8	4.8	4.9	4.8	4.0	3.3	3.8	4.5	4.6	5.5	—	2.7
251	—	—	5.7	4.6	3.3	2.5	4.9	1.9	—	3.1	3.2	2.6
366	3.5	1.8	2.4	2.0	2.5	1.4	1.6	1.5	2.5	2.7	—	—

AW. Changes in extensibility are similar, with little flexibility remaining after four to six weeks' exposure (*Table* 7).

Figure 12 shows that the peak in tensile strength is at one month for the 15-gal tung varnish, at two months for the 20-gal varnish, and at three months for the 30- and 40-gal varnishes. As in AW, the two shorter varnishes have higher tensile strengths than those containing more oil. The values in peak strength for 893 are 3500 psi for NW and 6115 psi for AW, although the latter is abnormally high in comparison with other AW values. A more realistic value would be 5600 psi, which is still considerably greater than that obtained in NW.

The effect of different oil types on tensile strength is illustrated in *Figure* 13, where it may be seen that tung and linseed varnishes have similar strengths, except at the initial and final exposures. Soya and DH castor exhibit similar, lower strengths.

The elongation results illustrate why higher oil content is not related to durability of phenolic varnishes. The 20-gal varnishes made with all four oils had the same low level of flexibility after 15 days' exposure. The varnishes containing 80% oil, however, also have low elongation after 45 days NW (*Figure* 14). Because all varnishes, whether short or long oil, become relatively inflexible within less than two months of weathering, high oil content cannot be important to durability. Other factors must be responsible for some of the varnishes being more durable.

Comparison of Natural And Accelerated Weathering

In general, the time-dependent change in flexibility of the different coatings was fairly comparable in both exposures. Differences in apparent behavior of alkyds can be attributed in part to the short length of the artificial test compared with the period of natural weathering. For example, E6 would have almost the same curve in *Figure* 10 as in *Figure* 6 if the natural exposure were terminated at 250 days.

The tensile strengths are in the same relative order within a group, but phenolic coatings have higher values in AW while alkyds are higher in NW. (In making comparisons, note the difference in the psi scale in certain figures.) This difference in behavior may occur if phenolics absorb more UV radiation in the accelerated test than they do on exterior exposure. It is known that the carbon arc produces two large peaks in the near

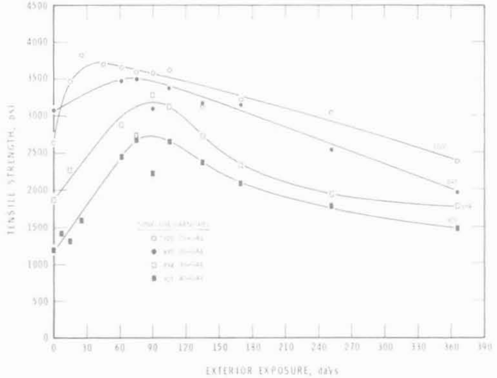


Figure 12—Tensile strength of tung phenolics with different oil contents

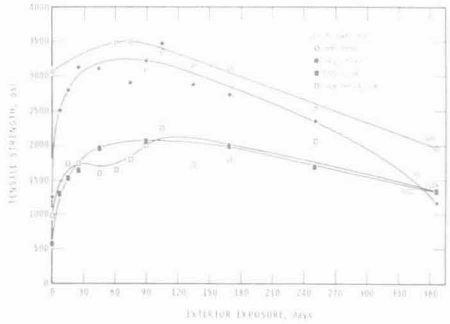


Figure 13—Tensile strength of phenolics with different oil types

UV that are not present in sunlight and that phenolics absorb more towards the visible region than do alkyds. Perhaps the radiation level in the accelerated test is too intense for the proper evaluation of phenolics. The only logical explanation of why alkyds are lower in tensile strength in AW, where the intensity of radiation is greater, is that the accelerated test was not long enough to allow them to reach the maximum strength.

Tensile Properties in Relation To Performance on Exterior Wood

Only clear finishes with NRP code numbers from 893 to 916, plus E3, had been exposed at Ottawa on red cedar panels in the second exposure series.[1] Measurement of physical properties to see which, if any, were related to performance commenced later, after other materials had been added because the exposure results indicated they were needed to supplement the original group. Consequently, it is not possible to relate the mechanical properties of all the materials tested to their actual performance on the test fence.

In the ortho alkyd series, 912 and 914 had the best combination of tensile strength and elongation in AW. In NW, the long soya, 913, had better elongation but its strength was much lower than that of the medium alkyds. After two years' exposure on wood, 912 and 914 had the highest durability ratings, being about the same, while 913 was poorer in performance. The 85% linseed-soya iso alkyd, E3 (same resin as 911 in Ref. 1), with AW tensile properties similar to those of 913, had about the same durability on wood. The short soya alkyd that exhibited a marked increase in tensile strength and a rapid decrease in elongation in both AW and NW had the lowest durability rating of alkyds applied to cedar. The latter result agrees with those of Schurr, et al.[9]

The relation between tensile strength changes and durability of phenolics, however, was completely the reverse of that predicted by Schurr. The short oil phenolic that exhibited the most rapid increase and decrease in tensile strength was also the most durable.

Figure 14—Flexibility of phenolics with different oil types

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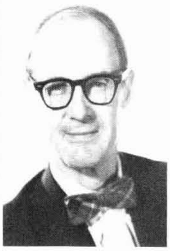

With phenolics, the peak in tensile strength appears to be more closely related to durability as shown by comparing the 20-gal tung and linseed varnishes with each other and with those containing more of these oils. Similarly, the 40-gal tung with more strength than the 40-gal linseed was the more durable of the two. Tung varnishes were also superior to those made with soya and DH castor in the first exposure series.[1] There was, of course, no correlation between durability and elongation results because all varnishes lost flexibility shortly after being exposed.

CONCLUSIONS

Using elongation at break as the measure of flexibility, this study shows that high oil content in alkyds does not lead to greater initial flexibility or to better flexibility retention during weathering. In fact, there is an optimum oil content for extensibility at about 56 to 60% oil for soya ortho alkyds that corresponds to better durability results on exterior wood. This is similar to p-phenylphenolic varnishes, the durability of which peaks at 58 to 66% oil. With iso alkyds the best combination of tensile strength and elongation occurs at 67 to 75% oil, but in this study there were no iso alkyds with less than 67% oil. Iso alkyds had a better combination of tensile properties than ortho alkyds of equivalent oil length. Ortho alkyds of high oil content and iso alkyds of very high oil content had low tensile strengths without a corresponding increase in flexibility. This is considered to confirm that in such alkyds some of the oil is present as a mixture only.

Both tensile strength and flexibility and their changes with exposure time are related to the durability of alkyds. Only strength correlates with the performance of p-phenylphenolics, as almost all varnish films had little flexibility after a short exposure to either natural or accelerated weathering. The high oil content varnishes that retained flexibility longest in the group are the least durable as clear coatings.

The high oil content coatings are soft after air drying for six weeks or more. Consequently, when first subjected to the tensile test they broke before being stretched to their potential maximum elongation. During natural and accelerated weathering they became somewhat tougher and were able to extend more before breaking. Hence, they exhibited an increase in flexibility in early exposure periods.

Alkyds had lower tensile strengths than phenolics in AW, but in NW the maximum strength of all but long ortho and very long iso alkyds was higher than that of phenolics. In both exposures the increase in the strength of alkyds was more gradual than with phenolics. Alkyds were also more flexible and retained this property longer in both tests. On the basis of mechanical properties, 40 cycles of accelerated weathering, using the 12-12 cycle but substituting high humidity for water spray, were not enough to produce the changes that occurred in alkyds in one year of natural weathering. The accelerated test, however, appears to have had a greater effect on the tensile strength of phenolics. Evidently an exposure cycle applicable to one type of clear finish is not necessarily appropriate to another, at least if free films are being exposed. On the other hand, when testing coated panels, the poor durability of wood may be so dominant that the different response of resins is markedly reduced.

Flexibility is generally considered to be an important property of coatings, particularly those designed for use on substrates subject to relatively large dimensional changes resulting from temperature or humidity variations. Radiant energy in accelerated and natural weathering causes marked changes in the mechanical properties of phenolics, which rapidly attain maximum strength with a concomitant loss in flexibility. On the other hand, the tensile properties of most alkyds change at a slower rate and they retain their flexibility for a fairly long period. This basic property of alkyds is one reason for the good exterior performance of pigmented alkyds. Clear alkyds, however, when exposed on wood to natural or accelerated weathering do not perform nearly so well as the short oil phenolics, which have very little elongation. Flexibility, therefore, is not so important as water absorption, water vapor permeation, or transparency to UV light in relation to the performance of clear finishes, even on such a dimensionally unstable substrate as wood.

ACKNOWLEDGMENTS

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European Orders of FSCT Educational Literature

Mr. Ray Tennant, of the Birmingham Society, will act as a source of Federation educational literature (Color-matching Aptitude Test Set; Infrared Spectroscopy; Paint/Coatings Dictionary) for United Kingdom customers. Anyone interested in receiving these items is urged to contact Mr. Tennant. His address is: Carrs Paints Limited, Westminster Works, Alvechurch Road, Birmingham B31 3PG, England.

Silane Adhesion Promoters In Acrylic Resins: Preliminary Research

Cleveland Society for Coatings Technology
Technical Committee

A series of silane additives were evaluated as adhesion promoters in a simple acrylic formulation. The one found to be most effective on steel substrate, namely N-beta-(Aminoethyl)-gamma-aminopropyltrimethoxysilane was studied in more detail by means of ESCA and Fourier Transform Infrared techniques to determine its relationship to the steel surface. As a result, a hypothesis is proposed to explain its mode of action.

INTRODUCTION

Adhesion promotors are generally effective as additions to polymer-based compositions, working better in one system or another. Most of those commonly employed are silanes,[1] phosphates,[2] and, recently, titanates.[3] It is thought that they act through some sort of affinity for the receiving substrate, either by chemical reaction at that surface, or by physical adsorption due to polar and dispersion forces. Although substrates treated separately to induce a change in surface chemistry followed by application of macromolecular compositions have been studied for adhesion,[4,5] there is little in the literature which indicated the presence at this interface of an adhesion promotor added to a composition prior to application. It is, therefore, the purpose of this investigation to study the metal coating interface by Fourier Transform Infrared (FTIR) and Electron Spectroscopy (ESCA) to determine whether an adhesion promotor can be found which is sufficiently strongly adsorbed at the metal even though its source was the original coating formulation. Since silanes are commonly used for this purpose, this project was centered on finding the most effective ones of a series which was previously chosen and then followed for more detailed analysis.

EXPERIMENTAL

Coatings Preparation

A single family of adhesion promoters and resins, commonly used in the coatings industry, were chosen for preliminary study. The silane adhesion promoters in acrylic resin films were thus focused on ten silanes, chosen as additives to a non-pigmented, unmodified solution acrylic resin. All films were drawn down with a doctor blade on mild steel substrates previously cleaned by an acetone wash and then dried at 60°C. Various concentrations of the silane adhesion promoting additives were used.

The ten adhesion promoting additives used in these experiments were low molecular-weight silanes. The general formula was R_3SiX, where $R=(OCH_3)$ or (OC_2H_5). The functional groups, X, encompassed a wide range of reactive moities. *Table* 1 lists the silane adhesion promoters.

The vehicle was a solution of Rohm and Haas Co. Acryloid® A-11 in technical grade methyl ethyl ketone (MEK). It is primarily a polymethyl methacrylate.[6] The solution was 40%, by weight, resin. Adhesion promoters (silanes) were added at 1%, by volume. Neat formulae were 35% by weight solutions.

Presented by Andrew Schiller at the 54th Annual Meeting of the Federation of Societies for Coatings Technology, October 28, 1976 in Washington, D.C.

Table 1—Silane Adhesion Promoters Used

Silane Adhesion Promoter	Supplier
N-beta-(Aminoethyl)-gamma-aminopropyltrimethoxysilane (A-1120)	Union Carbide Corp.
Chloropropyltrimethoxysilane (A-143)	Union Carbide Corp.
Vinyltriethoxysilane (A-163)	Union Carbide Corp.
gamma-Methacryoxypropyltrimethoxysilane (A-174)	Union Carbide Corp.
beta-(3, Epoxycyclohexyl)-ethyltrimethoxysilane (A-186)	Union Carbide Corp.
Mercaptoethyltriethoxysilane (A-1893)	Union Carbide Corp.
"Ethyl Silicate 40"	Hughson Chemicals Co.
Mercaptopropyltriethoxysilane (Z-6040)	Dow Chemical Co.
Methyltrimethoxysilane (A-163)	Union Carbide Corp.
Mercaptopropyltrimethoxysilane	Aldrich Chemical Co.

Table 2—Qualitative Adhesion Results

Additive	(Wt %) Concentration	Cross-Hatch	Knife Peel	Spatula Peel
A-143	0.25	−	−	−
A-151	0.25	−	−	−
A-163	0.25	−	−	−
A-174	0.25	−	−	−
A-168	0.25	−	−	−
A-1120	0.25	+	−	−
	1.25	+	+	+
A-1893	0.25	−	−	+
	0.63	−	+	−
	1.25	−	−	−
	2.50	−	−	−
X-6040	0.25	−	−	−
"Ethyl Silicate 40"	0.25	−	−	−
"90% Mercaptiosilane"	0.25	−	−	+

This thermoplastic resin was used because it does not adhere well to the chosen substrate. Any improvement in adhesion would be noted. The substrate panels were 4″ × 8″ steel Q-panels® (type R) with matte finish. Draw-down coatings were air-dried for 15 min. and force-dried at about 60°C for 30 min. No measurable solvent was retained in the coatings as determined by drying to constant weight. The films were tack-free and clear. Film thickness was kept constant by using identical coating procedures and using coatings of similar solids levels (35% total solids). An eight mil doctor blade was used for the draw-downs.

Testing

Contact angle approximations of the coatings solutions and a number of destructive tests were used as a preliminary screening to determine whether the adhesion promoting additive was functioning in the system under study. Tests were modified from the ASTM and Gardner standards using laboratory assembled equipment. Cross-hatch tape tests, knife peeling, and simple spatula scraping tests were the most common modes of testing chosen by the Cleveland Technical Committee. An optimum, or at very best a strongly functional, example of an adhesion promoted coating was sought. The practice of these subjective evaluations was employed to make the selection. Each test was repeated several times and the results averaged. (See *Table* 2.)

CROSS-HATCH TAPE TEST: This test was a modification of ASTM D3002-71. The cross-hatch adhesion test was performed by scribing five lines, with about two millimeters separation, and an overlapping series of five lines at 90° to the originals. Care was taken not to cut into the steel panels. A single roll of #610 Scotch® tape was used in the test. The test tape was pressed firmly onto the grid and then pulled off rapidly at 90° to the surface. If ten or more grids remained (out of a possible 16) the test was noted as passed (scored as a +). Nine grids or less was a fail score (−).

SCRATCH BUNDLES: This test was a variation of ASTM D2197 Method B. Scratch bundles are a series of scribed lines which begin with about ten millimeters separation and then get progressively closer. The nature of the film between the scribes was studied. A pass score (+) was recorded if the lines were less than two millimeters apart and the coating remained intact. Otherwise a final score (−) was noted.

KNIFE PEEL TEST: This test was a simplification of ASTM D2197 Method A.

The knife peel test, or variations thereof, was employed to subjectively analyze resistance to interfacial shear forces. Degree of film lift, beyond the actual knife cut, was noted. Less than one millimeter of edge lift was necessary for a pass score (+). Similarly, a spatula scrape test looks at the same phenomenon, but with the shear force being applied at about 20° to the panel instead of normal to the substrate as in the cross-hatch tape test. Degree of edge lift and the ease of shear are combined, as in the knife peel test, for the rating. No edge life and/or resistance to shear qualified for a passing score. Easy shearing of the coating from the panel indicates a negative score.

CONTACT ANGLE MEASUREMENT: Contact angle was determined by projecting the image of a pendant drop[7] on a clean, inverted Q-Panel. An opaque projector was used to project the image. Measurements are estimated to be accurate ± 10% due to divergent optics of the projector. Only trends were looked for. Results are given in *Table* 3.

The additive with the most positive effect on adhesion was the only one studied further, in conjunction with the neat polymer films, since as pointed out in the introduction the presence of the silane at the interface was of interest at this time. Characterization of these

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Q-Panel is a registered trademark of the Q-Panel Co.
Scotch Tape is a registered trademark of the 3M Company.

Table 3—Contact Angle Measurements on Q-Panels

Material	Contact Angle
Acryloid A-11 (40% in MEK)	62°
Union Carbide A-143	12°
Union Carbide A-151	0°
Union Carbide A-163	0°
Union Carbide A-174	22°
Union Carbide A-1120	24°
Union Carbide A-1893	0°
Union Carbide A-186	33°
Dow Z-6040	34°
Ethyl Silicate "40"	0°
90% Mercaptosilane	23°
A-11 + Ethyl Silicate 40	50°
A-11 + A-151	68°
A-11 + A-174	42°
A-11 + A-1120	53°

systems was performed primarily with FTIR Interferometry and ESCA.

FOURIER TRANSFORM INFRARED SPECTROPHOTOMETRY (FTIR): A unique emission cell was used to evaluate the FTIR spectra of Q-panel samples. The cell, designed at Case Western Reserve University, was used with a FTS-14 Model Fourier Transform Infrared Interferometer with a dedicated Digilab minicomputer. The apparatus is part of the Material Research Labs, of the Macromolecular Science Dept. at Case Western Reserve University.

The testing cell consisted of an aluminum heat sink with internal electric heating elements and thermocouple controller. An insulated chamber with three thermocouples down its length was positioned along the beam path with the aluminum heat sink at the end. The sample panel is clamped into the cell between the heat sink and the chamber. By heating the aluminum block (i.e., heating the sample), an emission spectrum of the inward-facing surface is obtainable. This technique was used to study the surfaces of the two panels from which the two coatings were reviewed; one contained the amino silane and the other the control.

The method devised by Koenig[8] involves the computor subtraction of the FTIR curves divided by the radiation emitted from a block body. The results obtained by this technique are illustrated in the curves of *Figure* 1. The two lower ones labeled A & B were obtained from the steel surfaces from which the coatings were removed. The upper one obtained by the technique described by Koenig shows the presence of emissions as a series of peaks between 1230 cm^{-1} and 1030 cm^{-1}. Their significance will be discussed later in this paper.

ELECTRON SPECTROSCOPY FOR CHEMICAL ANALYSIS (ESCA): ESCA involves the bombardment of the metal sample under study with monoenergetic X-rays which cause electrons to be ejected from the atoms with energies unique for each element. ESCA samples were 1 cm × 2 cm trays made from the clean Q-Panels by a mechanical shear press. Four such samples were analyzed:

(1) Clean blank panel.

(2) Panel soaked in A-11 resin for 94 hr (arbitrarily chosen), air-dried, and peeled with a knife.

(3) Panel soaked in A-11 resin, with adhesion promoting silane additives, for 94 hr (arbitrarily chosen), dried, and peeled.

(4) Same as (3), but washed with acetone (cold) until a "clean" surface was seen. Resin was not dried on the sample.

Sample (3) was prepared in order to detect the presence of nitrogen and silicon on the steel surface which was to be compared with (2). In the event that nitrogen and silicon were found to be present in (3), preparation (4) was planned to assess at least qualitatively the strength of the adsorbed species by determining whether it can be removed by a solvent wash.

RESULTS AND DISCUSSION

The series of scratch and peel tests showed N-beta (Aminoethyl)-gamma-aminoproplytrimethoxysilane to be superior in its adhesion promotion effects under the conditions described above. A tabulation of the results is given in *Table* 2.

The contact angle data are shown in *Table* 3. However, they produced nothing of significance relative to the objective of this project.

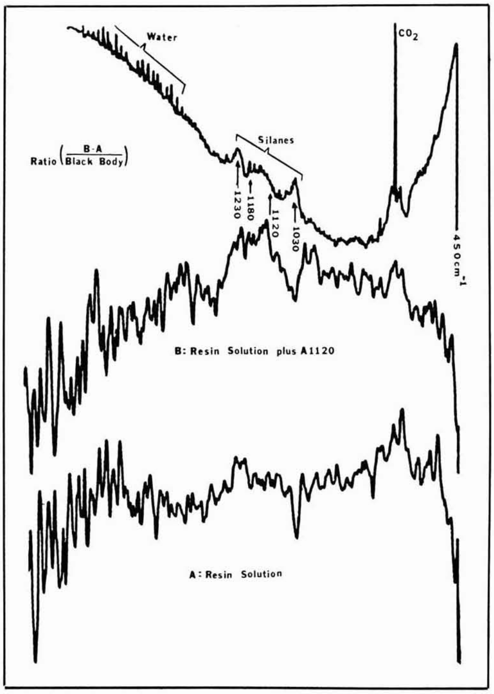

Figure 1—FTIR spectra after film removal

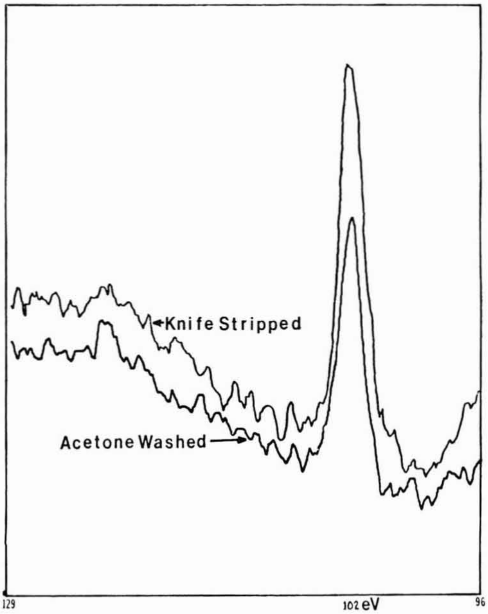

Figure 2—ESCA curves - silicone

The optimum system seems to be the one with 1.25% of the adhesion promoter A-1120 blended into the coating formula. Therefore, this formula was used for the characterization section.

