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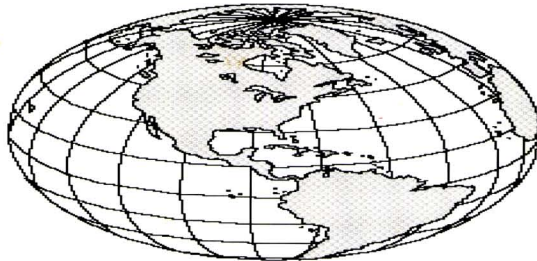
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JANUARY 1995   **VOL. 67, NO. 840**

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GENERAL

The JOURNAL OF COATINGS TECHNOLOGY is published monthly by the Federation of Societies for Coatings Technology for its membership of approximately 7,000 in 26 Constituent Societies in the United States, Canada, Great Britain, and Mexico. The JOURNAL is devoted to the advancement of knowledge in the science and technology of surface coatings, the materials comprising such coatings, and their use and performance.

The Editors invite submission of original research papers, review papers, and papers under the special headings *Open Forum* and *Back to Basics*, and *Letters to the Editor*. All manuscripts will be assumed to be previously unpublished writing of the authors, not under consideration for publication elsewhere. When review papers contain tables or graphs from copyrighted articles, the authors will be required to obtain permission for use from the copyright holders. When the organization with which the authors are affiliated requires clearance of publications, authors are expected to obtain such clearance before submission of the manuscript. Papers presented to associations other than the Federation must be released by written communication before they can be considered for publication in the JOURNAL OF COATINGS TECHNOLOGY. Authors are obligated to reveal any exceptions to these conditions at the time a manuscript is submitted.

The JOURNAL OF COATINGS TECHNOLOGY has first right to the publication of papers presented at the Annual Meeting of the Federation and at local regional meetings or symposia of the Constituent Societies.

Papers in which proprietary products or processes are promoted for commercial purposes are specifically nonacceptable for publication.

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Four complete copies should be sent to the Editor, JOURNAL OF COATINGS TECHNOLOGY, 492 Norristown Rd., Blue Bell, PA 19422. The cover letter should address copyright, clearance, and release issues discussed above and should specify paper category: *Original Research, Reviews, Open Forum,* or *Back to Basics.*

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MANUSCRIPT PREPARATION

In general, authors are advised to use the "Handbook for Authors" published by the American Chemical Society as a guide to the preparation of manuscripts (ACS, 1155 Sixteenth St., Washington, D.C. 20036). Another excellent reference work is "How to Write and Publish a Scientific Paper," by Robert A. Day (ISI Press, 3501 Market St., University City Science Center, Philadelphia, PA 19104).

Authors are encouraged to consider submissions in several categories and to prepare their manuscripts accordingly. The categories are:

Original Research Papers: The main technical content of the JOURNAL OF COATINGS TECHNOLOGY will continue to be original research papers. Editors support the trend in scientific writing to a direct, less formal style that permits limited use of personal pronouns to avoid repititious or awkward use of passive voice.

Review Papers: Papers that organize and compare data from numerous sources to provide new insights and unified concepts are solicted. Reviews that show how advances from other fields can beneficially be applied to coatings are also desired. Reviews that consist mainly of computer searches with little attempt to integrate or critically evaluate are not solicited.

Open Forum: Topics for this category may be nontechnical in nature, dealing with any aspect of the coatings industry. The subject may be approached informally. Editors encourage submission of manuscripts that constructively address industry problems and their solutions.

Back to Basics: Papers that provide useful guides to Federation members in carrying out their work are solicited. Topics in this category are technical but focus on the "how to" of coatings technology. Useful calculations for coatings formulation and procedures that make a paint test more reproducible are examples of suitable topics. Process and production topics, i.e., paint manufacture, will also be reviewed in the *Back to Basics* category.

If a submitted paper consists of the text of a presentation made previously to a monthly or special meeting of a Society for Coatings Technology, or to another technical group, the name of the organization and the date of the presentation should be given. If someone other than the author of the paper made the presentation, this information, too, should be noted. Papers originally composed for oral presentation will have to be revised or rewritten by the author to conform to the style described in this guide.

Manuscripts should be typed with double spacing on one side of $8^1/2$ x 11 inch (22 x 28 cm) paper, with at least one-inch (2.5 cm) margins on all four sides. All paragraphs should be indented five spaces, and all pages should be numbered at the top center, or upper right corner.

