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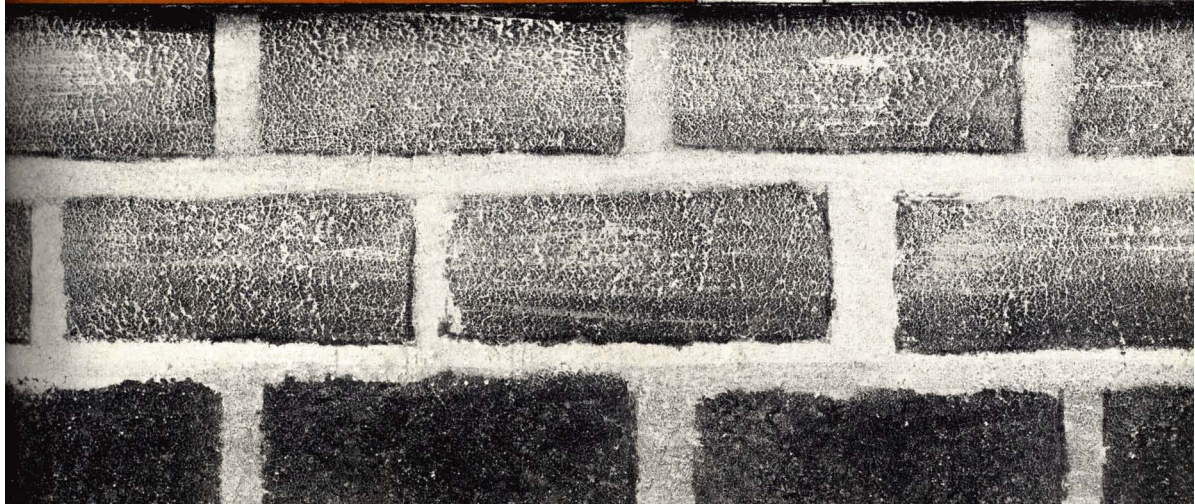


**JOURNAL OF
COATINGS
TECHNOLOGY**

Volume 49

Number 625

**Method for
Measuring
the Chalk
Adhesion
of Latex
Paints**



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276.0	38.15	Toluene
75.5	10.30	No. 100 Solvent ⁽²⁾
45.3	6.71	Butanol
45.3	6.67	Proprietary Ethanol
158.0	21.80	Butyl Acetate
753.6	100.00	

7.54 Lb./Gal.	17.00	% Nonvolatile
3:7 Ratio AROPLAZ 6201:CAB (solids basis)	26 secs	Approx. Viscosity #4 Ford Cup

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(2) Ashland Hi Sol 10 or equal

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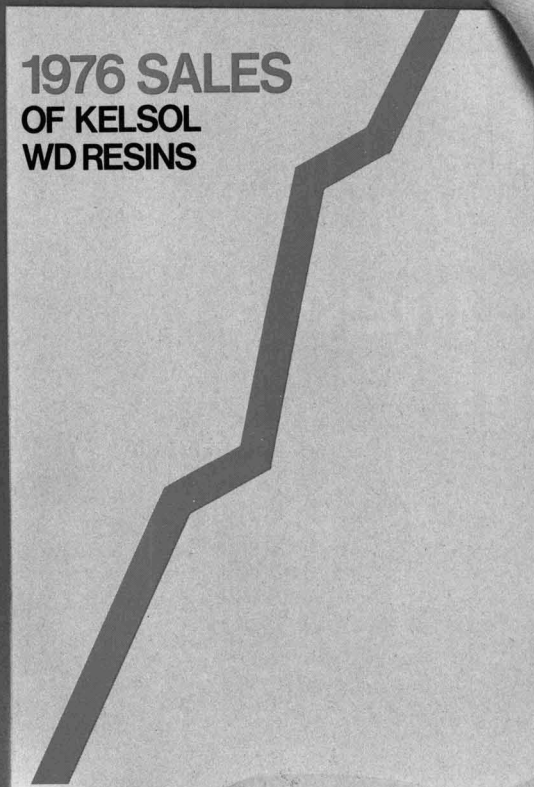
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JOURNAL OF COATINGS TECHNOLOGY

Volume 49 Number 625

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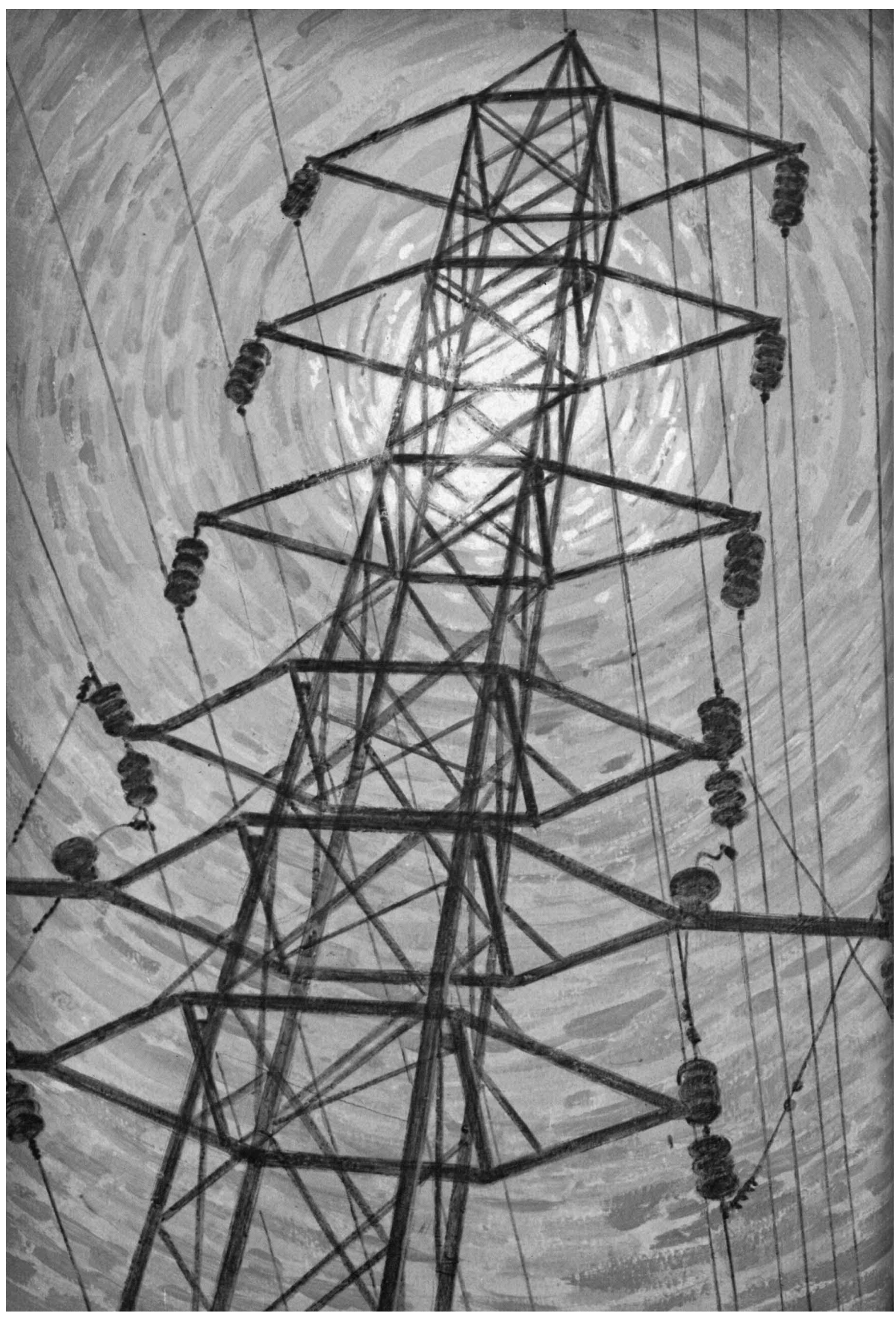
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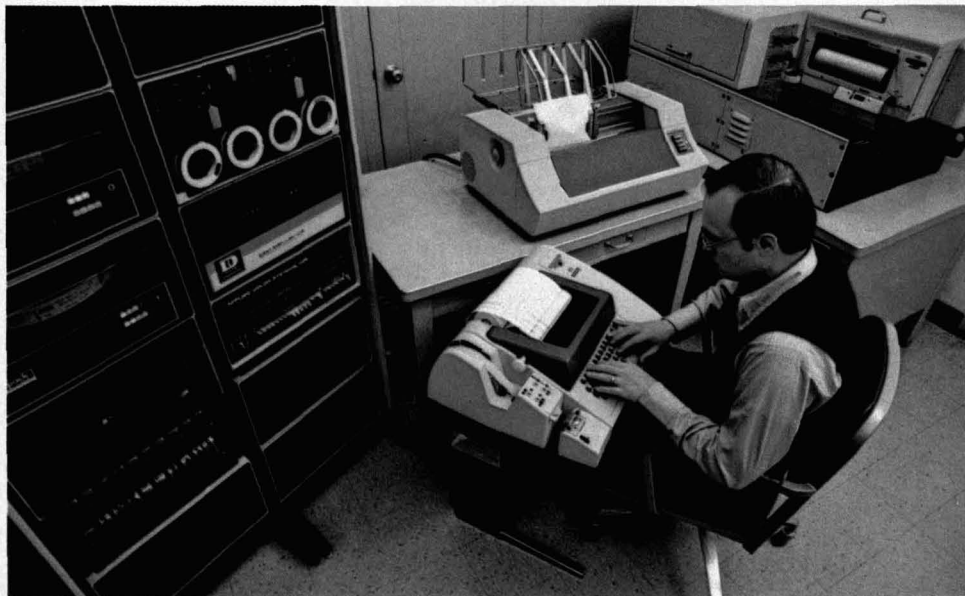
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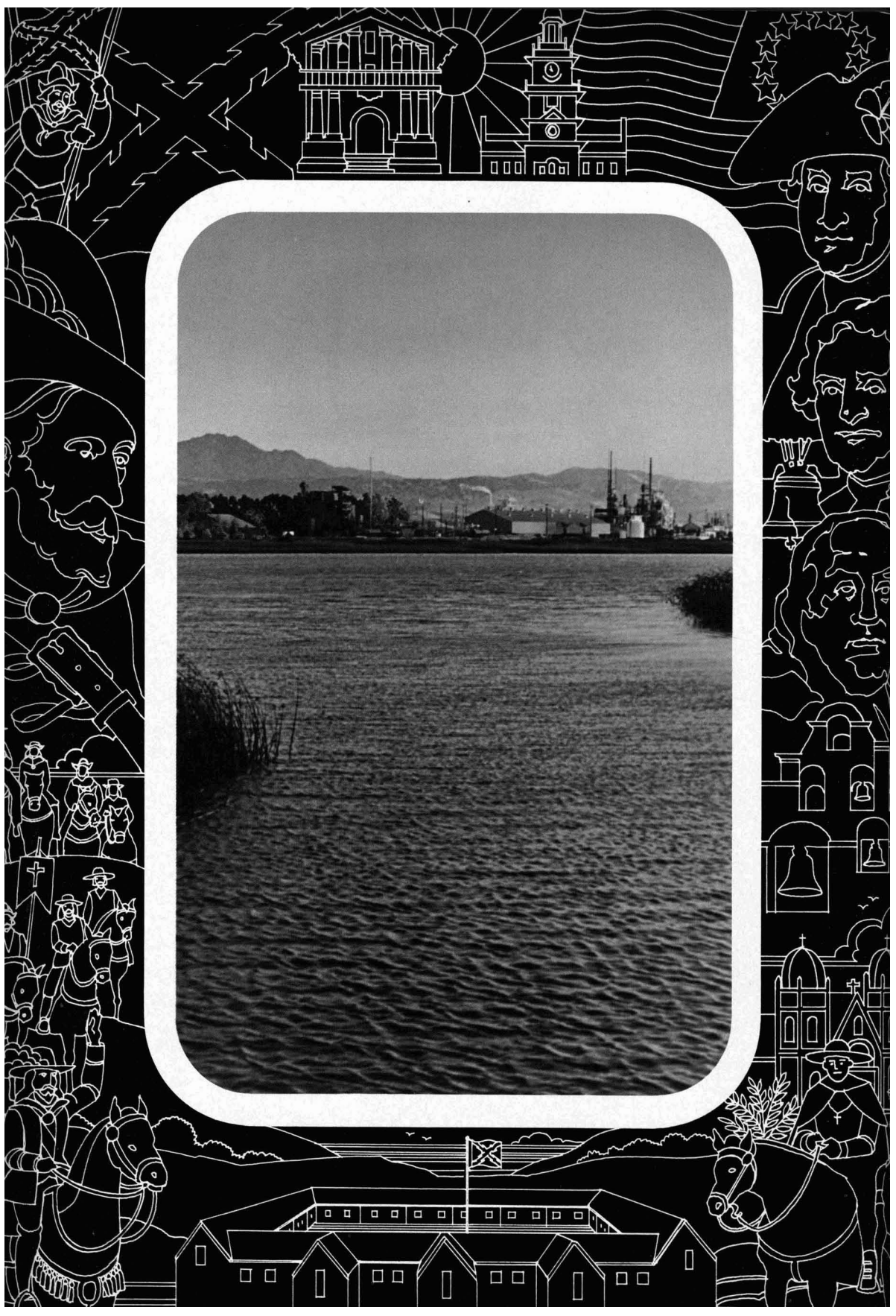
D-1 Celebrates Its 75th Anniversary

ASTM Committee D-1 on Paint and Related Coatings and Materials is observing its 75th anniversary this year, and the Federation is pleased to take note of the occasion to add its congratulations to the Committee and extend best wishes for continued success.

Committee D-1 is of particular interest to Federation members because its work is extremely vital to the paint industry. Included in the scope of the Committee's activities are development of test methods, definitions, practices, specifications, classifications and related knowledge for (1) paint, varnish, lacquer, printing ink, etc.; (2) components thereof; (3) preparation of surfaces to which such coatings are applied; and (4) coating-substrate systems. As witness to its accomplishments, the Committee boasts over 435 active standards, the largest number of active standards on record for any committee in ASTM.

This work is the result of the contributions of hundreds of volunteer committee members, one of whom, Dr. John C. Weaver, Consultant in the Coatings Group of The Sherwin-Williams Co. and former Technical Editor of JOURNAL OF COATINGS TECHNOLOGY, was recently awarded ASTM Honorary Membership in recognition of his eminent service.

Naturally, there's always room for more in the work to be done. So, if you're interested, contact the D-1 Committee Secretary, Harold W. Werner, Glidden-Durkee Div. of SCM Corp., 11001 Madison Ave., Cleveland, Ohio 44102.—TAK





FOURTH IN A SERIES

George Washington ... Thomas Jefferson ... Benjamin Franklin ... Juan Bautista de Anza ...

Juan Bautista de Anza? He was a Founding Father too, of sorts. 200 years ago, while a new nation was being born on the East Coast, Colonel de Anza was exploring northern California and laying the groundwork for what would become our most populous state. His achievements were recently honored near the grounds of our Antioch, California plant, which served as his main campsite.

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Juan Bautista de Anza may not have foreseen his contribution to the territorial growth of our country, but we can foresee ours to its industrial growth.

Abstracts of Papers in This Issue

EXPOSURE EVALUATION: QUANTIFICATION OF CHANGES IN APPEARANCE OF PIGMENTED MATERIALS—D. OSMER and R. JOHNSTON-FELLER

Journal of Coatings Technology, 49, No. 625, 25 (Feb. 1977)

Spectrophotometric technique for calculating the type and magnitude of changes in appearance of pigmented materials following exposure is described. The procedure is not intended to replace visual evaluation, but is, instead, designed to (1) provide analytical data concerning the nature and extent of the changes that have occurred and (2) provide objective numerical evaluation of changes to augment subjective visual evaluation. While the technique was developed primarily for the evaluation of paint panels exposed out-of-doors or in a Weather-Ometer®, it may be used to evaluate any materials exposed to any conditions expected to alter the appearance of the materials.

As applied to paint or plastic materials, the changes specifically determined are changes in pigment color (fading or darkening) or vehicle color (such as yellowing), changes in surface reflectance (such as changes in gloss, occurrence of bronzing, chalking or dirt accumulation) as well as the changes correlating with total visual evaluation (the integrated differences of all changes). The types of differences may be expressed in color difference terms as well as in color matching terms.

This type of objective evaluation has proven to be of great value in aiding the visual evaluation of exposed materials. Qualitatively, visual and instrumental results have agreed very well. Separating the types of changes has been particularly useful in comparing results in different vehicles, different pigment mixtures, and with different concentrations, formulations and degrees of dispersions.

METHOD FOR MEASURING THE CHALK ADHESION OF LATEX PAINTS—O.E. BROWN and K.L. HOY

Journal of Coatings Technology, 49, No. 625, 37 (Feb. 1977)

Chalk adhesion test methods and substrates over which chalky surface adhesion may be tested are reviewed and critiqued. A testing procedure is described that includes the preparation of a standard chalky test surface and an adhesion test method which, when combined, produce quantitative, reproducible adhesion data. Chalk adhesion data is presented for commercial and experimental latex house paints, latex paints formulated with and without alkyd modification and similar unmodified paints formulated with latices designed to improve chalky surface adhesion.

Correlation of these direct, intercoat adhesion measurements with actual exterior performance is pending generation of test fence data on paints now on exposure.

PAINTING WASTE LOADS ASSOCIATED WITH METAL FINISHING—G.E.F. BREWER

Journal of Coatings Technology, 49, No. 625, 48 (Feb. 1977)

The waste load generated during the painting of metal products is governed by four factors: Paint composition; Painting equipment; Curing method; and Miscellaneous unavoidable losses.

The scientific and trade literature was surveyed for the weights and volumes of the nonvolatile components (resins, pigments, etc.) of about 70 typical, widely used paints, and also for the weights and volumes of their organic volatile components. These data have been tabulated.

Nine paint application and paint curing processes (spray, dip, coil, flow, roll, curtain, electro, powder, and powder slurry coating) were surveyed and the upper and lower reported limits of the expected transfer efficiencies were tabulated. The preliminary data were sent to about 20 experts, and their criticisms, suggestions, comments, etc. have been made a part of the present paper.

THERMOSETTING HIGH SOLIDS COATINGS—TWO NOVEL TYPES—D.V. GIBSON and B. LEARY

Journal of Coatings Technology, 49, No. 625, 53 (Feb. 1977)

The physical and chemical requirements of high-solids binders for industrial one-pack coatings are examined. From an assessment of this data, high-solids coatings based on a direct compromise between viscosity and film performance factors are described. Another approach, which avoids this compromise by utilizing *in situ* oligomerization on the panel after application is proposed. This route allows the use of low viscosity blends which react *in situ* to form oligomers containing functional reactive groups for subsequent crosslinking reactions. The formation of functional oligomers *in situ* after application was confirmed experimentally by quantitative infrared analysis.

Practical evaluations of examples of both high-solids types demonstrate excellent performance with substantial reductions in solvent emissions.



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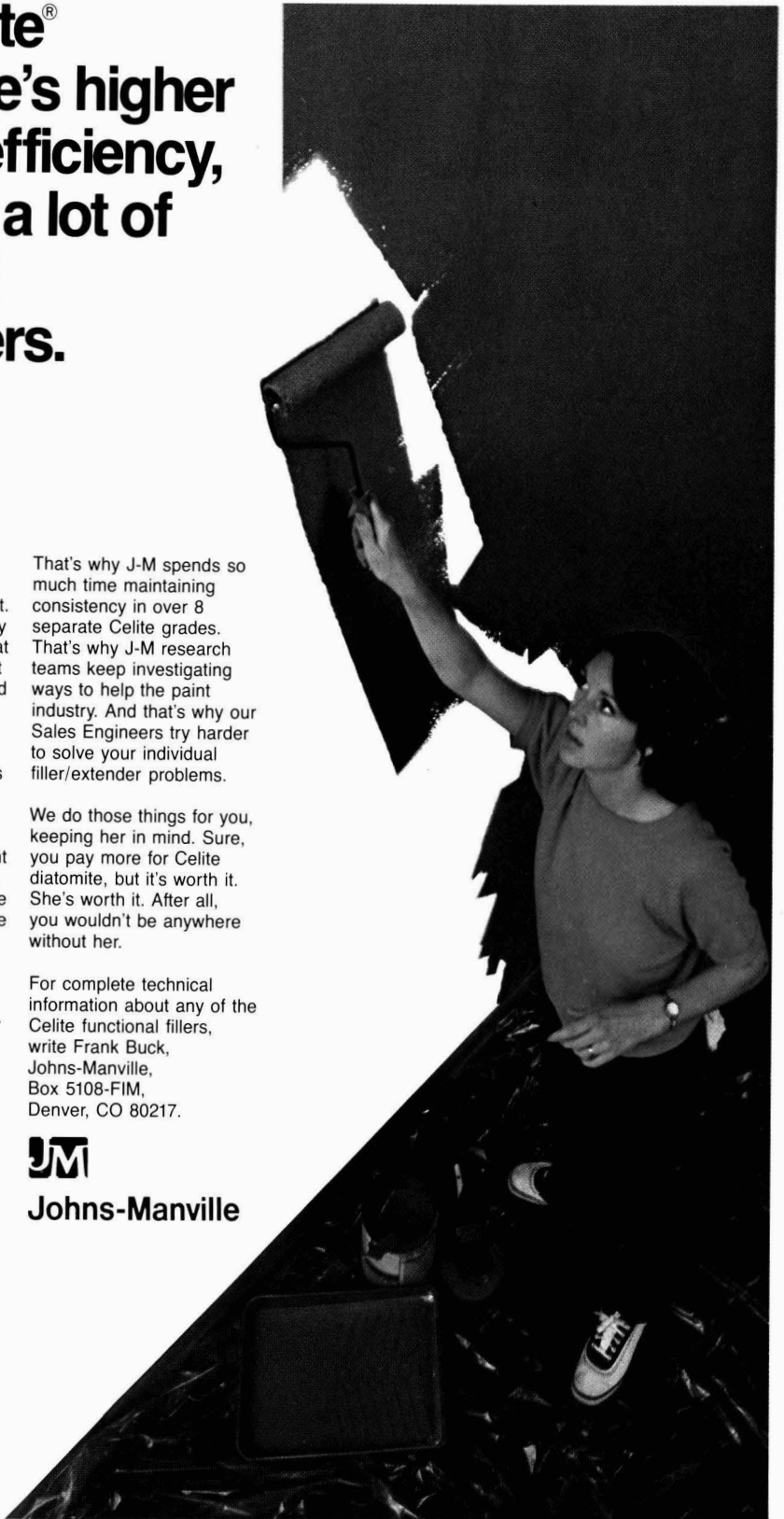
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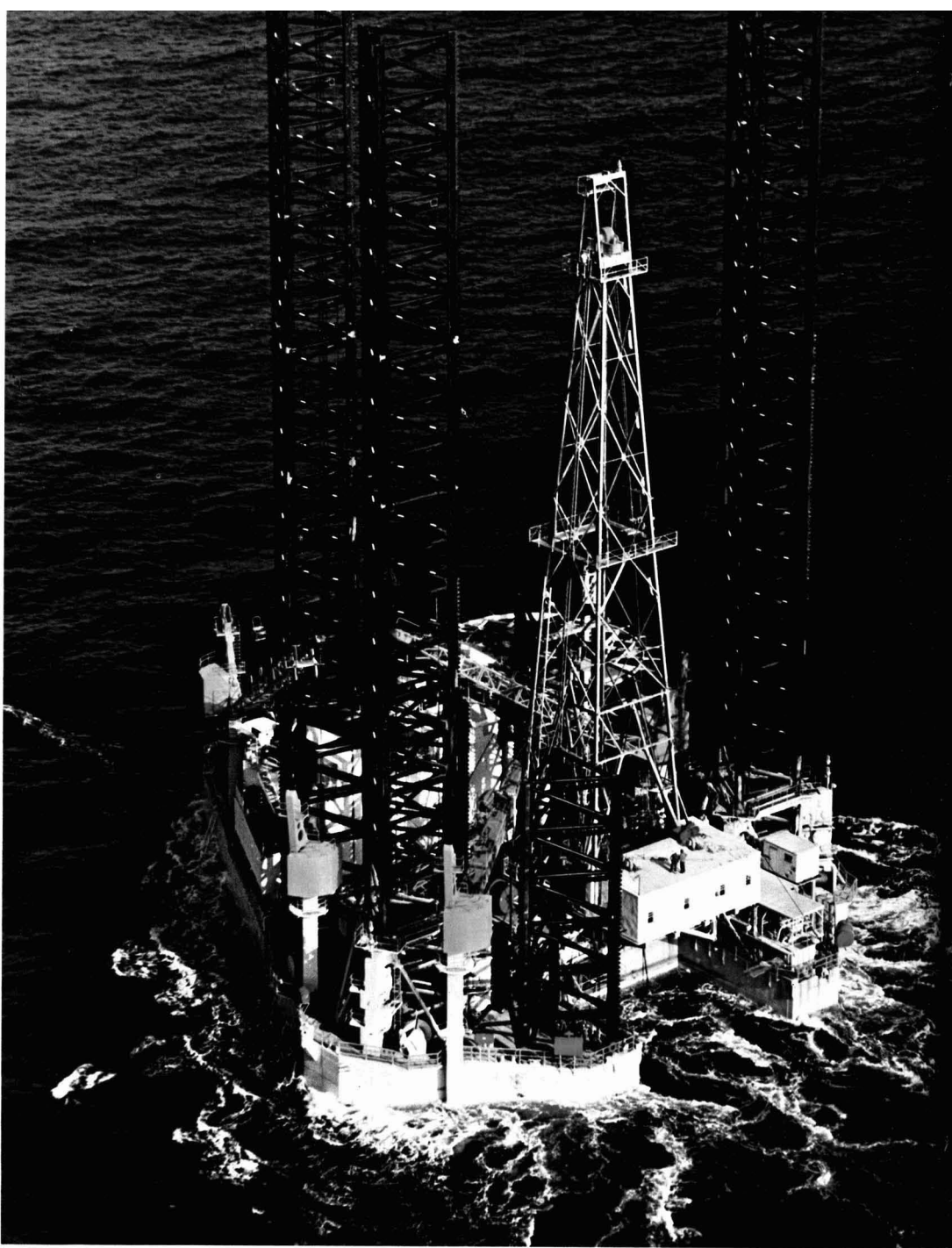


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Latex paints made with Rhoplex acrylic emulsions provide excellent corrosion protection on offshore oil drilling rig.

On the rig* in the photo, many metal parts of the platform are coated with latex paints based on Rohm and Haas Rhoplex acrylic emulsions. The paints were made by Porter Coatings, Division of Porter Paint Company. Coated parts include steel superstructures, deck housings, railings, plus walls and ceilings of living quarters. The acrylic paints were applied over conventional and zinc-rich primers. The rig was constructed in 1974-75. Paints were inspected in March 1976. All were in very good condition.

A paint that holds up in the fiercely corrosive environment that an offshore drilling rig calls home is a good bet to be a winner in almost any maintenance or marine application.

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Like more data and performance proof? Call or write for polymer literature and an appointment to tour painted equipment at our Philadelphia and Bristol plants.

*Photo shows rig being towed, with legs in raised position. Rig is put into operating state by lowering legs and raising platform above water. Rig in photo is owned by Field International Drilling Offshore. Is currently in operation on west coast of Africa.



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VP 535 is the product of two years of Henkel development and field testing in a wide range of alkyd, epoxy, acrylic and other water-reducible systems.

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Chemical Specialties Division



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MMA Awards for Notable Achievements in 1976 Presented To Cleveland, Golden Gate, and Philadelphia Societies

The 1976 MMA Awards for notable achievements were won by the Cleveland, Golden Gate, and Philadelphia Societies. Presentation was made at the recent Federation Annual Meeting in Washington, D.C.

The awards, established in 1975 by Materials Marketing Associates, a national marketing group of manufacturers' representatives, recognize notable achievements by Constituent Societies, excluding those Society papers presented at the Federation Annual Meeting.

Each winner receives \$350 in cash plus a handsome plaque.

Excellence of Educational Program

The Cleveland Society was cited for its educational efforts to serve the broadest possible spectrum of membership interests and needs, and to stimulate student interest in career opportunities in the coatings industry.

By assisting with planning and publicity, and by direct participation of several of its members as lecturers, the Society gave active support to a nine-session coatings course at Kent State University. The 27-hr course attracted 34 students who completed the requirements; 27 of them received either undergraduate or graduate credit.

An all-day symposium on "Latex Paints: Principles and Practice" held in February attracted a capacity registration of 161. Eight lectures were delivered by industry and university representatives.

A one-day combined short course and workshop on "Patent Law for the Coatings Industry" was held in October. Conducted by qualified patent lawyers, the program included discussions of trade secrets, as well as patent law and licensing.

An audio/visual presentation on "Tinting Strength of Paint by Instrumental Means" was completed, and forwarded to Federation headquarters for review.

Two credit courses on organic coatings (one introductory, one advanced) were recently initiated at Kent State University, with the Society Educational Committee providing assistance through suggestions on course content and dissemination of publicity.

In response to a request from a local high school, the Society provided representation for the school's "Career

Day" program, counseling students about career opportunities in the coatings and chemical industries.

Paint/Coatings Dictionary

The Philadelphia Society won an award for its dedicated efforts over a period of years in compiling definitions of coatings terms—ultimately to be published by the Federation as a "Paint/Coatings Dictionary."

In 1965, the Society Technical Committee, in searching for an authoritative glossary for the coatings industry, reviewed existing paint dictionaries and glossaries. They were all found to be either out-of-date or insufficiently comprehensive. The Committee, consequently, decided to undertake the ambitious project of compiling well-edited, concise definitions. A subcommittee was formed to work on this effort, which would define the "accepted" vocabulary of the industry.

Over the last 11 years, the subcommittee (averaging six members) has met for evening sessions approximately every three weeks—representing in excess of 26,000 person-hours of committee work.

The result of this effort is the compilation of some 5200 definitions of technical terms of the coatings industry and interfacing technologies.

Unique is the classification of these definitions into one or more of 72 categories (color, pigments, additives, etc.), which have been number coded and appear as superscripts at the end of each definition. Conversely, all the terms defined under each category are listed at the back of the dictionary, and serve as a check list for key words, research papers and literature searches. Pigments have also been classified into their Color Index numbers.

An appendix includes a decoding and explanation of the Color Index numbers, key to abbreviations, temperature and metric conversion tables, and a bibliography.

Publication of the dictionary, which will total approximately 450-500 pages, is anticipated by the end of 1977.

Manufacturing/Education Committee Contributions

The Golden Gate Society was cited for the continuing successful activities of its Manufacturing and Educational Committees.

The Manufacturing Committee traditionally sponsors an annual seminar, designed to help provide practical solutions to problems common to the industry. Their "Manufacture '76" featured 10 lectures dealing with a variety of subjects relating to the manufacturing area.

The Education Committee sponsors three courses in the Bay Area. A course in elementary coatings technology, conducted at the John Adams Adult Center, had an average attendance of 20 students. Two courses were given at San Jose Regional Vocational Center—one, a coatings technology course for high school students (which had maximum registration), the other a course in the fundamentals of color matching, which had 25 students enrolled.

Principles Governing Awards

The MMA Awards are for notable achievements in the field of education, manufacturing and training procedures, technology, public service, and for other achievements deemed proper and desirable.

The Awards are to be presented at the Federation Annual Meeting, but it is not mandatory that an award be presented each year.

The President of any Society wishing to enter the competition must send a letter of intent to the MMA Awards Committee Chairman (Ben Chatzinoff, Quaker City Chemicals, Inc., 7360 Milnor St., Philadelphia, Pa. 19136), no later than March 31. A full description of the Society activity to be considered for the awards must be submitted by the Society President by August 31.

Materials Marketing Associates is composed of the following: McCullough & Benton, Inc., Atlanta, Ga.; Lukens Chemical Co., Boston, Mass.; The Cary Co., Chicago, Ill.; A. Mueller Co., Cleveland, Ohio; Ribelin, Distributors Inc., Dallas, Texas; Matteson-Ridolfi, Inc., Detroit, Mich.; George C. Brandt, Inc., Kansas City, Kan. and St. Paul, Minn.; E. T. Horn Co., Los Angeles and San Francisco, Calif.; C. Withington Co., Inc., New York, N.Y.; Van Horn, Metz & Co., Inc., Philadelphia, Pa.; Walsh & Associates, Inc., St. Louis, Mo.; Apco Industries Co. Ltd., Toronto, Canada; Shanahan's Ltd., Vancouver, Canada; J. F. Shelton Co., Portland, Ore.; and Wm. B. Tabler Co., Inc., Louisville, Ky.

