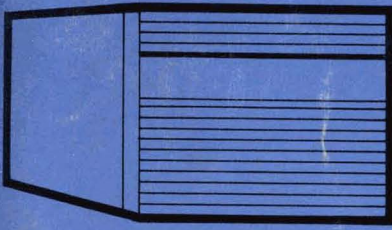
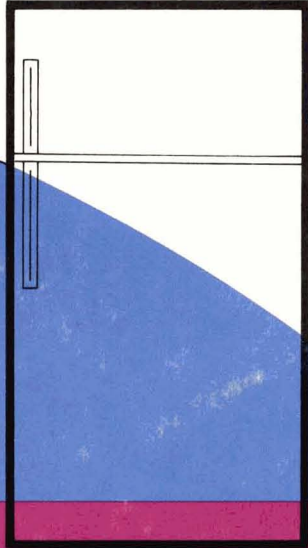
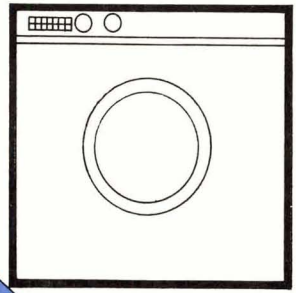
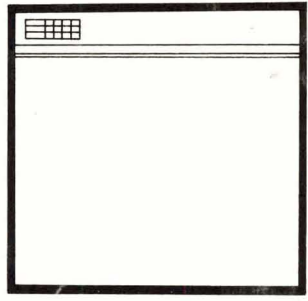
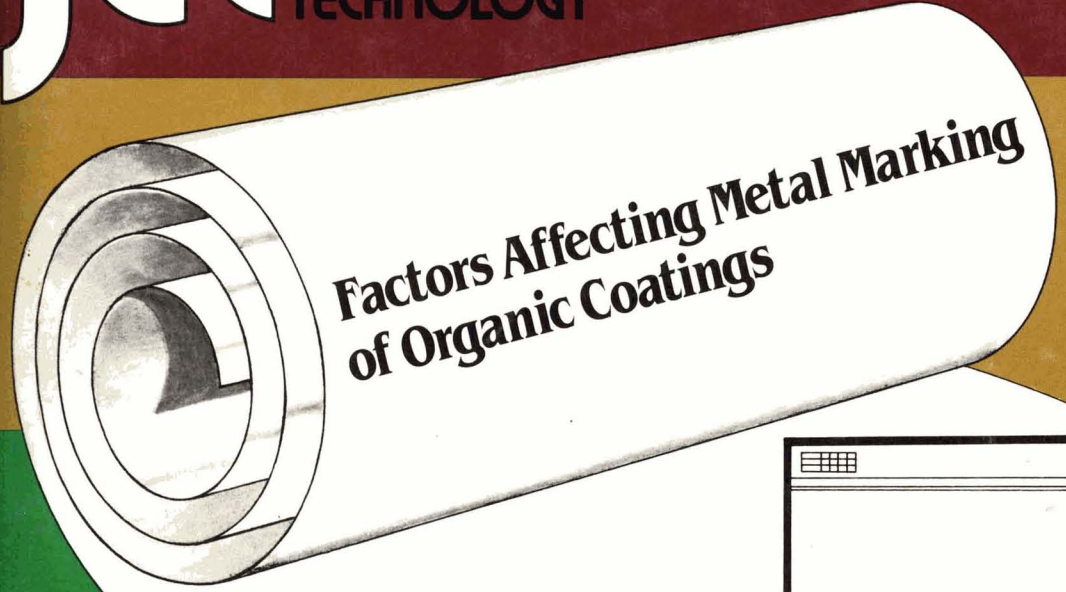


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JOURNAL OF COATINGS TECHNOLOGY

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FEBRUARY 1982

Factors Affecting Metal Marking of Organic Coatings





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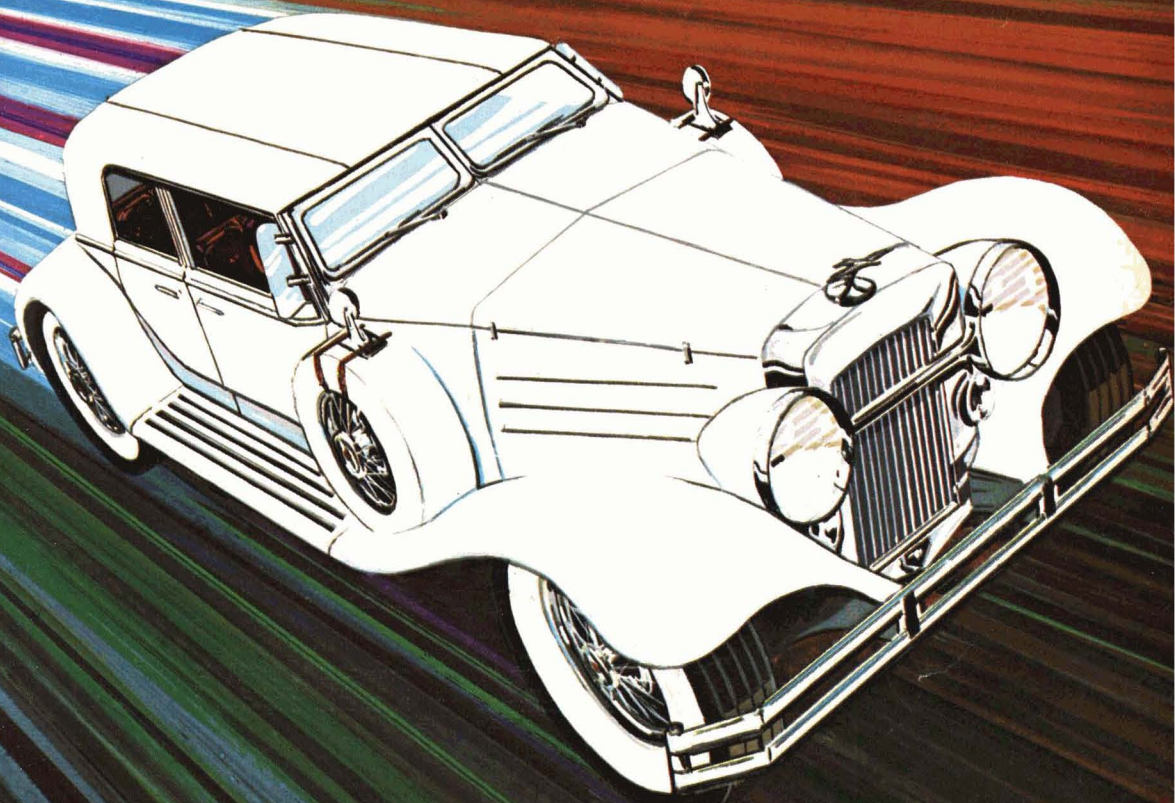
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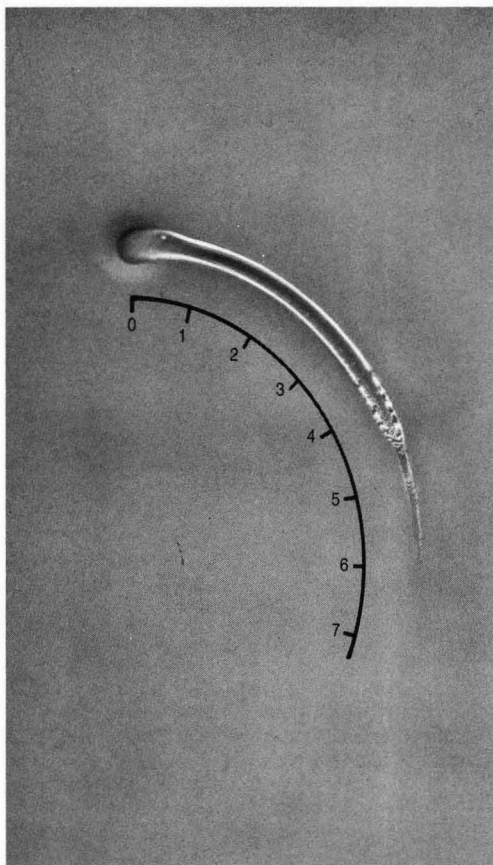
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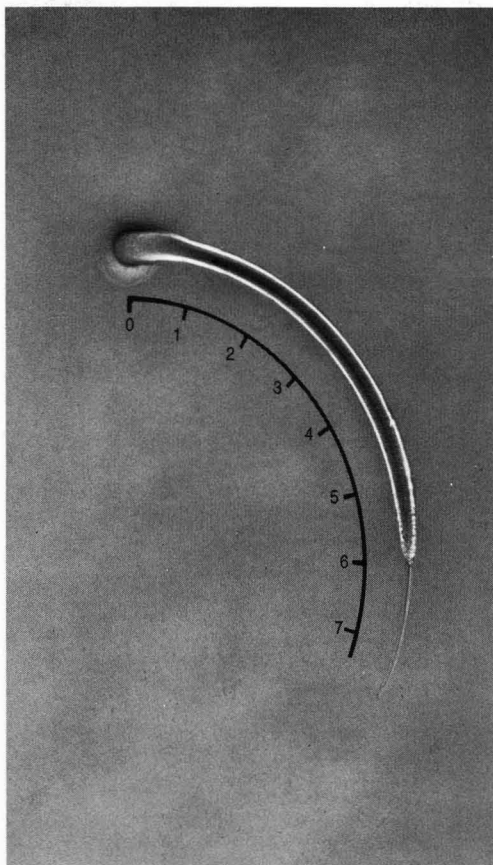
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JOURNAL OF
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VOLUME 54

NUMBER 685

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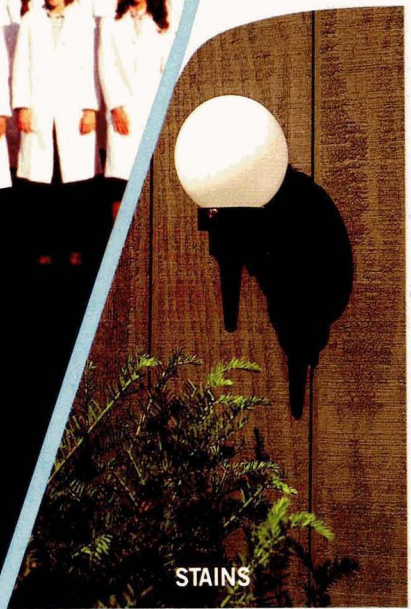
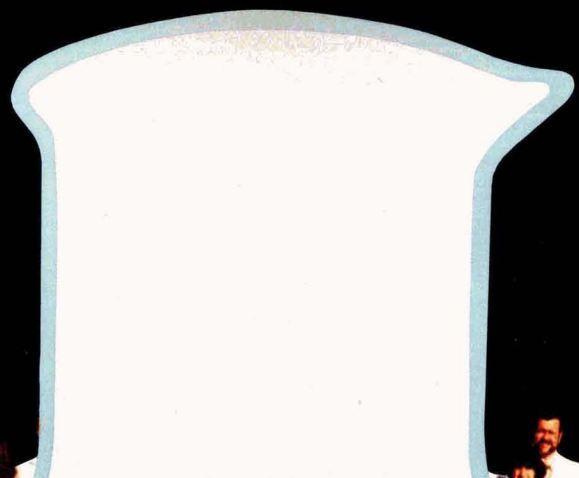
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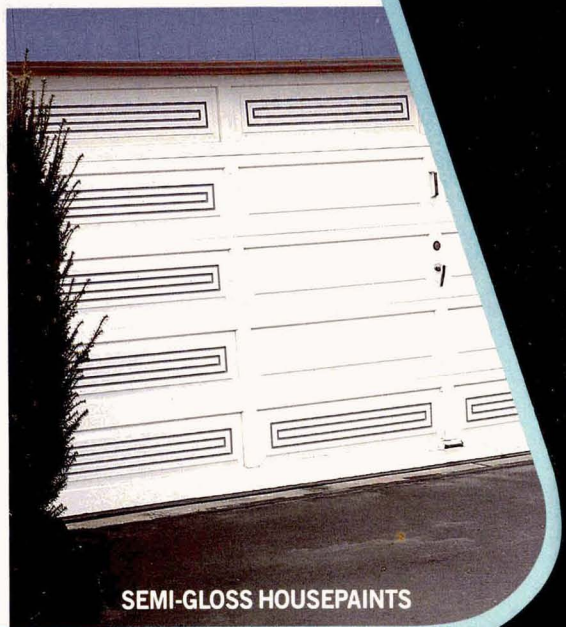
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Roon Awards

Each year, authors of outstanding papers presented at the Federation Annual meeting are honored recipients of the Roon Awards. Financing for these Awards, which are sponsored by the Federation's Paint Research Institute, has been graciously provided by the Leo Roon Foundation since 1957.

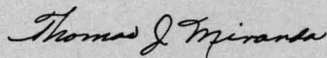
The objective of the Roon Awards competition is to stimulate the writing of papers which record significant contributions to the coatings industry, and over the years a number of truly outstanding papers have been presented by an impressive array of winning authors. In recent years, unfortunately, the number of entries in the competition has declined. This not only deprives the coatings industry of valued contributions, but also jeopardizes continued sponsorship of the Awards.

The Roon Awards Committee, chaired by Dr. Darlene Brezinski, of DeSoto, Inc., has available \$3,000 in prize money to award to authors of winning papers in the 1982 competition, and is actively seeking entries. In addition to the financial rewards, winning authors also derive prestige for themselves and their organizations.

We urge those who wish to participate to prepare now by submitting a letter of intent to compete, along with a title and abstract of the proposed paper, to Dr. Darlene Brezinski, DeSoto, Inc., 1700 S. Mt. Prospect Rd., Des Plaines, IL 60018.

Competing for a Roon Award is an excellent opportunity to make a contribution to the program for the 1982 Annual Meeting, improve your stature in the industry, and obtain a financial reward, as well.

Let's make this year's competition an overwhelming success!!



Thomas J. Miranda,
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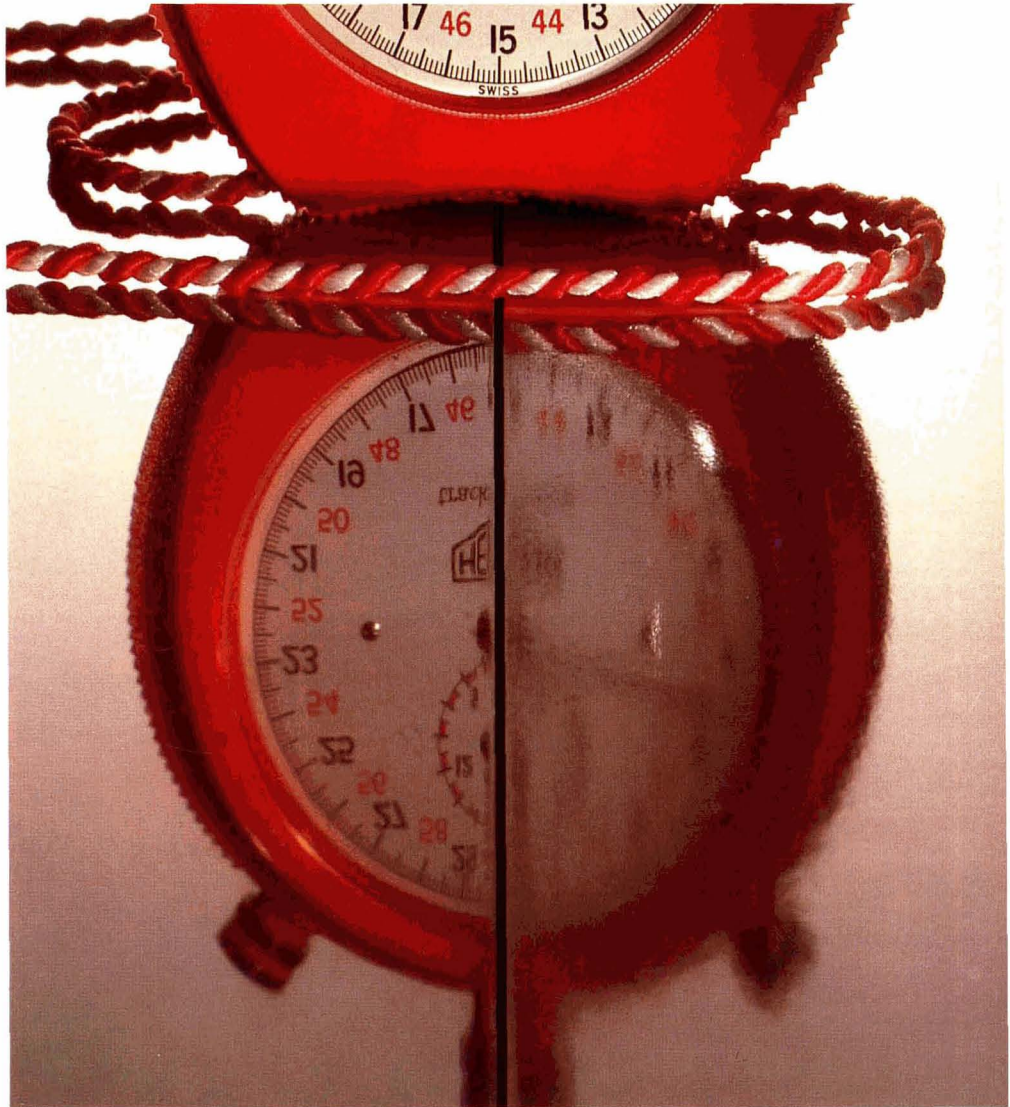
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MMA Award for Achievement Is Won by L.A. Society

The 1981 MMA Award for notable achievement by a Constituent Society of the Federation was won by the Los Angeles Society. Presentation of the Award was made at the recent Annual Meeting in Detroit.

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

There are three categories of Awards, based on Society membership size; however, Los Angeles was the only winning entry in the 1981 competition.

The Award carries with it a cash prize of \$350 plus a handsome plaque.

Industry Contribution Through WCCS Symposium/Show

Los Angeles was cited for sponsoring the 1981 Western Coatings Societies' Symposium and Show, held March 4-6, in Anaheim.

The event, attended by a total of 2073 registrants, provided an opportunity for industry personnel in the western U.S. to learn of new technologies, equipment, raw materials, and applications through the presentations at the technical sessions and the displays of supplier companies.

A total of 24 technical papers and three workshops were featured during the three-day event, along with the exhibits of 71 supplier firms.

Funds raised by the event support the Los Angeles Society scholarship fund.

Principles Governing Awards

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

Not eligible are Society papers offered for presentation at the Federation Annual Meeting. Although the Awards are to be presented at the Annual Meeting, it is not mandatory that they be presented to any or all categories each year.

The President of any Society wishing to enter the competition must send a letter of intent, no later than March 31, to the MMA Awards Committee Chairman (Al Heitkamp, Cargill, Inc., P.O. Box 9300, Minneapolis, MN 55440).

A complete description of the Society activity to be considered in the 1982 competition must be submitted by the Society President to Chairman Heitkamp by July 31.



Society Representative Robert A. McNeill (center) accepts MMA Award plaque won by Los Angeles Society for its industry contribution through sponsorship of Western Coatings Societies' Symposium and Show. Making the presentation is R.L. Ridolfi, President of Materials Marketing Associates. At left is Terry Johnson, Chairman of the 1981 MMA Awards Committee

Theme Announced and Papers Invited For 1982 FSCT Annual Meeting in Washington

The 1982 Annual Meeting of the Federation of Societies for Coatings Technology will have as its theme, "Quality Designed/Confidence Renewed," it was announced by Program Chairman John Ballard, of Kurfees Coatings, Inc.

The Annual Meeting will be held in conjunction with the Paint Industries' Show at the Sheraton Washington Hotel, Washington, D.C., on November 3, 4, and 5.

The theme focuses on the need to upgrade product quality, which is perceived as vital to renewing customer confidence in coatings.

Success in designing and maintaining a quality product in the market place will depend to a great extent on the degree to which modern technology is applied in the areas of management, research and production. Computers and a variety of scientific instrumentation, for example, offer coatings manufacturers a broad spectrum of applications in the office, laboratory and plant, and have the potential to substantially effect cost savings while contributing to increased productivity and product quality.

Prospective speakers are invited to present original papers on the theme and its various aspects, and are requested to submit abstracts for review to John C. Ballard, Kurfees Coatings, Inc., 201 East Market St., Louisville, KY 40202. *Deadline for receipt of abstracts is March 1.*

Assisting Chairman Ballard in developing the program is a Steering Committee composed of: Peter Hiscocks (Vice-Chairman), C-I-L Paints, Inc., Toronto, Canada; Stephen Crouse, Kwal Paints, Inc., Denver, CO; Loren W. Hill, Monsanto Plastics & Resins Co., Indian Orchard, MA; Gus W. Leep, Seymour of Sycamore, Inc., Sycamore, IL; Robert G. Modrak, Benjamin Moore & Co., Milford, MA; Thomas Ruland, Cook Paint & Varnish Co., Houston, TX; and Gary Van de Streek, Wyandotte Paint Products, Inc., Troy, MI.

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Abstracts of Papers in This Issue

FACTORS AFFECTING METAL MARKING OF ORGANIC COATINGS—L.A. Simpson

Journal of Coatings Technology, 54, No. 685, 27 (Feb. 1982)

Organic coatings are often marked by a sliding metal object. Although the phenomenon is well known its mechanism is not well understood. Results in this report show that when hard pigment particles are at or close to the surface of an organic coating, they can abrade a bare metal object sliding in contact with the surface. Abraded metal is then transferred to the surface of the organic coating where it produces a characteristic "metal mark."

A test method for assessing metal marking is discussed and factors associated with the organic coating which are responsible for its abrasivity are examined. In addition, methods for decreasing metal marking are suggested.

MICROBIOLOGICAL SPOILAGE OF LATEX EMULSIONS: CAUSES AND PREVENTION—J.A. Jakubowski, S.L. Simpson, and J. Gyuris

Journal of Coatings Technology, 54, No. 685, 39 (Feb. 1982)

Formulation ingredients and residual monomers, in the past, tended to limit the types of microorganisms that degraded latex emulsion systems. Improved technology, new application areas, and regulatory requirements create new worlds for a variety of microorganisms to explore in latex emulsion systems. Effective measures in the form of a well defined plant sanitation program, selection of more resistant raw material ingredients, and the use of broad spectrum biocides, such as 1,2-dibromo-2,4-dicyanobutane or benzyl bromoacetate, are described from case histories and experimental data.

FACTORS AFFECTING THE DISTINCTION OF IMAGE (DOI) OF PAINTED FIBERGLASS REINFORCED REACTION INJECTION MOLDED (RRIM) URETHANE—D.J. Hart

Journal of Coatings Technology, 54, No. 685, 47 (Feb. 1982)

Differences in DOI of painted RRIM parts containing various glass reinforcement levels are due to attack of the RRIM by the primer solvent causing increased macro-

surface roughening of the substrate. This roughness, on the order of 50–200 μ , is telegraphed to both the primed surface and the topcoated surface. The solvent attack is due to the solubility characteristics of the RRIM and is accelerated by the glass reinforcement in the RRIM. Removal or reduction of N-methyl-2-pyrrolidone in the given solvent formulation of the primer eliminates solvent attack, which in turn, results in improved DOI for painted RRIM parts.

CURE RESPONSE IN ACRYLIC COPOLYMER/MELAMINE FORMALDEHYDE CROSSLINKED COATINGS—D.R. Bauer and R.A. Dickie

Journal of Coatings Technology, 54, No. 685, 57 (Feb. 1982)

The cure response of typical acrylic copolymer/melamine formaldehyde coatings has been studied as a function of resin and formulation variables including polymer molecular and equivalent weight. Cure response has been characterized in terms of an effective crosslink density calculated from measured extents of conversion and a network model. Results have been cast in terms of the ranges of time and temperature, or cure window, over which acceptable film properties are obtained. The cure windows for formulations based on low molecular weight oligomers typical of high solids coatings have been found to be inherently narrower than those of conventional formulations. The cure response of high solids formulations has also been found to be more sensitive to small changes in resin and formulation variables than conventional coatings, effectively resulting in a further reduction in the width of the cure window.

EXPERIMENTAL ORIGINS OF THE 1931 CIE SYSTEM OF COLORIMETRY—W.D. Wright

Journal of Coatings Technology, 54, No. 685, 65 (Feb. 1982)

The system of colorimetry defined in 1931 by the Commission Internationale de l'Eclairage was based on color-matching data provided by Guild and the author. A color-matching "workshop" is described for measuring the spectrum locus in the chromaticity chart and calculating the color-mixture curves. The paper then traces the compromises that were reached between America and Britain that enabled the form of the system to be agreed just in time for the CIE meeting in September, 1931. The main architects of the system were H.E. Ives, I.G. Priest, L.T. Troland, J. Guild, and D.B. Judd.

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Battelle Indicates U.S. R&D Funding Will Surpass \$77 Billion This Year

Expenditures in calendar year 1982 for research and development in the United States are expected to reach \$77.6 billion, according to the annual forecast of Battelle's Columbus Division. This represents an increase of \$8.5 billion (12.4%) over the \$69.1 billion that the National Science Foundation estimates was to be actually spent for R&D in 1981.

While most of the increase will be absorbed by continued inflation (estimated at 8.7% for R&D in 1982), Battelle forecasts a real increase in R&D expenditures of 3.7%. This is slightly higher than the eight-year average rate of 3.4% in real R&D effort that has been experienced since 1973.

Industrial funding for R&D is projected to be more than government support, and is forecasted to be \$37.7 billion, up 14.8% from 1981. This will account for 48.6% of the total R&D funding. Battelle sees an increase of 13.3% in federal support for R&D, with funding expected to be about \$37.0 billion. This is 47.7% of the total R&D expenditures for 1982. Funding by academic institutions is expected to be \$1.7 billion (2.2% of the total), and other nonprofit organizations will provide \$1.1 billion (1.5%).

The Battelle report indicates industry will remain as the dominant performer of R&D. In 1982, performance of R&D by industry is expected to rise to \$55.0 billion, or 70.8% of all research performed. This compares with \$10.1 billion (13.0%) for the federal government, \$9.7 billion (12.5%) for academic institutions, and \$2.8 billion (3.6%) for other nonprofit organizations.

The Battelle forecast notes that federal funding supports research performance in all four sectors. Currently, about one-fourth goes to support R&D conducted by the government itself; almost half goes to industry; approximately one-fifth goes to colleges and universities; and the rest, about one-twentieth, goes to other nonprofits.

Industry absorbs almost all of its own funds, either performing the R&D itself or contracting with other industrial performers. Its contracts and grants to colleges and universities slightly exceed those to other nonprofit institutions. Other nonprofits finance both them-

selves and the academic institutions about equally; colleges and universities use up all the funds they originate.

Four government agencies dominate the federal R&D scene and are expected to account for 87.9% of total federal R&D funding in 1982. These are the Department of Defense, 57.0%; the National Aeronautics and Space Administration, 13.6%; Health and Human Services, 9.9%; and the Department of Energy, 7.4%.

The forecast notes that national security, reflected in the Department of Defense budget, is the dominant driving force in furthering R&D spending. While increases in real spending are expected in space and health, federal efforts in energy R&D are expected to decrease, with activity in energy research being assumed more by industry.

While the federal government has, in the past, been supportive of research in the so-called "soft" science areas, it is evident that such support will be significantly curtailed during the coming years. Decreases in real spending in these areas are expected to reflect the present Administration's policy of returning more program definition and decision making to lower levels of government.

Industrial support of research is growing in fields related to electronics, communications, advanced machinery, and in those fields most directly influenced by the need for more energy-efficient products and processes. R&D will be heavily self-funded in the manufacturing industries, where on the average, only 31.8% of the total will be supported by the federal government. The nonmanufacturing industries do relatively little R&D, and support for this activity will be divided almost equally between federal and industrial support.

As part of the forecast, Battelle estimated the industrial versus federal support for the R&D performed by several broad industrial sectors. In 1982, Battelle expects aerospace to be the industrial manufacturing sector leader in total R&D, with funding of more than \$12.2 billion. Of that, 26% will be industrially funded. The electrical machinery and communications industry is forecast to have the second largest total R&D support with nearly \$11.0 billion. Of that, 58.6% will be industrially funded.

Other industrial sectors Battelle estimates will receive more than \$1 billion in R&D funds include: Machinery—\$7.6 billion, 87.3% of which will be industrially funded; Autos, truck and parts, and other transportation—\$6.5 billion, 86.1% of which will be industrially funded; Chemicals—\$5.7 billion, 91.7% of which will be industrially funded; Professional and scientific instruments—\$3.0 billion, 91.8% of which will be industrially funded; and Petroleum products—\$1.9 billion, 84.0% of which will be industrially funded.

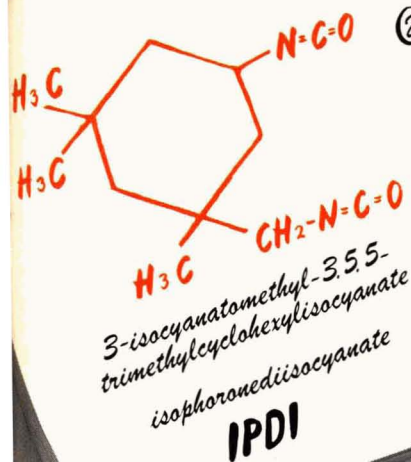
The Battelle report also compares the four performing sectors in terms of their relative costs of R&D. From 1972-1982, costs of all R&D, as an average, are estimated to have risen by 105.2%. Increases in the individual performing sectors, over this same time period, are expected to be: federal government, 108.2%; industry, 101.0%; colleges and universities, 124.3%; and other nonprofits, 117.2%. During 1982, the overall cost increase for all R&D is estimated to be 8.7%. By sectors, the increases are estimated as government, 11.4%; industry, 7.7%; colleges and universities, 10.3%; and other nonprofits, 12.1%.

In addition, the forecast discusses the impact the 1981 Administration postures and actions are likely to have on R&D expenditures in 1982.

According to the report, it is anticipated that the Administration's posture relative to business and industry may continue to provide an atmosphere more conducive to industrial R&D. In particular, greater efforts will be directed toward both short-term and long-term R&D aimed at an improved competitive position vis-a-vis foreign competition.

The move toward the so-called "reindustrialization", including the R&D necessary to adapt new processes to old product lines, will require continued investment in advanced technology. In addition, new tax credits for increases in industrial R&D are expected to have some small impact.

This positive attitude toward industrial R&D is partially tempered, however, by general business slowdowns, increased unemployment, decreased profitability, and high interest rates.



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Federation of Societies for Coatings Technology



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An educational Exhibit of Materials and Equipment Used in the
Manufacture of Paints and Related Coatings

Being held in conjunction with the
60th Annual Meeting of the Federation
of Societies for Coatings Technology

FEDERATION
newsletter



\$3,000 IS NOTHING TO SNEEZE AT

Perhaps you have seen the announcements and the news stories:

"Roon Awards Offer Cash Prizes"

With \$3,000 available, you would think that the competition would be keen....that coatings tech folks would wear their writing fingers down to the bone.

It is not and they are not.

Last year, \$2,000 of the prize money never left PRI's bank account.

Come on, guys and gals, there are many of you out there in paintland who could use the cash....many of you capable of writing a paper which will be a scientific contribution to the industry, the type of paper the Roon Awards encourage.

In addition to the money you also get:

- . The opportunity to present your paper at the Federation Annual Meeting
- . The publication of your paper in the world-travelling JCT
- . Photos/publicity in the trade press
- . Prestige for yourself and your employer
- . A handsome plaque

Think about it. Then check the Roon story and competition details on page 8 of the January JCT. Chairperson Darlene Brezinski must hear from all authors by March 1.

PRI SEEKS INPUT FROM TECHNICAL COMMITTEES IN SELECTING RELEVANT RESEARCH PROGRAMS

Suggestions from Society Technical Committees, regarding the selection of research programs, are being solicited by the Trustees of the Paint Research Institute.

At their January 6-7 meeting, the Trustees expressed interest in encouraging Society participation in recommending programs of relevance to the coatings manufacturing industry.

To assist in the effort, a questionnaire is being developed for distribution to Society Technical Committee Chairmen prior to their Federation-sponsored meeting with members of the Federation Technical Advisory Committee, sometime this spring.

Two Trustees, Ruth Johnston-Feller and Colin Penny, will attend that meeting to take part in the discussions and to seek input regarding PRI programs in Aqueous and High-Solids Coatings, as well as other research areas.

Peter Robinson, President of PRI, stated that another questionnaire is also under consideration; this would be directed to the coatings industry in general, and would be published in the JCI and the APJ.

At the January meeting, Dr. Raymond R. Myers, Research Director, reported that PRI's continuing program to combat the mildew defacement of paint is progressing satisfactorily under the direction of Dr. Charles Yeager. This research is supported by a consortium of eight companies (Buckman Labs., Inc.; Cosan Chemical Co.; the duPont Co.; Merck & Co.; PPG Industries, Inc.; Rohm and Haas Co.; SCM Glidden Coatings & Resins Div.; Troy Chemical Co.) as well as the National Paint and Coatings Association.

Research at the University of Alabama, led by Dr. Charles Pittman, has developed an experimental pentachlorophenyl acrylate latex, a small amount of which is being sent to the Technical Committees of the Chicago and Southern Societies for the purpose of formulating test coatings. Plans are underway to supply additional quantities of this "mildew busting" polymer to other Technical Committees. Mr. Penny is coordinating this activity for PRI.

Three new 12-month research projects in the Mildew Program were approved by the Trustees:

"Effect of Alternaria spp. on Paint"--Lock Haven State College

"Understanding Diffusion in Controlled Release Systems"--MIT

"Study of the Biodeterioration of Exterior Paint Films by Actinomycetes, Bacteria, and Algae"--National Bureau of Standards

Continuing programs are:

"Polymer-Anchored Mildewcides"--University of Alabama

"Control of Cell-Wall Biosynthesis in Aureobasidium pullulans"--University of Missouri-Rolla

In the Aqueous Program funded by PRI, two projects were renewed through 1982:

"Film Formation and Polymer Transitions"--Kent State University

"Surface and Physical Properties of Water-Borne Coatings"--Ecole Polytechnique

Another action of the Trustees was the appropriation of \$5,000 for a survey of the known problems associated with a major industry headache: "Waste Disposal." It is anticipated that the second step will be the recommendation of research proposals.

CALL FOR PAPERS TO BE PRESENTED AT 1982 FEDERATION ANNUAL MEETING

Authors wishing to present papers at the 1982 Annual Meeting of the Federation, November 3-5, in Washington, D.C., are invited to submit manuscripts for review.

Theme of the Annual Meeting Program is "Quality Designed/Confidence Renewed." The theme focuses on the need to upgrade product quality, which is perceived as vital to renewing customer confidence in coatings.

Prospective speakers should submit abstracts to the Chairman of the Program Committee: John C. Ballard, Kurfees Coatings, Inc., 201 E. Market St., Louisville, KY 40201. The deadline is March 1.

"A BATCH OPERATED MINI-MEDIA MILL"

ADDED TO A/V TRAINING SERIES

The Federation has added "A Batch Operated Mini-Media Mill" to its series of audio-visual training programs. Prepared by the Manufacturing Subcommittee of the New York Society, the program describes the design and operation of a batch operated mini-media mill, and was developed to assist in the training of plant personnel to operate such equipment.

The program runs for 8 1/2 minutes and includes a cassette tape, 51 slides, and an accompanying script -- all packaged in a vinyl album. It is available for \$60 from the Federation Office in Philadelphia.

90% OF EXHIBIT SPACE ALREADY RESERVED

FOR 1982 PAINT SHOW IN WASHINGTON

Ninety per cent of the available exhibit space has already been reserved for the 1982 Paint Industries' Show of the Federation, November 3-5, at the Sheraton Washington Hotel in D.C. To date, the total number of exhibitors is 138; 130 were in '81 Show.

NEWS BRIEFS FROM THE SOCIETIES

BALTIMORE--Richard S. Hunter, President of Hunter Associates Laboratory, received the Baltimore Coatings Industry's 1981 Herman Shuger Memorial Award. At the same dinner, merit awards were presented to Mike Beatty, of Athey Paint Co.; Joe Behan, of A.B. Kohl Sales Co.; Frank Gerhardt, of Bruning Paint Co.; Tom Mitchell, of Tenneco Chemicals, Inc.; Harry Schwartz, of Dutch Boy, Inc.; and Cal Tatman, of Glidden Pigments Group.....Colin Penny, a Past-President and a founder of the Virginia Section, continues in 1982 as Section Chairman.

DETROIT--25-year pins were presented to Jack Dentler, of Pfizer, Inc.; and Bob Sikorski, of Wyandotte Paint Products Co.

GOLDEN GATE--The winter/spring coatings courses sponsored by the Society and PCA are: Session III--"Business Aspects of Coatings" (given at Sherwin-Williams Co.) and Session IV--"Plant Tours" to Ampex Corp., Glidden, B.W. Norton, Ford, General Services Administration, Pfizer, and Hewlett Packard.

HOUSTON--Theme of the Southwestern Paint Convention in Houston, April 21-23, is: Quality in the '80's. Pete Schaff, of Houston Solvents, is General Chairman.

LOS ANGELES--Has had distinction and privilege of presenting four 50-year membership pins within past nine months. The first (last spring) was to Joe Cordero, of ACT Container Co. The second (in November) went to Mentis Carrere, who is 90 years of age and still active in the industry. Recently, the other two were presented to "Candy Man" Clarence Meyers, of John K. Bice Co.; and Carl Came, retired from Rohm and HaasHas published a "LASCT Bibliography," a compilation of all the library books

and magazines in the Society's library at the Commerce Public Library, City of Commerce.....Mailed a questionnaire to members to ascertain how they feel about the operation of the Society and the services offered.....At the January meeting, the Society attained the long-sought goal of 600 members. The 600th was Bill Lim, of Advanced Coatings & Chemical, and he was given a "Paint/Coatings Dictionary"..... Awarded Certificates of Completion to nine students who completed the Cal State Fullerton course in High Polymer Technology. A \$100 bond went to the best student, Douglas Cavanaugh.

NEW ENGLAND--Bob Marderosian, of Cypress Color & Chemical Co., has been named Chairman of the Society's second "Coatings Tech Expo," to be held at the Sheraton Inn & Conference Center in Boxborough, May 19-20. Theme of the exhibits and program sessions will be "PAT--Productivity, Availability, and Technology in the 80's." Working with Bob will be these subcommittee chairmen: Program--John Fitzwater, of Polyvinyl Chemical; Technical Sessions--Brad Brakke, of Lilly Chemical; Manufacturers Sessions--Tom Manning, of Samuel Cabot, and Fran Koebert, of Kyanize Paints; Publicity--Bob Modrak, of Benjamin Moore; Exhibits--Mike Paisner, of M.S. Paisner; and Social--Dan Toombs, of Lukens Chemical.

NEW YORK--Society and PCA held annual legislative update meeting in February. The featured speaker was the Hon. Bill Bradley, U.S. Senator from New Jersey.....The second semester of the training course in "Understanding the Basics of Coatings" gets started this month at New York City Technical College. Don Brody has been teaching this course for nine years. He is the current Society President..... Twenty-six more members have qualified for 25-year membership: Tom Accamando, of Everseal; Ed Berberian, of Columbian Chemicals; Dave Busker, of Kenrich Petrochemicals; Steve Cantor, of Uniroyal Chemical; Bob Cloughley, of Colonial Printing Ink; Fred Daniel, of Daniel Products; Joe Detrolio, of Solar Compounds; Lenny Freund, of Freund Assoc.; Joe Garvey, of ISIS Chemicals; William Jeff, of Armitage Co.; Charles Kalfian, of Randolph Products; Irv Kassman, of Landau & Co.; Paul Katzauer, of Stevens Paint Corp.; Jim Kennedy, Retired; Werner Klugman, of Landers-Segal Color Co.; Gerard Myers, of Petit Paint Co.; John Oates, of Troy Chemical Co.; Jim Parmentier, of NL Industries; Wendell Randolph, of Randolph Products Co.; William Rowe, of Polychrome Corp.; Arthur Rudykoff, of Cook & Dunn Paint Corp.; Bill Singer, of Troy Chemical Co.; Bill Stewart, of Tenneco Chemicals; John Toscano, of F.O. Pierce Co.; Len Treinkman, of Orelite Chemical Coatings; and Steve West, of United Labs. Co.

PHILADELPHIA--Continues to feature speakers at monthly Technical Committee meetings. Topics coming up are: Rheological Additives for Water-Base Coatings; Reduce the Cost of Bright Colored Coatings; and Cross Linkers in our Environment.

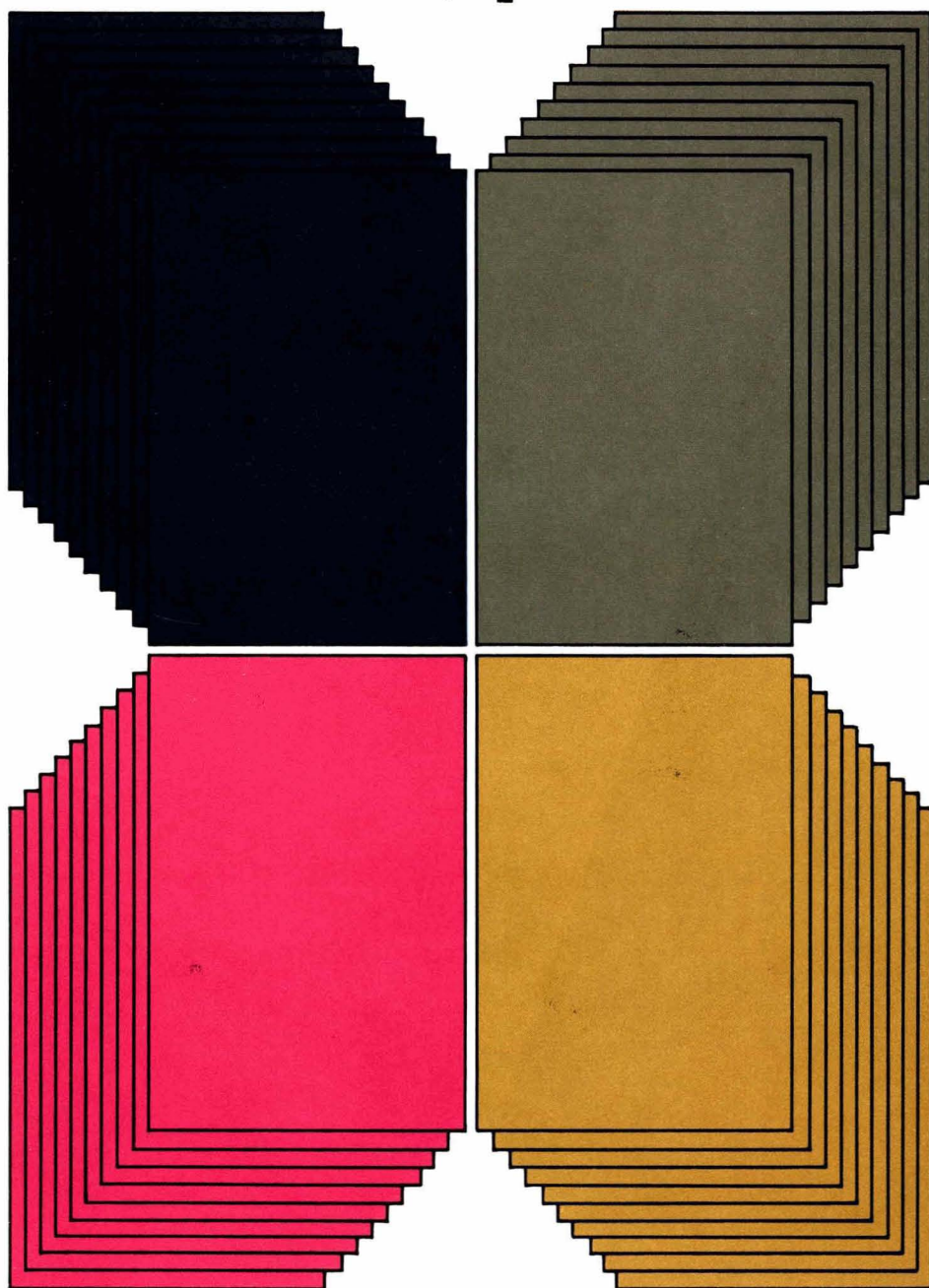
ROCKY MOUNTAIN--The 1981 Golden Nugget Award to George Neiberger, of Kwal Paints, was presented posthumously to his wife, Dorothy.

SOUTHERN--"Coatings Technology - Strategies for the Eighties" will be the theme of the annual meeting, March 10-12, in Savannah. The Keynote Address, "How's Our Visibility," will be given by Bill Bours, III, a Past-President of NPCA. John Dean, Vice-President, Chemical Marketing Services, will discuss "Coatings Opportunities in the Eighties--They Are Disguised as Problems." Other speakers will be Violete Stevens, of Dow; and Fred Schulenberg, former Editor of the American Paint Journal. A special "Past-Presidents' Paint Seminar" will review the latest developments in exterior clear coatings.

TORONTO--Past-President Andy Jones, of Reichhold, has been appointed liaison to the Montreal Society, re the Federation AM & PS in Montreal, October 12-14, 1983.