The FTIR emission data obtained from the stripped panels described previously were computer processed and plotted to produce *Figure* 1 where a series of peaks between 1230 cm^{-1} and 1030 cm^{-1} are noted in the ratio or upper curve. These peaks are characteristic of siloxanes. The peaks above 1100 cm^{-1} are evidence of siloxane (Si-O-Si) stretching.[6] This would lead to the hypothesis of polysiloxane crosslinking at the surface of the substrate. Methoxysilanes hydrolyze to form silanols in the presence of water [equation (1)].[7] Surely, in all except urethane grade solvents, enough water is available for this to occur. Silanols may subsequently undergo condensation polymerization forming siloxanes [equation (2)] and releasing water to cause further hydrolysis.[10]

$$R_3SiX \xrightarrow{\text{water}} R_{(3-n)}(HO)_n SiX, \quad \begin{array}{rll} & n & = 1, 2, \text{or } 3, \\ & R & = OCH_3 \text{ or } OC_2H_5, \\ \text{and} & X & = \text{reactive ligand.} \end{array} \qquad (1)$$

$$n\text{-}Si(OH)_2XY \xrightarrow{-H_2O} HO\text{-}SiXY\text{---}[O\text{-}SiXY]_{(n-1)}\text{---}OH, \qquad (2)$$

where n = integer
X,Y = non-hydrolyzing ligands.

The ESCA analysis of the steel substrates from which the coatings were removed emphasized nitrogen and silicon as the critical elements, since carbon, iron, and oxygen are normal components of the metal. If the adhesive effect of the amino silane additive were due to adsorption at the interface as suspected and as indicated by the emission FTIR (*Figure* 1), ESCA data should indicate the presence of nitrogen and silicon. That they are present is illustrated by the upper curves in *Figures* 2 and 3. Equally significant is the presence of nitrogen and silicon on the surface of the panels from which the adherant coating was stripped even after thorough washing with acetone. This indicates that the amino silane is strongly bonded to the surface, most likely first by the hydrolysis of the silane and by reaction with OH groups of the iron oxides on the steel surface and/or the strongly adsorbed water on that surface. Subsequently, the reacted monomer polymerizes to form a higher molecular weight compound.[10] It is also conceivable that some of the polar amine groups are also in contact with the metal surface. However, due to entropic and steric effects most of these should be oriented in such a manner as to intermingle with the A-11 polymer somewhat like an interpenetrating network. A more likely speculation regarding coupling of the silane with the polymethacrylate is the reaction of the NH_2 group on the silane with the methyl ester to form an amide. Similar chemistry is described by Kebler and Weissberger.[11]

SUMMARY

While conventional destructive analyses are sufficient for selection of effective adhesion promoters in coatings formulations, they do not tell us anything about their modes of action. The use of Cross-Hatch Tape Tests, Scratch Bundles, and Knife Peel Tests

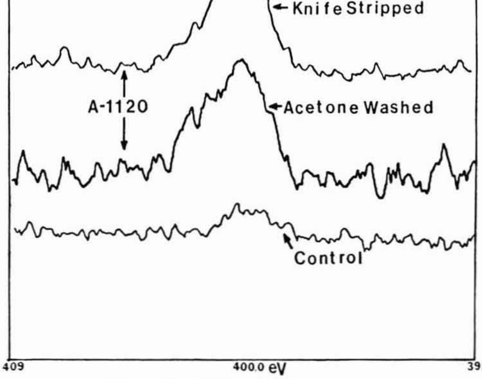

Figure 3—ESCA curves - nitrogen

were used in this test to establish the superiority of N-beta-(Aminoethyl)-gamma-aminopropyltrimethoxysilane as an adhesion promoting additive for a polymethylmethacrylate (Rohm and Haas Acryloid A-11) coating on a mild steel substrate (Q-Panel Co.). Measurements of contact angles of both the silane addition and neat resin formulations did not establish obviously supportive evidence for the superiority of the aminosilane additive.

To characterize the operative aminosilane system, two methods of analysis were used: Fourier Transform Infrared Spectrophotometry (FTIR) and Electron Spectroscopy for Chemical Analysis (ESCA).

ESCA results indicated the presence of silicon and nitrogen on the panels from which the additive containing films were removed even though they were subjected to thorough washing with acetone. They originated as components of a polymerized silane by reaction with water either adsorbed on the steel initially[12,13,14] or from partial hydrolysis (e.g., silanols and siloxanes), with the small amounts of water in the original formulation. The presence of siloxanes on the steel surface previously in contact with the coatings is indicated by the FTIR emission spectra.

ACKNOWLEDGMENTS

The Cleveland Society for Coatings Technology thanks Dr. John C. Weaver (Sherwin Williams Co., Retired) and Dr. Charles E. Rogers (CWRU) for their guidance in the researching of this paper. Charles A. Kumins (Tremco Inc.), Chairman of the Society's Technical Committee arranged the original project concept as a Society study. Most paint equipment used was donated by Tremco, Inc., Cleveland, Ohio.

The Acryloid A-11 and acrylic resin was donated by Lawrence E. Hoffman, a Technical Representative from Rohm and Haas Co., Cleveland.

Q-panels were contributed by George W. Grossman, President of Q-Panel Co.

ESCA analysis was supplied by Dr. Gheorghe Mateescu, of the Major Analytical Instruments Facility in the Chemistry Dept. at CWRU. Evaluation was aided by Narayna Doddopannini, also of CWRU.

Fourier Transform Infrared Interferometry and computer time were given by three colleagues in the Macromolecular Science Dept., Wayne Jennings, Ken Ishida, and Mitch Antoon.

CLEVELAND SOCIETY'S TECHNICAL COMMITTEE

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Editor of Australian OCCA Journal Needs Back Copies of Official Digest

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Evaluation and Modification Of the Beckman Variable Angle Accessory for Characterization Of Metallic Coatings

D. Thomas Roberts, Jr. and Bruce H. Todd
BASF Wyandotte Corporation*

The Beckman 198900 double beam variable angle reflectance attachment (VAR) was evaluated on a Beckman ACTA MIV spectrophotometer to determine its usefulness in helping to characterize the appearance properties of metallic automotive coatings. After some simple modifications it was possible to produce direct spectrophotometric reflectance curves of metallic coatings which appear to be a promising aid to relative measurement of the face and flop color. With the modified attachment, full goniophotometric capabilities are not possible: the angle of viewing is restricted to 20° off the incident (illuminating) angle.

Without modification the variable angle reflectance attachment is useful for measuring the thickness of transparent thin films over reflecting substrates.

INTRODUCTION

Visual assessment of metallic coatings in controlled situations is usually performed by comparing the color observed at viewing angles close to the normal (perpendicular to the surface, or 0°), generally referred to as the "face" color, with the color observed at angles approaching the grazing angle (75°–85° off the perpendicular), generally referred to as the "flop" color. In making visual assessments the observer should orient his lighting and viewing angles so that the first surface specular reflection, i.e., the surface gloss, is excluded from the field of view. In evaluating the quality of the color match, observations of the interior reflectance, i.e., the color, at both the "face" angle and the "flop" angle must be made.

To introduce objectivity into appearance evaluation of metallic coatings, reflectance measurements at these multiple angles of illumination and viewing—correlating with the subjective evaluations of the "face" color as well as the "flop" color—must be made, requiring the use of a goniospectrophotometer. Unfortunately, aside from custom built instruments, such as that described by Billmeyer and Davidson,[1] or imported instruments, such as the Leres Trillac[2] or Zeiss DMC-26 with goniohead, no domestic spectrophotometer manufacturer (to the authors' knowledge) except Beckman Instruments offers variable viewing angles as an integral option or an add-on accessory to its spectrophotometers.

EXPERIMENTAL RESULTS

The Beckman accessory evaluated in this work is the 198900 Double-Beam Variable Angle Reflectance Accessory (VAR) for use with Beckman 5200 and ACTA M-Series spectrophotometers.[3] The VAR, as originally designed, measures the relative *specular* reflectance of samples. On samples containing thin film coatings, such as anodized aluminum or semiconductors with epitaxial layers, this measurement can be used to compute the thickness of the thin films. The VAR angles of incidence and viewing are mutually dependent, but variable from 8° to 62° from the normal or perpendicular with a reported accuracy of ±2° and repeatability of better than 0.5°.[3] In *Figures* 1 and 2,

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Presented by Mr. Roberts at the Symposium on Color and Appearance Instrumentation, March 15, 1978 in Cleveland, Ohio.

*Pigments Div., 491 Columbia Ave., Holland, Mich. 49423.

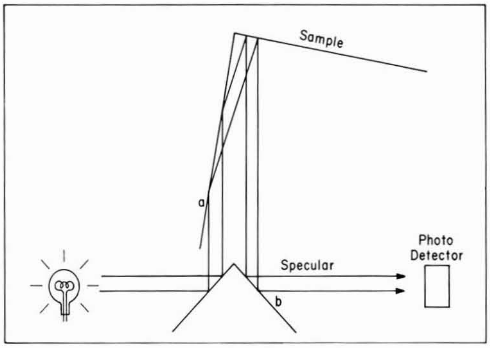

Figure 1—Optical geometry of the accessory at -10° angle of illumination and 10° angle of viewing

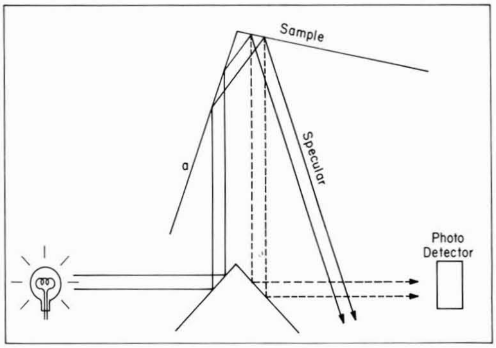

Figure 3—Optical geometry of the VAR accessory after modification. Illustrated at -30°/10°

schematics of the optical geometry of the VAR in the -10°/10° and -60°/60° illuminating/viewing modes, respectively, are shown. Note that the illuminating and viewing angles are equal, but opposite, as required for purely specular measurements.

For the evaluation described here the accessory was fitted to a Beckman ACTA MIV UV-visible-NIR Spectrophotometer. It is a digital, direct reading, double-beam, recording spectrophotometer. The basic instrument includes a single diffraction grating monochromator with a tungsten-halogen light source, and, for normal reflectance measurements, a 6 in. 2°/diffuse integrating sphere using monochromatic illumination (also an optional accessory to the basic instrument).

In its normal geometric configuration for the measurement of specular reflectance the VAR is not suitable for measuring the *color* of metallic coatings. Therefore, two simple modifications were made to the accessory:

(1) The movable illuminating mirrors (for sample and reference), i.e., "a" in *Figures* 1 and 2, were both displaced 10° to direct the first surface specular component away from the viewing mirrors, b, and photodetector port so that only a portion of the internal reflectance from the sample in the prescribed direction is measured. *Figures* 3 and 4 show the modified arrangement. This change resulted in an illuminating angle which is 20° greater than, and opposite to, the viewing angle. The VAR geometry could then be varied from -30°/10° through -80°/60°, with a constant 20° difference between illumination and viewing angles.

(2) The sample holder was enlarged, expanding the area of the sample illuminated. It was necessary to remove the lower portion of the holder because light from the movable mirror was striking this lower portion at angles greater than 60°, causing extraneous reflections to strike the viewing mirror.

One final problem remained for which internal compensations or adjustments could be made. The zero baseline was displaced progressively upward with change in illumination/viewing angles away from the perpendicular (probably caused by the greater area illuminated as the illumination angle moves away from the normal, a phenomenon which makes gonio measurements difficult to relate to "absolute" measurements). This necessitated a measurement procedure whereby the reference energy was adjusted for each angular setting, first adjusting the baseline using the zero-adjust and then setting the 100% line. Each time the illumination/viewing angles were changed, this resetting had to be made (a common adjustment necessary in gonio-type measurements). In the case of the VAR, the compensating adjustments could be ac-

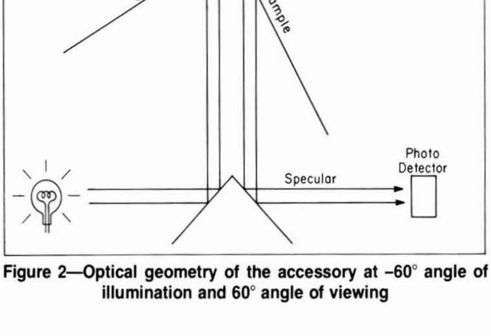

Figure 2—Optical geometry of the accessory at -60° angle of illumination and 60° angle of viewing

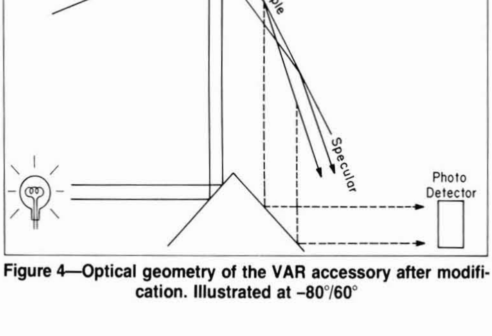

Figure 4—Optical geometry of the VAR accessory after modification. Illustrated at -80°/60°

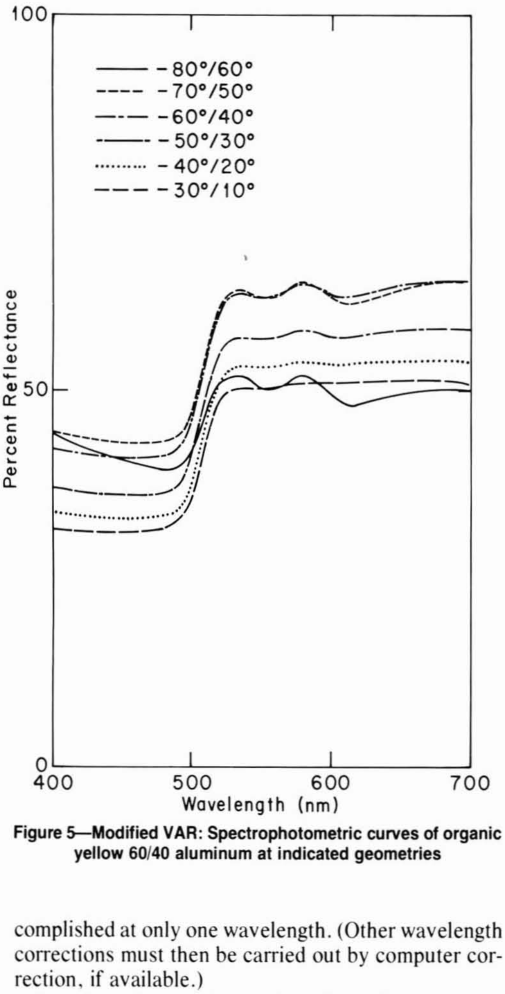

Figure 5—Modified VAR: Spectrophotometric curves of organic yellow 60/40 aluminum at indicated geometries

complished at only one wavelength. (Other wavelength corrections must then be carried out by computer correction, if available.)

Samples of metallic coatings in a thermosetting acrylic vehicle, all using the same aluminum pigment, were sprayed to complete hiding on metal panels. Respectively, the samples were an organic yellow at 60/40 pigment to aluminum ratio, a phthalo blue, a phthalo green, and a transparent red iron oxide, all at 90/10 pigment to aluminum ratio. They were measured relative to pressed $BaSO_4$, with the zero and 100% lines adjusted after every change in angle.

Inspection of the measured reflectance curves, *Figures* 5 through 8, shows an interesting phenomenon as the illumination/viewing angles are changed. The spectrophotometric curves are displaced progressively upwards from –30°/10° (near normal viewing) to –70°/50°. The –80°/60° lines are decreased in the region of greatest reflectance and increased in the absorption region. This is quite possibly due to the viewing angle leaving the specular envelope of the metallic pigments. This *may be* associated with the measurement of flop.

To date no attempt has been made to quantify the data in terms of tristimulus values or color difference values. Quantification along with possible correlation

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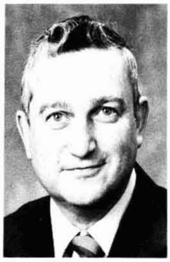

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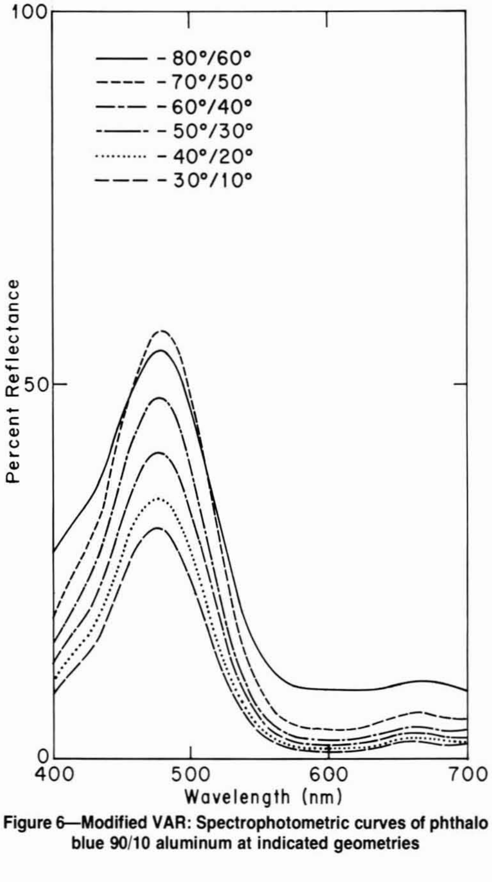

Figure 6—Modified VAR: Spectrophotometric curves of phthalo blue 90/10 aluminum at indicated geometries

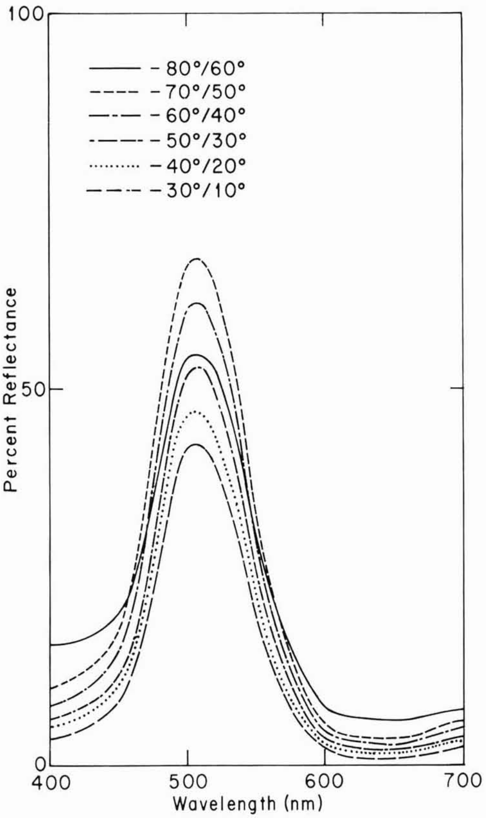

Figure 7—Modified VAR: Spectrophotometric curves of phthalo green 90/10 aluminum at indicated geometries

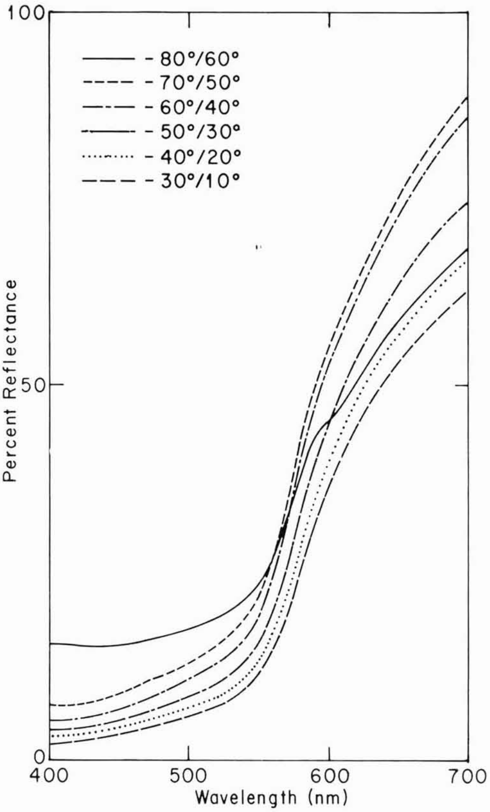

Figure 8—Modified VAR: Spectrophotometric curves of transparent red iron oxide 90/10 aluminum at indicated geometries

with a research goniospectrophotometer are highly desirable goals of future experimental efforts.

DISCUSSION

The results presented here are only preliminary in nature and should be viewed in this perspective. The reader is asked to note that the intent is to aid in characterizing metallic coatings objectively, an effort of primary importance to the automotive industry. This characterization must ideally include measurements using conventional spectrophotometers with near-normal/diffuse or the reverse geometry (i.e., diffuse/near-normal), specular measurements of the first re-

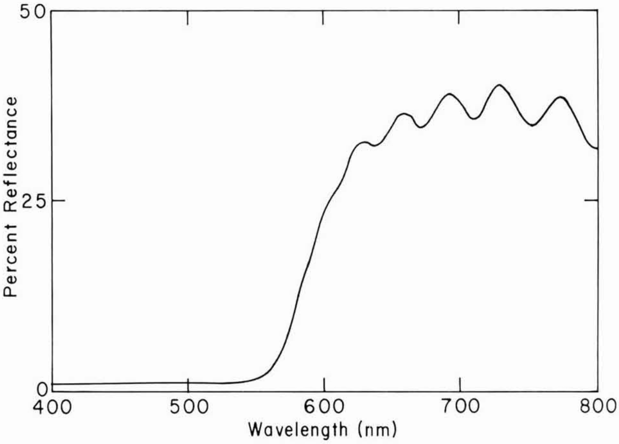

Figure 9—Interference fringe spectrum of metal deco coating tinted with transparent iron oxide

flecting surface (the gloss), quantification of the metallic effect, and measurement of the "flop" color.

Complete measurement of the metallic effect is not possible with the modified VAR described here because it separates the illuminating and viewing angles by a constant amount, i.e., 20°. Billmeyer and Davidson concluded that "The metallic effect as a whole can be characterized by measurements at two sets of illuminating and viewing angles: one selected to measure the reflectance within the specular envelope" of the metallic particles, "but off of the Fresnel first surface reflections; and the other to measure the reflectance outside this specular envelope" of the metallic particles. It is important to note that the necessary information can be obtained by the appropriate selection of two different viewing angles for one illuminating angle, or the reverse, but is not given by two measurements in which the illuminating and viewing angles (and thus the specular reflection and viewing angles) are separated by a constant amount."[1]

The Beckman VAR accessory is a useful tool in its normal (unmodified) configuration for characterizing the purely specular characteristics of any type of coating. For example, it is an effective tool for measuring the thickness of thin transparent films: the interference fringe spectrum is mathematically related to the film thickness and average refractive index over the wavelength interval considered.[4] It has been shown that this principle can be utilized in measuring the thickness of very thin films involved in metal deco coatings. See *Figure* 9.

CONCLUSIONS

Simple modifications to the VAR which result in displacement of the illuminating angle approximately 20° from, and opposite to, the viewing angle appear to have some limited usefulness for characterizing the color of glossy metallic coatings.