Title

The title should be as brief and informative as possible. Selection of titles that are key word-indexable is a helpful and recommended practice.

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Give complete names, company or institutional affiliations, and brief biographical sketches of all authors. If available, submit a 5 x 7 inch (13 x 18 cm) black-and-white photograph with glossy or smooth high sheen surface, for each author. See later section on photographs for further details.

Abstracts

A 75-100 word abstract must be part of the manuscript, and should be a concise description of the key findings or teachings of the work described in the paper. The abstract should not repeat the title or include reference numbers, nor should it duplicate the Conclusion or Summary.

Text

Main headings and sub-headings should be used to improve readability, and to break up typographical monotony. The text should *not* be presented as an alphanumeric outline.

The main headings usually should be INTRODUCTION, EXPERIMENTAL, RESULTS AND DISCUSSION, and SUMMARY or CONCLUSIONS. Sub-headings will be specific to the subject.

Only as much review as is necessary should be given to provide an introduction to the subject; the main burden for extensive background should be placed on the list of references.

Standard scientific and technical terminology should be used to convey clear and unambiguous meaning, but the use of technical jargon or slang should be avoided. Authors should bear in mind that the JOURNAL has an international audience, for many of whom English is a second, not native, language. Use of regional idioms or colloquialisms should be avoided. The use of obscure abbreviations is also discouraged. When appropriate, abbreviations should be made in parenthesis immediately following first mention of the term in the text, and then used alone whenever necessary.

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Metric system units should be used wherever applicable with the equivalent English units shown afterwords in parentheses. The ASTM Metric Practice Guide, E 380-72 (American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103) is a convenient reference.

Tables, Graphs, and Drawings

Tables, rather than descriptive text, should be used only when they are genuinely helpful. They should be proportioned in accordance with the height and width limitations of the JOURNAL'S pages. Each table should be typed on a separate sheet, rather than included in the text, and appended to the manuscript. Each table should be numbered and have a descriptive caption. Tables should be referenced in the text (e.g., "See *Table* 1").

In numerical data in tables, numbers less than one should have a zero before the decimal point.

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All photographs should be sharp, clear, black-and-white prints no larger than 8 x 10 inches in size. Photos should be clearly labeled on the reverse side, taking care not to mar the image.

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When illustrations are secured from an outside source, the source must be identified and the Editor assured that permission to reprint has been granted.

Nomenclature

Whenever possible, generic names should be used in preference to trade names. When trade names must be used to avoid ambiguity, and the name is a registered trademark, the symbol R, in a circle or parentheses, should be given immediately following, and the manufacturer listed as a footnote. In general, trade names should be used only in footnotes or in an appendix, rather than in the text.

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Equations

Equations must be typed, or written clearly, with equations numbered sequentially in parentheses to the right. If Greek letters are used, write out their names in the manuscript margin at the first point of use. Place superscripts[a] and subscripts[b] accurately. Avoid the use of superscripts in a manner that can lead to their interpretation as exponents.

Summary

The paper should be concluded with a summary which is intelligible without reference to the main text. The summary may be more complete than the abstract, listing conclusions drawn from the text. A well written summary can serve to inspire the busy reader to turn back to the paper, to read it thoroughly.

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(1) Pascal, R.H. and Reig, F.L., "Pigment Colors and Surfactant Selection," *Official* DIGEST, 36, No. 475 (Part 1), 839 (1964).
(2) Davidson, H.R., "Use and Misuse of Computers in Color Control," JOURNAL OF COATINGS TECHNOLOGY, 54, No. 691, 55 (1982).
(3) Stephen, H.G., "Hydrogen Bonding—Key to Dispersion?," *J. Oil & Colour Chemists' Assoc.*, 65, No. 5, 191 (1982).
(4) Patton, T. (Ed.), *Pigment Handbook*, Vol. 1, John Wiley & Sons, Inc., New York, 1973.
(5) Henderson, W.A. Jr. and Singh, B. (to American Cyanamid Co.), U.S. Patent 4,361,518 (Nov. 30, 1982).

OTHER INFORMATION

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* * * *

The Evolution of Technology and Information

In its 70-year history, the official publication of the Federation has been a consistent, reliable source of information for the industry.