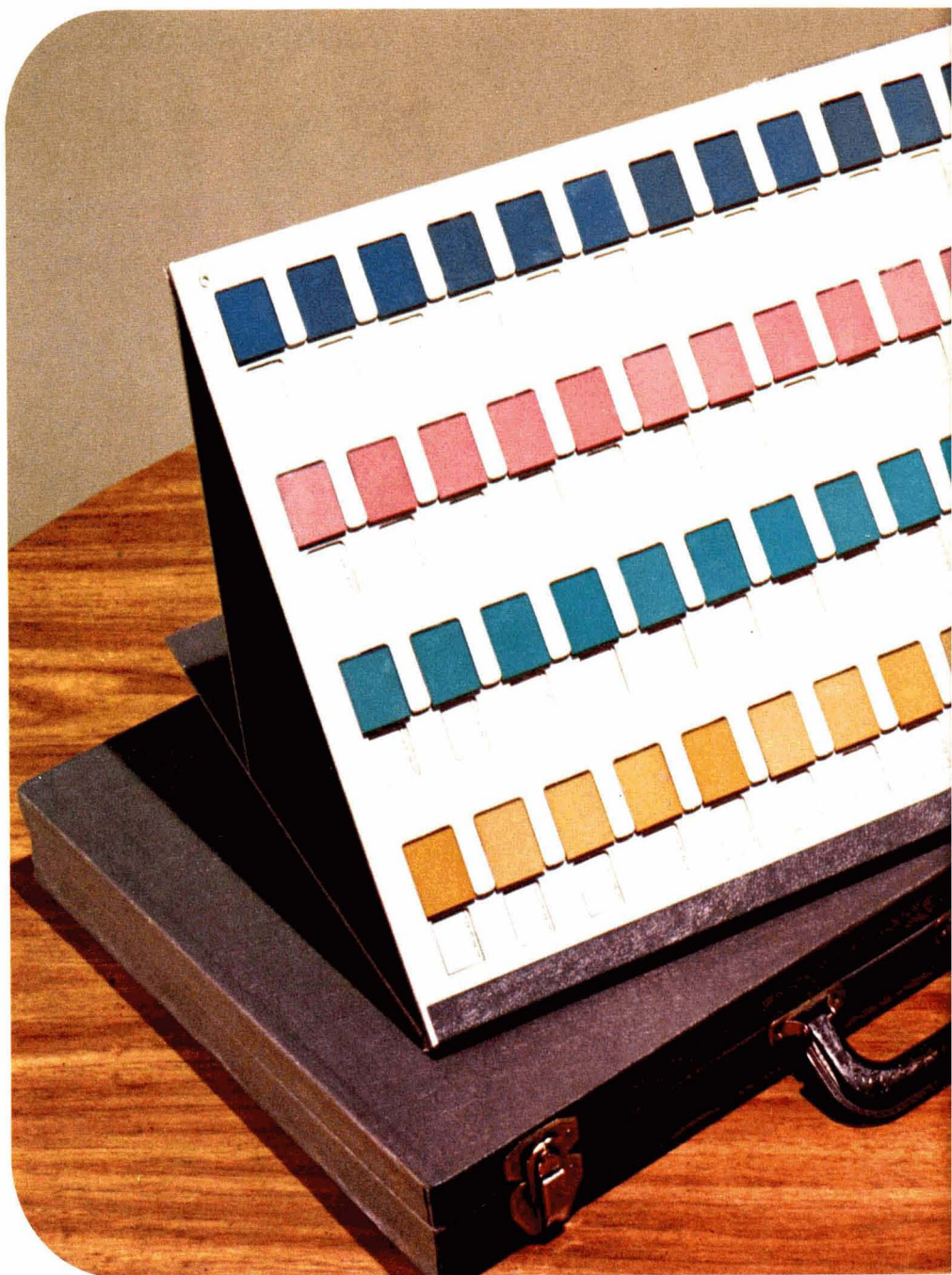
Federation of Societies for Coatings Technology

Color-matching Aptitude Test



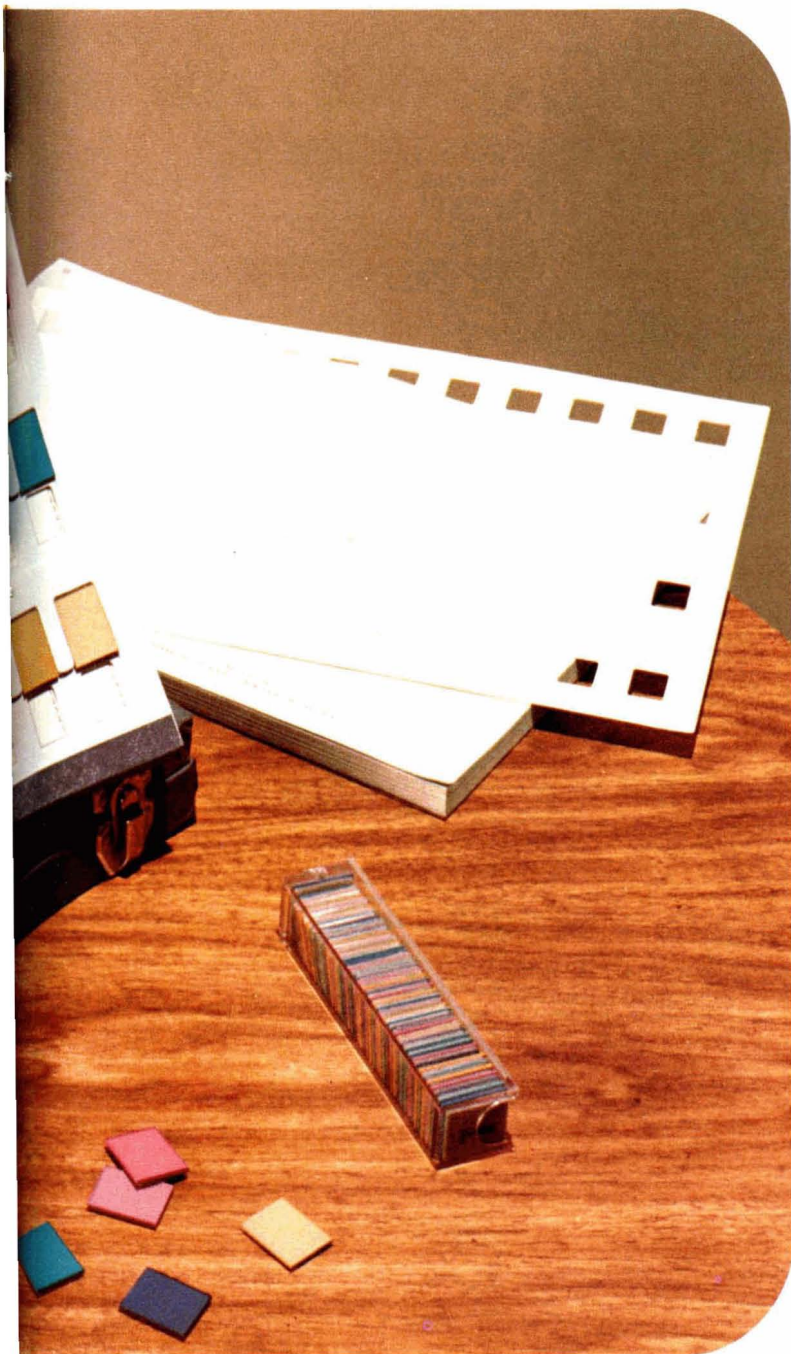
prepared by
The Color Test Evaluation Committee
of the INTER-SOCIETY Color Council

Color-matching **Aptitude** Test



The Color-matching Aptitude Test Set consists of a carrying case, an easel on which are mounted 48 color chips, a dispenser which holds 48 matching chips, score sheets, and a scoring key.

The 1978 edition



price
\$400.00
per set

plus shipping

were carefully established using spectrophotometric standards, and the intermediate steps produced by mixing the end-point colorants in proportions determined gravimetrically. The series thus produced were tested by 20 to 50 observers to make sure that they progressed in regular steps. Not until the series were found acceptable in this respect were they incorporated in the final Test.

LIGHTING

The test results are most satisfactory when the lighting is of the same spectral quality (average north-sky daylight with a correlated color temperature of about 6700 K) and of the same level of intensity (about 50 foot candles or 540 lux) as those used in standardizing the chips. Standard viewing booths or fluorescent lamps approximating daylight (with a color-rendering index of 85 or higher) should be satisfactory. Unfiltered incandescent (tungsten) lighting should be avoided because the chips so illuminated all appear more yellowish and close discrimination is more difficult.

The angle of the easel is set so that lighting from directly above the samples and perpendicular viewing will eliminate specular reflections from the chips into the viewer's eyes. Light from the illumination source should be shielded from the observer's eyes and no shadows should be allowed to fall on the Test easel. The chips should be viewed from a distance of ten inches or more.

STANDARD CONDITIONS

Although production of a proper set of chips is a prime essential, many other factors have to be controlled before a satisfactory test is achieved. If the Test is to measure gradations in ability to make color matches, subjects cannot be allowed to use their own special tricks to help them in deciding which colors match. In order that the matches may result in an adequate quantitative score the Test must be given under standard conditions. Therefore, one of the duplicate series of color chips which make up a Test set is mounted in a fixed order on a gray background with 1/2 inch strips between chips. The order is such that any two adjacent chips on the mounted field are perceptibly different and therefore one cannot obtain

clues from a comparison of two of the mounted chips at the same time. Likewise the mounting leaves only one edge of the chip free for matching so that the judgment of match is always made with the samples in a standard orientation. Only one loose chip at a time can be taken by the matcher and he is allowed to make only the selection of the best match for that single chip. There will be many cases in which the subject is uncertain as to which is the best match. Nevertheless, he must decide before he can go on to the next match because he must return the chip to the holder in order to get the next one.

The chip holder also serves to present chips for matching in a standard order. The order is random so that the subject cannot relate any match to a previous match in the same hue series. In addition, the standard order assures that the Test is the same for everyone who takes it, and that everyone performs the same task in the same way.

STANDARDIZATION

Standardization of the 1964 edition was based on experience obtained from evaluation of a large number of scores contributed by users of the 1953 edition. The changes in the 1978 edition relative to the 1964 edition are not sufficient to require new standardization.

The Inter-Society Color Council Subcommittee for Problem 10, Color Aptitude Test, will appreciate receiving copies of Test scores, with an appropriate description of the level of experience of the individual tested in each case, and any pertinent comments and criticisms of the Test which the user wishes to make. It is only in terms of the user's evaluation of the usefulness of the Test that the Subcommittee can continue its work of providing tests which are meaningful.

Send results and comments either to (1) Color-matching Aptitude Test, Federation of Societies for Coatings Technology, 1315 Walnut Street, Philadelphia, Pennsylvania 19107, or to (2) Color-matching Aptitude Test, Office of the Secretary, F. W. Billmeyer, Jr., Inter-Society Color Council, Department of Chemistry, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. Continued contributions of results from users of the Color-matching Aptitude Test will help to ensure that tests of value to persons involved in color, color-matching decisions, etc., will be created, refined, and made most useful.

order from

Federation of Societies for Coatings Technology

1315 Walnut Street, Suite 830, Philadelphia, Pa. 19107

(215) 545-1506

FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
presents
COLOR-MATCHING APTITUDE TEST
1978 Edition
prepared by
THE INTER-SOCIETY COLOR COUNCIL
SUBCOMMITTEE FOR PROBLEM 10, COLOR APTITUDE TEST

COLOR-MATCHING APTITUDE TEST

In 1940, the Inter-Society Color Council appointed a committee to undertake the development of a color aptitude test. After preliminary trials, both in the production of materials for the Test and in the establishment of proper testing techniques, the Experimental Edition of 1944 was produced. The excellent performance of the 1944 edition has been described both in reports to the Council and in independent journals. With the financial support of the Federation of Societies for Coatings Technology, a member body of the Inter-Society Color Council, a second edition of the Color Aptitude Test was released in 1953, and a third edition in 1964. No major changes have been introduced in the Test since the 1944 edition. The present 1978 edition incorporates only minor refinements which bring it closer to the original plan and should make it a still more successful tool for evaluating color-matching skill. The name has been modified for the 1978 edition to indicate more clearly the purpose of the Test, to provide a means for estimating color-matching skill.

AIM OF TEST

The basic aim of the Test is to provide an objective measure that will aid in determining an individual's ability to perform color-matching tasks accurately. A person's color-matching skill may change over a period of time, improving due to training, experience, and motivation, or deteriorating from lack of practice or as a result of health disorders. Retesting at regular intervals will provide an indication of any such changes in an individual's color-matching ability.

The Test is not designed to indicate or measure "color-blindness" (anomalous color vision). Special tests designed for this purpose should be used.

DESCRIPTION

The Test consists of duplicate sets of samples, from which a subject must make forty color matches. Each

set contains four groups of samples having constant hue and lightness but varying in saturation. Saturation series were chosen because in the preliminary work this dimension provided a satisfactory measure of matching skill and because series of equally spaced saturation steps can easily be produced with available industrial techniques. The total number of matches is limited, first by the number that an individual can be expected to make in one sitting, and second by the size of the field that can be properly lighted with simple equipment. The steps in the series have been made so small that rarely, if ever, will a subject make all matches correctly. This provision has two advantages. It places no upper limit on the score an individual can obtain, and it provides a basis for differentiation among persons in the higher brackets of color-matching ability.

In order that the forty matches furnish a good prediction of the subject's ability to match other colors, great care has been used in the selection and production of the color chips. To provide adequate coverage of the color range, matches must be made in each of the four basic hues, red, yellow, green, and blue, approximately Munsell hues 7.5 RP, 7.5 YR, 2.5 PB and 5.0 BG. The lightness of the samples is close to Munsell value 5/ and their saturation ranges from Munsell chroma /3 to /6.

The colorants used in the Test were chosen to assure permanence of the samples against fading. The color is applied as a coating to the back of plastic chips so that the surface is protected against abrasion. The resulting high gloss of the front surface of the chips requires the use of correct angles of illumination and viewing, specifically 45° from and along the normal (perpendicular) to the surface, respectively. When these angles are maintained there is no specular reflection from the chips into the subject's eyes. Since the subject must view a chip from directly in front, it may be necessary for him to shift his position from left to right as he works on the matching.

It is desirable that the steps in each series be equal. To assure this, the end-point colorants of each series

INSTRUCTIONS

for the Use and Care of Your INTER-SOCIETY COLOR COUNCIL COLOR-MATCHING APTITUDE TEST 1978 EDITION

CONTENTS:

An easel with 48 fixed color chips, a chip dispenser with 48 corresponding loose chips, 100 scoring sheets, a scoring chart, and a carrying case.

PURPOSE:

This test evaluates a person's efficient use of color perception by means of the accuracy with which he makes color matches. The color gradations are chosen so that the average individual may be expected to choose one of several colors as a match for a given chip. Only one is an "accurate" match. No individual is expected to choose only the "accurate" matches.

The use of very fine color gradations was dictated by the fact that the Test is intended for individuals who must work accurately with colors. "Color-matching aptitude" scores will depend upon the inherent color interests of the subject, his motivation at the time of testing, his previous training with color discrimination and his native capacity for profiting by training.

PROCEDURE:

THE TEST MUST BE GIVEN UNDER STANDARDIZED CONDITIONS, otherwise the scores cannot be interpreted correctly. Most of the controls are incorporated in the Test itself: (1) the matching field has a fixed arrangement of colors, (2) order of matching is predetermined by the numbering of the chips, (3) matching comparisons are reduced to one at a time and a standard position for comparison is assured by the arrangement and the spacing of the mounted chips, (4) the angle of the easel provides perpendicular viewing.

ILLUMINATION:

The test has been designed and standardized for average daylight conditions, therefore it should be given under this type of illumination. The test materials have been measured spectrophotometrically and their color specifications have been determined for C.I.E. illuminant C (about 6700°K). Standard viewing booths with simulated daylight illumination or fluorescent lamps approximating daylight (with a color rendering index of 85 or higher) should be satisfactory. Natural north daylight or light from a moderately overcast sky should be satisfactory. Incandescent (tungsten) lighting should be avoided. Whether natural or artificial light is used, the illumination should be uniform over the test field at approximately 50 foot candles.

Light should not fall into the subject's eyes and no shadows should be cast on the "matching field." Because the surface of the chips is glossy, standard conditions of 45° illumination and perpendicular viewing must be met by placing the light source directly above the test. Illumination of the subject's face or clothing must be avoided to prevent objectionable reflections. The subject must not be permitted to view the chips from a distance of less than 10 inches.

CHIP NUMBERS AND THE ORDER OF PRESENTATION:

The numbers on the backs of the loose chips give the order of presentation of the chips for matching. The subject should begin with chip #1 and proceed through the numerical series to chip #48. The chip holder is loaded so that the chips will be obtained by the subject in this order. If for any reason the original arrangement should be disturbed, e.g., by several of the chips falling out of the chip holder, the proper order should be restored.

SCORING:

Scores for matches are indicated on the "Scoring Key" in terms of the serial numbers of the order of presentation.

Scores are given for only 40 chips—#9 to #48, inc. Chips numbered 1 to 8 are introduced to give the matcher initial practice in the matching task under test conditions. They are easier matches to make than the rest of the series and are not given scores. However, the person taking the test should do his best to match them correctly, because in so doing, he will improve his performance in the remainder of the test.

Scores for every match appear on the Scoring Key alongside the spaces in which the subject has written the numbers of the loose chips. Scores have been weighted according to their predictive value of the total score determined from the standardizing test scores.

INTERPRETATION OF SCORES:

From the probabilities inherent in the scoring system, the following "cut-off" scores have been estimated:

| | |
|----------|-----------|
| 0 - 48 | Poor |
| 49 - 65 | Fair |
| 66 - 74 | Average |
| 75 - 83 | Good |
| 84 - 109 | Excellent |

In some 200 tests, on which standardization of the test is based, about 5% fell in the "Excellent" category. Test-retest reliability in a limited group proved to be good.

Because of the extreme difficulty of the discrimination judgments required in this test, score steps of less than 5 units probably have no meaning. Until more validation data become available it is best to use the verbal designations given above.

TIME FACTOR:

No time limit has been set because analysis of test data indicates that the 40 judgments constitute the minimum number that will give acceptable reliability. Instructions to the subject emphasize the need to work rapidly but not carelessly. In situations where information is desired concerning speed of matching, time should be recorded for matching the 40 chips beginning with #9 and including #48. Two speed factors may be calculated:

$$\text{time per match} = \frac{\text{total time}}{40}$$

$$\text{score per minute} = \frac{\text{total score}}{\text{total time}}$$

No standard time factors are available.

PLEASE SUBMIT TEST SCORES

The Inter-Society Color Council Subcommittee for Problem 10, Color-matching Aptitude Test, will appreciate receiving test scores of results obtained, with an appropriate description of the level of experience of the individual tested in each case, and any pertinent comments and criticisms of the Test which the user wishes to make. It is only in terms of the user's evaluation of the usefulness of the Test that the Subcommittee can continue its work of providing tests which are meaningful.

Send results and comments either to (1) Federation of Societies for Coatings Technology, 1315 Walnut Street, Philadelphia, Pennsylvania 19107, or to (2) CAT, Office of the Secretary, F. W. Billmeyer, Jr., Inter-Society Color Council, Department of Chemistry, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. Continued contribution of results from users of the Color-matching Aptitude Test will help to ensure that tests of value to persons involved in color, color-matching decisions, etc., will be created, refined, and made most useful.

CARE OF MATERIALS:

In constructing the Color-matching Aptitude Test, materials were selected that would provide the maximum resistance to color change either from exposure to light or chemical fumes. The color chips, the chip holder and the vehicle in which the pigments are dispersed are made of acrylic plastic. The pigments themselves are the most permanent known to the art. The highly glossy surface was purposely selected to facilitate cleaning the chips. In most instances it will be necessary only to wipe them off with a soft, lint-free cloth or a piece of optical tissue. In instances where this does not suffice, a damp cloth and mild soap may be used. DO NOT USE SOLVENTS OF ANY KIND, OR ANY ABRASIVE CLEANERS. While the surface will stand considerable cleaning with water, and the adhesives used are of the waterproof type, care should be exercised to prevent water from swelling the felt backing and smudging the numerals on the loose chips. While the color chips will exhibit excellent light fastness, they should not be unduly exposed.

REPLACEMENT PARTS:

In the event any of the color chips become lost or damaged replacements may be ordered from the Philadelphia office of the Federation of Societies for Coatings Technology (Address below.) Chips from the holder may be ordered by number. In ordering chips for the easel, where the numbers are not known, send in a score sheet marked with an X for each position you wish to replace. Additional score sheets, scoring keys, or other parts may be ordered in the same manner.

NEITHER THE INTER-SOCIETY COLOR COUNCIL NOR THE FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY (THE SPONSORING ORGANIZATION) MAKES WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED AND EXCLUDED. THE COUNCIL AND THE FEDERATION WILL NOT BE LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES ARISING IN CONNECTION WITH THE USE OF, OR INABILITY TO USE, THE TEST REGARDLESS OF WHETHER DAMAGES RESULT FROM ANY ACT OR FAILURE TO ACT BY THE COUNCIL OR FEDERATION, WHETHER NEGLIGENT, WILLFUL OR OTHERWISE.

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Factors Affecting Metal Marking Of Organic Coatings

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BTP Tioxide Limited*

Organic coatings are often marked by a sliding metal object. Although the phenomenon is well known its mechanism is not well understood. Results in this report show that when hard pigment particles are at or close to the surface of an organic coating, they can abrade a bare metal object sliding in contact with the surface. Abraded metal is then transferred to the surface of the organic coating where it produces a characteristic "metal mark."

A test method for assessing metal marking is discussed and factors associated with the organic coating which are responsible for its abrasivity are examined. In addition, methods for decreasing metal marking are suggested.

INTRODUCTION

The ability of an organic coating to withstand streaking or marking when a metal object is dragged across the surface of the coating is referred to as metal marking or ring resistance. Examples of potential metal marking are: rubbing one's belt buckle or ring against a car as it is being washed; a child sliding a metal toy along a wall or over a piece of furniture; or a housewife dragging a metal wash basket from the top of a washing machine. Metal marking is also encountered in the coating industry (in particular coil coating and roller coating applications) where on the production line, coated articles may come into contact with the uncoated parts of similar articles. As shown in this paper, the decorative appearance of the article is affected because a small amount

of metal or metal oxide has been transferred to the coating due to the abrasive wear of the metal by the surface of the coating.

In essence, metal marking is hypothesized as the result of hard asperities situated at the surface of the coating which indent, groove, and then cut material out of the metal object. It would be expected that with harder metals, there would be less indentation by the hard asperities and, consequently, the abrasive wear or metal marking would be decreased.

It is important that metal marking is not confused with marring since both are the consequence of the application of a dynamic mechanical force. To illustrate the difference between these two properties, consider a loaded metal stylus which traverses an organic coating. For relatively low loads, elastic deformation of the surface occurs and if the asperities at the surface of the organic coating are hard, metal marking may ensue. On increasing the load on the stylus, metal marking will increase but a stage will be reached whereby there is permanent deformation of the surface and within the area of deformation the coating will rupture. This stage of rupture is often referred to as the onset of marring. If, for example, a coating is extremely soft, then metal marking would not occur although marring would undoubtedly be evident. Occasionally other definitions for marring are used and these can be found in the literature.¹

From the examples mentioned above, it is evident that metal marking is quite a common problem although it would appear from the literature that it is a problem which has not been investigated to any great extent. In addition, a standard method for assessing metal marking has not been developed and accepted by the coating industry since the subjective test of rubbing a coin or gold ring over the coating under study is still widely used. Thus, a program of work was designed to establish a test method for measuring metal marking, and to determine the factors responsible for metal marking.

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EXPERIMENTAL

Test Method for Assessing Metal Marking

From the point of view of producing a reproducible metal mark, the following two factors are important: (1) the type of metal used and its shape, and (2) the load which is applied to the metal. A metal stylus was used in this program of work for marking, and is shown in *Figure 1* where a hemispherical tip which is supported by a copper coated steel rod has a diameter of approximately 4.5 mm. Tips of different composition were examined, and details are discussed in the section below.

A scratch resistance test machine manufactured by Research Equipment Ltd. was used for supporting the stylus. With this apparatus (see *Figure 2*) the load applied to the metal stylus is easily varied by placing known weights above the stylus. The coatings under study were applied to glass plates (15 cm × 10 cm × 0.2 cm) to produce a 25 μm thick dry film, and the glass secured to the bed of the machine by means of a clamp. The bed is essentially a sliding panel (velocity = 3.5 cm/sec) driven by a constant-speed motor. The procedure for marking the panel involves inserting the appropriate metal stylus into the chuck, balancing the beam using a counter load such that the stylus comes smoothly into contact with the coating, applying a known load to the stylus, and finally moving the coating in order that the stylus traverses one length of the coating. This procedure was repeated several times using fresh areas of film so as to ensure the reproducibility of the mark. In all cases, the direction of movement of the film was always the same.

It was evident from preliminary work that the type of substrate did not generally affect the result (e.g., card, tinplate, glass, and polyester film gave the same results within experimental error). However, with a substrate such as wood, which has a relatively coarse surface texture, the surface roughness of the paint film was affected and metal marking was generally much greater. Glass was used as the substrate for the test method since it was readily available, optically smooth, and could be used at elevated temperatures for stoving paints.

Several methods for quantifying the degree of metal marking were evaluated. For example, attempts were made to measure the amount of metal per unit length of

mark deposited onto the coating. In one case simple gravimetry was employed, and another method involved the use of X-ray fluorescence spectrometry in order to detect the amount of iron (using a steel stylus) and zinc (using a zinc stylus) on the surface. With both of these methods the experimental error was significantly large, therefore, it was decided to resort to the use of a series of standard marks (see *Figure 3*) based upon a numerical scale of 0 to 6, where 6 represented maximum metal marking and 0 no marking. In some cases a metal mark rating fell between two of the standard ratings (e.g., 2 and 3) and, therefore, an intermediate rating was given (e.g., 2+). Thus, a total of 13 ratings were available using this particular standard.

When using this method for assessing metal marking it was found that the assessment of the mark should preferably be carried out in daylight, and that the test method was only applicable for white and pastel tinted coatings.

Methods Used for Evaluating Surface Characteristics of a Coating

Since metal marking is primarily a surface phenomenon it was expected that several techniques would have to be employed to characterize the surface of an organic coating. The following properties were studied:

SURFACE ROUGHNESS: The surface roughness and texture of an organic coating were assessed using two techniques. Firstly, a mechanical/electrical profilometer (i.e., Talysurf™) was used, which enabled surface roughness to be quantified. In addition, it was possible to obtain a graphical output of the surface profile. The parameter used to give an indication of surface roughness was the center-line average (CLA) value, which is defined as the arithmetical average value of the departure of the surface profile above and below a reference line. It follows from this definition that a perfectly smooth surface has a CLA value of zero. Further details of this measurement are given in British Standards BS1134: Parts 1 and 2:1972.

The second technique used was microscopy, which involved the use of a Carl Zeiss Photomicroscope III and a Jeol 100CX (with scanning attachment) electron

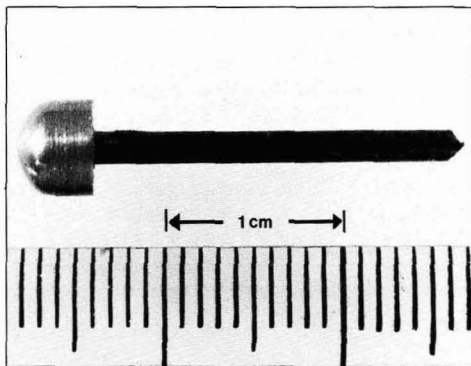


Figure 1—Stylus used for metal marking

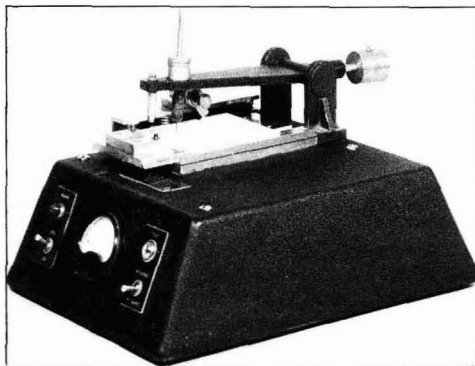


Figure 2—Apparatus used for metal marking

microscope. Details of specimen preparation are given in the appropriate sections.

GLOSS: Gloss was sometimes measured to give an indication of the degree of pigment dispersion at the surface of a coating.² Thus, 20°, 60° and 85° gloss values were obtained using a Byk-Mallinckrodt glossmeter. In all cases, the coatings (25 μm thick) were aged for at least 24 hours before gloss measurements were taken from the coatings which were applied to glass.

HARDNESS: In addition to using the Mohs' scale of hardness which gives an indication of the hardness of pigment and extenders, the hardness of the coating was measured using a König pendulum hardness tester. In all cases, the coatings under study were applied to glass so that the thickness of the dry film was approximately 25 μm. After aging for at least 24 hours, the time taken for the pendulum's amplitude to fall by half was recorded. The longer the time period, the harder the film.

Materials

To cover a broad spectrum of coatings, a variety of pigments, extenders, and resin systems were used. Details of the grades of pigment used are given in *Table 1*, whereas information on the extenders and resin systems are given in the appropriate sections below.

RESULTS AND DISCUSSION

Effect of Hardness of Metal And the Force Between Metal and Coating

Since it was assumed in the introduction that metal marking is the result of abrasive wear of the metal, one would expect that increasing the hardness of the metal and decreasing the load applied to the metal would result in a decrease in metal marking. In order to con-

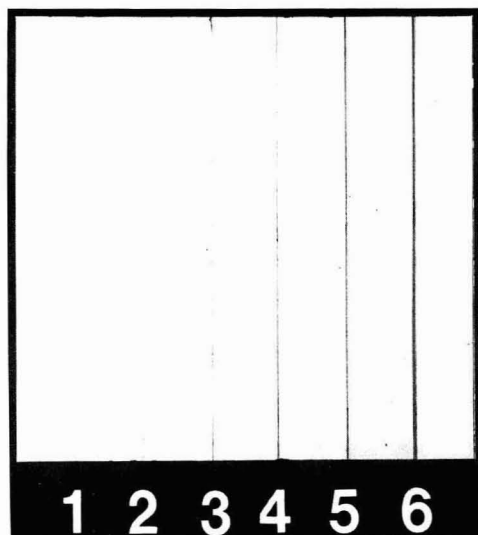


Figure 3—Reference standard used for rating metal marking

Table 1 — Typical Properties of Titanium Dioxide Pigments Used in Program

| Pigment | Crystal Size (μm) | Manufacturing Process | Rutile or Anatase | Coated or Non-Coated |
|---------|-------------------|-----------------------|-------------------|----------------------|
| A | 0.23 | Sulphate | Rutile | Coated |
| B | 0.22 | Chloride | Rutile | Coated |
| C | 0.15 | Sulphate | Anatase | Non-coated |
| D | 0.22 | Sulphate | Rutile | Non-coated |
| E | 0.23 | Sulphate | Rutile | Coated |
| F | 0.17 | Sulphate | Rutile | Coated |
| G | 0.24 | Chloride | Rutile | Coated |
| H | 0.21 | Sulphate | Rutile | Coated |

firm this supposition, four metal styli based on steel, aluminum, zinc, and brass were used to mark an acrylic based emulsion paint which was only pigmented with a typical general purpose rutile grade of titanium dioxide (pigment A) at a pigment volume concentration (p.v.c.) of 20%. Various loads were applied to each metal stylus, and the subsequent marks were rated. In addition, for the aluminum stylus, the average width of each mark was measured using an optical microscope. In *Table 2* the marking results are given and they show that irrespective of load, steel has marked the least, brass and zinc the worst, and aluminum has exhibited only slightly more marking than the steel stylus. If one considers the Mohs' hardness of these metals (viz., steel = 5-8.5, aluminum = 2-2.9, brass = 3, and zinc = 2.5) the results given in *Table 2* can to some extent be predicted. However, there is a slight anomaly in that the aluminum stylus is not producing the same amount of metal marking as brass or zinc, and this is probably attributable to the relatively hard aluminum oxide layer on the surface of the aluminum stylus.

The effect of increasing the load on the metal stylus has undoubtedly caused metal marking to increase, as shown by the results in *Table 2*. This is because the increase in force between metal and coating has resulted in a greater penetration into the coating by the stylus which has inevitably produced a wider metal mark. Thus, the number of contacts between the metal and the irregularities at the surface of the coating which are responsible for the abrasion has increased. To illustrate this, the aluminum marks obtained using 25 g, 100 g, and 300 g loads were examined in cross-polarised light using an optical microscope. In *Figure 4*, micrographs of the marks clearly show that at the low load of 25 g, the areas where metal is deposited (black areas) are relatively far apart, but on increasing the load to 100 g and 300 g, these areas have increased in size. Although considerable marking occurred with the 300 g load, there was still no signs of surface rupture.

Since the metal stylus is being abraded during the metal marking test (see *Figure 5* for a scanning electron micrograph of the tip of a brass stylus which has been used several times), it is important to ensure that the stylus is changed at regular intervals to obtain reproducible results. This interval depends upon the conditions under which the stylus is used (e.g., the load, the type of metal, and the nature of the organic coating).

Table 2—Effect of Stylus Type and Load on the Stylus, On Marking an Emulsion Paint (20% p.v.c.)

| Stylus Type | Mark Rating ^a | | | | |
|-----------------------------------|--------------------------|-----------|------------|------------|------------|
| | 25 g load | 50 g load | 100 g load | 200 g load | 300 g load |
| Steel..... | 1 | 2 | 2+ | 3+ | 3+ |
| Aluminum..... | 2 | 2+ | 3+ | 4 | 4+ |
| Brass..... | 2 | 3 | 4 | 5 | 6 |
| Zinc..... | 2 | 3 | 3+ | 5 | 6 |
| Width of aluminum mark (μm) | 135 | 210 | 270 | 285 | 300 |

(a) 6 = Severe marking; 0 = No marking

Since it can be inferred from these results that, as far as metal marking is concerned, the type of metal stylus used and load should not affect the relative difference between coatings, the subsequent work was mainly confined to the use of steel and brass styli, and an appropriate load was selected which produced adequate metal marking.

Influence of Pigment and Extender

Since the organic coating is the abrasive element which is responsible for metal marking, there are several formulation variables which could contribute to this abrasivity. Basically, a coating contains two major components: pigment/extender and binder, which could affect a coating's abrasivity. It is the former component which will be discussed in this section.

When formulating a coating using either pigment or extender, or both, a variety of materials are available which differ in chemical composition, shape, mean particle size, and hardness. One would expect the hardness of the pigment/extender to be the most important factor from the point of view of abrasion, followed by shape and mean size. To determine the importance of pigment/

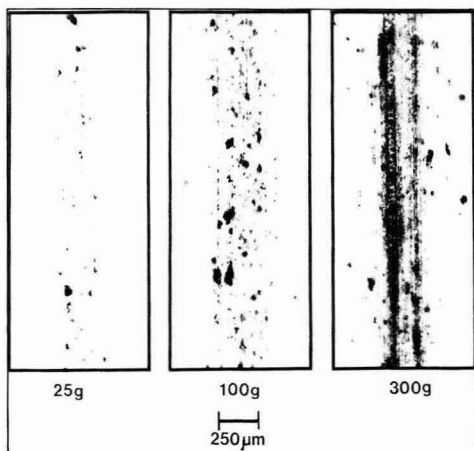


Figure 4—Amount of aluminum deposited onto an emulsion paint as a function of load

extender with regard to metal marking, emulsion paints were prepared in which the pigment/extender is exposed at the surface of the coating so that it can abrade the metal. A typical rutile grade of titanium dioxide (pigment B) and several commercially available extenders were selected in order to cover a range of hardness values, and these were individually incorporated into the emulsion paint system (based on an acrylic emulsion) at a pvc of 30%. In Table 3, a list of the properties of the pigment/extenders are given, and it can be seen that differences in hardness are accompanied by differences in shape and mean particle size. The paints produced were drawn down onto glass, and after 24 hours drying were marked with a steel stylus using 50 g and 200 g loads. In addition, the surface roughness (CLA value) of each film was measured, and these results together with the metal mark ratings are given in Table 4. It is clearly evident from these results that the titanium dioxide, which is the hardest of the minerals studied, exhibits the worst metal marking and the smoothest film. In this case, the metal stylus is in contact with a considerable number of hard titanium dioxide particles protruding above the surface of the emulsion. In contrast, talc is extremely soft, and no metal marking was evident although some marring occurred. To illustrate the difference between the titanium dioxide and talc containing coatings, the marks were examined in cross-polarized light (using a microscope) to highlight the areas where metal is deposited. A Nomarski interference contrast attachment was also used to study the topography of the surface. In Figures 6(a) and 6(b), micrographs of the titanium dioxide containing coating are shown; in Figures 7(a) and 7(b), micrographs of the talc coating are given. With the titanium dioxide coating, metal marking is evident [see Figure 6(a)] and when the coating is examined using interference contrast microscopy [see Figure 6(b)] the titanium dioxide responsible for the abrasion can be seen as small white particles within the lines of deformation. In contrast, no metal was deposited onto the talc coating although the surface

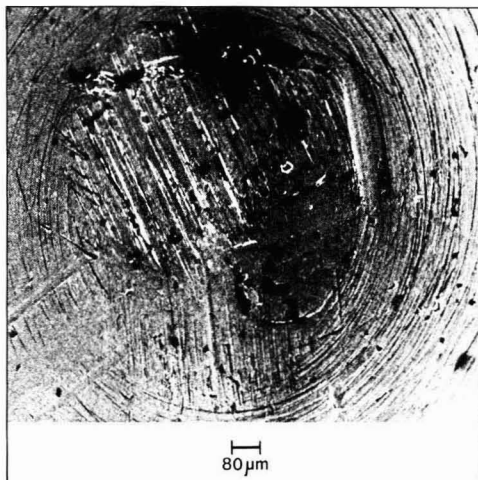


Figure 5—Scanning electron micrograph of the tip of a worn brass stylus

Table 3—Shape, Mean Size and Hardness Of Pigment and Extenders

| Pigment Extender | Particle Shape | Mean Particle Size (μm) | Hardness (Mohs) |
|-----------------------|----------------|--------------------------------------|-----------------|
| Pigment B | Nodular | 0.25 | 6-6.5 |
| China clay | | | |
| (calined) | Lamellar | 2.00 | 4.0 |
| Talc | Lamellar | 3.00 | 1.0 |
| Aluminum silicate | Ultrafine | 0.03 | 2-3 |
| Micronized silica gel | Nodular | 2.50 | 3-5 |

was deformed as shown by the "stress whitening" in *Figure 7(a)*.

The results given in *Table 4* do not show a perfect correlation between hardness of pigment/extender and metal marking since the surface roughness is another factor which has to be considered when examining the interaction between metal stylus and coating. Obviously,

Table 4—Metal Marking and Surface Roughness Of an Emulsion Paint Based on Several Pigment/Extenders

| Pigment/Extender | Mark Rating ^a | | CLA (μm) |
|-----------------------|--------------------------|--------------------|-----------------------|
| | 50 g Steel Stylus | 200 g Steel Stylus | |
| Pigment B | 3+ | 4+ | 0.13 |
| China clay | | | |
| (calined) | 1+ | 2 | 1.68 |
| Talc | 0 | 0 | 0.75 |
| Aluminum silicate | 0 | 0 | 2.74 |
| Micronized silica gel | 0 | 1 | 2.36 |

(a) 6 = Severe marking; 0 = No marking

a surface which contains relatively few albeit large (in height) asperities will reduce the area of contact between the metal and film and should, therefore, decrease the

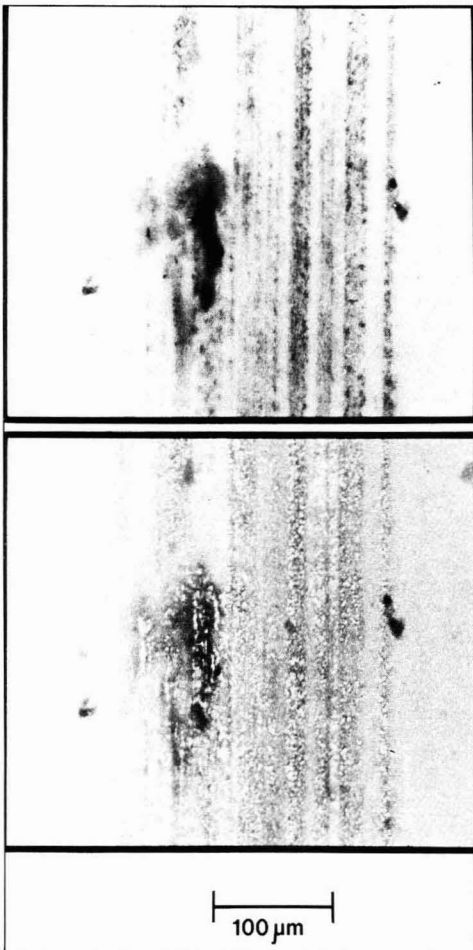


Figure 6—Optical micrographs of a marked emulsion paint containing only titanium dioxide (Top: (a), Bottom: (b))

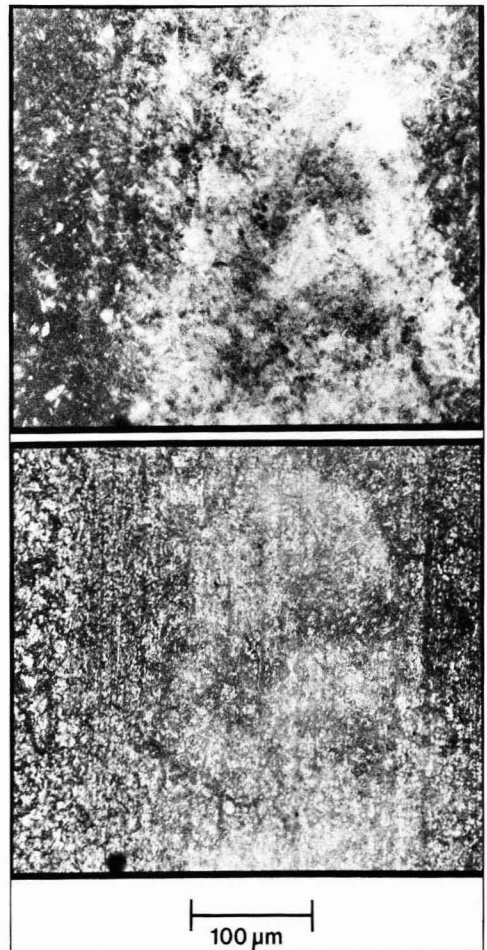


Figure 7—Optical micrographs of a marked emulsion paint containing only talc (Top: (a), Bottom: (b))

Table 5—Shape, Mean Size and Hardness of Several Extenders

| Extender | Particle Shape | Mean Particle Size (μm) | Hardness (Mohs) |
|-----------------------|----------------|--------------------------------------|-----------------|
| China clay (calcined) | Lamellar | 2.0 | 4.0 |
| Talc | Lamellar | 3.0 | 1.0 |
| Calcite | Nodular | 2.0 | 3.0 |
| Quartz | Nodular | 10.0 | 7.0 |

extent of the metal marking. This is illustrated in *Table 4* where if hardness was the only determining factor, the micronized silica gel should have exhibited the same marking as the china clay. Since this did not occur and the micronized silica gel coating was significantly rougher than the clay coating, the above hypothesis could explain this difference. Although with the various extenders the differences in metal marking are relatively subtle, the conclusion that titanium dioxide at the surface of a coating will increase metal marking is clearly evident.

To further illustrate the deleterious effect of titanium dioxide on metal marking, the same emulsion paint system as used above was pigmented with the same grade of titanium dioxide at a pvc of 20% and was used as a control coating. Several extenders (see *Table 5* for properties) were individually incorporated into this system so that the total volume concentration of pigment plus extender was 50%. Coatings were prepared and marked using a 50 g loaded steel stylus, and the surface roughness measured. These results (see *Table 6*) again show that titanium dioxide at the surface of a coating increases metal marking since the inclusion of extender causes a reduction in marking. Again, this is probably due to the fact that the relatively coarse extender which increased the surface roughness of the coating reduced the area of contact between stylus and pigment. It is only with the hard quartz extender that there was little reduction in marking. At first glance this result is a little surprising since one might expect that the incorporation of extra material similar in hardness to titanium dioxide would produce an increase in metal marking. However, this extender is extremely coarse (10 μm mean size) and presumably the area of contact is between the quartz and stylus. Consequently, the contact between titanium dioxide and the metal stylus is negligible.

Table 6—Metal Marking and Surface Roughness of an Emulsion Paint Containing (a) Only Titanium Dioxide (pigment B) And (b) a Blend of Titanium Dioxide (pigment B) and Extender

| Pigment/Extender | Mark Rating ^a (50 g steel stylus) | CLA (μm) |
|-----------------------|--|-----------------------|
| Pigment B (control) | 3+ | 0.14 |
| Pigment B | | |
| + | | |
| China clay (calcined) | 2 | 1.50 |
| Talc | 1+ | 0.62 |
| Calcite | 1+ | 0.71 |
| Quartz | 3 | 3.50 |

(a) 6 = Severe marking; 0 = No marking

Table 7—Metal Marking, Surface Roughness and Gloss Of an Emulsion Paint Containing Different Amounts of Polyester Bead

| Coating | Mark Rating ^a | | | |
|---------------------|--------------------------|----------------------|-----------------------|-----------|
| | (50 g steel stylus) | (200 g steel stylus) | CLA (μm) | 85° Gloss |
| Control (pigment B) | 4 | 6 | 0.14 | 41 |
| 5% beads | 1 | 5 | 0.75 | 31 |
| 10% beads | 0 | 2+ | 1.18 | 13 |
| 20% beads | 0 | 2 | 1.84 | 4 |
| 30% beads | 0 | 2 | 2.35 | 3 |

(a) 6 = Severe marking; 0 = No marking

Thus, the technique of reducing the area of contact between stylus and titanium dioxide is one possible method by which metal marking can be decreased. To illustrate this, the following example is given:

MATT EMULSION PAINT: An emulsion paint containing pigment B at a pvc of 30% was used as a control. Relatively large spherical fillers were selected to decrease the area of contact between the metal stylus and pigment. Glass ballotini (10 μm mean size), a PTFE dispersion (0.3 μm mean size), and an aqueous dispersion of solid polyester resin beads (15 μm mean size) were considered. Since all three types of beads exhibited similar effects (i.e., solid polyester beads were similar in performance to the ballotini but slightly better than the PTFE dispersion), only the results of the polyester beads will be given. The beads were added to the emulsion paint to give bead volume concentrations in the dry film of 5%, 10%, 20%, and 30%. Surface roughness and gloss (85°) of each film were measured and the films were marked using a steel stylus (50 g and 200 g loads). In *Table 7*, the results show that the addition of beads, which caused the gloss to decrease due to the increase in surface roughness, significantly diminished the extent of the metal marking. As mentioned above, this decrease in marking is due to the decreased contact between stylus and pigment. This can be easily appreciated if the surface of the coating is examined using a scanning electron microscope. For this purpose, the paint film containing 30% beads was embedded between two layers of epoxy resin and sectioned. In *Figure 8*, a section of the edge of the coating shows the polyester beads protruding above the film where the pigment is present. It is also interesting to note that there is no pigment on the surface of the beads. The difference in marking between the control and the bead containing films is evident irrespective of load, although at the high load there is some marking on the beaded paints which is due to the inherent abrasive nature of the beads. This can be seen in *Figure 9* where optical micrographs of the metal mark which was on the 10% beaded film (using a 200 g steel stylus) shows metal deposited (black areas) onto and in close proximity to the beads.