News from Washington

Lead Level to Be Reduced to 0.06% after June 22

The Consumer Product Safety Commission announced on December 17 that the maximum level of lead in household paint products will be 0.06% for residential paints manufactured after June 22, 1977. The current level is 0.5%.

In making the announcement, CPSC concluded that "because of the limitations of the existing available scientific data, it was unable to establish whether a level of lead in residential paint in excess of 0.06%, but not exceeding 0.5%, was safe."

Under the Lead Based Paint Poisoning Prevention Act (LBPPPA), as amended, CPSC Commissioners were required to hold hearings to determine whether a level of lead in paint greater than 0.06%, but not exceed 0.5%, was safe. The Commissioners had to make the decision by December 23, 1976.

Robert A. Roland, President of the National Paint and Coatings Association, said he was greatly disappointed with the lack of a definitive decision from the Consumer Product Safety Commission. He stated, "CPSC abdicated its responsibility to make a safe lead level determination. In the absence of a finding of unreasonable risk at the current 0.5% lead level, CPSC should have decided to maintain the 0.5% level. The National Academy of Sciences advised the Commission in July that the appropriate research to determine a safe lead level in children has never been done. The 0.5% level could have been maintained while the needed additional research was accomplished."

A public hearing was held on September 12, 1976. Mr. Roland testified at the hearing, stating that the Commission should engage in a thorough risk-benefit analysis on the question of a safe level of lead in residential paint products. He urged CPSC to base its decision on sound scientific evidence.

CPSC stated in its December 17 announcement that it had reviewed all information and literature available, including a study by an ad hoc committee of the National Academy of Sciences, the recommendations of the Secretary of the Department of Health, Education and Welfare, including comments from the Center for Disease Control, and testimony at the September 12 hearing.

According to the Commission, the term "lead-based paint" will apply to paints manufactured after June 22, 1977 which contain more than 0.06% lead by

weight, calculated as lead metal, in the total nonvolatile content of the paint, or the equipment of lead in the dried film of paint already applied, or both.

Impact of the 0.06% Decision

The lead decision is complicated by the fact that the new definition for lead-based paint affects three federal agencies under the LBPPPA, state and local laws whose definitions of lead-based paint are tied to the federal definition, and the Federal Hazardous Substances Act (FHSA).

Under the LBPPPA, the Department of Housing and Urban Development (HUD) is required to take necessary steps to prohibit the use of lead-based paint in residential structures constructed or rehabilitated by the federal government, or with any form of federal assistance.

The Department of Health, Education and Welfare (HEW) is also required to take necessary steps to prohibit the application of lead-based paint to any cooking, eating, or drinking utensil.

In both these agencies, the definition for lead-based paint manufactured after June 22, 1977 will be paint with a lead content greater than 0.06%.

The definition of lead-based paint will also apply to products under the Federal Hazardous Substances Act. The FHSA formerly was under the jurisdiction of the Food and Drug Administration, but was transferred to CPSC when it was formed in 1973. The FHSA regulates the level of lead in paint used on toys and children's articles; under LBPPPA, as amended, this coverage is expanded to include "furniture."

In a related development, CPSC on August 10, 1976 published a notice in the *Federal Register* of its intent to transfer the products regulated under the FHSA to the Consumer Product Safety Act (CPSA). The CPSA is similar to, but broader than, the FHSA and the Commission would have greater flexibility to act under CPSA. The penalties for violations under CPSA are more stringent. This is an unusual move, since CPSC may not have the authority to make this kind of a transfer. The authority may only rest with Congress.

It is anticipated that CPSC will ask the 95th Congress to transfer the FHSA and similar acts which were taken over by CPSC from the FDA. Similar legislation was submitted during the 94th Congress, but was never acted upon.

NPCA filed comments on the August 10 proposal with CPSC on September

24. At that time, the Association suggested that if the Commission believed that some regulation of furniture bearing lead-containing paint is necessary, it should limit the regulation to "Articles of furniture bearing lead-containing paint or similar surface-coatings materials which are *accessible to and chewable* by children. "Such a regulation would exclude all types of metal furniture, NPCA pointed out. The manner in which coatings for metal furniture are formulated and cured provides an extremely hard, durable paint film which makes it extremely unlikely (if not impossible) to be removed by biting, chewing, or gnawing."

"If the paint film cannot be removed and ingested," NPCA said, "there is no hazard, and — no need to regulate."

NPCA opposed the transfer of regulations under the FHSA to the CPSA on the grounds that it would serve no useful purpose, is confusing, and would interfere with orderly compliance.

CPSC has set a target date of April 1, 1977 for issuing final regulation on the August 10 proposal.

Product Liability Topic Of NPCA Seminar Series

Product liability and its ramifications are being explored in depth in a series of seminars held in various cities by the National Paint and Coatings Association.

Seminar Speakers are Harry A. House, President, Verlan Limited, and William A. D. Hare, Senior Vice-President, Fred S. James & Co. (head of that firm's consulting services on risk management). Discussions include present government action, development of risk management concepts to provide immediate assistance, and NPCA/Verlan involvement.

Seminars were held in February at Los Angeles, San Francisco, and New York. Upcoming are Houston (March 1), Chicago (March 22), and Louisville (April 5).

Registration fee is \$25, and includes printed material.

For further information, contact Georgene Savickas, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

Pending NPCA Petition For Exemptions under FHSA

NPCA still has a petition for exemption for seven categories of special purpose coatings pending with CPSC under the Federal Hazardous Substances Act.

On October 24, 1972, NPCA asked the Food and Drug Administration (which then was charged with administering the FHSA) to exempt certain coatings from the "banned hazardous substances" classification. These seven classes of special purpose coatings are: (1) automotive, agricultural, and industrial equipment refinishing coatings; (2) industrial (and commercial building) maintenance coatings, including traffic and safety marking coatings; (3) graphic arts coatings (products marketed solely for application on bill boards, road signs, and similar uses, and for identification marking in industrial buildings); (4) touch-up coatings for automobiles, agricultural and industrial equipment, boats, outboard motors, motorized recreational vehicles, and appliances; (5) exterior marine coatings for small craft application; (6) exterior rubber-based roof coatings; (7) exterior primer coatings for wood siding containing extractives.

FDA never acted upon this petition and it was transferred to CPSC when that agency was formed in 1973. The petition is still awaiting action.

Artist Paints Exempted

FDA did grant a special exemption for artist's paints and related materials in a separate action in early 1973. This exemption will still be in force even if the powers under the FHSA are transferred to the CPSCA.

Environmental Impact

CPSC is required to file an envi-

ronmental impact statement on its lead action taken under the FHSA or the CPSCA. A notice was published by CPSC in the December 3, 1976 *Federal Register* in which the agency requested information to help it draft an environmental impact statement. CPSC specifically requested information on the properties and effects of substitutes for lead driers used in paint. The deadline for submitting comments was December 31.

NPCA decided not to submit information to CPSC prior to December 31, but reserved its right to comment on the draft environmental impact statement when it is published.

Effect on Industry

The 0.06% level of lead in paints will affect only those products *manufactured after June 22, 1977*. Residential products which are manufactured before that date at the 0.5% lead level will still be allowed to be sold through normal distribution channels after June 22, 1977.

March 23 Workshop Slated On Interfacial Phenomena In Corrosion Protection

An International Workshop will be held March 23 at Marriott Hotel, New Orleans, La., on the subject, "Interfacial Phenomena in Corrosion Protection."

There will be no formal papers. Instead, discussion leaders will respectively preface a sub-discipline with an overview intended to create an Encounter Session which speaks to the theme, "What Are the Unsolved Problems in the Corrosion Complex and What New Approaches Are Available for Research on the Applicable Fundamentals?"

PRI Slates Symposium On Mildew Vulnerability

A two-day spring symposium on the subject of Mildew Vulnerability is being planned by the Paint Research Institute.

The event will be held May 16 and 17 at Battelle Memorial Institute, Columbus, Ohio.

Topics for discussion will include mildew physiology, combating mildew, evaluation and testing procedures, and results of PRI research.

There is a federal preemption attached to the new lead standard under LBPPPA, as amended, which will provide uniform lead level requirements under state laws and local ordinances. However, additional provisions of these state laws and local ordinances, relating to *sale and use* of lead-based paints may cause special issues to be raised in those jurisdictions.

A portion of the workshop will be devoted to amplify and discuss the 20 formal papers at the symposium on the same subject to be held March 21 and 22. Registration to the 173rd meeting of The American Chemical Society is required for both events.

The workshop is co-sponsored by the ACS, Divisions of Organic Coatings & Plastics Chemistry, Colloid & Surface Chemistry, and Industrial & Engineering Chemistry, in cooperation with Electrochemical Society (Corrosion Div.), and Federation of Societies for Coatings Technology.

Total of 52 Contributors Support 1976 PRI Programs

Funds in support of the research projects of the Paint Research Institute were recently received from the New England Society, Glidden-Durkee Div. of SCM Corp.; Midland Div. of Dexter Corp.; and William B. Bate.

These bring to 52 the number of contributors to the 1976 PRI programs. Their contributions supplement the funds committed by the Federation in support of the Paint Research Institute.

1976 Contributors to PRI

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Exposure Evaluation: Quantification Of Changes in Appearance Of Pigmented Materials

Ruth Johnston-Feller
Consultant*
and
Dennis Osmer
CIBA-GEIGY Corporation†

Spectrophotometric technique for calculating the type and magnitude of changes in appearance of pigmented materials following exposure is described. The procedure is not intended to replace visual evaluation, but is, instead, designed to (1) provide analytical data concerning the nature and extent of the changes that have occurred and (2) provide objective numerical evaluation of changes to augment subjective visual evaluation. While the technique was developed primarily for the evaluation of paint panels exposed out-of-doors or in a Weather-Ometer®, it may be used to evaluate any materials exposed to any conditions expected to alter the appearance of the materials.

As applied to paint or plastic materials, the changes specifically determined are changes in pigment color (fading or darkening) or vehicle color (such as yellowing), changes in surface reflectance (such as changes in gloss, occurrence of bronzing, chalking or dirt accumulation) as well as the changes correlating with total visual evaluation (the integrated differences of all changes). The types of differences may be expressed in color difference terms as well as in color matching terms.

This type of objective evaluation has proven to be of great value in aiding the visual evaluation of exposed materials. Qualitatively, visual and instrumental results have agreed very well. Separating the types of changes has been particularly useful in comparing results in different vehicles, different pigment mixtures, and with different concentrations, formulations and degrees of dispersions.

KEY WORDS: Spectrophotometric exposure analysis; Appearance analysis; Colorimetry; Weathering analysis; Exposure—analytical study; Gloss; Lightfastness; Chalking.

INTRODUCTION

One of the most important evaluations made by manufacturers and purchasers of colorants or colored products is the change in appearance when the materials are exposed to any kind of deleterious conditions, for example, light, moisture, various chemicals, combinations of these or other environments. Visual evaluations of the appearance changes are almost always of importance ultimately. But the nature and causes of the changes must be of concern as well, particularly if changes need to be made in product formulations to improve the performance.

Several types of changes can occur to paint films which affect changes in appearance: (1) pigment fading or darkening; (2) gloss changes; (3) surface chalking; (4) dirt accumulation; (5) bronzing of the surface; (6) resin or vehicle yellowing; and (7) internal separation of pigment and binder, for example. All of the above changes affect the perceived color of the paint film. We are not concerned here with the more severe failures such as blistering, peeling, rusting, etc.

If each of the seven types of exposure change described above occurred singly, the visual effect of each would be readily distinguishable. But, generally, several or more of the above effects occur simultaneously and, while the realization of this fact may be readily apparent, the actual magnitude of the effect of each change and its importance on the total perceived color difference is not. Visual examination primarily reveals the cumulative effects of all the actual types of changes which have occurred.

Special methods and instruments have been designed to quantify, on a relative basis, the magnitude of change of the various types. But most of these techniques do not supply data which is directly relatable to the total observed color difference. Although the measurement

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

*5244 Fifth Ave., Pittsburgh, Pa. 15232.

†Pigments Dept., 444 Saw Mill River Rd., Ardsley, N.Y. 10502.

Table 1—List of Symbols Used

R	— reflectance — % R, 400—700 nm in 20 nm intervals
SCI	— Specular Component of the reflectance Included (total reflectance)
SCE	— Specular Component of the reflectance Excluded (diffuse reflectance)
S	— Specular Component of the reflectance
Δ	— difference
TC	— total change
PC	— pigment and/or vehicle reflectance change
CC	— cleaning change
APC	— adjusted for pigment and/or vehicle reflectance change
ASC	— adjusted for specular reflectance change
AC	— adjusted for effect of cleaning change on the reflectance
ΔE	— total color difference, calculated using the FMC II equation
ΔRG	— difference in redness — greenness vector; plus indicates redder, minus indicates greener.
ΔYB	— difference in yellowness — blueness vector; plus indicates yellower, minus indicates bluer
ΔC	— chromatic difference
ΔL	— lightness difference; plus indicates lighter, minus indicates darker.
A/M	— alkyd melamine automotive quality enamel
TSA	— thermosetting acrylic automotive enamel
TPA	— thermoplastic acrylic automotive lacquer

Subscripts

- U — unexposed
- W — exposed, but uncleaned (weathered)
- C — exposed and cleaned

Superscripts

- T — total reflectance (SCI measurement)
- D — diffuse reflectance (SCE measurement)

of the color change using either a tristimulus colorimeter or a spectrophotometer can provide more objective information concerning the observed change than subjective visual evaluations alone, the interpretation of the type of change that contributed to the measured results is not obvious. An understanding of "what" is being measured is, therefore, essential if meaningful results are to be obtained. Each of the seven types of changes in appearance described above affects the reflectance curves differently when all aspects of the reflectances are considered.

The purpose of this paper is to describe how specific changes in the spectrophotometric curves of exposed paint panels are, in fact, a measurement of the certain types of appearance changes. Furthermore, an appropriate, relatively simple, mathematical handling of the measured data will be described which will provide quantitative information interpreted in terms of the effective changes in color difference units and, in certain cases, in quantitative terms of effective changes in pigment concentration. Examples will be given which illustrate such analyses applied to different paint systems and different types of exposure. These will also illustrate that, in some instances, the changes may "cancel each other" because they affect the perceived color in compensating directions. In such cases, visual examination alone might provide misleading information.

A list of the symbols used throughout this paper is given in Table 1.

BACKGROUND

There are a number of methods which are commonly used for rating the magnitudes of various appearance changes of exposed paint samples. Changes in gloss, for example, are generally measured with a glossmeter.¹ Such an instrument provides readings, however, which have no direct meaning in terms of the perceived color difference which results from the change in gloss. Color change may be rated visually by comparison to the similar change in the blue wool² scale or to a gray scale.³ Such visual comparison methods suffer from relatively poor agreement between observers⁴ and are confounded by concomitant changes in gloss or other changes in appearance. Color change may be measured with a tristimulus colorimeter or with a spectrophotometer followed by conversion to tristimulus units and calculation of a color difference from the unexposed panel expressed as ΔE .⁵ Such a method is certainly more objective than visual ratings alone, but depending on how the measurements are made, may be relatable to the total appearance change or only to some

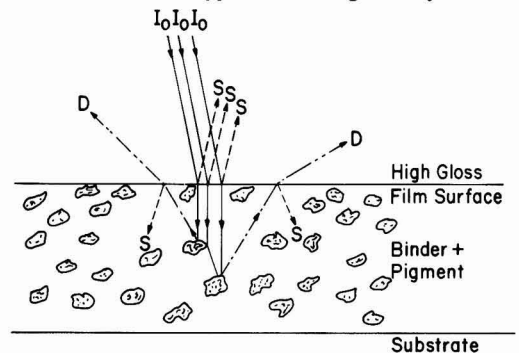


Figure 1-a

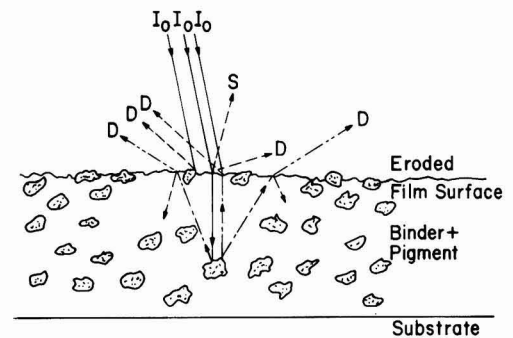


Figure 1-b

- Incident light
- - - Component of internal scattered light
- - - Fresnel surface reflected light
- - - External light emerging from film

Figure 1—Diagrams of light striking a paint film; 1-a is a high gloss surface, 1-b is an eroded surface after exposure when the surface reflectance is partially diffuse. Light incident on the surface is designated I_0 , light specularly reflected, S, and light diffusely reflected, D

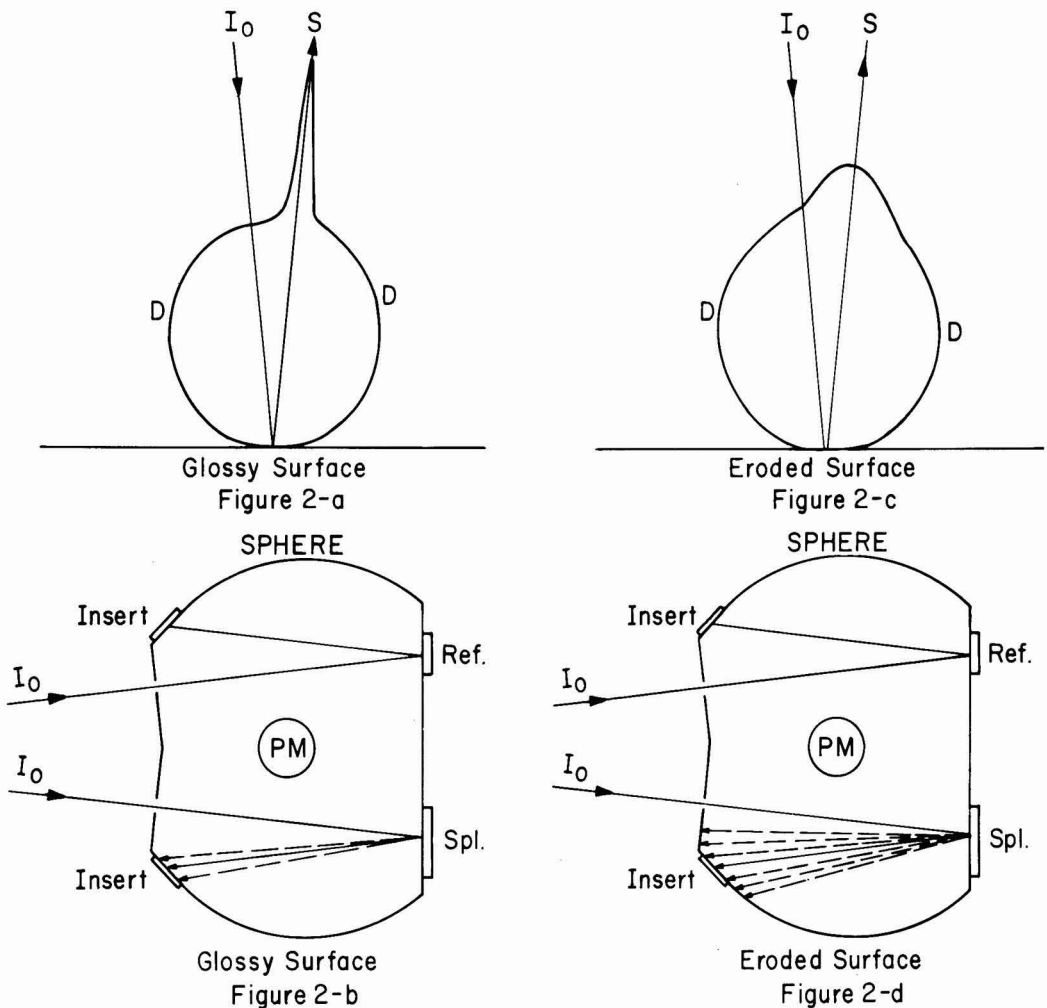


Figure 2—Diagrams describing the angular reflectance distribution curves of light reflected from the surfaces of paint films when light is incident at an angle near to the perpendicular. Figure 2-a illustrates the sharp specular peak obtained from a glossy surface; Figure 2-c illustrates the broadening of the surface reflectance (increase in diffuse reflectance) and lowering of the height of the reflectance at the specular angle. Figures 2-b and 2-d illustrate a typical integrating sphere used for color measurement corresponding to the two types of surface reflectances illustrated in Figure 1 and Figures 2-a and 2-c. Abbreviations Ref. and Spl. refer to the references and sample ports, respectively; PM refers to the detector photomultiplier tube. It can be seen that if the sphere insert is black in Figure 2-b, the surface reflectance will be excluded from the measurement; in Figure 2-d it is apparent that only a portion of the surface reflectance will be excluded

aspect of the change. Chalking is generally rated only as the "free chalking"⁶ by techniques using black or dark blue wool felt on lightly tinted paints or white wool felt for dark paints to rub off the chalk, rating the amount of powder removed on the wool by comparison to a photographic gray scale.⁷

Other methods for studying the physical changes of paint films have been used for purposes of studying the details and mechanisms of the changes. Use of instruments such as electron microscopes,⁸ goniophotometers, and infrared spectrophotometers (attenuated total reflectance, ATR)⁹ provide very useful and interesting information, but are not intended to describe visual changes per se.

In order to describe the method presented in this paper more vividly, the consideration of what happens to the light falling on a paint panel is perhaps helpful. Some of the light incident on the sample is reflected at the surface (Fresnel reflectance) because of the difference in refractive index of the paint film from air. The amount reflected at this surface depends on the effective index of refraction, the angle of incidence, and polarization of the incident light. The rest of the light enters the film and is bent (refracted) and then scattered or absorbed by the pigment particles. The effect of the pigment depends on its refractive index relative to that of the paint medium in which it is suspended and on its particle size, shape and distribution, and on agglomera-

Table 2—Spectrophotometric Reflectance Curve Diagnosis Scheme

Type of Appearance Change	Differences in Reflectance from Unexposed	Color Matching Adjustment to Match Unexposed
1.a Pigment fading	Increase in R_L^i in region of maximum absorption for each pigment; little or no change in region of maximum reflectance (minimum absorption).	Add pigment which faded—Amount necessary tells amount faded. (Use R_L^i to match R_D^i)
1.b Pigment darkening	Same as 1.a except a lowering of R_L^i in region of maximum reflectance.	Add pigment which degraded and subtract black. (Use R_L^i to match R_D^i)
2.a Decrease in gloss	Uniform decrease in S at all wavelengths.	Subtract all pigments except white. (Use ASC to match R_D^i)
2.b Increase in gloss	Uniform increase in S at all wavelengths.	Add all pigments except white. (Use ASC to match R_D^i)
3.a White chalking	Uniform increase in R_W^i at all wavelengths.	Add white pigment. (Use AC to match R_D^i)
3.b Chromatic chalking	Increase in R_W^i nonuniform with respect to wavelength, characteristic of pigments used in the coating.	Add chromatic (and white pigments). (Use AC to match R_D^i)
4. Dirt accumulation	Decrease in R_W^i uniform with respect to wavelength except in presence of white in chromatic chalking.	Add black pigment (in addition to others required in chalking). (Use AC to match R_D^i)
5. Bronzing	Nonuniform change in S with respect to wavelength.	Add chromatic pigment. (Use ASC to match R_D^i)
6. Resin or vehicle yellowing	Decrease in R_L^i in short wavelength region.	Add yellow oxide. (Use R_L^i to match R_D^i)
7. Internal separation of pigment from binder	Same as 1.a in symptoms, but represents an addition of white pigment.	Requires a subtraction of white pigment. Addition of all other pigments. (Use R_L^i to match R_D^i)

Color differences of the changes may be calculated by algebraically adding the appropriate differences in R to the R_D^i , calculating adjusted tristimulus values to use in calculating the color differences. The adjusted R's may also be used as a "batch" to be corrected to match the unexposed "standard" using a two constant computer color matching program. The specific exposure changes then are described in terms of relative pigment concentration differences.

tion characteristics. In order to see the effect of the pigment (i.e., the color), the light not absorbed inside the film must be scattered back out of the film, and again some of the light incident on the underside is reflected back into the film at the surface because of the Fresnel reflectance. The rest of the scattered light emerges from the film in different directions because of the scattering by the pigment particles and is, therefore, diffuse. It is this selective absorption and back-scattering that we see as the color of the paint film. When the surface of the film is smooth, like a mirror, the Fresnel reflectance of the incident light is sharp and mirror-like or specular. Subjectively, we call this specular reflectance, the gloss. But if the surface of the film is not smooth, that is, it is matte in character, light is reflected off the surface at many angles and we say that the film has low gloss. These phenomena are illustrated diagrammatically in *Figure 1*.

If we measure the reflectance as a function of angle, using a near normal (perpendicular) directional incident beam, the specular Fresnel reflectance is a sharp peak of reflectance approximately equal and opposite in direction to the incident angle. The scattered reflectance for a perfect diffuse, (i.e., perfectly matte) surface will follow the Lambert Cosine Law, resulting in a spherical measured angular reflectance distribution pattern.¹⁰ Intermediate gloss falls in between these two extreme reflectance patterns. When a high gloss sample loses gloss, the specular peak is lowered and the total diffuse reflectance is increased. Or conversely, if a matte surface is "burnished", increasing the specular reflectance,

the specular peak appears or is increased. These phenomena are illustrated in *Figure 2*.

If now we consider the design of color measuring instruments, we will see how the geometrical instrument design is related to "what we measure" as the reflectance. In the case of an instrument with an integrating sphere, light is generally incident at an angle near to the normal, i.e., perpendicular to the sample, generally 6 to 8° off the normal. The specular reflectance which is reflected at an angle equal and opposite to the incident angle falls on a specific area of the sphere. Therefore, for example, if a port is cut at this location, either a black insert (or light trap) or a white insert coated with the same diffuse white reflector as the rest of the sphere wall, may be inserted. If the black port is inserted, the specular reflectance will be absorbed, thereby eliminating the specular reflectance from the measurement, giving a measurement of diffusely reflected light only (SCE). If the white port is inserted, the specular reflectance is reflected back into the sphere and is included in the measurement, giving a measurement of all the light reflected by the sample, i.e., the total reflectance (SCI). The size of this port in relation to the size of the sample beam and of the sphere determines the portion of the surface reflectance which is excluded by a black port. In general, this is near to the portion that is excluded as gloss visually, so that an SCE measurement generally correlates with the visual evaluation of the color or diffuse reflectance alone on a glossy sample. On samples of intermediate gloss, an SCE measurement does not always correlate best with

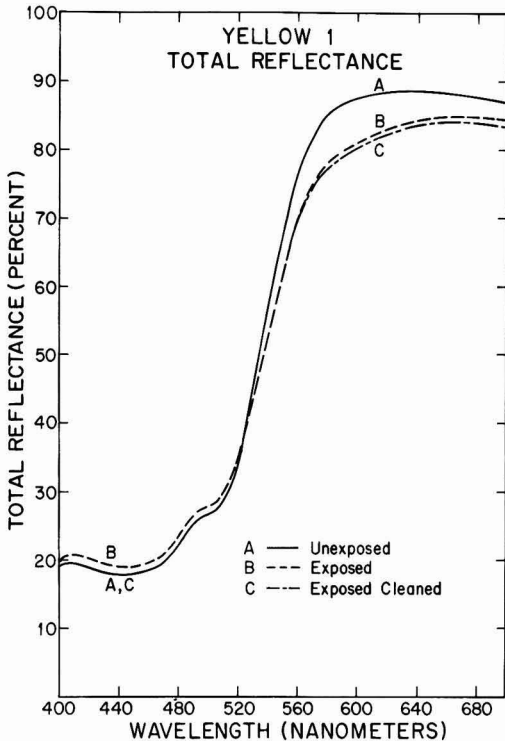


Figure 3—Spectrophotometric curves of the total reflectance (SCI) from Yellow 1, measured before exposure, A, after exposure but before cleaning, B, and after cleaning, C

visual examination, however. Figure 2 demonstrates this type of integrating sphere design.

Comparison of Figures 1 and 2 then, indicates that a measurement made with the specular component of the reflectance excluded by use of the black port, while perhaps correlating well with the visual observation made, excludes reflectance of a definite cone angle of light reflected by the sample. Hence, as the specular reflectance decreases, the surface reflectance peak decreases also as shown in Figure 2; it also broadens, so that more and more of the surface reflectance will be diffuse and included in the measurement made SCE, increasing this measurement. This same increase in the diffuse reflectance will be observed visually as a lightening of the color.

The increase in lightness caused by increased diffuse surface reflectance when the gloss decreases is difficult to visually separate from pigment fading. Observers, therefore, frequently restore the gloss by wetting the panel with moisture or a little oil in order to "see" the real effect of pigment change. It is, however, difficult to get a quantitative measurement of the two effects this way.

Spectrophotometric measurements made with the specular reflectance excluded, (SCE), and with the specular reflectance included, (SCI), or total reflectance made on the samples before exposure, after exposure, before cleaning, and after cleaning, coupled

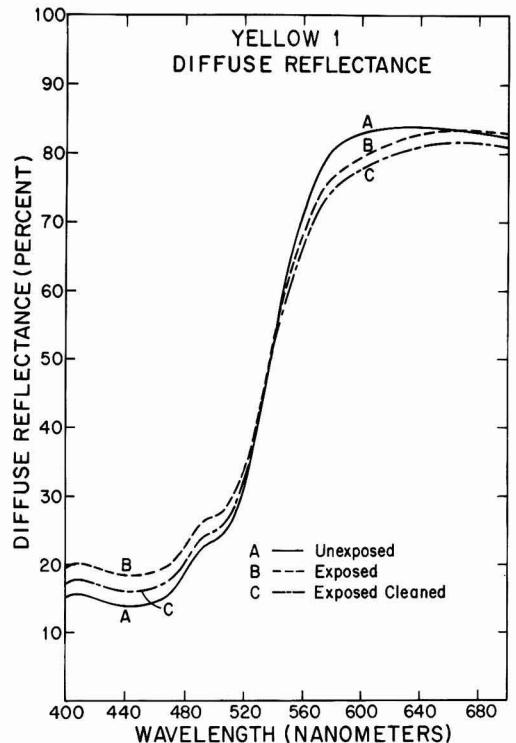


Figure 4—Spectrophotometric curves of the diffuse (SCE) reflectance from Yellow 1, measured before exposure, A, after exposure but before cleaning, B, and after cleaning, C

with an interpretation of the type of changes in the reflectance curves, can give a lot of information concerning the type and amount of the seven changes described initially. Table 2 summarizes the effect that each of the seven types of changes has on the spectrophotometric reflectance curves and also describes the changes which would be calculated with a color matching program in pigment concentration terms.

It can be seen from the description of the effect of changes on the spectrophotometric curve that the specular reflectance must be appropriately included or excluded. Therefore, descriptions of measurements of color change must include a description of how the measurements were made. It is necessary to know whether the specular reflectance was included or excluded. It is also helpful to know on what instrument the measurements were made. When such information is not included, the assumption is generally made that the specular reflectance was excluded which is the old conventional way of making color measurements on spectrophotometers then used primarily to compute color coordinates. Some tristimulus colorimeters and spectrophotometers utilize 45°/0° geometry, that is 45° incident light and a 0° viewing, or the reverse, 0°/45°. Such instruments automatically exclude the specular reflectance. These measurements possibly correlate best with visual color changes; however, it must be remembered that the change in gloss also affects these SCE measurements.

Table 3—Yellow #1 Percent Reflectance Data

Wavelength	PC (Pigment & Vehicle Change)	ΔS (Film Surface Change)	TC (Total Changes or PC+ΔS)	CC (Cleaning Change)
400	-0.19	2.24	2.05	2.18
420	-0.02	2.10	2.08	2.45
440	-0.09	2.18	2.09	2.32
460	-0.04	2.12	2.08	2.31
480	-0.37	2.07	1.70	2.37
500	-0.60	1.92	1.32	2.28
520	-1.14	1.75	0.61	2.20
540	-3.71	1.52	-2.19	1.89
560	-6.40	1.64	-4.76	1.77
580	-7.67	1.90	-5.77	1.78
600	-7.25	2.03	-5.22	1.80
620	-5.91	2.03	-3.88	1.80
640	-4.89	2.19	-2.70	1.71
660	-4.21	2.15	-2.06	1.78
680	-3.88	2.09	-1.79	1.76
700	-3.33	2.05	-1.28	1.72

In summary, the spectrophotometric method to be described is not intended to replace visual evaluation or other physical methods of analysis required, but it can give additional analytical information and has been found to be very valuable in the study of the behavior of a paint system under various exposure conditions. Comparison of exposure results obtained in various accelerated tests with outdoor exposure tests, for example, cannot reliably be made unless results "are supported by evidence of the determination having been produced by similar degradation mechanisms."¹¹

An indication that the type of chemical deterioration mechanism(s) which had contributed to the observed physical changes is associated with a specific component(s) of the formulation is the similarity in the type and magnitude of the various changes measured. For example, a consistent loss in gloss in the presence or use of a particular vehicle system, regardless of its pigmentation, is strong evidence that the vehicle system is the primary reason for gloss loss and not any other particular component of the system.