Originally known as the Official DIGEST, the publication provided a record of the activities and meetings of (as it was then called) the Federation of Paint and Varnish Production Clubs. The purpose was "the exchange of information and opinion looking toward improved routine practice, elimination of waste, and improved service to the consumer." The goals may be similar, but the appearance and format definitely changed over the years as the Official DIGEST evolved into the JOURNAL OF PAINT TECHNOLOGY (in 1966) and later into the JOURNAL OF COATINGS TECHNOLOGY (1976). With each alteration, the JOURNAL more accurately reflected the expanding areas of focus of the Federation as it moved beyond the early realm of the production clubs.

Through all of these changes, there has been one constant—the publication of technical papers whose reputation has been recognized by an international audience. The Official DIGEST—the "Bible"of the industry—established this reputation with its incisive papers on coating fundamentals and the JCT is dedicated to maintaining this tradition of excellence.

Now it's that time again. Time for the best to get even better. In answer to a growing industry need for a reputable source for practical solutions to common problems and for a wider variety of articles with emphasis on evolving technologies, the "new" JCT will have even more to offer! Beginning with this issue, the JCT will feature the original research papers that have become the mainstay for the industry, as well as articles with a broader focus, such as those involving manufacturing methods, the use of computers in the industry, quality control, testing methods, design of experiments, etc.

In addition, the 70-plus year old journal is getting a facelift (figuratively speaking). A new design, a new look—designed to offer information in a more attractive, readable format.

The coating industry is changing. For some, this represents an ever increasing challenge to remain informed of the latest techniques and innovations. Let the JCT provide you with the tools to meet this challenge.

Patricia D. Viola
Editor

Technical Abstracts

Additives Approach to Defect Elimination in Thermoplastic Waterborne Industrial Maintenance Coatings—J. Schwartz and S.V. Bogar

Airless spray applied industrial maintenance topcoats can suffer from defects such as microfoam, gloss loss, retraction, and a reduction in corrosion resistance. By careful selection of additives, such as dispersants, defoamers, and wetting agents, the coatings chemist can reduce ore eliminate these defects. Basic and empirical data are presented that will demonstrate how these defects were managed in several model industrial maintenance coating formulations.

Une Approche D'Additifs Pour Éliminer les Défauts de Revêtements Industriels Thermoplastiques à base d'eau—J. Schwartz et S.V. Bogar

Les revêtements de finition industrielle appliqués par pulvérisation sans air, peuvent éprouver des défauts comme micromousse, perte de lustre, rétraction, et une réduction de la résistance à la corrosion. A l'aide d'une sélection appropriée d'additifs, telle que dispersants, démoussants, et agents mouillants, le chimiste de revêtements peut réduire et même éliminer ces défauts. Des données de base et empirique sont présentées et vont démontrer comment ces défauts sont traités dans plusieurs modèles de revêtements industriels.

Acercamiento a los Aditivos que Sirven Para la Eliminación de Defectos en Recubrimientos Termoplasticos Para Mantenimiento Industrial—J. Schwartz y S.V. Bogar

La aplicación por espreado de recubrimientos para mantenimiento industrial puede presentar defectos como son, microespuma, perdida de brillo, retracción y reducción en la resistencia a la corrosión. Se pueden reducir o eliminar estos defectos con la selección adecuada de los aditivos como son dispersants, antiespumantes y agentes humectantes. Datos basicos y empiricos se presentan para demostrar como estos defectos pueden ser manejados en varias formulaciones de recubrimientos de mantenimiento industrial.

Thermal and Impact Induced Stress Failure in Painted TPO: The Role of Surface Morphology—R.A. Ryntz, A.C. Ramamurthy, and D.J. Mihora

Damage to exterior automotive plastics by stone chipping is of major concern to design engineers. Whether to resolve warranty claims or to increase general customer satisfaction, reducing or eliminating this type of damage over the extended service life of the vehicle is a major objective of the industry. With the introduction of new plastic substrates such as thermoplastic olefins (TPO), there is a need to establish a reliable baseline knowledge on stone impact response characteristics under a variety of impact conditions, coating types, coating application conditions, substrate processing, and surface pretreatment conditions.

Dynamic mechanical properties of engineering plastics and polymeric coatings are strong functions of the temperature and strain rate which in turn effect impact response. In injection molded plastics morphology, crystallinity, composition, and in-plane stresses at the surface can significantly differ from those observed in the bulk. In TPO, an injection molded plastic, a layered surface structure exists which consists of varying crystallinities of polypropylene and rubber. The surface layers, referred to as "boundary layers," are sensitive to injection molding processes as well as paint application processes and often afford a cohesively weak interface within the substrate.