Anatase Versus Rutile Titanium Dioxide Pigment

Since the anatase form of titanium dioxide is a little softer than the rutile crystal [i.e., 5-5.5 (Mohs' hardness)

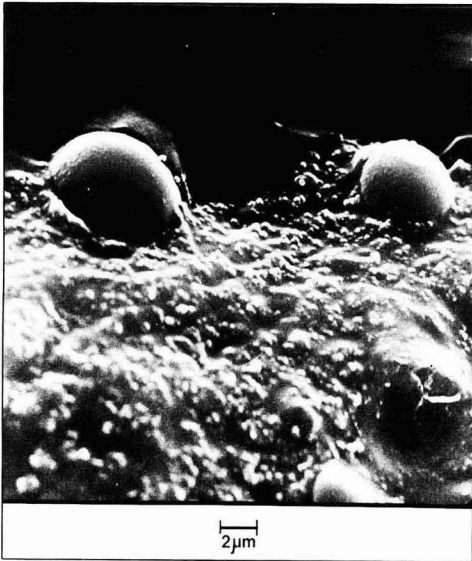


Figure 8—Scanning electron micrograph of a section of an emulsion paint containing 30% (by volume) polyester bead

for anatase vs 6-6.5 (Mohs' hardness) for rutile], one might expect that anatase titanium dioxide would exhibit slightly less metal marking than the rutile form. In the next section it is shown that the degree of pigment dispersion in a coating plays an important part in affecting metal marking. Therefore, in order to compare two types of titanium dioxide, it is important to ensure that the state of dispersion is the same. For this purpose, an emulsion paint (based on an acrylic emulsion) was formulated and pigmented with an uncoated grade of anatase titanium dioxide (pigment C) and an uncoated grade of rutile titanium dioxide (pigment D) so that the pvc varied from 20% to 50% by 10% increments. To give an indication of pigment dispersion, the surface roughness of each coating was measured, and the coatings were marked using a 50 g loaded steel stylus. Results given in *Table 8* illustrate that within experimental error both rutile and anatase based coatings exhibit similar surface roughness values for the same pvc, but the anatase coating is always slightly less prone to metal marking. The results also show that as the pvc is increased the degree of metal marking is increased. Obviously, this increase in metal marking, although not large, is the result of increased contact between metal and titanium dioxide. Generally, the difference between rutile and anatase forms would probably not be very significant, as shown by these results, particularly when other variables such as pigment dispersion play an important role in affecting metal marking.

Effect of Pigment Dispersion

In the above section, the effect of pigment and extender on metal marking was illustrated using a "model" paint. However, this type of system would generally have no practical significance with regard to the coating industry.

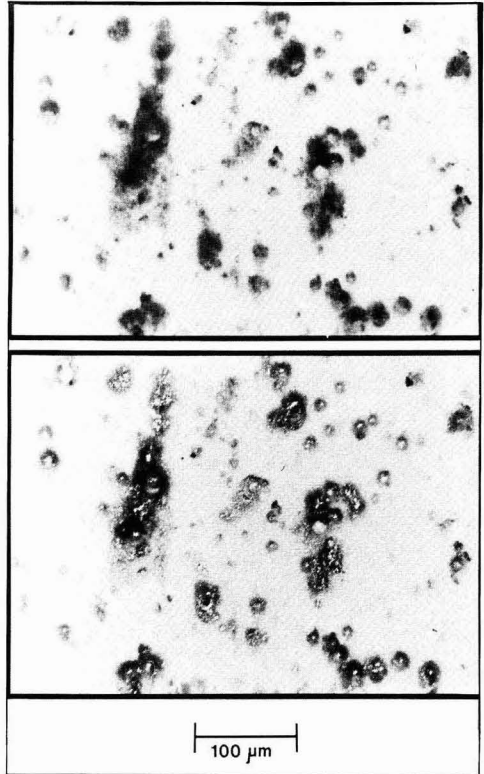


Figure 9—Optical micrographs of a marked emulsion paint containing 10% (by volume) polyester bead. Black areas indicate metal marking

In the work that follows, typical industrial finishes were selected.

It is well known that the degree of pigment dispersion in a coating can significantly affect such optical properties as gloss. For example, in a system where the pigment is flocculated, the pigment particles protrude further out from the surface of the coating thereby resulting in a rougher surface which produces a decrease in gloss. From an abrasive wear point of view, if more of the abrasive element is exposed, one would expect an increase in metal marking (c.f. the effect of increasing pvc on metal marking, see *Table 8*). It is important to note that this increase in surface roughness is relatively small and must not be confused with the large increases in surface roughness which occur when extenders are used.

To illustrate the effect of dispersion, three coated grades of rutile titanium dioxide (i.e., pigments A, E, and F) were selected which were known to exhibit differences in dispersion in an alkyd/urea formaldehyde stoving paint. The paints (pigment:binder = 1:1) were stoved on glass for 30 min at 120°C (recommended stoving schedule) and the following measurements were taken: (1) metal mark rating using a 200 g load on a brass stylus, (2) surface roughness, and (3) 20° gloss. In *Table 9* the results are given and although there are only small differences in surface roughness, they are sufficient to affect the

Table 8—Metal Marking and Surface Roughness Of an Emulsion Paint Pigmented with Anatase (pigment C) And Rutile Titanium Dioxide (pigment D) at Various PVC's

| % PVC | Mark Rating ^a for Pigment C (50 g steel stylus) | Mark Rating ^a for Pigment D (50 g steel stylus) | CLA (μm) for Pigment C | CLA (μm) for Pigment D |
|-------|---|---|--|--|
| 20 | 2 | 3 | 0.12 | 0.12 |
| 30 | 2+ | 3 | 0.16 | 0.14 |
| 40 | 3 | 3+ | 0.19 | 0.15 |
| 50 | 3 | 4 | 0.21 | 0.17 |

(a) 6 = Severe marking; 0 = No marking

degree of metal marking such that the metal marking has increased with increasing surface roughness.

It is well known that the presence of an acid catalyst in an acid catalysed alkyd/urea formaldehyde stoving paint can affect the shelf life of the paint by flocculating the pigment. From the above findings it would be deduced that the degree of metal marking would also be affected. Therefore, an acid catalyzed alkyd/urea formaldehyde paint containing 10% paratoluene sulphonic acid based on weight of urea formaldehyde resin was formulated using pigment B at a pigment:binder = 1:1. After the addition of acid, the paint was drawn down on glass and stoved for 30 min at 120°C. The paint was then allowed to age for five hours and 24 hours, and after each period, the paint was drawn down and stoved as above. Gloss and surface roughness measurements were carried out on the films to give an indication of the pigment dispersion at the surface of the coating, and metal marking was rated using a 200 g loaded brass stylus. In Table 10 the results show that the effect of aging the paint, which resulted in pigment flocculation, has caused the metal marking to increase slightly.

Comparison Between Titanium Dioxide Pigments Produced Using the Chloride and Sulphate Processes

Since it is frequently mentioned (particularly with regard to gravure printing inks) that titanium dioxide pigments manufactured using the chloride process are more abrasive than sulphate route pigments, one might expect that this difference would be reflected in metal marking resistance if the above statement is true. To determine if this was the case, two chloride pigments

Table 9—Metal Marking, Surface Roughness and Gloss Of an Alkyd/Urea Formaldehyde Paint Pigmented with Three Different Grades of Titanium Dioxide

| Pigment | Mark Rating ^a (200 g brass stylus) | CLA (μm) | 20° Gloss |
|---------|--|-----------------------|--------------|
| A | 2+ | 0.027 | 77 |
| E | 3 | 0.033 | 72 |
| F | 5 | 0.038 | 48 |

(a) 6 = Severe marking; 0 = No marking

Table 10—Metal Marking, Surface Roughness and Gloss Of an Acid Catalysed Alkyd/Urea Formaldehyde Paint As a Function of Age of Paint

| Age of Paint (hours) | Mark Rating ^a (200 g brass stylus) | CLA (μm) | 20° Gloss |
|-------------------------|--|-----------------------|--------------|
| Fresh | 3+ | 0.059 | 45 |
| 5 | 4 | 0.074 | 38 |
| 24 | 4+ | 0.232 | 4 |

(a) 6 = Severe marking; 0 = No marking

(pigments B and G) and one sulphate grade (pigment H) were incorporated into the alkyd/urea formaldehyde and an alkyd/melamine formaldehyde paint. The paints (pigment:binder = 1:1) were stoved on glass for 30 min at 120°C (for the alkyd/UF system) and 150°C (for the alkyd/MF system). The paints were also overbaked for 60 min at 180°C (for the alkyd/UF system) and 200°C (for the alkyd/MF system). As a measure of pigment dispersion, 20° gloss of each film was recorded, and each panel was marked using a 400 g loaded brass stylus.

In Table 11, with the same degree of pigment dispersion (i.e. gloss) there is little difference in metal marking between a chloride and a sulphate grade pigment. Irrespective of the stoving schedule, pigments B and H exhibit similar gloss and metal marking. However, with pigment G the dispersion is relatively poor and, therefore, it is more prone to metal marking.

These results (and others not mentioned in this report) would suggest that given the same degree of pigment dispersion, there is no inherent difference between a chloride and a sulphate grade pigment in regard to surface abrasivity.

Effect of Resin System

The above findings have illustrated that pigment dispersion can affect metal marking but for this to be the case, the pigment must be present at the surface of the coating. For example, in Figure 10 an electron micrograph of a section of a pigmented alkyd/melamine formaldehyde paint known to exhibit metal marking, shows the pigment protruding slightly above the surface of the resin. Depending on the resin system used, a clear resin layer can be formed at the surface of the coating.² This phenomenon is illustrated in Figure 11 where an electron micrograph of a section of an air drying polyurethane paint film is given. A clear layer is often found in air drying decorative paint systems. This is why this type of system does not often exhibit metal marking, although marring is likely to occur due to the relatively soft resinous surface.

To illustrate the protective effect of depositing a thin layer of resin between the surface of a coating and the metal stylus, a thermoplastic acrylic paint was formulated using pigment B such that the pigment:binder = 0.8:1. This paint was stoved for 30 min at 140°C after which gloss, surface roughness, and metal marking (600 g loaded brass stylus) measurements were taken. Using a K-bar applicator, a thin layer of the acrylic resin used in

Table 11—Metal Marking and Gloss of Two Alkyd Stoving Paints Pigmented with Chloride and Sulphate Grades of Titanium Dioxide

| Pigment | Normal Stoving Schedule | | | | Overbake Stoving Schedule | | | |
|---------|---|--------------|---|--------------|---|--------------|---|--------------|
| | Alkyd/UF | | Alkyd/MF | | Alkyd/UF | | Alkyd/MF | |
| | Mark Rating ^a (400 g brass stylus) | 20° Gloss | Mark Rating ^a (400 g brass stylus) | 20° Gloss | Mark Rating ^a (400 g brass stylus) | 20° Gloss | Mark Rating ^a (400 g brass stylus) | 20° Gloss |
| B | 3 | 72 | 1+ | 77 | 5 | 51 | 2 | 73 |
| G | 3+ | 66 | 2+ | 72 | 6 | 25 | 3 | 54 |
| H | 3 | 72 | 1+ | 79 | 5 | 39 | 2+ | 68 |

(a) 6 - Severe marking; 0 - No marking

the paint was applied over the surface of the coating so that its dry film thickness was about 2 μm . This system was then stoved as above and the same measurements taken from the coating. Results in *Table 12* show that the presence of a thin clear layer at the surface of the coating decreased the metal marking and also increased the gloss.

Since various factors associated with the resin can determine whether or not a clear layer is formed,^{2,3} these factors will also influence whether or not metal marking is likely to occur. Another factor associated with the resin which can play a part in affecting metal marking is resin hardness. To illustrate this, two styrene/acrylic emulsions (E_1 and E_2) of different hardness values (i.e., Sward rocker (%): $E_1 = 38$ and $E_2 = 11$) were used to produce 20% pvc emulsion paints based on pigment B. The paints were drawn down on glass, and after the films had aged for 24 hours, gloss, surface roughness, metal marking (using a 30 g loaded brass stylus), and pendulum hardness measurements were carried out. The results given in *Table 13* illustrate that the paint based on the harder of the two emulsions (i.e. E_1) is exhibiting slightly more marking even though the surface roughness is slightly less than the other system. Metal marking was also carried out on the clear emulsion films and showed no effect, illustrating that the resin does not abrade the metal to any great extent. The results in *Table 13* suggest

that there is a synergistic effect between emulsion and pigment. Perhaps the "exposed" pigment is partly coated by the emulsion which affects the relative hardness of the exposed pigment and therefore influences the extent of the metal marking. If this result is considered in broader terms, one could infer that the degree of cure of a crosslinked resin system could also affect metal marking. Unfortunately, variations in a curing schedule not only affect the degree of cure but also influence the extent to which pigment is present at the surface as shown by *Table 11* and therefore a change in one parameter could affect several other variables which might influence metal marking.

To study this aspect further, a water based acrylic coating, containing pigment B (pigment:binder = 1.1:1) was formulated such that the amount of catalyst (para-toluene sulphonic acid) varied from 0.05% to 0.2% on weight of paint. Paints were drawn down on glass and stoved for five seconds at 210°C. Metal marking was assessed using a 1200 g loaded brass stylus, and 20° gloss measured. In addition, the surface topography of each coating was studied using an electron microscope.

With the scanning electron attachment it was evident that there was no titanium dioxide present at the surface of any of the coatings, and by using an etching technique⁴ it was clear that the levels of catalyst had not affected the

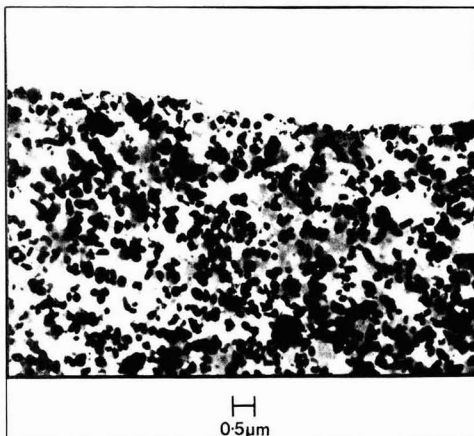


Figure 10—Electron micrograph of a section of an alkyd/melamine formaldehyde paint film

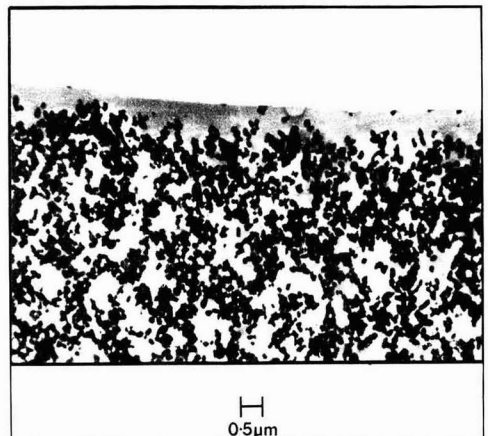


Figure 11—Electron micrograph of a section of an air drying polyurethane paint film which exhibits a clear layer

Table 12—Metal Marking, Surface Roughness and Gloss Of a Thermoplastic Acrylic Paint

| Coating | Mark Rating ^a (600 g brass stylus) | CLA (μm) | 20° Gloss |
|--|--|--------------------------|--------------|
| Thermoplastic acrylic system | 2 | 0.021 | 70 |
| Thermoplastic acrylic system plus resin at the surface | 0 | 0.019 | 84 |

(a) 6 = Severe marking; 0 = No marking

state of pigment dispersion. Consequently, to study the surface features of the coatings in more detail, replicas were obtained and examined using a transmission electron microscope (see Kay⁵ for technique). In Figures 12, 13, and 14, micrographs of the surface of paints containing 0.05%, 0.1%, and 0.2% catalyst are shown, and it is evident that there is no titanium dioxide present at the surface and that the surface roughness has decreased with increasing catalyst content. The metal mark ratings and gloss values are given in Table 14 and suggest that with increasing catalyst content, the metal marking has decreased and the gloss increased due to a decrease in surface roughness. Thus, the addition of catalyst, the primary purpose of which was to influence the rate of cure, has also reduced the surface roughness and, therefore, reduced the abrasivity of the coating.

To determine if there was a primary factor associated with the resin system which was responsible for metal

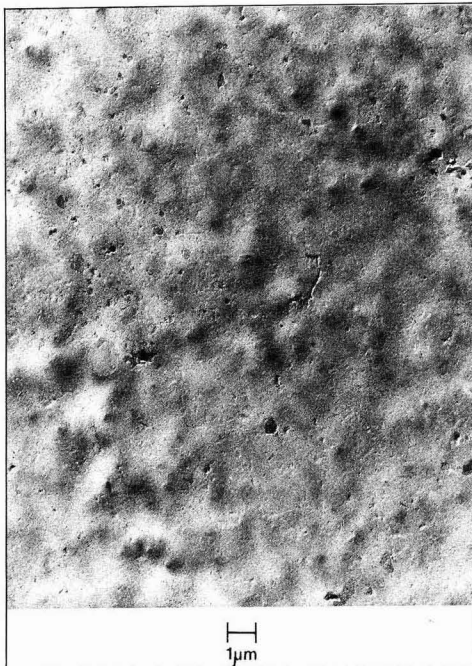


Figure 12—Electron micrograph of the surface (replica) of an acrylic water based coating containing 0.05% catalyst

Table 13—Effect of Emulsion Type/Hardness on Metal Marking

| Emulsion | Mark Rating ^a (30 g brass stylus) | Hardness (sec) | CLA (μm) | 20° Gloss |
|--------------------------|---|-------------------|--------------------------|--------------|
| E ₁ | 4+ | 40 | 0.15 | 38 |
| E ₂ | 3 | 19 | 0.21 | 35 |

(a) 6 = Severe marking; 0 = No marking

marking, five paint systems (containing pigment B) were arbitrarily selected for metal marking. In Table 15, the resin system used, pigment:binder ratio and stoving conditions are given. In addition to making these paints, the resins were also used to produce clear films (using the same stoving conditions) so that pendulum hardness values could be obtained. Since it is known that the presence of titanium dioxide can to some extent affect the degree of cure of a paint system (see Akay⁶ et al.) and therefore the hardness of the cured resin, the method of measuring the hardness of the unpigmented system was the only way to obtain an indication of resin hardness in the paint system. In Table 16, metal mark ratings (using a 400 g loaded brass stylus) and surface roughness values of the pigmented films are given together with the hardness values for the clear resin films. These results show that the hardness of the resin does not play a major part in affecting metal marking but it is clearly evident that there is a good correlation between surface roughness and metal mark rating. This would suggest that with all the resin systems studied, the primary factor which is



Figure 13—Electron micrograph of the surface (replica) of an acrylic water based coating containing 0.1% catalyst

Table 14—Effect of Catalyst on Metal Marking And Gloss for an Acrylic Water Based Paint

| Catalyst Level (%) | Mark Rating ^a (1200 g brass stylus) | 20° Gloss |
|--------------------|--|-----------|
| 0.05..... | 1+ | 63 |
| 0.10..... | 1 | 65 |
| 0.20..... | + | 71 |

(a) 6 = Severe marking; 0 = No marking

responsible for metal marking is presumably the extent to which the pigment exerts its presence at the surface of the paint film and this is the result of a specific interaction between pigment and resin.

Simple Theory of Metal Marking

From the onset of this project it was appreciated that metal marking was an abrasive wear phenomenon since certain simple experiments confirmed that wear was occurring (e.g., metal marking was proportional to the load applied to the stylus). When two surfaces are brought together (e.g., organic coating and metal stylus) they only touch at the tips of the highest asperities. Thus, the real area of contact, which is the important factor from a wear point of view, is only a small part of the apparent area of contact. Since it is difficult to assess the distribution of real areas of contact between an organic coating and a metal stylus, one must consider the simple case of a spherical particle (representing a

Table 15—Stoving Schedule, Pigment:Binder Ratio And Resin Systems Used in Order to Make Various Paints

| Resin System | Pigment:Binder | Stoving Schedule |
|-----------------------------------|----------------|------------------|
| Alkyd/urea formaldehyde | 1:1 | 30 min at 120°C |
| Alkyd/melamine formaldehyde | 1:1 | 30 min at 150°C |
| Thermosetting acrylic..... | 1:1 | 30 min at 120°C |
| Thermoplastic acrylic..... | 0.5:1 | 30 min at 138°C |
| Modified polyester..... | 1.5:1 | 15 min at 150°C |

titanium dioxide crystal protruding above the surface of the organic binder) indenting a smooth metal surface (see Figure 15).

Using Hertz⁷ equation, the radius *a* of the circular area of contact formed when a sphere of radius R is pressed against a flat surface under a load P can be calculated as follows:

$$a = \left(\frac{4}{3} \frac{K}{E} P R \right)^{1/3} \tag{1}$$

where E = Young's modulus of the metal surface

and K = Constant depending on the Poisson ratios of the sphere and metal surface.

It can be seen from equation (1) that if the load applied to the sphere increases, *a* increases, and if the hardness of the metal is increased (i.e. E) *a* will decrease.

To calculate a value for *a* using this equation, consider a 200 g load which is applied to a steel stylus so that a 300 μm width mark is produced (e.g., see Table 2). From Talysurf profiles and energy dispersive X-ray microanalysis carried out on marked stoving paints it would appear that points of contact between stylus and coating occur at approximately 10 μm intervals. Assuming that at these points of contact there is only one titanium dioxide particle (R = 0.1 μm) the load applied to this particle can be calculated (e.g., P = 2.2 × 10⁻⁴ kg). For a titanium dioxide/steel interface, K ≈ 1.58 and E = 210 × 10⁹ Pa. Thus, substituting these values into equation (1) results in *a* having a value of approximately

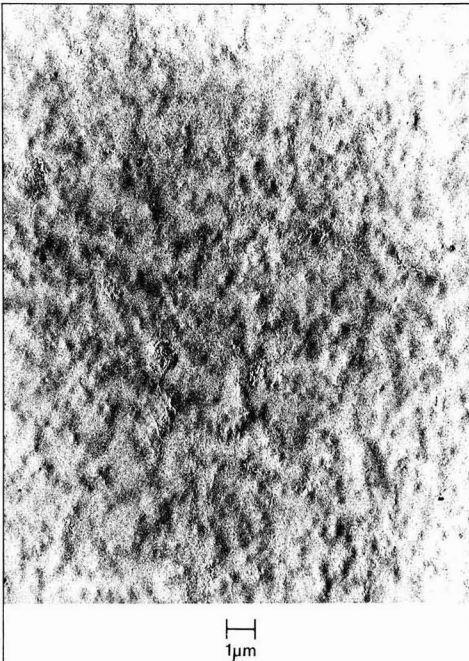


Figure 14—Electron micrograph of the surface (replica) of an acrylic water based coating containing 0.2% catalyst

Table 16—Effect of Hardness of Resin And Surface Roughness on Metal Marking

| Resin System | Hardness of Resin (sec) | Mark Rating ^a (400 g brass stylus) | CLA (μm) |
|-----------------------------------|-------------------------|---|----------|
| Alkyd/urea formaldehyde | 141 | 3+ | 0.045 |
| Alkyd/melamine formaldehyde | 87 | 3 | 0.040 |
| Thermosetting acrylic | 149 | 2 | 0.022 |
| Thermoplastic acrylic | 174 | 2 | 0.021 |
| Modified polyester | 30 | 3 | 0.040 |

(a) 6 = Severe marking; 0 = No marking

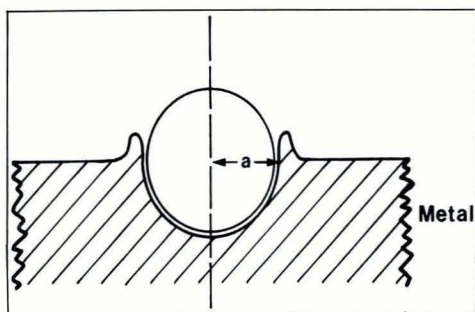


Figure 15—Indentation of a metal surface by a sphere

0.1 μm .^{*} Therefore, it is apparent using this value for a that when a 200 g load is applied to a steel stylus, titanium dioxide particles will penetrate the metal surface by about 0.1 μm . If, for example, the same paint system was flocculated then the number of points of contact would probably be decreased but given the same applied load; P would therefore increase as would the degree of indentation.

Equation (1) illustrates the fact that spherical particles like titanium dioxide will indent a relatively hard metal surface such as steel. However, in order to simulate the process of metal marking, this indented particle has to be subjected to a dynamic force which will result in metal being ploughed and transferred to the organic coating. Archard⁸ has shown that when this occurs the amount of metal removed (δV) at any one point of contact is:

$$\delta V = \gamma a^3 \quad (2)$$

where γ is a constant, and that the total wear rate (W) is given by

$$W \propto \sum \frac{\delta V}{2a} \quad (3)$$

where the summation is carried out for all the individual areas constituting the total area of contact.

Thus, using equations (2) and (3) it follows that:

$$W \propto \sum \frac{\gamma a^3}{2} \quad (4)$$

Equation (4) therefore shows that the wear rate of metal which is related to the degree of metal marking is proportional to the area of contact.

SUMMARY

The work has shown that metal marking is an abrasive wear phenomenon and is significantly affected by the type of metal used and certain formulation variables appertaining to the organic coating. In coating composition, titanium dioxide pigment is one of the most important components responsible for metal marking and, therefore, it is vital that it be well dispersed so that it does not affect the surface roughness to any great extent. Thus, there is no one grade of titanium dioxide which will inherently offer much better metal marking

^{*} This value can only be considered as approximate since accurate values were not available for calculating K .

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resistance than another since the primary factor which influences metal marking is the state of pigment dispersion at the surface of a coating (i.e., the best grade of titanium dioxide will be that which exhibits the highest gloss).

Two techniques can be adopted to reduce metal marking. Firstly, a coarse and soft extender/filler can be incorporated into the coating in order that the contact between metal and titanium dioxide is reduced. Obviously this procedure would result in a matt finish, but it is very effective. There are various paint additives referred to as slip aids which are claimed to reduce metal marking and these basically operate using the above principle (e.g., polypropylene beads). The second technique is to select a pigment/resin system which produces a clear layer or alternatively use a two coat application such that the final coat is a clear lacquer. In both cases, very high gloss will be obtained and there will be negligible metal marking. Additives are available which are often silicone based that function in a similar way to this technique in so far as they produce a thin layer of material between the surface of the coating and the metal, thereby lubricating the surface. However, the disadvantage with this type of product is that recoatability or printing can be a problem.

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Microbiological Spoilage Of Latex Emulsions: Causes and Prevention

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Formulation ingredients and residual monomers, in the past, tended to limit the types of microorganisms that degraded latex emulsion systems. Improved technology, new application areas, and regulatory requirements create new worlds for a variety of microorganisms to explore in latex emulsion systems. Effective measures in the form of a well defined plant sanitation program, selection of more resistant raw material ingredients, and the use of broad spectrum biocides, such as 1,2-dibromo-2,3-dicyanobutane or benzyl bromoacetate, are described from case histories and experimental data.

INTRODUCTION

Most types of latex emulsions have been demonstrated to be susceptible to some form of microbial decomposition. However, these problems in latex emulsions have intensified over the past several years. Styrene butadiene, acrylic, polyvinyl acetate, vinyl acrylic, vinyl acetate ethylene, and vinyl chloride latex emulsions are now all known to suffer from microbial spoilage.

Improved technology, new application areas, and regulations imposed by OSHA and the EPA have created new worlds for a variety of microorganisms to explore. The reduction of residual monomers is a significant change in the formulation of latex emulsions which tended to limit the types of microorganisms that degraded these systems.

Versatility of the new emulsion formulations creates the need for new, environmentally safe, broad-spectrum preservatives. A particular latex emulsion produced

today can possibly be used for latex paints, paper coatings, adhesives, carpet backing, and textiles, among other applications. The biocides of the past are not able to meet these novel challenges. Biocides must have both EPA and FDA approvals to meet the current needs of the industry.

This paper covers the multitude of problems that affect the microbiological stability of latex emulsions. Susceptibility of raw materials, factors that affect growth and degradation, microorganisms isolated and identified from commercial systems, and sources of contamination in manufacturing facilities are among the problems reviewed.

Effective solutions using plant sanitation programs and broad spectrum biocides are illustrated from case history studies.

RAW MATERIAL SUSCEPTIBILITY

Latex emulsions provide all the essential ingredients required by microbial populations to reproduce and flourish. Water, cellulosic thickeners, polyvinyl alcohol, surfactants, defoamers, and colloids all support the growth of one or more types of microorganisms. Many raw materials are more susceptible to attack by microorganisms than others. Laboratory evaluations were conducted with several surfactants, wetting agents, defoamers, and thickeners typically used to manufacture latex emulsions. The ingredients were added in water at concentrations generally used in a finished latex system and were inoculated with a variety of bacteria, yeast, and fungi isolated from spoiled resins.

Table 1 illustrates the results of the study. All of the materials demonstrated a varying degree of susceptibility to attack by bacteria, yeast, or fungi. Tests such as these have enabled latex emulsion manufacturers to custom select raw materials that tend to resist microbial attack and are more likely to require lower levels of biocides to protect a finished system.

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Table 1—Raw Material Susceptibility

| Raw Materials | Tested Conc. | Susceptibility to:* | | |
|---|--------------|---------------------|-------|-------|
| | | Bacteria | Yeast | Fungi |
| Surfactants/Wetting Agents | | | | |
| Polyethoxy ethanol | 0.3% | - | - | - |
| Ethoxylated tetramethyl decenediol (30 moles) | 0.3% | - | + | - |
| Ethoxylated tetramethyl decenediol (10 moles) | 0.3% | - | + | - |
| Nonylphenoxypoly(ethyleneoxy)ethanol A | 0.3% | - | - | - |
| Octylphenoxy polyethoxy ethanol | 0.3% | - | + | - |
| Sodium salt of alkylaryl polyether sulfate | 0.3% | - | - | - |
| Nonylphenoxypoly(ethyleneoxy)ethanol B | 0.3% | - | - | - |
| Nonylphenoxypoly(ethyleneoxy)ethanol, wax | 0.3% | - | - | - |
| Polyol emulsifier—liquid | 0.3% | + | + | - |
| Polyol emulsifier—solid | 0.3% | - | - | - |
| Defoamers | | | | |
| Proprietary liquid defoamer A | 0.07% | - | - | + |
| Specialty formulated defoamer | 0.05% | - | + | + |
| Proprietary liquid defoamer B | 0.05% | - | + | + |
| Proprietary liquid defoamer C | 0.07% | - | + | + |
| Thickeners | | | | |
| Hydroxyethyl cellulose thickener A | 0.4% | + | + | - |
| Hydroxyethyl cellulose thickener B | 0.16% | - | + | + |
| Hydroxyethyl cellulose thickener C | 0.44% | + | + | - |
| Others | | | | |
| Polyvinyl alcohol A | 0.65% | + | + | + |
| Polyvinyl alcohol B | 1.44% | + | + | - |

(a) + = Susceptible to microbial attack; growth beyond 7 days. - = Resistant to degradation following two successive inoculations with microorganisms.

ENVIRONMENT—pH AND TEMPERATURE

The pH of an emulsion is a critical factor in determining not only whether microorganisms will survive in the system, but also which types of microorganisms will degrade the emulsion. Certain bacterial species are known to survive at a pH as low as 0, whereas other species can grow in systems with a pH of 9 or higher.¹ Yeast and fungal organisms are particularly acid-tolerant and grow best in the lower pH range.

Most microorganisms are capable of surviving over a range of 3–4 pH units. However, optimum growth and reproduction usually occurs over a much more narrow range. Therefore, the susceptibility of an emulsion to degradation by a particular microorganism can often be changed by an adjustment in the pH of the system.

Microorganisms are tolerant of a wide range of temperature conditions.¹ The temperature tolerance of bacteria is one characteristic used in classification of an organism. Survival temperatures for microorganisms can fall anywhere in the range of 0°C to 90°C. The elevated temperatures of emulsion polymerization pro-

cesses are usually sufficient to destroy any initial contamination from raw materials. However, the ambient temperatures during cool-down, transfer, storage, and transit of the emulsion are well within the range in which most microorganisms can flourish.

MICROORGANISMS CAUSING SPOILAGE

Contamination in latex emulsions that were produced five to 10 years ago was traced primarily to a few types of bacteria. Preservation of these systems was easily achieved with low concentrations of organo-mercurials or formaldehyde-release type compounds. However, several species of true fungi, bacteria, yeasts, and bimorphic fungi were isolated and identified from the currently formulated latex emulsion systems. Table 2 provides a list of microorganisms and the emulsions from which they were isolated over the past five years. Note the broad spectrum of bacterial organisms and in particular the presence of yeasts and fungi in the broad range of latex emulsion systems.

Emulsion contamination can sometimes be traced to a particular species, or it may be the result of several types of microorganisms growing harmoniously in one system.

For example, a major emulsion manufacturer was experiencing significant spoilage problems in a particular polyvinyl acetate emulsion. This emulsion was so highly susceptible to microbial degradation that it was practically impossible to produce a sterile batch. Microbiological evaluation of the emulsion demonstrated the presence of *Enterobacter cloacae* (bacteria), a sulfate-reducing bacteria, a yeast species, and a fungus identified as a *Geotrichum* species.

Preservation of latex emulsions contaminated by the microorganisms listed in Table 2 was extremely difficult and will be discussed later in the paper. Microscopic examination, differential staining techniques, and specialized culture media were used to identify the microorganisms isolated from the latex emulsion systems. The identification of bacterial isolates was determined using the Minitek™ miniaturized system for classification, which is based upon a series of biochemical reactions. The test procedure involves inoculating the bacterial isolate onto paper discs which are impregnated with various biochemical substrates. The reactions are observed within 24–48 hours and a biochemical profile is obtained for the isolate. Identifications are obtained from a computerized listing of hundreds of different species. This technique has simplified procedures that once required several weeks to perform.

CAUSES OF CONTAMINATION

Plant inspections and samplings of latex emulsion manufacturing facilities have revealed the major sources and causes of continued microbial problems that lead to the degradation of these systems. Figure 1 illustrates the sources and locations of microorganisms in a typical latex emulsion operation.

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Table 2—Microbial Species Isolated From Emulsion Systems

| Microorganism | Latex Emulsion Systems | | | | | |
|---|------------------------|---------|-----|---------------|----------------|-------------------|
| | SBR | Acrylic | PVA | Vinyl Acrylic | Vinyl Chloride | Polyvinyl Alcohol |
| Bacteria | | | | | | |
| Achromobacter sp. | X | | X | | | |
| Bacillus sp. | X | X | X | | | |
| Citrobacter freundii | | | | X | | |
| Enterobacter cloacae | | | X | | | |
| Enterobacter sp. | | X | | | | |
| Klebsiella pneumoniae | X | | | | | |
| Proteus rettgeri | | | | | X | |
| Providencia alcalifaciens | | | | X | | |
| Providencia rettgeri | | | | X | | |
| Pseudomonas aeruginosa | X | | X | | | |
| Pseudomonas cepacia | | | | | | X |
| Pseudomonas fluorescens | X | | X | | | |
| Pseudomonas maltophilia | X | | X | | | |
| Pseudomonas sp. | | X | | | | |
| Serratia marcescens | | | X | | | |
| Unidentified bacillus (low pH) | | | | X | | |
| Yeast Fungi | | | | | | |
| Bimorphic fungus (unidentified) | X | | X | | | |
| Filamentous fungus (unidentified) | | | X | | | |
| Geotrichum sp. | X | X | X | X | | |
| Yeast sp. (Saccharomyces, Torula) | X | X | X | X | | |

Water

Water carries and supports the growth of a wide variety of microorganisms. River water, well water, city water, and deionized water were all identified as sources of the degrading microbes. Water storage tanks and transit pipelines also harbor fungi, bacteria, and yeasts. The anion exchange bed in the deionizing system was identified as a major microbial breeding ground in every survey conducted. Cellulosic destroying enzymes were also found in water from shallow wells that contained decomposing plant materials.

Residual Wash Water

Residual wash water is essentially a well diluted latex emulsion. It contains all of the nutrients to permit rapid growth of microorganisms. The residual and contaminated wash water in plants that experienced major problems was never drained and was allowed to flow into latex emulsion holding and storage tanks. Contaminated, stagnant, residual wash water was found in latex storage tanks, pipelines, filter equipment, transfer hoses, transit trucks, and railcars.

Latex Skins

Latex accumulations are often found in pipelines, filter equipment, pumps, storage tank sides and undersides, transfer hoses, transit trucks, and just floating on top of the emulsions in storage tanks. These thick semi-solid, moist accumulations harbor the fungi that continuously serve to contaminate the finished latex systems. The fungi growing in the skins also produce cellulosic

enzymes that leach into the emulsion. Coatings produced with the enzyme-containing latex can result in viscosity losses in cellulose thickened systems.

Raw Materials and Filtering Aids

Raw materials used as post adds in the latex emulsion were also found to be contaminated. Dirty storage tanks and measuring pails were identified as the primary causes of the microbiological growth. Jute filter presses and other textile filtering aids also contained fungi and yeasts that degraded latex systems.

Biocides

Poorly planned preservative programs were determined to be one of the primary causes of spoilage problems in latex emulsions. The biocides used were ineffective most often because they had a narrow spectrum of activity and were not active against the microorganisms that degraded the particular latex system. Insufficient biocide concentrations, absence of a biocide, or rapidly decomposing compounds were among the other problems encountered with the plant's biocide program.

PREVENTION OF SPOILAGE

Effective measures are available to latex emulsion manufacturers in the prevention of microbiological problems. A well defined plant sanitation program coupled with the use of a broad spectrum biocide will prevent the spoilage of latex emulsions while in production, filtration, storage, and transit.

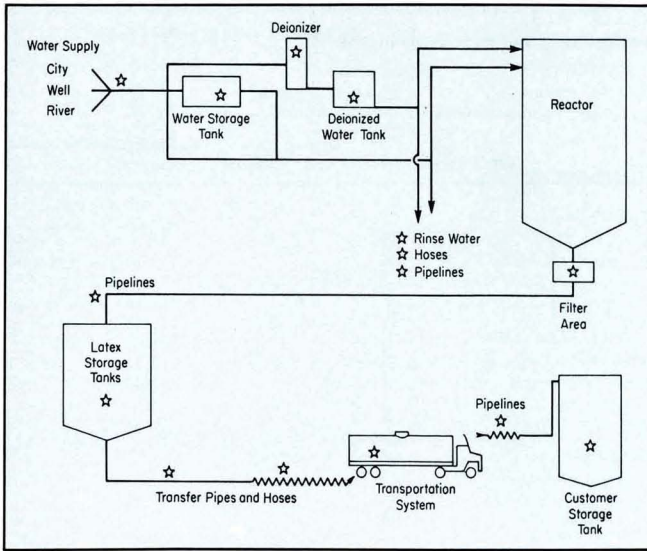


Figure 1—Locations (*) of potential microbiological contamination in a typical latex emulsion plant

Plant Sanitation Program

The initial steps required to bring microbiological problems under control relate to effective plant sanitation procedures. Without them, spoilage problems generally arise regardless of the biocides used. The following list of recommendations, drawn from numerous case histories of latex plant surveys, were found to be successful in eliminating microorganisms from contaminating and spoiling the finished emulsion:

(1) Install a chlorinator to treat the DI water and well water used for equipment washing and rinsing. Well water should be chlorinated after leaving the storage tank to the pipelines. DI water can be chlorinated following the anion exchange or after leaving the storage tank. Water treated with 0.5–1.0 ppm free residual chlorine provides effective microorganism control and avoids post-adding high levels of microbes to the finished latex emulsions.

(2) Establish plant sanitation procedures to keep the filters, side arms, and catch tanks drained of all residual latex wash water. This will prevent severe contamination of newly manufactured latex emulsions prior to entering storage tanks.

(3) Keep the emulsion storage tanks free of residual wash water. Contaminated stagnant water can eventually spoil the latex emulsions. Residual water permits fungi and yeasts to thrive in these areas.

(4) Routinely clean the filter screens. Do not permit resin skin build up or residual wash water to remain in the filter areas.

(5) Periodically change the water hoses in filtration and transit area. Microorganisms consume rubber causing etching in the hose interior thus allowing for a slime build-up. These microbes can eventually contaminate the clean latex emulsions.

(6) Install a rack (s) for hoses in the latex fill and transportation areas. Hoses should be stored in an inverted “U” or vertically following use so they may drain dry.

(7) Install caps on the bottom outlets from the latex emulsion storage tanks. Capping will avoid fungal contamination of the residual emulsion in these areas.

(8) Install caps on the outlet/inlet pipes in the filter area when not in use. Keep the pipes free of residual water or emulsion. Capping will avoid the yeast and fungal contamination so often found in these areas.

(9) Organize a program to periodically scrape or steam clean the latex storage tanks, filter screens, holding tanks, vibrators, and filter catch tanks of all skin accumulations.

(10) Frequently change the measuring pails used for post-added raw materials.

(11) Explore alternate filtration methods for the special latex systems. The jute filter press is a major source of microbiological contamination. In the meantime, treat the water used to fill the jute press with an effective biocide while the press stands idle.

(12) Review the preservative treatment program for your latex emulsions. Several were found to be contaminated in the storage tanks. The effective concentrations of biocides should be determined by lab tests with each emulsion using microorganisms isolated from the plant.

Broad Spectrum Preservatives

The biocides used to preserve latex emulsions must be effective against the microorganisms that degrade the particular system. They must also function in a wide variety of emulsions and must also meet the regulatory restrictions for environmental safety and minimal toxicity. The most commonly used preservatives in latex emulsions have been the formaldehyde and formalde-

Table 3—Antimicrobial Spectrum of Activity Of Typical Latex Emulsion Preservatives

| Latex Emulsion Isolates | Minimum Inhibitory Concentrations ^a (ppm) for Several Preservatives ^b | | |
|--------------------------------|--|------|------|
| | A | B | C |
| Bacteria | | | |
| Achromobacter sp. | 10 | >400 | >400 |
| Bacillus sp. | 10 | 200 | 200 |
| Citrobacter freundii | 10 | >400 | >400 |
| Enterobacter cloacae | 10 | >400 | >400 |
| Pseudomonas sp. | 100 | >400 | >400 |
| Serratia marcescens | 50 | 400 | 200 |
| Proteus rettgeri | 5 | >400 | >400 |
| Providencia alcalifaciens | 10 | 200 | 200 |
| Providencia rettgeri | 10 | 200 | 200 |
| Pseudomonas aeruginosa | 200 | >400 | >400 |
| Pseudomonas cepacia | 50 | >400 | >400 |
| Pseudomonas fluorescens | 200 | >400 | >400 |
| Pseudomonas maltophilia | 10 | >400 | >400 |
| Pseudomonas sp. | 100 | >400 | >400 |
| Serratia marcescens | 10 | 400 | 200 |
| Yeast/Fungi | | | |
| Bimorphic fungus | 100 | >400 | >400 |
| Filamentous fungus | 50 | >400 | >400 |
| Geotrichum sp. | 50 | >400 | >400 |
| Yeast sp. (vinyl acrylic) | 50 | >400 | >400 |
| Yeast sp. (Acrylic) | 50 | >400 | >400 |
| Yeast sp. (PVA) | 100 | >400 | >400 |

(a) Test Concentrations: 5, 10, 50, 100, 200, 400 ppm; A = 1,2-Dibromo-2,4-dicyanobutane; B = Formaldehyde Release Preservative D; C = Formaldehyde Release Preservative N.

hyde release type compounds. The organo-mercurials have restricted use in these systems since the same emulsions that are employed to manufacture paints may also have applications in food-grade adhesives and paper coatings.

An experiment was conducted in which two commercial formaldehyde release preservatives were compared to a new preservative, 1,2-dibromo-2,4-dicyanobutane. The biocides were evaluated for activity, using a medicated agar screening procedure² against the numerous bacteria, yeasts, and fungi mentioned in Table 2 and as isolated from various latex emulsions. This test is an evaluation of compound versus organism, without the

Table 4—Preservative Performance in Latex Emulsions

| Preservative Identity | Standard Pseudo-monas ^a | Microorganisms Isolated From Latex Emulsions and Facilities ^a | | |
|--|------------------------------------|--|-------|-------------------|
| | | Bacteria | Yeast | Geotrichum Fungus |
| Latex emulsion—no biocide | + | + | + | + |
| 0.05% 1,2-dibromo-2,4-dicyanobutane | - | - | - | - |
| 0.1% Benzyl bromoacetate | - | - | - | - |
| 1.0% Formaldehyde release preservative D | - | + | + | + |
| 1.0% Formaldehyde release preservative N | - | + | + | + |

(a) + = Heavy microorganism growth 14 days after inoculations. - = Sterile; no microorganism growth after two successive inoculations.

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presence of the latex emulsion system. The data from this screen are shown in Table 3. The results clearly show the broad spectrum effectiveness of 1,2-dibromo-2,4-dicyanobutane against all three classes of microorganisms—bacteria, yeast and fungi. The formaldehyde release compounds demonstrated a narrow spectrum of activity against some of the bacteria and were inactive against the yeast and fungal isolates. Screening tests provide a very good comparison of activity patterns of various compounds. However, the proof of preservative performance is in the actual latex emulsion made under plant conditions.

BIOCIDE PERFORMANCE UNDER PLANT CONDITIONS

The choice of an effective concentration of a broad spectrum preservative should be made based on extensive data generated in the emulsion, using the microorganisms that have been identified to degrade the particular

system. Microorganisms are selected from spoiled emulsions or from isolations made during plant inspections. These data prove to be the best solutions in preventing microbiological spoilage of latex emulsions during processing, storage, and transit.

The data illustrated in *Table 4* summarize the performance of four commercial preservatives in latex emulsions made under plant conditions. They were tested in the laboratory against a standard bacterium, *Pseudomonas aeruginosa*, and also against the bacteria, yeast, and fungi isolated from spoiled latex emulsions and from contaminated manufacturing facilities.

The results showed that all four preservatives effectively controlled the standard *Pseudomonas* bacteria. However, only two preservatives, 1,2-dibromo-2,4-dicyanobutane and benzyl bromoacetate were able to preserve the latex emulsions against the bacteria, yeasts, and fungi which were unique to the systems. Both formaldehyde release compounds demonstrated their narrow spectrum of activity by failing to control the unique latex emulsion microorganism isolates up to 1% concentrations in the emulsions.