METHOD—GENERAL CONCEPT

The method to be described is based on the assumption that the total hemispherical reflectance can be measured, i.e., both specular (mirror-like) reflectance, (SCI), as well as the diffuse reflectance alone, (SCE). Generally, a color measuring instrument using an integrating sphere for the measurement head is used.

The following description of the calculated types of changes are based on washed panel measurements as compared to original samples kept in the dark and not exposed. If the color change under the flap is desired, it can be handled in a like fashion and a comparison calculated of the unexposed sample relative to the exposed sample. Measurement of the washed and unmasked areas may also be made to measure dirt accumulation and chalking.

The SCI measurement (total reflectance measurement) is not greatly affected by surface characteristics,

because all the reflected light is included in the measurement, both that reflected from the surface and that reflected from inside the film. Whether light reflected from the surface is scattered, as is the case of a matte surface, or whether it is reflected specularly as is the case of a glossy surface, the total reflectance, (SCI), as an approximation for small changes on glossy samples, remains the same. Therefore, comparison of the data measured on exposed, as compared to the unexposed material, will reveal any pigment and resin color change (i.e., compare R_D^T with R_D^U).

On the other hand, the SCE measurement (diffuse reflectance measurement), is affected by the changes in the surface reflectance as well as by the pigment and vehicle color changes. In the SCE measurement, the narrow cone of light reflected specularly (at the angle equal and opposite to the incident angle) is absorbed by a black light trap or reflected back into the instrument, depending on sphere design. If a loss in gloss has occurred, so that more surface reflectance is diffuse, this surface-scattered light will be included in the diffuse reflectance measurement and integrated with the diffusely reflected light from inside the film. Visually, this would be interpreted as a part of the color change, probably as fading. Comparison of the SCE data, exposed to unexposed, will reveal the total visual changes that have occurred (i.e., compare R_D^T with R_D^U).

The portion of the observed color changes which is caused by changes on the surface can be described in terms of the change in the specular (mirror-like) reflectance. The magnitude of the specular reflectance from the surface of the sample can be calculated by subtracting the diffuse reflectance measurement from the total reflectance measurement ($R^T - R^D = S$). The specular reflectance determined in this way depends upon the specific optical geometry in the instrument used in making the measurements. For example, the Trilac¹² uses 8° incidence, the G.E.R.S. (Hardy) uses 6° incidence and their specular reflectance would correspond to four percent for a glossy material of 1.5 refractive index. If the incident light was 45°, the specular reflectance should be five percent of the total incident light for the same material.¹³

Table 4—Yellow #1 Tristimulus Data

	X	Y	Z
Unexposed (SCE)	60.78	57.33	15.58
Exposed and cleaned (SCE)	57.78	54.43	17.88
Adj. only for pigment and veh. change (SCE)	55.86	52.62	15.38
Adj. only for film surface change (SCE)	62.70	59.13	18.07
Adj. only for cleaning effect (SCE)	62.64	59.24	18.34

Components of Color Difference: FMC 2 Equation

Change	ΔRG	ΔYB	ΔC	ΔL	ΔE
Film surface	-2.51	-5.15	5.73	2.49	6.25
Pigment and vehicle	-0.90	-2.77	2.91	-6.47	7.10
Total	-3.50	-7.94	8.68	-3.97	9.55
Cleaning	-3.99	-5.79	7.04	2.59	7.50

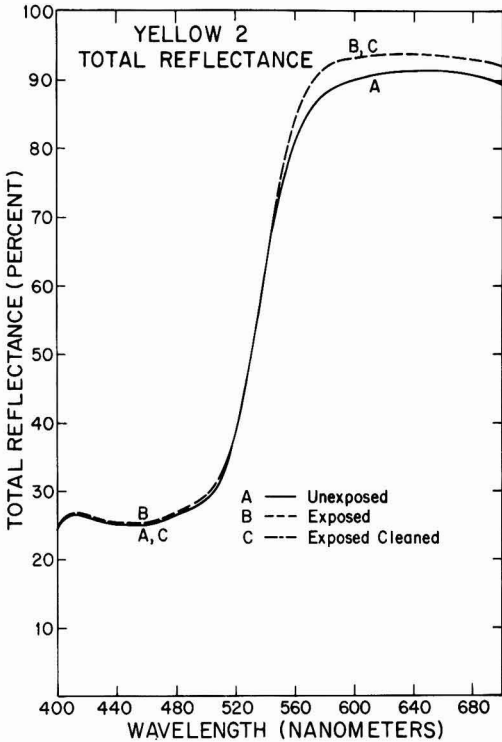


Figure 5—Spectrophotometric curves of the total reflectance (SCI) from Yellow 2, measured before exposure, A, after exposure but before cleaning, B, and after cleaning, C

Comparison of the specular component of the exposed sample to the unexposed sample will reveal the change in the surface which has occurred (e.g., compare S_U with S_C). The differences calculated above are algebraically added to the diffuse reflectance measurement on the unexposed standard, thus isolating each effect and giving uniform color difference calculations.

The effect of pigment and vehicle color change is calculated as follows.

$$\begin{aligned}
 PC &= R_U^T - R_C^T \\
 APC &= R_U^D + PC \\
 \text{Compare} & \quad APC \text{ to } R_U^D
 \end{aligned}
 \tag{1}$$

The effect of the film surface change is calculated by:

$$\begin{aligned}
 S_U &= R_U^T - R_U^D \\
 S_C &= R_C^T - R_C^D \\
 \Delta S &= S_U - S_C \\
 ASC &= R_U^D + \Delta S \\
 \text{Compare} & \quad ASC \text{ to } R_U^D
 \end{aligned}
 \tag{2}$$

If information about chalking or dirt accumulation is desired, a similar analysis can be made by measuring the diffuse reflectance of the samples before and after cleaning, thus determining the effect of the material which was removed. Quantitatively, the direction of the change indicates whether chalking is predominant (sample is darker after cleaning), or dirt accumulation is predominant (sample is lighter after cleaning).

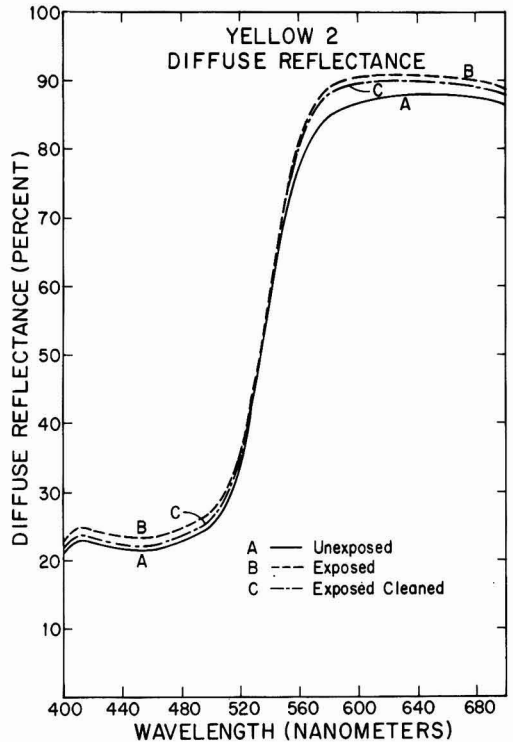


Figure 6—Spectrophotometric curves of the diffuse reflectance (SCE) from Yellow 2, measured before exposure, A, after exposure but before cleaning B, and after cleaning, C

The effect of cleaning is calculated by:

$$\begin{aligned}
 CC &= R_U^D - R_C^D \\
 AC &= R_U^D + CC \\
 \text{Compare} & \quad AC \text{ to } R_U^D
 \end{aligned}
 \tag{3}$$

DATA ANALYSIS

For more complete analysis of exposure effects, interpretations of the data are necessary and should be supplemented by careful visual evaluations.

Surface Change

If a large change in specular reflectance (S) is found, indicating a large change in the surface of the exposed sample, additional information should be obtained for further analysis. The chromaticity coordinates can be calculated for the specular reflectance of both unexposed (S_U) and exposed samples (S_C). If bronzing or selective reflectance has occurred, there will be a definite change in the chromaticity coordinates of the exposed specular reflectance compared to the coordinates of the unexposed. If the chromaticity coordinates of the specular component remain the same, or nearly so, then the major change is caused by gloss differences. Gloss measurements should be made at angles appropriate to the type of surface.

Table 5—Yellow #2 Percent Reflectance Data

Wavelength	PC (Pigment & Vehicle Change)	ΔS (Film Surface Change)	TC (Total Changes or PC+ΔS)	CC (Cleaning Change)
400	0.10	0.50	0.60	1.18
420	0.19	0.60	0.79	1.17
440	0.29	0.45	0.74	1.19
460	0.33	0.40	0.73	1.18
480	0.44	0.33	0.77	1.12
500	0.61	0.19	0.80	1.10
520	0.78	0.17	0.95	1.04
540	0.99	0.13	1.12	1.07
560	2.62	-0.03	2.59	0.99
580	3.52	-0.04	3.48	0.88
600	3.15	-0.24	2.91	0.99
620	2.68	-0.32	2.36	0.94
640	2.32	-0.31	2.01	0.78
660	2.20	-0.49	1.71	0.88
680	2.09	-0.42	1.67	0.91
700	2.22	-0.62	1.60	0.81

Pigment and Vehicle Change

When it can safely be assumed that the vehicle is highly stable in color, the calculated changes in pigment and vehicle based on SCI measurements are assumed to be pigment changes alone. A further check on this conclusion can be made by computing the changes necessary to make the exposed sample match the unexposed sample, using a computer color matching program. If it is found that yellow must be subtracted from the exposed sample, the possibility of resin yellowing must be considered. The magnitude of the pigment change can be at least semi-quantitatively determined.

Cleaning Change

If the SCE luminous reflectance of the cleaned exposed sample compared to the uncleaned exposed sample is higher (i.e., the reflectance is higher at all wavelengths), the assumption can be made that dirt was the major material removed from the surface. Conversely, if the luminous reflectance is lower after cleaning, the assumption can be made that chalk was the major material removed from the surface. This effect can be checked by using computer color matching to calculate the change in pigmentation required to match the uncleaned exposed panel. If white (and possibly other colorants used in the coating) must be added, chalking has occurred; if black has to be added, dirt accumulation has been removed; if both black and white (plus possibly other colorants) have to be added, both chalking and dirt accumulation have probably occurred.

EXPERIMENTAL DETAILS

All measurement data, presented or used in this paper, were obtained using a Trilac spectrophotometer. All samples were measured relative to BaSO₄. The three vehicle systems used, alkyd-melamine, thermosetting acrylic, and thermoplastic acrylic, were of automotive quality. Two methods of exposure were

used (Florida and EMMAQUA). The exposed samples were washed with water and lightly polished with du Pont #7 Auto Polish Cleaner.

RESULTS

Evaluation I: A/M Vehicle, EMMAQUA Exposure

Two different organic yellow pigments were exposed in EMMAQUA for 200 kilolangley (KLY). The vehicle used was an alkyd-melamine automotive enamel and the relative concentration of the yellow pigments were both 10% with 90% TiO₂. In order to perform the analytical exposure evaluation described above, the reflectance curves were measured on the original panels and on the exposed panels (before and after gentle polishing). Measurements were made with the specular component included (SCI) and excluded (SCE). The spectrophotometric curves are illustrated in Figures 3-6.

From an examination of the changes in the SCI measurement of yellow #1, Figure 3, it is apparent that the pigment has darkened on exposure (absorption maximum is relatively unchanged in reflectance, e.g., % R at 440 nm, while the reflectance maximum has decreased, e.g., % R at 640 nm). Careful comparison of Figures 3 and 4 (SCI and SCE measurement) indicate that yellow #1 showed a decrease in gloss (e.g., % R at 600 nm of SCI minus SCE measurement is less after exposure than before). For Figure 3, also the evidence of chalking is apparent (e.g., % R at 660 nm drops after polishing). Visual examination readily confirms the darkening of the exposed panel and a slight loss in gloss.

From an examination of the changes in the SCI measurement of yellow #2, Figure 5, it is apparent that the pigment has faded on exposure (absorption maximum has increased slightly in reflectance, e.g., % R at 450 nm, and the reflectance maximum has increased, e.g., % R at 640 nm). Careful comparison of Figures 5 and 6 (SCI and SCE measurements) indicate that yellow #2 showed only a minor change in gloss.

Table 6—Yellow #2 Tristimulus Data

	X	Y	Z
Unexposed (SCE)	65.24	61.20	22.99
Exposed and cleaned (SCE)	67.41	63.23	23.89
Adj. only for pigment and veh. change (SCE)	67.46	63.22	23.40
Adj. only for film surface change (SCE)	65.20	61.21	23.48
Adj. only for cleaning effect (SCE)	66.21	62.20	24.37

Change	Components of Color Difference: FMC 2 Equation				
	ΔRG	ΔYB	ΔC	ΔL	ΔE
Film surface	-0.92	-1.13	1.46	0.00	1.46
Pigment and vehicle	0.85	0.81	1.18	2.69	2.94
Total	-0.13	-0.31	0.34	2.69	2.71
Cleaning	-1.86	-2.33	2.98	1.30	3.26

Table 7—Yellow #3 Percent Reflectance Data

Wavelength	PC (Pigment & Vehicle Change)	ΔS (Film Surface Change)	TC (Total Changes or PC+ ΔS)	CC (Cleaning Change)
400	-0.38	1.10	0.72	0.98
420	-0.40	1.11	0.71	0.91
440	-0.36	1.03	0.67	0.93
460	-0.39	1.01	0.62	1.01
480	-0.34	0.97	0.63	0.99
500	-0.28	0.91	0.63	0.97
520	-0.30	0.93	0.63	1.00
540	-0.15	0.87	0.72	1.01
560	0.11	0.89	1.00	1.08
580	0.70	0.88	1.58	1.03
600	0.31	1.00	1.31	0.89
620	-5.14	0.94	-4.20	0.10
640	-7.60	0.83	-6.77	-0.52
660	-6.92	0.74	-6.18	-0.71
680	-5.63	0.73	-4.90	-0.77
700	-4.94	0.75	-4.19	-0.71

Evidence of chalking is not apparent in *Figure 5* (i.e., the reflectance does not greatly change after polishing). Visual examination confirms the slight fading of the exposed panel and a very slight loss in gloss.

A summary of the differences in reflectance of yellow #1 is presented in *Table 3*. A decrease in reflectance is indicated by a minus sign. The changes in the pigment or vehicle are obtained from calculating the differences in the reflectance measured SCI of the panel before and after exposure. Differences in the specular reflection (SCI minus SCE) are indicative of changes in surface reflectance (gloss). The total change is obtained from the differences in the reflectance measurements made with the specular reflectance excluded (SCE) and include the effect of differences in the pigment and vehicle as well as changes in the surface or specular reflectance (gloss).

The reflectance differences given in *Table 3* indicate that the panel containing yellow #1 darkened, lost gloss, and showed signs of chalking.

Table 4 gives the tristimulus values of the measured and adjusted reflectances. Color differences from each of the unexposed panels describe the magnitude of the changes in perceptibility terms. Color differences calculated with the FMC^{2,4} equation are given in *Table 5*. The effect of cleaning the panel is also presented as the color difference of the cleaned portion from the uncleaned portion of the panel.

A summary of the differences in reflectance of yellow #2 is presented in *Table 5*. These data indicate that the panel containing yellow #2 faded slightly, changed very little with respect to gloss, and showed some signs of minor chalking. The tristimulus values of the measured and adjusted reflectances are presented in *Table 6*, along with the color differences.

Evaluation II: TPA Vehicle, Florida Exposures

Three more formulations which demonstrate the usefulness of this technique are presented as Evaluation II. These samples were made in an automotive thermo-

Table 8—Sample #3 Relative Formulation*

Sample	Red	Moly	Black	White
Unexposed	20.00	80.00	0.00	0.00
Exposed and cleaned	14.05	80.55	0.09	5.31
Adjusted for pigment change only	15.39	78.05	6.56	0.00
Adjusted for film surface change only	16.71	71.54	0.00	11.75
Adjusted for cleaning effect only	14.85	75.63	0.02	9.02

*These formulations are computer color matches to the five sample types. By comparison of the different sample types, we can gather clues about what has happened to the panel during exposure.

plastic acrylic vehicle (TPA) and exposed in Florida at 5° South.

The first of these is an organic red-molybdate orange mixture at a ratio of 20 to 80 (sample #3). It was exposed in Florida for 18 months. *Table 7* gives a summary of the changes in reflectance that occurred; differences in SCI measurements after cleaning (pigment and vehicle change), differences in specular measurement after cleaning (film surface), and differences in the SCE measurement after cleaning (total change excluding the cleaning effect). The last column shows the difference in reflectance due to cleaning.

The separation of pigment change from film surface change is an important feature of this technique. At most wavelengths on sample #3, these changes were in opposite directions, compensating for each other in the total color difference. Therefore, any analysis which dealt only with the total or cumulative change would not tell the entire story about the changes that actually occurred during exposure. Sample #3 showed an almost uniform change in reflectance from the film surface with respect to wavelength, indicating that there was a loss in gloss and no bronzing.

The difference in reflectance between the uncleaned and cleaned exposed sample tell about the effect of cleaning or what was removed. The change in reflectance is not uniform across the spectrum. Since there was no TiO₂ in the formulation from the curve shape, it can be suspected that some of the red pigment was subsequently removed along with some resin.

A plot of pigment change is, moreover, very interesting. The shape of the curve is reminiscent of a blue shade red pigment in combination with black, but there is no black in the sample, only red and molybdate orange are present. Therefore, the major changes calculated as pigment changes are caused by the loss of red and darkening of the molybdate orange.

Table 9—Sample #3 Components of Color Difference: FMC 2 Equation

Change	ΔR_G	ΔY_B	ΔC	ΔL	ΔE
Film surface	-10.45	-8.61	13.54	1.88	13.67
Pigment and vehicle	-2.57	2.08	3.31	-2.05	3.89
Total	-13.02	-6.52	14.57	-0.16	14.57
Cleaning	-12.34	-8.81	15.17	1.60	15.25

Table 10—Yellow #4 Percent Reflectance Data

Wavelength	PC (Pigment & Vehicle Change)	ΔS (Film Surface Change)	TC (Total Changes or PC+ ΔS)	CC (Cleaning Change)
400	-0.50	1.80	1.30	0.40
420	0.72	1.50	2.22	0.99
440	1.33	1.40	2.73	1.81
460	1.25	1.30	2.55	2.04
480	1.10	1.22	2.32	2.09
500	1.00	1.17	2.17	2.06
520	0.90	1.10	2.00	1.99
540	0.89	1.01	1.90	1.91
560	0.87	0.86	1.73	1.89
580	0.11	0.90	1.01	1.39
600	-1.98	1.07	-0.91	0.26
620	-3.52	1.13	-2.39	-0.89
640	-4.01	1.12	-2.89	-1.50
660	-3.68	0.97	-2.71	-1.71
680	-2.81	0.85	-1.96	-1.78
700	-1.80	0.80	-1.00	-1.83

Table 12—Sample #5 Percent Reflectance Data

Wavelength	PC (Pigment & Vehicle Change)	ΔS (Film Surface Change)	TC (Total Changes or PC+ ΔS)	CC (Cleaning Change)
400	7.49	1.51	9.00	2.00
420	8.55	1.62	10.17	2.22
440	7.88	1.53	9.41	2.02
460	6.58	1.27	7.85	1.43
480	5.04	1.09	6.13	0.92
500	5.16	1.06	6.22	1.02
520	6.47	1.26	7.73	1.60
540	7.09	1.30	8.39	2.11
560	6.91	1.26	6.91	2.30
580	6.41	1.32	7.73	2.32
600	6.01	1.20	7.21	2.18
620	5.52	1.25	6.77	2.11
640	5.10	1.19	6.29	2.01
660	4.66	1.29	5.95	1.89
680	4.42	1.16	5.58	1.81
700	4.10	1.13	5.23	1.67

The reflectance data related to the various changes, coupled with a computer color matching program and a data library provides both additional information and the opportunity to express the changes in pigment concentration terms.

In Table 8 are given the concentration of pigments required to match the reflectances of the original unexposed panel altered by the differences attributable to each of the isolated effects given in Table 7. For example, if the only change which occurred was the change in pigment concentration, the resulting color would require 15.39% of red, 78.05% of molybdate orange and 6.56% black, confirming the examination of the difference curve described above. These concentrations were calculated using a two-constant computer color matching program.

The film change indicates a loss in gloss. This loss in gloss is now translated into the amount of white that would be necessary to add to a formula to compensate for this effect (i.e., contaminate a sample to achieve the same optical effect by compensation).

A close look at the total change (exposed and cleaned) shows the cumulative effect of pigment and film surface change. This illustrates the need to separate the changes which occur on exposure, because the pigment change and the film surface change were in opposite directions.

The cleaning effect shows that gloss is improved by cleaning and that some pigmentation was also removed along with the dirt accumulation. This data confirms the loss of the red pigment and that there was chalking.

The separation of various components of the observed total change is very helpful in understanding the entire exposure story. Because the film surface and the pigment change were in opposite directions, the total change does not tell the complete story. The color differences attributed to each type of change are given in Table 9.

The second example of pigments in an automotive thermoplastic acrylic vehicle (TPA) is a mixture of 25% of an organic red mixed with 75% rutile TiO₂; sample #4; exposed for 12 months 5° South in Florida. A summary of the reflectance differences is given in Table 10 and the corresponding color difference data are in Table 11. The results of the analytical exposure evaluation show: (1) the change in the film surface is a loss in gloss; (2) the change in pigmentation (assuming the vehicle is stable), is a loss of both colorants; and (3) the cleaning effect shows the removal of the red pigment along with the TiO₂, as well as some dirt accumulation.

The third example of pigments in an automotive thermoplastic lacquer (TPA) is a mixture of 25% of a phthalo blue mixed with 75% rutile TiO₂, sample #5, exposed for 12 months, 5° South in Florida. A summary of the reflectance differences is given in Table 12 and the corresponding color difference data are in Table 13. The results of the analytical exposure evaluation show: (1) the change in film surface is a loss in gloss; (2) the pigmentation change is a loss of both colorants (however, the loss of TiO₂ predominates); and (3) the cleaning effect shows the removal of the blue pigment along with TiO₂ and possible dirt accumulation. Note that the

Table 11—Sample #4 Components of Color Difference: FMC 2 Equation

Change	ΔRG	ΔYB	ΔC	ΔL	ΔE
Film surface	- 5.56	-3.75	6.70	2.02	7.00
Pigment and vehicle	-10.35	4.64	11.35	-0.55	11.36
Total	-16.03	-8.38	18.09	1.47	18.15
Cleaning	-14.11	-4.92	14.94	2.24	15.11

Table 13—Sample #5 Components of Color Difference: FMC 2 Equation

Change	ΔRG	ΔYB	ΔC	ΔL	ΔE
Film surface	9.17	2.13	9.41	3.82	10.16
Pigment and vehicle	42.71	10.94	44.09	19.22	48.22
Total	51.91	13.09	53.54	23.33	58.40
Cleaning	16.95	4.68	17.58	5.98	18.57

Table 14—Components of Color Difference: FMC 2 Equation

Change	ΔR_G	ΔY_B	ΔC	ΔL	ΔE	Sample
Surface	-0.63	-0.45	0.77	0.44	0.89	Inorganic gold
Pigment and vehicle	1.25	-0.74	1.46	-2.28	2.71	
Total	0.62	-1.20	1.35	-1.84	2.29	
Surface	-2.80	-4.17	5.03	1.78	5.33	Yellow/Gold 50/50
Pigment and vehicle	0.69	-2.60	2.70	0.17	2.70	
Total	-2.10	-6.78	7.10	1.95	7.37	
Surface	-1.96	-5.22	5.57	2.50	6.11	Yellow
Pigment and vehicle	-0.12	-2.27	2.27	0.82	2.42	
Total	-2.08	-7.49	7.77	3.32	8.46	
Surface	1.55	-3.67	3.99	2.98	4.98	Yellow/Blue 75/25
Pigment and vehicle	2.10	-2.70	3.42	0.42	3.45	
Total	3.65	-6.38	7.35	3.40	8.10	
Surface	4.00	-3.16	5.10	3.01	5.93	Yellow/Blue 25/75
Pigment and vehicle	1.92	-4.09	4.50	0.44	4.54	
Total	5.92	-7.25	9.37	3.46	9.99	
Surface	4.15	0.74	4.22	1.69	4.55	Blue
Pigment and vehicle	10.59	6.07	12.21	2.52	12.47	
Total	14.75	6.81	16.25	4.22	16.79	

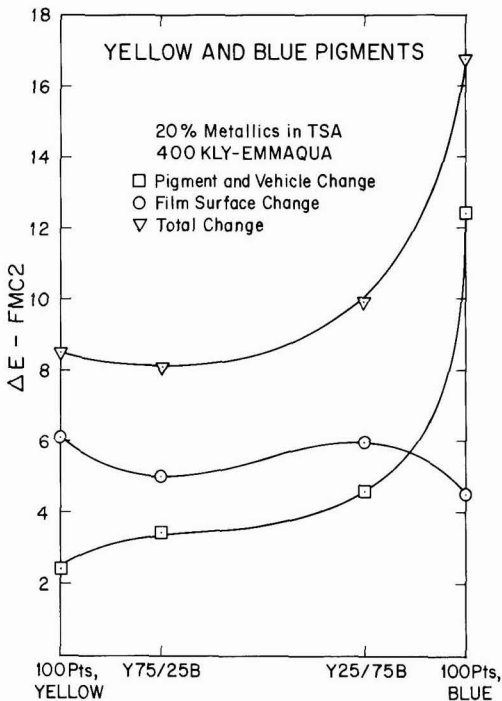


Figure 7—Color change, ΔE (FMC2, Illuminant C), attributable to two types of changes isolated from the total visual change after cleaning for a yellow, a blue, and mixtures of the two. All were mixtures of 20% nonmetallic pigment with 80% aluminum pigment, in a thermosetting acrylic automotive enamel. The panels were exposed in EMMAQUA for 400 kilolangleys

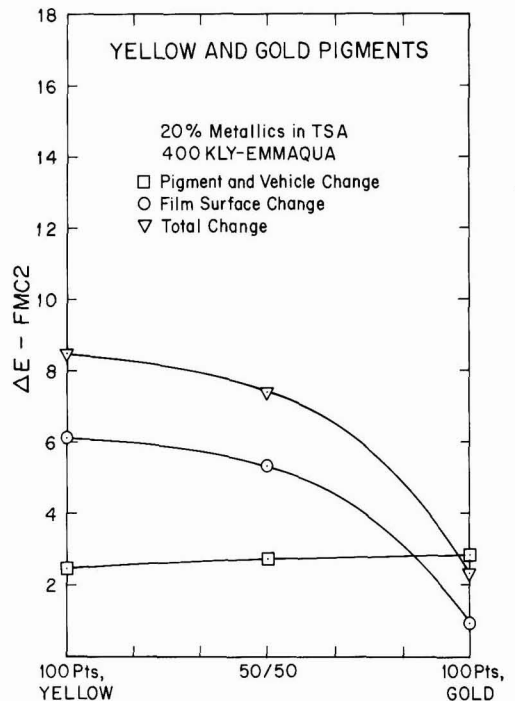


Figure 8—Color change, ΔE (FMC2, Illuminant C), attributable to two types of changes isolated from the total change after cleaning for a yellow, a gold, and a mixture of the two. All were mixtures of 20% nonmetallic pigment with 80% aluminum pigment, in a thermosetting acrylic automotive enamel. The panels were exposed in EMMAQUA for 400 kilolangleys

changes in the film surface and in the pigment-vehicle change are in the same direction, i.e., both increase the reflectance, so the total change is higher than either of the effects alone.

Evaluation III: TSA Vehicle, EMMAQUA Exposures

The panels evaluated in this section were exposed in EMMAQUA for 400 KLY. Visual evaluation of the panels showed that there were nonuniform changes in gloss after exposure. Water spotting appeared to be minimal and not uniform over the surface of the panel.

In Table 14, the formulations for six metallic samples made in automotive thermosetting acrylic enamel (TSA) are described. All the paints contained 80% aluminum pigment and 20% chromatic pigments. Table 14 also gives the results of EMMAQUA exposure broken down into surface, pigment, and total change.

The total color difference ($\Delta E - FMC2$) for the yellow and blue are plotted as a function of concentration of each on Figure 7. The surface change, within probable experimental error, is reasonably constant. The color differences calculated by the pigment change for the combinations of yellow and blue, fall between the differences for the individual pigments.

The total color different ($\Delta E - FMC2$), for the yellow and gold are plotted on Figure 8. The amount of difference attributable to pigment change was reasonably constant. The color difference caused by the surface change of the combination falls between the difference found for each individual pigment.

The example of the blue-yellow mixture shown in Figure 7 suggests that if the change in the individual pigments of a mixture are known, the change in the mixture will probably lie between these extremes. Note that the differences calculated for pigment change shown in Figure 8 for the yellow and gold also follow this general principle. Generally, within experimental error, differences calculated for pigment change of any mixture so far encountered follow this principle. One can assume that if a mixture behaves very differently, an interaction or synergistic behavior is occurring or that errors have been made.

CONCLUSION

The usefulness of this analytical technique has been demonstrated in several vehicle systems (A/M, TSA, and TPA), with different pigments and pigment combinations at various levels (metallics, masstone, and tints) and exposed by two different methods (Florida and EMMAQUA). This analytical exposure analysis technique has been applied to many exposure panels studied in the CIBA-GEIGY laboratory. Results have been extremely valuable, assisting in visual evaluations by quantifying changes occurring in the pigment, vehicle, and surface (gloss, bronzing, chalking, dirt accumulation, etc.). Thus, the method aids in learning and understanding the factors affecting the performance of pigmented materials. The authors hope that others will test this approach for objective evaluations of exposed pigmented materials. □

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ERRATA

The captions for Figures 2 and 3 appearing on page 60, of the December 1976 *JCT* should have read:

Figure 2—Infrared spectra (4000 cm^{-1} — 2500 cm^{-1}) for linseed oil film after 3 days and 10 days drying at $23 \pm 1^\circ\text{C}$

Figure 3—Infrared spectra (4000 cm^{-1} — 2500 cm^{-1}) for linseed oil film made $10^{-3}M$ in $\text{Cu}(\text{acac})_2$ after 3 days and 10 days drying at $23 \pm 1^\circ\text{C}$

Method for Measuring Chalk Adhesion of Latex Paints

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Chalk adhesion test methods and substrates over which chalky surface adhesion may be tested are reviewed and critiqued. A testing procedure is described that includes the preparation of a standard chalky test surface and an adhesion test method which, when combined, produce quantitative, reproducible adhesion data. Chalk adhesion data is presented for commercial and experimental latex house paints, latex paints formulated with and without alkyd modification and similar unmodified paints formulated with latices designed to improve chalky surface adhesion.

Correlation of these direct, intercoat adhesion measurements with actual exterior performance is pending generation of test fence data on paints now on exposure.

KEY WORDS: Latex paint; Chalk adhesion; Alkyd modification; Chalky test substrates; Adhesion tests.

INTRODUCTION

Since latexes were first employed as binders for house paints, it has been realized that their adhesion to weathered, chalky finishes is inferior to that of their oil-based counterparts. The formulation technique usually employed to improve chalk adhesion of latex paints is alkyd modification, i.e., incorporation of an alkyd resin in the aqueous paint by emulsification.

In the past, alkyd resins were less expensive than latex solids and they were frequently used in far greater quantities than required for adequate adhesion as a means of reducing the raw material cost of the product. For example, the alkyd content of commercial latex paints purchased in early 1974 was as high as 63% of the binder. With the excellent adhesion expected from high levels of modification, there was no critical need for a test method to accurately measure chalk adhesion.

Recently, the cost of alkyd resins used for this purpose has increased to the point that there is no longer an economic incentive for their use in latex paints, particularly when considering the deleterious effects they have on paint performance (e.g., reduced exterior durability, tint retention, and chalk resistance). In addition to the

cost-performance considerations, alkyd resins also increase the mildew sensitivity of latex paints, another important reason for carefully scrutinizing their use, considering the likelihood that future legislation will prohibit the use of mercurial mildewcides in trade sales products. As a result, paint formulators now tend to use the minimum quantity of alkyd modifier necessary to impart a sufficient level of adhesion.