Further modifications are desirable to: (1) increase the viewing angle to 70° or 75°, and; (2) to allow angle of view to be varied independently from the angle of illumination in order to characterize completely the metallic effect.

The unmodified VAR is an effective tool for measuring the thickness of thin transparent films over reflecting substrates by the interference fringe technique.

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ERRATUM on the article "Hydroxamic Acid Esters as Isocyanate Blocking Agents" as printed in the Journal of Coatings Technology of December 1978, by W.J. Mijs, J.B. Reesink and C.J. Groeneboom (Akzo Research) and J.P. Vollmer (Astral).

At the bottom of the text on page 60 it reads:

The activation parameters for the dissociation of BI were calculated: $\Delta H^{\neq} = 20$ kcal/mole and $\Delta S^{\neq} = -0.6$ e.u.

This should be: $\Delta H^{\neq} = 20$ kcal/mole and $\Delta S^{\neq} = -16$ e.u. a value which is also in better agreement with the transition of the dissociation of the hydroxamic acid ester blocked isocyanates.

The authors thank Professor Pappas of the North Dakota State University, who pointed out this error.

Review Of Geometric Attributes Of Appearance

John S. Christie, Jr.
Hunter Associates Laboratory, Incorporated*

For the sake of identification and measurement, appearance attributes can be roughly divided into two classes, those which vary in the spectral distribution of light and those which vary in light scattering or geometric distribution. This paper describes the physical characteristics of objects responsible for geometric differences, the psychological attributes (visual sensations), and the psychophysical scalar dimensions which have been developed to "quantify" gloss and other geometric attributes.

This is followed by a brief review of the historical development of the philosophy and measurement techniques applied in this area of appearance judgements. Types of instruments are described.

The CIE Committee 2.3 on Optical Properties of Materials includes a gloss subcommittee. The current work program of this subcommittee, aimed at improving correlation between visual judgements and instrumental measurements, is reviewed.

INTRODUCTION

When an attempt is made to describe and quantify the various aspects of appearance of materials, the need for classification and simplification becomes obvious. As a first step in reducing the complexity of the task, such attributes as form, size, and uniformity are generally ignored in order to focus on the two classes which are most important in the science of appearance measurement. These two are chromatic attributes (color), which relate to variations in the spectral distribution of light and geometric attributes, which relate to the variations in the scattering or angular distribution of light. This paper will be limited to those geometric attributes which relate to what we identify as gloss.

Just as with color, the word gloss can have different meanings depending on one's frame of reference. The physicist tends to describe gloss as the specular reflecting characteristics of a material. The paint technologist will sometimes refer to it as the numerical output of a glossmeter. To the psychologist, it is a shininess. Here, it is felt that there is no reason to believe that color† or gloss exist outside of the mind, and, therefore, the following definitions are recommended:

(1) *Gloss* is the perception of an observer of the shiny or lustrous appearance of a surface. Because it is the result of directionally selective reflection, this perception changes whenever there is a change in the relative position of the light source, the object, or the observer.

(2) *Physical properties responsible for gloss* are the reflection characteristics of a surface in and adjacent to the direction of specular reflection. It is associated with the distinctions and sometimes with the contrasts between specular reflection, diffuse reflection, and mixed reflection.

(3) *Psychophysical gloss scales* are numerical representations of perceived rank and difference judgements of specific types of aspects of gloss such as shininess, luster, distinctness of image, absence of haze, etc.

PHYSICAL PHENOMENON

The first part of this paper will describe the physical phenomena responsible for gloss properties and review the major discoveries relating to the interaction of light with objects.

Four processes are involved when light passes from a medium of one optical density into that of another den-

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Presented at the Symposium on Color and Appearance Instrumentation in Cleveland, Ohio, March 14, 1978.

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†A synthetic but quantitative identification of color is created by the use of the CIE Standard Observer. No such synthetic, quantitative psychophysical technique exists in the science of gloss. However, such a development should be feasible, once the proper experiments have been devised.

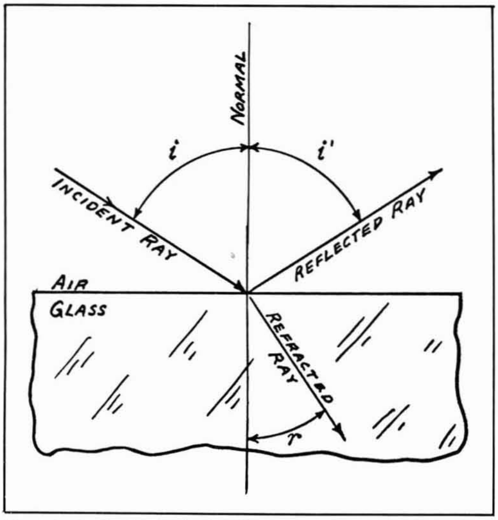


Figure 1—Reflection and refraction at a smooth surface interface

sity. They are reflection, refraction, diffraction, and absorption. Only the first two are involved in characterizing gloss properties of materials. The prime physical cause of glossy appearance is the reflection of light from a relatively smooth surface whose index of refraction is greater than that of air. Referring to *Figure* 1, when a ray of light strikes the smooth surface it is reflected at an angle equal to and opposite to the incident angle as measured from the normal. The light which is not reflected enters the material and is refracted, that is, changes direction. This change in direction is related to the change in velocity of the light and is proportional to the ratio of the indices of refraction of the media. This relationship was quantified in 1621 by W. Snell[1] by the following law:

$$\frac{N_2}{N_1} = \frac{\text{Sin } i}{\text{Sin } r} \qquad (1)$$

When the surface is not perfectly smooth, some of the specular reflectance is scattered in a way that is determined by the characteristics of the surface roughness. In addition, unless the medium is optically clear (or exhibits only selective absorption which is responsible for color) light will be scattered by multiple interaction with particles within the medium. This scattering is due entirely to the same processes as those which occur at the original surface. That is, at every boundary where the index of refraction changes, there is reflection and refraction. Nevertheless, it has been found convenient to separate first surface specular reflection from that which is highly scattered and is called diffuse reflection.

If these could be truly separated, and if the scattering were completely uniform, the two types of reflection could be represented as shown in *Figure* 2a. Real materials, however, do not behave this nicely and, therefore, *Figure* 2b is more representative of the reflecting characteristics.

In 1760, J.H. Lambert[2] determined the fundamental law for reflectance from a perfect diffusing surface. He deduced this from the fact that celestial bodies, such as the moon, do not appear as spheres but instead as uniformly reflecting, flat discs. Lambert's law is:

$$\frac{I_R}{I_I} = \frac{C}{d^2} \cdot \text{Cos } i \cdot \text{Cos } v \qquad (2)$$

in which I_R is the intensity of the reflected light, I_I is the intensity of the incident light, C is a constant of reflectance for the particular material, d is the distance to the observer, and i and v are the incident and viewing angles as measured from the normal. It follows that

$$I_R = I_0 \cdot \text{Cos } v \qquad (3)$$

where I_0 is the intensity of reflectance normal to the surface. What this tells us is that the actual intensity of the light reflected from an elemental area is proportional to the cosine of the angle as measured from the normal. The reason that this results in a constant brightness to the observer is because the area viewed increases by the reciprocal of the cosine v. It is interesting to note that no material has ever been found whose reflection characteristics precisely follow this law.

Materials can be further classified as diffuse, semidiffuse and highly specular reflecting types. A curve relating the angle of view to the intensity of the reflection characterizes the type of scatter. Polar coordinates are normally used and, therefore, it is called a polar diagram.

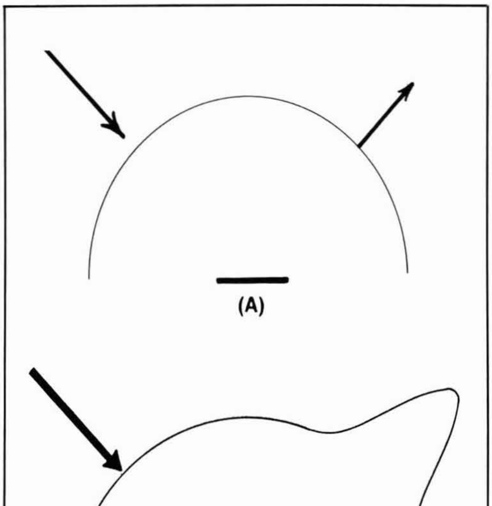


Figure 2—Representation of specular and diffuse reflectance: (a) Simplified; (b) Real material

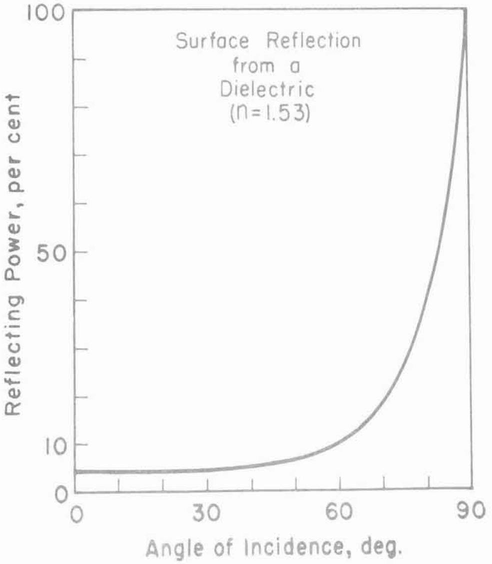


Figure 3—Specular reflectance vis. angle of incidence for a gloss surface

In 1762, P. Bouguer[3] made measurements using a very simple goniophotometer in an attempt to verify Lambert's cosine law. He presented these results in the form of polar curves and was, thus, the first known to make use of this type of diagram to characterize reflectance. *Figure* 2b is in reality a polar diagram.

In 1826, A.J. Fresnel[4] postulated the wave theory of light transmission and developed the fundamantal equations describing polarization and refraction of light at nonmetallic surfaces.

$$\frac{I_R}{I_I} = \frac{1}{2}\left[\frac{\mathrm{Sin}^2\,(i-r)}{\mathrm{Sin}^2\,(i+r)} + \frac{\mathrm{Tan}^2\,(i-r)}{\mathrm{Tan}^2\,(i+r)}\right] \tag{4}$$

In this, the quantities are defined as above and the equation describes how the specular reflectance varies with change in incident angle. *Figure* 3 shows this relationship for a normal glass surface.

This same law can be applied to curved surfaces or objects, but, of course, the computations become much more complex. If one examines the light intensity distribution curve of a transparent sphere, one will find it is composed of two branches. The major portion of the light is scattered in the forward direction and produces a polar curve very close to that of the Lambert law diffuser. The backward scattering branch is also nearly circular, but is much smaller since it is caused primarily by the reflection at the first surface. It is this type of scattering that occurs over and over again when particles are suspended in a medium of lower refractive index, for instance, titanium dioxide in a paint film. As the particles are made smaller and smaller, the number of interactions per unit depth increases and the scattering efficiency increases. Scattering is at a maximum when the particle diameter is somewhere between one quarter and one half the wavelength of the incident light.

At this point, however, the simple laws of refraction no longer hold since the phenomena of diffraction has taken over. During the years 1871 through 1914, Lord Rayleigh[5] (J.W. Strutt) developed theories for the forward and backward light scattering characteristics of single extremely small particles. The scattering characteristics are dramatically dependent on the size of the particle in relation to the wavelength of light. A particle whose diameter is many times smaller than the wavelength will produce equal forward and backward scattering characteristics. Rayleigh extended his theory up to particle diameters approximately two times the wavelength of light, showing that the forward to backward ratio increases as the particle diameter increases. In 1908, Mie[6] made a more complete investigation of these fundamental light scattering relationships and expanded the theory to a much larger range of particle sizes, thus laying the groundwork for subsequent mathematical approaches to defining the scattering within the body of the medium.

In 1903, F. Thaler[7] extended Bouguer's polar curve to include the entire azimuth, thereby showing a polar solid which displayed the scattering characteristics of diffuse materials. *Figure* 4a is a photograph of a model[13] illustrating the three dimensional scattering characteristics of a semi-diffuse metal surface when a single beam of light is incident on it at 32°. This illustrates the complexity of scattering in directions other than that of the plane containing the incident and specular light rays.

This model is made of a series of metal sheets, each cut to duplicate the polar curve in planes perpendicular to the specimen. Each curve shows the conditions in a plane rotated 15° (azimuth angle) from the previous one. *Figure* 4b shows these quantitatively and in greater detail. Each of these figures contains the line perpendicular to the specimen at the point of incidence. Azimuth angle (ϕ) is shown at the top of each figure on either side of the specimen normal line. The upper figure indicates the conditions at the plane containing the incident beam and the specular reflecting beam. ϕ has arbitrarily been given a value of 0° for the plane containing the incident beam and, therefore, the specular beam is at 180°. The following figures show polar curves which exist in planes as we rotate counter clockwise in 15° increments. Because of the tremendous difference in intensity between specular and diffuse reflectance, the photometric scale is logrithmic. Each reference semicircle on the figures indicate a ten-fold increase in light intensity.

The peaks which appear in the off-specular polar diagrams are probably due to metal grain and machine marks which in this case are perpendicular to the plane of the incident beam. The effect is more pronounced in metallic materials than in nonmetallic (dielectric) surfaces. It is only one of the differences between the reflectance characteristics of metallic and nonmetallic materials. This paper deals primarily with nonmetallic materials whose specular reflectance (of smooth surfaces) is in the order of 4% for incident angles up to 30°. Non-metallic specular reflectance increases dramatically at increasing incident angles, following Fresnel's

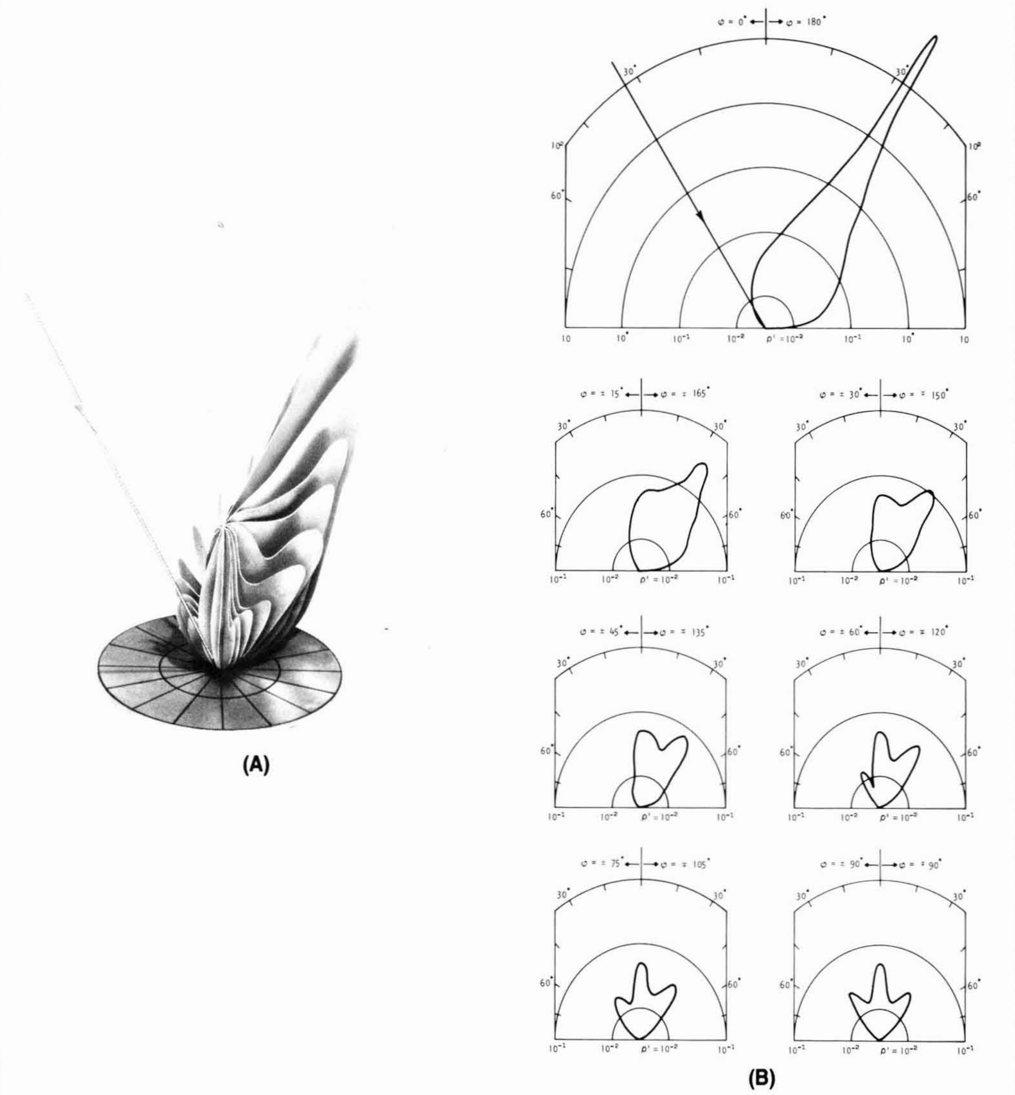


Figure 4—(a) Three dimensional model of reflectance from a semidiffuse metal surface. (from ref. 12); (b) Polar diagrams from 4a, taken every 15°, planes including the normal to the specimen

equation quite faithfully. Metallic surfaces present an entirely different situation, since light does not penetrate to any degree. Aluminum and the noble metals can reflect 90% or more of the incident light in the specular direction. The study of reflecting characteristics of metals is receiving more attention recently, but will not be covered in this paper.

Because of the almost impossible tasks of handling all of the data generated by a three axis goniophotometric study, the gloss measuring instruments described in the following section universally measure reflection in and near the plane containing the incident beam and the normal to the specimen.

There have been many attempts to develop models whose reflectance could be mathematically defined.[8] One of these was developed by Pokrowski[9] in the years 1924 through 1926. He proposed a theory which combines a surface reflectance obeying Frèsnel's law and a body reflectance obeying Lambert's law. He extended this to cover below-surface reflection and absorption and also extended it to three dimensions.

Another interesting theory was developed in 1939 by W.W. Barkas[10] when he outlined a model of an optically equivalent surface by describing two types of imaginary reflecting facets—those specularly reflecting and those diffusely reflecting. The polar curve is expressed in

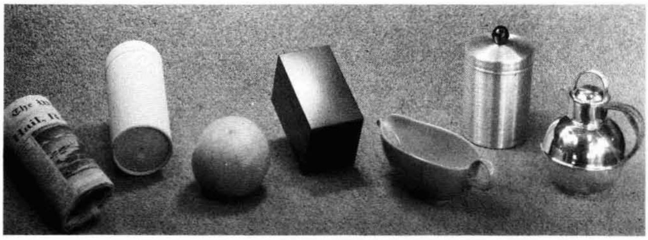


Figure 5—Everyday objects, showing range of gloss characteristics

terms of the distribution of these facets which would create optical properties similar to the material being evaluated.

The author has been unable to find many fundamental studies of the light scattering characteristics of surfaces in recent years (since the 1950's). Hasunuma[11] (1957) and Berreman[12] (1970) presented mathematical relationships defining the scattering of light from metallic surfaces which contain small particles. Nonmetallic surface directional reflectance has been studied by Nicodemus[13] (1965), Brandenberg and Neu[14] (1966), and Gasper and Sherman[15] (1972). Most other work in-

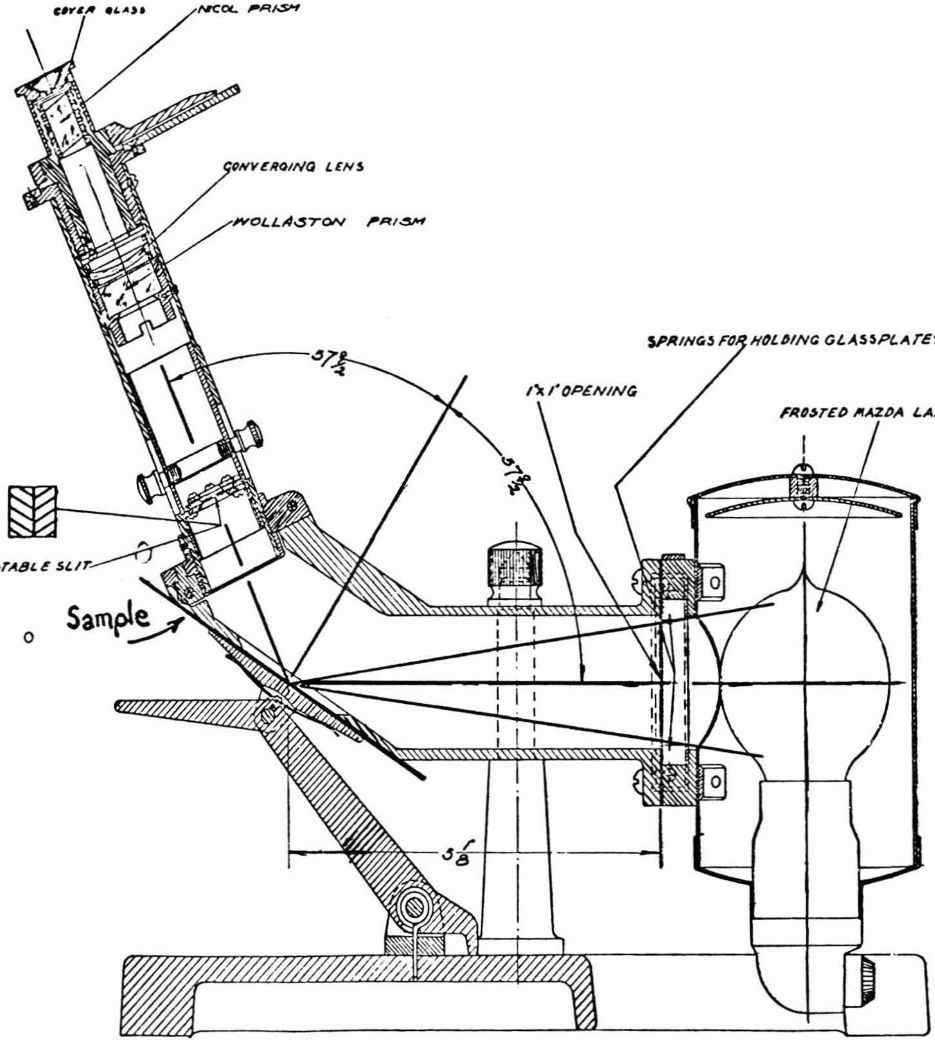


Figure 6—Optical diagram of the Ingersoll glarimeter

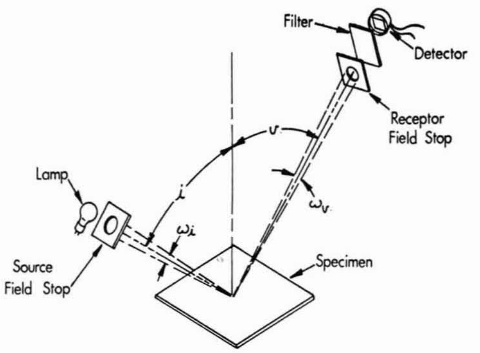


Figure 7—Diagram showing important angular dimensions in gloss instrument design

volves goniophotometric measurements and the greatest volume has been devoted to development of practical instruments for use in commercial applications. Zorll[16] has published a recent review covering primarily European work in the coatings field.