Experimental

Preservatives were added to 100 gram samples of plant made emulsions at concentrations from 0.025% to 1.0% based on total weight of the systems. Each treated emulsion was then separately inoculated with the appropriate bacteria, yeasts, and fungi at the rate of 10^6 microorganisms per gram of emulsion. A challenge of 10^6 microorganisms per gram was used since spoiled plant emulsion samples over the past several years supported these counts. All inoculations and samplings for microorgan-

ism counts were made from each system at appropriate intervals by using standard microbiological procedures.¹ A reinoculation was made after seven days. Two inoculations were used because case histories show that freshly manufactured latex systems can be subject to such severe treatments before they reach the customer's plant. *Table 4* illustrates the results after 14 days following the two microorganism inoculations.

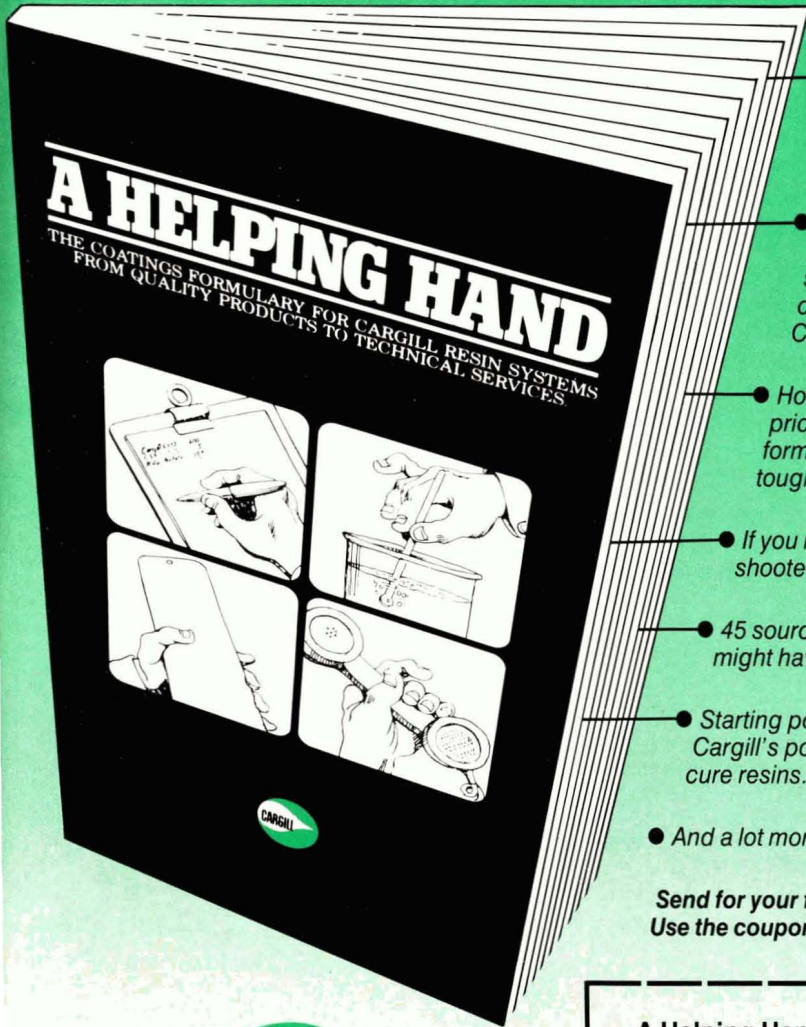
SUMMARY

Unique microorganisms, encompassing a variety of bacteria, yeasts, and fungi, were identified as causing spoilage in current latex emulsion systems. These organisms have been isolated from favorable pH and temperature environments of process water, residual wash water, and latex skins in the manufacturing facilities. Preservatives such as 1,2-dibromo-2,4-dicyanobutane and benzyl bromoacetate demonstrated their broad spectrum activity in controlling these unique microorganism isolates. Formaldehyde release preservatives are ineffective in preserving the latex emulsions made under plant conditions. A well defined plant sanitation program is also required to maintain microorganism control in the plant. The employment of select raw materials also results in more resistant latex emulsion systems.

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Factors Affecting The Distinction of Image (DOI) Of Painted Fiberglass Reinforced Reaction Injection Molded (RRIM) Urethane

Donald J. Hart
General Motors Research Laboratories*

Differences in DOI of painted RRIM parts containing various glass reinforcement levels are due to attack of the RRIM by the primer solvent causing increased macrosurface roughening of the substrate. This roughness, on the order of 50–200 μ , is telegraphed to both the primed surface and the topcoated surface. The solvent attack is due to the solubility characteristics of the RRIM and is accelerated by the glass reinforcement in the RRIM. Removal or reduction of N-methyl-2-pyrrolidone from the solvent formulation of the primer eliminates solvent attack resulting in improved DOI for painted RRIM parts.

INTRODUCTION

Urethane elastomers made by the reaction injection molding (RIM) process are used in the automotive industry. The use of these materials has recently been extended to higher modulus applications, such as fenders, by incorporating milled fiberglass reinforcement into the RIM part. These reinforced RIM (RRIM) fenders flex back into shape after minor impact, are lighter than their metal counterparts, and do not corrode.

Fiberglass reinforcement is incorporated into RIM fenders to increase stiffness and to reduce the coefficient of thermal expansion (CTE). Glass levels of 20% or 25% by weight are normally used to achieve the desired properties. However, we found that there are significant

differences in distinction of image (DOI) between painted RRIM samples and RIM samples containing no reinforcement. The unfilled RIM samples have DOI's that match that of painted automotive steel, whereas the DOI's of the RRIM samples are poorer.

A material's gloss is highly dependent on the roughness of the reflecting surface.¹ In the case of very smooth surfaces, irregularities with a height on the order of one-fourth the wavelength of light can reduce gloss.² The DOI of a material is a measure of the sharpness of a reflected image. As light waves strike the material and are reflected back, scattering of the light occurs. As light scattering increases, DOI decreases. Colling and co-workers³ showed that reductions in DOI occur when relatively large surface defects, such as a pronounced orange peel, are present on the painted surface. However, no attempt to quantify the magnitude of these surface defects or even to determine if other factors contribute to DOI reduction, have been made.

Since RRIM is used in the automobile industry where appearance is highly important, this study was concerned not only with how to improve the DOI of painted RRIM, but also with determining what factors influence the DOI. This paper describes investigations that address these concerns.

EXPERIMENTAL

The 20° gloss of the painted samples was obtained using a Hunterlab glossmeter. Surface roughnesses were determined using a Bendix Profilometer and a Gould Surfalyzer, Model 1200. Photomicrographs were obtained using a Leitz Ortholux Microscope equipped with a 4" × 5" bellows camera. Contact angle measurements were obtained on a Kernco Goniometer Model G-1.

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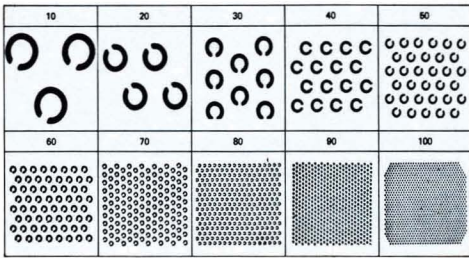


Figure 1—Landolt rings used to determine DOI of painted surfaces

Materials

The RRIM plaques were molded from Union Carbide RIM 120 resin. Owens Corning P117B milled glass fibers (1/32 inch) were used as the reinforcement. Unless otherwise noted, the RRIM plaques were prepared with an isocyanate/hydroxyl (NCO/OH) ratio of 1.05.

The RRIM samples were primed with a solvent-based elastomeric primer unless otherwise noted and topcoated with a black elastomeric topcoat. All solvents were reagent grade and used without further purification.

DOI Measurements

Pelligrini's⁴ method for the evaluation of the DOI of paint film surfaces was used. This method involves the projection of various size images onto a painted surface. These images, called Landolt rings, are circles with small openings (Figure 1). The rings are projected from a fluorescent light box at a specified distance of 10 cm above the sample under examination. By assigning a value of 100 to the smallest set of rings and a value of 90, 80, 70, etc. to the increasing larger rings, a rating scale is obtained which can be used to quantitatively evaluate the DOI of the painted surface. The DOI is then defined to be the number assigned to the smallest pattern in which all circles and their openings are seen clearly and distinctly.

RESULTS AND DISCUSSION

Cause of DOI Reduction

As mentioned previously, initial painting tests with RRIM samples showed significant differences in DOI between the samples reinforced with 20% or 25% fiber-

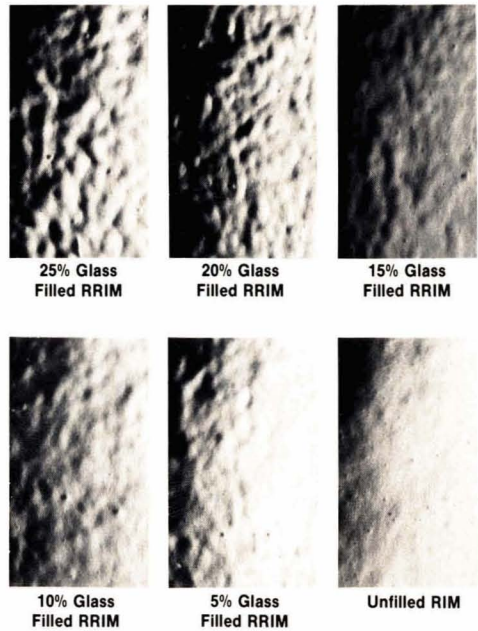


Figure 2—Photographs of topcoated surfaces of RRIM parts (23× magnification)

glass and the unfilled samples. To determine whether the DOI losses were gradual with increasing glass filler or whether there was a "threshold" limit after which the DOI dropped dramatically, a series of RRIM panels were molded in which the glass loadings were varied in 5% increments. Table 1 shows the glass loadings of the RIM resin and the glosses and DOI's of the painted RRIM samples. Although the gloss is unaffected by glass filler levels, a significant drop in DOI occurs with only 5% glass filler. A further gradual drop in DOI occurs as the glass loading increases.

The surfaces of the painted RRIM samples were studied using microscopy to determine whether the observations of Colling and co-workers³ regarding the presence of orange peel leading to reductions in DOI held true. Figure 2 shows that as the level of fiberglass reinforcement increased, the amount of orange peel (macro surface roughness) in the painted surface also

Table 1—Distinction of Image (DOI) of Various RRIM Samples

| Sample | Wt. % Glass | 20° Gloss | DOI ^a |
|----------------|-------------|-----------|------------------|
| A | 25.0 | 86 | 45 |
| B | 20.0 | 87 | 55 |
| C | 15.0 | 87 | 60 |
| D | 10.0 | 88 | 60 |
| E | 5.0 | 86 | 60 |
| F | 0.0 | 86 | 80 |
| G ^b | 0.0 | 88 | 80 |

(a) Painted as described in Experimental Section.
 (b) NCO/OH ratio = 1.10.

Table 2—Surface Roughness of Various RRIM and Steel Samples

| Surface Roughness (average) | RRIM | | | Steel | |
|-----------------------------|----------------------|-------|-------|-------|------------|
| | Glass Loading, wt. % | | | Bare | Phosphated |
| | 0 | 15 | 25 | | |
| No. of peaks | | | | | |
| > 0.13 μ | 100.7 | 106.3 | 129.6 | 298.1 | 368.0 |
| > 0.25 μ | 98.2 | 93.9 | 111.5 | 284.5 | 327.3 |
| > 0.63 μ | 55.2 | 67.8 | 100.2 | 246.8 | 247.8 |
| > 1.3 μ | 23.0 | 36.0 | 66.4 | 191.3 | 175.8 |
| > 2.5 μ | 4.6 | 8.7 | 14.7 | 120.5 | 90.7 |
| > 12.5 μ | 0.1 | 0.3 | 0.2 | 24.5 | 18.0 |

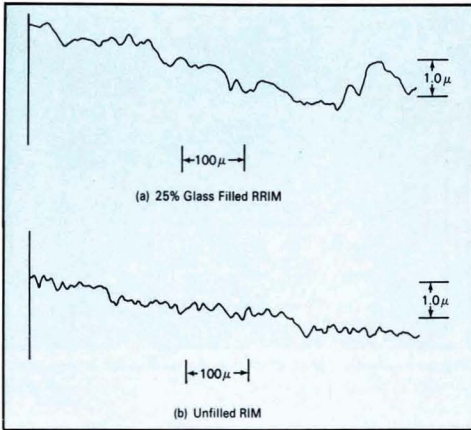


Figure 3—Surface profiles of RRIM samples

increased. Since all of these samples were painted simultaneously with the same primer and same topcoat, the RRIM substrate containing 25% glass had to be different than the unfilled RIM sample.

Profilometer measurements of the surfaces of the unpainted RIM samples containing fiberglass loadings of 0% to 25% by weight showed that differences in microsurface roughness of the surfaces do not affect DOI. Table 2 shows that microsurface roughness increases only slightly with increasing fiberglass loading and that steel, which has a high DOI when painted, is about three times as rough as the RRIM samples. Further examination of the surfaces of the unpainted RRIM samples by microscopy and a surfanalyzer also showed little or no differences in macrosurface roughness with different glass loadings. Figure 3 shows the surface profiles of RIM samples containing 25% and 0% glass reinforcement. Intermediate glass loadings and different NCO/OH ratios had similar profiles. Therefore, differences in macrosurface roughness of the unpainted samples could not account for differences in DOI.

Zisman⁵ has shown that the amount of wetting and spreading of a liquid over a substrate is directly related to the surface energy of that substrate. The degree of wetting and spreading of a paint film should affect its leveling and, subsequently, the amount of macrosurface roughness. Since differences in surface energies of the substrates might account for the differences in DOI of the painted samples, the surface energies of the RRIM samples were studied. Zisman⁵ demonstrated how surface energies of a substrate relate to contact angles of a liquid on that substrate. Consequently, contact angles of water on various RRIM substrates were measured. Figure 4 illustrates the distribution of contact angles of water on three different RRIM substrates. The two unfilled substrates have different contact angle distributions but identical DOI's. One of the unfilled substrates has a distribution very similar to that of the 25% filled substrate, but these two substrates have considerably different DOI's. Therefore the differences in surface energies cannot account for the differences in DOI.

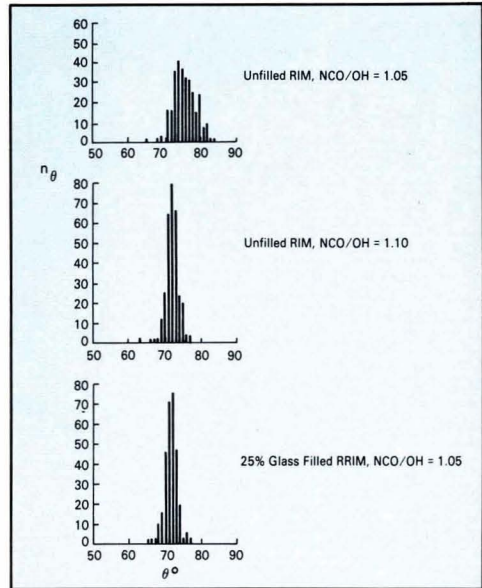


Figure 4—Histograms of contact angles of water on RRIM

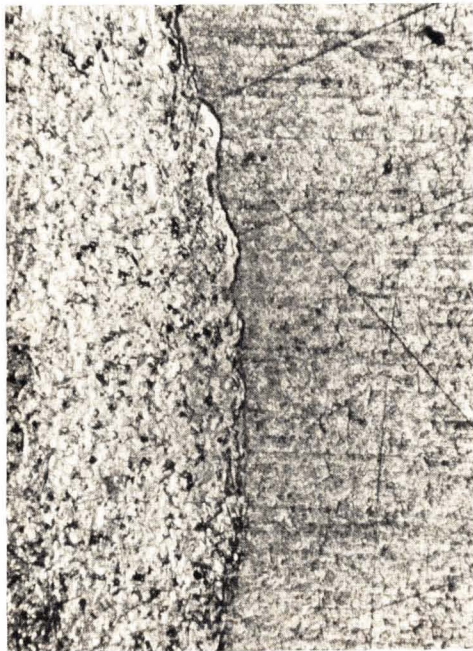
As discussed in the Introduction, DOI reductions are related to increases in the surface roughness of a substrate. An investigation was initiated to determine whether the solvent found in the solvent-based elastomeric primer caused a roughening of the RRIM surface and thereby, reduced the DOI of the painted part. Table 3 shows the composition of the solvent used in the primer. A drop of this solvent mixture was placed on each RRIM sample. After evaporation of the solvent, the RRIM samples were examined under the microscope. Samples containing no reinforcement were not roughened; surface roughening increased with increasing glass loading. Figure 5 shows the results for RIM containing 0% and 25% glass. This roughness was irreversible (due not only to solvent swelling) since storage under high vacuum did not reduce the roughness.

The increase in roughness is also apparent from the surface profiles as determined using a surfanalyzer. Figure 6 shows that both the depth of the surface roughness and the width of the peak-to-peak roughness of the solvent-treated 25% glass RRIM are much greater than that of the solvent-treated unfilled RIM. This increased roughness of the RRIM substrate is telegraphed to both the primed surface (Figure 7) and to the topcoat (Figure 2).

Examination of the individual solvents showed that

Table 3—Solvent Formulation of Solvent-borne Elastomeric Primer

| | Volume Percent |
|-----------------------------|----------------|
| Toluene..... | 42.50 |
| Xylene..... | 20.00 |
| N-methyl-2-pyrrolidone..... | 31.25 |
| Methyl isobutyl ketone..... | 6.25 |



Solvent Treated No Treatment
 25% Glass Filled RRIM



Solvent Treated No Treatment
 Unfilled RIM

Figure 5—Photographs of surfaces of RRIM parts (23× magnification)

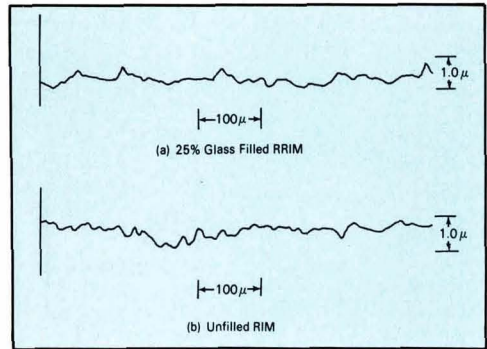


Figure 6—Surface profiles of solvent-treated RRIM samples

N-methyl-2-pyrrolidone caused the roughening. If it is removed, then no roughening of the RRIM surface occurs. This was demonstrated by the use of two other primers containing little or no N-methyl-2-pyrrolidone: (1) an elastomeric water-borne primer; and (2) a non-flexible primer normally used for steel parts. The latter primer contains no N-methyl-2-pyrrolidone while the elastomeric water-borne primer contains 5% N-methyl-2-pyrrolidone compared to 31% for the solvent-borne primer. This reduced amount does not adversely affect the surfaces of the RRIM parts due to changes in the primer's solubility parameters. Solubility parameters will be discussed in a later section. Figures 8 and 9 show that the surfaces of the RIM parts containing 25% glass and 0% glass are identical when primed with either of these two primers. RRIM samples containing intermediate amounts of glass also have identical surfaces when coated with these primers. After topcoating the RRIM samples that were primed with either of these primers, there was no difference in DOI regardless of glass loading. Table 4 shows the DOI for the elastomeric water-borne primed samples.

The roughness of the RRIM surface treated with solvent-borne primer can be reduced by sanding. This reduced roughness then gives improved DOI of subsequently topcoated parts.

Magnitude of Roughness

As discussed previously, the solvent in the flexible primer (specifically N-methyl-2-pyrrolidone) causes a roughening of the RRIM substrates. Figure 6 compares the surface profiles of 25% glass filled RRIM and unfilled RIM after solvent treatment. The peak-to-peak roughness is on the order of 50-200 μ for the reinforced RIM while the peak-to-peak roughness of the unfilled RIM is 10-20 μ.

Figure 2 illustrates that the painted surface of the 25% glass filled RRIM has considerably more orange peel than that of the unfilled RIM. The size of the macro-surface roughness that causes the significant drop in DOI for the 25% glass-filled RRIM is on the order of 50-200 μ. This is the same magnitude as the roughness of the solvent-treated substrate. In contrast, the magnitude of the macrosurface roughness of the painted unfilled RIM is on the order of 10-20 μ. This is also the

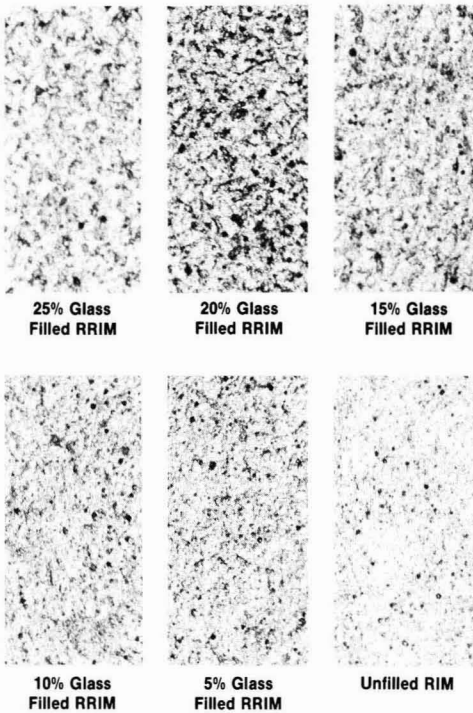


Figure 7—Photographs of primed surfaces of RRIM parts (23× magnification)

same magnitude as the roughness of the solvent-treated substrate. Thus, the major factor influencing DOI is surface roughness on the order of 50-200 μ . Roughness of 10-20 μ or less does not affect the DOI of these parts.

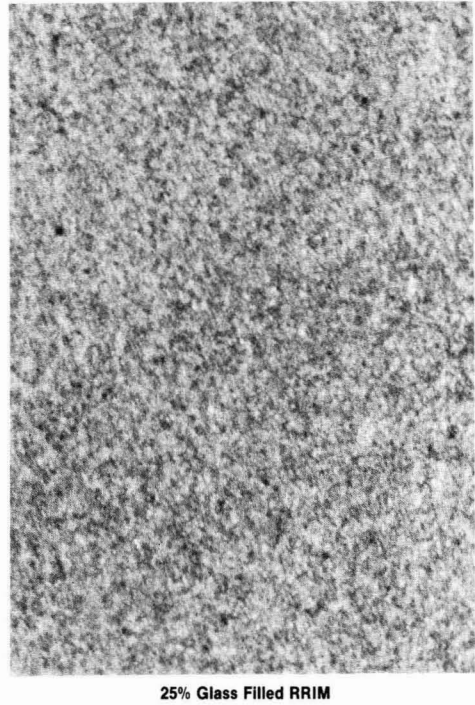
Some of the RRIM samples were annealed at 120°C for 30 minutes prior to solvent treatment. The goal of this experiment was to determine whether thermal stresses due to the fiberglass reinforcement could be relieved so that solvent attack would be diminished or eliminated. The surface profiles of RRIM samples containing 25% glass reinforcement that were annealed and then treated with solvent still showed a roughness of 50-200 μ . Annealing RRIM samples at 120°C for up to two weeks also failed to reduce roughening caused by subsequent solvent treatment.

Solubility Parameters

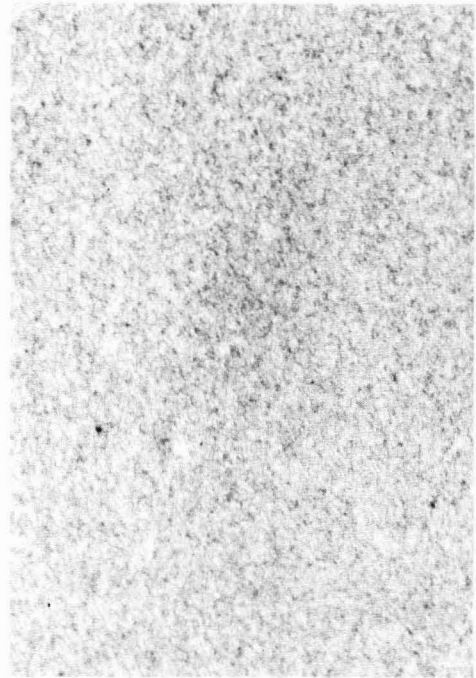
The roughening of the RRIM substrate by the solvent in the primer is due to interactions of the solvent with the substrate and can be explained by Hildebrand's solubility parameters.⁶ The solubility parameter (δ) of a material is related to its molecular cohesive energy ($-E$) per unit volume (cohesive energy density, CED) as shown in equation (1).

$$\delta = (-E/V)^{1/2} = (\text{CED})^{1/2} \quad (1)$$

One of the uses of the solubility parameter concept is to interpret phenomena involving polymer solubility and

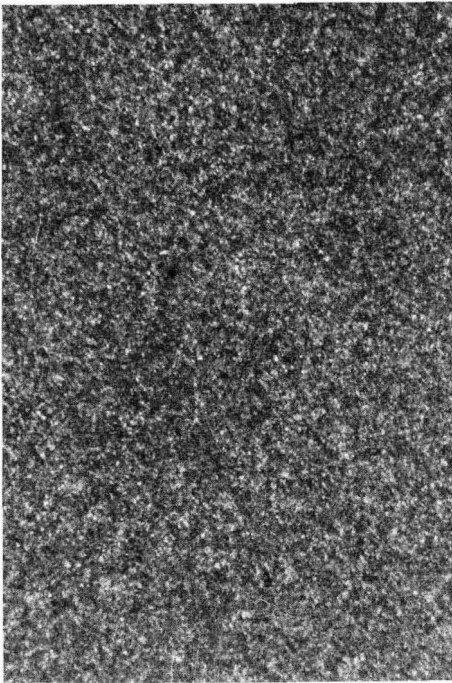


25% Glass Filled RRIM

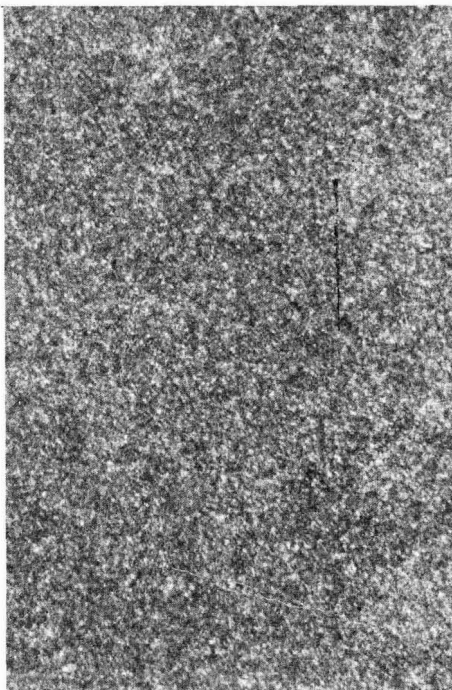


Unfilled RIM

Figure 8—Photographs of surfaces of RRIM parts primed with water-borne elastomeric primer (23× magnification)



25% Glass Filled RRIM



Unfilled RRIM

Figure 9—Photographs of surfaces of RRIM parts primed with nonflexible solvent-based primer (23× magnification)

Table 4—Distinction of Image (DOI) of Topcoated RRIM Samples Primed with Elastomeric Water-borne Primer

| Sample | Wt. % Glass | DOI |
|--------|-------------|-----|
| A | 25.0 | 80 |
| B | 20.0 | 65 |
| C | 15.0 | 80 |
| D | 10.0 | 80 |
| E | 5.0 | 80 |
| F | 0.0 | 80 |

compatibility. Equation (2) relates the energy of mixing (ΔE_{mix}) of two compounds to their solubility parameters:⁷

$$\frac{\Delta E_{mix}}{\phi_1 \phi_2} = V(\delta_1 - \delta_2)^2 \tag{2}$$

where ϕ_1 and ϕ_2 are the volume fractions of the components and V is the molar volume of the mixture. From equation (2), it is clear that a smaller difference in δ between two compounds results in a smaller ΔE_{mix} . A decrease in ΔE_{mix} gives a higher degree of swelling. As ΔE_{mix} approaches zero (δ_1 approaches δ_2), complete solubility results.

Hansen⁸ has divided the solubility parameter of a substance into contributions from dispersion forces (δ_d), dipole (δ_p), and hydrogen-bonding (δ_h) interactions:

$$\delta^2 = \delta_d^2 + \delta_p^2 + \delta_h^2 \tag{3}$$

Table 5—Solubility Parameters^a of Various Solvents at 25°C

| Solvent | δ_d | δ_p | δ_h |
|--|------------|------------|------------|
| Hexane | 7.3 | 0.0 | 0.0 |
| Toluene | 8.8 | 0.7 | 1.0 |
| Xylene | 8.7 | 0.5 | 1.5 |
| 1-Bromonaphthalene | 9.9 | 1.5 | 2.0 |
| Tetrahydrofuran | 8.2 | 2.8 | 3.9 |
| Dibenzyl ether | 8.5 | 1.8 | 3.6 |
| Acetone | 7.6 | 5.1 | 3.4 |
| Methyl ethyl ketone | 7.8 | 4.4 | 2.5 |
| Methyl <i>i</i> -butyl ketone | 7.5 | 3.0 | 2.0 |
| Ethyl acetate | 7.7 | 2.6 | 3.5 |
| <i>n</i> -Butyl acetate | 7.7 | 1.8 | 3.1 |
| 2-Ethoxyethyl acetate | 7.8 | 2.3 | 5.2 |
| <i>i</i> -Butyl- <i>i</i> -butyrate | 7.4 | 1.4 | 2.9 |
| Acetonitrile | 7.5 | 8.8 | 3.0 |
| Acrylonitrile | 8.0 | 8.5 | 3.3 |
| Nitromethane | 7.7 | 9.2 | 2.5 |
| Nitroethane | 7.8 | 7.6 | 2.2 |
| Aniline | 9.5 | 2.5 | 5.0 |
| N-methyl-2-pyrrolidone | 8.8 | 6.0 | 3.5 |
| Formamide | 8.4 | 12.8 | 9.3 |
| Dimethylformamide | 8.5 | 6.7 | 5.5 |
| N,N-dimethylacetamide | 8.2 | 5.6 | 5.0 |
| Dimethyl sulfoxide | 9.0 | 8.0 | 5.0 |
| Methanol | 7.4 | 6.0 | 10.9 |
| Ethanol | 7.7 | 4.3 | 9.5 |
| 2-Propanol | 7.7 | 3.0 | 8.0 |
| 1-Butanol | 7.8 | 2.8 | 7.7 |
| 2-Butanol | 7.7 | 2.8 | 7.1 |
| Benzyl alcohol | 9.0 | 3.1 | 6.7 |
| Ethylene glycol mono- <i>n</i> butyl ether | 7.8 | 2.5 | 6.0 |
| Diethylene glycol mono- <i>n</i> butyl ether | 7.8 | 3.4 | 5.2 |
| Ethylene glycol | 8.3 | 5.4 | 12.7 |
| Diethylene glycol | 7.9 | 7.2 | 10.0 |

(a) From reference 9.

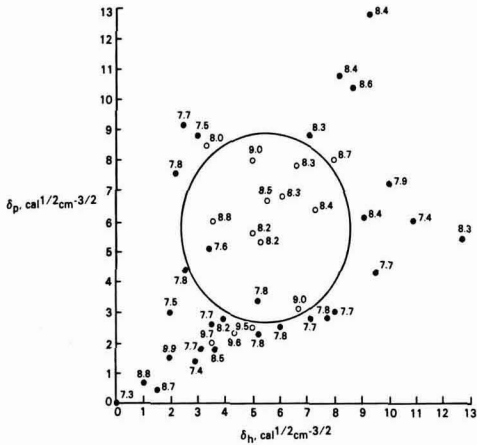


Figure 10—Solubility parameter diagram for RRIM resin. The closed circles represent solvents that have no effect on RRIM, the open circles represent solvents that roughen the surface of RRIM, and the numbers adjacent to each circle are the dispersion solubility parameters (δ_d) in $\text{cal}^{1/2}\text{cm}^{-3/2}$ for the respective solvents

By employing these three dimensional solubility parameters, regions of solubility for polymers can be found.

To establish the effect of solvents having various solubility parameters on the RRIM substrates, a number of solvents were investigated. Table 5 lists the solvents studied along with their three dimensional solubility parameters. Since dispersion interactions (δ_d) for solvents and polymers generally vary over a narrow range, a δ_p vs δ_d plot is useful for obtaining the solubility region for RRIM. Figure 10 shows the solubility parameter diagram for the RRIM resin. The closed circles represent solvents that have no effect on RRIM, the open circles represent solvents that roughen the surface of RRIM, and the numbers adjacent to each circle are the dispersion solubility parameters (δ_d) in $\text{cal}^{1/2}\text{cm}^{-3/2}$ for the respective solvents. Figure 10 illustrates that there is a distinct solubility region where the RRIM's surface is affected by solvents. Any solvents that have solubility parameters in this region will roughen the surface of the RRIM while solvents with solubility parameters outside of this region will not affect the RRIM.

N-methyl-2-pyrrolidone falls in the solubility region

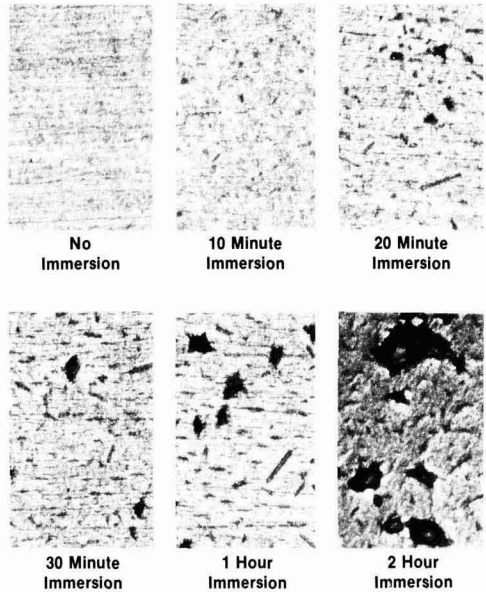


Figure 11—Photographs of surfaces of unfilled RIM parts immersed in N-methyl-2-pyrrolidone for varying periods of time (23X magnification)

for the RRIM and roughens the RRIM's surface. If one removes this solvent from the primer composition, or at least reduces its concentration so that the effective solubility parameter of the solvent blend always lies out of the solubility region for RRIM, then no roughening of the RRIM's surface occurs and the DOI of the resulting painted part is improved.

To demonstrate the usefulness of the solubility parameter concept with regard to RRIM, solvent mixtures were studied. The solubility parameter components for a mixture of two solvents can be expressed⁷ as:

$$\delta_{m_i} = \phi_1\delta_{1i} + \phi_2\delta_{2i} \quad (4)$$

$$i = d, h, p$$

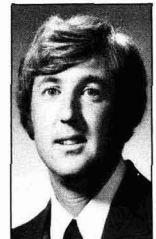
where δ_{m_i} is the solubility parameter of the mixture and ϕ_1 , ϕ_2 , δ_1 , and δ_2 are as defined before. Mixtures of formamide and tetrahydrofuran were studied as shown in Table 6. The solubility parameters of both of these solvents alone lie outside of the solubility region for

Table 6—Solubility Parameters^a Of Various Formamide/Tetrahydrofuran (THF) Mixtures

| Solvent Mixture (V/V) | δ_d | δ_p | δ_h | Solvent Attack? |
|-----------------------|------------|------------|------------|-----------------|
| Formamide/THF (100/0) | 8.4 | 12.8 | 9.3 | No |
| Formamide/THF (80/20) | 8.4 | 10.8 | 8.2 | No |
| Formamide/THF (60/40) | 8.3 | 8.8 | 7.1 | No |
| Formamide/THF (50/50) | 8.3 | 7.8 | 6.6 | Yes |
| Formamide/THF (40/60) | 8.3 | 6.8 | 6.1 | Yes |
| Formamide/THF (25/75) | 8.2 | 5.3 | 5.3 | Yes |
| Formamide/THF (0/100) | 8.2 | 2.8 | 3.9 | No |

(a) Calculated from equation (4).

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RRIM. Neither of these solvents affect the surface of RRIM. However, the solubility parameters of some mixtures of these solvents lie within the solubility region for RRIM. These mixtures cause a roughening of the RRIM's surface. To avoid solvent attack from the primer, it is necessary for the solvent in the primer to be formulated in such a way as to prevent the solubility parameter of the mixture from entering the solubility region for RRIM. Changes in the solubility parameter during the flash and bake period due to differences in the evaporation rate of each solvent must also be considered.

Since fiberglass reinforcement in the RRIM should have little or no effect on the solubility region for RRIM, one might suspect that attack by the primer solvent should occur on the unfilled RIM equally as on the 25% glass reinforced RRIM. However, it was found that the solvent causes a roughening of the surfaces of the RRIM substrates that increases with increasing fiberglass reinforcement. This observation can be explained by thermal stresses and wicking due to the glass reinforcement. Thermal stresses cause the solvent to attack the stressed RRIM resin considerably faster than the unstressed resin in the unfilled RIM samples. Wicking due to the glass fibers allows the solvent to enter the interior of the RRIM piece where it can do considerably more damage. The more glass present, the more severe is the solvent-induced damage.

These mechanisms that accelerate solvent attack also predict that the surface of the unfilled RIM will eventually roughen as the solvent works its way into the interior of the piece. *Figure 11* shows photomicrographs of unfilled RIM samples that were immersed in pure N-methyl-2-pyrrolidone for varying periods of time. Within 10 minutes of solvent immersion, the surface of the unfilled RIM is roughened. The same experiment with 25% glass-filled RRIM caused roughening within one minute. These conditions are considerably harsher, of course, than what the part would experience during painting, but it shows how glass reinforcement contributes to surface roughening by the primer solvent.

SUMMARY

Significant differences in distinction of image (DOI) between painted RRIM parts containing different fiber-

glass levels are due to solvent attack by N-methyl-2-pyrrolidone in the flexible primer used in the painting of the RRIM parts. This solvent attack leads to increased surface roughening of the RRIM substrate. Glass fibers in the RRIM accelerate this roughening process.

The magnitude of the peak-to-peak roughness is on the order of 50-200 μ . This roughness is telegraphed to both the primer and the topcoat of painted parts so that the roughness of the orange peel of the topcoat is also 50-200 μ . Substrate roughening of 50 μ or greater results in poor DOI.

N-methyl-2-pyrrolidone has a solubility parameter that lies in a distinct solubility region where the RRIM's surface is affected by solvents. If the concentration of N-methyl-2-pyrrolidone in the primer solvent is reduced or removed altogether, then the attack by solvent is eliminated. This then leads to improved DOI for the painted RRIM parts.

ACKNOWLEDGMENT

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Cure Response In Acrylic Copolymer/Melamine Formaldehyde Crosslinked Coatings

David R. Bauer and Ray A. Dickie
Ford Motor Company*

The cure response of typical acrylic copolymer/melamine formaldehyde coatings has been studied as a function of resin and formulation variables including polymer molecular and equivalent weight. Cure response has been characterized in terms of an effective crosslink density calculated from measured extents of conversion and a network model. Results have been cast in terms of the ranges of time and temperature, or cure window, over which acceptable film properties are obtained. The cure windows for formulations based on low molecular weight oligomers typical of high solids coatings have been found to be inherently narrower than those of conventional formulations. The cure response of high solids formulations has also been found to be more sensitive to small changes in resin and formulation variables than conventional coatings, effectively resulting in a further reduction in the width of the cure window.

INTRODUCTION

Thermoset coatings contain a mixture of resins and crosslinkers that have mutually reactive functional groups. The ultimate physical properties of these coatings are determined in part by the structure of the network that results from the crosslinking that occurs during the bake. Variations in bake conditions influence

the physical properties of the coating by affecting the extent of crosslinking and thus the structure of the network. While there is a great deal of empirical knowledge relating bake conditions and formulation to paint test results, there is little information on basic physical properties or on the relationship of these properties to the molecular structure of the coating. In a previous work,¹ infrared techniques were described that allow determination of the extent of crosslinking in acrylic copolymer/melamine formaldehyde coatings. It was found¹⁻⁴ that the extents of the different crosslinking reactions in these coatings were functions of the type of melamine crosslinker used, the amount and strength of acid catalyst used, and the bake conditions. Although the extent of reaction is an important variable in determining the network structure, other formulation variables are also important. Using a network model based on the approach of Macosko and Miller^{5,6} it was found that a particular network parameter, the elastically effective crosslink density (C_{el}), correlated well with the solvent resistance of these coatings. It was found that there was an optimum value of C_{el} which yielded coatings with optimum physical properties. This optimum effective crosslink density was found to be independent of the formulation variables.³ Thus, it is possible to use C_{el} as a measure of the state of cure of these coatings.

It is expected that there will be a range of crosslink densities around the optimum value of C_{el} for which the coating will have acceptable properties. It is the purpose of this paper to determine this range of C_{el} and to relate it to the range of bake conditions (time and temperature) that yield acceptable coating properties. In this way, the cure windows of coatings can be studied as a function

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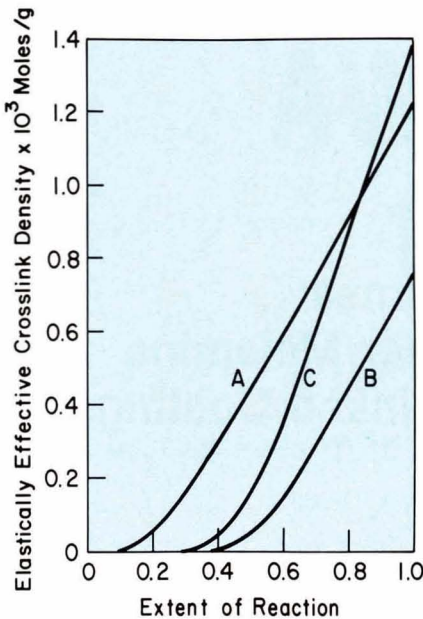


Figure 1— C_{ei} vs extent of reaction of the acrylic hydroxy group. The coatings are crosslinked with a fully alkylated melamine with a melamine methoxy to acrylic hydroxy ratio of 1.5. The number average molecular weight (M_n) and the hydroxy equivalent weight (E_w) are as follows: (A), $M_n = 10,000$ $E_w = 680$; (B), $M_n = 1,000$ $E_w = 680$; (C), $M_n = 1,000$ $E_w = 430$

of a variety of formulation variables. Since performance requirements for various applications differ, cure windows will depend on the anticipated application. In this paper, the range of C_{ei} is derived from performance requirements typical of automotive topcoats. The concept, however, is of general utility.

CROSSLINKING CHEMISTRY AND NETWORK STRUCTURE

The crosslinking chemistry of melamine formaldehyde crosslinkers has been reviewed by Blank.⁷ In the acrylic copolymer/melamine formaldehyde coatings studied previously,¹⁻⁴ it was found that two reactions dominate the crosslinking chemistry. The first is the condensation of hydroxy groups on the acrylic copolymer with alkoxy groups on the melamine to form polymer-melamine crosslinks. The second is the condensation of two melamine methylol groups to form melamine-melamine crosslinks. Fully alkylated melamines such as hexamethoxymethylmelamine contain no methylol groups and only form acrylic-melamine crosslinks. A detailed study of the kinetics of crosslinking in this melamine has been made.⁴ It was found that the extent of reaction initially increases rapidly with increasing bake temperature (or bake time). As the extent of reaction approaches unity, the rate of increase with increasing bake temperature (or bake time) slows down. Thus, the extent of reaction is less sensitive to bake conditions at high extents of reaction than at low extents of reaction. Similar effects

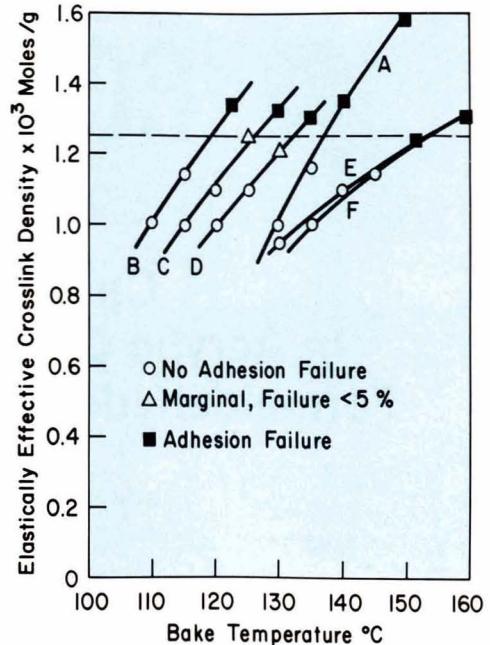


Figure 2— C_{ei} vs bake temperature. The number average molecular weight and equivalent weight are as follows: (A), $M_n = 2,200$ $E_w = 387$; (B) $M_n = 4,000$ $E_w = 387$; (C), $M_n = 4,000$ $E_w = 580$; (D), $M_n = 8,200$ $E_w = 580$; (E), $M_n = 2,200$ $E_w = 387$; (F), $M_n = 10,000$ $E_w = 720$. Coatings A-D were crosslinked with a fully alkylated melamine while coatings E and F were crosslinked with partially alkylated melamines

are observed in the crosslinking reactions of typical partially alkylated melamines.^{1,3} Because the kinetics of hexamethoxymethylmelamine are well known, this crosslinker has been used in most of the formulations studied here.

The network model used to calculate the elastically effective crosslink density has been previously described in detail.^{1,3} It was found that the critical formulation variables are the equivalent weight of reactive groups on the copolymer, the copolymer molecular weight, and the concentration and type of melamine crosslinker. Knowledge of these variables plus measurements of the extents of reaction are sufficient to calculate the elastically effective crosslink density and thus characterize the state of cure of the coating. In this network model we only consider the main crosslinking reactions described above. Of course, other crosslinking reactions may occur to a small extent in these systems (particularly with the more complex partially alkylated melamines). Neglecting these other reactions seems justified by the good correlation between C_{ei} and observed physical properties. The variation of C_{ei} with extent of reaction is shown in Figure 1 as a function of polymer molecular and equivalent weight. At any given extent of reaction, decreasing the polymer molecular weight causes a decrease in C_{ei} . The same number of reacted sites exists in the two formulations, but for the lower molecular weight system, relatively more sites contribute to chain extension and

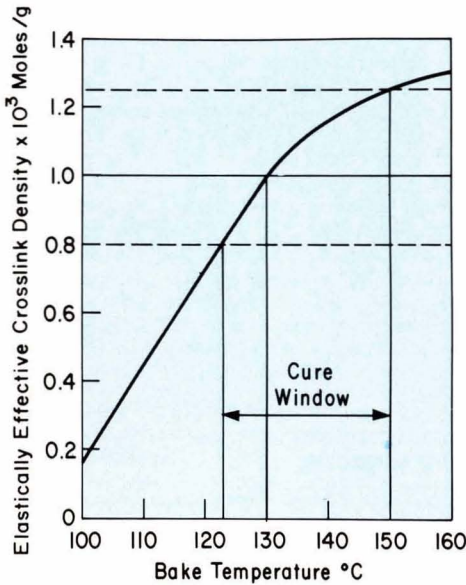


Figure 3— C_{el} vs bake temperature at a constant bake time of 20 min. The coating was crosslinked with a fully alkylated melamine. The polymer had a molecular weight of 2,000 and an equivalent weight of 560. The catalyst level was adjusted to yield an extent of reaction 0.85 at 130°C. The optimum crosslink density is indicated by —, while the upper and lower limits of C_{el} are given by ----

fewer to three dimensional network formation. This shows up as a higher extent of reaction at the gel point (i.e., the point at which C_{el} becomes nonzero) of the lower molecular weight material. To achieve the same value of C_{el} at a given value of extent of reaction for polymers with different molecular weight, it is necessary to decrease the equivalent weight (increase the amount of hydroxy functionality) of the lower molecular weight polymer. This has the effect of increasing the slope of C_{el} vs extent of reaction. As we shall see, this change in slope affects the cure window of the coating.