However, the question of what level of alkyd modification is required to achieve adequate chalk adhesion (or, for that matter, if modification is required at all) is of major concern in the paint industry today and involves an aspect of latex paint formulation in which there is an obvious difference of opinion. This is illustrated by the broad variation in the formulations of current latex house paints; most contain some alkyd, usually in the range of 10 to 30% of the binder, while several others are completely unmodified. This variation is attributed to a difference in judgment of paint makers regarding the relative importance of chalky surface adhesion and the extent to which other paint properties should be sacrificed to assure early paint failure is avoided when repainting chalky, weathered finishes.

The major barrier to resolving these uncertainties has been the previous unavailability of a reliable test method for determining the subject paint property. The authors have developed a test procedure by which quantitative adhesion data can be obtained. This technique involves a tensile measurement of the force required to separate the latex topcoat from the chalked undercoat and is therefore a fundamental and direct measure of intercoat adhesion.

As an integral part of the test procedure, a method is described for rapidly generating a reproducible and uniform chalky test surface by exposure of a standard chalking latex paint in a Weather-Ometer®.

In the search for a meaningful test, many of the techniques that have been employed by others were examined. The general observations made by the authors regarding merits and weaknesses of the various chalk substrates and adhesion tests investigated will be briefly discussed along with the procedures finally chosen for use with the chalk adhesion test described.

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Table 1—Chalk Substrate Types

Chalk Type	Method of Chalk Formation
Natural	Conventional exterior paints exposed to exterior weathering
Accelerated natural	Fast-chalking paints exposed to exterior weathering
Synthetic	Fast-chalking paints exposed to accelerated, artificial weathering
Artificial	Deposition of a pigment layer from a binder-free aqueous pigment dispersion

CHALK TEST SURFACE DEFINITIONS

There are two critical elements of a chalk adhesion test procedure that must be rigorously specified to obtain meaningful and reproducible adhesion data; (1) the chalky surface on which adhesion tests are to be conducted and (2) the method employed for measuring adhesion.

Several different types of test surfaces have been used in testing for chalk adhesion, but there is no general agreement on the terms used to describe these various chalk types. As a result, the same designations are at times used to describe quite different chalk types while, on the other hand, similar types are referred to variously.^{1,4,6,7} The designations listed in Table 1 will be used in this paper and are suggested for general use in describing the different types of test media that may be employed in chalky surface adhesion studies.

It is recognized that a broad range in paint formulation exists within any class of chalky paint listed and, in some extreme cases, a particular formulation may be placed in one class by one individual and the same formulation classified differently by someone else. Furthermore, there may be justification and need to subdivide some classes of chalk listed according to a specific characteristic of the paint from which the chalk was derived (e.g., gloss vs. flat paint, alkyd vs. latex vehicle, etc.).

ADVANTAGES AND DISADVANTAGES OF DIFFERENT TEST SURFACES

When conducting chalk adhesion measurements, one could exclusively use natural chalk and avoid the uncertainties of using substitutes. However, there are valid reasons for using simulated natural chalk for routine testing. The experimental adhesion data presented in this paper will demonstrate the need to employ relatively heavy chalk to detect measurable differences in chalk adhesion of typical latex house paints. Several years of conventional exterior exposure is usually required to develop sufficiently heavy chalk on typical house paints. Due to the time and expense involved in preparing routine test surfaces by this procedure, natural chalk is not considered practical for routine adhesion testing, and other means of preparing chalk test substrates must be employed.

Regardless of the test surface finally chosen for routine testing, it is mandatory that the adhesion data obtained is capable of being correlated with adhesion to

natural chalk. There is evidence that even the type TiO_2 employed in the paint influences the microstructure of the chalk formed.³ Major deviations from common practice in the formulation of the chalking paint may therefore result in chalk morphology that is quite different from that encountered in reality, and adhesion to such substrates cannot be assumed to be representative of that obtained over natural chalk in the absence of supporting data.

Accelerated natural chalk is probably the most common test substrate employed in the paint industry for chalk adhesion studies.^{4,6,7} Usually, the anatase/rutile TiO_2 ratios and/or the pigment volume concentration (PVC) of the chalking paint is increased above that of a conventional latex house paint to increase the chalk rate and reduce the time required for the generation of test panels. However, unless fast-chalking paint formulations are significantly different than conventional paints, up to one year's exposure time may still be required for development of sufficiently heavy chalk. With such drastic deviation from typical formulation practice, the nature of the chalk formed may be sufficiently different from that of natural chalk to cause major deviation in adhesion of latex top coats relative to that obtained over natural chalk.

Several different approaches have been taken to simulate the chalk that accumulates on the surface of a paint as it experiences binder degradation. Artificial chalk is most usually prepared by application of a binder-free, aqueous pigment dispersion to a rigid substrate.^{1,4} The principal experimental barrier encountered in the preparation of a suitable test surface with this technique is the difficulty of adequately controlling the thickness and uniformity of the dry pigment layer applied. When attempting to prepare a uniform test surface, usually a much thicker accumulation of chalk is obtained than is desired. Use of such unusually heavy chalk (e.g., approximate chalk rating of 1) significantly

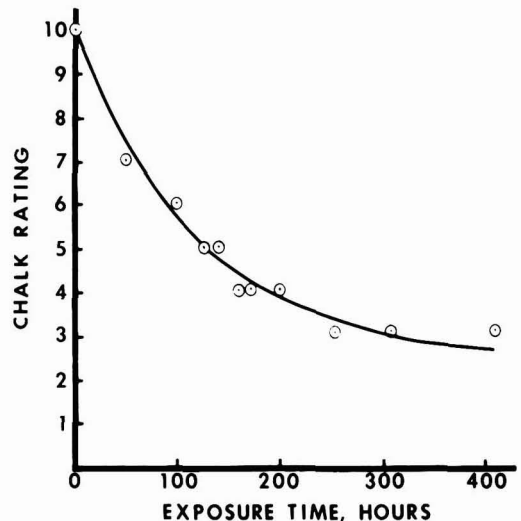


Figure 1—Chalk development of a fast-chalking vinyl-acrylic latex house paint in a carbon arc Weather-Ometer

reduces the base adhesion level for latex paints and therefore decreases the ability to detect moderate but significant changes in chalk adhesion. Under these conditions, highly alkyd modified latex paints, which are expected to have excellent chalk adhesion, are only marginally superior to similar unmodified paints and moderate changes in adhesion expected to accrue from variation in latex paint formulas cannot be detected.

Also, inherently poor control of chalk thickness uniformity on each test panel and the inability to obtain reproducible panel-to-panel average chalk depth results in poor reproducibility of adhesion measurements over artificial chalk.

In addition to these experimental difficulties, there are conceptual criticisms of artificial chalk that discourage its use. Water-soluble or dispersible ingredients common to latex paints (e.g., thickeners, dispersants, surfactants, etc.) are commonly employed in the aqueous pigment dispersion from which artificial chalk is prepared. Due to the combined effects of leaching and erosion occurring with the long-term exposure required for the generation of heavy chalk, these materials will not be present in natural chalk. However, with artificial chalk all nonvolatile ingredients in the aqueous pigment dispersion will remain in the pigment layer after evaporation of the volatiles and will be present in the chalk matrix during subsequent paint application and adhesion testing. Furthermore, the morphology of the pigment layer formed by solvent evaporation is certain to be much different than that formed in natural chalk by binder degradation of the paint film.

These conceptual deviations from natural chalk, when coupled with the experimental difficulties encountered in its preparation, preclude the use of artificial chalk as a meaningful test surface since other methods are available for generating test surfaces quickly.

PROPOSED TEST SURFACE

The test substrate the authors refer to as synthetic chalk is formed by the same binder degradation process that occurs in the formation of natural chalk, except that chalking takes place in an accelerated, artificial environment. The term synthetic is used here in the same sense in which it is generally used in the chemical industry to indicate a material produced by a synthetic process but which is essentially identical to one produced by a natural process.

The synthetic chalk used in this work is derived from a fast-chalking, vinyl-acrylic latex house paint which has experienced Weather-Ometer exposure to produce chalk. A complete description of the chalking paint formulation, special test panel preparation steps, and Weather-Ometer exposure variables and techniques employed are given in the test method procedure described in Appendix B.

The chalk rate of this paint in the Weather-Ometer is shown in Figure 1. Chalk ratings in this rate study and all other ratings reported in this paper were obtained with the Jacobsen Chalk Tester using the rating procedure supplied with this device.⁵ Other techniques of

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rating chalk were investigated but none were found to be capable of detecting when moderate changes occur in the heavy level of chalk required for observing differences in chalk adhesion of latex paints.

Chalk adhesion studies reported below demonstrate that a chalk rating near 4 is necessary to readily detect differences in chalk adhesion of latex paints. This level of chalk is obtained in approximately 170 hr of Weather-Ometer exposure with the subject fast-chalking paint. Including the time required for panel preparation, chalking paint dry time and Weather-Ometer exposure, heavy chalk panels can be available for adhesion testing three to four weeks from the time test panel preparation is initiated.

In addition to the advantage of providing routine test surfaces rapidly, this technique of producing chalk allows superior control over the depth of chalk developed and results in excellent reproducibility of adhesion data. Adhesion studies that follow demonstrate the dramatic dependence of latex topcoat adhesion on the extent of chalk accumulation on the test substrate; a ± 1 unit variation in chalk rating can produce a three-fold change in adhesion. With natural and accelerated natural chalk, one must rely on a crude, subjective chalk rating technique for definition of the chalk level. Experience has shown that the variation in chalk rating between individuals using different rating techniques may be as high as ± 2 units (e.g., chalk rating range of 2 to 6) while the reproducibility may be no better than ± 1 unit for any operator using a single rating method. With this variation in assessment of chalk rating, dramatic variation in chalk adhesion over natural chalk can result from the uncertainty of defining the chalk level of the test surface.

With synthetic chalk, the chalk level of the substrate is regulated by the length of time the chalking paint has experienced exposure in the Weather-Ometer. Excellent reproducibility of adhesion data over synthetic chalk developed from exposure for a standard time period confirms reproducibility of the chalk depth.

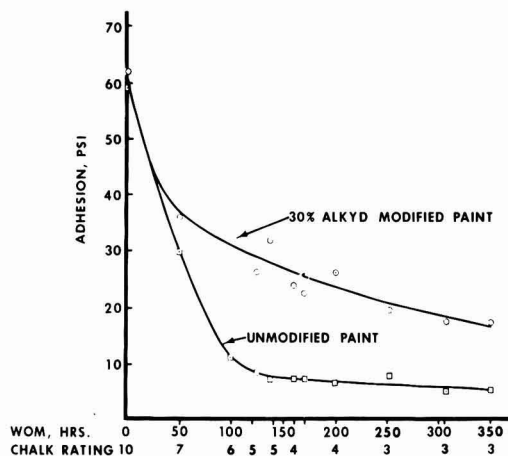


Figure 2—Adhesion of latex house paint topcoats as a function of chalk accumulation on the undercoat

Note the use of steel panels in the preparation of the standard chalk test surface. This substrate material is employed to allow adhesion testing of latex paints over a wide range of chalk level. Testing over wooden panels is restricted to chalk levels of 4 or heavier to avoid tensile failure of the wood that negates the adhesion test. It should therefore be possible, if desired, to use wooden test panels in the development of synthetic chalk provided the standard chalk level described in the test method procedure (170 hr of Weather-Ometer exposure) is employed.

REVIEW OF TEST METHODS

Several different types of tests have been used in the paint industry for directly or indirectly assessing chalky surface adhesion. Most of these tests are based on either a cross-hatch/tape adhesion test, a water treatment of the paint to produce blistering, or a combination of the two.^{4,6,7} Both tests have been investigated in the search for a reliable and meaningful test method.

The tape adhesion test has inherent limitations that restrict the range of intercoat adhesion for which it is useful since it is basically a pass-fail test. If the tape-topcoat adhesive bond is stronger than the intercoat adhesion between the topcoat and chalked undercoat, the latter will fail and give a zero adhesion rating. If the reverse is true, the tape-topcoat adhesive bond will fail and no intercoat failure will be detected. In order to obtain relative intercoat adhesive data, both must partially fail simultaneously. This pass-fail nature of the tape test is illustrated in data reported previously for adhesion as a function of alkyd concentration of modified latex paints.⁷ With from zero to 15% modification, complete (100%) intercoat adhesive failure was observed while at modification levels of 25% or higher, no such failure (0%) occurred. In the narrow band between these two extremes one could expect to detect varying levels of intercoat adhesion but the variability of such data is usually quite high and the actual change in adhesion represented by changes in tape adhesion ratings is undefined.⁹

Blister ratings, obtained on paint films applied to chalky surfaces and subjected to some type of accelerated moisture conditioning, have also been employed as a means of assessing chalk adhesion. The principle weakness of this approach is the difficulty of quantifying blister character and the uncertain relationship of blistering to chalk adhesion. Blister phenomena of latex paints is usually very nonreproducible itself and all attempts to quantify this property have reinforced this observation. The relationship of blistering to chalk adhesion is usually not straightforward; many alkyd modified latex paints have been observed to blister over heavy chalk but retain relatively good adhesion while wet. On the other hand, under identical conditions, certain unmodified latex paints show no visual blistering but adhesion while wet is extremely poor. In addition, one must closely examine the blisters developed to verify that they originate at the topcoat-chalked undercoat interface; blisters may originate in the prime coat of the paint system below the chalked finish and on dirty areas of the substrate on which there is no chalk.

The Early Blister Resistance Test reported in the literature is based on a combination of wet conditioning of latex paints followed by a tape adhesion test.⁶ Multiple coats of the test paint are applied to the natural chalk test surface and the final coat is dried for less than 24 hr. The panels are then subjected to overnight moisture conditioning in a fog box delivering "a fine mist in a volume equivalent to one year's rain." It appears that the conditions employed with this test are over-accelerated. Alkyd modified paints consistently fail by blistering when subjected to the test, whereas alkyd or drying oil modification is a generally recognized formulation technique for imparting chalk adhesion to latex paints despite the deleterious effects these modifiers may have on other paint properties.^{1,2,7}

Various types of mechanical, direct pull tests have been employed for measuring adhesion and cohesion of coating systems.^{4,8,10,11,12} This test may be conducted by cementing one end of a metal device to the coating to be tested and attaching the other end to a tensile testing instrument. Force is applied by the instrument until coating failure occurs and the maximum force recorded is the adhesive and/or cohesive strength of the coating system. Previously, the main failing of this test has been high variability of data, likely resulting from the simultaneous occurrence of adhesive and cohesive failure and the very high levels of adhesion characteristic of coating systems studied. When explored previously in studying chalk adhesion, uncontrolled substrate failure and poor control of instrument variables were among the reasons given for discontinuing its use.⁴

PROPOSED TEST METHOD

The mechanical pull adhesion test is uniquely suited for chalk adhesion studies of latex paints; the general level of topcoat adhesion can be incrementally reduced by increasing the chalk level of the test surface to the point that paint failure will only occur at the topcoat-chalked undercoat interface. This circumvents the high variability that occurs in tensile adhesion data resulting

Table 2—Adhesion of Latex House Paints to Natural Chalk

Undercoat Binder Undercoat Chalk Rating	Linseed Oil 6		Linseed Oil 5		Vinyl-Acrylic 3	
	Unmodified	Modified	Unmodified	Modified	Unmodified	Modified
Latex Topcoat	>140.8	>114.8	26.5	> 88.0	19.5	28.4
	>123.2	>120.4	28.3	> 85.3	20.2	37.0
	> 96.3	>127.6	9.9	> 72.8	18.3	29.6
	>118.7	>117.4	46.9	>120.7	37.9	39.8
	>143.1	>113.2	62.6	>130.1	41.2	44.6
	>115.9	>137.3	46.7	—	22.6	37.9
	—	—	57.3	—	24.1	26.7
	—	—	46.8	—	35.3	38.9
	—	—	50.4	—	28.5	36.8
Average adhesion	>123.0	>121.8	41.7	> 99.4	27.5	35.5
Standard deviation	—	—	16.8	—	8.6	6.0

from a combination of adhesive and cohesive coating failure.

Such a test method has been developed for measuring chalk adhesion of latex paints and has been proposed as a standard ASTM test method. A complete description of the test procedure is given in Appendix B. The adhesion studies that follow were conducted using this test and the synthetic chalk test surface described previously. Chalk adhesion studies reported over wooden substrates utilized the same test method with only a minor modification in the panel mounting procedure required to clamp the beveled wooden test panel in the mounting clamp on the Instron crosshead.

Adhesion Vs. Chalk Level

A study was conducted to determine the synthetic chalk level that provides optimum differentiation in chalk adhesion of typical latex house paints. The adhesion of an unmodified latex paint was compared to that of a paint essentially identical in formulation except 30 volume percent of the latex binder was replaced with a commercial alkyd resin designed for use in latex paints to improve chalk adhesion; the unmodified paint was expected to have poor, and the modified paint excellent, chalk adhesion. The formulations of these paints are given in Appendix A.

The chalk adhesion of these paints as a function of chalk rating of the substrate is illustrated in Figure 2. Each data point shown is the average of eight replicate adhesion measurements. Both paints have good adhesion to chalk ratings of 7 or above, but dramatic differences occur over heavier chalk. Adhesion of the unmodified paint drops precipitously as the undercoat

chalk rating approaches 5, after which little change occurs. In contrast, the rate of adhesion loss with the alkyd modified paint is much lower and is nearly linear in the 7 to 3 chalk range; adhesion of the alkyd modified paint is clearly superior to the unmodified paint within this chalk range.

Adhesion studies of the same latex paints applied to natural chalk show similar dramatic dependence of topcoat adhesion on undercoat chalk level. In Table 2, replicate adhesion data is presented for these paints applied to three levels of natural chalk. When applied to chalk with a 6 rating, no failure occurred at the topcoat-chalked undercoat interface; with all adhesion tests on both paints, the tensile strength of the western red cedar substrate was weaker than any point in the paint system and failure occurred exclusively in the wood. The "greater than" sign in the table indicates cases of wood failure in which the intercoat adhesion is greater than the tensile force recorded for substrate failure.

As the chalk level is increased to a 5 rating, paint intercoat failure occurs only with the unmodified paint, whereas similar paint failure is observed with the alkyd modified paint only at heavier chalk levels.

These studies over natural and synthetic chalk emphasize the need to critically assess the chalk rating over which latex paint adhesion is tested. If light levels of chalk are employed, both modified and unmodified paints exhibit excellent adhesion, while if extremely heavy chalk is used (chalk ratings of 1 or 2), neither paint will adhere well. Therefore, to detect modest changes in paint adhesion, intermediate levels of chalk must be employed and substrate chalk levels must be well defined.

Table 3—Chalk Adhesion of Commercial And Experimental Latexes

Latex Code	Latex Type	Adhesion, psi	Standard Deviation
A	Acrylic interpolymer	8.9	2.5
B	Acrylic	10.7	2.8
C	Acrylic	13.7	2.5
D	Experimental	19.8	2.3

Table 4—Chalk Adhesion Of Commercial Latex House Paints

Paint Code	Modification Level, %	Adhesion, psi	Standard Deviation
A	30.4	12.4	1.7
B	—	11.2	2.0
C	—	10.9	2.4
D	19.9	9.4	2.6
E	—	8.9	2.0
F	11.1	7.5	1.8

Table 5—Reproducibility of Chalk Adhesion Data

Paint Preparation Number	1	2	3	4
	Adhesion, psi			
	9.0	11.5	10.4	12.7
	12.7	11.4	8.5	12.2
	10.1	9.0	7.8	10.6
	10.0	7.3	9.2	11.3
	6.8	9.4	11.5	10.9
	6.3	10.0	11.5	9.9
	8.7	9.8	9.2	8.4
	9.3	10.1	9.5	3.1
Average adhesion	9.1	9.8	9.7	9.9
Standard deviation	2.0	1.3	1.3	3.0

Adhesion Vs. Latex Type

The specific characteristics of the latex employed in the latex paint topcoat can have a dramatic influence on chalk adhesion. Using the unmodified formula listed in Appendix A, several commercial latexes and one experimental latex were employed to determine the effect of latex design on chalk adhesion. Adhesion of these paints to the standard synthetic chalk test surface is shown in Table 3. Latexes A, B, and C are premium quality commercial latexes, the latter was designed for improved chalk adhesion as was experimental latex D. These data illustrate that the latexes specifically designed for improved chalk adhesion demonstrate a 35 to 100% increase in adhesion over the average adhesion of the conventional latexes.

Commercial Latex Paints

Premium quality latex house paints purchased in Charleston, W. Va. during January 1976 were also tested for adhesion to the standard synthetic chalk. In Table 4, the average adhesion and standard deviation are given for 10 to 12 replicate adhesion measurements of each paint, also on synthetic chalk. The modification level indicated by the label analysis is included in the table. Though adhesion generally follows the level of modification, the label analysis of paint C indicates it is unmodified while the extent or nature of modification of paints B and E is not specified.

Adhesion Data Reproducibility

To illustrate the quality of data obtained with the test method and synthetic chalk substrate described, the reproducibility of adhesion data obtained from four separate paint preparations of latex A in Table 3 is presented in Table 5. Each paint was tested at a different time over a two month time interval. Eight replicate adhesion tests were conducted on one test panel for each paint from which average adhesion and standard deviation were calculated for each panel.

CONCLUSIONS

A test procedure has been described for quantitatively measuring the chalk adhesion of latex paints. The significant advantage of the test method is that it pro-

vides a fundamental and direct measure of adhesion. This feature circumvents the operator variables and uncertainties that are characteristic of subjective tests which are inherently variable and are only indirectly related to adhesion.

The general trends in adhesion observed over the proposed routine test surface, synthetic chalk, were likewise observed over natural chalk. The question of why adhesion over natural chalk was generally higher than over synthetic chalk must be experimentally resolved. However, it is likely related to the decrease in tensile strength of synthetic chalk resulting from the higher PVC of the chalking paint formulation compared to that of natural chalk.

Finally, the proposed chalk adhesion test procedure described defines only initial, dry adhesion of the paint being tested. There is now a need to define accelerated paint weathering or conditioning procedures that should be conducted prior to the measurement of adhesion in order to promote early paint failure and simulate the effect of long-term exterior exposure on chalky surface adhesion.

Since the adhesive employed in the adhesion test will polymerize when applied to a damp test paint, a broad range of panel conditioning steps can be employed to accelerate paint failure and still allow the measurement of chalk adhesion immediately upon cessation of accelerated conditioning.

The direct chalk adhesion measurements described above must finally be correlated with test fence data to establish the relationship of intercoat adhesion to actual paint performance. Several of the paints employed in this study are now on exposure for generation of such data. □

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Trademark References

Weather-Ometer	Atlas Electric Devices Co.	Ti-Pure	E.I. duPont deNemours & Co., Inc.
Tamol	Rohm and Haas Co.	ASP	Engelhard Minerals & Metals Corp.
Victawet	Stauffer Chemical Co.	Aroplaz	Ashland Chemical Co.
Igepal	GAF Corp.	Multiprime	PPG Industries, Inc.
Dowicil	Dow Chemical Co.	Minitector	Gardner Laboratory, Inc.
Cellosize, Tergitol, UCAR, and Carbitol	Union Carbide Corp.	Colortrend	Tenneco Chemicals, Inc., Cal/Ink Div.
Horse Head	New Jersey Zinc Co.	Lorite	NL Industries, Inc.

APPENDIX A

Latex Paint Formulations

Latex Paint Type Pigment Grind	Unmodified		Alkyd Modified ^a	
	Pounds	Gallons	Pounds	Gallons
Water	194.3	23.35	194.3	23.35
Drew Y-280	3.0	0.39	3.0	0.39
Tamol [®] 850	5.0	0.50	5.0	0.50
KTPP	1.5	0.10	1.5	0.10
Victawet [®] 35B	7.0	0.70	7.0	0.70
Igepal [®] CTA-639	3.0	0.30	3.0	0.30
Dowicil [®] 100	1.0	0.15	1.0	0.15
Ethylene Glycol	25.0	2.70	25.0	2.70
Cellosize [®] QP-4400	4.5	0.39	4.5	0.39
Horse Head [®] XX-503	100.0	2.14	100.0	2.14
Ti-Pure [®] R-902	275.0	8.24	275.0	8.24
ASP [®] 400	115.0	5.34	115.0	5.34
Let Down				
Igepal CTA 639	2.0	0.23	4.0	0.45
Drew Y-280	2.0	0.23	2.0	0.23
Aroplaz [®] 1271 ^b	—	—	59.1	7.08
Propylene glycol	35.0	4.07	35.0	4.07
Phenyl glycol ethers	11.7	1.30	8.2	0.91
Acrylic latex (53%)	443.5	48.81	310.4	34.16
Water	6.6	0.79	71.0	8.53
NH ₄ OH (28% NH ₃)	2.0	0.27	2.0	0.27
	<u>1237.1</u>	<u>100.00</u>	<u>1226.0</u>	<u>100.00</u>
Weight solids, %		58.50		58.13
Volume solids, %		39.33		39.33
Pigment volume concentration, %		40.00		40.00

(a) Modification Level - 30.0 volume percent of total binder.
 (b) Premix with driers.

APPENDIX B

**Test Method For Determining Adhesion
 Of Latex Paints to Chalky Weathered Finishes**

(1) SCOPE

1.1 This method describes a procedure for determining the adhesion of latex paints to weathered finishes on which a layer of chalk has accumulated. As an integral part of the test method, a procedure is described for preparing a standard test substrate having a controlled layer of chalk on its surface.

(2) SUMMARY OF METHOD

2.1 Standard chalky test finishes are prepared by applica-

tion of a standard vinyl-acrylic latex chalking paint to specially prepared metal test panels. After drying, the paint is subjected to accelerated weathering in a carbon arc Weather-Ometer for a prescribed period of time to generate a controlled layer of chalk.

2.2 The latex paint to be tested for adhesion is applied to the standard chalky test surface. After drying, a stainless steel cylinder is cemented to the test paint and is attached to an

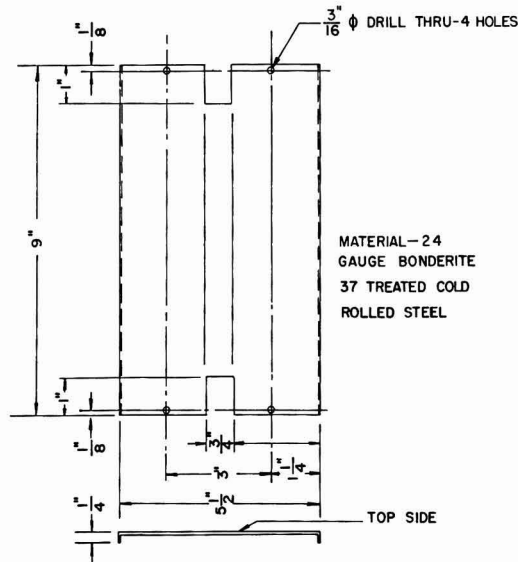


Figure 1—Test panel configuration

Instron tensile testing instrument. Adhesion is determined by measuring the force required to separate the test paint from the chalked undercoat by pulling the cylinder from the test panel with the Instron.

(3) APPARATUS

3.1 Steel test panels, made according to Figure 1, to serve as a rigid substrate on which test paints are applied and adhesion measured. (Steel is the preferred substrate material rather than wood because of more consistent panel-to-panel

surface smoothness and substrate failure is avoided when testing paints with high adhesion).

3.2 Multiprime® (UC-40054) heavy duty vinyl primer and vinyl thinner (UC-40138) as required to spray apply the primer to the above (3.1) unpainted metal test panel.

3.3 Standard chalking latex paint, prepared according to Table 1, which is to be spray applied to the primed metal test panel.

3.4 Paint spray gun for application of primer and standard chalking paint to the metal test panels.

3.5 Magnetic type film thickness gage (e.g., Minitector® GR-6230-A).

3.6 XW Sunshine Carbon Arc Weather-Ometer, equipped with a type VPR specimen rack used as the accelerated environment for developing chalk on the standard chalking latex paint. Black panel temperature is maintained at 140°F and an 18 min water spray period follows 102 min machine operation without water spray. Corex filters are employed and filter replacement is staggered so that one filter is replaced each 300 hr of machine operation (i.e., filters are replaced after a total of 2400 machine hours.)

3.7 Test latex paint (which is to be applied to the standard chalk test surface and tested for adhesion) formulated at 90±5 KU viscosity and 40±1 percent volume solids. Tint the test paint with 1.0 g Colortrend® GP 8811 D thalo green per 100.0 g paint to facilitate identification of the site of adhesive failure.

3.8 Magnetic chuck (5 1/16"×10 1/16"—Brown and Sharpe, Providence, R.I., cat. no. 510-1) for holding metal test panels flat and in place during application of test latex paint.

3.9 Film applicator of such design for application of a 5 mil x 4 3/4" wet film of the test paint over the standard chalk test surface.

3.10 Instron tensile testing instrument (Instron Engineering Corp., Quincy, Mass.) with a CT load cell (5 to 200 pound load range) for determination of paint intercoat adhesion.

3.11 Test panel clamp constructed according to Figure 4 to fasten panel to the Instron crosshead.

Table 1—Standard Chalking Paint Preparation

Ingredient Number	Ingredient	Pounds	Gallons	Pounds 100 Gallons
1	Water	287.99	34.61	383.99
2	Tergitol® NPX	4.0	0.45	5.33
3	Tamol 731 (25%)	8.0	0.87	10.67
4	Tetrasodium pyrophosphate	0.3	0.01	0.40
5	Cosan PMA-30	10.0	0.98	13.33
6	Ethylene glycol	20.0	2.16	26.67
7	Butyl Carbitol® acetate	15.0	1.85	20.00
8	Nopco NXZ	3.0	0.39	4.00
9	Cellosez QP-4400	5.0	0.43	6.67
10	Ti-Pure LW	215.1	6.63	286.80
11	325 Mesh waterground mica	25.0	1.06	33.33
12	Lorite®	100.0	4.72	133.33
13	Aroplaz 1271*	29.1	3.48	38.80
14	UCAR 360 (55%)	156.8	17.36	209.07
		879.29	75.00	1172.39
	% P/C	49.98		
	% Volume Solids	33.11		

Manufacturing Procedure

Charge ingredients 1 through 9 to a high speed disperser. Mix briefly at low speed. Charge ingredients 10 through 12 at low speed then increase speed to 3200 fpm for 20 min; maintain temperature below 53°C. Reduce to minimum speed and charge Aroplaz 1271 in a fine stream. Increase speed to 3200 fpm for five additional minutes. Cool to room temperature then charge latex (ingredient 14) at low speed and mix well.

*Premix with 1.5% of 12% zirconium and 1.5% of 12% cobalt driers.

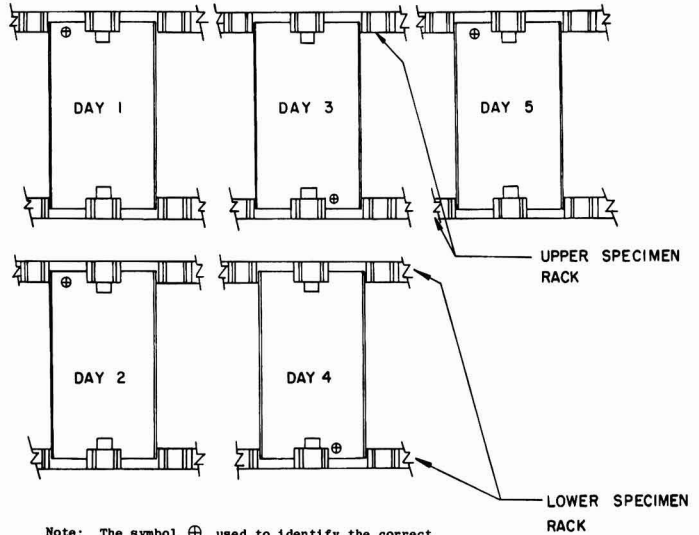


Figure 2—Test panel rotation in the Weather-Ometer

Note: The symbol ⊕ used to identify the correct positioning of the panel on the designated specimen rack

3.12 Adhesion testing cylinder and necessary hardware, shown in Figure 3, required to attach the cylinder to the tensile testing instrument for adhesion measurements.

3.13 5 lb. weight used to calibrate the Instron.

3.14 Rectangular piece of 3/8" thick plywood, 5 1/2" x 10", and four 3/16" diameter machine screws and nuts to serve as a stiffener for the metal test panels.

3.15 Eastman 910 adhesive (Eastman Chemical Products, Inc., Plastics Div., Kingsport, Tenn.) used to cement the adhesion testing cylinder to the surface of the test paint on which chalk adhesion is to be determined.

3.16 500 g weight used when cementing the adhesion test cylinder to the test paint.