INSTRUMENT DEVELOPMENT

And so let us review the development of instruments and procedures[17] directed toward measuring the surfaces of real objects such as those shown in *Figure* 5.

As with most scientific endeavors, certainly those applied to the field of appearance measurement, there has been a significant gap between the presentation of theories on physical analysis and the development of practical instrumentation for psychophysical measurement. As noted, the immense variety of surface characteristics and the subsequent variety of gloss characteristics almost defy simple measurement. In addition, the eye is simply too efficient to be easily displaced. However, the need for numerical specification was eventually recognized and measuring devices were developed. The following are some of the more significant steps in that development history. A more extensive survey, particularly covering European developments is included in Harrison's book.[8]

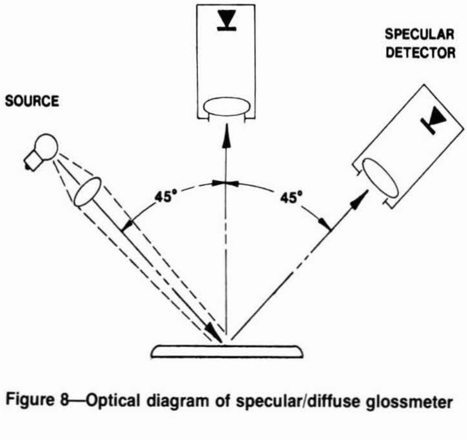


Figure 8—Optical diagram of specular/diffuse glossmeter

In 1914, L.R. Ingersoll[18] published a description of an instrument which he called "A Glarimeter" (*Figure* 6). He set the incident and viewing beams at 57½°, which, for many nonmetallic materials, is the angle at which specular reflection is almost completely polarized. This is called the Brewster angle. He measured the degree of polarization by means of an adjustable polarizer in the viewing beam. In 1921 he described an improved version of this instrument using the null balancing polarizing Martens[19] photometer. Incidentally, this is the same optical photometer system as that incorporated by Hardy in his recording spectrophotometer which was to become the reference instrument in the field of colorimetric spectrophotometry.[20] Since the glarimeter also measures the ratio of specular to diffuse light, it is apparent that Ingersoll felt that "gloss" or "glare" involved the relationship between specular and diffuse reflectance. He also recognized the fact that is not universally appreciated even today; that is, that measurements of optical properties made in specific directions essentially depend on the solid or field angles of the beams, not only on the specular angle utilized. *Figure* 7 illustrates these critical incident and viewing field angles, ω_i and ω_v.

L.A. Jones[21] worked with the visual quality of glossy photographic prints. In 1922 he found that for best viewing, prints should be illuminated at 45° and viewed at 0°. He then postulated that gloss is measured by a ratio of specular to diffuse reflectance and designed a glossmeter with a 45° incident beam and with a viewing system which compared specular reflectance at 45° with diffuse reflectance at 0°. This geometry is shown in *Figure* 8. He thus defined gloss as

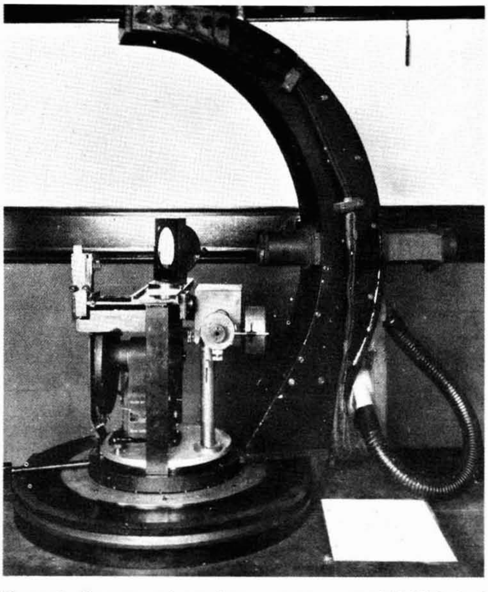


Figure 9—Source and specimen arrangement of McNicholas' goniophotometer

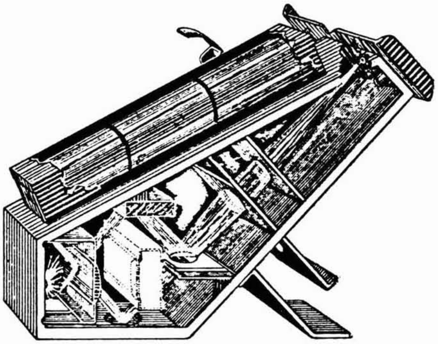


Figure 10—Hunter 45°/45° glossmeter

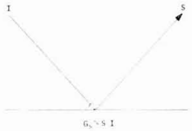
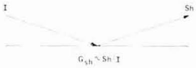
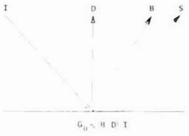
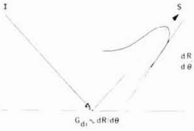
$$G = \frac{B_{45} - B_o}{B_o} = \frac{B_{45}}{B_o} - 1 \qquad (5)$$

where the B is brightness. Jones also seems to be the first to refer to goniophotometric curves of reflected light in a study of gloss properties.

In 1928[22] the Technical Association of the Pulp and Paper Industry (TAPPI) developed the first standard method for gloss measurement — namely T424. The method describes the use of the Ingersoll glarimeter for measuring gloss of papers.

In 1925, A.H. Pfund[23] described what appears to be the predecessor of today's most common type of glossmeter — a simple instrument with a 45° incident beam. He measured gloss as the ratio of light reflected by the sample in the 45° specular direction to that reflected by some standard. In 1930 he developed an

Table 1—Hunter's Six Types of Gloss

Types of Gloss	Visual Evaluation	Types of Surfaces	Reflectance Function
Specular gloss	Shininess, brilliance of highlights	Medium-gloss surfaces of book paper, paint, plastics, etc.	
Sheen	Shininess at grazing angles	Low-gloss surfaces of paint, paper, etc.	
Contrast gloss or luster	Contrast between specularly reflecting areas and other areas	Low-gloss surfaces of textile fiber, yarn and cloth, newsprint, bond paper, diffuse-finish metals, hair, fur etc.	
Absence-of-bloom gloss	Absence of haze, or milky appearance, adjacent to reflected highlights	High- and semigloss surfaces in which reflected highlights may be seen	
Distinctness-of-image gloss	Distinctness and sharpness of mirror images	High-gloss surfaces of all types in which mirror images may be seen	
Surface-uniformity gloss	Surface uniformity, freedom from visible nonuniformities such as texture	Medium-to-high-gloss surfaces of all types	Not a function of reflectance

instrument which has been used successfully in the paint industry for many years. He further suggested that there are two types of gloss — "objective" and "subjective". By objective gloss he meant measurements of specular reflectance now known as "specular gloss." He defined subjective gloss as the relationship between specular and adjacent diffusely reflected light. This we now call "contrast gloss" or "luster."

A 1930 paper by Pfund attempted to quantify objective gloss by defining it as the ratio of the intensity of light reflected specularly from a material at a particular angle of incidence to the intensity of light reflected in the same manner from a perfectly polished surface of the same material. Thus, each material has its own reference standard.

Through the years 1928 to 1934, H.J. McNicholas[24] carried out extensive work utilizing a goniophotometer for evaluating attributes associated with gloss and other geometric characteristics of reflectance. He accurately and completely identified conditions of reflectance measurements, indicating that he understood the importance of both the field angles as well as the axial directions of incidence and view. *Figure* 9 shows the incident beam arrangement and the specimen table of his apparatus. Note the large arc shaped source support, providing the ability to illuminate in directions other than the plane containing the specimen normal and the viewing beam. He extended his work by building a goniospectrophotometer in order to make instrumental measurements of all of the major physical attributes of materials responsible for appearance.

In 1934, R.S. Hunter[25] developed a 45° specular glossmeter which directly compares the ratio of light reflected from a sample to that reflected by a polished black glass. Note that this is not exactly the same as Pfund's reference and it permits the use of a more practical primary standard, because it is based on a common material whose index of refraction can be readily determined. Since gloss is primarily a surface characteristic, the degree of attainment of Pfund's "perfectly polished surface" could cause serious inter- and intra-laboratory reproducibility problems. The instrument was calibrated by gloss readings of liquids of known refractive index and a small correction was made for the effect of diffuse reflection. *Figure* 10 shows a diagram of Hunter's instrument.

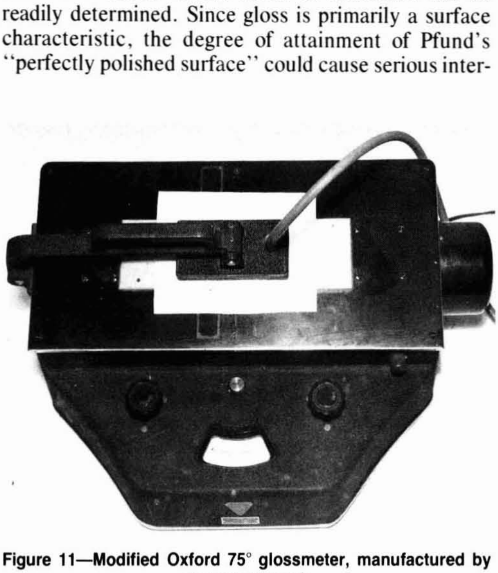


Figure 11—Modified Oxford 75° glossmeter, manufactured by Bausch & Lomb

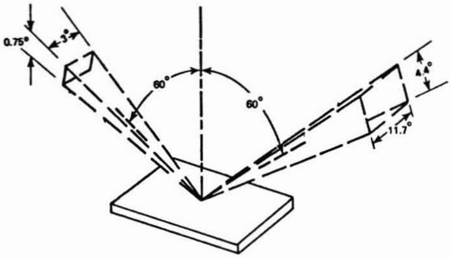


Figure 12—Specified angular dimensions of ASTM D523, 60° gloss test

It should be noted that in the instruments which have been described, the observer's eye is the detector. And, although optical means for balancing is provided, some subjectivity is still present in measurement.

In 1937, Hunter[26] showed that when one analyzes impressions of glossiness, there are at least six different appearance criteria used. Hunter identified these six as "types of gloss". He noted that different instrumental configurations would be necessary in order to measure those different characteristics. The six types of gloss are specular, sheen, contrast/luster, distinctness of image, absence of haze or bloom, and absence of texture. These are summarized in *Table* 1.

In the four decades since these identifications were proposed, significant progress has been made in the development of instruments and in the actual measurement of the first five characteristics. Classification of the sixth type, texture and its measurement, is still at a very elementary stage.

In 1937[27] the Institute of Paper Chemistry published a rather extensive report on gloss measurements of paper. They came to the conclusion that the 75° Oxford Gloss Meter (described in 1935 by Kress and Morgan[28]) was to be preferred over the polarization type glarimeter. Incidentally, this Oxford Paper Company instrument appears to be the first glossmeter utilizing a photocell instead of the eye as a sensing mechanism. Percent gloss was identified as a ratio of specular reflectance of the sample to that of the black glass standard in the same manner that Hunter had used earlier. *Figure* 11 is a picture of the photoelectric type Oxford 75° glossmeter.

Using a large range of samples of a variety of paint finishes, Hunter and Judd in 1939[29] compared the visual ratings for glossiness with instrumental ratings. They showed that a 60° specular glossmeter equipped with the proper field angle stops would produce numerical values correlating with visual appraisals. *Figure* 12 is a diagram showing the source and receptor field angles of the 60° glossmeter. The apparatus and procedure were incorporated into the American Society for Testing and Materials (ASTM) Method 523 which, after numerous revisions, is now the most widely used specular gloss test in the world.

In 1943, J.W. Ayers, of the C.K. Williams Company,[30] working with Army camouflage finishes, proposed a specular gloss meter for low gloss matte surfaces. The instrument provides for measurement at 75°, 80°, and 85° angles of incidence. Two light beams, sample and comparison, are directed to separate detectors. Standardizing and sample readings are made by nulling the two detector outputs. An optical wedge, located in the comparison beam, and controlled by the measurement dial, provides means for sample readings by use of optical null balance. In 1947, Horning and Morse[31] developed a 20° specular test measuring high gloss finishes. The 85° and 20° gloss measurement procedures have also been incorporated into ASTM Method D523.

In 1953, Middleton and Mundall[32] described a unique gloss meter in which the image of a source field stop, reflected by the specimen, is scanned by a narrow slit. The maximum rate of change of the resulting photodetected single is called "slope" and is directly correlated with distinctness of reflected image. This is the first photoelectric device to quantify the mirror-like qualities of materials. In 1961, W.H. Tingle and F.R. Potter[33] developed an instrument which measures the ratio between specular reflectance and very narrow angle off-specular reflectance as distinctness of image. Both of these instruments have been employed in the metals finishing field[34,35] and recently, the latter principal has been applied to the quality control of high gloss and automotive finishes.[36]*

Many of these studies and instrument developments have resulted in practical gloss measurement procedures. The gloss test methods of ASTM are perhaps the most extensive formally organized collection of procedures. In 1973, R.S. Hunter[37] summarized these, in addition to other methods for appearance measurements. All major gloss test methods of the ASTM and other societies currently practiced in the U.S. are covered in Appendix Table A.1 of Hunter's textbook, *The Measurement of Appearance*.[38] Gloss test methods used throughout the world generally duplicate or are similar to those used in the U.S. The overwhelming majority of these methods, and, in fact, most of current practice, involve the measurement of specular gloss only. It is obvious that there is much work to be done if measuring instruments and measurement methods covering even the currently recognized aspects of gloss appearance are to be provided.

FUTURE DEVELOPMENTS

An entire chapter of Harrison's book[8] is devoted to the investigations of the psychological responses (our visual sensations) which cause the perception of luster or gloss. With respect to the term luster particularly, he emphasizes that it is an effect which is easily recognizable, but is very difficult to describe. He expands on this in the final chapter and arrives at the conclusion that perhaps there is such a thing as "gloss Gestalt." This is a German term meaning that the final result of something that is composed of a number of items can be different from the sum or any combination of the parts and can be completely unique. That is, it is different from, and cannot be predicted by, the individual measurements of the various ingredients. The psychological (aesthetic) effect on the audience of work by artists, composers, and musicians is an example of this phenomena.

It is probably true that it will never be possible to completely quantify the psychological effect of the appearance of materials. On the other hand, in relation to the amount of effort spent quantifying the sensations of color and color difference, very little work has been devoted to psychophysical gloss scaling. Much of the early effort directed toward identifying the physiological and psychological factors related to gloss was carried out in Germany during the 1850's and 1860's, and later, in Germany and America during the 1920's. With the exception of the visual correlation work associated with the development of the gloss measuring instruments mentioned above, new literature is rather sparse. One recent gloss scaling investigation by J. Fleischer[39] involved a large number of observers and samples. He established gloss intervals by means of paired comparisons of selected samples. He reports good correlation between visual scaling and goniophotometric curve peak, half peak width, and average tangent slope. He states that the average tangent slope is suitable for scaling perceptions of gloss of flat, uniform samples.

The CIE Technical Committee 2.3 on materials has a gloss subcommittee which is devoting its work effort toward similar scaling objectives. The work program consists of two parts: first, to identify the scales and ranges which are presently used and, second, to carry out an experimental program of visual scaling and instrumental measurement to produce improved psychophysical scales. In this country several sets of samples, each of which covers a wide gloss range have been assembled. A series of visual experiments involving at least 30 observers is being conducted. Each observer is asked to first rank the specimens and then, by the paired comparison technique, estimate the gloss differences. It is hoped, through the statistical analyses, that quantitative visual scales can be established. Goniophotometric curves will be made of the samples and eventual correlation between some light scattering characteristic (identified by curve shape) and the visual scale will be attempted. The British contingent of the CIE Committee has conducted experiments on a set of

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*For a review of instruments applied to metals finishing and description of the development of the Dori-Gon Glossmeter, see J.S. Christie, "An Instrument For the Geometric Attributes With a Metalic Appearance," *Applied Optics*, 8, 9, 1969.

specimens which include metallic foils, coated papers, white and black papers, and plastics. In this work, observers were asked to simply rank the specimens according to gloss, ignoring the varieties of material and/or gloss type. Agreement between observers has been surprisngly good.

SUMMARY

In this paper, some of the physical phenomena responsible for what is called gloss have been described. Also outlined is a method for classifying the various appearance attributes of objects which are responsible for gloss. Terms used to describe the visual sensation or psychological response have been identified. In addition, some of the more important stages of instrument development have been noted.

Anyone seriously interested in this subject and willing to assist in this work is urged to contact the author. In this way, perhaps the work of this era can be a significant reference in a future review.

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Practical Aspects Of Instrumental and Computer Color Control In a Small Paint Plant

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A tristimulus colorimeter was used for 18 years for control of production color matches in a trade sales paint plant of small to medium size. Five years ago this was replaced by an automated abridged spectrophotometer and a general purpose minicomputer equipped with color matching software. Experience over the 23 year period is summarized and some specific solutions to problems are described. Subjects discussed include: stabilizing color standards; accepting instrument decisions; sampling and sample preparation; backup systems; effects on methods, procedures, and personnel requirements; evaluation and startup of computer color matching systems.

Introduction

The author's employer, a regional manufacturer which produces primarily trade sales paints, began to use a colorimeter for control of production color matching about 23 years ago. Five years ago a computer color matching system was installed. Both methods of color control have proven quite successful. The purpose of this paper is to relate some experiences and problems encountered, together with some solutions and conclusions reached, in the course of those 23 years.

The above title is certainly correct in describing the subject company as small during at least part of this period, and what follows will no doubt apply most directly to companies of like size. Differences in the approaches of large and small companies to any problem, however, are to a considerable extent due simply to differences in sizes of available budgets. The application of the paper might be better indicated, therefore, if its title were restated as "Low Budget Instrumental and Computer Color Control in a Paint Plant".

Equipment cost is of course the obvious budget item. A choice must be made between the available colorimeters, spectrophotometers, instruments with microprocessors, complete computer color matching systems—or no instrumentation at all. This is a critical decision. Excellent equipment is now abundantly available, however, and its selection is outside the scope of this paper. The basic equipment is by no means the entire cost of a color control system. In the long run, people often cost far more than equipment, and people determine the effectiveness of even the best equipment. Since these are the costs most difficult to evaluate when considering installation of a color control system, emphasis will be placed on operating methods and possible pitfalls, with considerable attention to personnel requirements. The review by Johnston[1] on operating methods and pitfalls is recommended reading.

Instrumental Color Control In General

The experiences described and opinions stated in this paper have been chosen simply because the author considers them most important. The first four subjects discussed have application to any paint color control operation based on an instrument, whether with or without a computer.

IMPORTANCE OF STABLE COLOR STANDARDS: When a coatings manufacturer has been depending on either wet or dry color standards stored at room temperature, his standards are almost certainly not color-stable. In this case, elimination of drift in the standards is by far the most significant thing that can be done to improve color control. Even very broad tolerances with no standard drift are much better than attempts to hold tight tolerances around moving standards.

The greatest color control improvement in the author's experience occurred when an instrument was first installed to replace wet color standards. The decrease in color complaints was dramatic. In fact, the improvement that is achievable under these conditions can be adequate justification for installation of a color instrument of some sort, although many decisions remain to be made.

That instrument installation, which took place in 1956, illustrates two things that can work to the advantage of small companies with limited budgets. One of these is the possibility of broader-than-expected tolerances, once standards are stabilized. The other is that sometimes limitations which apply to the general case may not apply in a specialized set of circumstances.

The instrument was an automated three-filter colorimeter* which was purchased for reasons related to sales. The problem then became to find a means of using it for color control. The solution was not obvious; the instrument was

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Presented at the Symposium on Color and Appearance Instrumentation in Cleveland, Ohio, March 15, 1978.

*5275 Peachtree Industrial Blvd., Atlanta, Ga. 30341.

*Automatic Color Difference Meter, Gardner Laboratories, Inc., Bethesda, Md.

". . . people determine the effectiveness of even the best equipment. . ."

known to be accurate only for measurement of small color differences, and at that time there was no known sure means of maintaining a stable standard for each product, from which batch deviations could be measured. A special situation existed, however, in that it was only necessary to stabilize standards; measurements were not required to agree with any other instrument. Also, as it developed, broad tolerances were acceptable.

Published descriptions of the limitations of filter colorimeters did not encourage the approach which was taken, but choices were also limited. A set of calibrated colored ceramic panels was obtained, and these were used as primary standards for instrument calibration. Hunter L, a, b, coordinates were established for each standard paint color, and tolerance of one full unit was permitted in any direction. Not only did this tolerance amount to roughly three to five FMC-2 units, but in addition the difference being measured between a particular paint standard and the closest available ceramic panel was frequently larger than desirable.

The results under these circumstances provide strong evidence as to how very poor wet standards actually are; the color control system was a spectacular success. Color complaints dropped to a negligible level, and the comparison of colors of retained samples from batches made before and after the advent of the new color control system became a very rewarding exercise.

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INSTRUMENTS AND COMPUTERS AS DECISION MAKERS: The next question to be discussed is, "To what extent should an instrument or computer be trusted to make go/no-go decisions on production color matches?" The position on this question which will be supported is that, once a system is working properly, it should seldom be overridden.

Several arguments against this position should be acknowledged at the outset, however. It is well known that color difference measurements are imperfect, and that they may not correspond to visual perception. It is also true that perfect color tolerances, neither too loose nor too tight, are difficult to set. These drawbacks are heavily outweighed, however, by the advantages of reducing the human element. Accuracy of color matches produced by a visual color control system is enormously influenced by such factors as friendship (or lack of same) between the shader and the quality control technician, the technician's digestion or marital happiness, or the length of time a batch has been holding for color approval, in addition to more objective matters such as differences in color perception between individuals.

An experience from the author's early days in the paint industry illustrates the human problem. An assigned task with a previous employer was the supervision of quality control, including visual approval of production color matches. The subject color matching operation was free from any obstruction from scientific knowledge or procedural control. The shader simply took a wet standard from the shelf and undertook to match it visually on his spatula, using any and every colorant he felt to be needed. He then brushed standard and batch side-by-side on a paper chart and brought it for approval. Decisions were based on examination in front of a window. An interesting aspect of this system was that it tended to be a game of wits. If the shader was getting impatient, he might present a chart with the paints brushed horizontally instead of in the normal vertical direction. If this strategem was not detected, the objective of getting the color approved had been achieved.