RANGE OF ACCEPTABLE CROSSLINK DENSITY

It was found³ that a value of C_{el} of 1.0×10^{-3} moles of crosslinks per gram of coating was required to achieve excellent solvent resistance (as defined by a previously described¹ solvent resistance test). The bake conditions required to achieve this crosslink density corresponded quite closely to those used in practice to achieve optimum physical properties in these coatings. This value of C_{el} corresponds to an optimum state of cure in typical acrylic melamine coatings. The variability in observed optimum crosslink density is around 15%, of which around 5% is due to errors in measuring the extents of reaction and the rest is due to errors in characterizing the formulation and to failure of the model to fully characterize the network structure. Thus, the reproducibility of C_{el} is significantly better than its overall accuracy. In comparing the state of cure of different formulations, we have chosen to correct the observed values of C_{el} so that the optimum value of

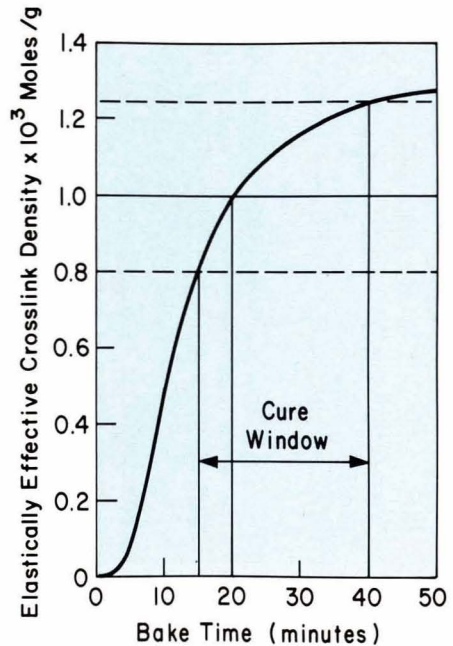


Figure 4— C_{el} vs bake time at a constant bake temperature of 130°C. Coating same as Figure 3

C_{el} is exactly 1.0×10^{-3} mole/gram. This is at most a 10% correction to the observed crosslink densities.

When coatings are baked at too low a temperature or for too short a time, they typically exhibit swelling or blushing in humidity tests, poor solvent resistance, and cold cracking. It was found¹ that coatings with values of C_{el} less than 0.6×10^{-3} moles/gram swelled badly or dissolved in methyl ethyl ketone. When C_{el} was between 0.6 and 1.0×10^{-3} moles/gram, the coatings softened on contact with MEK with the degree of softening decreasing with increasing C_{el} . It has been observed that typical coatings exhibit underbake problems when the value of C_{el} drops below 0.8×10^{-3} moles/gram. The exact value of the underbake limit of C_{el} will of course vary with the criteria that are used to determine what is acceptable underbake performance. This value may also depend somewhat on formulation type, but for the types of coatings studied here, this variation is expected to be small.

When coatings are baked at too high a temperature or for too long a time, they typically exhibit intercoat adhesion failure. That is, subsequent coats do not adhere well to the coat which has been overbaked. In humidity and solvent resistance, the relationship between C_{el} and performance is straightforward. The lower the value of C_{el} the greater the degree of swelling and the more likely the coating is to fail. The relationship between crosslink density and intercoat adhesion is less obvious. To determine whether or not a quantitative relationship between intercoat adhesion failure and C_{el} existed, intercoat adhesion measurements were made on a variety of acrylic melamine coatings as a function of crosslink

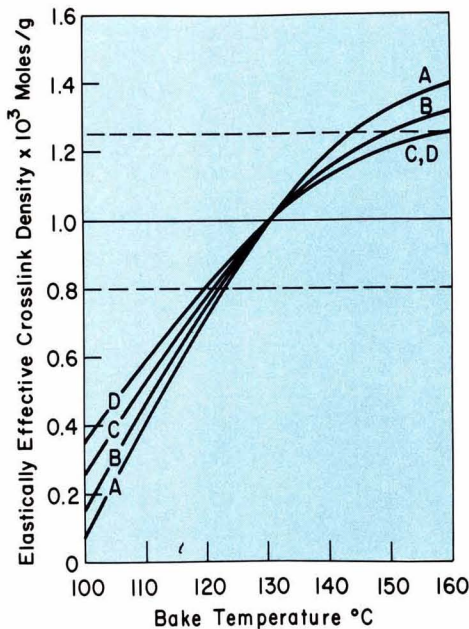


Figure 5— C_{el} vs bake temperature as a function of polymer molecular weight. The number average molecular weight and equivalent weight are as follows: (A), $M_n = 1,000$ $E_w = 430$; (B), $M_n = 2,000$ $E_w = 560$; (C), $M_n = 4,000$ $E_w = 650$; (D), $M_n = 10,000$ $E_w = 680$. The coatings are crosslinked with a fully alkylated melamine

density. Crosslink density was varied by varying the bake temperature of the first coat. After the first coat had cooled to room temperature, a second coat was applied and baked at the cure temperature which yielded the optimum value of C_{el} . Intercoat adhesion was determined by scribing the coating with a 2mm crosshatch

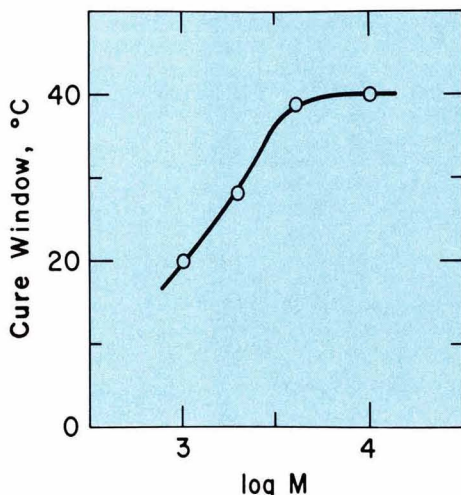


Figure 6—Cure window vs polymer molecular weight for the coatings listed in Figure 5

and noting the adhesion loss after taping. The results are shown graphically in Figure 2. All of these coatings exhibited adhesion failure for C_{el} greater than $1.25 \pm .05 \times 10^{-3}$ moles/gram. Coatings with smaller values of C_{el} had acceptable adhesion properties. Again, the exact value of the maximum acceptable crosslink density will depend on the criterion for failure. It also appears that the value of this parameter can be increased through the use of certain adhesion promoters.⁸ Since the maximum value of C_{el} is not a function of the formulation variables of interest in this study (i.e., the polymer equivalent and molecular weights), the value of the maximum C_{el} was chosen to be that value determined in the absence of adhesion promoters. Use of such additives would change the magnitude of the calculated cure windows but would not affect the qualitative trends observed.

CURE WINDOWS

The lower and upper limits of C_{el} define a range of values of C_{el} for which the selected coatings properties are acceptable. The cure window of a coating can be determined by measuring the extent of reaction as a function of bake conditions and combining this data with the relevant formulation variables to calculate C_{el} as a function of bake conditions. A plot of C_{el} vs bake temperature at a constant bake time of 20 minutes is shown in Figure 3 for a typical high solids coating. A plot of C_{el} vs bake time at a constant bake temperature of 130°C is shown in Figure 4 for the same coating. Since the information that is obtained is essentially equivalent in both plots, only the bake temperature is varied in the remaining calculations. The bake time is held constant at 20 minutes.

One approach to achieving higher solids coatings is to lower the molecular weight of the polymer. As was noted in Figure 1, lowering the molecular weight of the polymer results in a decrease in C_{el} . To compare the effect of molecular weight on cure window, it is necessary to adjust the equivalent weight of the polymer so that the coatings will reach the optimum value of C_{el} at the same extent of reaction (or bake temperature). As shown in Figure 5, lowering the polymer number average molecular weight increases the slope of C_{el} vs bake temperature, especially as the molecular weight drops below 4,000. This is a result of the fact that lowering the molecular weight while requiring a constant bake temperature requires a lower equivalent weight which, as shown in Figure 1, causes an increase in the slope of C_{el} vs extent of reaction (and thus also vs bake temperature). The cure windows of these coatings are shown in Figure 6 as a function of resin molecular weight. Lowering the molecular weight from 10,000 to 4,000 causes only a slight reduction in cure window, but further lowering the molecular weight to 2,000 and 1,000 greatly reduces the cure window.

The equivalent weights of the coatings in Figure 5 were adjusted so that the optimum value of C_{el} was reached at an extent of reaction equal to 0.85. As was noted earlier, the dependence of the extent of reaction on bake temperature decreases with increasing extent of

reaction. If we increase the equivalent weight of the polymer so that the optimum value of C_{ei} is not reached until the extent of reaction is 0.9, the coating should be less sensitive to bake temperature. Of course, unless the catalyst level in the formulation is changed, the optimum bake temperature will also be increased. Plots of C_{ei} vs bake temperature are shown in Figure 7 for coatings whose molecular weight is 2,000 and whose equivalent weights have been adjusted so that the optimum cure level is reached at different extents of reaction. The upper part of the cure window (i.e., T for $C_{ei} = 1.25 \times 10^{-3}$ M/g minus T_{opt} (for $C = 1.00 \times 10^{-3}$ M/g)) and the lower part of the cure window (i.e., T_{opt} minus T for $C_{ei} = 0.8 \times 10^{-3}$ M/g) are shown separately for these formulations in Figure 8. It is clear that if a wide cure window is necessary, it can in principle be achieved but only at the cost of increased bake temperature (or higher catalyst level). Likewise, if a narrow cure window can be tolerated, substantial reductions in cure temperature can be achieved.

It has been shown that polymer molecular weight influences the cure window. The molecular weight of the crosslinker also influences the cure response. In Figure 9 a plot of C_{ei} vs bake temperature is shown for three different melamines. The polymer molecular weight was 2,000. The polymer equivalent weight and the catalyst levels were adjusted so that all three coatings reached the optimum cure level at 130°C. Figure 9 shows that the use of higher molecular weight melamines gives improved underbake response. This is a consequence of the fact that the higher molecular weight melamines have a higher effective functionality per melamine molecule and thus the gel point is lower and more of the crosslinks initially formed are elastically effective. Of course, the use of higher molecular weight melamines reduces the solids level of high solids coatings. In general, increasing the solids level by lowering the molecular weight of the polymer or crosslinker tends to decrease the cure window.

All of the calculations in Figures 1-9 assume that the formulation variables are known exactly. In practice, formulation variables such as polymer molecular weight will vary around an average value. Typical upper and lower limits of a given formulation variable can be determined and C_{ei} calculated for these limits as a function of bake temperature. Figure 10 is a plot illustrating how variations in polymer molecular weight affect the cure window of a typical high solids coating. In this coating the nominal number average molecular weight is 2,000. Batch to batch variations in number average molecular weight range from 1,500 to 3,000. By calculating C_{ei} at the lower and upper limits of molecular weight, a range of C_{ei} at each bake temperature is determined. As shown in Figure 10, variations in the polymer molecular weight cause the true cure window to be smaller than the nominal cure window. The value of the true cure window is plotted as a function of the degree of variability of polymer molecular weight in Figure 11 for both a low solids and a high solids coating. The polymer number average molecular weights of the two coatings were 10,000 and 2,000, respectively. Variations in polymer molecular weight did not significantly affect the cure window of the low solids coating, but even small varia-

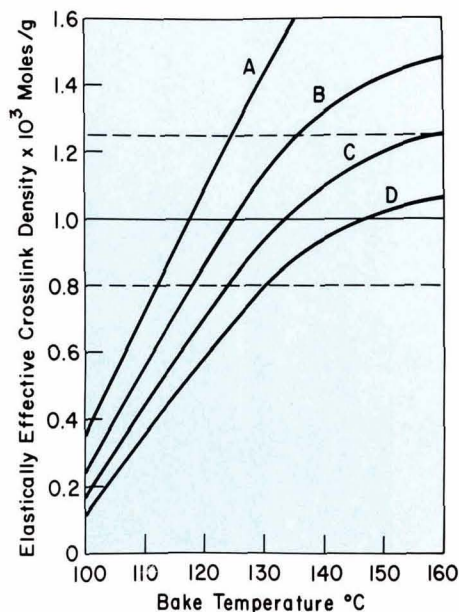


Figure 7— C_{ei} vs bake temperature. The coatings were crosslinked with a fully alkylated melamine and had a polymer number average molecular weight of 2,000. The polymer equivalent weight and the extent of reaction which yields $C_{ei} = 1.0 \times 10^{-3}$ moles/gram (Ext) are as follows: (A), $E_w = 400$ Ext = 0.70; (B), $E_w = 500$ Ext = 0.79; (C), $E_w = 600$ Ext = 0.88; (D), $E_w = 700$ Ext = 0.97

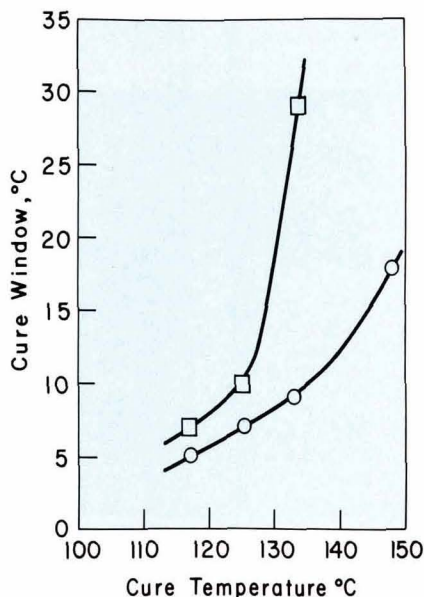


Figure 8—Upper (□) and lower (○) parts of the cure window vs the optimum bake temperature for the coatings listed in Figure 7

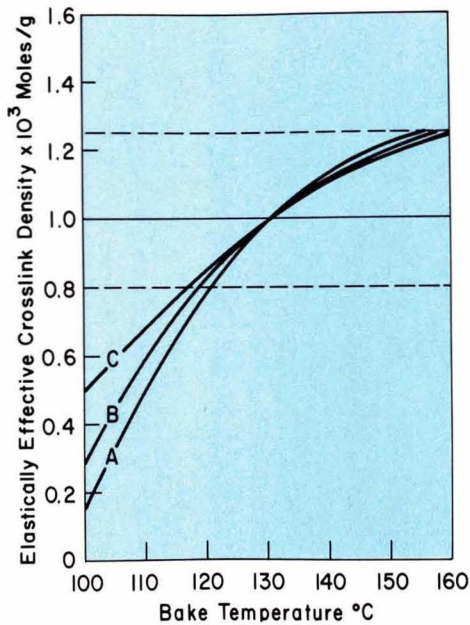


Figure 9— C_{el} vs bake temperature. The coatings have a polymer molecular weight of 2,000. The weight average molecular weights of the melamine crosslinkers are as follows: (A), 390; (B), 500; (C), 5,000

tions in the molecular weight of the high solids coating caused a marked reduction in cure window. This means that control of polymer molecular weight is much more important for high solids coatings than it is for low solids coatings.

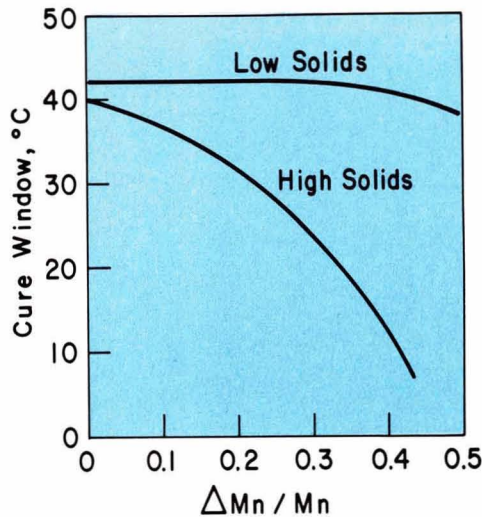


Figure 11—Cure window vs $\Delta M/M$ for a low solids (nominal $M_n = 10,000$) and a high solids (nominal $M_n = 2,000$) coating. Both coatings are crosslinked with partially alkylated melamines

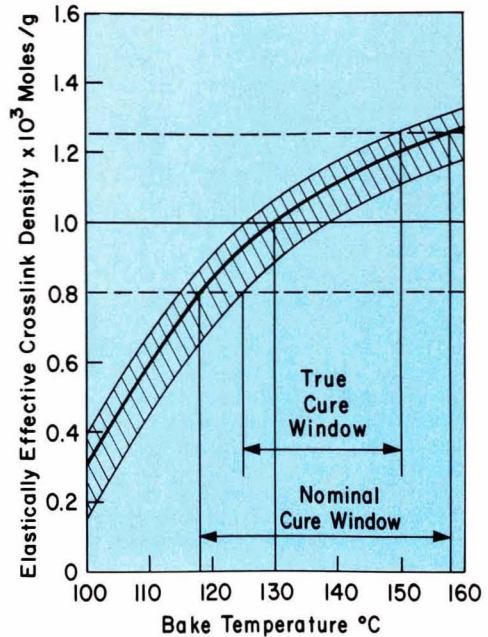


Figure 10— C_{el} vs bake temperature. The coating has a range of polymer number average molecular weight between 1,500 and 3,000 with a nominal value of 2,000. The coating has an equivalent weight of 387 and is crosslinked with a partially alkylated melamine

A similar plot can be made for the reduction in cure window caused by variations in crosslinker reactivity that might be caused by aging of the crosslinker, batch to batch variations in crosslinker reactivity, and batch to batch variations in catalyst level. For the purposes of

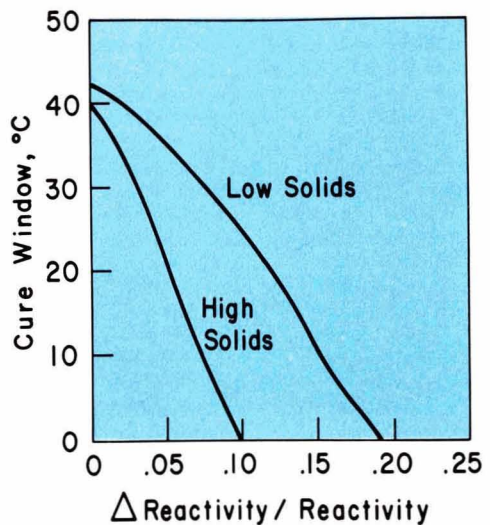


Figure 12—Cure window vs Δ reactivity/reactivity for the same coatings as Figure 11

the calculation, the extent of reaction was assumed to be proportional to crosslinker reactivity. In *Figure 12*, the cure window of the high solids coating is twice as sensitive as the low solids coating to variations in crosslinker reactivity. Even if it is possible in principle to formulate a high solids coating with as wide a cure window as a low solids coating, in practice such an achievement could prove exceedingly difficult and require stringent control of polymer and formulation variables.

CONCLUSION

It has been shown that acrylic copolymer/melamine formaldehyde coatings exhibit acceptable physical properties when the elastically effective crosslink density of the coating is within a certain range. This range depends on the criteria established for acceptability and may also depend somewhat on the coating formulation. Using humidity sensitivity as a criterion for underbake, and using intercoat adhesion as a criterion for overbake, the range of elastically effective crosslink density that yielded acceptable properties was $0.8\text{--}1.25 \times 10^{-3}$ M/g for the coatings tested. By determining the elastically effective crosslink density as a function of bake conditions it is possible to determine cure windows. Lowering the polymer or crosslinker molecular weight (e.g., to increase solids) results in a narrowing of the cure window. The cure window can be widened by formulating the coating to cure to the optimum crosslink density at a higher degree of chemical conversion. Holding other variables constant, this requires an increase in the bake temperature or bake time. The cure windows of high solids coatings are also more sensitive to variations in formulation than are low solids coatings. Thus, high solids coatings require a tighter degree of quality control to maintain their cure window.

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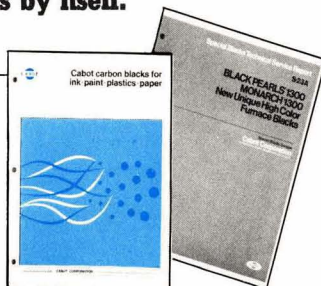
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CSB 105A

Experimental Origins Of the 1931 CIE System of Colorimetry

W. David Wright*
Consultant

At the Symposium on Color and Appearance Instrumentation (SCAI) held March 24–26, 1981, in Louisville, Kentucky, the participants were fortunate to hear Professor W. David Wright present a special guest lecture describing, from a participatory point of view, the establishment of the International Commission on Illumination (CIE) system for describing color. Beginning students of color and vision learn very quickly that the definition of the CIE 1931 Standard Observer was based on the observer spectral response measurements made by Wright and Guild, each working independently and using different methods. The remarkably close agreement between the two sets of data encouraged the CIE to accept the average observer color matching functions, and to establish the color notation system which has had such a vital import to communications, commerce, and industry. Although examined and reexamined many times since that time, the original data have been fully substantiated and have thoroughly withstood the tests of time and advanced experimental techniques. It is with a great deal of pleasure and gratitude to Professor Wright that we offer to our readers his reminiscences concerning this development, which has been of so much value to color-marketing industries.—Ruth Johnston-Feller, *Publications Committee*

The system of colorimetry defined in 1931 by the Commission Internationale de l'Eclairage was based on color-matching data provided by Guild and the author. A color-matching "workshop" is described for measuring the spectrum locus in the chromaticity chart and calculating the color-mixture curves. The paper then traces the compromises that were reached between America and Britain that enabled the form of the system to be agreed just in time for the CIE meeting in September, 1931. The main architects of the system were H.E. Ives, I.G. Priest, L.T. Troland, J. Guild, and D.B. Judd.

*68 Newberries Ave., Radlett, Herts WD7 7EP, England. Presented at the Symposium on Color and Appearance Instrumentation, March 24–26, 1981, Louisville, KY.

Introduction

The system of colorimetry defined and approved by the Commission Internationale de l'Eclairage (CIE) in 1931 was essentially Anglo-American in concept, and agreement was only reached after considerable give-and-take of ideas. After I had written the first draft of this paper, I came to realize that what I was really writing was the script of a play, even a drama if you like, in which there were about half-a-dozen leading characters, with some walk-on parts for a few more.

The main architects of the 1931 System were H.E. Ives, I.G. Priest, L.T. Troland, J. Guild, and D.B. Judd. I was also rather

intimately involved with the events leading up to 1931, but I was not one of the architects. I merely provided half the bricks with which the system was constructed.

The Cast in Order of Appearance

H.E. IVES: Ives was a physicist who carried out much fundamental work on heterochromatic photometry between 1912 and 1923 and was mainly responsible for establishing the viewing conditions, especially the use of a 2° field of view, under which lights of different color should be compared either by flicker photometry or by direct (or step-by-step) brightness matching. These viewing conditions were those which were used in the experimental work leading up to the definition by the CIE of the standard visibility function (the 1924 V_{λ} curve). This is the basic relation which links radiometry with photometry. Since the standard observer for colorimetry had to be defined using the same viewing conditions as those used to define the V_{λ} curve, Ives' studies had a direct influence on the 1931 system of colorimetry. The color transformation equations which Ives published in two important papers in 1915 and 1923¹ also paved the way for the form in which the system was defined. Ives worked initially for the United Gas Improvement Company and later for Bell Telephone. He died in 1953.

I.G. PRIEST: Priest was a physicist who was made Chief of the Colorimetry Division of the Bureau of Standards in 1913 and carried out much experimental re-

search in colorimetry. He also developed a number of colorimetric instruments and techniques. He was the chief spokesman for the United States in the detailed discussions preceding the 1931 CIE meeting and at the meeting itself. Unfortunately, he was taken ill soon after returning from the meeting and died in 1932.

L.T. TROLAND: Troland was a brilliant American psychologist who became President of the Optical Society of America in 1922 at the early age of 33. He was appointed Chairman of a Colorimetry Committee set up by the OSA in 1920 to report on the state of the art in colorimetry and he was also the author of a massive report on "The Present Status of Visual Science."² It was in this report that he wrote in 1921: "It is greatly to be desired that before long a careful and systematic redetermination of the three-color excitation curves should be made. Only three systematic determinations have thus far been recorded, those of Maxwell, of König and Dieterici, and of Abney. All of these may be considered out of date on account of improvements in methods and conceptions since they were made." Troland's influence on the development of colorimetry was considerable and I regard this statement of his as the moment of conception of the 1931 Standard Observer. Sadly, he died in tragic circumstances in 1932.

J. GUILD: Guild was a physicist on the staff of the Optics Department of the National Physical Laboratory in England and was our leading colorimetrist in the 1920's until he became involved in other branches of optics after 1931. He developed several color measuring instruments and followed up Ives' papers on color transformations with two papers of his own. He also gave a very impressive "Survey of Modern Developments in Colorimetry" at an Optical Convention held in London in 1926.³ This was the British equivalent of Troland's OSA Colorimetry Report. He was responsible for formulating the proposals for the 1931 Observer based on his own and my measurements and acted as the negotiator on behalf of the British Colorimetry Committee in the 1931 discussions. He died in October, 1979, shortly before his 90th birthday.

D.B. JUDD: Deane Judd was physicist, psychologist, and mathematician and joined Priest's Colorimetry Division at the Bureau of Standards in 1926. He made a major contribution to the form in which the 1931 system of colorimetry was eventually defined through a paper which he published in 1930,⁴ describing primaries which yielded an all-positive system, two of the primaries also having

zero luminosity. When Priest died in 1932, the task of explaining the 1931 decisions to American colorimetrists fell to Judd and we are all, of course, very familiar with the many contributions to colorimetry which he continued to make for a further 40 years. He died in October, 1972.

THE AUTHOR: Since I appear in the 1931 story at certain unexpected times and places, I should explain that I was a graduate student in the Optical Engineering Department of Imperial College in London from 1926 to 1929, when I built my colorimeter and did my colorimetry research. From 1929 to 1930, I was employed in the Research Department of Westinghouse Electric and Mfg. Co. in Pittsburgh as a member of Dr. V.K. Zworykin's team working on the early development of television. When I returned to England in 1930, I first continued television research in industry and was then appointed to the staff of Imperial College where I resumed my color vision research.

Prologue

1924 V_{λ} CURVE: Ives' fundamental work on heterochromatic photometry provided the basis for a number of studies in America on the visibility curve of the spectrum and in 1920 a mean curve was adopted by the American Illuminating Engineering Society and the Optical Society of America to represent the average eye. It was this curve, with a few minor adjustments, that was submitted by K.S. Gibson, of the Bureau of Standards, to the 1924 meeting of the CIE for approval as the international standard visibility function.⁵

OSA EXCITATION CURVES: In 1922, Troland's OSA Colorimetry Report⁶ had been published laying the foundations for modern colorimetry, dealing at length with Nomenclature, Standard Psychophysical Data, Physical Standards, and Methods of Colorimetry. Troland was aware of the need for an agreed set of color-mixture curves, but the "color box" which Maxwell had constructed and used to measure these curves in 1860 did not yield results of sufficient accuracy to warrant serious consideration by the Committee. However, in 1892, König published more reliable data which he had obtained using Helmholtz's color-mixing apparatus, while Abney, in 1895, provided further curves which he had measured with his "color patch" apparatus at Imperial College. E.A. Weaver, a member of Troland's Committee, therefore derived a set of curves from the combined results of König and Abney and these became known as the OSA

Excitation Curves. These curves, together with the pre-1924 Visibility Curve, were published in the Colorimetry Report and were used fairly extensively by colorimetrists in the United States up to 1931. Nevertheless, Troland clearly regarded these excitation curves as merely an interim set of curves, since he refers to plans which he was making with Weaver to undertake their re-determination, although these plans never materialized.

GUILD'S 1926 "SURVEY": The very lengthy Survey³ which Guild gave to the Optical Convention in 1926 included a detailed review and discussion of the American contributions to the establishment of the 1924 V_{λ} curve and to the various instrumental and theoretical developments in colorimetry in the United States. In effect, he brought Troland's 1922 Colorimetry Report up-to-date with an account of his own contributions since 1922. He echoed Troland's call for new color-matching data and by the time of his Survey, he had probably already embarked on his own re-determination of the curves using his filter trichromatic colorimeter. The interest aroused by Guild's Survey was also responsible for my being offered a research grant to build my colorimeter and carry out an independent study of the mixture-curves at Imperial College.

CIE COLORIMETRY COMMITTEE: In the meantime the CIE itself had taken important steps that were to bear fruit in 1931. At its 1924 meeting, a small Study Committee was set up to prepare the way for colorimetry to become a recognized subject with which the CIE should be actively involved. The two members of this Study Committee were Priest from the Bureau of Standards and T. Smith, head of the Optics Department of the National Physical Laboratory. At the 1928 CIE meeting, a full Colorimetry Committee was established with the British Committee being given Secretariat responsibilities. The program of work agreed for the ensuing three years was based on proposals submitted by Priest and included three main items, namely nomenclature, standard white illuminants for colorimetry, and the sensation curves. (These curves have been variously referred to as sensation curves, excitation curves, color-mixture curves, spectral distribution curves and, more recently, as color-matching functions.)

CIE SIGNAL GLASSES COMMITTEE: Another CIE Committee, the Signal Glasses Committee, was very much concerned with color measurement and at the 1928 meeting was already specifying the colored glasses used in signal lights in terms of the OSA Excitation Curves. Guild, too, made some use of his unpub-

lished color-mixture curves. The Signal Glasses Committee even passed a resolution, independently of the Colorimetry Committee, recommending that the OSA Excitation Curves should continue to be used for the specification of signal glasses until better data became available. Reading between the lines, it was evident that the Signal Glasses Committee were putting pressure on the Colorimetry Committee to get on with the job of providing an internationally agreed system of color specification.

Act I: Battle of the Illuminants

"WHITE LIGHT" MEMORANDUM: The British Secretariat Committee on Colorimetry soon went into action on the proposal for a standard white illuminant and submitted a lengthy Memorandum in June, 1929, with recommendations for an illuminant based on a gas-filled tungsten lamp run at a specified color temperature and used in conjunction with blue liquid filters to give energy distributions that simulated sunlight and daylight. This Memorandum was discussed at the Autumn, 1929, meeting of the Optical Society of America held at Cornell University. (I still have the Minutes of that Meeting, supplemented by written submissions, the main contribution coming from Priest. I should explain that I have these Minutes because by that time I was working for Westinghouse and they had agreed to my attending the OSA meeting. At that meeting I was invited to join the small group which had been called to discuss the "White Light" Memorandum and my comments are duly recorded as part of the American reaction to the British document!)

DAVIS-GIBSON FILTERS: The main points of contention between the British and Americans concerned the choice of liquid filters and whether the source should be defined by its spectral energy distribution or by the color temperature of the tungsten lamp and the chemical constitution of the liquid filters. Both the NPL and the Bureau of Standards had developed their own filters and, naturally enough, both sides were in favor of their own filters being adopted for the international standard. However, the filters developed at the Bureau by R. Davis and K.S. Gibson⁷ had been studied in much greater detail than the NPL filters, and when the final decision was made in 1931, this point was conceded by Guild and the Davis-Gibson filters were adopted.

PHILOSOPHY OF STANDARDIZATION: The argument about how the source should be defined raised very interesting

questions on the philosophy of standardization. Guild took the view that a standard must be defined in such a way that it could always be reproduced in the laboratory without ambiguity. He therefore maintained that the filters should be defined in terms of their chemical composition and not in terms of their spectral transmission. The American view, on the other hand, was that the energy distribution of the source was the all-important feature and it was this that should be standardized. Guild argued that since it was the composition of the filters that could be directly controlled in the laboratory and not the energy distribution of the lamp plus filter, we might find that we had a standard which could not be reproduced in the laboratory if it were defined by its energy distribution. Guild eventually won this argument by the time the three illuminants S_A , S_B , and S_C were defined in 1931. The energy distributions were, however, included as a supplement to the CIE resolutions.

These two different points of view were influenced in part by the belief in the United States that the future of colorimetry lay with the recording spectrophotometer as the basic instrument for color measurement, whereas Guild believed that most practical colorimetry would continue to be carried out by direct visual color matching. In this, of course, the U.S. view was correct. Nevertheless, we are now in a somewhat similar predicament over the new daylight distribution, D_{65} , which the CIE defined in 1964 from new spectro-radiometric measurements of daylight, including the ultra-violet. For the measurement of samples which fluoresce, a laboratory source which accurately simulates the D_{65} distribution is often required, but none is available. It might have been better, therefore, to have followed Guild's principles by developing a laboratory source which had an energy distribution close enough to the D_{65} distribution for most practical purposes, and to have made that source the standard instead of the daylight distribution itself.

Act II: "Workshop" on Color Matching

VISUAL COLORIMETRY: Trichromatic colorimetry is about color matching and we can only understand what a CIE specification really means if we do some basic experiments with a visual colorimeter. Therefore, I want you to imagine that we are engaged in a "workshop" with my colorimeter at Imperial College.

The instrument uses a prism system to produce two spectra, one spectrum providing the red, green, and blue instrument primaries, and the other the mono-

chromatic test color to be matched. The red-green-blue mixture illuminates one half of the 2° field of view and the observer has three knobs to turn to vary the amounts of the primaries in the mixture. The test color, which can be taken from any wavelength in the spectrum, is seen in the other half of the field, and a small amount of one or other of the primaries can be added to the test color as required.

Before starting our observations we have to decide on the wavelengths we should use for our red, green, and blue instrument primaries. These can be chosen solely on their practical convenience because, as Ives showed, we can always transform the results of our color matching to another set of primaries if we wish to do so. The practical considerations are, in fact, very similar to those which face the television engineer when he has to decide on the red, green, and blue phosphors to use in a television receiver. Ideally, they should be chosen so that their additive mixture embraces as wide a range of colors as possible, but if the instrument primaries, or the phosphors, are of too deep or saturated a color, then the brightness or luminance of the mixture is affected. So some compromise is necessary between saturation and brightness. The compromise I reached was to choose a red of wavelength 650nm, a green at 530nm, and a blue at 460nm.

We also have to decide on how the amounts of the primaries in the matches we make should be recorded. There are three possibilities, namely to use radiometric units (watts) or photometric units (lumens) or colorimetric units in which the amounts of the red, green, and blue primaries are normalized in a match on some defined white. Colorimetric units are generally the most convenient, and these are the units I used although in a modified form, in which the red and green primaries were normalized in a match on a monochromatic yellow of wavelength 582.5nm and the blue and green were normalized in a match on a monochromatic blue-green of wavelength 494nm. With these units it was possible to analyze the observer differences as due either to absorption in the ocular media or to differences in the spectral sensitivity of the retinal receptors.

FIRST TESTS ON YOUR COLOR VISION: One of the first matches I would ask you to make would be on a monochromatic yellow, say on my unit wavelength 582.5nm. Among observers with normal vision, there is usually very little variation in this match, but if you need more red in the match than the normal, this suggests your color vision is defective

and of the protan type. If you need more green than normal, then you are probably a deutan defective.

The next match I would give you would be on a spectral blue-green, say on my other unit wavelength 494nm. If your match was very different from the normal, it could be that you were a tritanomalous observer and other color vision tests such as the Farnsworth-Munsell 100-Hue test would identify this abnormality. More probably, though, your abnormal match would be due to absorption, or lack of it, in your eye. One source of this absorption is the crystalline lens, which becomes yellow with age. At my age, my lens must be very yellow and I have to turn up the blue knob when matching 494nm to compensate for the blue absorption in my crystalline lens. There is also some yellow pigmentation in the central, macular, area of the retina, and the density of this pigment varies very considerably from one observer to another, although not, so far as we know, with age. So an observer with a dense macular pigment has to turn up the blue knob in his 494nm match, while observers with little or no macular pigment will turn the blue knob down.

When you have matched the 494nm wavelength, I would then ask you to look to one side of the field so that you now observe the match with an area of the retina outside the pigmented area. Unless you are an observer with very little macular pigment, you now find that you have to turn the blue knob down to restore the match. This is a significant observation as it explains some of the differences that are found between matches made using small fields and those using large fields. It also explains why the large-field 10° color-matching functions adopted by the CIE in 1964 had to be based on observations made with annular fields in which the central macular area was excluded or ignored.

NEED FOR DESATURATION: In the first test color I gave you to match, namely 582.5nm, I would probably not have bothered to desaturate it by adding any of the blue primary to it, and I expect you would find you could make an acceptable match if not quite an exact match. The same would not be true, though, of the 494nm test color unless I desaturated it by adding some of the red primary. The reason for this is that the spectral sensitivities of the three retinal receptor processes responsible for our color vision are broad overlapping curves, and the green primary, 530nm, stimulates the red process to a much greater extent than does the test color, 494nm. There are, in fact, no spectral primaries, still less any color-filter primaries, that give pure red, green, and

blue responses in the retina, so that any spectral test color that I set up has to be desaturated to some extent before it can be matched exactly. It is, however, for the blue-green test colors that the need for desaturation is most marked.

PLOTTING THE SPECTRUM LOCUS: Once these preliminaries have been completed, you are now ready to make a series of color matches through the spectrum. Even if you proved to be color-defective, we could still measure your color-matching functions although they would not agree with the 1931 Observer. First, I would set you the normalizing wavelengths 582.5nm and 494nm to match, and then a series of wavelengths through the spectrum over a wavelength range from 750nm to 400nm at, say, 10nm intervals. I would ask you to make three or more matches at each wavelength depending on how good an observer you were, a reasonably good observer being able to repeat his matches to about 2 or 3% for the red and green primaries, but perhaps only 4 or 5% for the blue. These figures depend very much, though, on the colors being matched. The calculation of the chromaticity coordinates involves normalizing the units, subtracting the amount of desaturating primary, and then dividing by the sum of the red, green, and blue values to give the unit coordinates. You will now be in a position to plot the wavelengths you have measured in the chromaticity chart, but this will not be the XYZ chart of the CIE system. Your chart will be an RGB chart, where R is 650nm, G is 530nm, and B is 460nm, and because all your spectral colors will have one negative value for either R, G, or B, your spectrum locus will lie outside the triangle RGB except where it passes through R, G, and B.

WHITE POINT AND THE COLOR-MATCHING FUNCTIONS: Depending on how much time you had to spare and on how detailed a study you wished to make of your color vision, there are further observations you could make. These would include a match on a standard white, so that you could plot your white point in the chromaticity chart to give a graphical illustration of the pigmentation in your eye. Then I could adapt my colorimeter for luminance measurements by flicker photometry, first to measure the relative luminances of unit quantities of the red, green, and blue primaries, and next to measure your V_{λ} curve. You would then have all the data you needed to sub-divide your V_{λ} curve into its component color-matching functions.

COURSES ON COLOR MEASUREMENT: Before I retired from Imperial College,

we used to run courses on color vision and color measurement, and the experiments which I have just described would form the foundation of the course. I would commend this as a very desirable approach to the subject, especially in these days when we are caught up in the world of the microprocessor. The numbers which we get out of our highly sophisticated instruments mean no more, and no less, than the numbers I can get out of my colorimeter. You just get more of them and you get them faster. It has always surprised me that after 1924, when the United States led the world in visual photometry, it did not follow this work up with comparable studies in visual colorimetry. So far as I know, there is still no equipment in the U.S. with which the color-matching functions can be measured. They can, of course, be measured in Dr. Wyszecki's laboratory [National Research Council of Canada] in Ottawa, but this is not the United States—not yet, anyway!

Act III: 1931 Standard Observer Data

THE GUILD EXPERIMENTS: Now we must trace the actual events that led up to 1931. After Guild had delivered his Survey at the 1926 Optical Convention, he pressed on with his determination of the color-mixture curves following the observing procedures which I have just outlined, but with his own apparatus.⁸ He used two Hilger constant-deviation monochromators in series to act as a double monochromator to deliver a spectral test color effectively free from stray light. This illuminated one half of the field of his filter trichromatic colorimeter, with provision for desaturation by the addition of a small amount of one or other of his filter primaries. The test color could then be matched by a mixture of his red-green-blue primaries in the other half of the field. His field of view subtended an angle of approximately 2° for the reason, as Guild explained, "It lies almost entirely within the average 'yellow spot' of the retina and is of similar dimensions to the field to which the standard visibility data apply. It is of the greatest importance that quantitative work on the properties of the eye should all apply to the same region of the retina, and color-matching with fields extending beyond the macula lutea may give results which are not at all representative of foveal vision."

MY SPECTRUM LOCUS MEASUREMENTS: Guild must have completed the measurements he made on his seven observers by 1927 but, as we shall see, he did not publish his results until 1931.

In the meantime, I built my colorimeter and measured the spectral chromaticity coordinates for 10 observers and the white points for 36 observers, and I reported my results in a paper which I gave at a meeting of our Optical Society in London on March 14, 1929.⁹ Guild welcomed these results but regretted that I had not expressed them in terms of the wavelengths which the NPL had adopted as reference primaries, namely 700nm, 546.1nm, and 435.8nm. Since no one had ever told me about these wavelengths, I naturally could not use them and had given my results in terms of my instrument primaries 650nm, 530nm, and 460nm. This prevented Guild from making an immediate comparison between his results and mine, and since I was off to Westinghouse in a few days, there was no chance of my transforming the data before I left. In fact, it was not until I returned to England a year later and presented another paper to our Optical Society on the color-mixture curves,¹⁰ in which I also included my spectral chromaticities transformed to the NPL reference primaries, that Guild was able to compare our data.

This paper, which I had worked on while I was in Pittsburgh, involved combining my spectrum-locus data with the 1924 V_λ curve. I will not go into the details of the calculations, but I first had to assume likely values for the relative luminances of unit quantities of the primaries and then multiply the spectral chromaticity coordinates by these values. I could then break up the V_λ curve into the three component mixture curves and if I had chosen the correct relative luminances, the areas under the three curves should be in the same proportions. By a series of trial calculations and successive approximations, I eventually achieved the agreement and internal consistency I was after.

Although I did not make these calculations on Westinghouse time, I must confess that I did use Westinghouse graph paper. In fact, I still have the graphs and my method of working out the areas was to count up the number of millimeter squares under the curves. I hope the younger generation will spare a thought for the rather primitive aids that we had at our disposal in those pre-computer days!

GUILD-WRIGHT AGREEMENT: The meeting at which I gave my "Mixture Curves" paper was held on April 10, 1930, and this was the occasion when Guild was able to report that my published results and his unpublished data were in very close agreement. It was also the moment when he realized for the first time that a real chance existed for the

standard observer to be defined at the CIE meeting due to be held in England in September, 1931.

Although he did not think much of my method of calculating the mixture curves, he did make the rather nice comment: "This agreement adds enormously to the value to be attached both to Mr. Wright's data and to our own, because it must be remembered that the two determinations were made by different groups of observers employing entirely dissimilar apparatus. . . . It is thus clear that Mr. Wright's trichromatic coefficients, which are, so far, the only published set based on modern experimental work, can confidently be regarded as a very close approximation to the properties of an average eye."

AVERAGE OBSERVER DATA: Time was going to be very short for Guild to achieve his goal of a standard observer by September, 1931, but he set to work to prepare his paper on "The Colorimetric Properties of the Spectrum"⁸ in which he first reported his results and also derived the color-mixture curves for an average observer based on the mean of his and my measurements. This paper was submitted to the Royal Society in February, 1931, was read before the Society in April, and published in June. Priest, though, only received a copy on July 18th, exactly two months before the Colorimetry Committee of the CIE were due to meet. This was very short notice by any standard, but Guild had anticipated this difficulty by preparing a Memorandum on behalf of the British Colorimetry Committee on "A Normal Eye for Colorimetry" and this was dispatched to Priest in February, 1931. Much of the text of this memorandum was taken from Guild's Royal Society paper, but it did not include those portions of the paper dealing with the experimental details of the NPL investigation, nor of the method of reducing the results or of fitting these to the 1924 V_λ curve. Priest and his colleagues were therefore being asked to take much of the work on trust, and they were clearly not very happy at being rushed in this way.

Act IV: Touch-and-Go in 1931

To his credit, Priest did respond to Guild's Memorandum in a document dated July, 1931. This document included lengthy comments from Priest himself, together with shorter comments from Ives (Bell Telephone), H.P. Gage (Corning Glass), W.F. Hamilton (University of Louisville), and Judd (Bureau of Standards). There was general agreement that it was a fair assumption that the Guild-Wright data were the best now

available, and the two industrialists, Ives and Gage, were in favor of a system being adopted on the basis of the new data. The physiologist Professor Hamilton, on the other hand, was very doubtful about the advisability of standardizing a physiological mechanism about which we knew practically nothing and he also considered that I had argued in a circle when trying to separate the relative contributions which macular pigmentation and retinal sensitivity made to observer differences in color matching. Judd thought that the most compelling reason for using the Guild-Wright data in place of the OSA Excitation Curves was that the 1924 V_λ curve had been incorporated in the color-mixture curves.

PRIEST'S CRITICISMS: Priest had a number of objections in addition to his concern about the lack of time for adequate consideration of the proposals. He doubted whether the new results were a significant improvement on the 1922 OSA Excitation Curves, and quoted comparative specifications on the colors of signal glasses to support his contention. He criticized the limited number of observers we had used and did not believe that our data had any title to be regarded as a highly statistical average of the earth's human population. On the other hand, he attached no great importance to obtaining such an average for most of the purposes for which color specification was required. He did, though, think it would be of great practical interest to have more definite quantitative information as to systematic differences between groups with respect to race, sex, and age.

It is interesting to note the almost patriotic fervor with which Priest and Judd viewed the OSA Excitation Curves, as if they were based on American experiments. Weaver, it is true, had calculated them for the American Colorimetry Committee, but they were derived from König's work in Germany and Abney's in England!