3.17 Interval timer required for timing the length of time pressure is applied to the adhesion test cylinder to effect curing of the cement.

3.18 Cheesecloth used in the removal of excess adhesive from the test paint surface after attachment of the adhesion test cylinder.

3.19 7 in. stainless steel spatula, one end rounded, one end square (Fisher Scientific Co., N. Y., N. Y., cat. no. 14-373), to aid in removal of excess adhesive from the test paint surface.

3.20 Sharp knife or single edge razor blade for cutting through the test paint, around the adhesion testing cylinder, just before the adhesion measurement.

(4) PREPARATION OF STANDARD CHALKY TEST SURFACE

4.1 Fabricate metal test panels as described in Figure 1. Remove any burrs of rough edges that may interfere with subsequent draw-down application of the test latex paint. Reduce the vinyl-alkyd primer to spray viscosity with the vinyl thinner specified and spray apply to all surfaces to obtain an average thickness of 0.8±0.2 mils; dry overnight at ambient conditions.

4.2 Reduce the standard chalking paint (Table 1) to spray viscosity with distilled water and spray apply to the panel top surface (see Figure 1) to give a dry film thickness of 2.5±0.5 mils; dry for at least seven days at ambient conditions.

4.3 Place the metal panels in the Weather-Ometer for development of chalk. The test panels are designed to occupy the spaces ordinarily used for two 3" x 9" panels. In order to

assure chalk develops uniformly over the panel surface, rotate the panels daily according to the sequence shown in Figure 2*. Expose the chalking paint for a total of 170±1 hr in the Weather-Ometer.

(5) APPLICATION OF TEST PAINTS

5.1 Test paints are applied to the standard chalky test surface by a draw-down technique. This method is employed to minimize adhesion variation that would result from use of an application technique (e.g., brushing) that would redistribute the chalk layer during test paint application. Before applica-

*Note the symbol ⊕ used to identify the correct positioning of the panel on the designated specimen rack.

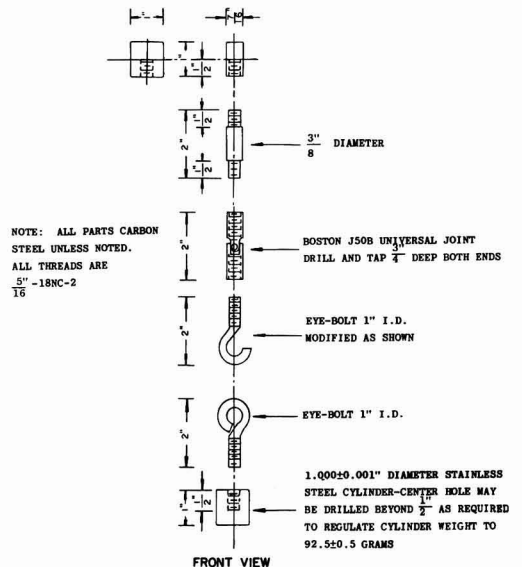


Figure 3—Test cylinder and Instron attachment hardware

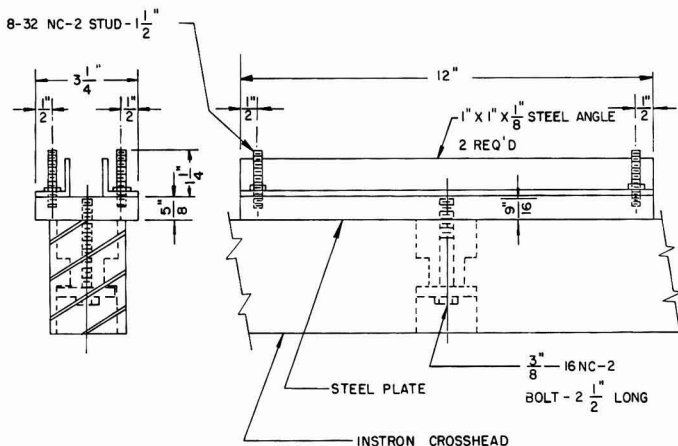


Figure 4—Test panel mounting clamp

tion, the test paint should be mixed in such a manner as to assure homogeneity while minimizing foam formation. To apply the test paint, a standard chalky test panel is placed on the magnetic chuck and the test latex paint is applied to produce a 5 ± 1 mil wet film. The test paint is air-dried at ambient conditions for a total of seven days; adhesion testing is done exactly one week from the date of application.

(6) ADHESION TESTING

6.1 The Instron tensile testing instrument is equipped with a CT load cell and the required change gears to give a crosshead speed of 0.2 in./min and a chart speed of 10 in. min. The design of the test panel mounting clamp specifically constructed for this adhesion measurement is shown in Figure 4 along with its location on and attachment to the Instron crosshead. The hardware shown in Figure 3 is assembled and clamped in the Instron jaw and the recorder pen is adjusted to give a zero reading. A 5 lb. weight is attached to the assembly and the recorder is calibrated to give full-scale deflection on the 5 lb. scale; verify a 5 lb. scale reading is obtained when the load scale range is set on 10, 20, 50 and 100 lbs. Recheck the zero reading (without the 5 lb. weight) and full-scale deflection (with the weight) to assure both are correctly established.

6.2 The metal test panel on which a test paint has been applied is attached to the piece of plywood with four machine screws and nuts. The adhesion test cylinder is subsequently cemented to the test paint surface. The purpose of the wooden stiffener for the metal panel becomes important at this point; it is very critical to minimize flexing of the metal panel that would move the panel relative to the rigid cylinder. Such movement would stress the paint system, weaken or destroy the intercoat adhesion and either negate the adhesion test or result in an erroneous adhesion measurement.

6.3 An area on the test paint is selected for attachment of the cylinder and two drops of Eastman 910 are placed in the center of the one inch diameter test site chosen. The cylinder is carefully placed on the cement so the latter is in the center of the cylinder test surface. Sufficient finger pressure is applied to the cylinder so that the cement is forced from under the cylinder *completely around its circumference*. A 500 g weight is placed on top of the cylinder for exactly five minutes during which time care is taken to prohibit the cylinder from moving from its original position.

6.4 Using cheesecloth and the square end of the spatula, the excess adhesive that oozed from under the cylinder is carefully blotted up. The adhesion test area is isolated from the remainder of the paint sample by cutting *completely* around the cylinder circumference down to the metal sub-

strate with a sharp knife or razor blade. Care must be taken during both of these steps to avoid exerting lateral pressure on the test cylinder. Allow at least 30 min before conducting the adhesion test.

6.5 Transfer the metal test panel, on its plywood stiffener, to the Instron for the adhesion measurement. When handling the test panel on which the test cylinder has been cemented, always keep the panel in a horizontal position and avoid bumping or jarring the panel which could result in slight movement of the heavy adhesion test cylinder. Any cylinder movement would weaken the paint intercoat bond and result in an erroneous adhesion measurement; when testing paints with relatively poor adhesion, such careless handling may completely break the intercoat bond and negate the adhesion test.

6.6 Mount the test panel on the Instron crosshead and align the panel in the mounting clamp so that the adhesion test cylinder is directly under the eyebolt when the latter is visually in a vertical position.

6.7 Lower the Instron crosshead three to four inches and screw the eyebolt approximately $1/4$ " into the test cylinder *very carefully* to avoid any movement of the test cylinder that may weaken the intercoat bond or negate the test as described above.

6.8 Hold the modified eyebolt to one side with one hand and slowly raise the Instron crosshead with the manual positioning knob so that the modified eyebolt can pass through the conventional eyebolt attached to the adhesion test cylinder, without making physical contact with the latter. Manually lower the crosshead very slowly until the gap between the eyebolts is approximately $1/16$ "

6.9 Set the full scale load on the Instron at 50 lbs., actuate the chart drive and the drive system to move the crosshead down at 0.2 in./min. Stop the crosshead when it is obvious that the test cylinder has separated from the test panel and a sharp force peak has been obtained on the Instron recorder.

6.10 The adhesion in lbs./in.² (PSI) is calculated by dividing the total force recorded by 0.7854, the surface area (in square inches) of the one inch diameter of the paint tested, as follows:

$$\text{Adhesion (psi)} = \frac{\text{Total force measured}}{0.7854} \quad (1)$$

6.11 At least eight adhesion tests should be conducted on each paint sample so that an average adhesion value can be calculated. After obtaining the first force reading, subsequent determinations should be conducted with the load scale selected to produce a reading of 50 to 75% of full-scale.

6.12 To readily obtain replicate data, a technique of mounting multiple test cylinders on a single test panel is recommended for conducting rapid adhesion measurements. Four cylinders can be mounted in a line across the width of the test panel by allowing approximately $\frac{1}{8}$ " between adjacent cylinders and between the outer cylinders and the edge of the test panel. After initially mounting the test panel in the clamp on the crosshead and performing the first adhesion measurement, it is necessary to slightly loosen the clamp and move the panel to the adjacent cylinder for the next measurement.

6.13 However, use of multiple cylinders requires that the weight of all cylinders employed is very uniform since the Instron will be calibrated with only one cylinder. Deviation in the weight of cylinders used for routine adhesion measurements, relative to the cylinder used for calibration, will affect the total force measured. Therefore, the center hole in the cylinder, as shown in *Figure 3*, may be drilled beyond $\frac{1}{2}$ " or the height of the cylinder can be regulated to maintain the cylinder weight within the range of 92.5 ± 0.5 g.

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Painting Waste Loads Associated with Metal Finishing

George E. F. Brewer
Consultant*

The waste load generated during the painting of metal products is governed by four factors: Paint composition; Painting equipment; Curing method; and Miscellaneous unavoidable losses.

The scientific and trade literature was surveyed for the weights and volumes of the nonvolatile components (resins, pigments, etc.) of about 70 typical, widely used paints, and also for the weights and volumes of their organic volatile components. These data have been tabulated.

Nine paint application and paint curing processes (spray, dip, coil, flow, roll, curtain, electro, powder, and powder slurry coating) were surveyed and the upper and lower reported limits of the expected transfer efficiencies were tabulated. The preliminary data were sent to about 20 experts, and their criticisms, suggestions, comments, etc. have been made a part of the present paper.

KEY WORDS: Waste load; Paint composition survey; Volatile to nonvolatile ratio; Paint application methods; Paint transfer efficiencies.

INTRODUCTION

Large quantities of waste are generated during the painting of industrial merchandise. These wastes form three classes:

- (1) Vapors of organic liquids (solvents, etc.), which are emitted into the air unless they are incinerated.
- (2) Solid or semi-solid materials (resins, pigments, etc.), combined with some adhering solvents are buried in the ground directly, or after partial incineration. Some of the paint solids are reclaimed, in certain cases.
- (3) Minor quantities of waste (water soluble solvents, salts, surfactants and other additives) may find their way into clearing lagoons or sewers.

Yet, the literature contains no comprehensive survey of the painting waste load, and the limited number of published articles is confined to narrow facets each, which have not been expressed under a common denominator.

The present study reports data on the waste loads

generated during the application of widely used paints by common painting techniques. Further work is in progress on the development of mathematical equations for the prediction and for the comparison of the waste loads to be expected from the use of various paints and painting processes.

Approximately 70 detailed formulations which resin manufacturers make available, have been made the basis of this study, and the findings were then circulated among about 30 experts, who contributed their corrections and suggestions.

ORIGIN OF WASTE

This study has identified four unavoidable causes of waste in industrial painting:

- (1) Paints include sacrificial volatile organic material.
- (2) Painting equipment cannot be operated without losses.
- (3) Paint curing, sanding, and stripping methods will cause losses.
- (4) Accidental losses will occur.

These four factors are schematically represented in *Figure 1*.

SELECTION OF PAINTS

Until quite recently paints and painting methods were selected according to quality and cost. Now, environment and energy consumption are considerations, and most desirable new paints and painting methods have been developed. Painted merchandise, however, has to be wear resistant for protection of the consumer.

Unfortunately, it is not generally known that it takes about five years of process experimentation, and laboratory and field testing before a metal finisher has reasonable assurance that a certain paint will meet quality, cost, and environmental and energy requirements. The reasons for the long testing period are the laboratory tests, field tests, and outdoor exposure tests.¹

Obviously, a paint which will carry a guarantee or expected life of two years will have to be tested for more than two years. In most cases hundreds or even

Progress Report on work partially supported by Research Grant No. R803467 of the U.S. Environmental Protection Agency. This paper appeared in the September 1976 preprint booklet of the American Chemical Society, Division of Organic Coatings and Plastics Chemistry, and is reprinted by permission of the ACS, the copyright owner.

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ORIGIN OF WASTES

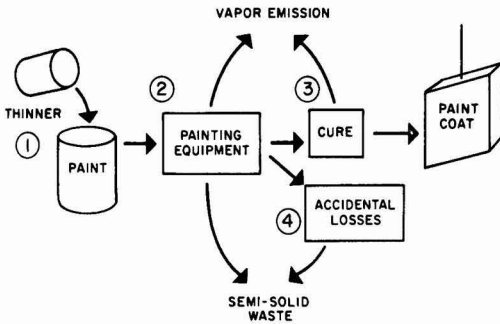


Figure 1—Origin of wastes in painting

thousands of pieces are tested in the field. If the pieces fail in the second year of experimentation a new improved series has to be tested.

USING AND BUYING PAINTS

The industrial finisher buys paint by weight (kg or lb) and applies the paint to the surface of merchandise in a thin layer, to meet certain specifications. These include color, hardness, gloss, corrosion resistance, etc., and film thickness.

Suppose several paint manufacturers offer paint samples which meet a certain set of specifications, each paint having its own price and composition. The best commercial buy is that paint which contains the largest volume of paints solids at the lowest cost. The least wasteful buy is the paint which contains the largest volume of nonvolatiles (NV) and the smallest amount of volatiles, particularly organic volatiles (OV). Even water in paint increases the cost, since it has to be evaporated by use of energy. Figure 2, shows the method used here for reporting the bought and used materials.

CLASSIFICATION OF PAINTS

The paint composition is carefully formulated for compatibility with the required equipment and cure. For instance, filmforming acrylics can be applied as spray, dip, roll coats, etc. Dip coats require less solvent than spray coats, and roll coats still less.

It is, therefore, the paint application and curing techniques which influence the solvent content of a paint. Furthermore, most of the normal losses during painting are connected with these techniques.

Thus, it seems advisable to classify the surveyed paints according to application and curing methods, and to assign code numbers to facilitate cross references. While surveying paints, attention was drawn to three classes of new paints, which are not yet generally available. These new paints have been developed by resin or paint manufacturers largely to meet environmental requirements. The common denominator of these formulations is the use of small quantities of or-

Table 1—Classification of Surveyed Paints

(1) Spray paints Air drying solvent-borne water-borne Bake cured solvent-borne water-borne	(4) Electrocoats Bake cured water-borne
(2) Dip coating paints Air drying solvent-borne water-borne Dip, flow, & curtain coats Bake cured solvent-borne water-borne	(5) Powder paints Bake cured
(3) Roll coat & roll coat Air drying solvent-borne water-borne Bake cured solvent-borne water-borne	(6) Radiation cured Electron beam Ultraviolet
	Newly Developed Paints not yet in General Use:
	(7) High solids spray Air drying solvent-borne Bake cured solvent-borne
	(8) Low solvent paints Bake cured water-borne
	(9) Powder slurries Bake cured water-borne

ganic solvents. Thus, nine classes of paints are listed in Table 1.

WASTE LOAD DATA

The waste load for any given installation is based upon:

- Volume of paint nonvolatiles 1 NV (gal NV)
- Density of paint nonvolatiles . . . g/ml NV (lb/gal NV)
- Weight of organic volatiles associated with 1 vol NV kg OV/1 NV (lb OV/gal NV)

Data found in the literature are usually aimed at the paint manufacturing process, rather than the computation of waste loads. Thus, these data have to be mathematically converted to yield the desired information.

Approximately 70 typical paint formulations were selected, covering the above listed nine classes of paints. The weight of organic volatiles associated with the unit volume of paint nonvolatiles were computed, and the upper and lower observed limit values were tabulated (see Table 2).

INDUSTRIAL PAINTING

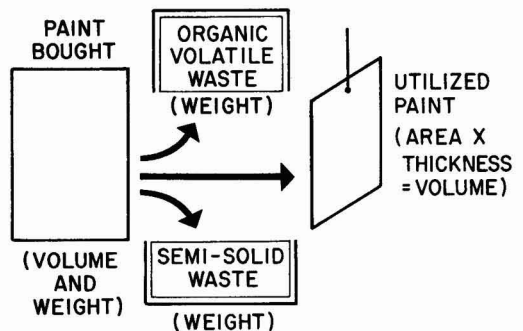


Figure 2—Units of measurement of waste

Table 2—Observed Limits of Organic Volatiles

Paints	Cure	Carrier	kg OV/IV	(lb OV/gal NV)
Spray	Air dry	Solvent	1.09 -4.45	11.6 -37.1
		Water	0.52	4.3
	Bake	Solvent	1.03 -7.27	8.6 -60.6
		Water	0.67 -0.84	5.6 - 7.0
Dip	Air dry	Solvent	1.96 -2.09	16.3 -17.4
		Water	0.11 -0.12	0.9 - 1.0
	Bake	Solvent	1.16 -2.09	9.7 -17.4
		Water	0.76 -1.01	2.3 - 8.4
Roll	Air dry	Solvent	1.10 -1.69	9.2 -14.1
		Water		
	Bake	Solvent	0.66 -0.85	5.5 - 7.1
		Water	0.32 -0.84	2.7 - 7.0
E/coat Powder	Bake	Water	0.31 -0.47	2.6 - 3.9
	Bake	-0-	0.005-0.12	0.05 - 1.0
Radiation cure	e/beam	-0-	0.05	0.4
	UV	-0-	0.024-0.06	0.2 - 0.5
High Solid	Air dry	Solvent	0.68	5.7
	Bake	Water	0.50 -0.59	4.2 - 4.9
Low Sol.	Bake	Water	0.18	1.5
Slurry	Bake	Water	0.018	0.15

EFFICIENCY OF PAINTING EQUIPMENT

The waste load depends upon the transfer techniques in three ways:

(1) Paints are formulated to lend themselves to the desired transfer technique. The relative amounts of organic volatiles are therefore, related to the transfer technique.

(2) Paint is lost in the transfer from the drum onto the merchandise, whether the most primitive or the most sophisticated method is used, since adhering paint has to be cleaned from the equipment. Dripping or over-spray, etc. is unavoidable.

(3) The kind of merchandise to be painted is a factor.

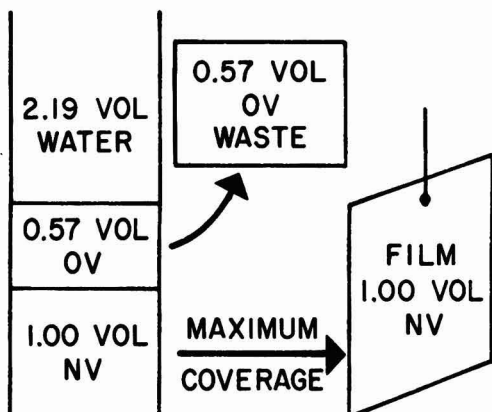


Figure 3—Ideal transfer from paintpot onto merchandise would be accompanied by volatile waste only

Flat, large merchandise will receive a higher percentage of paint than will small pieces or wire mesh.

Thus, it can be expected that only a certain percentage of paint will be transferred onto the merchandise. This is usually expressed as “% expected transfer effi-

Table 3—Expected Transfer Efficiency

Transfer Device	% Expected Transfer Efficiency
Air atomized conventional	43% ¹ ; 50% ² ; 30%-60% ⁸
Air atomized electrostatic	87% ¹
Centrifugally atom electrostatic	68%-87% ⁹
Airless atomized conventional	93% ¹
Airless atomized electrostatic	85%-95% ⁹
Dip, flow and curtain coat	65%-70% ³
Coil and roll	85%-90% ³
Electrocoat	75%-90% ⁴
Powder coat	90%-98% ⁴
	96%-98% ⁷
	90%-96% ⁴
	99% ²
	50%-80% ⁵
	98% ² ; 90%-99% ⁶

(1) Miller, E. P., Ransburg Co., SME paper FC73-553.

(2) Antonelli, J. A., E. I. duPont de Nemours & Co., Inc., SME paper FC74-654.

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(9) Miller, E. P., Ransburg Co., (direct communication).

ciency (% exp.t.e.).” The % exp.t.e. cannot, therefore, be stated as one distinct figure per method, but will have to be reported as upper and lower limits. Table 3 presents the data found in literature and/or received through direct communication.

Waste at Expected Transfer Efficiency

Smaller transfer efficiency means higher waste load, both in organic volatile (OV) and nonvolatile (NV) waste. Let us consider the following case:

A certain paint is composed of 1.00 volumes NV, 0.57 vol OV, and 2.19 vol H₂O. The maximum area which can be painted by 1 vol NV is accompanied by the generation of 0.57 vol OV waste (see Figure 3).

If the expected transfer efficiency is, for instance, only 50%, then twice as much paint is involved:

One volume of paint nonvolatile will be utilized plus a second volume which will form semi-solid (NV) waste. In addition the organic volatile (OV) waste is increased (see Figure 4).

In general, for any given paint the OV-waste increases at a constant rate as the expected transfer efficiency decreases within practical limits. The NV-waste, however, increases at an accelerating rate with decreasing % expected transfer efficiency (see Figure 5).

The NV-waste diminishes toward zero as the expected transfer efficiency approaches the practically impossible ideal, and the OV-waste diminishes toward a definite minimum weight, namely the weight of OV associated with the applied weight of NV.

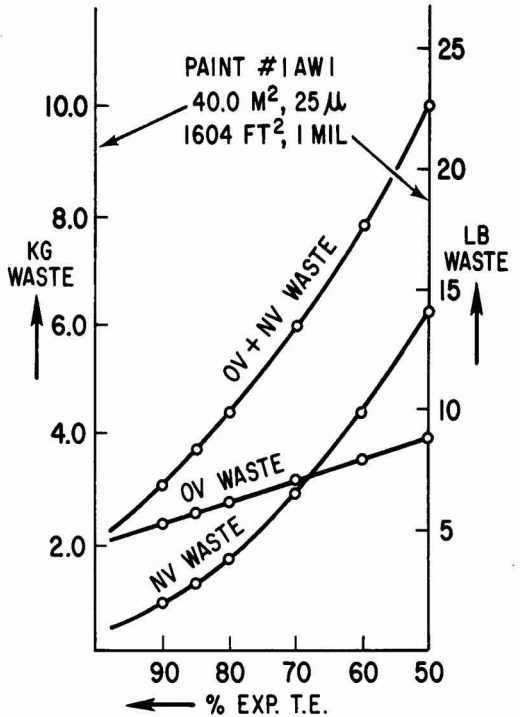


Figure 5—Expected transfer efficiency vs. waste load for a typical air-drying water-borne spray paint

PAINT CURING

The process by which a wear-resistant paint film forms is known as “curing”. This is accomplished in several ways: ambient temperature curing (air drying); moisture curing; two component system; baking; radiation curing (ultraviolet rays or electron beams).

Some organic volatiles are generated by certain paints during the curing process. Those volatiles are called co-reactants (co-R) and their weight is reported as less than 5 wt% of the nonvolatile portion of the paint.² The most frequent co-reactants are water, methanol, etc. Heavy malodorous fumes are sometimes detected during the paint curing. These are currently the subject of odor analysis.³

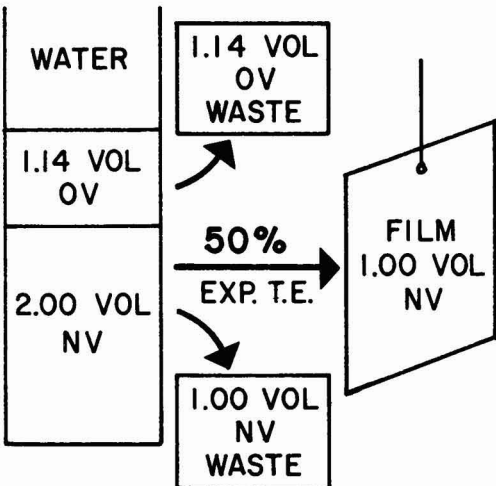
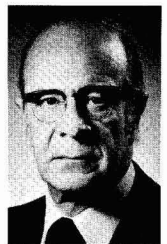


Figure 4—Actual transfer from paintpot onto merchandise varies from over 95% to about 50% expected transfer efficiency and gives rise to volatile and nonvolatile waste

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SANDING

Cured paint films show some imperfections due to metal defects, settling of dust, and some roughness or orange peel inherent in the paint or painting technique. The imperfections are abraded by dry or wet sanding, which gives rise to small amounts of waste. In fact, the weight should include the weights of the discarded disks or belts of sandpaper, plus detergents or oils involved.

STRIPPING

A stripping bath is composed of water plus paint-lifting chemicals, usually caustic soda, surfactants, etc., and usually heated. Melted salts are also used for stripping. While the weight of paint solids to be stripped is small, the weight of stripping chemicals which have to be disposed of, is sizable.

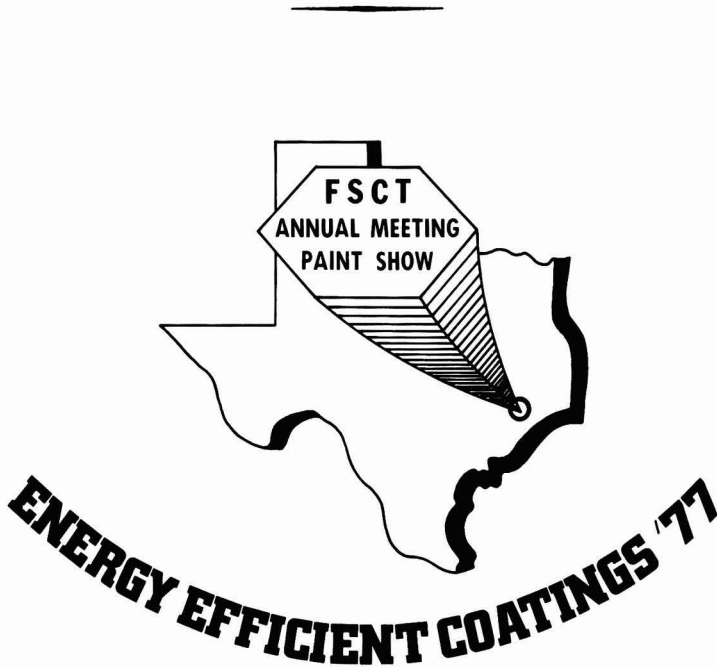
CONCLUSIONS

In theory, the waste load in painting could be significantly reduced by judicious choice of paint, equipment, cure, and skill.

In practice, the process of waste reduction is under way by reasons of law enforcement and money saving, but it will take years of field testing before currently used materials and methods can be replaced while insuring the protection of the consumer. □

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Thermosetting High-Solids Coatings

Two Novel Types

David V. Gibson and Bruce Leary
Dulux Australia Limited*

The physical and chemical requirements of high-solids binders for industrial one-pack coatings are examined. From an assessment of this data, high-solids coatings based on a direct compromise between viscosity and film performance factors are described. Another approach, which avoids this compromise by utilizing *in situ* oligomerization on the panel after application is proposed. This route allows the use of low viscosity blends which react *in situ* to form oligomers containing functional reactive groups for subsequent crosslinking reactions. The formation of functional oligomers *in situ* after application was confirmed experimentally by quantitative infrared analysis.

Practical evaluations of examples of both high-solids types demonstrate excellent performance with substantial reductions in solvent emissions.

KEY WORDS: High-Solids; Thermosetting; Industrial coatings; *In situ* oligomerization; Autoxidative; Automotive primers.

INTRODUCTION

Over the past decade there have been increasing social and legislative pressures for coating technologists to develop coatings which result in much lower solvent emission levels on application and stoving. These pressures have given rise to three main low pollution coating types being offered to industry, namely water-borne, powder, and high-solids coatings. The relative merits of each of these three main candidates have been reviewed in recent papers.^{1,2,3}

High-solids coatings, sometimes referred to as low volatile matter coatings, may be arbitrarily defined as coatings able to be applied at greater than 70% by weight nonvolatile solids content. These coatings offer advantages, particularly in the short term, over the other contenders. One-pack, high-solids coatings in particular have manufacturing and application characteristics similar to present day low-solids coatings. From the coating user's viewpoint this usually means ready adaption of existing application and stoving equipment together with the advantages of higher film builds per coat, faster throughput and higher produc-

tivity, as well as substantial reductions in solvent emission levels. Advantages from the coating manufacturer's viewpoint are also evident as lower solvent levels result in higher paint manufacturing capacity and lower manufacturing costs for a given volume of paint solids. In comparison, powder and water-borne coatings require special plant for both the paint manufacturer and user.

This paper describes some experiments which illustrate parameters and compromises involved in the development of one-pack industrial thermosetting high-solids coatings. Two novel binders types based on an assessment of this data are described and are shown to perform well when evaluated in automotive primers.

INDUSTRIAL COATING REQUIREMENTS

The performance characteristics of modern thermosetting industrial coatings require that not only must mechanical and resistance properties of the stoved film be satisfactory but that application and curing must be amenable to mass production. To attain these properties the cured film should comprise a high molecular weight polymeric network.

In addition, as particular industrial markets are catered to, modification of the chemical composition has been found necessary. For example, it has been found that the corrosion properties of coatings are upgraded by the incorporation of bisphenol A moieties, usually via epoxy resins, into the binder. In a similar fashion it has been observed that for automotive stoving primers the inclusion of autoxidative material into the binder via drying or semi-drying oils or fatty acids results in improved flexibility and intercoat adhesion properties over a wide range of stoving conditions.

High molecular weight polymers require large quantities of solvent to reduce their viscosity for application. Intuitively, it would appear that simply decreasing molecular weight would give higher solids coatings at application viscosity. However, in practice, this involves many compromises and film properties of the resulting stoved films may be degraded.

To illustrate the effect of simply reducing molecular

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Table 1—Binder Molecular Weight vs. Film Properties

Molecular Weight	Application solids (wt %)	Humidity Resistance	Hardness/Flexibility
7000	52	good	good
3500	62	good	fair
1500	68	fair	poor
650	80	poor	fair

weight, a series of esters of a commercially available range of bisphenol A diepoxides* and drying oil fatty acid was prepared. These epoxy esters had molecular weights ranging from about 7000 (a conventional primer) down to about 650, while maintaining the ratio of bisphenol A groups to autoxidizable chains at a constant level. The ratio of epoxy resin to soya fatty acid used was 60:40 by weight. After pigmentation, each of these epoxy esters was blended with hexamethoxy methyl melamine (HMMM)† at a ratio of 90:10 by weight, prepared as films, stoved and tested. The results are set out in Table 1. From this table it is clear that although solids at application have been considerably increased as the molecular weight has been decreased this has been accompanied by an unacceptable drop in film properties. This example confirms the view that a simple reduction in molecular weight is not adequate and a different approach to formulation is needed.

FORMULATION PARAMETERS



It is proposed to consider the formulation of high-solids coatings under two main headings.

- (1) Physical properties of the binder required to attain the highest practical nonvolatile solids content.
- (2) Chemical curing properties of the binder necessary to achieve adequate crosslinking and film properties on stoving.

Physical Property Requirements

For polymers in solution the principal viscosity determining factors are chain extensibility and inter-

Table 2—Chemical Structure vs. Viscosity

Compound	Molecular Weight	Viscosity (cps., 20°C)
CH ₃ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃	114	0.5
 -CH ₂ -CH ₃	106	0.7
 -CH = CH ₂	104	0.8
CH ₂ = CH-CH ₂ -O-CH ₂ -CH $\begin{matrix} \text{O} \\ \\ \text{CH}_2 \end{matrix}$	114	1.1
CH ₃ -O-CH ₂ -CH ₂ -O-CH ₂ -CH ₂ -O-CH ₃	134	2.0
CH ₃ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -COOH	116	3.2
CH ₃ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -OH	116	7.0
CH ₃ -OH	32	0.6
CH ₃ -CH ₂ -CH ₂ -OH	60	2.3
HO-CH ₂ -CH ₂ -OH	62	21
HO-CH ₂ -CH ₂ -CH ₂ -OH	76	46
CH ₂ -CH-CH ₂	92	1070
$\begin{matrix} \text{OH} & \text{OH} & \text{OH} \end{matrix}$		

molecular interactions which are related to the length of the chains, the type of solvent present and the number and character of the chemical groups present.

A consequence of lowering the molecular weight of a species is that volatility is increased and ultimately volatilization will occur before the species can react into the film binder. The type and number of chemical functional groups also influence volatility. In order to quantify the influence of molecular weight on viscosity and volatility, a series of commercially available poly(ethylene oxides)** was evaluated (see Figure 1).