While that shader did realize that brushing both sides of a panel from a standard can was not good practice, it is possible that an occasional stubborn color overcame his conscience in this regard.

The color control operation just described was unquestionably a horrible example even in its day, but certainly serves to illustrate the problems which can arise from leaving production color decisions entirely in the hands of people.

In the position previously stated, that instrument decisions on color matches should seldom be overridden, the word "seldom" requires further comment. As with all rules, provision must be made for exceptions. In this case a good decision on when an exception should be made involves, in the author's opinion, a cardinal principle for use of any instrumental or computer color control system. This principle is admirably stated by two words used repeatedly by Billmeyer and Saltzman[2] in their excellent elementary textbook on color technology. These words are *look* and *think*.

In the present case, *look* means that no color match should ever be approved without visual verification that it is reasonable. *Think* means that no instrument or computer output should ever be followed until someone has considered whether it makes sense. *Look* and *think* simply check for input errors by people and for malfunction by machines. Fortunately such errors are almost always large enough to be detected by the *look/think* method.

Therefore, for the reasons just discussed and occasionally for other reasons, instrument decision should be overridden. This should not be done frequently, however, and should not be done at technician level. Frequent need to override an instrument may indicate that tolerances are too tight or that some other problem needs correction.

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SAMPLING AND SAMPLE PREPARATION: Sampling and Sample Preparation are universally recognized problems in any quality assurance program. In the case of color panel preparation, the problem at the practical level is always a matter of finding the best compromise. That is, the panel used for a decision must be acceptably close to what the customer will see, but panel preparation must be sufficiently fast so as not to significantly affect turnaround time of finishing tanks. Sampling problems are of course much the same with or without a color instrument. Like some other variables, however, with an instrument they become much more difficult to ignore. While control of sampling errors tends to be specific to each operation, a few comments can be made.

Probably every manufacturer uses some means of accelerating the cure of color panels, in order to minimize the time required to achieve a match. Like every other part of a good color control system, this process requires careful design and excellent control. Any product with which the author has had experience can be cured in not over one hour with excellent reproducibility of color. The accelerated panel may vary up to three or four FMC-2 units from the color of the same batch after normal cure, but this need not be a problem if the target instrument readings are taken from a similarly accelerated panel. It cannot be overemphasized that failure to carefully control the accelerated cure of color panels can negate all other efforts to achieve a good color control system.

The most common error made in the preparation of color panels may well be failure to apply all opaque products at sufficient film thickness to achieve complete opacity. Admittedly, enforcement of this procedure can be initially difficult, but failure to do so will detract seriously from the success of a color control system.

Fortunately, a computer, together with a good set of records, can be an excellent means of detecting sampling problems. Getting this benefit from a computer depends on following the admonition of Billmeyer and Saltzman—to *think*. The rule is simply this. If successive additions of color do not move a batch in a logical manner and in reasonable agreement with history, there is reason to look for trouble. Questions to be investigated include whether the batch has had adequate mixing time since color was added, whether the batch is exhibiting normal color acceptance, and whether the color panel was properly made.

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BACKUP SYSTEMS: Every instrument or computer will of course inevitably break down. An adequate backup system should therefore be an integral part of every good color control operation. This is particularly important with smaller companies, where the maximum number of instruments and computers will certainly be one each.

Obviously, an essential part of any backup system where there is only one instrument is someone who retains skill at visual color matching.

Wet standards, however, are definitely not needed for products on which there is some color matching history. A much better means of maintaining visual standards is available. This is a method first published 14 years ago, abundantly verified in print eight years ago, and still very little used. In 1965, Huey[3] described successful storage of dried color standards at low temperatures—specifically, at –5° to 0°F in an ordinary household freezer. In 1971, the Southern Society for Paint Technology published substantiation of Huey's results.[4]

More than ten years of everyday experience with this method has shown it to be easy to use, inexpensive and extremely reliable. The final color panel from which each production batch is approved may be stored for two years or more without significant color change. Batch-to-standard color difference measurements should also be retained. If any standard color must then be matched without an instrument, the stored panels for that color, along with their known color differences from standard, amount to a group of visual limit standards for the color. These cold storage panels are also useful for adjusting tolerances and in other ways.

Transition to a Computer

Not every manufacturer will have the opportunity, as did the author's employer, of moving from a well established instrumental color control system to a computer color control system. Nevertheless, application of "hindsight" to that experience reveals considerable useful information, because the use of an instrument resulted in unplanned but effective preparation for a computer, in both methods and personnel.

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DISCIPLINE AND ORGANIZATION: A color instrument prepares a color matching operation for a computer primarily because both require moves in the direction of better discipline and organization. The necessity for setting color tolerances, which has been mentioned, is one case in point. Several others will now be illustrated from experience.

Of course we knew before acquiring an instrument that metamerism could only be avoided if the group of colorants used to match each standard color was controlled. As in many visual color matching operations, however, enforcement of this rule was less than rigid. With the instrument, the increased danger from failing to control the colorants used was recognized, since colorimeters are quite unable to detect metamerism. The additional emphasis which was then placed on this matter is an excellent example of the beneficial discipline which instruments can provide. (It should be noted that a spectrophotometer with a color computer permits more flexibility in this area. Information on metamerism is provided by the color measuring instrument and computer, making it possible to deviate intelligently from standard colorants. As a starting point, however, a standarized group of colorants is more essential than ever.)

As time passed, our color matchers became instrument-dependent. They became receptive to suggestions that the amount of each colorant required to effect a given color change be measured and recorded, in order to provide a better basis for predicting the size of color adds. This led to development of simple systems for measurement of colorants and for recording colorant adds versus instrument readings, all done by color matchers.

Again there was a disciplinary effect. If measurements were to be meaningful, colorants had to be standardized. The first step was to find a practical means of keeping colorants well mixed and sealed at all times. When this had been accomplished it was discovered that the colorants already in use were sufficiently well controlled, as to strength and hue, to permit useful measurement, even though they were not "machine" colorants.

The semi-automated color matching system which evolved was quite imperfect, but nevertheless reduced the average number of "hits" by about 15%.

When a computer was eventually installed, the methods already in use for maintaining standardized colorants were found almost good enough. It was only necessary to tighten control on purchasing of substitute materials and to make certain that the exact pigments and colorants in use at all times were known.

It can be seen that the amount of recordkeeping required became significant. While this took time, it also resulted in accumulation of much information on the color matching process, and it became possible to spot off-standard batches in some cases simply because they could not be color matched in the normal way. With the advent of a computer, recordkeeping increased still more, but established habits made resistance to this change relatively light.

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SELECTION OF PERSONNEL: The colorimeter also helped prepare for a computer in the area of personnel selection. The pre-instrument color control operation included one shader and one quality control technician. When the instrument was installed it was decided to let the shader use it, making and reading all panels until readings were within tol-

". . . the computer will be an indispensible tool of . . . every coatings manufacturer. . ."

erance. Quality Control then used the instrument to confirm the match. Working daily with the instrument for years, shaders came to rely on it for help. This led, as already described, to development of a semi-automated color matching system, and to increasing emphasis on recordkeeping as an important part of the color matching job.

An unplanned but desirable change occurred in the type of person needed for color matching. With requirements for careful panel preparation, interpretation of instrument readings and good recordkeeping, the shader's job became less that of an old fashioned craftsman and more that of a laboratory technician.

By the time a computer was installed in 1974, this pattern was well established and the decision as to who should operate the computer was easily made. One shader was given the entire job. That is, he operated the computer, used its output to determine what colorant additions to make, made the additions, prepared panels, kept the records and was responsible for the condition of the colorants. Backup for this man was provided by training a quality control technician on the computer.

As experience was gained with the computer, it became clear that a practical knowledge of color matching was very helpful to the operator in interpreting its output. Numerous nonstandard situations arose such as contaminated batches, re-worked material and new colors which had no color matching history. The computer programs gave very accurate answers if full and accurate data were available for input, but this was not always the case. A knowledgeable operator could often bridge a gap in the data by knowing such things as the right question to ask a program, whether or not output appeared reasonable, and how much caution to exercise in making adds from an output. Of course the type of practical color knowledge needed is of a general sort which might be taught to a laboratory technician, and not the specific skills developed by a visual color matcher.

A final matter deserving comment in the area of personnel selection is that of supervision of a computer color system in a small company. It is obviously not practical, as might be done in a large organization, to bring in or develop an expert on computer color matching. It is very important, however, to have one able, technically trained person assigned to learn the system, supervise and trouble shoot the installation and continue to routinely oversee the operation. Later, as time permits, all chemists, formulators and production supervisors who have contact with the system should learn as much as possible about it.

Deciding Whether to Install A Computer

This paper has become increasingly involved with computers. It is appropriate now, therefore, to examine the questions facing a company which is seriously considering purchasing a color computing system. These questions include economic benefits, methods of evaluating systems, and the amount of start-up effort required.

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Economic Benefits: Concerning economic benefits, five years of experience with one computer color matching system* have indicated the following to be practical, achievable goals of a color matching system based on a computer.

(1) The average number of man-hours required to achieve a factory color match should be about one third of the man-hours required in a good visual color matching operation.

(2) The average number of "hits" per color match should be approximately two.

(3) Turnaround time of tanks in which batches are finished should be four to six working hours faster than was the case with a good visual color matching operation. Frequently, this will mean that batches are completed one day earlier than would have been the case without a computer.

(4) Formulation of new colors in the laboratory should require approximately 25% of the man-hours needed without a computer.

(5) Very few batches should be misshaded, resulting in elimination of the majority of this cost.

At least two other computer applications can result in significant cost savings, but our experience does not provide quantification in these areas. These are reformulation of colors using lowest cost pigmentation, and calculation of optimum pigment loading to eliminate wasted opacity.

Impressive as these benefits are, however, they will not provide justification for purchase of a computer for many paint manufacturers.

If a color matching operation is large enough to keep a computer relatively busy in making batch corrections, and/or if a laboratory does several color formulations per day, no further justification will be needed. Many companies, however, like the author's employer, do not have this amount of color activity. In our own case, color requires less than half of the available machine time per shift. The computer is used, therefore, to do many other jobs needed by the laboratory and factory, such as paint formula design, batch ticket generation and formula costing. As a result of benefits from all applications, economic justification for the system is much more than adequate.

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Evaluating a Color Computer System: Thorough evaluation of a color computer system requires considerable time and effort, but this is certainly justified in view of the investiment involved. The following five questions are recommended as particularly important for investigation.

(1) *For each application which is of major interest to the potential user, does the system produce the kind of results needed, when actual data from the operation in question are used?*

If the investigator will take time and trouble to provide the data, he should be able to obtain unequivocable answers to this question from the color computer supplier, in the form of hardcopy output.

(2) *What maintenance and downtime expense should be expected?*

Availability of service, cost of maintenance contracts and experience of others users should be determined for both the computer and the color instrument. Also it should be realized that the calibration of primaries which is discussed below in connection with start-up will have to be maintained as pigments and formulas change.

(3) *Is the system a general-purpose computer? Does it include operating and programming software which will allow it to be used for virtually any other desired application, in addition to color?*

Even though a company has no computer programming capability at the time of the original purchase, many companies will develop this capability or may wish to procure source language

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*ACS-300-S, Applied Color Systems, Inc., Princeton, N.J. Color instrument is a Diano Automate, Diano Corp., Woburn, Mass.

programs in the future. For these purposes, it is very desirable that the system be able to handle the Basic and Fortran languages.

(4) *Is the system modular and expandable? Can it be enlarged or improved in the future in an economical manner? Will software updates be readily available?*

Computer technology changes so rapidly that these questions are extremely important.

(5) *Is adequate training and support available from the supplier?*

Very few coatings manufacturers will succeed in installing a computer color system without extensive help from the supplier. Its ready availability is essential.

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START-UP EFFORT: The amount of start-up effort required for a new computer color matching system will vary considerably with the number of "primaries" (pigments and pigment dispersions) which must be calibrated, and time required to complete the calibration will depend on laboratory manhours available. Once calibration of primaries is complete, a considerable break-in period will be required before the system is running with reasonable smoothness and efficiency. This break-in period can also vary greatly in length, depending among other things on whether conversion to computer control is done in one step or several.

Our own experience included a period of approximately ten weeks during which calibration of pigments and colorants was a high-priority laboratory project. We then made the switch to computer color control literally overnight on all products, and another six months was required to achieve stable, satisfactory performance.

Determination of the size of the calibration job involves not only a count of the number of pigments and pigment dispersions to be calibrated, but also decisions as to how many duplications will be needed in different coating systems. Suppliers have made software improvements which reduce the need for duplication by permitting adjustment for such things as the color contribution of the binder, substitutions of different grades of titanium dioxide, and variation in concentration of titanium dioxide or other principal pigments in formulas. It is nevertheless extremely doubtful, to say the least, that any color software package will permit good color control of a varied line of coatings products using only a single file of primaries. Problems arise for which the only effective adjustment is recalibration of the needed pigments, using the particular coating in question as the base. The following are a few examples of such situations:

(1) Paints formulated above critical pigment volume concentration (CPVC) or which contain microvoids for other reasons, such as a high concentration of calcined clay;

(2) Vehicle systems in which some of the available colorants develop color less than perfectly;

(3) Ingredients used for purposes other than opacity or color, but which nevertheless contribute to optical behavior, such as zinc oxide and barium metaborate.

Full credit should be given to software suppliers for providing the coatings industry with excellent products. Nevertheless, with apologies to Shakespeare, there are likely to be more things in coatings formulations than are dreamed of in the color system supplier's philosophy.

Success or Failure?

In this concluding section some personal opinions will be offered as to what are the most critical factors in determining the success or failure of a new instrument or computer color control operation.

The first and most important item on this list, without which a successful beginning cannot be made, is a positive attitude throughout the organization. Everyone involved—management, laboratory people, and production supervisors—must believe that the system will work and must be willing to contribute patience and effort. Any attitude short of this, if held by key people, may be sufficient cause to bring about failure. A passive attitude, if it includes a reluctance by key people to use the system, can have the same effect.

For ongoing successful operation, the following are suggested as the most critical requirements:

(1) Careful daily calibration and thorough periodic checks of the instrument;

(2) Good sampling and panel preparation;

(3) *Looking* and *thinking*, that is, constant alertness to be sure outputs are reasonable and colors are visually in range.

The following additional requirements apply specifically to computer color systems:

(4) Extreme care in calibration of primary pigments, and adequate maintenance of calibrations as formula changes occur;

(5) Accurate input—giving the system the true facts about each batch;

(6) Making careful, accurately measured "hits", using only colorants which are kept in excellent condition.

Conclusion

One very strong conviction is offered which goes beyond the selection of a color control system. This conviction is that the time is rapidly approaching when the computer will be an indispensable tool in the laboratory and/or production department of every coatings manufacturer. Color and other optical properties will be among several major applications areas for these computers. The day of computerized coatings manufacturing is still in the future, but the time may already have arrived when to ignore its coming could be hazardous.

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(3) Huey, S. J., *Color Engineering*, *3*, No. 5, 24 (1965).

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How to Select the Right Antifoam for Water-Based Paints

Results are What Count

Below is just one example of the results you get when Nalco tackles a foam problem. Take a good look. Results are what count and what Nalco is committed to.

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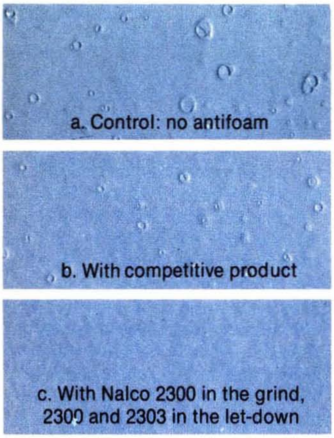

a. Control: no antifoam

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1. It should prevent and destroy foam.
2. It should be persistent.
3. It should not adversely affect color acceptance, gloss, water sensitivity, or intercoat adhesion.
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A Systematic Approach

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Analyze Your Formulation The surfactants, co-solvents, flow control additives, pH, pigments, and resin type in your formula are studied since they affect foam stability and antifoam performance.

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Analyze Your Application Procedures Techniques involving recirculation and high shear, such as spray and flow, can cause persistency problems and are considered when solving the foam problem.

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Society Meetings

Baltimore — April 19

Jack Cherry, of Rohm and Haas Co., and Mason Wetzel, of Dutch Boy Paint, Inc., spoke on "BACTERIAL PROBLEMS IN MANUFACTURING AND HANDLING LATEX EMULSIONS."

GORDON ALLISON, *Secretary*

Birmingham — April 5

H.J. Pullen, of Redland Purle Limited, spoke on "WASTE DISPOSAL."

Mr. Pullen began by saying that several methods of disposal are available, including a range of suitable incineration plants with afterburners, gas scrubbers, and encapsulation techniques. Landfill, however, is the most widely used method in the U.K., he said. Careful selection of landfill sites, by geologists and geochemists, is followed by regular monitoring of the chemical composition from boreholes at different levels, thereby preventing excessive build-up of pollutants in the soil.

Only after solvent recovery has failed do solvents become a problem for the waste disposal industry, continued Mr. Pullen. If there is no segregation in the effluent treatment plant, recovery is uneconomic.

About 5 million tons of dangerous waste are produced in the U.K. each year. Special tankers are used to transport the liquid waste. In many cases it is mixed with solid domestic waste. Mr. Pullen said that one ton of domestic waste absorbs 0.72 tons of liquid waste.

Q. What about drummed waste?

A. If the contents are flammable they must be burned. Authorities do not like closed containers on landfill sites because of the possibility of re-evacuation after the site has been finished and because of fire hazards. Fiber kegs which are biodegradable are preferred.

Q. What contents would you accept in a fiber drum?

A. Polymeric materials are acceptable, but low flash point materials are not.

BRIAN F. GILLIAM, *Publicity Officer*

Kansas City Society Officers for 1978-1979. (left to right): Society Representative—Terryl Johnson of Cook Paint & Varnish Co.; Secretary—William Smith IV, of Conchemco, Inc.; President—William Fitzpatrick, of Cook Paint & Varnish Co.; and Treasurer—Richard Warren, of Cook Paint & Varnish Co.

C-D-I-C — April 9

Dr. Graham Swift, of Rohm and Haas Co., discussed "β-HYDROXYALKYLAMIDES, LOW POLLUTING CROSSLINKERS FOR CARBOXYL CONTAINING POLYMERS."

The Educational speaker, Lew Larson, presented a program on "WHO ARE THE PEOPLE THAT ARE GETTING INTO THE COATINGS INDUSTRY."

W. J. FROST, *Secretary*

Cleveland — Mar. 13

Honored guests in attendance included Federation President-Elect Elder Larson and Field Director Tom Kocis, who spoke briefly about the current affairs of the Federation.

The technical program consisted of a panel discussion on the topic, "NEW CONCEPTS IN PAINTS/COATINGS APPLICATION TECHNOLOGY," chaired by Girish Dubey, of Maintenance, Inc.

Jack Adams, of Binks Manufacturing Co., spoke on "THE INDUSTRIAL ROBOT." Mr. Adams discussed the spray gun manipulator, a hydraulic machine, electronically controlled and programmed to duplicate human movement in spray painting.

Les Feyma, of Graco, Inc., discussed "THE SIGMA 30," which is an electrostatic finishing system, designed to improve quality and reduce overspray.

Roy Nickerson, of Interrad Corp., spoke on his company's equipment for the "APPLICATION OF POWDER COATINGS."

J.S. MALAGA, *Secretary*

Cleveland — April 10

The meeting started with a tour of the Perry Nuclear Power Plant in N. Perry, Ohio. The plant, expected to be fully operational in 1983, was started in 1974.

J.S. MALAGA, *Secretary*

Dallas — Mar. 15

Ada C. Nielsen, of Nalco Chemical Co., spoke on "FOAM IN COATINGS—ITS PREVENTION AND DESTRUCTION."

Ms. Nielsen pointed out that a pure system would not foam; however, when mixtures are added, foaming will occur. Although no universal defoamers have been developed yet, some ways to prevent foaming are to keep the pH high and the viscosity as low as practical.

R.D. WILLIAMSON, *Secretary*

Detroit Mar. 27

James Johnson, of Union Process Co., discussed "ATTRITOR GRINDING AND DISPERSING."

Mr. Johnson indicated that the attritor is designed for producing a very fine dispersion with short grinding times. The mills may be used with hardened steel balls (used with dark colors), stainless steel balls (used with waterborne materials), and porcelain balls (used with white and light colors). Attritors, he said, are well suited to continuous batch grinding of the same paint or closely related paints to avoid excessive cleaning between batches. Frequently, the paste may be ground and the entire batch let down and finished in the mill, he said. This is very good for materials which do not flow well, he added.

Awarded 25-year pins were the following members: James Burke, David Veres, George Poy, Richard Sadwoski, Walter Kachorek, Bondan Melnyk, Robert MacLareu, Lawrence Hughes, and Finn Wallace.

Also attending the meeting were the following Society Past-Presidents: Paul Ziegelbaur (1951-52), John Martin (1960-61), Robert Minshill (1964-65), Louis Milgram (1965-66), Charles Linaham (1966-67), Harry Majcher (1968-69), George Poy (1971-72), Paul McCurdy (1972-73), Richard Partusch (1974-75), and Donald Hayes (1976-77).

GARY VAN DE STREEK, *Secretary*

Golden Gate April 16

Robert Lattie, of Atlas Electric Device Co., spoke on "ACCELERATED WEATHERING — YESTERDAY, TODAY, AND TOMORROW."

Mr. Lattie discussed the advantages, and development of the Weather-Ometer, and what conditions may be controlled and duplicated. He also explained the interpretation of test data and the evaluation of the method.

Q. If you have a light spectrum that approximates natural sunlight, how do you get accelerated tests?

A. It can give you 24 hours a day of natural sunlight, 365 days a year, and an increased level of radiance.

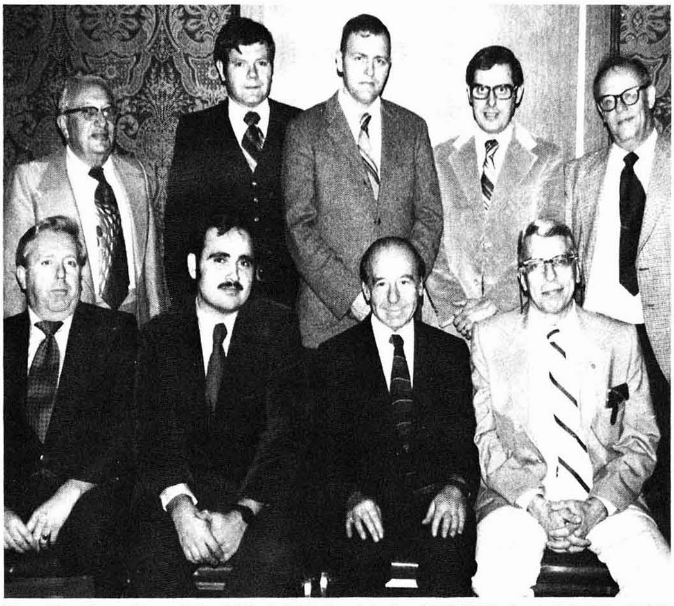
Q. Can you judge UV absorption or lightfastness of different pigments?