Based on the morphological complexity of the TPO substrate, stone impact response of a painted TPO surface can be expected to be a complex phenomenon. The objective of this work is to present an approach to predict the locus of failure due to stone impact on TPO via numerical simulation based on a physical model developed in our laboratories.

Echec au Stress Thermique et D'Impact Chez les TPO Peinturées: Le Rôle de la Morphologie de Surface—R.A. Ryntz, A.C. Ramamurthy, et D.J. Mihora

Les dommages causés par l'écaillement dû aux pierres aux plastiques automobile extérieurs concerne grandement les ingénieurs en design. Résoudre les réclamations de garanties ou bien augmenter la satisfaction générale du client, réduire ou éliminer ce type de dommage sur la durée de vie du véhicule est un objectif majeur de l'industrie. Avec l'introduction de nouveaux substrats en plastiques comme les oléfines thermoplastiques (TPO), il y a un besoin d'établir une connaissance de base digne de confiance sur les caractéristiques de réponse de l'impact aux pierres sous une variété de conditions d'impact, types de revêtements, conditions d'applications des revêtements, traitement du substrat et conditions de prétraitement de la surface.

Les propriétés dynamiques mécaniques des plastiques d'ingénierie et des revêtements polymériques sont des fonctions de la température et du degré de tension qui en retour affecte la réponse à l'impact. Dans la morphologie des plastiques à moulage par injection, l'apparence cristalline, composition, et les stress en plan à la surface peuvent différer de façon significative de ceux observés en bloc. Dans les TPO, un plastique de moulage par injection, une structure de surface en couches existe qui consiste en des variations cristallines de polypropyléne et de caoutchouc. Les couches de surface, appelés "boundary layers" sont sensibles aux procédés de moulage par injection de même qu'aux procédés d'application de peintures et offre fréquemment une interface de cohésion faible à même le substrat. Basé sur la

complexité morphologique du substrat TPO, on peut s'attendre que la réponse de l'impact aux pierres de la surface TPO peinturée soit un phénomène complexe. L'objectif de ce travail est de présenter une approche pour prédire le point de défaillance due à l'impact aux pierres sur une TPO via une simulation numérique basé sur un modèle physique développé dans nos laboratories.

Fallas de Tensión Termicas y de Impacto en Pinturas TPO: El rol de la Morfología de Superficie—R.A. Ryntz, A.C. Ramamurthy y D.J. Mihora

Los daños al exterior en plásticos automotrices por astillamiento o impacto es lo que debe preocupar mas a los ingenieros de diseño, ya sea para resolver reclamos de garantía o para incrementar la satisfacción general del cliente reduciendo o eliminado este tipo de daños sobre el servicio de vida del vehículo, el cual es el objetivo principal de la industria. Con la introducción de nuevos sustratos plásticos como las olefinas termoplásticas (TPO) es necesario establecer una base formal de conocimiento en relación al astillamiento o impacto para responder a las características bajo una variedad de condiciones como impacto, tipo de recubrimientos, condiciones de aplicación de recubrimientos, procesamiento de sustratos y condiciones de pretratamiento de superficie.

Propiedades mecánico dinámicas de la ingeniería de plasticos y recubrimientos poliméricos son funcion de la tempertura y estan en proporción de la fuerza en el cual el efacto del impacto responde. En pinturas TPO con moldeo de plástico por inyección, una capa en la estructura de superficie existente consiste de cristalinidades variantes de polipropileno y hule. Las capas de superficie, son sensitivas a los procesos de moldeo por inyección tanto como los procesos de aplicación de pintura y frecuentemente ofrece una fuerza cohesiva de interface con el sustrato.

Basandose en la complejidad de morfología de sustratos de TPO la respuesta al impacto de piedras de una superficie TPO recubierta se espera que sea un fenómeno complejo. El objetivo de este trabajo es presentar una aproximación para predicir fallas debido al impactamiento o astillamiento en TPO via simulación númerica basandose en el modelo fisico desarrollado en nuestros laboratorios.