Viscosity was measured on an ICI cone and plate viscometer, at 25°C at a shear rate 10,000 sec⁻¹. Volatility was estimated by baking thin films for 8 min at 177°C, a temperature typical of industrial coatings stoving schedules. In practice this volatility test is useful for excluding certain compounds from consideration as components of high-solids binders. A test result in which 5% or less of the compounds was volatilized was arbitrarily taken as being satisfactory, indicating that a molecular weight of at least 300 is necessary to meet volatility requirements. The viscosity results show an

* Shell Epikote® 828, 1001, 1004 and 1007 were used.
 † American Cyanamid Cymel® 301 was used.

** Obtained from ICI Australia Ltd.

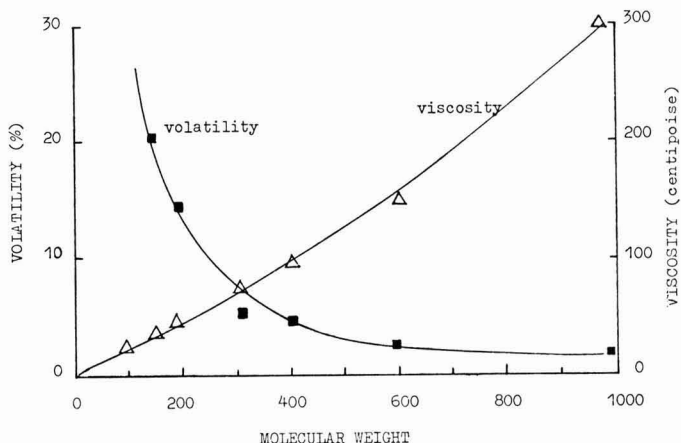


Figure 1—Relationship of viscosity and volatility to molecular weight for poly(ethylene oxide)

approximate linear relationship with respect to molecular weight.

To indicate the influence of chemical structure on viscosity, the viscosities of a range of liquid compounds of similar molecular weight have been set out in *Table 2*. It can be seen from this series that hydroxyl groups are major contributors to viscosity. Carboxyl groups, epoxy groups, and methoxy groups contribute less to viscosity while aliphatic groups make only very small contributions.

Also included in *Table 2* are the viscosities of molecules in which the number of hydroxyl groups per molecule is varied. It is apparent from the series *n*-propanol, 1,3 propylene glycol, and glycerol that the viscosity of compounds, at least for these low molecular weight molecules, is very dependent on the number of chemical groups per chain when that chemical group itself can be classified as significantly contributing to viscosity, as in the case here with the hydroxyl group. This viscosity increase can be seen to be of the same order whether the concentration of hydroxyl groups per unit of molecular weight was held constant (methanol, ethylene glycol, and glycerol) or whether the carbon chain length was held constant (*n*-propanol, 1,3 propylene glycol, and glycerol).

In practice, some solvent is required for satisfactory application of high-solids coatings. While the selection is usually made on the grounds of volatility and conductivity for electrostatic application as well as compliance with 'Rule 66', solvency must also be borne in mind.

The conclusions arrived at from this study of model compounds has been found to be useful in practice. However, the prediction of results can be complicated in more complex systems by the nonadditive character of properties. Complications are exemplified in the case of the practical series of esters of the diglycidyl ether of bisphenol A, and fatty acid described previously, where viscosity trends can only be interpreted in general terms as both functionality and molecular weight vary. However, in terms of minimizing viscosity, the important principles are that the number of viscosity contributing groups per molecule must be kept to a minimum and so too must the overall molecular weight.

Chemical Curing Requirements

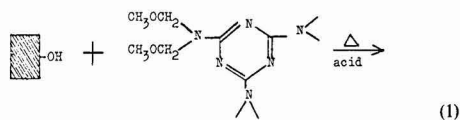
In order to obtain good film properties, a highly crosslinked polymeric network must be formed during curing. It follows that the reactive monomers must be at least difunctional. It has been established by early workers⁵ in this field that the higher the functionality of each of the monomers the lower the degree of conversion necessary for the gel point or formation of an infinite polymeric network. In the practical case of stoved industrial coatings, where the extent of reaction is inhibited by factors such as time available for reaction and mobility of reactive groups due to increased viscosity, these considerations are particularly relevant. In particular, in the case of low molecular weight compounds where many more reactions are involved, a functionality in excess of two should be necessary.

The following section summarizes some chemical curing reactions that are suitable for one-pack, high-solids coatings and factors which determine adequate film properties after crosslinking.

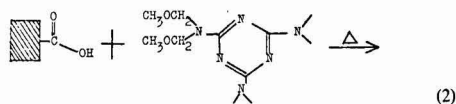
Crosslinking Reactions

Conventional thermosetting finishes have widely used *N*-alkoxy methyl groups as coreactants with hydroxyl groups to form films on stoving. The reactive *N*-alkoxy methyl groups have often been incorporated in coatings by using derivatives of urea, melamine, and benzoguanamine, commonly known as nitrogen resins. The widespread use of these groups can be attributed to their efficient reaction, excellent can-stability, the emission of mostly only lower alcohols as by-products, their good chemical resistance, and finally, the capability of readily tailoring crosslinking agents suitable for specific requirements. For high-solids coatings low molecular weight analogues are desirable, particularly where the by-product is the lowest molecular weight alcohol, methanol. A consequence of using low molecular weight materials for high-solids binders is that the crosslinking reactions must be very efficient. A material which meets these needs particularly well is hexa methoxy methyl melamine (HMMM).

The reaction of HMMM with hydroxyl and carboxyl containing molecules under varying conditions has been documented.⁶ Typical reaction schemes are:



Reaction of hydroxyl group and *N*-methoxy methyl group



Reaction of carboxyl group and *N*-methoxy methyl group

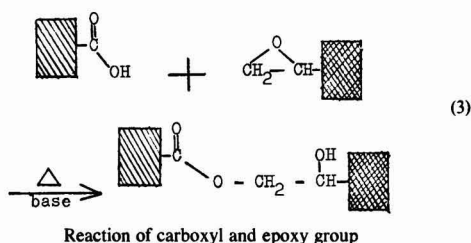
The reaction of HMMM with hydroxyl groups is fast in the presence of acids. The reaction of HMMM with carboxyl groups is considerably slower and thus is less useful for high-solids industrial crosslinking reactions. In both cases the principal by-product is methanol, the monitoring of which enables the progress of the reaction to be followed. In practice we have found that under typical stoving conditions only about three of the

Table 3—Binder Functionality vs. Film Properties

Acid Component	Functionality of Binder	Hardness (Knoop)	Chemical Resistance
Ethyl maleate	1.5	<1	very poor
Ethylene glycol dimaleate	2.0	4	poor
Trimethylol ethane trimaleate	2.5	18	good
Pentaerythritol tetramaleate	3.0	19	good

theoretically six available reactive n -methoxy methyl groups react with hydroxyl groups.

Another well-known film-forming reaction involves carboxyl and epoxy groups as coreactants.⁷ On stoving these can form highly crosslinked chemical resistant films with good film properties. A typical reaction scheme is:



An advantage of these coreactants is the absence of any by-product. However poor can-stability sometimes requires them to be used as two-pack systems.⁸ Under the stoving conditions usually employed, the reaction of hydroxyl and epoxy groups is too slow⁷ to be useful.

Effect of Crosslink Density

It is well established that for a conventional thermosetting coating to provide adequate film properties, a certain level of crosslink density must be attained. It has been reported⁹ that for high-solids coatings where

the polymers are much lower in molecular weight, higher crosslink densities are required. This study attempts to relate these requirements to the average number of reactive functional groups per molecule in a practical case. An important film property, the balance of mechanical properties such as hardness and flexibility is not dealt with here. Other workers have demonstrated that this balance is dependent on not only the crosslink density but also the types of chemical units and linkages present in the binder.

The effective crosslink density for a series of compositions based on low-molecular weight compounds was assessed by chemical resistance and hardness as a function of varying the average reactive functionality per molecule. Epoxy and carboxyl coreactive groups were selected for this investigation and the functionality of the carboxyl component was varied. The proportions used were such that equal equivalents of epoxy and carboxyl were present. The epoxy component used was a commercial grade of the diglycidyl ether of bisphenol A, which is essentially difunctional.

The carboxyl components used were the ring-opened reaction products of maleic anhydride and a range of hydroxyl compounds. By selecting the hydroxyl compound, the functionality of this component was varied. For example, the equimolar reaction product of maleic anhydride and ethanol is the mono-functional acid ethyl maleate; similarly, 1 mole of trimethylol ethane and 3 moles of maleic anhydride gave a trifunctional acid as product. A tertiary amine catalyst of 0.5% was added to the blend. Bearing in mind practical applications, compositions were applied as thin films to steel panels and baked for 25 min at 177°C. Chemical resistance was assessed by solvent resistance and hardness was measured using a Tukon hardness instrument.

The results as a function of the average reactive chemical functionality of the composition are presented in Table 3. These results confirm the theoretical proposition that an average functionality of more than two is

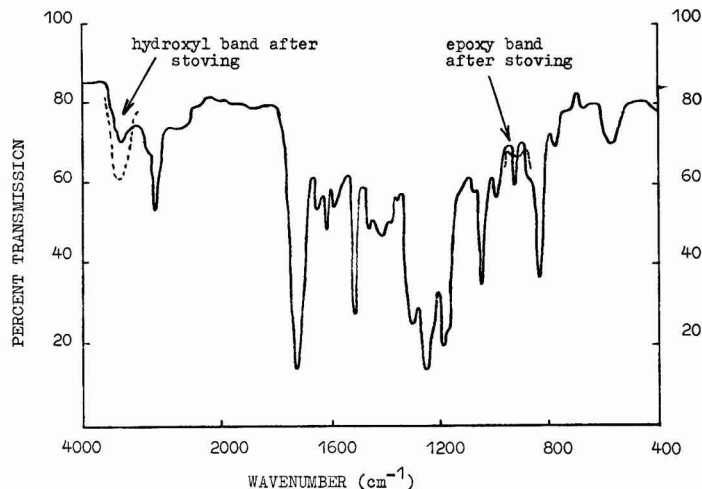
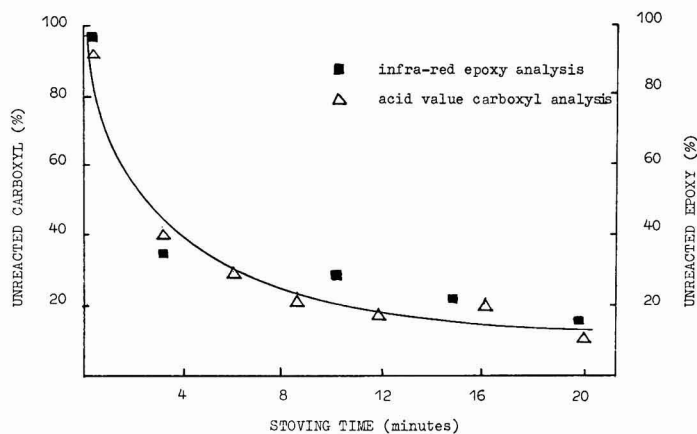


Figure 2—Infrared spectrum of DGEBA and EGDM before and after stoving

Figure 3—Reaction of EGDM and DGEBA



necessary for useful films but that a functionality of 2.5 or more is shown to be desirable.

As expected, the viscosity of the carboxyl compounds was found to increase rapidly as their functionality increased. This opposes the viscosity minimizing requirements previously discussed, unless "nonviscous" reactive groups such as fatty acid residues containing autoxidizable unsaturation are introduced to augment the crosslink density. From this point of view, a typical conventional epoxy ester system has a high functionality after esterification of the epoxy resin by autoxidizable fatty acids. However, as has been shown in Table 1, conventional epoxy-ester binders require large amounts of solvents for application, even though a high proportion of fatty acids is present. It was also shown that simply reducing molecular weight reduced functionality as well as viscosity and this could account for the unsatisfactory films which resulted.

NOVEL HIGH-SOLIDS BINDERS

Following the work discussed above, two types of high solids binders were developed. The first of these directly balances the many conflicting requirements. A description and full evaluation of this binder in an automotive stoving primer is described later. The second binder is based on an indirect *in situ* oligomerization process. The principles of this latter process are discussed in detail in the following sections.

FILM FORMATION VIA OLIGOMERIZATION

A review of the above section suggested that for any particular coating composition, higher solids would be obtained at application viscosity if hydroxyl groups were absent. After noting that a carboxyl/epoxy reaction generates a hydroxyl group (see equation (3)), we proposed that such a binder system, free of hydroxyl groups at application, could be based on these reactive groups. After a short stoving schedule the reaction of a mixture of diepoxides and dicarboxylic acids should have taken place to such an extent that an oligomer

having a hydroxyl functionality of more than two would be formed. If HMMM was also included, the hydroxyl groups generated could then be used for the desirable hydroxyl/*N*-methoxy methyl reaction previously described in equation (1) to give a highly crosslinked film.

The potential advantage of such a reaction scheme would be that an hydroxyl functional oligomer which is normally too viscous for high-solids coatings, could be used by forming that oligomer *in situ* on the panel after application. Such a scheme, which would avoid the main compromise between viscosity and the number of hydroxyl functional groups per molecule, was then studied.

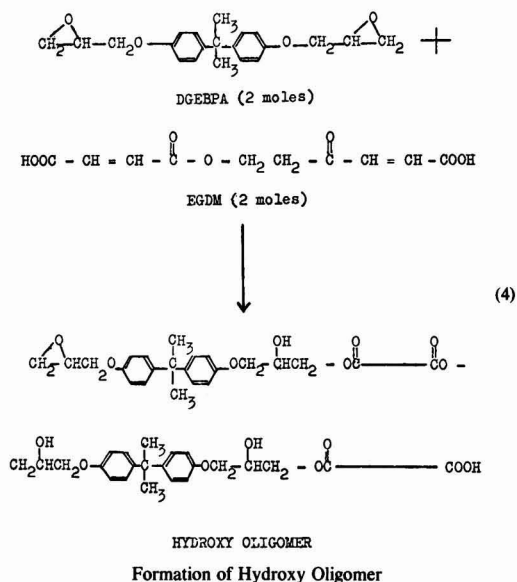
Reaction Mechanism

To investigate the feasibility of this proposition we studied further the epoxy/carboxyl reaction by stoving a thin film prepared from a blend of ethylene glycol dimaleate (EGDM) (1 mole, 258 parts) and a commercial diglycidyl ether of bisphenol A (DGEBA) (1 mole, 400 parts). The film was analyzed at various times during the stoving cycle at 177°C using both acid-value and infrared analysis.

The infra-red spectral bands used were:

SPECTRAL BAND (cm ⁻¹)	FUNCTIONAL GROUP
3400	Hydroxyl stretching
920	Epoxy stretching
830	Aromatic ring bending

The reaction of the epoxy groups of DGEBA was monitored by assessment of the infrared absorption band at 920 cm⁻¹ corresponding to the epoxy functional group. Calculations from the infrared spectra were standardized by reference to the aromatic band at 830 cm⁻¹. A typical IR spectrum of the blend before and after stoving is given in Figure 2. Reaction of the carboxyl groups of the EGDM was monitored by acid value titration. The results are shown in Figure 3. For convenience, the initial values of acid value and epoxy content are designated 100%. From these results it was possible to calculate that after 8 min of stoving, sufficient esterification had taken place to form oligomers of about 4 units as follows:



Further confirmation of the formation of such an oligomer was obtained by observing from the spectrum that the hydroxyl band increased on stoving. However, this band did not lend itself to quantitative measurement.

To take the hypothesized reaction scheme based on this formation of an hydroxyl functional oligomer a stage further, we tried to show the formation of an oligomer during stoving a thin film of a blend comprising the three constituents EGDM, DGEBA, and HMMM in a mole ratio 3:3:2.

The preceding discussion of the epoxy/carboxyl reaction indicated that infrared spectral analysis provided similar results to acid-value determinations and as it was the more suitable method, IR was chosen for further work. For the three component blend containing HMM, adjustment had to be made for the absorption

band of the triazine ring structure which is at the same wavenumber as that due to the epoxy. However, as the peak corresponding to the triazine absorption is constant during stoving in these blends appropriate adjustment could be made to the calculations.

The results are shown in Figure 4. For convenience the initial level of epoxy is again designated 100%. We believe that the substantial decrease in the epoxy absorption band in the early part of the stoving cycle indicates the formation of the proposed oligomer. Undoubtedly there are synergistic effects when all three reactants are heated together. For example, the epoxy/carboxyl reaction is known to be accelerated by the presence of the weak base HMMM¹², increasing the likelihood of formation of the proposed oligomers.

On the basis of the above evidence we believe the following reaction scheme occurs in the blend: Firstly, the diepoxide reacts with the di-carboxylic acid to form a poly hydroxyl functional oligomer. Secondly, the hydroxyl groups of this oligomer react with the HMMM to form a highly crosslinked structure.

Film Formation

To further test this proposed reaction scheme, an oligomer was prepared in the laboratory, by the reaction of equal mole proportions of EGDM and DGEBA. A conventional glassware set-up was used. Reaction was stopped when the degree of reaction corresponded to that which was attained after stoving thin films for approximately 8 min at 177°C. This oligomer had an acid value of 50 mg KOH/g indicating the presence, on average, of three hydroxyl, one carboxyl, and one epoxy groups per molecule (see equation (4)). An 85% by weight solution of oligomer in ethanol had a viscosity of 10,000 centipoise (cP) in contrast to a blend of the unreacted constituents at the same solids in ethanol which had a viscosity of 200 cP.

The oligomer was then blended with HMMM in a ratio that corresponded to equal equivalents of hydroxyl groups and available reactive N-methoxy methyl

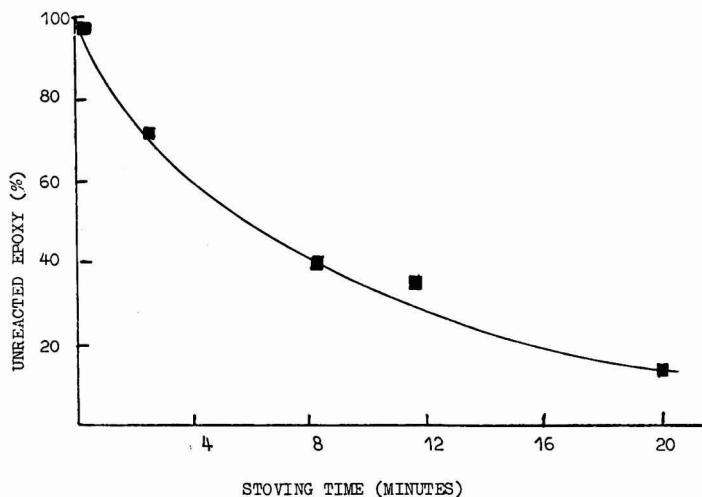


Figure 4 — Reaction of EGDM and DGEBA in a blend of EGDM/DGEBA/HMMM

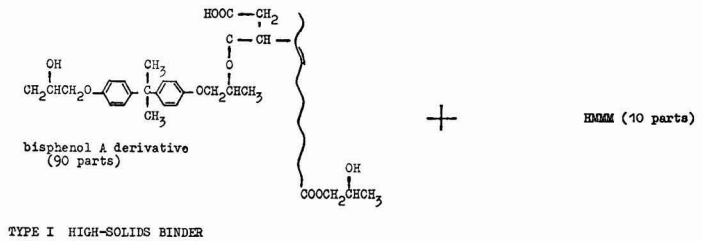
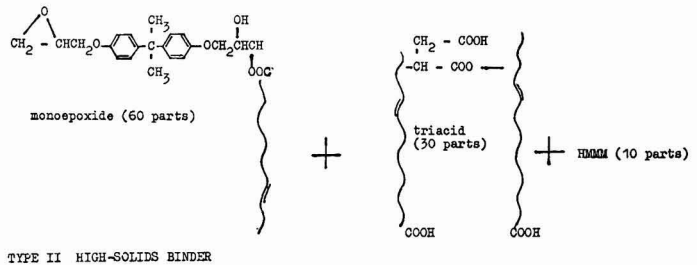


Figure 5—Two types of high-solids binders



groups to form a coating binder. As a control, a blend was prepared of the unreacted constituents of this oligomer with the same level of HMMM as used with the oligomer. Thin films were prepared from both of these binders and stoved at 177°C for 20 min. The relative film properties after stoving, together with infrared spectra for both blends after stoving, were very similar, supporting the proposal of similar film formation routes.

It is clear the *in situ* film formation route is a viable method of overcoming the compromise between viscosity and the number of hydroxyl groups per molecule discussed above, while retaining the efficient N-methoxy methyl/hydroxyl reaction. This novel route therefore offers potentially higher solids at application and improved film properties by being capable of in-

creasing the crosslink density while minimizing the number of hydroxyl groups per molecule present during application.

The model binder system described above illustrates the principle of *in situ* production of hydroxyl function oligomers. This principle was successfully developed into an automotive primer as described in the following section.

EVALUATION

In this section the preparation and comparative evaluation of two examples of high-solids coatings are described. The binder of the first of the two examples represents a direct compromise of the parameters discussed earlier in this paper.¹⁰ The second coating com-

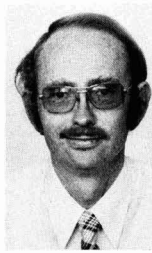
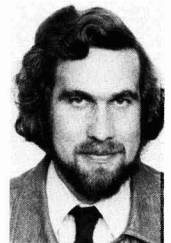
Table 4—Comparative Coating Characteristics And Test Results

Property ^b	Type I	Type II	Control
Application solids (wt % at 20 sec Ford 4 viscosity)	78	82	52
Viscosity stability (16 hrs @ 60°C)	no change	no change	no change
Adhesion to metal ^a	9	9	9
Intercoat Adhesion ^a	9	9	9
Gravellometer ^a	8	9	8
Impact (80 in/lb)	moderate cracking	slight cracking	moderate cracking
Flexibility ^a	8	9	6
Salt-spray ^a	7	8	8
Humidity ^a	8	9	8
Volatiles/g stoved coating	0.28 g	0.22 g	0.92 g

^a Rated 0-10, the higher number the better the performance.

^b More detailed information on these tests are set out in U.S. Pat. No. 3,956,210.

DAVID GIBSON received an Honors Degree in Colloid and Polymer Chemistry from Sydney University in 1971. Since joining Dulux Australia Ltd. in 1972 he has been working on research projects exploring new coatings.



BRUCE LEARY, Manager of Exploratory Research at the Central Research and Development Laboratories of Dulux Australia Ltd. (formerly BALM Paints Ltd) and a graduate of Swinburne College of Technology, Melbourne, has, since joining Dulux in 1959, been involved in research projects including nonaqueous dispersions, microvoid paints and high-solids coatings.

prises a binder which exemplifies the indirect route involving *in situ* oligomerization.¹¹ The binders used for this evaluation are illustrated in *Figure 5* as Type I and Type II, respectively.

Type I binder comprises a blend of HMMM and the halfester of bispropoxylated bisphenol A maleinized fatty acid, modified so as to have on average two hydroxyls and one carboxyl group per molecule. Type II binder comprises a blend of HMMM, Epikote 828/fatty acid monoester and a tricarboxylic acid (the reaction product of ricinoleic acid and maleinized fatty acid).

The above two binders and a control, a conventional epoxy-ester binder, were formulated into automotive primers suitable for spray application. Each of the coatings was identically pigmented with barytes, rutile titanium dioxide, and silica to give a pigment binder ratio of 1.9:1. The three primers were adjusted to the same viscosity and sprayed onto zinc phosphated steel panels to give a dry film build of 25-30 μm . After stoving for 25 min in a 177°C hot air oven the panels were coated with a 40 μm (dry film build) layer of a commercial acrylic enamel and were stoved for 30 min in a 130°C oven.

The panels were subjected to a series of tests. The results of these tests and characteristics of these coatings are shown in *Table 4*. These results show that film properties for both the coatings prepared from the novel binders are at least as good as the control and that substantial savings in the emission of volatiles is achieved. The cost per unit volume of stoved coating for both Type I and Type II coatings is similar to that for the control.

CONCLUSION

The physical and chemical requirements of industrial stoving high-solids coatings have been identified. Two

types of novel high-solids binders have been described; the first type represents a direct compromise of these requirements; the second involves an indirect *in situ* oligomerization process. A comparative evaluation of examples of both these binder types in an automotive primer has shown their general performance and properties to be at least as good as a conventional low-solids primer with the major advantage of substantially lower levels of volatile emissions.

ACKNOWLEDGMENTS

The authors thank the management of Dulux Australia Ltd. for permission to publish this paper. We also acknowledge the assistance and contributions of fellow research workers involved in our high-solids program. □

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FSCT Scholarship Program

As part of the Federation's continuing program to support and promote educational activities designed to train students in coatings technology, scholarship funds have been made available to University of Southern Mississippi, North Dakota State University, and University of Detroit.

These funds are to be used as grants-in-aid for students in the coatings technology program at each institution, with preference given to qualified scholarship applicants who are children of members of the Federation.

Members who have children wishing to make application for the 1977-78 academic year should contact Federation headquarters. Deadline for receipt of applications is April 1, 1977. Write Scholarship Fund, Federation of Societies for Coatings Technology, 1315 Walnut St., Suite 830, Philadelphia, Pa. 19107.

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Society Meetings

Birmingham December 2

R. G. Smith, of Arthur Holden & Sons Ltd., spoke on "U.V. CURING." Mr. Smith described the toxicological considerations and practical advantages of using ultraviolet light to polymerize coatings. Beginning with the theory and different types of chemical bonding, he continued by detailing the mechanism of U.V. curing by means of free radical formation and photoinitiation. The requirements of a good photoinitiator were described and the advantages and drawbacks of the different types were explained in detail. The steps that can be taken to overcome the inhibition of free radicals by molecular oxygen were also explained.

Q. Can U.V. coatings be applied only to flat surfaces?

A. U.V. light follows the inverse square law so there is a sharp decrease in the cure rate the further away from the U.V. source, and can only be used for flat sheets and rotating cylinders. Electron beam curing should be used for other shapes.

Q. What is the normal speed of cure?

A. A 5-ft curing chamber with line speeds of 1000 fpm are possible, but present machinery cannot handle faster throughputs.

Q. What occurs during pigmentation of U.V. finishes?

A. Titanium dioxide acts as a catalyst at low PVC. Films of 1 micron or less present no problems. However, at 6-7 microns, the TiO_2 absorbs the U.V. producing a slow cure due to scattering,

and the problem of surface cure but no through cure. Problems may be encountered due to the U.V. absorption spectrum of the pigment, particularly organics.

Q. Where is U.V. going in the future?

A. U.V. curing is well established in inks and woodfinishes. Paper and board curing is a continuing procedure. Metal decorating looks promising, however, it is lagging behind due to the lack of suitable resin systems.

BRIAN F. GILLIAM, *Publicity Officer*

C-D-I-C December 13

Dr. Bruce H. Garth, of E.I. du Pont de Nemours & Co., Inc., spoke on "PIGMENTATION OF WATER-BORNE INDUSTRIAL COATINGS."

Dr. Garth described du Pont's work using TiO_2 pigments in commercial water-borne vehicles, such as acrylics, polyesters, alkyds, and some baking acrylic emulsions. He indicated that as the vehicle changed some pigment changes were also required. Five basic pigments were used in their study: enamel type, general purpose, maximum chalk resistant, flat grade, and low gloss high chalk resistant. The performance of these systems in regard to gloss, hiding power, grind fineness, etc. is dependent upon the vehicle selection except for polyesters. Stability data indicate that there is no change in hiding power with acrylic or polyester water-borne systems, however, the pH changes in the polyesters as does the viscosity on storage at room temperature.

The Educational speaker, Dave Trearson, of Rohm and Haas Co., spoke on "ACRYLIC URETHANES."

Mr. Trearson remarked that most of the urethane resins are photoreactant and are degraded by sunlight. The acrylics are transparent and exhibit outstanding exposure resistance and are used as modifiers with other resins. They can now be reacted with polyurethanes and offer many advantages, according to Mr. Trearson.

LLOYD J. REINDL, *Secretary*

Houston December 14

Larry Durr, of Interdyne, Inc., spoke on "PROPER ECONOMIC AND ENVIRONMENTAL ASPECTS OF SOLVENT RECOVERY."

Mr. Durr explained that the continued escalation of costs in general is tending to make solvents one of the most expensive natural resources. The two major methods of distillation of dirty solvents, the conventional convection method, and the newer steam injection system, were compared by Mr. Durr. He listed the following advantages of the steam injection system which are largely achieved through operational efficiencies: low maintenance factor, high quality distillate, relatively low energy consumption, low labor factor, and relatively short pay off time.

Q. How would the unit handle materials that tend to polymerize inside the distillation chamber?

A. A unit can be equipped with a feed system to inject chemicals such as caustic soda to retard polymerization.



Executive Committee of the Los Angeles Society for Coatings Technology for the year 1976-77. Left to right: Council Representative—William H. Ellis, of Chevron Research Co.; Vice-President—Robert F. Koperek, of Mobil Chemical Co.; Treasurer—Fred Croad, of Engard Coatings Corp.; Secretary—Albert Seneker, of Ameron Corp.; and President—Gerald L. West, of Ameritone Paint Corp.

Dr. Roy Tess, of Shell Chemical Co. and immediate Past-President of the Paint Research Institute, reported on the PRI Symposium on mildew held during the Federation's Annual Meeting in Washington, D.C. in October. Some conclusions reached, he said, were that the point that mercurial mildeicides react with decomposition products of other ingredients in the paint film rendering the mildeicides useless, could be looked into by society Technical Committees and perhaps some preferentially sacrificial material could be used to react with the decomposition products instead of the mercury compounds.

THOMAS RULAND, *Secretary*

**Northwestern
December 7**

Donald Cope, of Byk-Mallinckrodt, spoke on "NEW CONCEPT OF PIGMENT WETTING IN AQUEOUS COATINGS SYSTEMS."

Mr. Cope said that the basic concept of initial pigment wetting is the same as described in the theory for solvent-based coatings. The primary pigment particle first has to be made hydrophobic by attaching a hydrophobic monolayer of wetting agent on the pigment surface. In order to achieve this result, he said, wetting agents are used to disperse the pigment in water soluble resin and not in water with the presence of surfactants as was previously done. Mr. Cope indicated that by using this approach, grinding times are reduced while hiding power, color development, and tinting strength are increased. Settling and flocculation are also eliminated, he added.

Q. Are there differences in appearance between dipping applications and spray applications, and how do you eliminate the differences?

A. Start with a highly polar grinding vehicle which is a good wetter and then optimize the wetting agents for best results.

Q. If other additives are required in the formulation, would low or high surface tension additives be recommended?

A. Low surface tension additives, because the high surface tension additives break the effectiveness of the defoamers.

ROBERT HESKIN, *Secretary*

**Northwestern
January 4**

Dr. Loren Hill, of North Dakota State University, spoke on "VISCOSITY VARIATION OF VARIOUS MOLECULAR WEIGHTS OF WATER SOLUBLE SYSTEMS."

Dr. Hill discussed the variations in viscosity during the dilution of the paint after application and before cure. It was found, he said, that on dilution of various water-based paints (alkyds, polyesters, and acrylics) the viscosity would increase initially, and then decrease, at first gradually, then rapidly. The extent and height of this plateau curve were found to be dependent on various factors. A study was made of the effect of the addition of pigment or melamine and similar curves were obtained, said Dr. Hill. In the measurement of viscosities, the curves had lower plateaus when the shear rates were increased, he added.



Officers of the Northwestern Society for Coatings Technology for the year 1976-77. Left to right: President—Raymond J. Mueller, of Frost Paint & Oil Corp.; Vice-President—James E. Fanslow, of Farwell, Ozmun, & Kirk; Treasurer—Al Heitkamp, of Cargill, Inc.; Secretary—Robert Heskin, of Valspar Corp.; and Council Representative—Lowell F. Wood, of Frost Paint & Oil Corp.

Q. What would happen if a blend of a water soluble resin and latex were used?

A. This is presently being studied in the area of using the water solubles as flow agents in latex paints.

Q. Why do the aggregates contract on the addition of water?

A. Water is a poor solvent, hence the polymers contract and become more coiled.

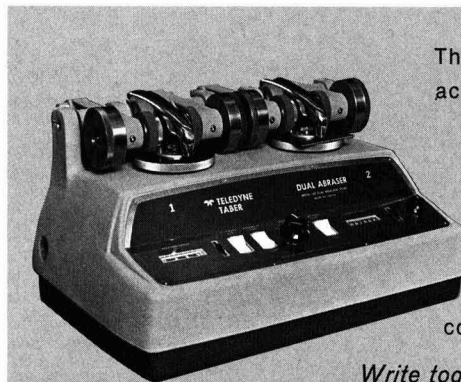
ROBERT HESKIN, *Secretary*

**Philadelphia
December 9**

Wolfgang Zinnert of Byk-Mallinckrodt, presented a talk on "NEW CONCEPT OF PIGMENT WETTING IN AQUEOUS COATING SYSTEMS."