A. You can judge which pigments will hold up better.

Q. Do longer wavelengths cause more fading?

A. It is a very generalized statement, but, in general, yes they do.

SHARON VADNAIS, *Secretary*



Executive Committee of the Philadelphia Society for 1978-1979. Seated (left to right): Treasurer—Matt Hanrahan, of Lilly Industrial Coatings; Secretary—Barry Oppenheim, of McCloskey Varnish Co.; President—Lothar Sander, of Amchem Products, Inc.; Society Representative—J. Richard Keifer, of McCloskey Varnish Co.; Ben Chatzinoff, of Quaker City Chemicals; Ellis Moore, of Gulf & Western Industries; Wayne Kraus, of Lawrence-McFadden; P.J. Sotorrio, of DeSoto, Inc.; and Bill Johnson, of Atlantic Richfield Co.

Kansas City Mar. 8

John Ormsby, of Farmland Industries, was voted and accepted by the Society as an Honorary Member.

Robert Vash, of Byk-Mallinckrodt, spoke on "HYDROPHOBIC WETTING AGENTS."

Mr. Vash explained the wetting action of these agents and how they could be used to prevent floating and flooding.

W.A. SMITH, *Secretary*

Kansas City April 12

Cap Bannister, of Air Products & Chemicals, Inc., discussed the "FUTURE OF EMULSION POLYMER INDUSTRY."

Mr. Bannister reviewed the 1983 outlook of the availability of the base monomers and their comonomers. Using a slide presentation, he proposed that ethylene monomer and vinyl chloride would require the least energy to produce. However, he predicted that handling costs would be somewhat higher.

W.A. SMITH, *Secretary*

Los Angeles April 11

This meeting was designated "Past-Presidents' Night," and those in attendance were: Ted Hawlish, Frank Martin, Al Hershey, Roy Fredericks, Allan Yerby, Trevellyan Whittington, D.G. Cromwell, William Ellis, Kenneth O'Morrow, Gerald West, and Robert Koperek.

Robert Lattie, of Atlas Electric Devices Co., discussed "ACCELERATED WEATHERING — YESTERDAY, TODAY AND TOMORROW."

Mr. Lattie presented the history of accelerated weathering and fading tests as related to the paint industry. He also talked about the past, present, and future of natural and laboratory weathering and illustrated, by way of slides, the types of equipment used plus the factors that most influence the test results.

Q. How does your equipment relate to actual exposure?

A. The answer to that question is really another question: 'What is actual exposure?'. Actual exposure is less repeatable than accelerated weathering, where all conditions are controlled. To answer — No, there is no correlation between natural and accelerated weathering.

JAN P. VAN ZELM, *Secretary*

Louisville April 18

Ralph Stanziloa, of Applied Color Systems, Inc., spoke on "COMPUTER COLOR CONTROL FOR THE COATINGS INDUSTRY. DOES IT WORK? IS IT WORTH THE TROUBLE?"

Mr. Stanziola indicated that computer color control will produce a very favorable return on the investment in hardware necessary to do the job. However, satisfactory initial matches or production adjustments following the first trial formulation are not guaranteed.

Some people, he said, feel that many of the problems with computer color control come from limitations in the traditional mathematical approach used for the calculation of color formulas. Most industrial color control problems have nothing to do with this approach in calculating formulas or making production corrections. The real problem, he said, results from the limits of most industrial operations to quantify and control the elements of their operations which effect the color of the material they produce.

In order to obtain the maximum benefits from instrumental color control, a relatively small investment must be made to acquire the necessary hardware and software, but a much larger commitment must be made to the idea that each of the elements of manufacturing related to the tinting operation must be reasonably controlled. Common sense and a relatively simple, but quantitative and analytical, approach is needed in addition to the instruments, he said.

P.W. HARBAUGH, *Secretary*

Cleveland Society Executive Committee for 1978-1979. (left to right): Past-President—Helen Skowronska, of Sherwin-Williams Co.; Lydia Bazarko, of Sherwin-Williams Co.; Secretary—Jack S. Malaga, of Body Bros., Inc.; Treasurer—T.D. Tuckerman, of Coatings Research Group; President—Charles K. Beck, of Premier Industrial Corp.; Society Representative Fred Schwab, of Coatings Research Group, Inc.; and Vice-President—Paul J. Houck, of Morgan Adhesives Co.

Montreal April 11

Among honored guests in attendance were Elder C. Larson, Federation President-Elect, and Frank J. Borrelle, Federation Executive Vice-President.

A 25-year pin was presented to Eric Krayer, of SICO Inc., by Mr. Borrelle.

Art Hagopian presented Mr. Larson with a check for PRI activities.

Mr. Larson then discussed the many advantages of being a member of the Federation. He mentioned that the duties of the Federation are basically information, innovation, and education. He also complimented the Montreal Society on its Long Range Planning Committee.

Mr. Borrelle, aided by a slide demonstration, discussed Federation structure and activities, including PRI.

R. KUHNEN, *Secretary*

New York April 10

The meeting began with an afternoon tour of the Benjamin Moore & Co. plant.

The evening's meeting was designated "PAST-PRESIDENT'S NIGHT," and those in attendance were Bill Greco, Herb Hillman, John Congleton, Moe Bauman, Ben Chatzinoff, Tony Skett, John Oates, John Toscano, Herman Singer, Sid Levinson, Don Koenecke, Moe Coffino, Dick Schmidt, Al Sarnotsky, Bill Singer, and George Dippold.

Certificates were awarded to the following people who were elected to Honorary Membership: Lou Eromenok, Mort Treade, John Congleton, Tony Skett, Sy Mountsier, and Bill Greco.

Louisville Society Officers for 1978-1979. Seated (left to right): Past-President—Nick Lanning, of Progress Paint Co.; President—Joe B. Lococo, of Reynolds Metals Co.; Society Representative—Joe Bauer, of Porter Paint Co.; Standing (left to right): Vice-President—Gary Gardner, of Porter Coatings Div.; Treasurer—Kirk Menefee, of Hy-Klas Paint Co.; and Secretary—Phil Harbaugh, of Reliance Universal, Inc.

Nick Roman, of Rohm and Haas Co., spoke on "THERMOSETTING AQUEOUS INDUSTRIAL COATINGS."

Mr. Roman indicated that three basic types of resins were used in aqueous baking finishes — water-soluble or reducible, colloidal dispersions, and emulsions. He also said that either monomeric or polymeric melamine resins are generally used to crosslink all three types. Mr. Roman then outlined some typical application problems and their solutions as follows: Blistering — limit dry film thickness and increase flash-off time; Cratering — check for contamination and foaming; Frosting — may be due to excess acid catalyst; and Orange peel of sagging — adjust solvent for slower or faster evaporation.

MARVIN J. SCHNALL, *Secretary*

Pacific Northwest, Vancouver Section — Mar. 22

John Bax, of Scott-Bader, spoke on "NEW DEVELOPMENTS IN THE FIELD OF GLOSS EMULSION PAINTS."

R.P. STEWART, *Secretary*

Piedmont — Mar. 21

Jack Simpson, of Ashland Chemicals, spoke on "HANDLING AND STORAGE OF FLAMMABLE LIQUIDS."

W.H. CUNANE, *Secretary*

Piedmont — April 18

Among honored guests in attendance were Elder C. Larson, Federation President-Elect, and Frank J. Borrelle, Federation Executive Vice-President.

Mr. Larson's presentation highlighted the autonomous nature of each Society.

Mr. Borrelle used a slide presentation to illustrate Federation activities, budget, and educational programs.

W.J. CUNANE, *Secretary*

Pittsburgh — April 2

George Larson, of Georgia Kaolin Co., spoke on "PARTICLE SIZE, SHAPE, AND EFFECT ON WATER-BASED COATINGS."

Mr. Larson described the basic structure of clay minerals as any layered silica material. He said that in waterborne coatings the larger particle clays lose water faster than fine particle clays. For best hide with titanium dioxide, the finer particle size clay should be used, and for best scrubability, the calcined clays should be used, he concluded.

RAY UHLIG, *Secretary*

Toronto — April 10

Among honored guests in attendance were Elder C. Larson, Federation President-Elect, and Frank J. Borrelle, Federation Executive Vice-President.

The Manufacturing Committee showed their recently completed slide/tape presentation, "Introduction to a Resin Operation," which was then given to Mr. Borrelle in order for the Federation to make it available to other Societies and members.

ALUN G. MORRIS, *Secretary*

Officers of the Pittsburgh Society for 1978-1979. (left to right): Society Representative—Gerald B. Ward, of Royston Laboratories; Secretary—Raymond C. Uhlig, of Technical Coatings Co.; President—John S. Dahl, of J.H. Matthews Co.; Treasurer—Richard A. Trudel, of Mobil Chemical Co.; and Vice-President—Robert T. Marcus, of PPG Industries, Inc.

Elections

CHICAGO

Active

Abacan, Crispin D. — Coughlin Mfg. Co., Frankfort, Ill.
Achurra, Reynaldo J. — Premier Paint & Varnish Co., Inc., Elk Grove Village, Ill.
Adams, Lon — DeSoto, Inc., Des Plaines, Ill.
Austin, Jay — Halox Pigments, Hammond, Ind.
Behrman, William S. — Pioneer Paint Products, Melrose Park, Ill.
Caprell, William T. — General Paint & Chemical Co., Cary, Ill.
Czizco, Raymond J. — Glidden Coatings & Resins Div., Chicago, Ill.
Dade, Ronald J. — Sherwin-Williams Co., Chicago.
De Young, Duane D. — Premier Paint & Varnish Co., Elk Grove Village, Ill.
Goldblatt, Philip H. — PRA Laboratories, Inc., Chicago.
Heisner, Neil W. — Hammond Lead Products, Hammond.
Hollinger, Ronald — The Richardson Co., Melrose Park.
Kwong, Gary W.Y. — DeSoto, Inc., Des Plaines.
Licht, David L. — Testor Corp., Rockford, Ill.
Ulmer, Robert W. — DeSoto, Inc., Des Plaines.
Urs, Bhaskar — Hench Industries, Gurnee, Ill.
VanBenthuysen, Dan — Valspar Corp., Rockford.
Westerhoff, Terry L. — Sherwin-Williams Co., Chicago.

Associate

Fischer, Elias — Stepan Chemical Co., Northfield, Ill.

CLEVELAND

Active

Anikienko, George — Glidden Div., SCM Corp., Cleveland, Ohio.
Dubey, Girish C. — Cambridge Coatings, Cleveland.
Graham, Robert A. — Sprayon Products, Inc., Bedford Heights, Ohio.
Mining, Paul H. — Harshaw Chemical Co., Cleveland.
Moncrief, De Villa — Sherwin-Williams Co., Cleveland.

Associate

Patterson, Alan — Hughson Chemicals Co., Erie, Pa.

Educator/Student

Rogers, Charles E. — Case Western Reserve University, Cleveland, Ohio.

GOLDEN GATE

Active

Arnhold, Bruce — Dysan Corp., Santa Clara, Calif.
Hinds, Tom — Duncan Enterprises, Fresno, Calif.
Huy, Anton — Glidden Coatings & Resins Group, San Francisco, Calif.

Associate

Bustillos, Richard M. — Union Carbide Corp., San Francisco, Calif.
Cochran, Jr., W. Wayne — Tenneco Chemicals, Inc., Pleasanton, Calif.
Fults, Richard N. — Frank D. Davis Co., Oakland, Calif.
Pompeo, B.P. — American Cyanamid Co., Los Angeles, Calif.
Wendt, W.A. — Scholle Corp., Compton, Calif.

HOUSTON

Active

Dunn, James R. — Gulf States Paint Co., Houston, Tex.

MEXICO

Active

Martinez M., Bernardo — Pints. Pittsburgh S.A., Mexico D.F., Mexico.
Rivera G., Raul — Pints. Pittsburgh S.A., Mexico D.F.

NEW ENGLAND

Active

Edelstein, Joel J. — K.J. Quinn Co., Inc., Malden, Mass.

Associate

Canty, Francis P. — George Mann & Co., Stoneham, Mass.
Hansen, Jr., Edwin B. — Cabot Corp., Boston, Mass.
Krzynowek, Ted — Polyvinyl Chemical, Inc., Wilmington, Mass.

Retired

Hahn, Frank J. — Monsanto, Wilbraham, Mass.

NEW YORK

Active

Baird, Edward — International Paint Co., Inc., Union, N.J.
Bobb, Ronald E. — Lehman Bros. Corp., Jersey City, N.J.
Bruce, David O. — Union Ink Co., Inc., Ridgefield, N.J.
Crowley, Steven D. — Technical Coatings Co., Nutley, N.J.
Goldberg, Paul I. — Benjamin Moore & Co., Newark, N.J.
Lefkovic, L. Z. — Seal Rite Paint Corp., Brooklyn, N.Y.
Lehman, Peter L. — Pyramid Paint Products, Inc., Brooklyn, N.Y.
Lehnert, Garry A. — Benjamin Moore & Co., Newark.
Loncke, Vincent F. — Polymer Research Corp. of America, Brooklyn.
Magdits, Frank M. — Benjamin Moore & Co., Newark.
Meyer, Victor B. — Cellomer Corp., Newark, N.J.
Mullick, Muhammad Ilyas — Atlas Coating Chemical Corp., L.I.C., Jamaica, N.Y.
Oliveri, Michael R. — Technical Coatings Co., Nutley.
O'Malley, Thomas F. — Polychrome Corp., Clark, N.J.
Schroeder, Robert W. — Darworth-EB Industries, Avon, Conn.
Seymour, Dr. John P. — CIBA-GEIGY, Ardsley, N.Y.
Shah, Subhash V. — Maas & Waldstein Co., Newark.
Siegmund, Robert F. — CIBA-GEIGY Corp., Ardsley.
Super, Gary W. — Randolph Products Co., Inc., Carlstadt, N.J.
Vozza Judith L. — Red Devil Paints & Chemicals, Mount Vernon, N.Y.
Woodhull, Roger — Hempel's Marine Paints, Inc., Wallington, N.J.
Wright, Wayne E. — Union Ink Co., Ridgefield, N.J.

NORTHWESTERN

Active

Bell, Icy Jean — H B Fuller Co., Fridley, Minn.
Dauderman, Chuck — Valspar Corp., Minneapolis, Minn.
Eriksen, Robert J. — Viking Paints, Inc., Richfield, Minn.
Jones, Frank N. — Cargill, Inc., Minneapolis, Minn.
Keplinger, Orin — Valspar Corp., Minneapolis.
Murphy, Jr., George R. — Applied Texture, Inc., Minneapolis.
Stinn, Sarah E. — H B Fuller Co., Minneapolis.

Associate

Burkhard, D. Richard — Tenneco Chemicals, Inc., Chicago, Ill.
Frede, David J. — Wisconsin Solvents, Burnsville, Minn.
Jacoby, William A. — Coatings Consultant, Hager City, Wis.

Little, C. Fred — Graco, Inc., Minneapolis, Minn.
Stuhlfaut, Willard C. — Union Chemicals Div., Minneapolis, Minn.

Educator and Student

Chiew-Wah, Koay — North Dakota State University, Fargo, N.D.
Kuang-Jong, Wu T. — North Dakota State University, Fargo
Nelson, Greg M. — North Dakota State University, Fargo.

PACIFIC NORTHWEST

Active

Weil, Ronald A. — Weil Coatings, Inc., Bellevue, Wash.

Associate

Ainslie, James F. — ESSO Chemical Canada, Vancouver, B.C.
Doan, Garry — Kingsley & Keith (Can) Ltd., Vancouver.
Edwards, Terry — Nacan Products Ltd., Surry, B.C.

PHILADELPHIA

Active

Tozer, Robert — Clement Coverall Co., Camden, N.J.
White, Edward W. — McCloskey Varnish Co., Philadelphia, Pa.

PIEDMONT

Active

Shapiro, Ira Jene — Prillaman Co., Martinsville, Va.

Associate

Gravett, John — Ashland Chemical Co., Greensboro, N.C.
Kavalek, Richard J. — Diamond Shamrock Corp., Greensboro.
Taylor, Wayne C. — Ashland Chemical Co., Charlotte, N.C.
Whittaker, Wayne M. — Moreland McKesson, Greensboro.

PITTSBURGH

Active

Craun, Gary P. — Calgon, Pittsburgh, Pa.
Eritano, Ronald G. — Mobay Chemical Corp., Pittsburgh.
Fletcher, Peter W. — PPG Industries, Inc., Allison Park, Pa.
Gregg, David E. — St. Joe Zinc Co., Monaca, Pa.
Schwartz, Ralph — PPG Industries, Inc., Springdale, Pa.
Sylvester, Robert A. — Mobay Chemical Corp., Pittsburgh.

Associate

Oehl, Daniel J. — Mobay Chemical Corp., Pittsburgh, Pa.

Educator/Student

Granata, Richard D. — Carnegie-Mellon University, Pittsburgh, Pa.

ROCKY MOUNTAIN

Active

Ciocchetti, Denis — Komac Paint Co., Denver, Colo.
Fuge, Peter K. — Diamond Vogel Paint Co., Longmont, Colo.
Henry, Richard P. — Coatings Bench Report, Steamboat Springs, Colo.

Associate

Whitworth, Don Q. — E.I. DuPont de Nemours & Co., Inc. Littleton, Colo.

ST. LOUIS

Active

Carroll, John E. — Rainbow Paint Co., Inc., Springfield, Mo.
Jarboe, Rodney D. — Futura Coatings, Inc., St. Louis, Mo.
Melchior, William — Banner Paint, St. Louis, Mo.
Owen, Dennis R. — Carboline Corp., St. Louis.
Soboleski, Jr., Stan F. — Grow Chemical Corp., St. Louis.
Zanardi, A.E. — Grow Chemical Corp., U.S. Paint Div., St. Louis.

Associate

McDerby, Jr., James N. — Mobay Chemical Corp., St. Louis, Mo.

WESTERN NEW YORK

Active

Benton, Richard M. — Spencer Kellogg Div., Textron, Inc., Buffalo, N.Y.
Hallissy, Robert P. — Union Carbide Corp., Niagara Falls, N.Y.
Hong, Richard K. — Spencer Kellogg Div., Textron, Inc., Buffalo.
Hudak, Stephen F. — Spencer Kellogg Div., Textron, Inc., Buffalo.
Kowalski, John B. — Spencer Kellogg Div., Textron, Inc., Buffalo.
Martin, Brian — Hughson Chemicals, Fairview, Pa.
Mohar, Arnulf F. — Spencer Kellogg Div., Textron, Inc., Buffalo.
Norby, David B. — Spencer Kellogg Div., Textron, Inc., Buffalo.
Price, Robert N. — Spencer Kellogg Div., Textron, Inc., Buffalo.
Russell, H. William — Bisonite Co., Inc., Buffalo.
Wolinski, Leon E. — Pierce & Stevens Chem. Corp., Buffalo.

Associate

Jordan, Dennis P. — L.V. Lomas Chemical Co., Buffalo, N.Y.

Technical Articles in Other Publications

Compiled by the Technical Information Systems Committee—H. Skowronska, Chairman

Australian O.C.C.A. Proceedings and News

Published by Oil and Colour Chemists' Association Austrialia, ℅ D.S. Myles, 44 Beaver Street, Malvern East, Victoria 3145.

Vol. 16 No. 1-2 Jan.-Feb. 1979

Simpson, L.A.—"Microwave Excited Oxygen Etching of Pigmented Coatings;" 5-10.

Deutsche Farben-Zeitschrift (Defazet)
(in German)

Published by Elvira Moeller GmbH, Karl-Benz-Strasse 11, Postfach 11 68, 7024 Filderstadt 1

Vol. 33 No. 1 January 1979

Sonntag, M., Riberi, B., and Slawyk, W.—"Studies of Polyurethane-Based Shop Primers;" 2-7.
Koth, D. and Ferch, H.—"Measuring of Reflectance of Synthetic Silicas;" 8-12.
Schwindt, R.—"A New Method to Characterize the Durability of Titanium Dioxide Pigmented Coatings;" 13-16.
Ledwoch, K-D.—"Coatings Exposed to Radiation in Nuclear Power Units;" 17-20.

Journal of the Oil and Colour Chemists' Association

Published by Oil and Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex, HAO 2 SF England

Vol. 61 No. 11 November 1978

Carr, W. - "Theory and Practice of Pigment Dispersion;" 397 - 410.
Callaghan, B.G. - "Corrosion and Protection of Metals in the Building and Construction Industries;" 411-418.
Vetere, V., Rozados, E., and Carbonari, R. - "Measurement of Conductivity, Capacity, Electrical Resistance and Permeability of Paint Films in an Aqueous Solution;" 419-426.
Guruswamy, S. - "Electrical Resistance of Electrodeposited Rubber Per Unit Coulomb;" 427-430.

Paint Manufacture

Published by Wheatland Journals Ltd., 157 Hagden Lane, Watford WD1 8 LW, U.K.

Vol. 48 No. 3 April 1978

Ellinger, M.L. - "R & D Report: Anti-Corrosion Paints" (literature review); 13, 14, 16, 17.
Boxall, J. - "History of Paint Technology. Part 1: Pre-18th Century;" 18, 20, 22.
Walton, A.J. - "Interaction in Non-Aqueous Paint Systems. Part 1: Pigments" (literature review); 29-32.

Vol. 48 No. 4 May 1978

Walton, A.J. - "Interaction in Non-Aqueous Paint Systems. Part 2: Solvent - Binder Relations" (literature review); 13-14.

Vol. 48 No. 5 June 1978

Walton, A.J. - "Interaction in Non-Aqueous Paint Systems. Part 3: Dispersion Process;" 15, 16, 18, 19, 22.
Boxall, J. - "History of Paint Technology. Part 2: 18th Century to Mid-19th Century;" 23, 24, 34.
Ahmed, H. and Yaseen, M. - "Evaluation of Solubility Parameters of Halogenated Polymers by a Group Contribution Technique" (19 refs); 28, 30.