Bivariate approach to Viscosity Adjustment—M.J. Eiseman

This article outlines a method to produce temperature-corrected solvent reduction charts to enable high-solids coating manufacturers and users to simply, quickly, and accurately adjust the viscosity of a coating before application. The method allows accurate control of viscosity without requiring the operator to bring a sample to a standard temperature. Generation of the charts requires minimal and easily obtainable data.

A bivariate strategy is the key to this method. Modeling the kinematic viscosity of the coating, v^2, using an empirical equation (8) enables simultaneous prediction of the effects of temperature, T, and weight fraction solvent reduction, r.

Since equation (8) is linear with respect to the fitting parameters, simple multiple linear regression yields parameter estimates. One typically achieves correlations with R^2 values of 0.99.

Ajustement de la Viscosité par une Approche Bivarée—M.J. Eiseman

Cet article expose un méthode pour produire des tableaux de réduction de solvant corrigé pour la température, pour permettre aux manufacturiers de revêtements à haute teneur en matières solides de même qu'aux utilisateurs d'ajuster simplement, rapidement et de façon précise, la viscosité d'un revêtement avant son application. La méthode permet un contrôle précis de la viscosité sans avoir recours à un échantillon à une température étalon. La production des tableaux requirère peux de données que l'on peut facilement obtenir. Une stratégie bivariée est la clef de cette méthode. Modéliser la viscosité cinématique de revêtement, v^2, en utilisant une équation empirique (8) permet une prédiction simultanée des effets de la température, T, et de la fraction de masse de la réduction de solvant, r.

Etant donné que l'équation (8) est linéaire par rapport aux paramètres d'ajustement, une simple régression linéaire multiple produit les paramètres estimés. On peut obtenir des corrélations avec des valeurs R^2 de 0.99.

Aproximamiento Bivariado para el Ajustamiento de la Viscosidad—M.J. Eiseman

Esta artículo describe un método para producir cartas de temperatura corregidas para la reducción de solventes para ser manejados por fabricantes de recubrimientos de altos sólidos y usuarios, simplificando y agilizando el ajuste de la viscosidad del recubrimiento antes de la aplicación. El método permite un control exacto de la viscosidad sin requerir que el operador lleve muestras a temperatura standar. La generación de estas cartas requiere datos obtenidos minimos y faciles.

Una estrategia bivarida es la llave a este método. Modelando la viscosidad cinematica del recubrimiento, v^2, usando una ecuación empírica (8) que habilitan predicciones simultaneas de los efectos de la temperatura, T, y la reducción en el peso de la fracción del solvente, r.

La ecuación es lineal con respecto a parametros apropiados, las campos por una regresión simple lineal estiman los parametros. Un típica correlación con R^2 da un valor de 0.99.

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1995 FSCT Spring Week Program in Cancun Focuses on "Coatings in the Americas"

Focusing on "Coatings in the Americas: Regulatory and Technological Issues," the 1995 FSCT Spring Week Technical Seminar will be held on May 17-18, at the Fiesta Americana Coral Beach Hotel in Cancun, Mexico.

The emergence of the North American Free Trade Agreement (NAFTA), combined with technological advancements and changing environmental regulations, requires coatings industry professionals to be astute in a variety of topics. Past industry rules are no longer applicable in this new climate. The 1995 Spring Week seminar is designed to provide the necessary information to compete in the international coatings marketplace.

Seminar Program

Simultaneous English-Spanish-English translation will be offered during the seminar. Topics to be covered at the two-day conference include:

▼ REGULATORY ISSUES:

NAFTA and the free movement of raw materials and finished goods
Transportation issues
VOC—waste handling and disposal
Exporting and importing into Mexico
Labeling issues and regulations
General overview of lead issues
HAPS

▼ NEW COATINGS TECHNOLOGIES:

General trends in coatings in the United States, Europe, and Asia; specifically, VOCs, high solids, waterborne, emulsions, and lead substitutes
New technologies in process equipment
Process techniques for using new technologies (for manufacturers and applicators)
Economics of the new technologies
Areas of coverage: Automotive (OEM and refinishing), can coaters, coil coatings, wood finishes, industrial maintenance finishes

▼ QUALITY ISSUES:

ISO 9000—what it is and what it covers
Methods of getting a company certified
Overview of certified companies
Explanation of the difference between 9001, 9002, etc.
Establishing a good methodology
Steps needed to achieve certification

Flow of tasks that must be done to become certified
Review of Automotive Unified Standards for Quality
Success stories of companies who have achieved ISO 9000 certification.