One thing was crystal clear from the American comments, namely that for a system of colorimetry to be acceptable in the United States, it would have to be expressed in terms of hypothetical primaries giving all-positive color-matching functions, and not in terms of the physical wavelengths that Guild had used, which necessarily included negative lobes in the functions. As Priest stated on this question: "There is a special difficulty in that I cannot report any crystallization of American opinion on just what the new primaries should be, although there is a substantial unanimity of opinion that they should be chosen to result in all-positive values of the ordinates of the distribution curves. Dr. Judd has given

(and is still giving) considerable attention to the question of putting the data in the most convenient form for routine computation. Dr. Ives is in favor of putting the data to be proposed for formal adoption into one of the forms suggested by Dr. Judd. But these questions are still in a state of flux and cannot be adequately discussed prior to the publication of Dr. Judd's papers."

Priest anticipated that the data would have to be transformed to "all-positive" primaries before united support for the new system could be achieved and, as he said, such a transformation "cannot be done overnight." In any event, that is exactly what Guild and Smith did!

Priest evidently had no difficulty in assembling some convincing arguments that could be deployed as delaying tactics, and when he arrived in England in September, 1931, he almost certainly had no intention of agreeing to the adoption of the new standard observer data at the CIE meeting. But a week at the NPL prior to that meeting was to change all that. Poor Priest! He must have been subjected to intense pressure from Guild and Smith, but to give them their due, they put themselves under intense pressure too. Each evening they recalculated and transformed the data, on one occasion staying up all night on the job, as they endeavored to meet the objections which Priest had raised during the day. Yet through these efforts on the part of all three of them, they were able to present an agreed-upon set of proposals to the CIE Colorimetry Committee when it met at Trinity College, Cambridge, on Thursday, September 18, 1931.

THE ANGLO-AMERICAN COMPROMISE: The compromise that they reached was essentially that the standard observer should be defined in terms of color-matching functions expressed in terms of spectral primaries (this satisfied Guild), but that the data should be transformed to hypothetical primaries giving an all-positive set of functions, for use in practical colorimetry (thus satisfying American opinion; mine, too, as a matter of fact). The transformation they selected also took advantage of Judd's proposal for the red and blue hypothetical primaries to be located on the alychne. The resolutions included the definition of the standard illuminants to be used in colorimetry, and these employed the Davis-Gibson filters (another plus to America). The liquid filters, though, were specified in terms of their chemical composition (so Guild was pleased), but the energy distributions of the illuminants were also tabulated (to satisfy American requirements). What a happy international compromise!

W.D. WRIGHT earned a degree in Optical Engineering from Imperial College, London and a Physics degree and a Ph.D. in Science from London University. From 1951-1973, Dr. Wright was a professor of Applied Optics at Imperial College. While employed at Westinghouse Electric and Manufacturing Co., Pittsburg, PA and at Electrical and Musical Industries, England, Dr. Wright conducted industrial research on television. He has published several articles on the measurement of color and research on color vision. Dr. Wright was elected President of the International Color Association, 1967-69, and Secretary-Treasurer of the International Commission for Optics, 1953-66. He has been honored with the Newton Medal of the Color Group (Great Britain), the Mees Medal of the Optical Society of America, the Judd-AIC Award of the International Color Association, and the MacBeth Award of the Inter-Society Color Council.



Yet it was in no sense a multi-national agreement, but a purely Anglo-American operation. Only six countries were represented at the meeting, namely France, Germany, Great Britain, Japan, The Netherlands, and the United States, and although we had been sent Agenda Papers in advance, giving the Resolutions on which we were expected to vote, these were all out-of-date on account of the Priest-Guild-Smith discussions held the previous week. The new Resolutions that were put on the table at the meeting were a complete surprise to most of the delegates, and although the main Resolutions were approved unanimously at the meeting, France and Germany subsequently reversed their votes, no doubt feeling that the whole thing had been far too rushed. Yet there are times when quick decisions are preferable to long-drawn-out arguments, and in due course the CIE officially confirmed the new Resolutions, in spite of these reversed votes, to Guild's relief.

Epilogue

I would want to pay tribute to the American reaction to the situation once the new color-matching functions had been adopted by the CIE. In spite of their previous reservations, colorimetrists in the United States abandoned the OSA Excitation Curves without demur and Judd published a paper¹¹ describing the new functions and formally accepting them in place of the OSA Curves. With Professor A.C. Hardy's recording spectrophotometer now being manufactured by the General Electric Company, spectral reflection measurements became a viable commercial proposition for the color industries. Also, in 1936 Hardy published his *Handbook of Colorimetry* which did more, I believe, to popularize the CIE System than almost any other publication. Other countries were slower than the United States, but the CIE itself made almost immediate use of the 1931 chromaticity chart to define color limits for road, rail, and aviation signal colors.

In fact, it is probably true to say that the main pressure for an international system of color specification had come initially from the transport industry.

THE V_{λ} CURVE: So far as I know, there has never been any suggestion that the Guild-Wright color-matching data have been in error in any respect for the viewing conditions under which the matches were made. The defect that does exist in the color-matching functions at the violet end of the spectrum must be attributed, I regret to say, to the poor choice, from among several American investigations, of the data used to define the 1924 V_{λ} curve in the far violet. For some reason which I still do not understand, the studies which gave the correct values in the violet, namely those recorded at the Bureau of Standards by Coblenz and Emerson and by Gibson and Tyndall, were ignored when the average V_{λ} values were being derived. This mishap has, however, had a much smaller effect on the color-matching functions than might have been expected. Some discussion is currently taking place on whether the V_{λ} curve should have been incorporated with the color-matching data in the first place and I think a case could be made out for treating photometry separately from colorimetry. This suggestion, though, would have been quite contrary to the climate of opinion prevailing in 1931.

COLOR DIFFERENCES AND COLOR TOLERANCES: Where trichromatic colorimetry does fail is in the specification of color differences. I am sorry about this, but we have to face the fact that the detection of small color differences involves elements in the physiological and psychological process of color perception additional to the spectral sensitivity of the retinal receptors on which color matching depends. As a result, color differences do not obey the nice linear laws which color-matching equations obey, and I suspect that all the attempts that have been made, and are

still being made, to work out a single all-embracing color-difference formula that will satisfy all visual situations and all commercial requirements, are doomed to failure. I think we have to be much less ambitious and develop instead a number of different formulae, each formula being valid only for a particular restricted viewing situation and application. This is disheartening to the theorists among us, but we do have to be realistic and accept that the color vision process was not designed primarily for the convenience of colorimetrists and industrialists!

It is fitting, I think, to close by referring again to the comment from Professor Hamilton, of the University of Louisville, in which he warned colorimetrists against standardizing a physiological mechanism. This was a fair comment, but it was a danger of which Guild was well aware. In his Royal Society paper⁸, he specifically stated that the color-mixture curves we had determined should, in the first place, be regarded as additions to our quantitative knowledge of the human eye and from that point of view, there could be no question of standardizing the data or of defining any set of experimental results as "true" or as representing the performance of the average eye. On

the other hand, there was a utilitarian aspect of our measurements which made it desirable to standardize certain data for use in technical and industrial work.

So Guild and Hamilton really saw eye to eye on this matter, but it is unfortunately true that the 1931 Standard Observer has sometimes been used in visual research as if it did represent a standard physiological mechanism. What the CIE defined in 1931 was a conventional set of color-matching functions for use in technical colorimetry to specify colors on an internationally agreed system. The system has also served as a valuable tool in the color industries. And on that note, as the curtain falls on our story, I want to pay a special tribute to the memory of the two principle characters in the drama, Irwin G. Priest and John Guild.

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Society Meetings

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Nov. 5

T. Cadby, of Holden Surface Coatings Ltd., presented a talk entitled "FLEXIBLE PACKAGING."

Mr. Cadby explained that the flexible packaging market has undergone phenomenal growth in the last 15-20 years, from a beginning of a few simple packs to today's complexed combinations of materials. According to Mr. Cadby, the growth of flexible packaging is due to a number of factors, the most important being the introduction of supermarket style shopping. For this type of retail selling, it is essential that the products are prepackaged in attractive portion packs with an adequate life for the supermarket shelves and display cabinets.

If you can imagine your local supermarket with all the glass bottles and tin cans removed, you will have some idea of what flexible packaging is, said Mr. Cadby. All the containers you see are constructed from plastic, paper, board, and thin gauge aluminum. They take the form of cartons, pouches, sachets, lidded pots, plastic bottles and tubes, skin and blister packs, etc., explained Mr. Cadby.

A slide presentation illustrated examples of products used in packaging. The advantages and disadvantages of each type of substrate, each method of sealing, the protection afforded to content, and the decoration for sales appeal were explained by Mr. Cadby.

The use of surface coatings was described as being required at a number of locations within a multi-layer of substrates, including protective coating, barrier coating, heat sealing, adhesive and overprint varnish. Mechanical strength also had to be considered to allow for the joining stages, said Mr. Cadby.

The processes of skin and blister packaging (not normally used for foods) was illustrated by slides.

Mr. Cadby concluded that flexible packaging is ever changing since new substrates, techniques, and coatings are constantly being introduced. A recent example had been the introduction of cold sealing, mainly for the packaging of confectionary and band-aid plasters.

D.H. CLEMENT, *Secretary*

C-D-I-C

Nov. 9

"HIGH SPEED DISPERSION" was presented by James White, of Hockmeyer Equipment Co.

Mr. White explained that dispersion is not grinding, but is the breaking down

of agglomerates to the primary particle size. The primary particles are held together by molecular attraction forces and valence bonding forces. The strength of the bond, according to Mr. White, determines the energy needed to break the bonding force and achieve the primary particle size.

Several rules that are useful parameters for general dispersion were discussed. They included: (1) the tip of the blade should be traveling at 5,000-6,000 ft. per minute, (2) the blade diameter should be about 1/3 the diameter of the mixing vessel and should be positioned about 1/2 of a blade diameter above the bottom of the tank and the height of the batch should be about twice the blade diameter, (3) 1 hp. is needed for every 10 gallons of batch.

Mr. White explained the importance of the shape of the dispersing tank. For batches up to 500 gallons, Mr. White suggested a flat bottom tank could be used satisfactorily but will curve the flow below the blade and cause an undesirable back pressure. Therefore, a round bottom tank is more efficient since it allows the flow pattern both above and below the blade to assume its natural shape. A conical bottom tank is most versatile and the most efficient, according to Mr. White, for batches over 750 gallons since the cone shape reinforces the natural flow pattern of the batch causing a funnel-shaped vortex which is called cyclonic action.

What actually occurs on and around the blade during dispersion was discussed by Mr. White. He explained that the teeth on the blade do not break up agglomerates. In a normal flow pattern

the material coming down onto the blade is accelerated across the blade and enters a zone of attrition which extends 2-2½ inches beyond the blade. About 85% of the energy put into the batch is expended in this zone of attrition, said Mr. White. In this zone of attrition you have material coming off the surface of the blade at one speed, material coming off the base of the blade at another speed, and material above the blade at a third speed all coming together in a 2-inch area. The scrubbing action caused by these differences in speed will give you about 70% of your dispersion. About 25% of the dispersion will occur on the surface of the blade and 5% occurs while moving back to the blade. The dispersion on the blade occurs when a slow moving particle strikes the blade which is moving much faster, and again you have the scrubbing action caused by acceleration. The particle will go around the blade in a spiral until it hits the edge and is thrown off into the zone of attrition, explained Mr. White.

One of the more common problems occurring in high speed dispersion is over vortexing, said Mr. White. This occurs when the mill base does not cover the top of the blade and hits only the edge which causes a severe drop in efficiency. This problem can usually be cured by changing the position of the blade in the tank.

Mr. White reviewed the four main types of blades presently in use. The F Style which is the most widely used for dispersion and dissolving resins, has alternating teeth above and below the plane of the blade ¼-¾ inch high and 1-2 inches long. The G Style is a high vane blade and gives less shear but more pumping action and is used mainly for



The 1981-82 Birmingham Club Executive Committee. Seated (left to right): Secretary—D.H. Clement; President-Elect—R.B. Tennant; President—J.R. Green; Immediate Past-President—R. Ingleston; and Treasurer—H.J. Griffiths. Standing (left to right): B.J. Addenbrooke, J.R. Jukes, J.N. Hitchin, and D. Penrice



Cleveland Society Officers for 1981-82. (Left to right): Treasurer—H.A. Scott; Secretary—Donald C. Dennison; President—Carl J. Knauss; and President-Elect—Girish C. Dubey

thixotropic water based dispersions. The cabbage cutter blade is in between the high vane blade and the dispersion blade. It pushes particles down as well as up and out. It has less shear than the F Style blade but more pumping action, said Mr. White. It finds wide usage for dissolving resins and rubber based products. The ring blade has no teeth but fine slits that promote the scrubbing action necessary for dispersion. It works better in low viscosity grinds with relatively low levels of pigment particles and is widely used for coil coatings where maximum color development is needed, explained Mr. White.

Some techniques for obtaining the best efficiency in the dispersion process were reviewed. Mr. White explained that the concentration of pigment particles needs to be high for maximum dispersion with a saw tooth blade. If the number of particles is too low, there is no interaction between them and poor dispersion will result. Today's titanium dioxide pigments are easy to disperse, however some other pigments need to be mixed at slow speed to allow time for adequate wet out to occur. Another problem that occurs occasionally is off-grade material that perhaps has a slightly different particle shape that can cause poor dispersion, said Mr. White.

A number of safety features that are available for high speed dispersion equipment were discussed. These included mixing shaft guards, height limit switches, locks for portable tanks, safety switches for tank locks, nonrotating switches, tank covers, and belt covers. Mr. White listed safety precautions relating to the operator. These included no loose clothing, on-off switches located in unobstructed view of the machine, keeping safety devices and the machine itself in good repair, good housekeeping around the machine particularly keeping the shaft clean, and no horseplay around the machine. He also noted that no one

under the influence of alcohol or drugs should be allowed to operate a disperser.

Q. What is an optimum distance from the 2 1/2" zone of attrition to the side of the tank?

A. Go back to the basic parameter of the diameter of the blade being 1/3 the diameter of the tank. At lower viscosities of about 3,000 cps, you might have to go to about 1/4 of the tank diameter, and at higher viscosities of 10,000 cps, you may get good results at 1/2 the tank diameter assuming you have good flow.

Q. What can you do if your blade is too close to the bottom of the tank?

A. It's difficult to always get proper blade and tank configuration in a production situation. If the blade is less than 1/2 a diameter from the bottom you will get an area under the blade which will not move. The only thing you can do is raise the blade and clean out the undispersed material underneath and start the disperser up again.

Q. What are the possibilities for high speed dispersion of phthalo pigments?

A. At this time not too good. We can get a dispersion using a stationary ring around a saw tooth blade which will increase the residence time at the tip of the blade. This technique requires a lot of horsepower and generates a lot of heat. We can get a good grind gauge reading but color development is relatively poor.

ROBERT A. BURTZLAFF, *Secretary*

Chicago

Sept. 14

A panel discussion on "PAINT QUALITY" was presented by Federation President-Elect Howard Jerome; Royal Brown, Technical Vice-President of the National Paint and Coatings Association; Frank Ness, President of the Decorating Products Association of Greater

Chicago and owner of Wright's Decorating Center, Chicago, IL and Niles Color Center, Niles, IL; and Ted Ebert, President of the Painting and Decorating Contractors of America and owner of Theo Ebert & Co., Chicago.

JOHN R. INGRAM, *Secretary*

Chicago

Oct. 5

Dr. Albert L. Rocklin, of Shell Development Co., presented "A COMPUTER METHOD FOR PREDICTING EVAPORATION BEHAVIOR OF MULTICOMPONENT AQUEOUS SOLVENT BLENDS."

"WATER-BORNE MAINTENANCE COATINGS" was discussed by David B. Norby, of the Spencer-Kellogg Div. of Textron, Inc.

JOHN R. INGRAM, *Secretary*

Golden Gate

Nov. 16

Edward Antonucci, of Drew Chemical Corp., presented a talk entitled "FLASH RUST PHENOMENON."

Theories of the causes of flash rusting and chemical mechanisms by which flash rusting occurs were explained by Mr. Antonucci. Methods to minimize or eliminate flash rust were discussed along with an analysis of several chemicals designed to prevent flash rusting.

Q. What is the effect of the chromic acid pretreat relative to coatings flash rust inhibition?

A. We have not studied this problem as of now.

Q. Did you know that linseed oil could be used as a flash rust inhibitor?

A. Yes, indeed I am aware of the effect of linseed oil as a way of preventing oxygen from getting to the surface of metal in water-based systems and thereby inhibiting the flash rust potential.

K.E. TRAUTWEIN, *Secretary*

Houston

Oct. 14

George Brandt, of George C. Brandt, Inc., spoke on "TECHNOLOGY AND PROFITS IN THE PAINT INDUSTRY."

According to Mr. Brandt, there has always been pressure on the purchasing and technical aspects of a paint company to produce a good coating, but at a low price. There are three major areas where money (profit) can be made. The first is in the area of raw material selection, but most coatings manufacturers have reduced the formula costs through raw material selection to the point where there is nowhere to go, barring a radical new material that has little or no cost,

explained Mr. Brandt. The second area involves the manufacturing process. Here again, the profit available has diminished to the point that only revolutionary new procedures or equipment will make any difference to the profit margins now realized. Finally, Mr. Brandt pointed to the marketing area as a means of increasing profit. He discussed that the sales forces should be stressing quality versus the price of the goods being sold. The "Picture It Painted" campaign of the National Paint and Coatings Association helped improve the attitude of the buying public by improving the image of paint and coatings.

A number of companies are now working to sell paint on the basis of what it will do, explained Mr. Brandt. They are emphasizing quality rather than price-cutting. By increasing profits, the industry may be able to pay better salaries and attract better qualified people. The money could also be used to improve the working environments of the plant employees. As a final note, Mr. Brandt again stressed the point of selling coatings on how well they work. To do this will take the cooperation of marketing and management.

GEORGE SCHWARTZ, *Secretary*

Los Angeles

Nov. 11

Clarence Meyers, of the John K. Bice Co., was presented with a 50-year pin, by President Van Zelm. Mr. Meyers has been a Federation member since 1928, when he began his career with Devco & Reynolds. He has been active in the Los Angeles Society for 33 years, serving on various committees.

"FLASH RUST INHIBITION IN WATER-BASED PAINTS" was presented by Edward Antonucci, of Drew Chemical Corp.

Mr. Antonucci gave a brief background on the problem of flash rusting, which the industry has experienced for the last 20 years. The problem, according to Mr. Antonucci, began with the use of emulsion paints in trade sales applications and appeared as nail head rusting. Presently, the problem is much more severe with excessive usage of emulsion paints in industrial applications. Mr. Antonucci explained that flash rusting occurs in 1-4 hours or faster in a forced-dry system, and early rusting occurs in 12-48 hours.

Corrosion is an electro-chemical process allowing reaction to occur between the anode and cathode, said Mr. Antonucci. Reaction occurs at the cathode, and oxidation at the anode. Corrosion occurs at the anode, explained Mr. Antonucci. Corrosion equations were discussed in relation to coatings and "crevice corrosion."

Analysis of various inhibitors was discussed. Mr. Antonucci explained that anodic and cathodic inhibitors were tested. Emulsifiers, esters, acids, salts, amines, and commercial products were evaluated and their limitations discussed. According to Mr. Antonucci, laboratory experiments were designed with three goals: (1) remove dissolved oxygen from the paint vehicle, (2) improve surface bonding, and (3) neutralize acidity. Successful products and paint formulations were described incorporating these objectives.

Mr. Antonucci discussed some common questions and conclusions developed from these studies. Flash rust occurs and becomes polarized, so point of rusting is no longer a corrosion cell. However, rust spots are sites for salt-spray chamber corrosion. A flash rust inhibitor can hurt salt-spray resistance, said Mr. Antonucci. Pretreatment of metal helps prevent flash rust. Strontium chromate will not prevent flash rust. Emulsions with improved flash-rust resistance incorporate amines or surfactants to raise pH. Talc, mica, or zinc oxide pigments improve oxygen impermeability (tighten film) and help prevent flash rust, according to Mr. Antonucci. He concluded, by recommending that formulators work closely with both emulsion and additive suppliers for proper formulation.

Q. Is the particle size of the latex important in the phenomenon of flash rusting?

A. A better coalescing latex should coat the metal better and inhibit flash rusting, but I do not know how particle size affects coalescing. I will defer to

someone more knowledgeable about particle size.

Q. What is the pH range for your new product? Does performance of your new product depend on the wetting agents and emulsifiers in the latex system?

A. pH range varies from 5-9. It is effective in both vinyl acrylic and acrylic systems. Our product is a dry powder. With proper wetting agents and emulsifiers our product can be added as dry powder. In other cases, a 10% solution is recommended for addition.

Q. Is there a relationship between in-can corrosion and flash rusting and their inhibitors?

A. Yes. In-can corrosion is a vapor-phase problem versus a coating on a substrate. Our product does not prevent in-can corrosion at the liquid-vapor interface. However, the corrosion mechanism is similar—oxygen and moisture attacking the metal.

Q. You mentioned that entrapped air supplied oxygen to promote flash rusting. Does it also provide a physical site (i.e., the bubble on the surface)?

A. Yes. An unbroken bubble allows moisture and air to penetrate the film. Any crater or film imperfection provides a site for both flash rusting or corrosion of the metal.

EARL B. SMITH, *Secretary*

Montreal

Oct. 7

Dr. D.J. Smith, of Imperial Chemicals Industries, Ltd., spoke on "A NEW LATEX PAINT FOR THE PROTECTION OF STEEL."

According to Dr. Smith, the main problems to be overcome in the protec-



Houston Society Officers for 1981-82. (Left to right): Treasurer—Donald R. Montgomery; Secretary—George Schwartz; Vice-President—Klebert D. Jacobson; and President—A. Duane Fields



The 1981-82 Officers for the Kansas City Society are (left to right): Society Council Representative—Norman Hon; Vice-President—Richard Warren; Treasurer—Gene Wayenberg; President—Mike Bauer; and Secretary—Melvan Boyer

tion of steel were those of adhesion and water vapor permeability. He then discussed the mechanism of corrosion.

A vinyl acrylic (vinylidene chloride + acrylate) latex resin was described as being an excellent barrier to water vapor. But due to its high Cl^- content, said Dr. Smith, the latex resin tends to undergo dehydrochlorination in the high pH range of a typical paint formulation. This problem can be overcome by formulating with a low initial pH, as in the case of the described primer formulation where the initial pH was 5.0.

A test formulation was compared to two styrene acrylic and three acrylic paint systems formulated at pH level of 9.0-9.5 in accelerated tests including: Salt Spray, Distilled Water Soak, and ASTM Salt Spray versus a commercial alkyd system. Mechanical property testing included: flexibility, scratch, impact, cross hatch adhesion, and pull off adhesion. Exterior testing was carried out for 1.25 years coastal, 1.5 years rural, and 1.5 years industrial exposure. Results indicated that the performance of the vinyl acrylic copolymer system was equal to or better than that of the other paint systems in practically all of the tests carried out, explained Dr. Smith.

Q. Is brushability adequate?

A. This property is associated with the thickener, and any problem can usually be overcome by a change in thickener.

Q. Can stability of a system with pH 5.0?

A. This problem is avoided by using plastic containers.

ERIC J. TEMPLETON, Secretary

Montreal

Nov. 4

"THE LATEST DEVELOPMENTS IN EPOXY RESINS AND CURING AGENTS" was presented by Alan G. Whittall, of Shell Chemicals, Canada.

Although epoxy resins are not new, they are excellent building blocks for the coatings chemist, said Mr. Whittall.

Market trends in coatings resins were reviewed and the figures indicated that epoxies constitute a significant quantity of organic coatings produced. One advantage for epoxies is that they are not subject to the regulatory pressures of other materials, explained Mr. Whittall.

The application of epoxy resins in water-borne finishes was outlined including the chemistry and mechanism involved. According to Mr. Whittall,

they have proved very successful in cathodic electrodeposition automotive primers providing greater corrosion resistance compared to anodic deposition coatings. Water-borne epoxies have also proved to give excellent performance in lining beer and beverage cans due to outstanding adhesion, lower organoleptic effects, and high corrosion resistance compared to conventional coatings. Catalysts and bake cycles were discussed by Mr. Whittall.

Also available are water-borne ambient cure systems and due to the variety of curing agents available, the formulating possibilities are infinite, said Mr. Whittall.

Epoxies have been developed for use in high solids coatings which are currently the center of attention in development of compliance coatings systems, explained Mr. Whittall. Here, economics are evident due to solvent reduction alone. Relationships between solids content and viscosity, storage stability versus catalyst level, and storage stability versus solids level (55-80%) were discussed.

New low viscosity, weatherable epoxy resins were described which when formulated as a high solids baking finish exhibited superior color stability and durability compared to the acrylic and corresponding conventional liquid epoxy controls. Two package coatings in a 600 hour UV test showed excellent gloss retention and durability close to polyester/urethane systems, suggesting potential for use in high performance applications, according to Mr. Whittall.

The development of powder coatings was discussed. Mr. Whittall stated that 10 years ago the greatest hope for powder was in the automotive field since this industry indicated that all cars would be powder coated by 1975. However, powder coating is still alive and well with only a minor share in automotive appli-



Montreal Society Executive Committee for 1981-82. Seated (left to right): Secretary—Eric Templeton; Treasurer—Bert Papenburg; President—Raye Fraser; and Vice-President—John Flack. Standing (left to right): Jean Brunet, Bob Payette, Luigi Catroni, Joe Roberge, and Dave Gerelus

cation. Other markets have not developed as fast as anticipated, but the steadily growing demand has seen the evolution of a number of resin systems and curing agents, said Mr. Whittall. The epoxy resins themselves have not changed in basic design except for a much wider range of molecular weight being made available.

Mr. Whittall concluded with the hope that his presentation had helped to convey the versatility displayed by epoxy resins in the formulation of coatings systems.

ERIC J. TEMPLETON, *Secretary*

New England

Nov. 19

William B. Neuberg, of Shamrock Chemical Corp., spoke on "AN INVESTIGATION OF ABRASION RESISTANCE."

Mr. Neuberg defined wax and illustrated by slides that it is crystalline in nature due to its effects on polarized light. The slides showed that waxes migrate to the surface and provide their mar resistance by acting as a lubricating wedge between the paint surface and the abrading surface. Only small amounts are necessary to function as a surface lubricant. The effects can be demonstrated at the 0.5% level, and 2% appears to be the maximum level before the wax effects gloss, explained Mr. Neuberg. The lubricity of the wax is caused by the wedge formed as the wax liquifies under pressure.

PTFE (polytetrafluoroethylene) can be used to obtain surface lubricity also, but, unlike a wax, its performance is the result of shear along the crystal planes of the PTFE particles, explained Mr. Neuberg.

Water-borne coatings generally require a greater addition of wax to get the same effect as noted in a solvent-borne coating, said Mr. Neuberg.

Special waxes have been developed to minimize effects on gloss by lowering the number of fines, according to Mr. Neuberg. The largest particle size possible should be used to minimize effects on gloss and maximize positive lubricity effects. Mr. Neuberg stressed that it is the number of particles present that effect the gloss; a larger number of particles will tend to lower the gloss more effectively than a few particles.

Mr. Neuberg mentioned that melting point correlates closely with solubility, and that recoatability becomes a problem with highly soluble waxes.

Q. Do the density differences cause variations in degree of floating or migration of the waxes?

A. The surface tension forces are the

major influence and are so much greater that they swamp the gravitational forces.

Q. Does the wax hardness effect block resistance?

A. Higher melting point waxes usually give better block resistance, but waxes are generally not used in this case.

Q. How do harder waxes effect mar resistance?

A. Harder waxes are generally more effective, but the formulator must be aware of other problems such as solubility.

Q. Do waxes effect outdoor durability?

A. Tests are limited, but there appears to be no effect.

Q. Are there calculated HLB values for waxes?

A. This is being worked on, but any of the waxes can go into water using wetting agents.

Q. What is the difference between polyethylene waxes and polypropylene waxes?

A. Very little. Differences are more likely related to melting point.

N. BRADFORD BRAKKE, *Secretary*

Northwestern

Oct. 6

Dr. Albert L. Rocklin, of Shell Development Co., presented a talk entitled "COMPUTER PREDICTION OF EVAPORATION OF AQUEOUS SOLVENT BLENDS WITH ANY NUMBER OF COSOLVENTS AT ANY HUMIDITY."

Shell Development originally developed the equations and methods of predicting the evaporation of blends of hydrocarbons and oxygenated solvents. As the solvents evaporate, the solvent balance changes and the solvent remaining could have a preponderant effect on the paint, explained Dr. Rocklin. The addition of water to solvent blends presents other complications as well. As with conventional solvent blends, the water blends have to be chosen for proper application. The viscosity has to be right, the blend has to atomize properly, have the correct rheology, and has to dry at an acceptable rate. So, the interest in evaporation is of considerable importance, said Dr. Rocklin.

The film quality is effected by the solvent balance. The rate of evaporation is very important as it is possible to get a kick out if the solvent balance remaining in the paint during the evaporation is not correct, explained Dr. Rocklin.

With water being introduced to paints one further complication arises. Relative humidity can have a devastating effect on the properties of paint. The reason

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The 1981-82 Northwestern Society Officers. From left to right: Treasurer—Robert Mady; Vice-President—Donald Emch; President—Dale Ernst; Secretary—Herb Davidson; and Council Representative—Lowell Wood

for this is as the humidity goes up it can slow down the evaporation of the water component of a blend of water and cosolvents, explained Dr. Rocklin. If the cosolvents must be present throughout the evaporation or at least at the end of the evaporation, it is possible that in a high relative humidity area that the humidity will hold back the water and that the cosolvents could evaporate before the water, causing an undesirable effect in the paint.

A computer program was developed to try to understand what effect humidity has on the evaporation characteristic of blends of water and cosolvents, said Dr. Rocklin. It doesn't do everything but it does enough to be a useful tool, he added.

The evaporation characteristics of solvents and solvent blends are measured by using ASTM D-3539 method, standard conditions, known air stream and using a filter paper suspended on a scale in a chamber which is continually being weighed and recording the weight loss. Using a standard test procedure they can compare the evaporation rate of various solvents, said Dr. Rocklin. An example of the range in evaporation rates was: Acetone—82 seconds; Water—1300 seconds; Butyl Ether of Ethylene Glycol—6500 seconds. Using this method they have assigned numerical rates to the various solvents.

Their laboratory work pointed out the importance of humidity on the evaporation rate of blends containing water and cosolvents. They were able to create an equation which will predict the way in which a blend of solvents will evaporate if that blend was put on the filter paper in the evaporometer, explained Dr. Rocklin. Not only did they want to know at what rate the solvent blend will evaporate but also the curve of the evaporation rate. The evaporation curve is very useful in comparing solvent blends, according to Dr. Rocklin. Not only did they want to calculate the rate of evaporation but they wanted to know

the composition of the blend as it evaporates. This is quite an important factor in making up a solvent blend.

Larry Brandenburger was a pioneer in this work. The evaporation rate of a blend of solvents consists of contributions from each solvent, said Dr. Rocklin. Calculate what the contribution of each solvent is to the evaporation. The contribution of each solvent is proportional to its concentration and is also proportional to what the individual evaporation rate of the solvent is when it is by itself. However, this is only true if you have a perfect solution. A fudge factor, activity coefficient, was added to the equation which translated it from perfection to reality. The activity coefficient can be calculated so you don't have to obtain it from laboratory work, said Dr. Rocklin.

One must also take into account the effect of temperature as the activity coefficient is strongly affected by the temperature, explained Dr. Rocklin. He showed the evaporation equation which they developed. You then have to correct for humidity, but it's only water where they correct because it affects only the water component of the blend. The other solvents do not see the water vapor. It is only the water that sees the water vapor and has its rate of evaporation suppressed according to what the concentration of the water is in the water vapor above it. The reason the blend evaporates more slowly, according to Dr. Rocklin, is that the cosolvents are being kept in a state of dilution and the dilution factor is slowing down the evaporation and not the humidity directly.

The computer program will calculate time to reach different stages of evaporation, draw a curve, how much has evaporated as a function of time, and calculate solvent balance as the evaporation proceeds. What are the individual concentrations of each solvent as the evaporation proceeds? This program will calculate it for you, said Dr. Rocklin.

If no water is present, it will calculate

solution parameters like hydrogen bonding, polarity, etc. This is useful if you are looking for a solvent blend replacement. It will also give you a cost for all the various blends. The computer is well suited to run the calculation as each 5% of the blend evaporates.

Dr. Rocklin showed the relationship of an evaporation curve of a blend of 3 components; one being water at 15% relative humidity. It was 1178 seconds. At 75% relative humidity it was 3680 seconds, almost three times as long. The water was being held back by the high relative humidity. At the 75% relative humidity, the water became enriched. By the time we had evaporated 60%, we had lost all the cosolvents. If you didn't need the cosolvents at the end you were all right. If you did, you were in trouble. They verified the computer prediction with a laboratory evaporation test. The results showed that they were very close together, therefore, they felt they could predict evaporation characteristics, said Dr. Rocklin.

Examples of evaporation characteristics of various blends of solvents and methods of changing cosolvents using the computer to predict the composition during evaporation were given by Dr. Rocklin. The method accommodates blends containing water with as many cosolvents as you want to put in. It predicts the evaporation characteristics of any blend you make and at any humidity you desire, explained Dr. Rocklin.

An on-line demonstration of the computer program was given using data submitted by some of the people that were in attendance.

HERB DAVIDSON, *Secretary*

Pacific Northwest Oct. 22

William E. Machermer, of Troy Chemical Co., spoke on the "USE OF MERCURY IN PROTECTIVE COATINGS."

"With the possible banning of mercury, what do we do for a preservative?", asked Mr. Machermer. A number of different mercury products have been tested as well as nonmercuricals, explained Mr. Machermer. The mercury products were more effective than nonmercuricals but some new nonmercuricals showed promise. We must find preservatives for clay and titanium slurries so that there is no discoloration. A 0.1% amino methyl addition to slurries seems to help, said Mr. Machermer.

Mr. Machermer concluded that mercury is still the best preservative but is not totally effective against sulfur organisms in clay slurries. Few fungicides protect paint from but a combination of non-mercury and mercury compounds seems to work the best.

O. SCHMIDT, *Secretary*

Philadelphia

Nov. 12

Robert Dey, of NL Chemicals, Inc., presented "PAINT RHEOLOGY AND RHEOLOGICAL ADDITIVES."

The basics of rheology were presented as they relate to paint manufacture and paint performance. Mr. Dey then discussed the proper selection of rheological additives (organic or inorganic) with respect to paint type, manufacturing procedures, and paint performance.

Slides illustrated both data and visible effect of rheological additives on coating performance. Mr. Dey stressed the importance of procedure in using these very low level but powerful additives.

Q. In reference to a given grade of organo-clay in an aliphatic system, is there any advantage to making the thickener slurry first without the resin?

A. Not any great advantage. The resin will give the pregel some flow and the opposite is usually true. The thickener without resin is short and buttery.

Q. Would the organo-clay used in an aliphatic system be usable in a more polar toluol-xylol system with a different polar additive?

A. The ultimate adjusted polarity of the system will determine this. An organo-clay designed for a very polar ketone-ester system may not require any polar activator. In borderline systems, like toluol-xylol, the situation is critical. Most probably a different organo-clay would be preferred. To try to use the same organo-clay with its activator would probably mean going outside the manufacturer's recommendations. It is always much better to stay within the maker's recommendations. You would not use a product geared for ketone and alcohols in an aliphatic system. It probably would not disperse.

RALPH MYERS, *Secretary*

Piedmont

Nov. 18

Richard L. Hong, of Spencer Kellogg Div. of Tectron, Inc., discussed "FORMULATING FOR HIGH SOLIDS IN INDUSTRIAL COATINGS."

The use of high solids coatings is gaining increased acceptance throughout industry due to the rising costs of organic solvents and governmental air emission regulations, explained Mr. Hong. The need to control product costs and reduce VOC emissions in the work area forces the paint formulator to investigate high solids formulations. There are six categories that the formulator should research while developing a high solids system, according to Mr. Hong. As follows: (1) Solvent: low specific gravity, low viscosity, V.O.C. level application

property and solids content; (2) Cross-linkers: amino resins, epoxy resins, urethane resins; (3) Catalyst: strong acids, weak acids, or metal salts; (4) Pigments: avoid pigments of high pH and high oils demand; (5) Additives: low viscosity additives for sag control; pigment suspension, surfactants; and (6) Reactive Diluents: low viscosity, excess functional groups, humidity resistance, durability.

High solids coatings systems initially cost more per gallon but with greater mileage than conventional systems, the product costs are very competitive and environmentally acceptable, said Mr. Hong. High solids systems are not the ultimate answer to industry's coating needs but allow the formulator an opportunity to meet the technical challenge of today's consumer.

J.E. HUSTED, *Secretary*

Pittsburgh

Nov. 2

"USE OF TITANATE COUPLING AGENTS IN COATINGS" was presented by David Busker, of Kenrich Petrochemicals, Inc.

In formulating coatings, the amounts of functional fillers have increased without affecting the properties of the coating, explained Mr. Busker. Titanates can be used to replace inhibitive pigments in corrosion resistant coatings. According to Mr. Busker, they can be used in polypropylene coatings, epoxy coatings, and electrical coatings.

Q. What is the effect on exterior durability?

A. Exterior durability should improve because of hydrophobic qualities of titanates and improved adhesion.

Q. Will they interfere with other additives?

A. Titanates will help reduce or eliminate the use of other additives.

Q. Can more than one titanate be used to improve certain qualities?

A. This can be done but they should be introduced separately to the mix and not be mixed together.

Q. Can titanates be used in FDA approved coatings?

A. We wouldn't recommend it.

MICHAEL GILLEN, *Secretary*

St. Louis

Oct. 20

Pat Nickens, of Radio Shack, Division of Tandy Corp., spoke on the topic of "MICROCOMPUTERS."

Mr. Nickens stated that he sees the field of microcomputers today in the early stages of an explosion that will change our lives and our world. His main

points about microcomputers included (1) they handle data fast and error free; (2) when you buy a microcomputer system be sure it can not only do the immediate job but be expandable; (3) do not expect too much too early; (4) microcomputer technology is advancing rapidly: two advancements include hard discs to replace floppy discs and the capability of connecting 255 computers together; and (5) when considering software remember that programmers are expensive; adjusting to ready-made programs is less expensive.

Q. Can further price reductions and advancements in microcomputer hardware and software be expected?

A. In my opinion, Yes!, but don't wait to buy. You will be further and further behind in the learning process involved.

Q. Can Tandy software handle cost changes of paint raw materials to change many computer reports?

A. Yes! Tandy's VisiCalc program.

Q. Is Fortran Language used?

A. It can be, but for more complicated set-ups, ie. 255 computers hooked up together, ASYNC is used for one way and BISYNC is used for two way communication.

Charles Fuller, of Reichard-Coulston, Inc., gave a review featuring "SYNTHETIC IRON OXIDES, NATURAL IRON OXIDES, AND RAW AND BURNT UMBERS AND SIENNAS."

Mr. Fuller exhibited numerous color drawdowns made from 30% Yellow Oxide plus white, plus various organic colors. These colors are not as brilliant as 100% organic colors but are being accepted because they are cheaper, lead-free alternatives with good hiding, explained Mr. Fuller.

Mr. Fuller discussed Miceaceous Iron Oxide—an opaque, nonmagnetic, lamellar, flaky pigment with particles 100-150 microns long and 10 microns thick. This pigment, MIOX, at four to five pounds per gallon in structural steel coatings gives excellent corrosion protection by its lamellar shape protecting the binder. Slides were shown exhibiting excellent long term corrosion protection on European bridges. This pigment is metallic black and glitters on age in an exposed film, said Mr. Fuller. It has worked very well in silicone alkyds and in chlorinated rubber coatings. Ten percent of aluminum is often added for a consistent metallic color.

Q. Are certain vehicle types recommended for use with MIOX?

A. Excellent results have been ob-

tained with long oil alkyds, parlon, vinyl, epoxy, and coal tar epoxy.

Q. Is MIOX heat resistant?

A. Yes! Will withstand 1000° F.

Q. Is MIOX sensitive to overgrinding?

A. Yes! Goes red.

ROBERT J. GIERY, *Secretary*

St. Louis

Nov. 17

Dr. Loren W. Hill, of Monsanto Plastics and Resins Co., spoke on "DESIGN CONSIDERATION FOR HIGH SOLIDS REACTIVE COATINGS."

Dr. Hill discussed the viscosity in unpigmented coatings. At temperatures

above T_g (glass transition temperature), volume increases. T_g determines viscosity in high solids polymers, explained Dr. Hill. A lower molecular weight means a lower T_g, more volume, and flow.

In solvent selection, three important factors should be stressed: reduced T_g, H bonding, and solubility parameter, said Dr. Hill. High H bonding cuts viscosity and the type of H bonding is also important, eg., OH bonds of polymers not interrupted by xylene creates poor H bond, and therefore, high viscosity. A high number of OH bonds in a polymer and a high molecular weight also creates high viscosity. According to Dr. Hill, different solvents interact differently due to H bonding. If the solvent parameter is

too different between the polymer and the solvent, high viscosity is produced.

Viscosity in pigmented coatings was discussed. Pigments added to the polymer and flocculation increase viscosity, said Dr. Hill. A lower viscosity will be attained when some binder is replaced with more pigment.

In the curing process, structure, gel point, and stability are important, according to Dr. Hill. Chain extension of the polymer is needed during the curing process followed by complete cure. Approximately twice as much crosslinker is needed to cure the low molecular weight in high solids baking polymers.

Q. Can initiators be used for cure?

A. Yes.

Q. Define gel point.

A. Rapid rise in viscosity, no more massive flow.

Q. Can the H bonding interaction of solvents with high solids polymers lead to new types of solubility parameters for solvent selection with these polymers?

A. More work could lead to this.

Q. Is oil absorption of pigments helpful in high solids design?

A. Yes, same as conventional.

ROBERT J. GIERY, *Secretary*



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Toronto

Oct. 5

"CHLORITE: A NEW EXTENDER IN THE PAINT INDUSTRY" was presented by William D. Meadows, of Cyprus Industrial Minerals Co.

Mr. Meadows explained that chlorite combines many of the properties of clays and talcs. He discussed the chemistry and structure of the extender. It has a platy structure and is easily dispersible in water-based and solvent-based paints.

The pigment has been used for many years in the ceramic industry, explained Mr. Meadows, and is presently being refined for the paint industry. The raw material, which is being mined in Montana, has advantages such as: low settling tendencies because of its platy structure; no frosting in dark colored latex paints; good durability; good scrub; and burnishing properties.

Results of evaluations were shown of chlorite extenders versus delaminated and calcined clays. Mr. Meadows explained that the results generally showed that the calcite pigment compared very favorably to the calcined and delaminated clays for optical and film integrity properties. The use of this extender also permits the reduction of TiO₂ in latex flat wall paints, said Mr. Meadows.

R. KUHNEN, *Secretary*

Future Society Meetings

Birmingham

(Feb. 26)—ANNUAL LADIES NIGHT.
(Mar. 4)—“WETTING AND DISPERSING AGENTS FOR NON-AQUEOUS SYSTEMS”—Mr. Quednau, Byk-Mallinckrodt Chem. Prod. GmbH, Ltd.
(Apr. 1)—“COPING WITH UNCERTAINTY IN BUSINESS”—L.N. Sneddon, Sundridge Park Management Center.
(May 6)—“COMPARISON OF EXPOSURE TEST METHODS”—Speaker from Hoechst UK Ltd.

Chicago

(Mar. 1)—“ANATOMY OF A LATEX PAINT”—Dr. L.R. Freimiller, Rohm and Haas Co., and “GLOSS LATEX PAINTS”—J. Bax, Pacific Scott Bader Co.
(Apr. 5)—“TECHNICAL EFFECTIVENESS”—E.B. Euchner, SCM Corp., and “STRESS MANAGEMENT”—Mel Clapp, Cities Service.

Cleveland

(Feb. 16)—JOINT MEETING with National Association of Corrosion Engineers. “STATISTICAL ANALYSIS AND EXPERIMENTAL DESIGN FOR COATINGS CHEMISTS”—Earl Hill, Lord Corp. “POLYURETHANE COATINGS FOR HEAVY DUTY MAINTENANCE”—Richard Hergenrother, Mobay Chemical Co.
(Mar. 16)—MINI-SYMPOSIUM on High Solids. “VERSATILITY OF HIGH SOLIDS INDUSTRIAL COATINGS”—Rich Johnson, Cargill, Inc. “DESIGN CONSIDERATIONS FOR HIGH SOLIDS REACTIVE COATINGS”—Dr. Loren W. Hill, Monsanto Plastics and Resins Co.
(Mar. 23-24)—25th SYMPOSIUM ON ADVANCES IN COATINGS TECHNOLOGY.

Dallas

(Mar. 11)—“OPTIMIZING RESINS AND SOLVENTS FOR LOW VOC HIGH SOLIDS COATINGS”—Steve Belote, Eastman Chemical Co.
(May 13)—“ANATOMY OF AN EMULSION POLYMER”—Benjamin Kine, Rohm and Haas Co.

Golden Gate

(Feb. 15)—“ANIMATION MAGIC—THE PART PAINTS PLAY”—Ron Stark, International Animated Film Society.

(Mar. 15)—“THE UNIQUE PROPERTIES OF ULTRA-FINE SILICA”—John C. Becker, Jr., Omya, Inc.
(Apr. 19)—“HAZARDOUS WASTE DISPOSAL”—Michael L. Markowitz, Rollins Environmental Services of Texas, Inc.
(May 17)—“NEW DEVELOPMENTS IN SANDMILL DISPERSIONS TECHNOLOGY”—Ronald E. Swett, Moorehouse Industries, Inc.

Houston

(Mar. 10)—“OPTIMIZING RESINS AND SOLVENTS FOR LOW VOC HIGH SOLIDS COATINGS”—Steve Belote, Eastman Chemical Products, Inc.
(May 12)—“ANATOMY OF AN EMULSION POLYMER”—Benjamin Kine, Rohm and Haas Co.

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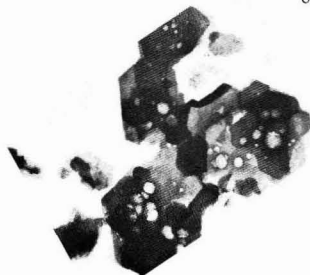
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Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Eudowood Gardens, Towson). JOSEPH D. GUISTO; Lenmar, Inc., 150 S. Calverton Rd., Baltimore, MD 21223.