Farbe und Lack
(in German)

Published by Curt R. Vincentz Verlag, Schiffgraben 41-43, 3000 Hannover 1, Postfach 62 47, Germany

Vol. 85 No. 2 February 1979

Anon. - "Rising Prices for Paints;" 93.
Haagen, H. - "About Causes and Relations of Shrinkage with Internal Tensions in Coatings;" 94-100.
Dittrich, H.K. - "Adjustment of Specific PVC Values with Secondary Pigments. Extremely Shifted Specific Weights of Pigmentation;" 100-102.
Kockott, D. - "Technical Possibilities Regarding Accelerated Testing of Weathering;" 102-106.
Bruss, H.K. - "Production Processes Involving Manufacture of Paint Raw Materials. Progress in Rheological Control;" 107-111.
Brushwell, W. - "Ecological Problems in the Paint Industry" (literature review); 111-113.
German Standard Draft DIN 55 987: Testing of Pigments; Determination of a Hiding Power Value of Pigmented Media; Colourimetric Method; 118-120.

Vol. 85 March 1979

Schwegmann, B.—"Possibilities of Stock-keeping in the Paint Industry;" 163-164.
Möhler, H. and Lohr, R.—"Isocyanate-Cured Polyesters With and Without Accelerators. Thermoanalytical Determinations;" 165-171.
Lotz, U.—"Quantitative Determination of Monomeric Isocyanate. Assessment in Liquid Polyurethane Glues and Lacquers by Means of Gelpermeation Chromatography;" 172-175.
Schulz, R.C.—"Reactive Polymers—Possibilities and Limits;" 175-179.
Meyer, W. and Schwenk, W.—"Causes of Blisters on Coated Steel in Aqueous Medium;" 178-182.
Brushwell, W.—"Economic and Ecologic Influences on Paint Technology;" 183-186.
German Standard Draft DIN 53 217 Part 1: Testing of Paints, Varnishes and Similar Coating Materials; Determination of Density; General—194.
German Standard Draft DIN 53 217 Part 2: Testing of Paints, Varnishes and Similar Coating Materials; Determination of Density; Pyknometer Method—195.
German Standard Draft DIN 55 951: Binders for Paint and Varnishes; Test Methods for Resins—199.

Polymer Preprints

Papers presented before Division of Polymer Chemistry at the Joint American Chemical Society / Japanese Chemical Society Honolulu Meeting

Vol. 20 No. 1 April 1979

New Polymers, New Processes (24 papers).
Structure/Properties Relationship of Solid Polymers (18 papers).
Polymeric Materials and Pharmaceuticals for Biomedical Use (24 papers).
Photo- and Radiation Chemistry in Polymer Science (19 papers).
Surface Chemistry in Biology and Medicine: Molecular Association and Biometics Catalysis (4 papers).
Special Topics in Polymer Chemistry (203 papers).
For information regarding price and availability of Polymer Preprints, contact R. Saxon, P.O. Box 415, Bound Brook, N.J. 08805 (201-356-2000, ext. 3523).

Industrial & Engineering Chemistry - Product Research & Development

Published by American Chemical Society, 1155 - 16th Street NW, Washington, D.C. 20036

Vol. 17 No. 4 December 1978

Seiner, J.A. - "Microvoids as Pigments - A Review;" 302-317.

Pierce, P.E., Kovac, Z., and Higginbottom, C. - "Kinetics and Mechanism of Film Growth During Electrodeposition Process;" 317-322.

Vol. 18 No. 1 March 1979

Devay, J., Meszaros, L., and Janaszik, F. - "Electrochemical Techniques to Monitor Performance of Polymer Coatings in Corrosion Protection;" 13-18.

Allen, C.W. and Du Pont, J.G. - "Novel Propenylfluorophosphazene - Styrene Copolymers;" 80-81.

Progress in Organic Coatings

Published by Elsevier Sequoia, S.A., Lausanne, Switzerland

Vol. 7 No. 1 1979

Schenk, H.U., Spoor, H., and Marx, M. - "Chemistry of Binders for Electrodeposition;" 1-77.

Leidheiser, H., Jr. - "Electrical and Electrochemical Measurements as Predictors of Corrosion at the Metal - Organic Coating Interface;" 79-104.

Frisch, H.L. and Frisch, K.C. - "Polyurethane - Epoxy Interpenetrating Polymer Networks - Barrier and Surface Properties;" 105-111.

Pigment & Resin Technology

Published by Sawell Publications Ltd., 127 Stanswell Road, London SE23 1 JE

Vol. 7 No. 9 September 1978

Chandra, S. and Jindal, D.K. - "Polycarbonate Modified Alkyds;" 4-9.

Coatings Update: Chlorinated Rubber Technology (literature review); 10-12.

New and Revised British Standards (covering pigments, paint testing, and paint flow cups); 13.

Zirconium Compounds in Paint; 15.

Vol. 7 No. 10 October 1978

Zeller, R.C. - "Colour Measurements in the Iron Oxide Pigments Industry;" 4-9. (First published in November 1977 issue of JOURNAL OF COATINGS TECHNOLOGY.

Joshi, S.K. and Chatterjee, P.C. - "Emulsion Polymerisation of Linseed and Safflower Vinyl Esters;" 9.

Coatings update: General Reviews (literature review); 12-14.

Nitidandhaprabhas, O. - "A Tung Oil Substitute for Printing Ink;" 17

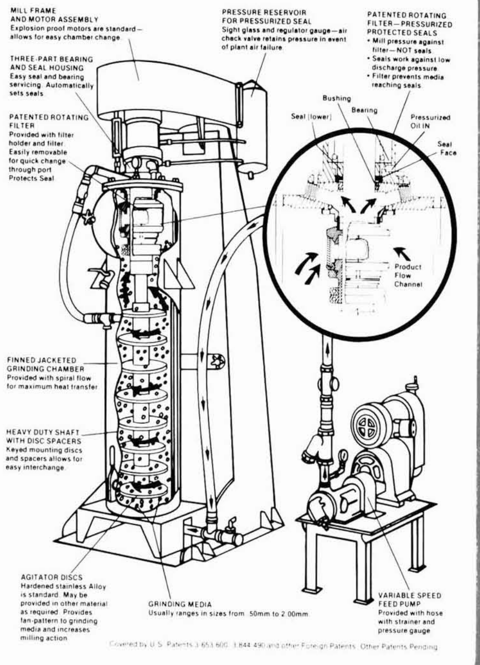
Vol. 7 No. 11 November 1978

Hutchinson, G.H. - "Progress in Water-Based Printing Inks;" 4-14.

Smith, E.A. - "Vibration Ball Mills: Have They a Place in Pigment and Resin Technology?;" 15-17.

Tschudy, R. - "Meeting the Requirements of Modern Mixer Technology;" 18-20.

Mixers, Dispersers and Strainers: A Look at some New Equipment; 21-22.



PNW Society Hosts Over 300 at Annual Symposium

An attendance of just over 300 participated in the 32nd Annual Symposium of the Pacific Northwest Society for Coatings Technology, held in Vancouver, B.C., May 3-5.

The technical program was comprised of the following presentations:

"Rheology and the Correct Use of Rheological Additives"—J.W. Joudrey, of NL Industries, Inc.

"Chlorite—a New Concept in Extender Pigments"—B. Meadows, of Cyprus Industrial Minerals Co.

"Formulating to C.A.R.B. Type Regulations"—N. Estrada, of Reichhold Chemicals, Inc.

"Properties and Technical Advantages of Micronized Iron Oxide Pigments"—Dr. R.H. Odenthal, of Mobay Chemical Corp.

"Influence of Titanium Dioxide Pigments on Flow and Levelling of Gloss Latex Paints"—D. Cook, of Tioxide Canada, Ltd.

"Latex Interior Gloss Paints - an Update"—A.C. Boyce, of Nacan Products Ltd.

"A New Environmental Approach to Trade Sales Wood Finishes"—R.C. Vasishth, of Flecto Co.

"Epoxy Finishes - a Review of Present Day Finishes"—A. Whittall, of Shell Canada Ltd.

Speakers at the business session were James A. McCormick, President, and Frank J. Borrelle, Executive Vice-President, of the Federation.

Also at the business session, PNW Society President, Mike Griffin, and Golden Gate Society President, Ken Probst, presented $450 and $540 checks, respectively, to Mr. McCormick for the Paint Research Institute.

Officers for 1979-80 will be: President—Walter Clyde, of Glidden Coatings and Resins Div.; President-Elect—Curt Bailey, of Jarvie Paint Co.; Secretary—Dick Stewart, of Stainco Prestainers Ltd.; Treasurer—Robert Miller, of Imperial Paint Co.; and Society Representative—John A.J. Filchak, of the General Services Administration.

The annual athletic competition between the Vancouver, Portland, and Seattle Sections of the Society was a rowing regatta in the Society's private canal in back of the Bayshore Inn. A torrential downpour forced the cancellation of the event. The judges declared a draw.

Members of the Symposium Committee were: Dick Stewart, Chairman, Art Bragg, Lorne Brown, Dave Cook, Mike Griffin, Fred Grimmett, Ted Jefferys, Barry Lamb, Bob Nickells, Deryk Pawsey, John Physick, Bob Pinfield, and Jim Stewart.

The 1980 Symposium is scheduled for the Marriott Hotel in Portland, Ore., May 1-3.

Trustees of the Paint Research Institute, 1978-79. Left to right: Dr. Roy W. Tess, of Shell Chemical Co.; Royal A. Brown, of National Paint and Coatings Association; Secretary Charles Kumins, of Tremco Mfg. Co.; Peter V. Robinson, of Glidden Coatings & Resins Div.; Treasurer William H. Ellis, of Chevron research Co.; Dr. Philip Heiberger, of the duPont Co.; Marco Wismer, of PPG Industries, Inc.; Dr. Raymond R. Myers, Research Director of PRI from Kent State University; Leonard C. Afremow (partly hidden), of DeSoto, Inc.; John Weinmann, of Reichhold Chemicals, Inc.; and President Orin C. Keplinger, of Valspar Corp. Also, Elder C. Larson, President-Elect of the Federation

Polymer Science Scholarship At USM Founded by Interstab

To promote study and excellence in polymer science, a new undergraduate scholarship in that field has been established at the University of Southern Mississippi at Hattiesburg by Interstab Chemicals, Inc., of New Brunswick, N.J.

The $300 annual scholarship will be presented this fall to a full-time polymer science undergraduate who must make a 2.75 grade point average overall and in any given semester to maintain the award.

"The Department of Polymer Science at the University of Southern Mississippi has gained worldwide recognition for its academic programs in coatings and polymer science and, accordingly, USM was a logical recipient for Interstab's scholarship contribution," declared Harley R. McNair, marketing director for Interstab.

Dr. S. George Bufkin, Chairman of the Department of Polymer Science, said emphasis is on career training by preparing students for the plastics, fibers, elastomers or coatings industries. The 71 polymer science majors of the past semester were given a comprehensive theoretical and applied background relative to the entire polymer industry.

Mr. McNair presented the check establishing the scholarship to Dr. Bufkin and Dr. Gary Wildman, dean of the College of Science and Technology, at the recent Sixth Annual Water-Borne and Higher-Solids Coatings Symposium at New Orleans.

SLF to Celebrate 25th Year at Ninth Congress, Oct. 15-17

The Ninth Congress of the Federation of Scandinavian Paint and Varnish Technologists, noting the 25th anniversary of the Federation, will be held in Stockholm, Sweden, October 15-17.

Hotel accommodations will be available at the Amaranten, Birger Jarl, and Sjofartshotellet Hotels.

The following papers will be featured on the technical program:

"Unintended Chemical Reactions in Coatings"—C. Christensen, of Sadolin & Holmblad A/S, Denmark.

"Macromolecular Dyes. Oligomeric and Unsaturated Dyes for UV Curing"—Prof. E. Marechal, of Universite Pierre et Marie Curie, France. (Official FATIPEC Lecture).

"Color Measurement as a Tool in Production Control"—S. Rosenlof, of Tikkurilan Varitehtaat Oy, Finland.

"Use of Amines to Inhibit Viscosity Decrease in Latex Paints Caused by the Presence of Oxidants and Reductants"—Dr. Harvey Winters, of Fairleigh Dickinson University, U.S.A. (Official FSCT Lecture).

"The Chemical Industry, in Front of New Challenges From Environment, Research, and Development"—Prof. T. Rafta, of Norges Handelshoyskole, Norway.

"Dispersion Stability in Pigmented Systems"—Dr. D.M. Varley, of Ciba-Geigy (UK) Ltd., England. (Official OCCA Lecture).

"Computer Process Control in the Production of Emulsion Polymers"—R. Feledy, of Alford & Cronholm, Sweden.

"Effluorescence and White Deposits on Paint Films"—F. Giese, of S. Dyrup & Co. A/S, Denmark.

"Gradient Formation in Films and Thermochemical Investigations"—Prof. L. Dulog, of Research Institute for Pigments and Paints, Germany.

"Solving Air Pollution Problems in the Manufacture and Use of Surface Coatings"—N.A.R. Falla, of the Paint Research Association, England.

"Moisture Movement in Painted Wood"—E. Nilsson and C. Hansen, of the Scandinavian Institute for Paint and Printing Ink Research, Denmark.

The program will also include sightseeing excursions, special receptions, and the banquet.

For registration information, write to: 9 SLF Congress, % AB Wilh. Becker, Fack S-102 70, Stockholm, Sweden.

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The President of the Scandinavian Federation is Borje Andersson, of AB Wilh. Becker.

The Federation of Societies for Coatings Technology will be represented at the Congress by President and Mrs. James A. McCormick.

British Journal Will Sponsor Resins and Pigments Exhibition In Copenhagen, November 7-8

The second "Resins and Pigments Exhibition" sponsored by *Polymers, Paint and Colour Journal*, Surrey, England, will be held at the Royal Hotel, Copenhagen, Denmark, on November 7-8, 1979.

The exhibitors (companies involved in the manufacture and supply of major raw materials for the coatings and ink industries) will show their products on free-standing display units in individual hotel rooms.

For further information, contact Mike McIntyre, International Symposia & Exhibitions Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, England.

People

Nicholas E. Lynam has been named to the newly created position of Vice-President, Manufacturing, for the Petrochemical Group, Union Chemicals Div., Union Oil Co., of Calif. In directing the group's six polymer and adhesive plants, he will maintain his headquarters in Schaumburg, Ill.

As a result of recent elections, **Donald K. Lutes, Sr.,** of the Sherwin-Williams Co., will assume the position of President of the National Coil Coaters Association. The NCCA Board of Directors has also named **A.R. McInnes,** of Pre Finish Metals, Inc., and **J.R. Pickering,** of Lilly Industrial Coatings, Inc., to the position of Vice-President. **John H. Geyer,** of Amchem Products, Inc., was re-elected Treasurer of the association.

The following have been appointed to serve as officers of the Board of Directors: **Thomas A. Fernley III,** Executive Director; **Jere D. Lawrence,** Executive Secretary; **Don White,** Marketing Services Director; and **Tony Carroll,** Associate, Marketing Services. All are with Fernley & Fernley, Inc.

In addition, the Board of Directors for the coming year will include: **L.E. Dwyer,** of Supracote, Inc.; **D.E. Cieslak,** of American Roller Co.; **J.S. Smith,** of Roll Coaster, Inc.; **R.R. Robertson,** of The Valspar-Conchemco Corp.; and **George M. Schlosser,** who will serve on the Management Staff of NCCA.

The Industrial Chemicals Div. of NL Industries has appointed **Thomas K. Mo** to the position of Market Manager, Coatings Chemicals. In this new position, he will be responsible for the commercial development of the division's business to the industrial paint, laminating resin, and ink market.

Roger Scriven has been promoted to the position of Senior Development Associate of the PPG Industries, Coatings and Resins Div., Research & Development Laboratory in Allison Park, Pa. He is a member of the Pittsburgh Society and the American Chemical Society.

Donald A. Wostratzky has joined the Additives Dept. of CIBA-GEIGY Corp. as a Technical Representative. He will be responsible for the nationwide marketing of the firm's light stabilizers, anti-oxidants, and photocuring agents.

N.E. Lyman

D.K. Lutes

C.M. Scholle

V.J. Talamini

Carroll Scholle, Past-President of the Federation of Societies for Coatings Technology, has announced his retirement from the Sherwin-Williams Co. Prior to his association with this company, he was employed by Jewel Paint & Varnish Co., Chicago. In his 42 years of involvement with the coatings industry, Mr. Scholle's technical, educational, and organizational contributions have included service on nearly every committee and all elected offices of the Chicago Society for Coatings Technology. He was the recipient of the Society's Outstanding Service Award in 1963. Mr. Scholle now serves on the Memorial Committee of the Chicago Society.

Urbano Moreno has been appointed to the position of Technical Director of Venezolana de Pinturas, C.A. in Valencia, Venezuela.

For the past 10 years Moreno has been active at the Sherwin-Williams International Coatings Operation, in the position of director of technical services and manufacturing and laboratory coordinator for Mexico, Central/South America and the Caribbean Region.

He is a member of the Federation of Scoeities for Coatings Technology and the National Association of Corrosion Engineers.

Witco Chemical Corp. has appointed **Donald H. Marone** Divisional Vice-President—Eastern Regional Sales for its Organics Div.

Atlanta Solvents & Chemical Co. has appointed **William J. Cochran III** as Technical Sales Representative. Mr. Cochran is a member of the Southern Society for Coatings Technology.

Hockmeyer Equipment Corp., Harrison, N.J., has promoted **Victor J. Talamini** to the position of Manager of the Engineering Dept.

Rohm and Haas Co. has appointed **Bobby C. Osborne** a Technical Representative in the Western district for its Polymers, Resins & Monomers business team.

Meanwhile, **Alan R. Hatter** has been transferred from the Ohio district to the company's home office. A member of the Pittsburgh Society for Coatings Technology, Mr. Hatter has been appointed Market Planning Manager, Trade Sales Coatings.

In recognition for his development of a "plastic pigment" for use in latex paint, **Dr. Alexander Ramig, Jr.,** has received an SCM Corporation Award for Scientific and Technical Achievement. Dr. Ramig, a scientist at the firm's Glidden Coatings & Research Center, is a member of the Cleveland Society for Coatings Technology.

In a series of appointments, Glidden Div. has named **Howard J. Horton** Director, Manufacturing; **James B. Hayes, Jr.,** Director, Quality Control and Process Engineer; and **Joseph C. Sherwood,** Coordinator, Environmental Affairs. Succeeding Mr. Sherwood as Quality Assurance Manager is **James A. Aloye, Jr.**

Meanwhile, joining the marketing staff of Glidden Pigments are: **William J. Brinton**—West Coast Regional Sales Manager for titanium dioxide, inorganic pigments, and fine particle silica; **Francis J. Clark**—Sales Representative for the Lousiana, Mississippi, Tennessee, and Alabama area; and **Patrick E. Pitner**—Sales Representative for the Chicago area.

Morris Coffino, Technical Vice-President of the D. H. Litter Co., Inc. was chosen as the 1979 recipient of the New York Society for Coatings Technology's PaVaC Award. This honor is bestowed on members of the Society "for their outstanding contributions to the advancement of the coatings industry and the New York Society."


M. Coffino

Mr. Coffino began his paint industry career in 1941 at the Basic Varnish and Research Corp., and joined D. H. Litter as a Development Chemist in 1952.

A member of the New York Society for 29 years, he is currently Chairman of the Scholarship Committee, and has previously served as Chairman of the Education, Program, and Finance Committees, as well as Technical Subcommittee 64. He has also served as a member of the Board of Directors, and was President of the Society in 1973. He is a 1960 recipient of the New York Society's Roy H. Kienle Award. Nationally, Mr. Coffino has served as Chairman of the Federation's A. F. Voss/APJ Awards Committee, Vice-Chairman of the Technical Advisory Committee, and is currently Chairman of the Program Committee for the 1979 Annual Meeting in St. Louis.

Dwight Cole has joined VIP West, Inc., Emeryville, Calif., as Sales Manager. Mr. Cole is a Past-President of the Golden Gate Society for Coatings Technology.

Richard F. Nording has joined the staff of Colony Paints as Chief Chemist in charge of the Los Angeles laboratory. Mr. Nording is a member of the Los Angeles Society for Coatings Technology.

Reichhold Chemicals, Inc., has appointed **Edwin B. Gienger** Senior Vice-President of Operations. Mr. Gienger will continue as Assistant to the Chief Executive Officer and will work closely with the president, regional managers, and financial officers of the company.

Charles F. Duff, of Precision Paint Corp., has been promoted to Vice-President of Sales and Marketing. Mr. Duff joined the company in 1977 and has over 27 years of experience in the paint coatings industry.

In a series of executive appointments, Spencer Kellogg, Div. of Textron, Inc., has named **Donald M. Krueger** Vice-President, Sales; **Paul E. Raimondo,** Vice-President and Controller; and **C. James O'Donnell,** Vice-President, Administration.

Melvin T. Vincent has been appointed Sales Manager of the Coating Raw Materials Div. of Kraft Chemical Co. Mr. Vincent, a member of the Chicago Society for Coatings Technology, will manage the paint, rubber, plastic and adhesive products in the Kraft Chemical line.

Gene Wagner has been named Marketing Manager of the Custom Finishes Div. of Deft Chemical Coatings, Irvine, Calif. Since 1971, Wagner has been involved in the application, sales, and distribution of all types of automotive finishes.

Norman T. Johnson has been named Senior Sales Representative for the Resins Div. of Henkel Corp. In his new position, he will be responsible for sales of the corporation's resins products line, and will be headquartered in Des Plaines, Ill.

Dr. Norman Sonntag, Technical Director for Southland Corp.'s Chemical Div., has been elected President of the American Oil Chemists' Society for 1979-80.

Other officers elected to serve in the coming year are: **Frank Naughton,** of NL Industries—Vice President; **Frank Luddy,** of Eastern Regional Research Center—Secretary; **T.H. Smouse,** of Ralston Purina Co.—Treasurer. The members of the AOCS Governing Board will be: **J.L. Beare-Rogers,** of the Dept. of Health and Welfare, Ottawa, Canada; **Erl Lowery,** of Proctor & Gamble Co.; and **L.D. McClung,** of CPC International.

Obituary

William H. Johnson, 70, retired President of The Hilton-Davis Chemical Co., a division of Sterling Drug, Inc., died of a heart attack on April 5, 1979. Mr. Johnson retired in 1975 following an association of 44 years with the company.

Literature

Alkyd Processing

A new, 28-page brochure comprised of alkyd processing ideas has been completed. This processing guide shows what equipment is needed, how to design alkyd formulations, step-by-step examples of processing actual resins, techniques for shortening process times, and trouble-shooting hints. To obtain a copy of Bulletin IP-65, write Amoco Chemicals Corp., Dept. JPAT, Mail Code 4102, P.O. Box 8640A, Chicago, Ill. 60680.