Mr. Zinnert explained in some detail the concept of using hydrophobic wetting agents for aqueous coating systems. He outlined differences of nonionic, anionic, and cationic surfac-

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Society Meetings (Continued)

tants and their function in aqueous paints. He also discussed the differences between surfactant function of pigment wetting and hydrophobic wetting agents. In order to demonstrate a proper functioning surfactant system, the pigment must be surrounded by a double layer—one being hydrophilic (outer layer) and the other being hydrophobic.

Mr. Zinnert illustrated his talk with some colorful slides.

He further discussed the method of addition for hydrophobic wetting agents.

Q. Could you tell us what chemical group these additives are identified with?

A. These compounds are classified as high molecular weight fatty acid esters.

Q. What molecular weight or diameter length do these compounds fall in?

A. The molecular weight is generally in the range of 800–1200 MW. If the diameter length and MW is below 600–700, the additive becomes water soluble.

Q. Would you classify Soya Lecithin as a hydrophobic wetting agent?

A. Not really. Soya Lecithin is an efficient pigment wetting agent. It quite readily emulsifies in a pigmented system.

LOTHAR S. SANDER, *Secretary*



Executive Committee of the Philadelphia Society for Coatings Technology for the year 1976-77. Seated left to right: Assistant Treasurer—Barry Oppenheim, of McCloskey Varnish Co.; Treasurer—Carl W. Fuller, of Cities Service Co.; President-Elect—Wayne N. Wood, of Allentown Paint Mfg. Co.; President—Wayne A. Kraus, of Lawrence-McFadden Co.; and Secretary—Lothar Sander, of N L Industries, Inc. Standing left to right: Member-at-Large—Joseph Beno, of DeSoto, Inc.; Council Representative—J. Richard Kiefer, Jr., of McCloskey Varnish Co.; Alternate Council Representative—John A. Stigile, of duPont de Nemours & Co., Inc.; Educational Committee Chairman—Ben Chatzino, of Quaker City Chemicals; Membership Committee Chairman—Lawrence J. Kelly, of George A. Rowley & Co.; Immediate Past-President—Michael L. McGroarty, of DeSoto, Inc.; and Technical Committee Chairman—Stanley LeSota, of Rohm and Haas Co.

Piedmont November 17

William Arnheim, of Inmont Corp., spoke on "PIGMENT DISPERSION, THEIR TECHNOLOGY AND END USE."

Peter Teague, Education Committee Chairman, presented a check for \$200 to the Chemistry Dept. of Appalachian State University for the A.R. Smith Scholarship Fund.

James Bohlen was elected for another three-year term as the Society's Council Representative.

CHARLES B. WILSON, *Secretary*

Piedmont December 15

Norman Graham, Attorney; Robert Kelley, Accountant; and William Walke, of Equitable Life Assurance Society, spoke on "ESTATE PLANNING."

They stressed the desirability and need for intelligent planning in order to insure that the surviving members of a family be spared unpleasant surprises in the desired division of money and property.

CHARLES B. WILSON, *Secretary*

Western New York November 9

Society President Joan K. Helm announced that Paul Guevin had won the Trigg Award of 1975-76 Society Secretaries. He shares the award with two other secretaries.

Dr. Harold Wittcoff, of General Mills, Inc., spoke on "CONSEQUENCES OF CHANGE."

Dr. Wittcoff noted the effects of increased technology and consumption on society and, specifically, the paint industry.

LEONARD H. GIELNSKI, *Secretary*



Officers and Committee Chairmen of the Montreal Society for Coatings Technology for the year 1976-77. Seated (left to right): House Committee—R. Snyder, of Duron (Canada) Ltd.; Treasurer—Paul Ruiz, of Duron (Canada) Ltd.; President—Peter Hiscocks, of Tioxide of Canada Ltd.; By-Laws Committee—V.K. Sharma, of Bertrand Paints, Inc.; and Immediate Past-President—K.E. Delamater, of Sico, Inc. Standing (left to right): Environmental Control Committee—J.C. Asselin, of Betonal Ltee; Technical Committee—R. Rauch, of Tioxide of Canada Ltd.; Special Events Committee—D. Kasner, of Reichhold Chemicals Ltd.; Symposium Committee—A.K. Hagopian, of Canadian Industries Ltd.; Council Representative and Membership Committee—Horace Philipp, of Sherwin-Williams Co. of Canada Ltd.; Awards and Nominations Committee—F. R. Gregory, of Sherwin-Williams Co. of Canada Ltd.; Corresponding Secretary—J. Melsback, of Sico, Inc.; Educational Committee—W. Kolanitch, of Sherwin-Williams Co. of Canada Ltd.; and Manufacturing Committee—B. A. Laughton, of Sherwin-Williams Co. of Canada Ltd. Officers not shown: Vice-President—R. L. Sheppard, of Pfizer Co. Ltd.; Recording Secretary—A. Parent, of Monsanto (Canada) Ltd.; Archivist—S. Dalva, of Sico, Inc.; and Long Range Planning Committee—V. R. Pedersen, of Tioxide of Canada Ltd.

Elections

CLEVELAND

Active

EDWARDS, JAMES B.—International Minerals & Chems., Hillside, Ill.
MANDLEY, ROY L.—Dexter Midland Corp., Cleveland, Ohio
SCHILLER, ANDREW D.—Fasson Div., Painesville, Ohio
WALKER, THOMAS E.—Jamestown Paint & Varnish Co., Jamestown, Pa.

Associate

BEATO, LOUIS J.—Cities Service Co., Akron, Ohio
BREEN, ROBERT W.—Donald McKay Smith, Inc., Lakewood, Ohio

HOUSTON

Active

HATCH, RAYMOND L.—Shell Development Co., Houston, Tex.
OLSON, JOHN M.—Shell Development Co., Houston.
SHERBURNE, PARTICIA S.—EXXON Chemical Co., Houston.

Associate

DELAY, ROY E.—Crozier Nelson Chems. & Containers, Inc., Houston.
KONCI, MICHAEL J.—N L Industries, Inc., Springs, Tex.

LOS ANGELES

Active

ALAM, M.—Chemical Coatings Consultant, Placentia, Calif.
ANDERSON, F. BRUCE—Rohm and Haas Co., Los Angeles, Calif.
BALEY, JESSE F.—City of L.A.—Waste Water, Los Angeles.
BISSONNETTE, YANCY—Scholle Corp., Norco, Calif.
BRODT, BARRY B.—Inmont Corp., Anaheim, Calif.
CLUFF, FRED W.—Western Chemical & Manufacturing Co., Los Angeles.
CONRAD, BRUCE H.—Ashland Chemical Co., Sante Fe Springs, Calif.
CULLEN, GEORGE C.—Emery Industries, Inc., Downey, Calif.
DEFENDORF, EDWARD J.—Morehouse Industries, Inc., Fullerton, Calif.
DEMEYER, ROBERT J.—PPG Industries, Inc., Torrance, Calif.
DICKMAN, ROBERT F.—Spencer Kellogg Div. Textron, Long Beach, Calif.
DOSTALIK, J. V.—Dostachem, Chula Vista, Calif.
ENGSTROM, E. PAUL—Bradco Co., Cudahy, Calif.
EVANS, JAMES E.—United Coatings, Inc., Los Angeles.
FARFAN, JUIS S.—Shiva, Inc., Torrance.

GRAFF, LEO E.—E.I. du Pont de Nemours & Co. Inc., Arcadia, Calif.
GROSS, ED A.—Modern Coatings, Cerritos, Calif.
HASSIS, CARL H.—Tenneco Chemicals, Inc., Buena Park, Calif.
HAVASHIDA, KEITH H.—Conchemco, Inc., Los Angeles.
HAYDEN, LAWRENCE N.—Stay & Day Paint Materials Co., Los Angeles.
HERBER, KATHLEEN M.—Ameron, Brea, Calif.

HUEMME, DOUGLAS W.—Whittaker Corp., Los Angeles.
HUTZLER, JOHN C.—Morehouse Industries, Inc., Fullerton.
KIM, KEITH K.S.—Union Oil Research, Brea.
KING, JOSEPH E.—J.E. Bauer, Los Angeles.
KUMAR, SURESH—Harshaw Chemical Co., Sylmar, Calif.
LALAIN, DAVID A.—PPG Industries, Inc., Torrance, Calif.



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 LILI, DONGHWA—International Service Lab. Torrance.
 MARQUEZ, LINDA A.—Ameron, Brea.
 McLAUGHLIN, CHARLES D.—Chevron Research Co., El Segundo, Calif.
 MICHAUD, CHARLES F.—Rohm and Haas Co., Los Angeles.
 MILICI, STEPHEN G.—Deft, Inc., Irvine, Calif.

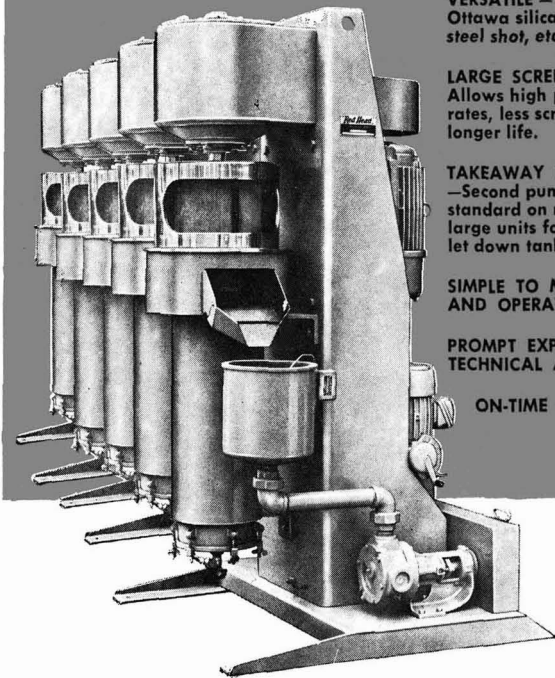
MOISEVE, DAVID J.—Western Specialty Coatings, Commerce, Calif.
 MOONEY, CHARLES P.—Major Paint & Varnish Co., Torrance.
 MORAN, EDWARD E.—Whittaker Corp., Los Angeles.
 MOREHOUSE, DALE H.—Harrisons & Crossfield (Pacific) Ltd., Newport Beach, Calif.
 MYINT, THAN—Modern Coatings, Cerritos.
 NEERMAN, LOWELL S.—Modern Coatings, Cerritos.

NEISLER, LLOYD L.—Reichhold Chemicals, Inc., Azusa, Calif.
 NI, RAIN W.—Luminall Paints, Inc., Commerce.
 PIZZO, THOMAS M.—Commerce Chemical Co., Santa Ana, Calif.
 PROBIZANSKI, ANNE M.—E. T. Horn Co., La Mirada, Calif.
 RICHARDSON, JOHN I.—Ameron, Brea.
 ROBINSON, ROBERT E.—Glidden-Durkee Div., SCM Corp., Commerce.
 ROWDER, ALAN G.—Sun Chemical Pigments Div., Pico Rivera, Calif.
 SCHADE, CAROL L.—Chemetron Pigments, Santa Fe Springs, Calif.
 SCHINGECK, GARY H.—Modern Coatings, Cerritos.
 SELTZER, EDWARD C.—Union Carbide Corp., Marina Del Rey, Calif.
 SHADLE, BRICE W.—Old Mission Specialties, El Toro, Calif.
 SMITH, CAL C.—Inmont Corp., Anaheim.

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 STUMP, DAVID M.—Sinclair Paint Co., Los Angeles.
 SWEET, ROLAND—Morehouse Industries, Inc., Fullerton.
 TENBERGEN, ERIC—McCloskey Varnish Co., Los Angeles.
 THOMAS, JIM E.—Paint & Coatings Corp., Industry, Calif.
 VALDEZ, GUILLERMO—Ameron, Brea.
 VAN ZELM, JAN P.—McCloskey Varnish Co., Los Angeles.
 WEISMANTEL, GUY—Guy Weismantel Co., Camarillo, Calif.
 WILLER, ROBERT J.—Ameritone Paint Corp., Long Beach.

MONTREAL

Active

CLAUDE, ASSELIN JEAN—Betonel Ltee, St. Louis Terrebonne, Que.

Associate

CREVIER, MICHEL G.—Uniroyal Chem., Ville d'Anjou, Que.
 JONES, WAYNE E.—Frank E. Dempsey & Sons, Lachine, Que.
 PARK, S. GRAHAM—Kingsley & Keith (Canada) Ltd., Montreal, Que.

NORTHWESTERN

Active

FISCHER, PATRICK G.—Valspar Corp., Minneapolis, Minn.
 HENNEN, CANDICE ANN—Valspar Corp., Minneapolis.

LARSON, DONALD R.—Midland Co., Minneapolis.

MOORE, JOHN P.—Valspar Corp., Minneapolis.

Associate

HEAL, PAUL L., JR.—Inmont Corp., Chicago, Ill.

JONES, MIKE—Union Carbide Corp., Edina, Minn.

PACIFIC NORTHWEST

Active

ALEXANDER, CHARLES J.—Simpson Timber Co., Redmond, Wash.

DORNAN, DAVID J.—Boysen P.T. Co., Portland, Ore.

DUNSMORE, J. GRANT—Reichhold Chemicals, Inc., Port Moody, B.C.

HIRATA, TADAMITSU—Asahipen America, Inc., Seattle, Wash.

INCH, JOHN—B.C. Hydro, Vancouver, B.C.

KIER, DOUGLAS J.—Asahipen America, Inc., Seattle.

KO, REY—Gilonite, Inc., Portland.

MAHONEY, KARL E.—Forrest Paint Co., Eugene, Ore.

MCCLUNG, MURRAY E.—Bapco Paint Ltd., Surrey, B.C.

MILLER, ROBERT T.—Imperial Paint Co., Portland.

POON, KENNETH—International Paints Ltd., N. Vancouver, B.C.

SADOWSKI, WALTER—Daniel Boone Paint Co., Seattle.

Associate

MCGUNAGLE, ROBERT J.—A.T. Hutchins, Lake Oswego, Ore.

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Associate

BROWN, THOMAS G.—Engelhard Minerals & Chems. Corp., Menlo Park, Edison, N.J.

RYLAND, SCOTT G.—Bucks Co. Crime Lab., Levittown, Pa.

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Active

DAVID, MICHAEL S.—CPL-APCO, Inc., Hickory, N.C.

KURZ, CLARK J.—Mobil Chemical Co., High Point, N.C.

MACLEAN, DOUGLAS M.—CPL-APCO, Inc., Hickory.

RASH, THOMAS B.—Warlick Paint Co., Inc., Statesville, N.C.

Associate

MOSELEY, WILLIAM V., JR.—Va. Dept. of Highways & Transportation, Richmond, Va.

TORONTO

Active

LIN, JOHN — MacNaughton-Brooks Ltd., Weston, Ont.

NARANCIC, NADA M. — Glidden Co. Ltd., Toronto, Ont.

STEVANOVIC, MAYA D. — Ashland Oil Canada Ltd., Mississauga, Ont.

TAYLOR, STEWART M. — Trioxide of Canada Ltd., Toronto.

Associate

DRAPEAU, MICHEL — Hercules Canada Ltd., Montreal, Que.

FIASER, BRUCE H. — Reed Ltd., Toronto.

GIURLANDA, PETER J. — Steelcase Canada Ltd., Don Mills, Ont.

OSTER, MICHAEL A.J. — Velsicol Corp. of Canada Ltd., Mississauga.

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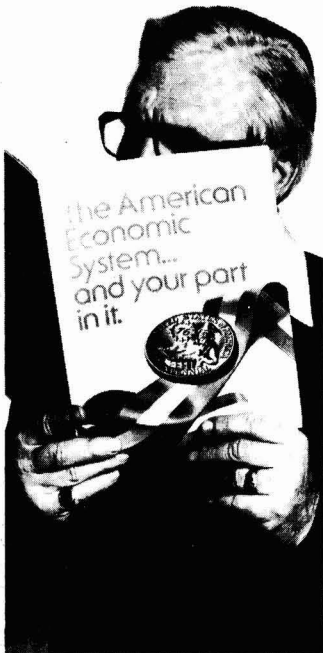
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Committee Activities

METRIC SYSTEM

Nominations to U.S. Metric Board Are Announced

President Ford has made the following nominations to the U.S. Metric Board, subject to approval by the Senate: Chairman—Lewis Polk; Consumers and Retail Affairs—Satening St. Marie; Small Business—Michael McKeivitt; Construction—Frances R. Dugan; Education—Frank Hartman; and Members-at-Large—Gerald McReal and Kenneth Taylor. All were nominated for six-year terms.

Nominated for a four-year term of office were: Engineering—Valerie Antoine; Labor—Ralph Durham, Sr.; State and Local Government—Harry Kinney; Small Business—Carl Beck; and Member-at-Large—W. E. Hamilton.

Nominated for two-year terms were: Science—Dr. Harold Agnew; Manufacturing—A. G. Weaver; Labor—Andrew Kenopensky; Weights and Measures—Sydney Andrews; and Member-at-Large—Virginia Knauer.

The appointment of the board, repre-

senting the broad spectrum of business, labor, manufacturing, consumer interests, science, and government, represents a significant step forward in the conversion process in the U.S.

In Canada, General Motors recently announced that the first three years of the firm's metric conversion have proceeded according to plan, and that costs were found to be less than anticipated. Many machine tools were easily adaptable to metric use and required no replacement. In other conversion news, a North American soft drink firm has also found that its costs were far less than originally estimated. Conversion in the textile industry is reported to be on schedule and is expected to be complete by 1979.

On the European front, all firms trading with the United Kingdom and the Irish Republic will be required to label their products in metric only, effective April 1978.

E. L. HUMBURGER, *Chairman*

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Technical Articles in Other Publications

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

Defazet (Deutsche Farben-Zeitschrift) (In German)

Published by Lack- und Chemie-Verlag Elvira Moeller GmbH,
Karl-Benz-Strasse 11, Postfach 11 68, 7024
Filderstadt 1, Germany

- Vol. 30 No. 10 October 1976
Kelch, W.—“Colored Pigments for Automotive Finishes;” 430-433.
Anselm, D.—“Color Tolerances in Automotive Finishing;” 433-435.
Schweitzer, E.—“Paint Removal—Practice and Theory;” 436-439.
Mücher, E.—“Development and Introduction of New Paint and
Coating Systems from the Paint User’s Point of View;” 439-444.
Goldschmidt, A.—“Development of New Painting Systems from the
Paint Manufacturer’s Point of View;” 444-449.
Anon.—“Two Examples of Automotive Finishing—Vertical Electro-
trodposition of Automotive Bodies;” 449-453.
Völz, H.G.—“Quantitative Optical Characterization of Transparent
Pigments. Part 2: Experimental Part;” 449-453.

Double Liaison—Chimie Des Peintures (in French)

Published by Les Presses Continentales, Rue du
Cherche-Midi, F-75006, Paris, France.

- Vol. 23 No. 254 October 1976
Goossens, H.—“Present Binders for Anti-Corrosive Paints;” 21-31.
Huxtable, D.J.—“Calcined China Clays: Shape and Nature of Particles and Their Properties in Paint Systems;” 32-38.
Piot, R.—“Cellulose Ethers and Wall Coatings;” 39-48.

Industrial & Engineering Chemistry, Product Research & Development

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

- Vol. 15 No. 4 December 1976
Petrie, E.M.—“Effect of Surfactant on the Viscosity of Portland
Cement—Water Dispersions.” (Anionic Surfactants Based on
Alkyl Naphthalenesulfonic Acid); 242-249.

Farbe und Lack (in German)

Published by Curt R. Vincentz Verlag, 3 Hannover, Postfach
6247,
Schiffgraben 43, Germany

- Vol. 82 No. 12 December 1976
Sander, H., and Kroker, R.—“Acrylic Resins Containing Carboxylic
Groups for Stoving Lacquers with Reduced Solvent Content;”
1105-1111.
Wenderdel, H., and Knappe, E.—“Possibilities of Gas-
Chromatographic Investigation of Emissions at Stoving Lacquer
Coatings;” 1112-1116.
Dittrich, H.K.—“Wettable Surface of Solid Particles in a Disperse
Medium, Especially Considering Formulation and Manufacturing
of Lacquers;” 1117-1123.
Knecht, A., and Kreisler, R.—“Flame- and Explosion-Proofness of
Electrostatic Hand-Spraying of Powder Coats Containing Alumi-
num;” 1124-1126.

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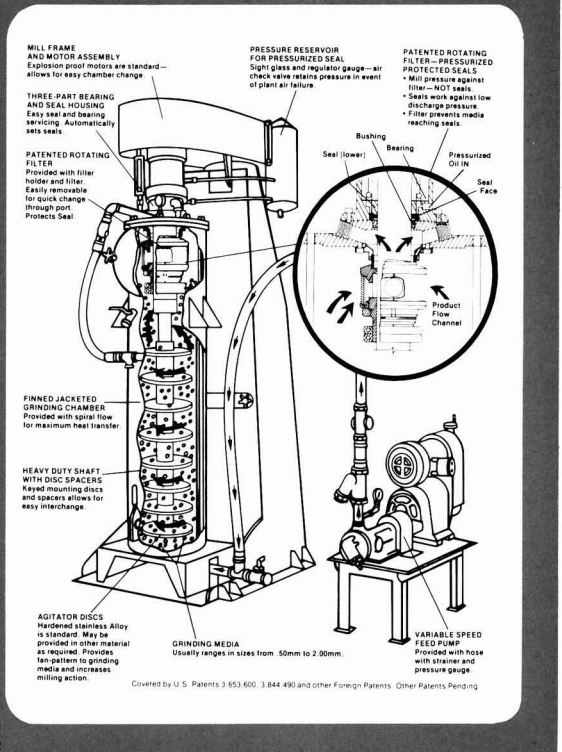
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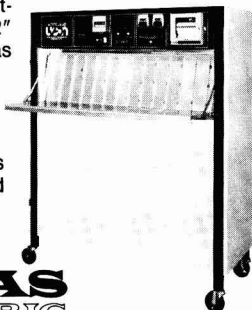
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- Brushwell, W.—“Lacquer Curing by Radiation” (Literature Review); 1127-1134.
 German Standard Draft DIN 53 193: Testing of Pigments: Determination of Density; 1135-1148.
 Uhlemann, G.H.—“Printing Inks Enforce Progress in Endless Printing. Market Value, Composition and Width of Application of Endless Printing Inks;” 1149-1152.

Journal of the Oil and Colour Chemists' Association

Published by Oil and Colour Chemists' Association, Priory House,

- 967 Harrow Road, Wembley, Middlesex, HAO 2SF England
 Vol. 59 No. 12 December 1976
 Saarnak, A., Nilsson, E., and Kornum, L.O.—“Usefulness of the Measurement of Internal Stresses in Paint Films;” 427-432.
 van der Werff, A.—“Comparison of the Effects of Resin Composition and pigments on the Anti-Corrosive Properties of Powder Coatings;” 433-438.
 Zorll, U.—“Progress Towards International Agreement on Gloss Measurement of Paint Films;” 439-442.
 Carr, W.—“Optical Properties of Films;” 443-452.

Paint Manufacture

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

- Vol. 46 No. 8 October 1976
 Anon.—“Standardisation of Package Sizes of Paint” (based on a paper read by N. Hilli to Finnish Packaging Association); 17, 20-21.

Pigment and Resin Technology

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

- Vol. 5 No. 10 October 1976
 Berger, W.—“Accelerated Weathering for Testing of Binders;” 8-11.
 Vol. 5 No. 12 December 1976
 Americus—“Coatings Update: Coil Coatings;” 15-19.

Plaste und Kautschuk mit Fachtteil Anstrichstoffe (in German)

- Published by VEB Deutscher Verlag für Grundstoffindustrie, Karl-Heine-Strasse 27, 7031 Leipzig, E. Germany DDR
 Vol. 23 No. 11 November 1976
 Winn, F., Schöllner, R., and Kiessling, D.—“Influence of the Molecular Weight of Linear Polyesters on their Oxidation Behaviour;” 838-840.
 Müller, K.—“On Determining the Sedimentation of Pigments and Fillers in Bituminous Paint Materials;” 841-845.

La Rivista del Colore—Verniciatura Industriale (in Italian)

Published by La Rivista del Colore, S.R.I., Via Imbriani 10, 20158 Milan, Italy

- Vol. 9 No. 102 October 1976.
 Anon.—“Painting of Alfa Sud; a Combination of Decorative Finish and Anticorrosive Protection;” 323-330.
 Solventi, P.—“Guidelines for Construction of Pretreatment and Coating Lines;” 331-335.
 Lanino, P.G.—“Safety in Paint Shops Using Solvent-Based Paints;” 339-342.
 Vol. 9 No. 103 November 1976
 Santagata, F.—“Application of Paints for the Inside of Fuel-Gas Pipe Lines;” 363-369.
 Pittator—“Guide for a Plant Design for Pretreatment and Painting—Part V: Tunnel for Pretreatment of Metallic Surfaces;” 371-374.
 Ferraris, E., and Guidetti, G.—“Plafiorization (One Stage Process for Degreasing and Phosphating at Room Temperature)—Working Conditions;” 377-379.

Meetings/Education

West Coast Symposium/Show Set for March 2-4

The 13th Biennial Western Coatings Societies' Symposium and Show, spotlighting three days of technical presentations and the displays of some 40 supplier firms, will be held March 2-4 at the Marriott Hotel, Los Angeles, Calif.

The technical program will feature 24 paper presentations on a variety of topics, with special emphasis on water-borne industrial and trade sales coatings and the chemistry of low-energy conversion coatings. Also featured are workshops on government labeling regulations and dispersion.

The Symposium/Show, jointly sponsored by the Los Angeles, Golden Gate, Rocky Mountain, and Pacific Northwest Societies for Coatings Technology, is held in alternate years in either San Francisco or Los Angeles. Last held in San Francisco in March 1974, the event was delayed until this year inasmuch as the Federation Annual Meeting and Paint Industries' Show was held in Los Angeles in October 1975.

The following program presentations are scheduled:

MARCH 2

GOVERNMENT LABELING REGULATIONS WORKSHOP—Panel of federal and state officials will discuss labeling regulations as they concern the paint industry. A question-and-answer session will follow.

"Applications of Appearance Measurements (Color, Gloss, Opacity and Luminous Reflectance) in the Coatings Industry"—Richard S. Hunter, of Hunter Associates Laboratory.

"Color Measurements in the Iron Oxide Industry"—Robert C. Zeller, of Pfizer Minerals, Pigments & Metals Div.

"Physical Properties of Organic Color Pigments for Trade Sales Paints"—Ralph E. Edelman, of Pigments Div., E. I. du Pont de Nemours & Co., Inc.

"Flushed Color Story, Including Properties of Various Pigments as They Relate to the Flushing Technique"—Gustav Gurska, of Hilton-Davis Chemical Co.

MARCH 3

"Physical Properties of Water-Dispersible Vehicles"—Don C. Pelowe, of Cargill, Inc.

"Corrosion Resistance and Water Dispersibility"—Paul C. Stievator, of Spencer Kellogg Div. of Textron, Inc.

"Water-Reducible Resins as Coat-

ings Vehicles"—Gary A. Miller, of The Goodyear Tire & Rubber Co.

"High Solids Coatings for Wood, Metal and Plastics"—James D. Crowley, of Eastman Chemical Products, Inc.

"Kinetic Considerations in Low Energy Curing Coatings"—Dr. Zeno W. Wicks, Jr., of Polymers and Coatings Dept., North Dakota State University.

"Developments of Water-Borne Vehicles for Use in Industrial Wood Coatings"—J. Hortensius, of Synres International.

"New Approach to Formulation of Water-Borne Coatings"—Werner J. Blank, of American Cyanamid Co.

"Low Temperature Cure Aminoplast Systems"—Timothy F. Desmond, of Monsanto Co.

"New Concept of Pigment Wetting in Aqueous Coating Systems"—Wolfgang Zinnert, of Byk-Mallinckrodt.

"Practical Application of Characteristic Physical Data of Various Extenders on Their Durability in Coatings Systems"—Carl Thorstad, of Johns-Manville Products Corp.

"Particle Size and Shape of Extender Pigments and Effect on Water-Based Coatings"—George P. Larson, of Georgia Kaolin Co.

"Behavior of Nitropropane in Complying Solvent Blends"—Robert Bennett, IMC Chemical Group.

MARCH 4

"High Performance Isocyanate-Oxazolidine Coatings"—Dr. William D. Emmons, of Rohm and Haas Co.

"Evaporation Phenomena: Precise Comparison of Solvent Evaporation Rates from Different Substrates"—Dr. Albert L. Rocklin, of Shell Development Co.

"Long-Term Durability of Solvent Vinyl Coatings"—Dr. Thomas Ginsberg, of Union Carbide Corp.

"Instrumental Techniques as a Means to Rheological Control of Coatings"—Dr. Eric Ernich, of N L Industries, Inc.

"Polyamide-Epoxy Vehicle: Mechanism of Film Formation"—Dr. Harold Wittcoff, of General Mills Chemicals, Inc.

"Role of the Curing Agent in Solvent-Free Epoxy Coating Systems"—John Sinclair, of Anchor Chemical Co., Ltd.

"Unique, Water-Dispersible,

Acrylic-Epoxy Coatings"—Ralph R. Shelley, Jr., of Dow Chemical Co.

"Water-Borne Epoxy Resins"—Dr. Edward G. Bozzi, of CIBA-GEIGY Corp.

GOLDEN GATE SOCIETY MANUFACTURING WORKSHOP ON DISPERSION—"Economic and Technical Parameters of Pigment Dispersion"—Fred Daniel, of Daniel Products Co.; "Selecting the Proper Equipment for Dispersing"—Robert W. Norris, of Norris Paint Manufacturing Co.; "Sand Mills for Dispersing"—Dale Morehouse, of DHM Co.; "Small Media Mills and Media"—Leo Dombrowski, of Chicago Boiler Co.; "Variations in High Speed Dispersers and What They Will Do"—Phillip Myers, of Myers Engineering Co. Discussion period will follow the presentations.

The Show will run concurrent with the technical sessions, and will also be held at the Marriott.

Complete details on the event and information on registering are available from Romer E. Johnson, Dorsett & Jackson, Inc., 3800 Noakes St., Los Angeles, Calif. 90023.

Organic Coatings Short Course Underway in Philadelphia

An Organic Coatings Short Course (series of eight 2-hr lectures monthly) is being sponsored by the Joint Education Committee of the Philadelphia Society for Coatings Technology and the Philadelphia Paint and Coatings Association. The lectures, initiated January 13, are held preceding the Philadelphia Society's monthly meetings. Twenty-four students are enrolled.

Designed and conducted by Dr. Seymour Hochberg, Research Fellow, E. I. du Pont de Nemours & Co., Inc., the presentation is a Short Course of the American Chemical Society and concentrates on the principles involved in the technology or organic coatings, their manufacture, application to surfaces, and properties. Qualitative understanding of principles and mechanisms is emphasized rather than mathematics.

Registrants are required to have a knowledge of undergraduate physics and chemistry. The course is designed to be of benefit to chemists, formulators, or technicians who wish to broaden their knowledge of the field. Even those chemists who have considerable background and experience will gain valuable insight and knowledge.

Coatings Papers Highlight NACE Conference

Two panel discussions and 35 technical papers will be presented on protective coatings to control corrosion during CORROSION/77, the annual conference of the National Association of Corrosion Engineers, which will be held March 14-18 at the San Francisco Hilton, San Francisco, Calif.

Included in the presentations are:

"Sulfides—Their Effect on Coatings and Substrates"—C. G. Munger, of Ameron.

"Analysis of Problems in Protective Coatings Applications"—J. F. Monte, of Carboline Co.

"General Nuts and Bolts Chemistry of Coatings and How It Relates to Coatings Performance"—K. B. Tator, of Kenneth Tator Associates.

"Inorganic Zincs—Fact and Fancy"—M. Hendry, J. Eng, N. Kemp, and J. P. Dowd, of Napko Corp.

"A Closer Look at the Zinc Particles in a Zinc Rich Primer"—R. T. Bell, of R. T. Bell & Associates, and J. L. Baker, of Shell Oil Co.

"Present Trends in Pipe Coatings to Protect Pipe-Type Cable Lines in the Utilities Industries"—R. N. Sloan, of H. C. Price Co.

"Surface Coatings as a Means of Corrosion Control"—K. Lowrey, of Colbrand Ltd., and R. DeGeorge, of Pullman-Kellogg.

"Recent Advances in Marine Coatings"—A. H. Roebuck and G. C. Cheap, of Fluor Engineers.