BIRMINGHAM (First Thursday—Calthorpe Suite, Edgbaston). D. H. CLEMENT, Holden Surface Ctg. Ltd., Bordesley Green Rd., Birmingham B94TQ, England.

CHICAGO (First Monday—meeting sites in various suburban locations). JOHN R. INGRAM, DeSoto, Inc., 1700 S. Mt. Prospect Rd., Des Plaines, IL 60018.

C-D-I-C (Second Monday—Sept., Jan., Apr., June in Columbus; Oct., Dec., Mar., May in Cincinnati; Nov., Feb., in Dayton). ROBERT A. BURTZLAFF, Potter Paint Co. of Ind., P.O. Box 265, Cambridge City, IN 47327.

CLEVELAND (Third Tuesday—meeting sites vary). DONALD C. DENISON, JR., Hilton Davis Chemical Co., 5254 Berkshire Dr., N. Olmsted, OH 44070.

DALLAS (Thursday following second Wednesday—Steak & Ale Restaurant). T. LEON EVERETT, Dan-Tex Paint & Ctg. Mfg., Inc., P.O. Box 18045, Dallas, TX 75218.

DETROIT (Fourth Tuesday—meeting sites vary). SHEILA G. DRAKE, Wyandotte Paint Products, Inc., 650 Stephenson Hwy., Troy, MI 48084.

GOLDEN GATE (Monday before third Wednesday—Alternate between Sabella's Restaurant on Fisherman's Wharf and the Sea Wolf at Jack London Square, San Francisco). KEN E. TRAUTWEIN, Sherwin-Williams Co., P.O. Box 23505, Oakland, CA 94623.

HOUSTON (Second Wednesday—Sonny Look's, South Main). GEORGE SCHWARTZ, Cook Paint & Varnish Co., P.O. Box 3088, Houston, TX 77001.

KANSAS CITY (Second Thursday—Cascone's Restaurant). MEL BOYER, Patco Coatings Products, 3947 Broadway, Kansas City, MO 64111.

LOS ANGELES (Second Wednesday—Steven's Steak House). EARL SMITH, Spencer Kellogg Div., Tectron, Inc., P.O. Box 7205, Long Beach, CA 90807.

LOUISVILLE (Third Wednesday—Hasenour's Restaurant). E. D. THOMASON, Louisville Varnish Co., 1400 Maple St., Louisville, KY 40207.

MEXICO (Fourth Thursday—meeting sites vary). TERESA SUAREZ, Sherwin-Williams Co., Mexico, D.F., Mexico.

MONTREAL (First Wednesday—Bill Wong's Restaurant). ERIC TEMPLETON, NL Chemicals Can., Inc., 2140 Sun Life Bldg., Montreal, Que., Can., H3B 2X8.

NEW ENGLAND (Third Thursday—Fantasia Restaurant, Cambridge). N. BRADFORD BRAKKE, Lilly Chemical Products, P.O. Box 188, Templeton, MA 01458.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). H. ELLIS, D. H. Litter Co., Inc., 116 E. 16th St., New York, NY 10003.

NORTHWESTERN (Tuesday after first Monday—Edgewater East Restaurant). HERBERT DAVIDSON, Spencer-Kellogg Div., Tectron, Inc., 525-25th Ave. S.E., Minneapolis, MN 55414.

PACIFIC NORTHWEST (Portland Section—Tuesday following second Wednesday; Seattle Section—the day after Portland; British Columbia Section—the day after Seattle). WILLIAM SHACKELFORD, Gaco-Western, Inc., P.O. Box 88698, Seattle, WA 98188.

PHILADELPHIA (Second Thursday—Valle's Steak House). RALPH MYERS, Del Vac Ink & Color Co., 1301 Taylors Ln., Riverton, NJ 08077.

PIEDMONT (Third Wednesday—Howard Johnson's Coliseum, Greensboro, NC). JAMES E. HUSTED, Mobil Chemical Co., P.O. Box 2438, High Point, NC 27261.

PITTSBURGH (First Monday—Skibo Hall, Carnegie Mellon Univ.). MICHAEL GILLEN, Van Horn, Metz & Co., Inc., 400 Keystone Dr., Carnegie, PA 15106.

ROCKY MOUNTAIN (Monday following first Wednesday—Gusthaus Ridgeview, Lakewood, CO). DONALD SHILLINGBURG, Union Chemical Div. of Union Oil, 1535 W. 13th Ave., Denver, CO 80204.

ST. LOUIS (Third Tuesday—Salad Bowl Restaurant). ROBERT J. GIERY, Spatz Paint Industries, Inc., 1601 N. Broadway, St. Louis, MO 63102.

SOUTHERN (Gulf Coast Section—Various Dates; Central Florida Section—Third Thursday after first Monday; Atlanta Section—Third Thursday; Memphis Section—Second Tuesday; Miami Section—Tuesday prior to Central Florida Section). J.E. GEIGER, Sun Coatings, Inc., 12295 75th St., N., Largo, FL 33540.

TORONTO (Second Monday—Mayfair Restaurant). R. KUHNEN, Tioxide Canada, Inc., 1 Eva Rd., Etobicoke, Ontario, Canada M9C 4Z5.

WESTERN NEW YORK (Third Tuesday—Lord Amherst Restaurant, Williamsville, NY). MICHAEL C. KAUFMAN, Bisonite Co., Inc., P.O. Box 84, Kenmore St., Buffalo, NY 14217.

Los Angeles

(Mar. 10)—"UNIQUE PROPERTIES OF ULTRA FINE SILICA"—John C. Becker, Jr., Omya, Inc.

(Apr. 14)—"HAZARDOUS WASTE DISPOSAL"—Michael L. Markowitz, Rollins Environmental Services of Texas, Inc.

(May 12)—"NEW DEVELOPMENTS IN SANDMILL DISPERSION TECHNOLOGY"—Ronald E. Swett, Moorehouse Industries. (June 9)—"COMPLIANCE SOLVENTS FOR INDUSTRIAL COATINGS"—Violette Stevens, Dow Chemical Corp.

Montreal

(Mar. 3)—JOINT MEETING with Quebec Paint Industry Association (AQIP). (Apr. 7)—Manufacturing Committee Presentation.

(May 5)—"THE PURCHASING, SALES INTERFACE"—John Humfreys, Sherwin-Williams Co., and Paul Rheaume, NL Chemicals, Canada, Inc.

Piedmont

(Feb.)—JOINT DINNER/DANCE with Piedmont Paint & Coatings Association. (Mar. 17)—"COMPLIANCE—SOLVENT OPTIONS"—Speaker from Dow Chemical Corp.

(Apr.)—JOINT MEETING with Virginia Section.

(May 20)—"COMPUTER SELECTION OF SOLVENT BLENDS"—Dr. Albert Rocklin, Shell Development Co.

(June 16)—"ECONOMIC RECOVERY OF SOLVENT VAPORS"—Larry J. Durr, DCI Corp.

Pittsburgh

(Mar. 1)—"THE WHYS AND WHEREFORES OF CARTRIDGE FILTRATION IN THE COATINGS INDUSTRY"—Donald S. Onnen, AMF Cuno Div.

(Apr. 5)—"ENVIRONMENTAL UPDATE"—Dr. Hugh M. Smith, Sun Chemical Co.

(May 3)—"DESIGN CONSIDERATION FOR HIGH SOLIDS REACTIVE COATINGS"—Dr. Loren W. Hill, Monsanto Plastics and Resins Co.

Rocky Mountain

(Mar. 8)—"THE UNIQUE PROPERTIES OF ULTRA FINE SILICA"—John C. Becker, Jr., Omya, Inc.

(Apr. 12)—"HAZARDOUS WASTE DISPOSAL"—Michael L. Markowitz, Rollins Environmental Services of Texas, Inc.

St. Louis

(Feb. 16)—VALENTINE'S NIGHT and Federation Visit.

Elections

BALTIMORE

Active

CHRISTHILF, HAROLD—Sherwin-Williams Co., Baltimore, MD.
DEAR, HING—Tracor, Inc., Crofton, MD.

Associate

DE MOHAN, SAIENDRA—W.D. Byron & Sons, Inc., Williamsport, MD.
McKAMY, CHARLOTTE—Cummings Chemical Co., Elkridge, MD.
PIGNETI, VINCENT—Genstar Corp., Hunt Valley, MD.

BIRMINGHAM

Active

CHOUHAN, BHANUBHAI—Croda Paints Ltd., Birmingham, England.
PITT, DAVID D.—R. Cruickshank Ltd., West Midland, England.
REILLY, ANNE B.—Holden Surface Ctg., Birmingham, England.
ROBERTS, JACK F.—Dexter Midland Ctg., Clwyd., England.

C-D-I-C

Active

BUFKIN, B. GEORGE—DAP Inc., Dayton, OH.
ECKLER, PAUL E.—International Minerals and Chemicals Corp., Terre Haute, IN.
ENGELKE, WILLIAM—Muller Ind., Inc., Cincinnati, OH.
PASCARELLA, VINCENT J.—Riverain, Dayton, OH.
REINSEL, ROBERT W.—PPG Industries, Inc., Delaware, OH.

Associate

ROETTKER, RICHARD W.—B.H. Roettker Co., Inc., Cincinnati, OH.

CHICAGO

Active

BABNIK, TONY S.—Midland Div., Dexter Corp., Waukegan, IL.
CHIN, DANIEL V.—Universal Chem. & Coating, Elk Grove Village, IL.
FISCHER, DAVID—Mobil Chemical Co., Kankakee, IL.
FLAMENT, MARY JANE—Midland Div., Dexter Corp., Waukegan, IL.
HENDRICKSON, GARY D.—Rust-Oleum Corp., Evanston, IL.
KAZIK, KRIS M.—Midland Div., Dexter Corp., Waukegan, IL.
KRAVITZ, FRAN K.—DeSoto, Inc., Des Plaines, IL.
LAFFOON, MICHAEL D.—Midland Div. Dexter Corp., Waukegan, IL.
LIETZ, DENNIS—Daubert Chemical Co., Chicago, IL.

LINDERS, ROBERT D.—Midland Div., Dexter Corp., Waukegan, IL.
McINTOSH, GERALD L.—Rust-Oleum Corp., Evanston, IL.
PANIZZI, ROGER—Mobil Chemical Co., Kankakee, IL.
RAPSON, RICHARD H.—Mobil Chemical Co., Kankakee, IL.
REASOR, LARRY L.—Midland Div., Dexter Corp., Waukegan, IL.
REINHARDT, JIM—Olympic Stain, Batavia, IL.
ROWE, CHARLES D.—Daubert Chemical Co., Chicago, IL.
SANTAMARIA, V.W.—Valspar Corp., Chicago, IL.
SCHMIDT, KARL E.—Nalco Chemical Co., Naperville, IL.
SECRETO, MARIO A.—PPG Industries, Oak Creek, WI.
SEIBEL, LAWRENCE P.—Midland Div., Dexter Corp., Waukegan, IL.
WINTERS, BILLY K.—Cargill, Inc., Carpentersville, IL.
YATES, THOMAS P.—United Coatings, Inc., Chicago, IL.

Associate

CRANSTOUN, RICHARD L.—Tenneco Chemicals, Chicago, IL.
DESIMONE, DANIEL J.—Maroon Chemical Grp., Wheaton, IL.
GENCO, PAUL V.—Thorson Chemical Corp., Des Plaines, IL.
GOLDSTON, BERNARD—Reliance Resins, Woodstock, IL.
HICKEY, PETER A.—Dow Chemical USA, Des Plaines, IL.
OTTERBEIN, WILLIAM L.—Mobay Chemical Corp., Chicago, IL.
REID, MARK J.—PPG Industries, Rosemont, IL.
NOWICKI, ROMAN—Daubert Chemical Co., Chicago, IL.
SANZO, EDWARD—T.H. Hilson Co., Richton Park, IL.
SCHMIDT, MARK H.—Mooney Chemicals, Palatine, IL.
STAYART, SCOTT H.—Reichhold Chemical, Barrington, IL.

CLEVELAND

Active

ADAMS, STEVENS J.—Midland Div. Dexter Corp., Cleveland, OH.
ALLEN, DAVID L.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
ANSPACH, JOHN A.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
AUST, THOMAS L.—Cook Paint & Varnish Co., Cleveland, OH.
BACON, AGNES K.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
BARRICK, JAMES G.—Coatings Research Group, Cleveland, OH.
BELL, ERNEST P.—Akron Paint & Varnish Co., Akron, OH.
BURGVAN, ALADAR—Ferro Corp., Cleveland, OH.

DAHL, ELIZABETH A.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
EDDINGTON, RALPH J.—Cook Paint & Varnish Co., Cleveland, OH.
GREEN, ROBERT R. JR.—Cook Paint & Varnish Co., Cleveland, OH.
HARDING, MADELYN K.—Sherwin-Williams Co., Cleveland, OH.
HERSHFIELD, STEFAN A.—Cleveland Pigments & Color, Akron, OH.
HORGER, RICHARD A.—Cook Paint & Varnish Co., Cleveland, OH.
HRICK, JAMES D.—Cook Paint & Varnish Co., Cleveland, OH.
LANCHANSKI, ANTHONY B.—Cook Paint & Varnish Co., Cleveland, OH.
LOWETH, CHARLES F.—Sherwin-Williams Co., Cleveland, OH.
MAMBUCA, LOUIS J.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
MANN, LARRY J.—Universal Cooperatives, Alliance, OH.
PLOCIAK, RICHARD—Davies Can Co., Solon, OH.
REBAR, JOHN THOMAS—Glidden Ctg. & Resins Div. SCM Corp., Westlake, OH.
ROSLAN, RICHARD R.—Cook Paint & Varnish Co., Cleveland, OH.
SALVAGGIO, JAMES—Body Brothers, Inc., Bedford, OH.
SMITH, PRESTON D.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
TOIH, ROBERT L.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.
TSANGEOS, MICHAEL S.—Sherwin-Williams Co., Cleveland, OH.
WALTON, J.P.—Jamestown Paint & Varnish Co., Jamestown, PA.
WEIGMANN, ROBERT—Lord Corp., Erie, PA.
WOOST, CARL O.—Glidden Ctg. & Resins Div. SCM Corp., Strongsville, OH.

Associate

MALAGA, GERALD—Seegott Inc., Chagrin Falls, OH.
MCGROARY, JON T.—Tenneco Chemicals, Inc., Cleveland, OH.
OYENQUE, E.L.—Pigment & Chemical Corp., Mogadore, OH.
SELMANTS, JOSEPH P.—Monsanto Co., Medina, OH.
SOSENKO, GARY—J.M. Huber Corp., North Ridgeville, OH.

Retired

BLANK, ROBERT—Brecksville, OH.
RITTER, HARTIEN S.—Akron, OH.
WERNER, HAROLD M.—Olmsted Twp., OH.

Educator and Student

THAKKAR, SHARAD—Kent State University, Kent, OH.

GOLDEN GATE

Active

BENEDETTI, RAYMOND J.—HiLine Paint Mfg. Co., Inc., Campbell, CA.

CARDANA, DAVID A.—Sherwin-Williams Co., Emeryville, CA.
 ELWOOD, TOM—Harrison & Crossfield, Inc. Emeryville.
 ENG, RICHARD Y.—The Flecto Co., Oakland, CA.
 GATWOOD, THOMAS—The O'Brien Corp., South San Francisco, CA.
 HUFFMAN, CONSTANCE W.—The O'Brien Corp., South San Francisco.
 KANANI, JAYANT—Jasco Chemical Corp., Mountain View, CA.
 LOUKIANOFF, MICHAEL A.—Dalmo Victor Operations, San Francisco, CA.
 MANLOVE, JAMES C.—Reichhold Chemicals Corp., South San Francisco.
 POLGAR, BELA—Ampex Corp., Redwood City, CA.
 RUDOLF, HOWARD—Spencer Kellogg Div. of Textron, Inc., San Carlos, CA.
 SENFF, PHILIP T.—The O'Brien Corp., South San Francisco.
 WILLIAMS, DONALD C.—Technical Coatings, Santa Clara, CA.

Associate

SCHOFFIELD, JACK—Vivion Chemical Co., Belmont, CA.

HOUSTON

Active

BEHR, J.A.—S. Texas Tropical Weather Test Serv., Brownsville, TX.
 BRAY, HARRY—ITI Anti-Corrosion, Houston, TX.
 CONFER, KENNETH L.—Sunbelt Chemical, Houston.
 HUFFMAN, CHARLES E.—Cook Paint & Varnish, Houston.
 IGNATOV, JAMES—The O'Brien Corp., Houston.
 LAROSE, LINDA L.—Shell Oil Co., Houston.
 LINDER, KEVIN—Mastics & Adhesives, S. Houston, TX.
 LUNDQUIST, CHARLES M.—Crozier-Nelson, Houston.
 MAZZONE, DON L.—The O'Brien Corp., Houston.
 TARNEJA, PREM S.—Ferro-Lox, Houston.
 TURPIN, CYNTHIA B.—The O'Brien Corp., Houston.

Associate

BISCHOF, PAT—Hunter Laboratory, Conroe, TX.
 MATTOX, SANDRA S.—R.B. Patterson Co., Houston.
 MCALLISTER, ANDREW, A.—Gulf States Paint Co., Houston.
 SMITH, CLARK E.—Henkel Corp., Houston.
 WINTERS, MIKE—Ribelín, Houston.

KANSAS CITY

Active

BELCHER, JAMES WILLIAM—Cook Paint & Varnish Co., Kansas City, MO.
 D'ARCY, YVONNE—Cook Paint & Varnish Co., Kansas City.
 HEFLING, JERRY—Loctite Corp., Kansas City, KS.
 HENDRICK, BILL L.—Cook Paint & Varnish Co., Kansas City.

RALSTON, RONALD L.—Cook Paint & Varnish Co., Kansas City.
 VARINA, DONALD R.—Hydrozo Coatings Co., Lincoln, NE.

Associate

PERKINS, JACK H.—SCM Corp., Glidden Pigments Div., Madrid, IA.

LOS ANGELES

Active

AMPARAN, MARK—Artex Manufacturing Co., Culver City, CA.
 ANGENET, CONRAD—Western Specialty Ctg., Los Angeles, CA.
 BEAUPRE, JOSEPH A.—Lilly Industrial Ctg., Montebello, CA.
 BERRY, DAVID L.—Ameron Protective Ctg., Div., Brea, CA.
 BLODGETT, ROBERT L.—Bee Chemical Co., Gardena, CA.
 BLUNT, JOHN F.—Con/Chem, Inc., Hawthorne, CA.
 BORNEO, JOSE C.—Pacific Dispersions Co., Inc., Cudahy, CA.
 BUSTAMANTE, RAY—McCloskey Varnish Co., Los Angeles, CA.
 CABRERA, JOHN C.—Avery Label Co., Glendale, CA.
 CHANG, SHING KANG—Sinclair Paint Co., Los Angeles, CA.
 COMBS, WAYNE E.—Pratt & Lambert, Inc., Orange, CA.
 DENNEY, VERLIN—Guardsman Chemicals, Southgate, CA.
 DICKMAN, ROBERT F.—Reichhold Chemical Co., Azusa, CA.
 DULLUM, BRUCE E.—Bechtel Group Inc., Norwalk, CA.
 DYBAS, CHESTER A.—Kelly Moore Paint Co., Inc., Ontario, CA.
 ESQUEDA, RUBEN A.—Tnemec Co., Inc., Compton, CA.
 FENSKE, DAN—Bostik West Div. USM Corp., Torrance, CA.
 FIFER, VERN—Dunn-Edwards Corp., Los Angeles, CA.
 GARCIA, JORGE D.—Pinturas Agricolas E. Inds. S.A., Zapopan, Mexico.
 GRIMM, FLOYD E.—Dunn-Edwards Corp., Los Angeles.
 GROSS, EDWARD A.—Engard Ctg. Corp., Huntington Beach, CA.
 HALL, JAMES D.—Fredericks-Hansen Paint Co., San Bernardino, CA.
 HARRISON, WILLIAM C.—Swedlow, Inc., Garden Grove, CA.
 HARNACK, GERHARD—Ameron Protective Ctg. Div., Brea.
 HEIBER, WILLIAM G.—Deer-O-Paints, Phoenix, AZ.
 HOLDER, JIM R.—McCloskey Varnish Co., Los Angeles, CA.
 HUBERT, KIM H.—Stic-Adhesive, Los Angeles, CA.
 JOHNSON, ROBERT A.—Western Specialty Ctg., Los Angeles.
 KAPADIA, SAILAN JOHN—Cargill Inc., Lynwood, CA.
 KATIGBAK, ESTRELLA G.—Ameron Protective Ctg. Div., Brea.
 KEISLER, GREG—Ameron Protective Ctg. Div., Brea.
 KHAN, OMAR—Zolatone Process, Inc., Los Angeles, CA.

KING, JOSEPH E.—Chemical Ctg. Corp., Westlake Village, CA.
 MANNINO, FRANK—Devoe Marine Ctg., Riverside, CA.
 MAY, GORDON—Pacific Dispersions Co., Inc., Cudahy.
 MCKIBBEN, CHARLES J.—Ameritone Paint Corp., Long Beach, CA.
 MCNAUGHTON, MICHAEL—Modern Ctg., Inc., Cerritos, CA.
 MENDOZA, MYRNA Q.—Lilly Industrial Ctg., Montebello.
 MITRA, ARUP R.—Trail Chemical Corp., El Monte, CA.
 MITZEL, WILLIAM J.—Oil & Solvent Process Co., Azusa, CA.
 MORA, AGUSTIN—Pinturas Agricolas E. Inds. S.A., Zapopan, Mexico.
 MOSES, GEORGE DR.—Avery Label Co., Azusa.
 MULDOWN, MICHAEL J.—Mar-Lak Industrial Ctg., Hawaiian Gardens, CA.
 NEUBAUER, KENNETH P.—Devoe Marine Ctg., Riverside, CA.
 PARATHARA, THOMAS J.—Harshaw Chemical Co., Sylmar, CA.
 PARSON, LEE M.—Ameron Corporate Res., South Gate, CA.
 ROSENFELD, NORMAN—Chemical Technology Labs, Lynwood, CA.
 SARTI, EDUARDO L.—Lilly Industrial Ctg., Montebello.
 SCHOWENGERDI, RON—PPG Industries, Inc., Torrance, CA.
 SENKLER, ALBERT—Ameron Protective Ctg. Div., Brea, CA.
 SHAH, SUBHASH—Koppers Co., Los Angeles, CA.
 SHAH, TUSHAR—Spectratone Paints, South El Monte, CA.
 SHIMOYAMA, ISAO—Edoco Technical Products, Long Beach, CA.
 SIY, ENRIQUE—Bauer Div. of Wittaker Ctg. & Chemicals, Los Angeles, CA.
 SOUZA, RONALD—Ameritone Paint Corp., Long Beach.
 STANBRIDGE, WALTER L.—WLS Ctg., Inc., Harbor City, CA.
 STEPHENSON, WILLIAM C.—Devoe Marine Ctg., Riverside.
 THIES, JAMES P.—Ashland Chemical Co., Santa Fe Springs, CA.
 THOMPSON, CARL V.—Pemaco, Inc., Maywood, CA.
 VAN PATTEN, BRUCE E.—Lyle Van Patten Co., Los Angeles.
 WICHSLER, MIKE—WLS Ctg., Inc., Harbor City.
 WEISMAN, MARTIN J.—Sher-Mar Cosmetics, Gardena, CA.
 WIDNER, RONNIE—Benjamin Moore & Co., Los Angeles, CA.
 YOUNGER, ALONZO—Ameron Protective Ctg. Div., Brea.
 YU, CICHIA L.—Pacific Dispersions Co., Inc., South El Monte, CA.
 ZYWOCHENSKI, JOHN M.—Consultant, Whittier, CA.

Associate

ARMSTRONG, BOB—McKesson Chemical Co., Riverside, CA.
 BIXLER, NANCY H.—Borden Chemical Inc., Compton, CA.
 BROOKS, GARY L.—Oil & Solvent Process Co., Azusa, CA.
 CIAMBELLA, PERRY A.—Spencer Kellogg Div. Textron, Inc., Long Beach, CA.

DETLAUF, KEN S.—Oil & Solvent Process Co., Azusa.
 DYE, JAMES A.—Trans Western Chemicals, Cerritos, CA.
 ELLIS, ANDREW R.—NL Industries, Inc., Los Angeles, CA.
 ESCHBORN, RALPH J.—duPont de Nemours & Co., Inc., Laguna Hills, CA.
 HEFFERN, DON—John K. Bice Co., Los Angeles, CA.
 JOHNSON, RON—TCR Industries, Inc., Carson, CA.
 JOOS, WILLIAM H.—Sun Chemical Corp., Santa Ana Hts., CA.
 KECK, JERRY R.—Stan Keck Co., Orange, CA.
 KIRSCH, HENRY J.—Trans Western Chemicals, Cerritos.
 KNIGHT, LARRY P.—Alcolac, Chatsworth, CA.
 KNUFVEN, ROBERT U.—Dow Chemical U.S.A., Pasadena, CA.
 LLOYD, BRENT—Day-Glo Color Corp., South El Monte, CA.
 MCCAULEY, MICHAEL J.—Exxon Chemical Corp., Long Beach, CA.
 MCKAY, ALLEN—Oil & Solvent Process Co., Azusa.
 MITCHELL, SAM K.—Mobay Chemical Corp., Monterey Park, CA.
 MOORE, SHARON R.—Roper Plastics, Inc., Norwalk, CA.
 NUNN, MIKE—Union Chemicals Div., La Mirada, CA.
 O'DALY, FRANK—Pacific Dispersions, South El Monte, CA.
 PINNEY, ZORA SWEET—Zora's, Inc., Los Angeles, CA.
 ROBERTS, ARCHIE—BASF Wyandotte Corp., Norwalk, CA.
 ROCKETT, THOMAS E.—Oil & Solvent Process Co., Azusa.
 ROEST, HANS—Tenneco Chemicals, Inc., Buena Park, CA.
 ROMERO, FRANK—Stay & Day Paint Materials Co., Los Angeles, CA.
 ROSS, RITA—Roper Plastics, Inc., Artesia, CA.
 RUTLEDGE, MELINDA K.—Allo Chemical Co., Ontario, CA.
 STUKKIE, BETH—McKesson Chemical Co., Riverside.
 TODD, MIKE—McKesson Chemical Co., Riverside.
 TURCOITE, RACHEL—Roper Plastics, Inc., Fullerton, CA.

Educator and Student

BAUTISTA, FRANCIS D.—Dunn Edwards Corp., Los Angeles, CA.

LOUISVILLE

Active

BRAWNER, BOB—Olympic Stain, Louisville, KY.
 COZINE, JOHN R.—Porter Paint Co., Louisville, KY.
 GRIFFIN, WILLIAM B., JR.—Porter Paint Co., Louisville.
 LETTON, JAMES A.—Porter Paint Co., Louisville.

OSER, STEVE L.—Jasper Chemical Ctg., Jasper, IN.
 RICKERT, MILTON E., JR.—General Electric Co., Louisville.

Associate

CONIGLIO, PHILIP R.—Nalco Chemical Co., Cincinnati, OH.
 GALLAGHER, JOHN J.—NL Chemicals, Inc., Middleburg Heights, OH.
 LUDWIG, MARCIA S.—Eastman Chemical Prod. Inc., Prospect, KY.
 MCCURRY, CHARLES A.—American Cyanamid Co., Hamilton, OH.
 WARD, GEORGE A.—Davies Can Co., Solon, OH.
 WAREHIME, GARY C.—Spencer Kellogg Div., Textron, Inc., Cincinnati, OH.

NEW ENGLAND

Active

AALTO, ERIC—Waterlac Ind., Danvers, MA.
 ABELON, LEON—Rule Paint & Chemical Co., Gloucester, MA.
 GARDNER, DONALD M.—Monsanto Co., Indian Orchard, MA.
 KARP, RUTH J.—Technical Coatings Laboratory, Avon, CT.
 MULKERN, KEVIN A.—Nu-Brite Chemical Co., Taunton, MA.
 O'NEIL, MICHAEL H.—Imperial Wallcovering, Plattsburgh, NY.
 PAUL, WERNER H.—Schenectady Chemicals, Inc., Schenectady, NY.
 SKIBICKI, EDWARD G.—Waterlac Ind., Danvers, MA.

Associate

DAVIS, THOMAS P.—Commonwealth Chemical, Tewksbury, MA.
 GLASS, DARRELL W.—Pfizer, Inc., Uniondale, NY.
 HANDT, RICHARD P.—Eagle Can Co., Peabody, MA.
 OCKO, BRUCE—The Truesdale Co., Brighton, MA.

NEW YORK

Active

BOBB, RONALD E.—New York Bronze Pwdr., Elizabeth, NJ.
 COOPERSMITH, ALLEN B.—US Polychemical Corp., Spring Valley, NY.
 ENGEL, WALTER D.—Standard Coating Corp., Ridgefield, NY.
 ERICSON, GILBERT L.—Mobay Chemical Corp., Hawthorne, NJ.
 GATECHAIR, LESLIE R.—Ciba-Geigy Corp., Ardsley, NY.
 GREENBERG, HARRY—Hoboken Paints, Inc., Lodi, NJ.
 MEYERS, FRANCIS H.—Chemtex, Inc., New York, NY.
 NEITHARDT, WILLIAM A.—Keuffel & Esser Co., Morristown, NJ.
 SKLAK, BRUCE Z.—Chromatic Paint Corp., Garnerville, NY.

SUPER, GARY W.—Selectoflash, W. Orange, NJ.
 VARA, FULVIO J.—GAF Corp., Wayne, NJ.

Associate

GLASS, DARRELL—Pfizer, Inc., Uniondale, NY.

PHILADELPHIA

Active

BAUER, EDWARD J.—Campbell Soup Co., Camden, NJ.
 HUNT, PATRICK J.—Lawrence McFadden Co., Philadelphia, PA.
 JOHNSON, CHRISTIE B.—Pennwalt Corp., Philadelphia, PA.
 MOLSKI, JOHN—United Gilsonite Lab, Scranton, PA.
 TOZER, ROBERT L.—Delkote, Inc., Penns-grove, NJ.

Associate

BOYLAN, RICHARD—Nordson Corp., Norristown, PA.
 FRIEBELY, DEBORAH Z.—Arco Specialty Chemicals, King of Prussia, PA.
 GILMAN, IRWIN SCOTT—Jersey Steel Drum, Willingboro, NJ.
 HALLER, JANE M.—Hercules, Inc., Wilmington, DE.
 HOWE, JOHN F.—Reliance Universal, Somerset, NJ.
 JOYCE, RICHARD T.—Loos & Dilworth Inc., Bristol, PA.
 LIPSKIN, STUART J.—Byk-Mallinckrodt Inc., Chalfont, PA.
 LOMBARDO, JOSEPH—Rohm and Haas Co., Philadelphia, PA.
 LOUDON, RICHARD L.—Pfizer Inc., Hat-boro, PA.
 NELSON, FRANK—Charles A. Wagner Co., Inc., Philadelphia.
 SCOTT, STEPHEN W.—Loos & Dilworth Inc., Bristol.

PIEDMONT

Active

BROOME, EARNEST L.—Guardsman Chemicals, High Point, NC.
 JARRETT, FRANKLIN L.—Prillaman Co., Martinsville, VA.
 LOFLIN, JOHN D.—The Lilly Co., High Point, NC.
 McMAHAN, BILLY R.—Spruance Southern, Inc., Winston-Salem, NC.
 WATERS, GRAY L.—Paint Products Co., Walkertown, NC.
 WOOD, CHARLES E.—Spruance Southern Inc., Winston-Salem.

Associate

EDELMAN, RALPH E.—DuPont Co., Charlotte, NC.
 KECK, FRAN—Cargill, Inc., Forest Park, GA.
 LOCHARY, TED—W.R. Clayton Co., Baltimore, MD.
 NOELL, LOUISE T.—Shell Chemical Co., Charlotte.

PITTSBURGH

Active

HENDERSON, ROBERT S.—Alcoa, Alcoa Center, PA.
KOLICIUS, DIANE M.—Mobil Chemical Co., Allison Park, PA.

Associate

BRACCO, JACK J.—Mobay Chemical Corp., Pittsburgh, PA.
BRAINERD, DONALD L.—E.I. du Pont Co., Sewickley, PA.
DURR, DAVID R.—Durr Marketing Assoc., Pittsburgh, PA.
FETCHIN, PAUL D.—Melville Chemical Co., Pittsburgh.
LUTZ PATRICK B.—E.I. du Pont de Nemours, Bethel Park, PA.
LYMAN, RAY—Durr Marketing Assoc., Pittsburgh.
POHLMAN, RICK—Maroon Chemical Grp., Lakewood, OH.
WOODWORTH, JAMES D.—Davies Can Co., Sewickley, PA.

ROCKY MOUNTAIN

Active

CRANDELL, RICK—Komac Paint, Inc., Denver, CO.
FERRARO, MICHAEL—J.D. Mullen Co., Denver.
GOTTSCHALCK, BERT A.—Caliber Ctgs., Corp., Draper, UT.
HEISER, RON—Komac Paint Co., Inc., Denver.
LEE, KYU S.—Caliber Ctgs., Corp., Draper.
ROMANEK, JERRY—Benjamin Moore & Co., Denver.

Associate

KELLER, JOE Y.—Oil & Solvent Process Co., Commercial City, CO.
SWITZER, PAIGE C.—Oil & Solvent Process Co., Commercial City.

SOUTHERN

Active

BUDASH, JOSEPH A.—Scott Paint Corp., Sarasota, FL.
BUTTRICK, GEORGE—Union Carbide Corp., Tucker, GA.
GRANELLO, GARY A.—Products Research Service, Belle Chasse, LA.
HIRT, RICHARD F.—Ameron Enmar Div., Little Rock, AR.
LANE, THOMAS A.—Dyco Chemicals, Inc., Clearwater, FL.
PAGE, BEVESTER, Buckman Laboratories, Memphis, TN.
PINHOLSTER, DAN F.—AZS Chemical Co., Atlanta, GA.
RUEBUSCH, PATRICK—Armor Paint, Inc., Clearwater.
SPEIGHTS, SAMUEL J., JR.—Glidden Corp., Atlanta.
WELLS, A. K.—Buckman Laboratories, Memphis.

Associate

FERRIS, RICHARD A.—McKesson Chemical Co., Maitland, FL.
HUGHES, ED—Durr Marketing Assoc., Marietta, GA.
JOHNSON, VALERIE W.—Union Chemicals, Memphis, TN.
KECK, FRANCIS D.—Cargill, Inc., Forest Park, GA.
SCHUMANN, KENNETH C.—Ciba-Geigy Corp., Norcross, GA.

Educator and Student

ADAMS, JANEI KAY—University of Southern Mississippi, Hattiesburg, MS.
HSU, SHUI-TEN, RAYMOND—University of Southern Mississippi, Hattiesburg.

ST. LOUIS

Active

BAILEY, SUSAN C.—Marsh Stencil & Machine Co., Belleville, IL.
CONSUEGRA, ANTONIO—Don. V. Davis Co., St. Louis, MO.
GIERY, ROBERT J.—Spatz Paint Industries, Inc., St. Louis, MO.
KLEINMAN, CHARLES E.—Cardinal Paint Co., St. Louis, MO.
LIVINGSTON, JAMES—Spatz Paint Industries, Inc., St. Louis.
OKRAGLY, RICHARD—Carboline Co., St. Louis, MO.
PARRISH, CLYDE F.—Wabash Industrial Oil Co., Effingham, IL.
SOKOLOWSKI, SAM—P.D. George Co., St. Louis, MO.

Associate

LYNE, JEFFREY S.—Columbian Chemicals Co., St. Louis, MO.
PFAFF, PAUL—Superior Terminals Inc., St. Louis, MO.
SCHELL, JOHN K.—Reichard-Coulston, Inc., New York, NY.
ZEISSET, GERALD—F.R. Hall Inc., St. Louis, MO.

TORONTO

Active

BIEBER, M.C.—Technical Coatings Ltd., Burlington, Ont.
BUCKLEY, WILLIAM J.—Custom Colour Paints, Brampton, Ont.
CHINCHOLI, B.S.—Para Paints, Weston, Ont.
CHUNG, Y.—Benjamin Moore & Co., Toronto, Ont.
COATES, RONALD C.—Nor-Var Paints, Owen Sound, Ont.
CRICHTON, NOEL—CIL Paints, Toronto.
DUERMAYER, GYSBERTUS—Tenneco Chemicals, Bramalea, Ont.
DEVALK, PETER J.—Sico, Inc., Rexdale, Ont.
DURGAN, R.L.—Kelco Spec. Colloids, Toronto.
ECCLESTON, DENNIS—International Paints, Toronto.
FISK, RONALD—MIA Chemical, Mississauga, Ont.

GEORGE, HAROLD G.—XYZ Paint Co., Cambridge, Ont.
GERRITSE, GARY—Indusmin Ltd., Don Mills, Ont.
HELLINGS, DOROTHY P.—K-G Pkg., Concord, Ont.
HEESE, LORNE—International Paints, Toronto.
HO, SUM—K-G Pkg., Concord.
HUNT, RAYMOND P.—Nuodex Canada Ltd., Toronto.
KIM, JAE K.—Reichhold Ltd., Weston.
LAI, LIM K.—Halladay Armstrong, Mississauga.
MARSHALL, PAUL W.—Inmont Canada, Brantford, Ont.
MENDONCA, FERNANDO—XYZ Paint Co., Cambridge.
MILNE, ROBERT A.—XYZ Paint Co., Cambridge.
MOHAMMED, WAHID—International Paints, Toronto.
NICHOLL, JIM—International Paints, Toronto.
OLIVEIRA, ZACHARY M.—XYZ Paint Co., Cambridge.
PARSONS, GERALD—DeSoto Coatings Ltd., Toronto.
PASILDO, GLORIA F.—K-G Pkg., Concord.
PENG, LOREN—Lorcon Chemicals, Milton, Ont.
PRASHAD, S.—K-G Pkg., Concord.
RAYMER, RICHARD—Custom Colour Paints, Brampton.
READ, PHIL—Sico, Inc., Rexdale.
REISS, WALTER B.—MacNaughton-Brooks, Toronto.
STAYZER, RICK—Pratt & Lambert, Port Erie, Ont.
WIGGINS, JANE—Technical Coatings, Burlington.
WILKINSON, TERRY—CIL Paints, Toronto.
WINTER, MARK—Hoechst Canada Ltd., Willowdale, Ont.

Associate

BABINSKY, RON—Ashland Chemicals, Mississauga, Ont.
BEARD, RICHARD W.—Continental Can of Canada, Downsview, Ont.
BIENKOWSKI, JACK—Maple Leaf Monarch, Toronto, Ont.
DICKSON, DOUG—Shell Canada Chem., Don Mills, Ont.
ERSKINE, JOHN R.—Bate Chemical, Don Mills.
FULLER, R.T.—Shell Canada Chem., Toronto.
GOODWIN, IAN J.—Tioxide of Canada, Etobicoke, Ont.
HAVERY, MARVIN—Canada Colours & Chem., Don Mills.
HOUSE, RONALD A.—Pride Equip. Co., Oakville, Ont.
JOBLING, PETER—Quandra Chemicals, Mississauga.
LANGLEY, VIC—Canada Colours & Chem., Don Mills.
MORRISON, IAN N.—Celanese Canada, Mississauga.
MOTEM, EBRAHIM—Bayer Canada, Mississauga.
NIJMIUS, ELIBERTUS—Maple Leaf Monarch, Toronto.
PAUL, EDWARD G.—Esso Chem. Canada, Toronto.
PHILPOTT, CORY—Kingsley & Keith, Etobicoke.

NPCA To Sponsor 22nd Annual Marine Coatings Conference

The National Paint and Coatings Association (NPCA) will present the 22nd Annual Marine and Offshore Coatings Conference, March 8-10 at the Grand Hotel, Point Clear, AL.

The conference is designed to provide a forum for encouraging a dialogue be-

tween coatings suppliers, raw materials suppliers, and end users. It offers a unique opportunity for ship and rig operators and builders, representatives of repair yards, naval architects, and representatives of government agencies to meet with paint industry personnel.

A preliminary program was announced by NPCA Marine Coatings Committee Chairman Joseph Harrington, of Farboil Co., and Program Chairman Armand Herreras, of Devco Marine Coatings

Co., which includes a series of papers examining comparative cost data on the use of various generic types of coatings. Additionally, a series of workshop sessions will include: "Back to Basics;" "Blasting and Painting;" "Problem Solving—Marine and Offshore;" and "Applicator Problems."

For further information, contact Mark Padow, NPCA, 1500 Rhode Island Ave., N.W. Washington, D.C. 20005, (202) 462-6272.

Reindustrialization Is Theme For Plant Engineering Show

The elements necessary for the reindustrialization of the American industry will be the focus of attention in the exhibits and conference sessions when the National Plant Engineering and Maintenance Show and Conference convenes at McCormick Place, Chicago, IL, March 29 through April 1.

Exhibition and conference are produced by Clapp & Poliak, Inc., New York, NY, the international exhibition and conference management firm that has annually produced the twin events since 1950.

Robotics, manufacturing resource planning, energy conservation, and training of maintenance personnel are among the subjects to be discussed. In addition, a full range of equipment, materials, and systems to keep factories operating efficiently, while protecting health and safety of the workers, controlling pollution, conserving energy, and improving productivity will be on display.

The National Design Engineering Show and Conference will run concurrently at McCormick Place.

Visitor information is available from Clapp & Poliak, Inc., 245 Park Ave., New York, NY 10167.

L.A. Society Gives \$1,000 Coatings Grant to UMR

The Los Angeles Society for Coatings Technology presented a \$1,000 grant to the University of Missouri-Rolla at the Federation's Annual Meeting in Detroit, MI. The money is to be used for the university's undergraduate coatings program.

Presenting the grant was Society President Jan P. Van Zelm, of Byk-Mallinckrodt, with Dr. James Stoffer, Associate Professor of Chemistry, accepting for the university.

Robotics Seminar To Be Offered By UMR in St. Louis, March 29-30

The University of Missouri-Rolla is sponsoring a two-day seminar, "Robotics: Fundamentals and Technology of Computerized Robots," March 29-30 at the Marriott Pavilion Hotel, St. Louis, MO.

The seminar will provide participants with a knowledge of the current state-of-the-art in robotics technology and an understanding of what robots can do and the economics involved. Sessions will cover the history and development of robots; how robots have helped to increase productivity and improve product quality; the fundamentals of robotics technology; planning, evaluating, selecting, and implementing computerized robots; the future of robots in industry; and operational characteristics of robots.

The seminar will be taught by Professor Ralph E. Lee (director), UMR Professor of Computer Science and Director of

Computer Science Continuing Education; Dr. Peter C. Ho, UMR Associate Professor of Computer Science; and Craig C. Cook, Manager of the Graphics Data Management Department of Computer Science, Bedford, MA.

Fee for the seminar is \$375 and includes registration, instructional materials, and a reception. Lodging is not included. A discount of 10% per person is available to companies that send a team of three or more persons to the seminar.

For further information contact Professor Lee, Computer Science Dept., Mathematics-Computer Science Bldg., UMR, Rolla, MO 65401, (314) 341-4491. To register contact: Martha K. Fort, Coordinator, Arts & Sciences Continuing Education, 105A Humanities-Social Sciences Building, UMR, Rolla, MO 65401, (314) 341-4943.

Amendment to By-Laws and Standing Rules

This proposed amendment to the By-Laws and Standing Rules will be presented for first reading at the April 30, 1982 meeting of the Federation Board of Directors.

Re Equal Voting and Office-Holding Privileges

WHEREAS the Pittsburgh Society has proposed that the existing Federation By-Laws and Standing Rules be amended to extend equal voting and office-holding privileges to all Federation Active and Associate members while still maintaining the existing classes of membership, be it

RESOLVED that the Federation By-Laws and Standing Rules be amended wherever applicable in order to extend voting and office-holding privileges to all Active and Associate members.

Inter-Society Color Council Discusses Plans for the Future

The Inter-Society Color Council (ISCC) held a Long-Range Planning Conference July 24-26 at the Airlie Foundation, Airlie, VA. Fifteen members of the ISCC Planning Committee and Board of Directors met to discuss ways of improving the function of the Council and better servicing its membership.

A detailed report of this meeting, ISCC Technical Report 81-1, has been prepared and sent to all members of the ISCC. The report contains an introduction explaining the reasons for holding a Long-Range Planning Conference; a history of past ISCC planning committee

activities; the format and agenda for the meeting; lists of recommendations for each of seven discussion topics; and a summary of recommendations to be presented to the Board of Directors.

The seven topics discussed at the Conference included: The ISCC and its membership; ISCC program structure and contents; problems—committee and projects; color problems—unresolved and useful; ISCC publications; balance among ISCC roles—science, art, industry; and ISCC roles in government regulatory developments.

All members of the ISCC are being encouraged to comment on the report,

the recommendations, and the future of the ISCC. Any nonmember of the Council may purchase a copy of ISCC Technical Report 81-1 for \$2.00 by contacting Secretary, Dr. Fred W. Billmeyer, Jr., Rensselaer Polytechnic Institute, Department of Chemistry, MRC 217, Troy, NY 12181.

Spray Finishing Workshop To Be Held at Bowling Green

The semi-annual Spray Finishing Technology Workshop, sponsored by Bowling Green State University and the DeVilbiss Co., will be held March 22-26 at the University campus and in the Technical Center of the DeVilbiss Co., World Headquarters, Toledo, OH.

Featured will be sessions on equipment and material selection, spray finishing techniques associated with automotive refinishing, furniture, and industrial spraying. Topics featuring the latest technology will include powder coatings, automatic spraying, and plural components. Each participant will have an opportunity for "hands-on" practice.

The workshop, which may be taken for credit or noncredit, is under the direction of Dr. Richard A. Kruppa, Chairman of Manufacturing Technology, School of Technology, Bowling Green State University. For additional information, contact Dr. Kruppa, Bowling Green, OH 43403, 419-372-2436.

AFP/SME To Hold "Radiation Curing VI" Sept. 21-23

The Association for Finishing Processes of the Society of Manufacturing Engineers (AFP/SME) is sponsoring its Radiation Curing VI Conference and Exhibition, September 21-23, Ramada O'Hare Inn, Des Plaines, IL.