High Performance Resins

New data involving high performance resins in coatings applications have been published recently. Three individual bulletins, covering an amine-based epoxy resin, epoxy cresol novolacs, and an epoxy phenol movolac resin, describe viscosities, solubilities, and compatibilities with other resin systems. For more information write Resins Dept., CIBA-GEIGY Corp., Ardsley, N.Y. 10502.

Phenoxy Resins

A 20-page booklet which describes high molecular weight phenoxy resins, has been released. The brochure lists the typical physical properties and applications of Bakelite phenoxy resins — thermoplastics which exhibit many of the properties of thermosetting resins — for solution coatings. Copies of Booklet F-41521B are available from Union Carbide Corp., Coatings Materials, Dept. JLS, 270 Park Ave., New York, N.Y. 10017.

Wet Sieving Instrument

Information has been prepared which describes a newly developed wet sieving instrument. A copy of the literature can be obtained by writing Micromeritics Instrument Corp., 5680 Goshen Springs Rd., Norcross, Ga. 30093.

Liquid Chromatograph System

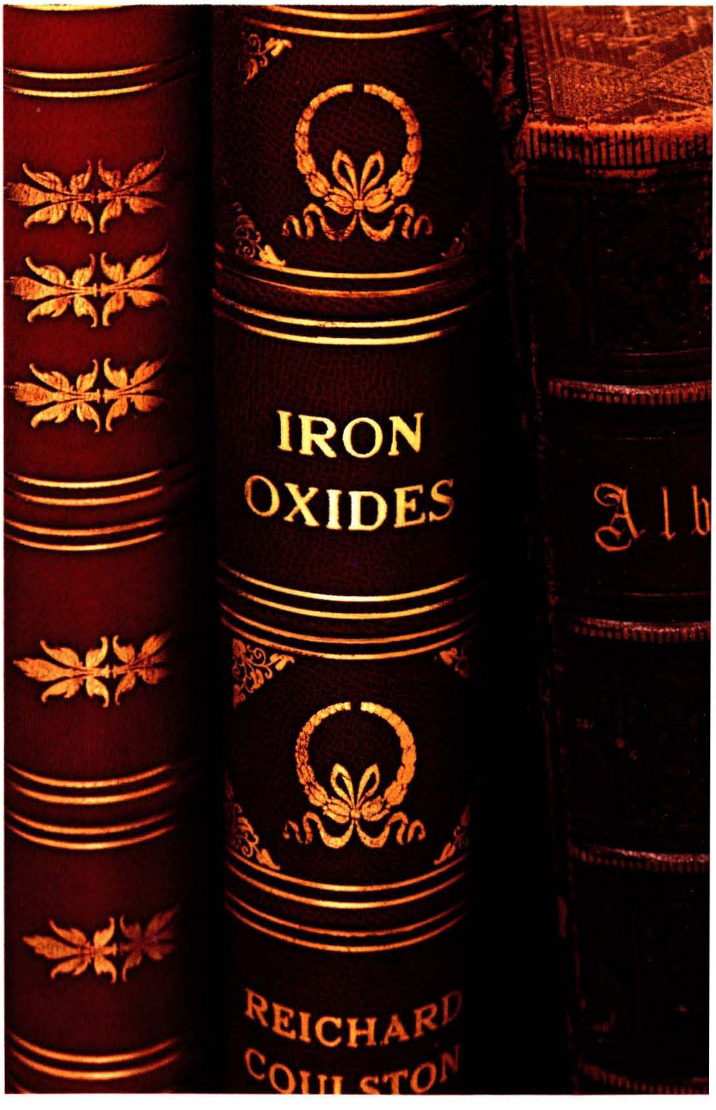
A new gradient liquid chromatograph system has been introduced in recent literature. This integrated system offers data reduction capability and increased system flexibility without additional cost. For this bulletin, write Micromeritics Instrument Corp., 5680 Goshem Springs Rd., Norcross, Ga. 30093.

Atomic Absorption Spectrophotometer

An atomic absorption spectrophotometer, developed for simplicity, performance, automation, speed, and flexibility has been detailed in a new 18-page, full-color brochure. For copies of this brochure, write Order No. L-566, Perkins-Elmer Corp., Instrument Div., Main Ave., Mail Station 12, Norwalk, Conn. 06856.

Solvent Property Chart

A new solvent property chart has been published. Listing properties for glycols, alcohols, ketones, amines, glycol ethers, esters and aliphatic, aromatic and chlorinated solvents, this chart also indicates those solvents exempt under Rule 66. For copies of Bulletin 1408, contact Ashland Chemical Co., Dept. SPC, Box 2219, Columbus, Ohio 43216.



Dry Film Tests

A data sheet explaining a method of testing for dry film coatings on sheet metal is now available. These tests include methods for evaluating the adhesion, porosity, flexibility, and ductility of any dry film coating over sheet metal through deformation of the substrate. For information, contact Frank Rueter, Zormco, Dept. B2, 8520 Garfield Blvd., Cleveland, Ohio 44125.

Carbon Black Guide

A new carbon black product guide has been published. In addition to providing basic definitive information, this guide includes discussions of the physical characteristics and rubber stress/strain properties of a complete line of furnace blacks for use in rubber applications. For copies, write Ashland Chemical Co., Dept. CB, Box 2219, Columbus, Ohio 4216.

Management Manual

A manual, designed to improve profitability and cash flow through inventory management in paint manufacturing companies, has been published. Focusing specifically on the paint industry, the manual is intended to help companies balance maximum customer service, minimum inventory investment, and efficient plant operations. To order a copy, contact the Management Information Div., National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

Low-Molecular-Weight Polyethylenes

Information is now available concerning the properties and many uses of low-molecular-weight polyethylenes and copolymers. First produced 25 years ago, recent developments of this product include its use as an additive to improve processability in plastics and as a key ingredient in a "strippable coating" to protect transportation equipment and buildings. To obtain literature, write Specialty Chemicals Div., Allied Chemical Corp., P.O. Box 1087R, Morristown, N.J. 07960.

Computer Program

A new computer program that can provide qualitative and quantitative information on the elements which contribute to changes in exposed pigmented materials has been published. Available to the general industry for the first time, the program characterizes changes in pigment color or vehicle color, changes in surface reflectance, as well as total change from the sum of all effects. Data requirements, an operational outline, technical papers, and the program can be obtained by writing to CIBA-GEIGY Corp., Saw Mill River Rd., Ardsley, N.Y. 10502.

Patent Information

Patents and their relation to the paint industry are discussed in a recently published survey. Included in this survey are the legal and business aspects of the subject, information from and about patents, and patents as indicators of economic trends. For additional information, contact Mrs. C. Veitch, Information Dept., Paint Research Association, Waldegrave Rd., Teddington, TW11 8LD, England.

Committee Activities

METRIC SYSTEM

U.S. Metrication Moving Slowly, While Canada Progresses

Events affecting the U.S. Paint Industry's conversion to the metric system have been slow moving of late, so, unfortunately, there is little to report. NPCA's Metric Task Force meeting last fall failed to resolve the issue of the physical dimensions of the four-liter and one-liter paint cans, although some progress was made toward a final decision. More surveys will be made and these results, hopefully, will be available for their spring meeting.

The Government Accounting Office has recently issued a voluminous antimetric report which, since metrication is inevitable, is a disservice to American industry. Any attempt to delay metric conversion will merely add to costs and prolong the disadvantage of working with nonmetric units and producing nonmetric goods in a metric world.

Quite the contrary in Canada where metrication is making good progress. The "square" (screw-top type) cans used for solvents are now metric and paint thinners are now sold metric. The Paint Industry will soft-convert at the end of 1979. Unfortunately, since the Canadian coatings industry wishes to adopt the same can dimensions as the U.S., hard conversion must await the standardization of U.S. cans.

In other Canadian business, the Printing Ink industry is completely converted and the Adhesives and Sealers industry is now largely metric. The latter industry side-stepped the issue of availability of metric cans by filling by weight. This will continue either permanently or until metric cans are available.

The Soap and Detergent industry provides a good example of how conversion can be used to reduce costs and achieve greater efficiency. By filling metric containers (hard metric conversion) by volume instead of by weight, they have reduced the number of package sizes needed. Also, new package sizes of different physical dimensions will not be needed if, in the future, new detergents with different bulking densities are introduced. A considerable savings—thanks to metric conversion!

Of great interest to the consumers is the recent change of gas pumps to metric which occurred this January and is progressing nicely. Oil is now sold by the liter and new car efficiency is now expressed in liters per 100 kilometers instead of miles per gallon. This is a better and more practical way of expressing efficiency since L/100km is a rapid and direct estimate of the cost of driving a certain distance. All of these changes were made without any major difficulties and the public is taking it in its stride. Who says metric conversion is difficult?

E.L. HUMBURGER, *Chairman*

Letters to the Editor

Reader Looks to Industry's Future

TO THE EDITOR:

At the recent Western Coatings Societies' Symposium in San Francisco, the panel on Government Regulations received some criticism, evidence of which is Mr. Gohman's letter in this space (see April JCT, p. 92—Ed.). That writer and the Dallas Society for Coatings Technology have been meeting these challenges for some time. One specific instance is the way they reacted to local media's highly exaggerated stories about lead poisoning among children in the Dallas area.

There are some things that must be said, however, about the way the coatings industry has been meeting the problems generated by EPA, CARB and the Clean Air Act of 1970 and 1977. It would be impossible to add up the hours, time, energy and money spent by industry members in this frustrating task. Some people like Frank Martin, Bob Minucciani, Barry Brodt, Gordon Rook and many others have wondered if they were spending as much time on their jobs as they spent in meetings, hearings and such. The smaller manufacturers have banded together and initiated a suit to call a halt to regulations that threaten their very livelihood. There has been a very close, productive cooperation between the Societies and the Associations in Los Angeles and the San Francisco areas and Larry Thomas and Ray Connor, of NPCA, spent almost as much time on the Pacific Coast as they did in Washington for over a year.

There were, and are, some real handicaps under which the work has been done. The make-up of CARB is not the way the California Legislature specified in the Health and Safety Act and the result is that unqualified non-technical persons had a major impact on regulations of a highly technical nature. This obstacle can be charged to the lack of watchfulness on the part of the California Senate, which had to ratify the appointments of members for the CARB.

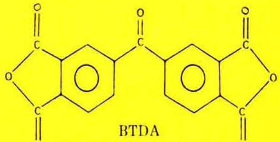
Because of a lack of technical knowledge in the leadership of CARB, there was a corresponding lack of experience in their staff as regards coatings. This has made it much more difficult to communicate effectively. It must be pointed out that the staff members, in general, desire to do a good job and they have spent much time learning about the coatings industry. This, too, has cost industry a lot of time and money because industry people have had to do the teaching in many long sessions.

One of the most serious handicaps, strange as it may seem, is industry itself. Our marketing and advertising people, in their enthusiasm, have printed literature that completely contradicts Mr. Gohman's statements about poor protection of wooden and metallic surfaces. CARB simply picked up literature in paint stores in California and asked industry if the printed statements were true or if the technical people's concerns were real. One or the other, obviously, had to be wrong. That was the most difficult point to handle. Look at any company's promotional stuff or go to a paint store where you are not known and ask the clerk or store manager how to paint something. You may be shocked by the reading material and advice you will get.

Well, enough of this, the past is only prologue and there is much to be done. As I see it, both regulations and economics are going to drive the coatings industry away from dependence on volatile organic solvents. I believe that we will have to depend more and more on really new, innovative ideas. Paint companies have a serious problem keeping up with the day-to-day problems of quality control, production maintenance and customer service. Little of their laboratory time can be spent on innovation. Raw materials manufacturers have to concentrate on their related areas of interest so the backlog of innovative ideas will, to a great extent, have to come from our Universities.

The five schools with coatings courses that receive scholarship money from the Federation and also from some member Societies, should be the springs from which innovative ideas will come. These Universities need some things from coatings people in responsible positions. First, we need the kind of scholarship support given through the Federation and the Societies. Second, we need summer jobs and work-study programs for students in our coatings courses. Third, we need help in recruiting high school and junior college students for our chemistry courses so we can help them become coatings scientists. Last, but not least, we need competent people from industry to help guide the programs in the Universities.

JOHN A GORDON, JR.
Chemistry Dept.
University of Missouri—Rolla
Rolla, Mo.



Book Review

POLYMER MOLECULAR WEIGHT METHODS

Edited by
Myer Ezrin
American Chemical Society
Washington, D.C.
1973 (350 pages)
$24.50

Reviewed by
John Wuepper
Whirlpool Corp.
Benton Harbor, Mich. 49022

A part of the American Chemical Society's Advances in Chemistry Series, this book is essentially a collection of papers from a joint Analytical and Polymer Symposium, held in 1971, which was entitled, "Recent Trends in the Determination of Molecular Weight." Twenty-six papers, each with references, and an index are included. While approximately one third of the papers deals with gel permeation chromatography topics, also included are less conventional topics such as self-beat spectroscopy, thin layer chromatography, mass chromatography and electrospray spectroscopy.

The editor emphasizes the importance of the exchange of ideas between those involved with areas of chemistry that employ similar methods. For example, papers dealing with molecular weights in biochemical, as well as polymer physical chemistry areas, are included. This book displays a diversity of subject within the general area of polymer molecular weights and thus, provides a well organized and interesting cross section of the field.

CLASSIFIED ADVERTISING

Coming Events

FEDERATION MEETINGS

(Oct. 2)—Federation Board of Directors Meeting. Sheraton St. Louis Hotel, St. Louis, Mo. (FSCT, Suite 832, 1315 Walnut St., Philadelphia, Pa. 19107).

(Oct. 3-5)—57th Annual Meeting and 44th Paint Industries' Show. St. Louis Convention Center, St. Louis, Mo. (FSCT, Suite 830, 1315 Walnut St., Philadelphia, Pa. 19107).

SPECIAL SOCIETY MEETINGS

(Sept. 19-20)—Montreal and Toronto Societies Joint Symposium. Toronto—19th; Montreal—20th.

1980

(Mar. 12-14)—Southern Society 44th Annual Meeting. Terrace Garden Inn, Atlanta, Ga.

(April 14-16)—Dallas and Houston Societies. Southwestern Paint Convention, Hilton Inn, Dallas, Tex.

(May 1-3)—Pacific Northwest Society Annual Symposium. Marriott Hotel, Portland, Ore.

OTHER ORGANIZATIONS

(Aug. 11-15)—"Corrosion Control by Organic Coatings," sponsored by National Association of Corrosion Engineers. Lehigh University, Bethlehem, Pa. (Prof. Henry Leidheiser, Jr., Sinclair Lab. #7, Lehigh University, Bethlehem, Pa. 18015).

(Aug. 26-31)—Short Course on "Advances in Emulsion Polymerization and Latex Technology." Davos, Switzerland. (Dr. Gary W. Poehlein, Director, School of Chemical Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332).

(Sept. 11)—National Paint and Coatings Association. Hazardous Waste Management Seminar. New York, N.Y. (Georgene Savickas, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

(Sept. 11-12)—Institute of Applied Technology, Mini Course, "Coating Inspection: Instruments and Practices." St. Louis, Mo. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(Sept. 23-26)—67th Canadian Paint Manufacturers Association Convention, sponsored by the Ontario Paint Association. Harbour Castle, Toronto, Ont. Canada. (R.E. Green, 1666 Aimco Blvd., Mississauga, Ont. L4W 1V4 Canada).

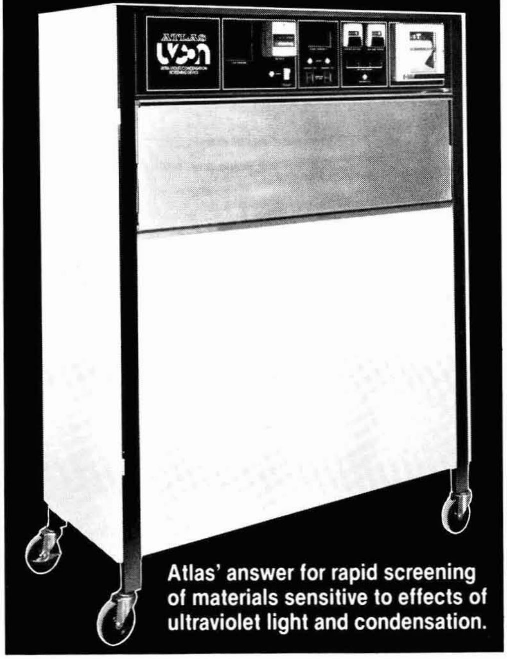
(Sept. 24-28)—Institute of Applied Technology, Training Course, "Painting and Coating for Industry." Honolulu, Hawaii. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(Sept. 24-28)—"Colloids and Surfaces." Carnegie-Mellon University. (Mrs. Gerry Cohen, Course Coordinator, Post College Professional Education, Carnegie Institute of Technology, Carnegie-Mellon University, Schenley Park, Pittsburgh, Pa. 15213).

(Sept. 25-27)—National Association of Corrosion Engineers Coatings Symposium. Ramada Inn, Niagara Falls, N.Y. (Robert Walpole, Walpole Associates, P.O. Box 622, Wellsville, N.Y. 14895.

(Sept. 27)—National Paint and Coatings Association. Hazardous Waste Management Seminar, Chicago, Ill. (Georgene Savickas, NPCA, 1500 Rhode Island Ave. N.W., Washington, D.C. 20005).

(Sept. 30-Oct. 2)—National Coil Coaters Association Fall Technical Meeting. Hyatt Regency O'Hare Hotel, Chicago, Ill.



Coming Events (Continued)

(Don White, National Coil Coaters Association, 1900 Arch St., Philadelphia, Pa. 19103).

(Oct. 10-12)—Fifth International Photopolymer Conference: Principles, Processes, and Materials, sponsored by the Mid-Hudson Section, Society of Plastics Engineers. Nevele Country Club, Ellenville, N.Y. (Dr. Maung Htoo, 10 Rabbit Trail Rd., Poughkeepsie, N.Y. 12603).

(Oct. 15-17)—9th Congress of the Federation of Scandinavian Paint and Varnish Technologists. Stockholm, Sweden.

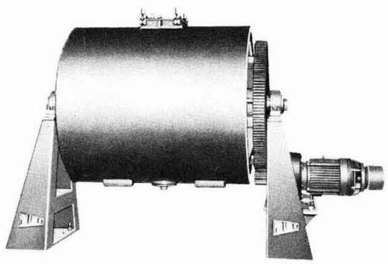
(Oct. 15-19)—Institute of Applied Technology, Training Course, "Marine Coating Procedures." Phila., Pa. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(Oct. 16-18)—Sixth Annual UMR-DNR Conference and Exposition on Energy. Conducted by the University of Missouri-Rolla and the Missouri Dept. of Natural Resources. (Dr. J. Derald Morgan, Conf. Dir., 108 Electrical Engineering Dept., University of Missouri—Rolla, Rolla, Mo. 65401).

(Oct. 23-25)—"Finishing '79," sponsored by the Association for Finishing Processes of SME. Convention Center, Cincinnati, Ohio. (Edward Cherryholmes, AFP/SME, One SME Dr., P.O. Box 930, Dearborn, Mich. 48128.

(Oct. 29-31)—National Paint and Coatings Association Annual Meeting. San Francisco Hilton Hotel, San Francisco, Calif. (Georgene Savickas, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Oct. 30-31)—Institute of Applied Technology, Mini Course, "Designing for Protective Coatings." Boston, Mass. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).



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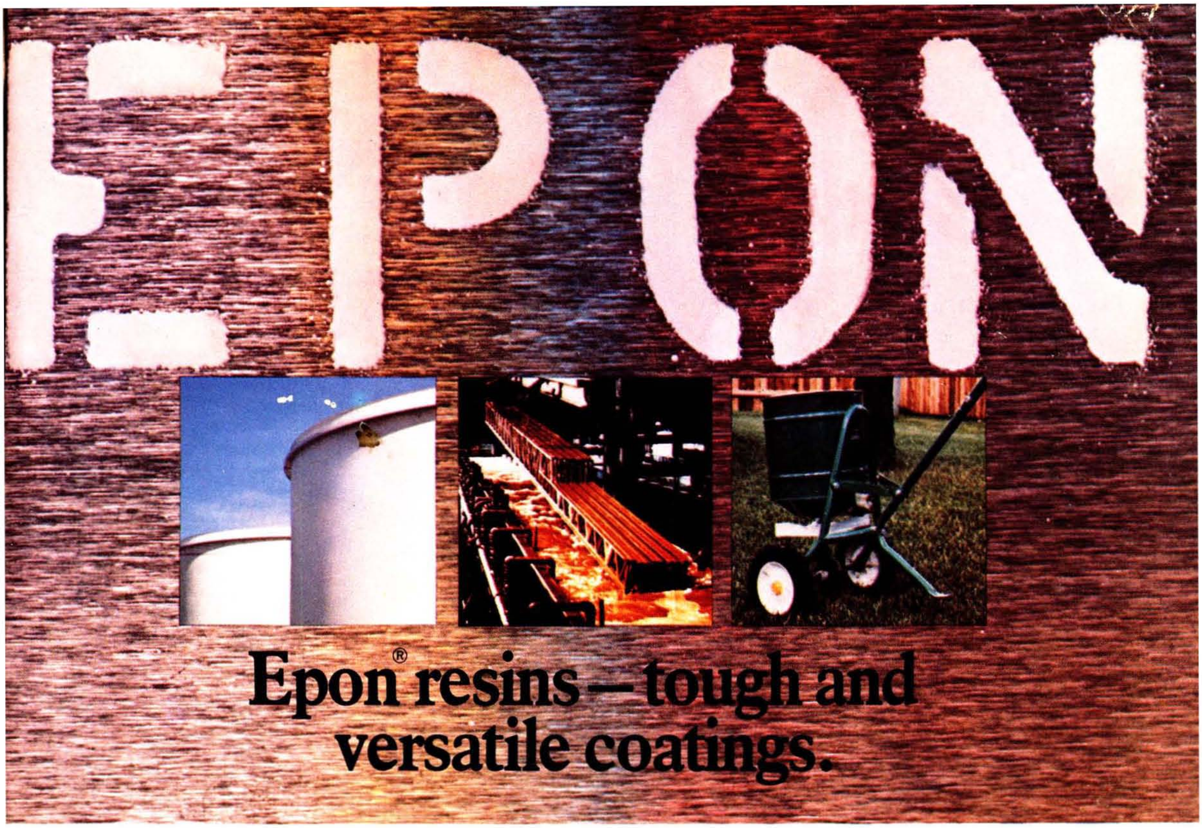
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