"Iron Sulfide Coatings to Reduce Hydrogen Damage in H₂S Environments"—D. Dautovich and Malcolm Hay, of Ontario Hydro.

"Polyethylene-Extrusion Coating of Buried Steel Pipe, Properties, Experiences, Valuation"—N. Schmitz-Pranghe, of Mannesmannroehren-Werke AG, and W. von Baeckman, of Ruhrgas AG.

"Coating Selection and Maintenance Painting Costs—Pulp and Paper Industry"—L. E. Parks, of Carboline Co.

These papers are among more than 200 presentations featured in 33 symposia sponsored by NACE Technical Committees at the annual meeting. Individual meetings of the NACE Technical Committees are also scheduled to provide a forum for discussion on all phases of corrosion control. The Corrosion Research Conference, a series of five sessions comprised of presentations on specific corrosion problems, is another featured segment of the program.

Additionally, the concurrent Materials Performance & Corrosion Show will feature approximately 100 booths displaying the products and services of supplier companies.

Registration fees are: NACE members, \$45; nonmembers, \$60.

For additional information, contact William Carlin, National Association of Corrosion Engineers, 2400 W. Loop South, Houston, Texas 77027.

Series of Courses Scheduled On Special Protective Coatings

A series of five 40-hr courses is being sponsored by the Protective Coatings Section of The Institute of Applied Technology, designed to prepare personnel engaged in inspection and supervision of application of safety related nuclear coatings and coating systems specified for corrosive environments.

The courses consist of subject matter of importance to all with responsibilities for the maintenance of performance standards in the field. They include inspector and applicator training subjects outlined in nuclear guidelines manuals (as well as for refining, chemical and petrochemical, paper, pulp, food and related processing industries); nuclear and conventional power generation facilities; marine, shore-line and offshore projects; transmission lines; water and sewage treatment plants; structural steel and storage tanks; industrial and commercial applications; transportation and housing.

Use and calibration of measurement equipment and coating application practices and equipment will be emphasized.

Classroom instruction encompasses an introduction to coatings technology; coating for corrosion control; relevant industry standards, specifications and guidelines; methods of surface preparation, coating application, testing and inspection; and recordkeeping and reporting.

Field training is included, specifically the use of surface preparation and application equipment and the use of testing and measurement devices.

Visitations will be made to a nuclear power plant, coating test facility, environmentally acute process plant, or marine exposure site for background and orientation.

Certification of satisfactory completion of course will be awarded.

The first of the Monday-through-Friday courses was held in February in Philadelphia. The four remaining courses will be held as follows: Chicago—Mar. 28-Apr. 1; Houston—May 9-13; San Francisco—Sept. 26-30; and Pittsburgh—Nov. 14-18.

The course fee is \$480, which includes tuition, lecture notes, reference materials, and supplies, as well as five lunches and two dinners.

Complete information is available from the Institute of Applied Technology, P.O. Box 32080, Washington, D.C. 20007.

Detroit Society Co-Sponsoring Coatings Technology Course

A 12-week course in "Surface Coatings Technology" is being sponsored by the Detroit Society for Coatings Technology, in conjunction with the Detroit Paint and Coatings Association and The Polymer Institute of the University of Detroit.

Initiated January 31, the course is given in two-hr sessions on Monday evenings. The sessions include lectures on modern coatings technology and some lab demonstrations illustrating the properties, application, characteristics, and test results of various coatings.

Among the topics to be covered are: principles of formulation; color concepts and color matching; white and extender pigments; color pigments; pigment dispersion; paint calculations; paint driers and additives; and formation and structure of paint films.

USM Polymer Science Seminar Mar. 18 to Honor Dr. J. S. Long

Dr. B. George Bufkin, Chairman of the Department of Polymer Science, has announced that the University of Southern Mississippi will sponsor an all-day symposium on polymer science in honor of Dr. J. Scott Long, who was, to a great extent, responsible for starting the Polymer Science program at USM.

No registration fee will be charged, and all polymer scientists, engineers, and technologists interested are cordially invited to attend the event, to be held at the University of Southern Mississippi, Hattiesburg, Miss.

Southern Society and USM Co-Sponsor Symposium On Water-Borne and Higher-Solids Coatings

The Southern Society for Coatings Technology joined with the University of Southern Mississippi's Department of Polymer Science in co-sponsoring a symposium on "Water-Borne and Higher-Solids Coatings," held February 14-16 at the International Hotel, New Orleans, La.

This was the third consecutive year the Society and USM have held the event.

The following paper presentations were featured:

"Prospects for Low Emission Liquid Industrial Coatings"—Lou R. Lebras, of PPG Industries, Inc.

"Why High Solids?"—Jim Larson, of Cargill, Inc.

"Control of Hydrocarbon Emissions from Stationary Sources"—James C. Berry, of U.S. Environmental Protection Agency.

"Epoxy Derived Resins for Water-Borne Can Coatings"—Marcel M. Gaschke, of CIBA-GEIGY Corp.

"New Approach to Formulation of Water-Borne Coatings"—Werner Blank, of American Cyanamid Co.

"Microbiology and Water-Borne Coatings"—Milton Goll, of Cosan Chemical Co.

"Crosslinking Studies of Thermosetting Emulsion Polymers"—David R. Bassett and Michael A. Sherwin, of Union Carbide Corp.

"Formulation and the Environment—Keys to Performance of Water-Borne Coatings"—Vincent Calder, of Rohm and Haas Co.

"Viscosity of Concentrated Oligomer Solutions"—A. W. Garner and J. R. Erickson, of Glidden-Durkee Div. of SCM Corp.

"Coatings in Transition"—Thomas

J. Miranda, of Whirlpool Corp., and Technical Editor of JOURNAL OF COATINGS TECHNOLOGY.

"High Solids—Low Energy Cure Coating Systems"—George H. Wilhelm, of Ashland Chemical Co.

"Higher Solids Coatings for Metals and Plastics"—Larry G. Curtis, of Eastman Chemical Products, Inc.

"Latex Caulks"—Walter Aberth and Donald Dahm, of DAP, Inc.

"Chemically Resistant Electrodeposition Vehicle"—James H. Sample and Richard J. Pokusa, of Sherwin-Williams Chemicals.

"Pressure Sensitive Adhesives: Structure-Performance Relationships"—M. R. Rifi, of Union Carbide Corp.

"Problems in Formulating Water-Borne Industrial Coatings"—Robert S. Bailey, of Lilly Industrial Coatings, Inc.

"Behavior of Pigment Colors in Water-Borne Industrial Coatings"—T. L. Kolski and B. H. Garth, of E. I. du Pont de Nemours & Co., Inc.

"Advances in Equipment for Applying Water-Borne and High-Solids Coatings"—James Scharfenberger, of Ransberg Corp.

"PETA—Based Higher Solids Coatings"—Eli Levine, of Celanese Chemical Co.

"Future of High Solids"—Martin B. Price, of Reliance Universal, Inc.

"Silicones as Crosslinking Agents for Organic Polymers"—Gary E. Legrow, of Dow Corning Corp.

"Cycloaliphatic Epoxy Based High-Solids Coatings"—Oliver W. Smith, J. V. Koleske and J. G. Kucsma, of Union Carbide Corp.

"Water and Solvent Evaporation from Latex Paint Films"—D. A. Sullivan, of Shell Chemical Co.

Lehigh Conferences To Study Polymer Research Problems, March 17 and 18

Two research definition conferences will be held at Lehigh University, Bethlehem, Pa. on March 17 and 18, respectively.

The first conference will deal with "Viscosity Drift in Latex Coating Formulations with Particular Emphasis on Carpet-Backing Formulations." The following day, Lehigh will host the second meeting, "Mud Cracking in Latex Paints."

The purpose of these conferences is to define a relevant research program which would yield results to help industrial organizations deal effectively with the above problems. The programs will be arranged to encourage an exchange of information and ideas. Overviews of the problems will be followed by presentations and discussions by program participants.

Additional information is available from Dr. Gary Poehlein or Dr. John W. Vanderhoff, Emulsion Polymers Institute, Sinclair Laboratory No. 7, Lehigh University, Bethlehem, Pa. 18015.

NCCA to Host Seminar In Chicago, March 28-30

The National Coil Coaters Association will sponsor a special educational seminar, "Focus: Coated Coil 2," at the Hyatt Regency Hotel, Chicago, Ill., March 28-30.

The three-day event will feature the theme "Energy, Economy, and Ecology" in coated coil. Speaker presentations, five problem-solving workshops, and over 100 product displays illustrating coated coil's versatility will highlight the meeting. Over 400 designers, engineers, purchasing managers, production supervisors, and materials specifiers are expected to attend the seminar.

The advantages and uses of coated coil will be emphasized in presentations by industry representatives and will be augmented by comprehensive technical exhibits.

Five concurrent workshops will feature the major industries associated with coated coil: building products, automotive, agricultural and earth moving equipment, appliances, and specialties. The sessions will give attendees an opportunity to present questions.

The seminar's final session will focus on the market advantages inherent in the use of coated coil, as well as NCCA industry support.

Registration fee is \$145.

For further information write National Coil Coaters Association, 1900 Arch St., Philadelphia, Pa. 19103.

Plastics Engineers to Hold Conference on Rigid Vinyls

A Regional Technical Conference (RETEC), sponsored by the Delaware Valley Section and the Vinyl Plastics Div. of the Society of Plastics Engineers, will be held at the Sheraton Poste Inn, Cherry Hill, N. J., March 1 and 2. Topic of the two-day conference will be "Rigid Vinyls—A Review and What's New."

George P. Schmitt, a member of the Society's Executive Committee will be a luncheon speaker, as will Dr. Peter Romanoli, superintendent of the Willingboro, N.J., public schools, and Gerald F. Scannell of the Department of Labor's Occupational Safety and Health Administration.

Thirteen papers will be delivered, plus a panel discussion on "Additives

for Rigid PVC," which will treat with stabilizers, lubricants, fillers and modifiers. The papers will deal with quality control testing of PVC compounding ingredients, dryblend compounding of rigid PVC, compounding the PVC foam and calendaring, injection molding and extruding the resin. Three papers will discuss PVC markets and another paper will update the health and safety aspects of PVC.

General chairman of the RETEC is Boris Gutbezahl of Rohm & Haas Co. Registration chairman is Karl Lauer of Harwick Chemical Corp., Box 5083, Trenton, N.J. 08638. Advance registration is \$60 for members and \$65 for non-members. On site registration is \$5 additional.

"Coatings: Dynamics and Design" Is Theme of Chicago Society's SYMCO '77

SYMCO '77, jointly sponsored by the Chicago Society for Coatings Technology and the Chicago Paint and Coatings Association, will focus on the theme, "Coatings: Dynamics and Design." The event will be held March 15 and 16 at the Sheraton-Oakbrook Hotel, Oakbrook, Ill.

Keynote Address will be delivered by Milton A. Glaser, of Midland Div., Dexter Corp.

The following paper presentations are scheduled:

"Toxicology, TLV's and Tomorrow"—Gerald L. Cooper, of DeSoto, Inc.

"Solubility Parameters Pertaining to

New York Coatings Course Begins Spring Semester

The spring semester of "Fundamentals of Coatings Technology" began February 9 at the New York City Community College, the second part of a two-semester course being offered by the Joint Education Committee of the New York Society for Coatings Technology and the New York Paint and Coatings Association.

The course is designed to meet the needs of people just entering the coatings industry, as well as those who wish to gain a broader background in coatings fundamentals. The spring semester (15 two-hr evening sessions) is limited to those who have successfully completed Part I, or individuals who already have a good grounding in coatings raw materials.

Part II emphasizes coatings formulation, calculations of important parameters, application methods, and equipment and test methods.

Industrial Painting Course Offered at Lehigh, Mar. 14-15

A two-day short course on "Waste in Industrial Painting: Mathematical Prediction and Determination," will be offered at Lehigh University, Bethlehem, Pa., March 14 and 15, 1977.

Reviewing the major classes of industrial paints and the most widely used painting methods, the course is designed to provide paint formulators and users a more quantitative basis for selection and application of paints. Emphasis will be on the prediction of waste loads for various painting methods.

Industrial Formulations"—Theodore Muzyczko, of Roosevelt University.

"New Developments in Urethane Coatings"—Dr. Andrew Mercurio, of Rohm and Haas Co.

"Air-Dry and Low Temperature Cured Water-Based Coatings"—Al Heitkamp, of Cargill, Inc.

"Experimental Design as It Pertains to Trade Sales Coatings"—Dr. Hillman Harris, of E. I. du Pont de Nemours & Co., Inc.

"Accelerated Testing for Evaluation of Fungus Resistance of Paint Films"—Richard T. Ross, of Buckman Laboratories.

"Manufacturing Equipment for Trade Sales Coatings"—Albert M. Lechner, of Carl Lechner, Inc.

"Microbial Viability in Water-Borne Coatings"—Dr. Milton Goll, of Cosan Chemical Corp.

"Theories of Opacity as Produced by Rutile Titanium Dioxide"—Fred B. Stieg, Consultant.

For complete information, or to register, contact Program Chairman Theodore J. Fuhs, of DeSoto, Inc., Adm. & Research Center, 1700 S. Mt. Prospect Rd., Des Plaines, Ill. 60018.

Filtration Conference Slated For Apr. 25-29 at Valley Forge

Filtration Days '77, a conference for technical people interested in techniques for the separation of particles from fluids, will be held April 25-29 at the Sheraton Hotel, Valley Forge, Pa., under the sponsorship of the Filtration Society.

Day-long short courses, covering various aspects of separation technology,

Lehigh Announces Expanded Industrial Liaison Program In Emulsion Polymers

Lehigh University's industrial liaison program in emulsion polymers has been expanded and now includes 17 industrial participants.

The program is among several educational and research activities conducted by the Emulsion Polymers Institute.

Purpose of the Institute's liaison program is to provide a mechanism whereby organizations with a commitment to emulsion polymer technology can help support a broad-based research program that can be utilized by each participating organization to help solve its own problems.

Among specific goals of the liaison program are: to carry out fundamental and applied research in the interests of program members; provide a meeting ground for members and academic researchers, not only from Lehigh but from other universities; compile and make available to members the extensive literature on the subject; make available to members results of current research; advise members on technical matters, such as feasibility studies; and facilitate the spread of ideas and concepts from one area of application to another.

will highlight the meeting.

The featured subjects include:

"Fundamentals of Filtration/Handling of Filtration Date"—Dr. Frank Tiller, of University of Houston.

"Waste Water Treatment/Advanced Waste Water Treatment"—Dr. Robert Bauman, of Iowa State University.

"Fundamentals of Membrane Separations"—Dr. Harry Gregor, of Columbia University.

"Fundamentals of Air Filtration"—Dr. Trevor Crosby, of American Air Filters, Ltd.

"Fundamentals of Particle Technology"—John Stockam, of ITT Research Institute.

"Fundamentals of Lube Oil and Hydraulic Fluid Filtration"—Dr. Ernest Fitch, of Oklahoma State University.

A concurrent exposition will feature the displays of over 70 suppliers.

Complete information on the event is available from the Filtration Society, P.O. Box 126, Mount Holly Springs, Pa. 17065.

People

Dr. Albert Paolini, Jr. has been named General Manager, Research and Development for the Midland Div. of the Dexter Corp. He will be directly responsible for the company's national product lines of industrial coatings and for coordinating the technical activities of Midland's laboratories here and abroad. He is a member of the FSCT, American Chemical Society, and the New York Academy of Science.



A. Paolini, Jr.



J. E. Long



H. G. Sholl



C. O. Martin

James E. Long has been appointed to the new position of Group Vice-President of Diamond Shamrock Corp.'s International and Diversified Technology Unit. He will be responsible for overseeing the following divisions of the Unit: New Technology and Licensing, Metal Covering, Functional Polymers, and Process Chemicals.

The company has also appointed **John R. Ruggirello** Plant Manager of its Jersey City, N.J. Soda Products Div. He replaces **Thomas Amon** who is now Plant Manager of Diamond Shamrock's silicates plant in Cincinnati, Ohio.

Myers Engineering has named **Bruce A. Myers** Assistant General Manager specializing in sales engineering. He was formerly an instructor in engineering physics at Seattle Community College and has been a consultant with Myers for 15 years. At the same time, **Horton N. Meyer** has joined the company as Factory Representative for the eastern United States and Canada. He will be headquartered in Orchard Park, N.Y.

Cletus O. Martin has been named General Sales Manager for Georgia Kaolin. He was formerly Assistant General Sales Manager.

Howard G. Sholl, Vice-President, Technical Director, and General Manager of Bruning Paint Co. has retired recently following a career of over 40 years in the coatings industry. He is a Past-President of the Federation of Societies for Coatings Technology (1958-59), and has also served in that position in both the Baltimore Society and Baltimore Coatings Association. Following his retirement, he will continue to serve on the Board of Directors of the FSCT, a post to which he was elected during the 1976 Annual Meeting in Washington, D.C. Mr. Sholl was the first recipient of the Herman Shugar Award in 1956 of the Baltimore Society for his outstanding contribution to the coatings industry.

Colin D. Penny, President of Hampton Paint Mfg. Co., Inc., Hampton, Va., received the 1976 Herman Shugar Award at the Nov. 18 annual awards meeting held jointly by the Baltimore Society for Coatings Technology and the Baltimore Paint and Coatings Association. Mr. Penny served as President of the Baltimore Society in 1972-73, and was Chairman of the Dinner/Dance Committee for the 1976 Federation Annual Meeting in Washington, D.C. During the year, he also served on the Federation's Finance and Paint Show Committees. He is the Alternate Council Representative for the Baltimore Society.

At the same meeting, Merit Awards were given to: **John Emmerling**, of Lenmar Lacquers; **Harry Dahl**, of Leidy Chemicals Corp.; **Charles Miller**, of Fein Container Corp.; **Ed Countryman**, of Baltimore Paint & Chemical Corp.; **Mitchell Dudnikpov**, of Harry T. Campbell Sons Co.; and **Jerry Goldstein** and **Robert Hopkins**, of Glidden-Durkee Div. of SCM Corp.

Union Camp Corp. has made a series of promotions in its Chemical Div.: **Frank J. Luhn**—National Accounts Executive for Inks, Adhesives, and Coatings Group; **Randall R. Lunn**—Sales Representative for the Group; and **Walter L. Jones**—Division Marketing Specialist.

The Protective Coatings Div. of International Paint Co., Inc. has named **Jack Voyles** and **Al Ellis** as Engineering Specialists. Headquartered at the division's Houston, Texas offices, both men will work with firms on coatings specifications.

Asphalt Oil, Inc. has appointed **John R. Hall** Executive Vice-President assuming responsibility as a group operating officer for the company's petroleum and chemical activities. He will report to **Robert E. Yancey**, President.

H. W. Zussman has retired as President of CIBA-GEIGY's Plastics and Additives Div. in Ardsley, N.Y. after more than 30 years in the coatings industry. He will continue as a part-time consultant to CIBA-GEIGY.

Sherwin-Williams Co. has announced the election of **Ronald F. Curley** as Executive Vice-President of the corporation and President of its coatings group. Formerly Group Vice-President, Coatings, he will continue to serve as Chief Executive Officer of Sherwin-Williams Co. of Canada, Ltd. **Wendell D. Gillund** was also elected Group Vice-President, Specialty Products.

Meanwhile, **Torrey N. Foster** has been named Vice-President, International Coatings. He will direct activities of six foreign subsidiaries and be responsible for services to licensees in 19 countries.

In a series of appointments to its Marketing Dept., Pfizer Chemicals Div. has named **Franklin P. Chapman** Director of Marketing, and **Charles N. Mastin** Director of Marketing Services.

Edward D. Ward has been named Laboratory Manager of the St. Louis facilities of Carboline Co. He was formerly Plant Manager of the Lake Charles, La. manufacturing plant.

Obituary

Dr. Edward C. Haines, 76, died December 25. Active in the paint industry for some 50 years, he served with both du Pont and Weatherill Varnish Co. Following his retirement he did consulting work for Superior Varnish & Drier Co. and Sapolin Paint Co. He was President of the Philadelphia Society for Coatings Technology (then Paint & Varnish Production Club) in 1933, and was awarded that Society's Liberty Bell Award in 1961.

Literature

Dispersing Agents

Two, multi-functional dispersing agents for water thinnable pigment systems are described in a new bulletin. Their minimal effect on gloss and water resistance in low PVC coatings is detailed. Additional information and samples of Disperse-Ayd® W-22 and W-28 are available from Daniel Products Co., Dept. C-6, 400 Claremont Ave., Jersey City, N.J. 07304.

Rust Inhibitor

Technical reports are now available concerning a new, nontoxic zinc phosphate rust inhibitor. Designated "317", the product also improves brushability and minimizes hills and valleys. The reports, along with a basic formulation and working sample are available from Reichard-Coulston, 15 E. 26th St., New York, N.Y. 10010.

Vinyl-Acrylic Polymer

A brochure has been published which describes a high molecular weight vinyl-acrylic polymer designed for use in formulating interior and exterior house paints. Formulations for a medium-cost, first-line quality interior flat wallpaint that provides good overall performance are detailed. Significant properties based on the polymer are described and formulations are suggested. For a copy of brochure F-43036 write Union Carbide Corp., Coatings Materials, Dept. JLS, 19th Floor, 270 Park Ave., New York, N.Y. 10017.

Drum Agitator

Literature describing the use and function of a removable drum agitator is now available. This is a low cost agitator designed to eliminate the need for the traditional 55, 30 & 16 gallon agitator

drums. It can be transferred from drum to drum and is available lined or unlined. For further information write Allen-Stevens Drum Accessories Corp., 27 School House Rd., Somerset, N.J. 08873.

Methacrylic Resins

A 24-page booklet has been published which details methacrylic resins for floor and wall coatings. The full-color publication gives general information on the properties of the resins and lists detailed references for the main coating applications. A tabular summary of the chemical resistances of the individual resin types is also provided. The brochure on Degadur® resins is available in German only; however, English and French versions are being prepared. For a copy write Dequssa, Postfach 2644, D 6000, Frankfurt am Main 1, Germany.

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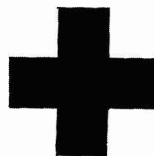
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Coming Events

FEDERATION MEETINGS

(May 20)—Spring Council Meeting. The Galt House, Louisville, Ky.

(Oct. 26-28)—55th Annual Meeting and 42nd Paint Industries' Show. Astrohall, Houston, Texas. (FSCT, Suite 830, 1315 Walnut St., Philadelphia, Pa. 19107).

SPECIAL SOCIETY MEETINGS

(Mar. 2-4)—Western Coatings Societies' Symposium and Show. Marriott Hotel, Los Angeles, California. (Romer E. Johnson, Dorsett & Jackson, Inc., 3800 Noakes St., Los Angeles, Calif. 90023).

(Mar. 11)—Symposium on "Accelerated Weathering: Myth vs. Reality." Technical Education Committee, Cleveland Society. (Carl J. Knauss, Chemistry Dept., Kent State University, Kent, Ohio 44242).

(Mar. 15)—Northwestern Society Seminar on "Computer Applications in the Paint Industry." Marriott Hotel (Airport), Minneapolis, Minn. (Don Pellowe, Cargill, Inc., Cargill Bldg., Minneapolis, Minn. 55649).

(March 15-16)—Chicago Society SYMCO '77. Sheraton-Oakbrook Hotel, Oakbrook, Ill. (Theodore J. Fuhs, DeSoto, Inc., Admin. & Res. Center, 1700 S. Mt. Prospect Rd., Des Plaines, Ill. 60018).

(Mar. 23-26)—Southern Society Annual Meeting. Fairmont Roosevelt Hotel, New Orleans, La. (Thomas E. Marek, Coronado Paint Co., P.O. Box 308, Edgewater, Fla. 32032).

(Apr. 27)—Detroit Society Symposium on "FOCUS '77—Future of Coatings Under Study." Michigan Inn, Southfield, Mich.

(May 2)—Philadelphia Society Seminar, "Nonpetroleum-Based Coatings/Raw Materials." Hilton Hotel, Mt. Laurel, N.J. (J. Richard Kiefer, Jr., McCloskey Varnish Co., 7600 State Rd., Philadelphia, Pa. 19136).

(May 5-7)—Pacific Northwest Society Spring Symposium. Thunderbird Motor Inn, Portland, Ore. (John Hatfield, Reliance Universal, Inc., 1660 Cross St., S.E., Salem, Ore. 97302).

(June 13)—Golden Gate Society Manufacturing Seminar, "Government Agencies' Regulations—Have Reasons." (Louie F. Sanguinetti, Jasco Chemical Corp., 1090 Terra Bella, Mountain View, Calif. 94042).

PAINT RESEARCH INSTITUTE MEETING

(May 16-17)—Paint Research Institute Symposium on Mildew Vulnerability. Battelle Memorial Institute, Columbus, Ohio. (Dr. Raymond R. Myers, Chemistry Dept., Kent State University, Kent, Ohio 44242).

OTHER ORGANIZATIONS

(Mar. 1)—NPCA Product Liability Seminar. Houston Marriott Hotel, Houston, Texas. (Georgene Savickas, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Mar. 1-2)—Regional Technical Conference on "Rigid Vinyls—A Review and What's New." Sheraton Poste Inn, Cherry Hill, N.J. Sponsored by the Delaware Valley Section and Vinyl Div. of Society of Plastics Engineers. (Boris Gutbezahl, Rohm and Haas Co., P.O. Box 219, Bristol, Pa. 19007).

(Mar. 8-11)—Painting and Decorating Contractors of America Annual Convention. Hyatt Regency Hotel, Houston, Texas. (PDCA, 7223 Lee Highway, Falls Church, Va. 22046).

(Mar. 14-15)—Lehigh University Short Course, "Waste in Industrial Painting: Mathematical Prediction and Determination."

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Coming Events (Continued)

(Dr. Gary W. Poehlein, Dept. of Chemical Engineering, Lehigh University, Bethlehem, Pa. 18015).

(Mar. 14-18)—National Association of Corrosion Engineers Annual Conference and Materials Performance and Corrosion Show. San Francisco Hilton, San Francisco, Calif. (NACE, 2400 West Loop South, Houston, Texas 77027).

(Mar. 16-18)—Annual Marine Coatings Conference, Broadwater Beach Hotel, Biloxi, Miss. (John Montgomery, National Paint and Coatings Association, 1500 Rhode Island Ave., Washington, D.C. 20005).

(March 17, 18)—"Viscosity Drift in Latex Coatings Formulations" (March 17). "Mud Cracking in Latex Paints" (March 18). Lehigh University, Bethlehem, Pa. (Dr. Gary Poehlein or Dr. John W. Vanderhoff, Emulsion Polymers Institute, Sinclair Laboratory #7, Lehigh University, Bethlehem, Pa. 18015).

(Mar. 18)—Polymer Science Symposium. University of Southern Mississippi, Hattiesburg, Miss. (Dr. B. George Bufkin, Department of Polymer Science, University of Southern Mississippi, Hattiesburg, Miss. 39401).

(March 21-23)—6th Annual Gas Chromatography Short Course. Occidental College, Los Angeles, Calif. (Dr. R. L. Arney, Dept. of Chemistry, Occidental College, Los Angeles, Calif. 90041).

(Mar. 22)—NPCA Product Liability Seminar. Holiday Inn O'Hare Kennedy, Rosemont, Ill. (Georgene Savickas, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Mar. 22-25)—OCCA-29. Oil and Colour Chemists' Association 29th Annual Technical Exhibition. Alexandra Palace, London, England. (The Director & Secretary, Oil and Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex HA0 2SF, England).

(Mar. 28-30)—National Coil Coaters Association, "Focus: Coated Coil 2." Hyatt Regency O'Hare Hotel, Chicago, Ill. (Don White, NCCA, 1900 Arch St., Philadelphia, Pa. 19103).

(Mar. 30-31)—NPCA Seminar on "The Design, Construction, and Operation of Modern Paint Manufacturing Plants." Atlanta Hilton, Atlanta, Ga. (Georgene Savickas, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(April 4-6)—Course on Introduction to Polymer Chemistry. International Hotel, New Orleans, La. (Department of Continuing Information, University of New Orleans, New Orleans, La. 70122).

(Apr. 5)—NPCA Product Liability Seminar. Executive West Hotel, Louisville, Ky. (Georgene Savickas, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(April 15-17)—Western Decorating Products Show. Disneyland Hotel Convention Center, Anaheim, Calif. (National Decorating Products Association, 9334 Dielman Industrial Drive, St. Louis, Mo. 63132).

(Apr. 25-26)—Washington Paint Technical Group's 17th Annual Symposium. Marriott Twin Bridges Hotel. (Mildred A. Post, % U.S. Dept. of Commerce, National Bureau of Standards, Washington, D.C. 20234).



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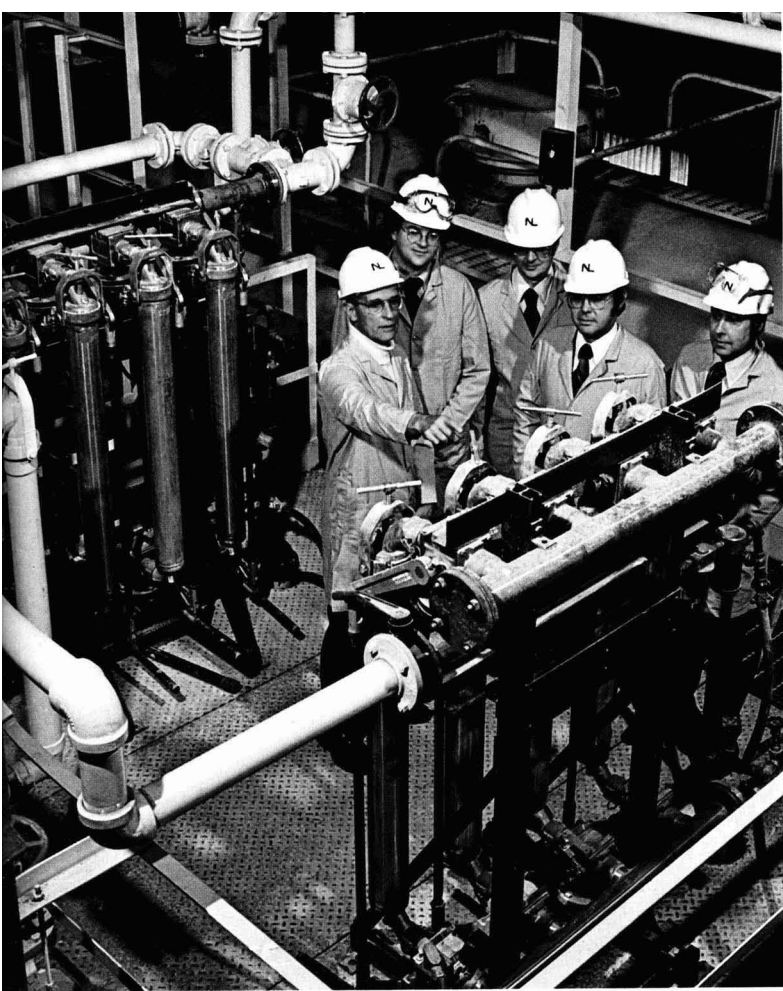
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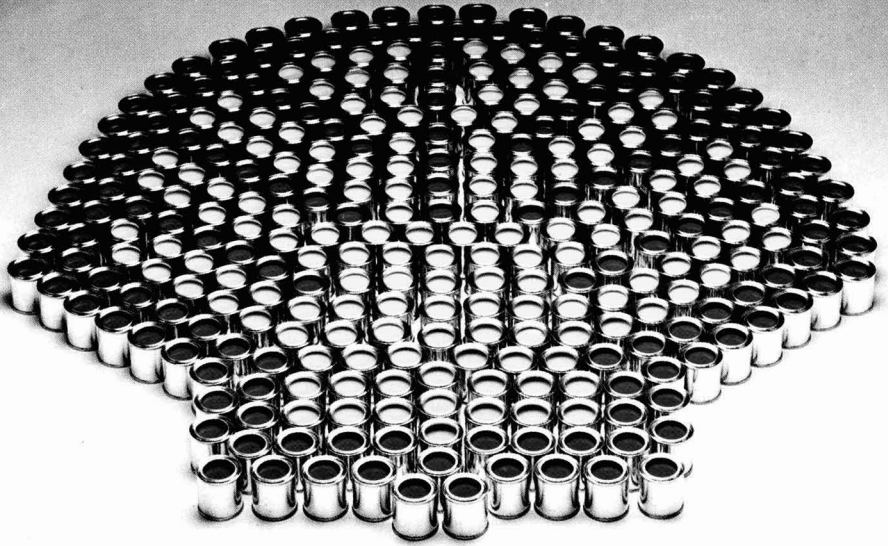
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