Designed to examine advanced technologies, the conference will feature industry leaders who will discuss existing technologies and applications in the field and make projections about future developments and usages. Topics to be discussed include: safety and handling practices; quality assurance; adhesives; infra-red, ultraviolet, and electron beam applications; plastics; wide web converting; curing equipment; metal and wood finishing; electronics; and marketing data.

Suppliers of radiation curing products and systems will offer demonstrations from 1:30 pm—6:00 pm each day of the conference.

For additional information, contact Susan Buhr, Technical Activities Dept.,

Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48128.

Scandinavian Paint and Varnish To Hold 10th Congress

The Federation of Scandinavian Paint and Varnish Technologists (SLF) will hold its 10th Congress, October 11-13, at Hotel Scandinavia, Copenhagen, Denmark.

Fifteen technical papers will be presented, with a special session devoted to printing ink.

For further information contact 10th SLF Congress, Gladfaxevej 300, DK-2860, Saborg, Denmark.

Cleveland Society Announces Computer Symposium

The Manufacturing Committee of the Cleveland Society for Coatings Technology will present "The Use of Computers in the Manufacture of Coatings" Symposium, October 5, at the Cleveland Engineering and Scientific Societies Building, Cleveland, OH.

The symposium will feature speakers representing coatings manufacturers who currently use computers in the manufacture of coatings and personnel from the computer industry. An open panel discussion and question and answer forum with all speakers participating will conclude the program.

For additional information, contact Chairman Charles K. Beck, Premier Industrial Corp., 4415 Evelid Ave., Cleveland, OH 44103.

CALL FOR PAPERS

ASTM Symposium on New Concepts for Coating Protection Of Steel Structures

January 26, 1983
Lake Buena Vista, Florida

A call for papers is issued for the Symposium on New Concepts for Coating Protection of Steel Structures, January 26, 1983, Lake Buena Vista, FL. The symposium is sponsored by the American Society for Testing and Materials Committee D-1 on Paint and Related Coatings and Materials and the Steel Structures Painting Council.

The symposium will be held in conjunction with the semi-annual meeting of Committee D-1 which will run through January 23-27, at the Dutch Inn, Lake Buena Vista.

Original, unpublished papers are sought from industry, government, universities, and other institutions for presentation. Emphasized will be corrosion protection of steel structures. Papers will be chosen for their interest and responsiveness to the state-of-the-art advances in the evaluation of new coating materials, experience with developing application methods, and surface preparation.

Prospective authors are requested to submit a title, a 300 to 500-word abstract, and an ASTM Paper Submittal Form by July 15, 1982. Information may be sent to Symposium chairman R.F. Wint, Hercules Incorporated, 910 Market St., Wilmington, DE 19899.

People

The White Pigment Corp., Florence, VT, has announced the appointment of **Ronald H. Rowland** as Manager of Technical Service responsible for technical assistance to the coatings, inks, adhesives, and allied industries in the United States and Canada. Mr. Rowland is a member of the Montreal Society.

John Bax was named President of Pacific Scott Bader, Inc., Richmond, CA. Prior to his appointment, Mr. Bax served as Technical Services Manager for the firm. Mr. Bax is a Golden Gate Society member.

Mike Ferraro has joined the technical sales force of J.D. Mullen Co. with primary responsibility to develop new customer accounts and manage physical distribution in the Denver, CO area.

Daniel J. Hailey, Jr., President of Finnaren & Haley, Inc., was elected President of Coatings Research Group, Inc., by the board of directors of CRGI. Mr. Hailey, whose term of office began November 1, succeeds **Ralph S. Chancy**, President of The Standard Manufacturing Co. Mr. Chancy is a member of the Montreal Society.

Other officers elected were: Vice-President—**R. Dwight Weed**, Chairman of the board of Durako Paint & Color Corp.; Secretary—**Thomas J. Bonner**, President of Stebbins & Roberts, Inc.; and Treasurer—**Hiram P. Ball**, President of Ball Chemical Co. Mr. Weed is a member of the Detroit Society and Mr. Ball is a Pittsburgh Society member.

Aceto Chemical Co., Inc., Flushing, NY, has announced the appointment of **Roy Goodman** to Products Manager of coatings and adhesives raw materials in the Industrial Chemicals Department. Mr. Goodman is a member of the New York Society. Promoted to the position of Assistant Products Manager in the department was **Vincent G. Miata**.

John Bilinski, a 19-year veteran of the paint and coatings industry, was promoted to Vice-President of Operations of the Chemray Coatings Corp., Middlesex, NJ. He is a member of the New York Society.

Donald E. Colombo has been appointed National Sales Manager of Day-Glo Color Corp., Cleveland, OH. Appointed Manager of Eastern Operations for the firm, is **Charles E. Lowden**.



R.H. Rowland



J. Bax



S.M. Jackson



L. Silver

Spencer Kellogg Div. of Textron, Inc. announced the appointment of **Suzanne M. Jackson** to the position of Sales Representative, headquartered in Rutherford, NJ. Ms. Jackson is a member of the New York Society.

The promotion of **James H. Jakubowski** to the position of Detroit District Sales Manager was announced by the Spencer Kellogg Div. of Textron, Inc. Mr. Jakubowski will be based in Troy, MI.

Union Chemicals Division, Union Oil Co. of California, has appointed **Ken Rose** as Manager of its Technical Service Center, Charlotte, NC.

The appointment of **Todd C. Walker** as Vice-President and General Manager of the Thermoplastics Division has been announced by Borden Chemical Co. He succeeds **Dr. Milton W. Kline** who has been named Director of Business Development for the firm's vinyl, plastics, and ink group.

Richard J. Drexel, Jr. has been promoted to the position of Manager-Technical Services by Freeport Kaolin Co., Gordon, GA. Joining the firm as Research Chemist-Production, is **Ellen S. Forbus**.

Guy H. Danforth has been appointed General Manager of the Interlux Yacht Paint Division of International Paint Co., Inc., based in Union, NJ. Also announced by the division was the promotion of **Edward H. Kilgus** to the position of Northeast/Mid-Atlantic Regional Sales Manager.

American Hoechst Corp. has announced the election of **Harry R. Benz** and **Dr. Hans F. Holzapfel** to the positions of Executive Vice-President and **Alban W. Schuele** to the office of Treasurer.

At the 56th Annual General Meeting of the Paint Research Association, **Leslie Silver** was installed as President. Mr. Silver formerly has been president of OCCA, the Paintmakers Association, and the Paint Industries Club. He is owner of a paint manufacturing business which he set up in 1940.

The appointment of **Theodore Doering** as Director of Marketing and Sales for the Plastics Color Division was announced by Crompton & Knowles Corp., Somerset, NJ.

Isis Chemicals, Inc., Stamford, CT, has elected **Bronson B. Bump** Vice-President of Operations. He assumes responsibilities for the financial and manufacturing services to the four Isis Chemicals' plants located in Stamford and in Jefferson City, MO.

Maurice G. Bradley, President of C-I-L Paints, Inc., was elected President of the Canadian Paint and Coatings Association for 1982. He succeeds **Jack G. McWade**, of Inmont Canada Ltd.

K.G.W. Smith, Manager, Finishes Div., duPont Canada Ltd., was elected President-Elect.

The 1982 convention of CPCA will be held in Toronto, September 18-21.

Drew Chemical Corp., Boonton, NJ, has announced several promotions in their Specialty Chemicals Division. **Gordon E. Haym** was named Vice-President and General Manager while **Daniel C. Rosiak** was appointed Divisional Vice-President of Marketing. **Richard T. Korol** was promoted to Sales Manager, Process Chemicals and **Daryl G. Luxmore** was named Sales Manager, Chemical Additives. Mr. Korol and Mr. Luxmore are members of the New York Society and Chicago Society, respectively.

Sun Chemical Corp., Cincinnati, OH, has announced the promotion of **Carolyn Tully** to Group Leader, Coatings Group, Technical Services Department. In this position she assumes responsibility for providing specialized services and support in those areas where the company's pigments are used by the coatings industry. Ms. Tully is a member of the C-D-I-C Society.

Union Carbide Corp. has announced the promotion of **Dr. R. Alan Gregory, Jr.** to Associate Director in the Bound Brook, NJ Research and Development Department of its Coatings Materials Division. Dr. Gregory most recently served as Technology Manager for solution vinyls, phenoxy, ethyl silicates, and cellosize.

Edward J. Duda has been promoted to West Coast District Manager for VEDOC Powder Coatings, Coatings Division, Ferro Corp. Based in Los Angeles, CA, Mr. Duda will be responsible for direct sales development, technical support, and distributor sales for a 12-state area. Also announced by the firm, was the appointment of **Mary-Anne Newell** as Sales/Service Representative for VEDOC Powder Coatings, based in Cleveland, OH.

Bruce Bentley has joined Georgia Kaolin Co. as Director, Marketing and Strategic Planning at the firm's headquarters in Elizabeth, NJ.

Richard S. Hunter, President of Hunter Associates Laboratory, Inc., received the Baltimore Coatings Industry's 1981 Herman Shuger Memorial Award on November 19, at the annual joint meeting of the Baltimore Society and PCA. Mr. Hunter was recognized for his professional abilities in solving appearance evaluation problems, for innovative designs of new instruments, and for his leadership in standardization techniques during more than 40 years of association with the coatings industry. The Shuger Award was established in 1956.

Also at the Shuger Awards Night, Merit Awards were presented to: **Mike Beatty**, of Athey Paint Co.; **Joe Behan**, of A.B. Kohl Sales Co.; **Frank Gerhardt**, of Bruning Paint Co.; **Thomas Mitchell**, of Tenneco Chemicals, Inc.; **Harry Schwartz**, of Dutch Boy, Inc; and **Calvin Tatman**, of Glidden Pigments Group.

Diamond Varnish Co., Burton, OH, has announced the appointment of **Henry N. Bittner**, founder and former President of Faribo Industries, to the position of Executive Vice-President/Sales.

Joseph A. Kennedy has joined Expert Industries, Inc., Brooklyn, NY, as Vice-President of Engineering.

The C.P. Hall Co., Chicago, IL, has announced the promotion of **G.C. "Jerry" Wicker** to the position of Western Region Sales Manager. Mr. Wicker, who is based at the firm's Torrance, CA facility, is a member of the Los Angeles Society.

Hercules Incorporated, Wilmington, DE, has announced two promotions to positions of Senior Technical Sales Representatives. **Mary Ellen Einstein** serves in the Organic Resins Division in the Northeastern Region, headquartered in Wilmington, and **Lonnie U. Haynes** is based in Oak Brook, IL, in the Water Soluble Polymers and Coatings Division for the Midwestern Region.

William S. Freeh, Jr. has been named Chemical Coatings Analyst for Glidden Coatings and Resins, Division of SCM Corp., headquartered in Cleveland, OH.

Glidden Chemical Coatings, Charlotte, NC, has announced the appointment of two customer service specialists, Powder Coatings Division: **William Dale Francis** and **Samuel A. Rhue**.

Steven F. Prodomo was named Midwest Regional Manager for the Colors/Pigments Department at the Hilton-Davis Chemical Group. Mr. Prodomo is a member of the Dallas Society.

Bertrand Gardner and **Wendy Harrison** have been promoted to the position of Coatings Chemist, Packaging Laboratory and Waterbase Container Coatings, respectively, for The Dexter Corp., Midland Division.

Ben B. Stranz has been appointed Senior Vice-President of the Development Division of M&T Chemicals Inc., Woodbridge, NJ. Also announced by the firm was the appointment of **David A. Daniels** as National Sales Manager of Chemicals.

McCloskey Varnish Co., Los Angeles, CA, has announced the appointment of **Bruce M. Farber** to the position of Industrial Sales Manager. Mr. Farber is a member of the Los Angeles Society.

McCloskey Varnish Co. of the West appointed **Robert C. Burall** to the Industrial Sales Division of the Los Angeles plant. In his new position, he will assume responsibility for territory sales of industrial vehicles with particular emphasis on high solids and water reducible alkyds. Mr. Burall is a member of the Los Angeles Society.

Max Potash was appointed Director of Technology and Development for Beatrice Chemicals, a division of Beatrice Foods Co. Mr. Potash had been, since 1954, President and General Manager of Polyvinyl Chemical Industries, which was acquired by Beatrice Chemicals in 1965.

Dr. James R. Fleming has been appointed Group Manager of Permuthane and Polyvinyl Chemical Industries, operating units of Beatrice Chemical.

Donald E. Walker, of the Pigments Department of the Dyes and Pigments Division of Mobay Chemical Corp., has retired after 33 years of service and 19 years in Detroit, MI.

Lester C. Jacobson has been named Manager of Pigment Sales for the New Jersey Zinc Co.

Dr. Nelson N. Schwartz has joined Thibaut & Walker, Inc., as Technical Director responsible for development of emulsion polymers. Also joining the staff is **Andy Romano**, responsible for the firm's Quality Control Department.

Southern Products Co., Atlanta, GA, has appointed **S. Shaw Painter**, Vice-President—Operations. In his new position, Mr. Painter assumes the responsibility for manufacturing at the firm's Atlanta and Houston, TX operations.

S.L. (Bud) Steinberg has been named Executive Vice-President of the Carboline Co., St. Louis, MO. Mr. Steinberg joined the firm in 1966 and most recently served as Vice-President of Marketing.

Obituary

Stanley T. Schellenback, 76, Past-President of the St. Louis Society for Coatings Technology, died October 28. He was a retired chemist with Steelcote Manufacturing Co., St. Louis, MO, after serving the firm for 23 years before his retirement on June 1, 1981.

Albert Shuger, 85, died November 18. He was President of the Baltimore Paint & Chemical Co. (now a division of The Sherwin-Williams Co.) until his retirement in 1963.

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Disposal of Hazardous Waste

A new brochure is available which can aid manufacturers in the disposal of empty steel drums that contain residue defined as "hazardous waste" by the EPA. Outlined are ways a portable, self-propelled drum deheader can facilitate removal of the contents and rinsing in compliance with new EPA regulations. For a copy of the brochure, write Wizard Drum Tool Div., Hydro-Thermal Corp., 1263 N. 70th St., Milwaukee, WI 53213.

Urethane Emulsions

New water soluble urethane emulsions are the subject of recent literature. Features of the emulsions are described such as exceptional package stability, and resistance to freeze-thaw and hydrolytic degradation. In addition to providing excellent physical properties, they offer a wide range of modulus values to meet coating requirements for all types of surfaces and substrates. For information, contact Permuthane, A Beatrice Chemical Co., Div. of Beatrice Food Co., Corwin St., P.O. Box 3039, Peabody, MA 01960.

Tank Cleaners

Literature is available featuring rotary tank cleaning machines with a smoother exterior design for better self-cleaning operation and internal design changes which simplify maintenance by allowing easier access to the turbines. For information, contact SYBRON/Gamlen, 121 S. Maple Ave., South San Francisco, CA 94080.

Liquid Polymers

Epoxy modification with Hycar amine terminated butadiene-acrylonitrile reactive liquid polymers is the topic of a new bulletin. Entitled "Improving Epoxy Resins, RLP-3," the 14-page color brochure describes the addition of Hycar ATBN liquid polymers to the amine-containing hardener side of a two-component system. Miscibility and cure characteristics of these systems are featured along with an investigation of compatibility, viscosity, and cure behavior of mixtures of specific amines and Hycar ATBN polymers. Photographs and viscosity measurements illustrate the stability of the ATBN-amine mixtures. Copies of the brochure can be obtained from the Public Relations Dept., BFGoodrich Chemical Group, 6100 Oak Tree, Cleveland, OH 44131.

Accelerated Weathering Tester

An accelerated weathering tester which is a radical departure from traditional methods of laboratory weathering, is the subject of recent literature. The tester can replace carbon arc and xenon arc in laboratories while simulating rain, dew, and the effects of sunlight. For information, contact the Q-Panel Co., 26200 First St., Cleveland, OH 44145.

Paint Filling and Sealing

Information is available on a redesigned model line of paint filling and sealing equipment. Described are basic ½ pint to five gallon fillers which have been updated in pneumatic controls, metal fabrication, and finishing. Advantages such as design simplicity, improved product flow, safety, and the introduction of new, longer lasting materials at critical wear points are featured. For information, write C.M. Ambrose Co., Redmond, WA 98052.

Antireflection Coatings

A new six-page, two-color brochure is available describing an extensive line of antireflection coatings. The literature includes performance graphs and specifications for the coatings, all of which are highly durable, efficient, and environmentally stable. Applications for the coatings are also included. For a copy of the Antireflection Brochure, write Balzers Optical Group, 211 Second Ave., Waltham, MA 02254.

Spectrocolorimeters

Literature is available featuring a new series of spectrocolorimeters which are ideal for the paint industry because they generate accurate information about appearance, establish permanent records, improve quality, and reduce cost. For information, write Hunter Associates Laboratory, Inc., 11495 Sunset Hills Rd., Reston, VA 22090.

Abstract Newsletter

A weekly abstract newsletter is available which covers such areas as adhesives and sealants; coatings, colorants, and finishes; corrosion and corrosion inhibition; elastomers; materials degradation and fouling; and plastics. For more information, contact the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

Directory of Chemical Producers

The latest annual Directory of Chemical Producers—Western Europe has been released by SRI International. This comprehensive two-volume set provides current information about chemical producers and the products they manufacture. Detailed descriptions of more than 3,000 companies illustrate divisional structure, plant locations, and products manufactured. More than 10,000 commercial chemical products are listed, showing producers and locations, and more than 125 capacity tables are included. A revised regional index lists 5,000 plants by country, region, and city. Two supplements published during the year update the directory. For further information, contact Elaine Klapproth, Program Director, SRI International, 333 Ravenswood Ave., Menlo Park, CA 94025.

Water-Based Ink

Literature describing a new water-based ink, developed for a variety of substrates including vinyls, has been recently published. Featured are the unlimited capabilities in the printing of vinyl, paper, labels, decals, posters, and flags. Advantages, applications, and colors are discussed. For additional information, write International Coatings Co., Inc., 13929 E. 166th St., Cerritos, CA 90701.

Computer Program Package

A brochure has been published which features new computer programs for color matching, correction, and quality control in paint and coatings. The program package is designed for both industrial coatings and trade sales applications. For information, write Applied Color Systems, Inc., Princeton Service Center, U.S. Highway One., P.O. Box 5800, Princeton, NJ 08540.

Curing Agents

A technical bulletin is available which provides information on the use of MXDA and 1,3-BAC in five epoxy resins curing formulations, laboratory methods for the preparation of the curing agents, comparisons, and a summary of the properties. Areas of use of these curing agents are also featured. To obtain copies of Technical Bulletin 169, write to Sherwin Williams Chemicals, Publications, Dept., 10909 S. Cottage Grove Ave., Chicago, IL 60628.

Color Chart

A new 32-color, powder coating chart is available which includes 20 epoxy and 12 polyester/polyurethane powder coatings colors. For a free copy of Ferro's Powder Coatings Color Chart, write, VEDOC Powder Coatings/Coatings Div., Ferro Corp., P.O. Box 6550, 4150 E. 56th St., Cleveland, OH 44101.

Green Pigment

A new green copper phthalocyanine high solids pigment is the subject of recent literature. Recommended uses, design formulations, and advantages are described. For information, contact Ted Kolski, Du Pont Co., Chemicals and Pigments Dept., Technical Service Lab., Wilmington, DE 19898.

Valves

A new line of compact wafer-style butterfly valves with PVC bodies and discs is the subject of recent literature. Design, features, advantages, and cost of the valves are described in the literature. For more information, contact Doris Bernath, Advertising Coordinator, +GF+ Plastic Systems, Inc., 2882 Dow Ave., Tustin, CA 92680.

Antisettling Agent

A pourable pigment antisettling agent, in toluene, for use in solvent-based industrial coatings, nail lacquers, and gravure inks, has been introduced in recently published literature. Information is available from NL Chemicals/NL Industries, Inc., P.O. Box 700, Hightstown, NJ 08520.

Underlayment Products

Literature is available featuring a line of underlayment products which solve a variety of floor leveling and patching problems over virtually any solid sub-flooring: wood, concrete, and steel. For additional information, contact Tamms Industries Co., 1222 Ardmore Ave., Itasca, IL 60143.

Product Catalog

Ashland Chemical has published its 1982 Product Catalog which highlights a complete and unusual range of chemical and specialty products designed for use by industrial chemical users. For a copy of Bulletin 1493, write Ashland Chemical Co., Dept. AD, P.O. Box 2219, Columbus, OH 43216.

Acrylic Emulsion

Literature is available introducing a new, fast air dry acrylic emulsion with excellent adhesion to poorly prepared metal surfaces and plastics. Featured is its use in primers and topcoats for engine enamels, rough metal castings, plastic business machines, and construction and agricultural equipment. Also described are its advantages such as high gloss, hardness, and superior humidity and corrosion resistance. Further information may be obtained from Polyvinyl Chemical Industries, Michael Pezzuto, 730 Main St., Wilmington, MA 01887.

Gauge


Information is available featuring a new magnetic coating thickness pull-off gauge with hold feature for measurement of any nonmagnetic dry film coating. The pentest coating thickness gauge features a magnetic probe tip and the ability to hold the coating thickness reading even after the instrument has been detached entirely from the surface being measured, facilitating its use. Write Frank Rueter, Vice-President Marketing, Zorelco Ltd., P.O. Box 25468, Dept. G-23, Cleveland, OH 44125.

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Inorganic Zinc Rich Primer

A new self-curing ethyl silicate inorganic zinc rich primer with high zinc loading for maximum cathodic protection has been introduced in recent literature. Advantages of the primer are described which include high performance applications, excellent adhesion to surfaces prepared by commercial blast, fast dry to recoat time, minimal topcoat bubbling, added film build tolerance, and good mudcrack resistance. For further information, contact Devoc/Prufcoat Div., Devoc & Reynolds Co., Div. of Grow Group, Inc., P.O. Box 7600, Louisville, KY 40207.

Resins

Literature is available introducing a new series of solid thermosetting polyester resins. Data sheets, including typical properties of the base polyester; starting formulations; and test results are available for each individual polyester type. For additional information, contact Resins Dept., Ciba-Geigy Corp., Saw Mill River Rd., Ardsley, NY 10502.

Water-Based Silicone Alkyds

Literature has been published featuring water-based silicone alkyds with the weatherability, gloss, application ease, and other performance characteristics of solvent-based silicone coatings. Applications, formulations, and properties are discussed for these new water-based materials, designed for use as coatings for a broad range of manufactured goods. For additional information, write Phil Blumer, Dow Corning Corp., Midland, MI 48640.

Condensation Tester

Literature is available featuring a condensation tester which tests materials for resistance to moisture in the form of rain or dew. Information describes how the system provides faster tests than conventional humidity, and more realistic tests than salt fog, while maintaining foolproof control of water purity, oxygen saturation, and test temperature. For additional information, write The Q-Panel Co., 26200 First St., Cleveland, OH 44145; or 102 Taylorson St., Ordsall, Salford M5 3HA, England.

Abrader

Literature introducing an abrader for washability, wet abrasion, or other abrasion testing is now available. Features, applications, and testing abilities are described. For information, contact Pacific Scientific, Gardner Laboratory Div., P.O. Box 5728, 5521 Landy Lane, Bethesda, MD 20014.

Analyzers and Systems

An extensive line of analyzers and systems for monitoring toxic vapors and gases is capsulized in a recently published brochure. The four-page publication discusses the varying needs of diverse industries for different types of air monitoring instruments to ensure safe working environments and to comply with government regulations. Illustrations and brief descriptions summarize the various instruments which employ infrared spectroscopy and gas chromatography. For a copy of the brochure, contact Foxboro Analytical, A Division of The Foxboro Co., 140 Water St., P.O. Box 5449, S. Norwalk, CT 06856.

Filling Machine

A brochure is available describing a new, low-cost filling machine for paint and stain accommodating 2 oz. cans to 55 gal drums. The new lab unit is intended for use in the laboratory, pilot plant, and small-to-medium production runs. Write, Beltron Corp., Megill Rd., Farmingdale, NJ 07727.

Toxicology Review

A new brochure entitled "Ecology, Toxicology, and Industrial Hygiene Aspects of Organic Pigments" has been recently published. The publication is designed as a general guide for users of pigments and contains technical information on specific pigments that are useful in promoting a safe and healthful workplace. To obtain a copy, contact Environmental Dept., Pigments Div., Sun Chemical Corp., 411 Sun Ave., Cincinnati, OH 45232.

Flush Color Products

A revised edition of the brochure "Flush Color Product Line" is now available from the Pigments Division of Sun Chemical Corp. The publication is designed to assist oil ink makers by reviewing the flush color systems and to provide information on formulation. Write, Marketing Dept., Pigments Div., Sun Chemical Corp., 411 Sun Ave., Cincinnati, OH 45232.

Silicone Defoamers

Four new silicone defoamers for the paint and coatings industry have been introduced in recent literature. These defoamers are blends of silicone and organic and inorganic active components dispersed in a hydrocarbon carrier. Formulations, uses, and applications are described. For more information, contact Specialty Chemicals Div., Drew Chemical Corp., One Drew Chemical Plaza, Boonton, NJ 07005.

Guide to Energy

The *Guide to Energy*, a 526 page report including over 140 tables and 50 figures, has been recently published. The report details all facets of energy including projected shifts in demand, technological impacts, and vital supply availability factors affecting industrial users over the coming decade. Orders for the *Kline Guide to Energy*, priced at \$175 a copy, are being accepted at Charles H. Kline & Co., Inc., 330 Passaic Ave., Fairfield, NJ 07006.

Coating Reclaimer

An electrostatic coating reclaimer, which maintains particle uniformity and material purity, is described in a new one-page bulletin now available. The publication highlights the ECR's key user advantages, including its effective removal of oversize and tramp material and lint, its ability to process all coating materials including epoxy, polyester, nylon, ground glass and hydrated lime, and the reclaimer's self-cleaning, anti-binding one-deck design. Complete specifications for standard ECR units are also featured, along with process flow diagrams. For a free copy of the bulletin, write Robert W. Kenagy, SWECO, Inc., 6033 E. Bandini Blvd., P.O. Box 4151, Los Angeles, CA 90051.

Extender Pigment

A technical data sheet has been published which features an extender pigment, a new type of calcined extender uniquely applicable to paint and coatings formulations. Uses, advantages, and specifications are highlighted. For Technical Data Sheet TD-89, write Georgia Kaolin Co., P.O. Box 277, Elizabeth, NJ 07207.

Dispersion Mill

Information is now available on a new 1400 gallon, high-speed dispersion mill for use in either batch or continuous operation. For additional information, contact Robert Kritzer, Kinetic Dispersion Corp., 127 Pleasant Hill Rd., P.O. Box 869, Scarborough, ME 04074.

Sectional Ladder

A new "inside-the-van" sectional fiberglass ladder, designed to allow for storage and transit inside a van or station wagon is featured in recent literature. The highly portable sections replace conventional extension ladders for work up to 21'6". For further information, contact the R.D. Werner Co., Inc., Greenville, PA 16125.

Chemicals & Solvents Catalog

The Industrial Chemicals and Solvents Division of Ashland Chemical Co. has revised its Organic Chemicals & Solvents catalog for industrial chemicals users. The up-dated brochure highlights industrial organic chemicals and solvents representing products from most major chemical manufacturers. Also, a representative listing of those organic products currently available is included. Separate literature on exempt solvents, inorganic chemicals, reagent chemicals and information on custom solvent blending are also available. For additional information, write Ashland Chemical Co., Industrial Chemicals and Solvents Div., Dept. CS, P.O. Box 2219, Columbus, OH 43216.

Violet Pigment

A new, reddish, dioxazine violet pigment for use in the coatings industry is the subject of recent literature. Described are its uses which include all types of coatings and plastics, and its advantages such as brighter hue, more reddish shade, and higher color strength. For more information, contact Sandoz Colors & Chemicals, East Hanover, NJ 07936.

NPCA Proceedings

The Proceedings of the National Paint and Coatings Association (NPCA) 21st Annual Marine and Offshore Coatings Conference are available. Cost for the Proceedings is \$20 each, which are available from NPCA Headquarters, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

Photosensitizer

A technical bulletin has been published featuring a new liquid photosensitizer for UV systems. Results of laboratory tests, advantages, and features are highlighted. To obtain Technical Bulletin 168, write Sherwin Williams Chemicals, Publications Dept., 10909 S. Cottage Grove Ave., Chicago, IL 60628.

Spectrophotometer

A new model spectrophotometer with infrared measurement capability designed for use with computer control color systems, is the subject of recent literature. For additional information, contact Applied Color Systems, Inc., P.O. Box 5800, Princeton, NJ 08540.

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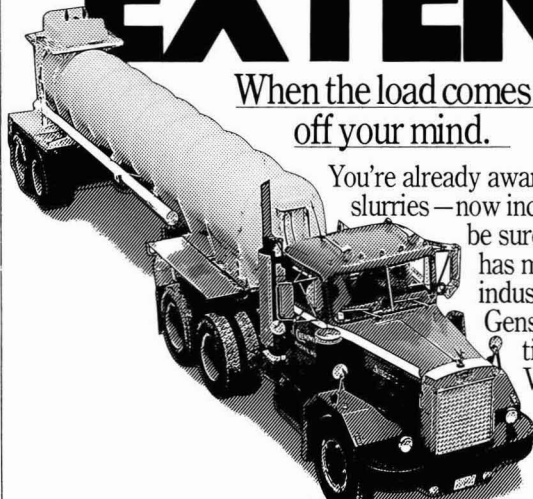
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Note

Revision to Statement of Ownership, Management and Circulation of September 30, 1981: Item F, "Copies not distributed" has been changed to 304, with Item G, "Total" revised to 9385 average number of copies each issue during preceding 12 months.—Ed.

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Coming Events

FEDERATION MEETINGS

(Apr. 29–30)—Spring Meetings. Society Officers on 29th; Board of Directors on 30th. Lenox Hotel, Boston, MA. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

(Nov. 3–5)—60th Annual Meeting and 47th Paint Industries' Show. Sheraton Washington Hotel, Washington, D.C. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

1983

(Oct. 12–14)—61st Annual Meeting and 48th Paint Industries' Show. Queen Elizabeth Hotel, Montreal, Quebec, Canada. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

SPECIAL SOCIETY MEETINGS

(Feb. 17–19)—Water-Borne and Higher-Solids Coatings Symposium sponsored by Southern Society for Coatings Technology and University of Southern Mississippi—Department of Polymer Science. Hyatt Regency Hotel, New Orleans, LA. (Mr. Fred M. Ball, Eastman Chemical Products, Inc., P.O. Box 431, Kingsport, TN 37662).

(Mar. 10–12)—Southern Society Annual Meeting. Hyatt Regency, Savannah, Ga. (Dan Dixon, Freeport Kaolin Co., P.O. Box 337, Gordon, GA 31031).

(Mar. 23–24)—25th Annual Technical Conference of the Cleveland Society for Coatings Technology. Baldwin-Wallace College, Berea, OH.

(Apr. 21–23)—Southwestern Paint Convention. Shamrock Hilton Hotel, Houston, TX.

(May 6–8)—Pacific Northwest Society. Annual Symposium. Bayshore Inn, Vancouver, B.C. (Barry Lamb, Harrisons & Crossfield, Ltd., 810 Derwent Way, New Westminster, B.C. V3M 5R1).

(May 19–20)—New England Society Coatings Tech Expo '82. Sheraton Inn, Boxborough, MA.

1983

(Feb. 23–25)—16th Biennial Western Coatings Societies' Symposium and Show. Hyatt Regency, San Francisco, CA.

OTHER ORGANIZATIONS

(Feb. 22–24)—The Adhesion Society's Fifth Annual Technical Meeting. Mobile Hilton, Mobile, AL. (Pat Dreyfuss, Institute of Polymer Science, The University of Akron, Akron, OH 44325).

(Mar. 3–5)—"The Versatile Thermosets" RETEC, Society of Plastics Engineers, Inc. and the Thermoset Division. Marriott Oakbrook Motor Hotel, Oakbrook, IL. (Paul Fina, College of DuPage, Box P, Riverside, IL 60546).

(Mar. 8–10)—National Paint and Coatings Association's Marine and Offshore Coatings Conference. Grand Hotel, Point Clear, AL. (Armand P. Herreras, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Mar. 8–10)—Production Planning and Inventory Management Seminar. Atlanta, GA. (National Paint and Coatings Association, Meetings and Conventions Div., 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Mar. 10–13)—Painting and Decorating Contractors of America. 98th Annual Convention. Aladdin Hotel, Las Vegas, NV. (Glen Craven, PDCA, 7223 Lee Highway, Falls Church, VA 22046).

(Mar. 15–19)—"Principles of Color Technology" Workshop. Philadelphia College of Textiles and Science. Philadelphia, PA. (PCT&S, Department of Chemistry & Physical Science, School House Lane and Henry Ave., Phila., PA 19144).

(Mar. 22–26)—CORROSION/82. Albert Thomas Convention Center, Houston, TX. (National Association of Corrosion Engineers, P.O. Box 218340, Houston, TX 77218).

(Mar. 22–26)—"Introductory Short Course on Composition of Coatings." University of Missouri-Rolla, Rolla, MO. (Norma R. Fleming, Arts & Sciences Continuing Education, UMR, Rolla, MO 65401).

(Mar. 22–26)—Semi-Annual "Spray Finishing Technology" Workshop. Bowling Green State University and the DeVilbiss Co. Headquarters, Toledo, OH. (Dr. Richard A. Kruppa, School of Technology, Bowling Green State University, Bowling Green, OH 43403).

(Mar. 29–30)—"Fundamentals and Technology of Computerized Robots" Seminar. University of Missouri-Rolla, Rolla, MO and Marriott Pavillion Hotel, St. Louis, MO. (Norma R. Fleming, UMR, Rolla, MO 65401).

(Mar. 29–Apr. 1)—National Plant Engineering & Maintenance Show and Conference. McCormick Place, Chicago, IL. (Clapp & Poliak, Inc., 245 Park Ave., New York, NY 10167).

(Apr.)—Symposium on Color in Protective Coatings sponsored by the Chemical Institute of Canada, Protective Coatings Division. Montreal and Toronto. (D.S. Wiersma, Celanese Canada, Inc., 2 Robert Speck Pkwy., Suite 900, Mississauga, Ont., L4Z 1H8 Canada).

(Apr. 5–9)—"Introduction to Paint Formulation" Short Course. University of Missouri-Rolla, Rolla, MO. (Norma R. Fleming, UMR, Rolla, MO 65401).

(Apr. 12–16)—"Advanced Paint Formulation—Trade Sales" Short Course. University of Missouri-Rolla, Rolla, MO. (Norma R. Fleming, UMR, Rolla, MO 65401).

(Apr. 19–20)—Inter-Society Color Council. Annual meeting. Charlotte, N.C.

(Apr. 19–20)—22nd Annual Symposium of the Washington Paint Technical Group. Marriott Twin Bridges Motel, Washington, D.C. (John Montgomery, Secretary, Washington Paint Technical Group, P.O. Box 12025, Washington, D.C. 20005).

(Apr. 21–28)—Hanover Fair '82 for Surface Treatment and Coatings Technology Equipment and Materials. Hanover, West Germany. (The Hanover Fairs Information Center, P.O. Box 338, Whitehouse, NJ 08888).

(Apr. 27–29)—Oil & Colour Chemists' Association's 34th Annual Exhibition, "International Forum for the Surface Coatings Industries." Cunard International Hotel, Hammersmith, London, England. (R.H. Hamblin, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex, HA0 2SF).

(May 2–5)—National Coil Coaters Association's Annual Meeting. Marriott's Camelback Inn, Scottsdale, AZ. (Don White, NCCA, 1900 Arch St., Philadelphia, PA 19103).

(May 2–6)—American Oil Chemists' Society 73rd Annual Meeting. Sheraton Centre, Toronto, Canada. (James Lyon, Executive Director, AOCS, 508 S. Sixth St., Champaign, IL 61820).

(May 9–14)—XVth Congress of FATIPEC, Brussels, Belgium.

(May 11–13)—Powder & Bulk Solids Conference/Exhibition. O'Hare Exposition Center, Rosemont, IL. (Cahners Exposition Group, 22 W. Adams St., Chicago, IL 60606).

(May 17–21)—"Dispersion of Pigments and Resins in Fluid Media" Short Course. Kent State University, Kent, OH. (Carl J. Knauss, Chemistry Dept., Kent State University, Kent, OH 44242).

(May 18-20)—"Estimating Workshop for Painting Contractors." University of Missouri-Rolla, Rolla, MO. (Norma R. Fleming, UMR, Rolla, MO 65401).

(May 25-28)—"Basic Microcomputer Programming for Coatings Manufacturers" Short Course. University of Missouri-Rolla, Rolla, MO. (Norma R. Fleming, UMR, Rolla, MO 65401).

(June 7-11)—"Adhesion Principles and Practice for Coatings and Polymer Scientists" Short Course. Kent State University, Kent, OH. (Carl J. Knauss, Chemistry Dept., Kent State University, Kent, OH 44242).

(June 13-16)—Dry Color Manufacturers' Association Annual Meeting. The Greenbrier, White Sulphur Springs, WV. (P.J. Lehr, DCMA, Suite 100, 1117 N. 19th St., Arlington, VA 22209).

(June 20-23)—American Society for Testing and Materials Committee D-1 Meeting on Paint and Related Coatings and Materials. Sheraton Center, Toronto, Canada. (Jane M. Turner, ASTM, 1916 Race St., Philadelphia, PA 19103).

(June 21-25)—"Applied Rheology for Industrial Chemists" Short Course. Kent State University, Kent, OH. (Carl J. Knauss, Chemistry Dept., Kent State University, Kent, OH 44242).

(Aug. 16-20)—"Physical Testing of Paints and Coatings" Short Course. University of Missouri-Rolla, Rolla, MO. (Norma R. Fleming, UMR, Rolla, MO 65401).

(Sept. 18-21)—Canadian Paint and Coatings Association. 70th Annual Convention. Four Seasons Hotel, Toronto, Ont. (R. Murry, CPCA, 515 St. Catherine St. W., Montreal, Que., Canada H3B 1B4).

(Oct. 11-13)—10th Congress of the Federation of Scandinavian Paint and Varnish Technologists. Copenhagen, Denmark. (G. Christensen, Sadolin & Holmblad Ltd., Holmbladsgade 70, DK-2300, Copenhagen S, Denmark).

(Oct. 18)—"Fire Resistant Coatings: The Need for Standards" Symposium. Philadelphia, PA. (Symposium Chairman Dr. Morris Lief, County College of Morris, Dover, NJ 07801).

(Nov. 1-3)—National Paint and Coatings Association. 95th Annual Meeting. Washington Hilton Hotel, D.C. (Karen Bradley-Welch, NPCA, 1500 Rhode Island Ave. N.W., Washington, D.C. 20005).

(Nov. 12-14)—National Decorating Products Association 35th Annual Show, Superdome, New Orleans, LA. (Lillian Smyser, NDPA, 9334 Dielman Industrial Dr., St. Louis, MO 63132).

1983

(Jan. 23-27)—Semi-Annual Meeting of the American Society for Testing and Materials Committee D-1 on Paint and Related Coatings and Materials. Dutch Inn, Lake Buena Vista, FL. (ASTM, 1916 Race St., Philadelphia, PA 19103).

(Jan. 26)—"New Concepts for Coating Protection of Steel Structures" Symposium sponsored by ASTM Committee D-1 on Paint and Related Coatings and Materials and the Steel Structures Painting Council. Lake Buena Vista, FL. (Cochairman R.F. Wint, Hercules Incorporated, 910 Market St., Wilmington, DE 19899).

(June 15-18)—Oil & Colour Chemists' Association Biennial Conference on "The Efficient Use of Surface Coatings." Viking Hotel, York, England. (R.H. Hamblin, Director and Secretary, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex, HA0 2SF, England).

(Sept. 28-Oct 1)—Oil & Colour Chemists' Association's Silver Jubilee Convention and Exhibition. Southern Cross Hotel, Melbourne, Australia. (O.C.C.A.A., 1983 Pacific Coatings Convention, C/- Tiioxide Australis Pty. Ltd., Private Bag 13, Ascot Vale, Victoria, 3032, Australia).

(Oct. 11-13)—"Finishing '83" sponsored by the Association for Finishing Processes of the Society of Manufacturing Engineers. Cincinnati Convention Center, Cincinnati, OH. (Susan Buhr, AFP/SME Administrator, One SME Dr., P.O. Box 930, Dearborn, MI 48128).

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'Kumbug' from Hillman

Diary of a First Time Conventioneer

Day Three

I awoke pretty late this morning with a hazy recollection of some kind of festivities last night. I must have had a good time. If not, the way I felt was an awful waste of agony. My head hurt and my mouth felt like it was full of cotton. The taste was terrible. Going to a convention is a wonderful learning experience. I am learning that my capacity for carousing is very limited. From now on it will be strictly technical business and early to bed.

I finally managed to get myself up and start the day. After a quick breakfast, I decided to devote myself to the paint show. I bused over to the convention hall—a little bleary-eyed with my badge on upside down. One look at the exhibit hall, though, and I became wide awake and excited. What an impressive sight! That paint show is really great—some beautiful girls in short shorts, prizes, gifts, magicians, a guy who makes bubbles, and all kinds of games. Was I impressed!

The first thing I learned at the show was that my putting is not as good as I had thought. I don't know if the girls running the little golf game are pros but they certainly had my attention. Although I went back in line six times, I couldn't win that darn flashlight. Yet, whatever company that ran that booth certainly did a fine job.

I did better at shooting pool. I won a prize. When I find out what products the sponsor sells, I sure am going to get some samples.

I can't wait to get back on the golf course. I took a free lesson from that golf pro at the show and watched myself on video tape instant replay. For the first time I could really see why I hook my shots so often. It was a great demonstration. I stood around for about an hour and watched some others get instruction. I think I learned a lot. Very educational!

It seems that Atari was one of the big exhibitors there. Video games all over the place. I knocked off several warriors from outer space and won a prize. Finally, I got shot down and lost interest.

Exhaustion was starting to overtake me and I finally realized after several hours that it was getting late. The show was about to close so I grabbed a couple of those free shopping bags and ran around picking up key rings, pens, tees, balls, can openers, and as much literature as I could stuff in the bags. As I picked up a brochure, I stopped and recognized that it held just the information I had been looking for back at the lab. I went over to the rep at the booth to get some more data but he politely pointed out that they were about to turn out the lights.

What a jerk I've been!—there is a lot more to this show than golf and video games. I vowed to be back at this show tomorrow as I wearily limped my way to the bus. Riding to the hotel I almost fell asleep standing up. When I got back to my room, I lay down on the bed to rest before dinner. I guess I fell asleep. Talk about getting to bed early!!!

• • •
As time goes on, Howard Jerome—our dapper but aging President—has revealed some further bits of evidence on "how to know you're growing older." I wouldn't be surprised, Howard, if the Presidency was accelerating the process.

Your knees buckle but your belt won't.
You're 17 around the neck, 44 around the waist, and 105 around the golf course.
You stop looking forward to your next birthday.
You are startled the first time someone calls you Old-Timer.
You remember today that yesterday was your wedding anniversary.
You just can't stand people who are intolerant.
You burn the midnight oil after 9:00 p.m.
Your back goes out more often than you do.
Your pacemaker makes the garage door go up when you watch a pretty girl walk by.
You get all your exercise being pallbearer for your friends who exercise.

It was nice to get a note from friend Peter Tepperman who sent along the following [quoted from *The Science of Winning* by B.P. Fabricand] with the comment that it reminds him of some of the reports he gets from his lab.

A medical research worker, testing the effect of a new drug on cancer in chickens, was overjoyed to find that it seemed to cure in a high percentage of cases. Word of his success quickly spread, and he was invited to address a medical convention. In his talk, he described the drug, his techniques, and finally his results. These he reported as follows: "An amazingly high percentage of the chickens, one-third of them, showed a complete cure. In another third, there seemed to be no effect, and er. . . the other chicken ran away."

And from an anonymous donor, the following gems of wisdom are offered.

"Science is built of facts the way a house is built of bricks, but an accumulation of facts is no more science than a pile of bricks is a house."—*Henri Poincaré*

"There is no question that there is an unseen world. The problem is, how far is it from midtown and how late is it open."—*Woody Allen*

"Experience is not what happens to you; it is what you do with what happens to you."—*Aldous Huxley*

"Be careful about reading health books. You might die from a misprint."—*Mark Twain*

"He uses statistics as a drunken man uses lamp-posts—for support rather than illumination."—*Unknown*

"I think that as life is action and passion, it is required of a man that he share the passion and action of his time at peril of being judged not to have lived."—*Justice Oliver Wendell Holmes*

—Herb Hillman

Color-matching Aptitude Test



Color-matching Aptitude Test Set was created by the Inter-Society Color Council and sponsored by the Federation. It is in world-wide use as a means for estimating color-matching skill. The 1978 edition contains minor refinements over the previous editions (1944, 1953, 1964), and these bring it closer to the original ISCC plan, making it a still more successful tool for evaluating color-matching skill.

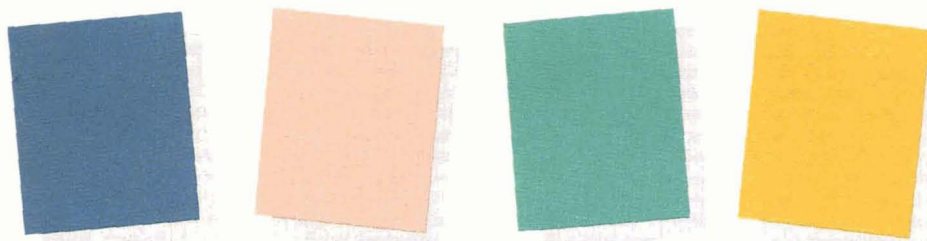
The basic aim of the Test is to provide an objective measure that will aid in determining an individual's ability for performing color-matching tasks accurately. Changes in a person's color-matching skill may occur over a period of time, improving due to training, experience, and motivation, or lessening when removed from practice, or as a result of health disorders. Retesting at regular intervals will provide an indication of any such changes in an individual's ability.

The Test is not designed to indicate or measure "color-blindness" (anomalous color vision). Special tests designed for this purpose should be used.

The Color-matching Aptitude Test Set consists of a carrying case, an easel on which are mounted 48 color chips, a dispenser which holds 48 matching chips, score sheets, and a scoring key.

Brochure available upon request. Price: \$400.

Orders must be prepaid. U.S. and Canada—Add \$10.00 shipping. All others—Add \$50.00 shipping.



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resistance, plus high gloss. Both have excellent spray characteristics, rapid hardness development, fast set and tack-free time, plus high resistance to alcohol and salt spray.

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