Hotel Information

The five-star Fiesta Americana Coral Beach hotel will be the host hotel for the 1995 FSCT Spring Week.

Each guest room in the beachfront hotel is a suite offering a bedroom and sitting area as well as a veranda with an ocean view.

The hotel is within walking distance to many popular restaurants and nightclubs in Cancun. Rates are $135 (U.S.) for a single or double plus 10% tax. To make reservations, complete the necessary information on the Spring Week Registration Form.

Room reservations must be guaranteed by credit card or check for one night's stay plus tax. Cancellations received within seven days of arrival will be billed for one night's stay plus tax. No-shows will be billed for two nights' stay plus tax. The cut-off date for receiving the group rate is March 31, 1995.

Traveling to Cancun

U.S. citizens need only furnish an original birth certificate and photo ID for entry to Mexico and return to the States. Citizens of other countries should contact FSCT for further information.

Ground Transportation

The official airport shuttle transportation company for Spring Week is EPIC. The service will assist attendees at Cancun International Airport with luggage and will provide transportation to the Fiesta Americana Coral Beach Hotel. Reservations for the shuttle must be placed in advance using the Spring Week Registration Form. The shuttle fee is $10 (U.S.) per person each way.

Airfare

The FSCT Travel Desk has a variety of options available for travel to Cancun, including tour package deals with hotel and airfare combined. If interested in a tour package, we ask that you make your reservations through the FSCT Travel Desk so that the Federation can receive "room nights used" credit for your hotel stay during the Spring

Week. In this way, you will be helping the FSCT to defray expenses while receiving discounted travel prices.

To place air reservations or to inquire about special tour packages:
Call 1-800-448-FSCT or
215-628-2540
FAX: 215-628-0310

Post-Seminar Excursions

The Federation has planned two excursions during Spring Week. Participation is by pre-registration and pre-payment only. Registration closes May 9.

▼ ARCHEOLOGICAL ADVENTURE

On Friday, May 19, visit Tulum and Xcaret. Dating from the Post-Classic period, Tulum (located approximately one hour and 45 minutes from Cancun) is an important archeological site of the Mayan culture. It is one of the few sites surrounded by a wall and constructed along the sea. There are approximately 60 structures on the site, and participants will receive a guided tour.

Following Tulum, the tour visits Xcaret, an ecological park complete with a botanical garden and zoo as well as an underground river for snorkeling. Participants are encouraged to bring a change of clothes should they desire to swim or snorkel at Xcaret.

The tour will depart from the hotel on deluxe motorcoaches at 8:30 am and return at 5:00 pm. The price is $79 U.S. per person which includes admission fees to both stops as well as lunch at Xcaret.

▼ MARKETS TO MALLS

On Saturday, May 20, explore Cancun's markets and malls for a mixture of bustling crafts markets, exclusive boutiques, and elegant department stores. A guided visit through the Flea Market in downtown Cancun and also a visit to a modern shopping mall will be included.

The tour will depart on deluxe motorcoaches at 9:00 am and return at 12:00 noon. The price is $15 U.S.

A tour desk exclusively for Spring Week participants will be set up in the Fiesta Americana Coral Beach Hotel to assist in arranging other types of tours for individuals as well as for restaurant reservations.

For additional information, contact FSCT Headquarters, (610) 940-0777 or FAX, (610) 940-0292.

FSCT 1995 SPRING WEEK REGISTRATION FORM

Register Today! Advance housing registration closes March 31, 1995.
Complete this form and mail or fax with payment to:
FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350 USA
610-940-0777 ▪ FAX: 610-940-0292

Seminar Program

Name _____   Nickname (For badge) _____

Company _____

Mailing Address _____

City _____ State (Province) _____ Country _____ Mailing Code _____

Phone _____ Fax _____

COMPANY (Check one)
- ❏ Manufacturers of Paints, Varnish, Lacquer, Printing Inks, Sealants, etc.
- ❏ Manufacturers of Raw Materials
- ❏ Manufacturers of Equipment and Containers
- ❏ Sales Agents of Raw Materials and Equipment
- ❏ Government Agency
- ❏ Research/Testing/Consulting
- ❏ Environmental Services
- ❏ Educational Institution
- ❏ Paint Consumer
- ❏ Other _____

POSITION (Check one)
- ❏ Management/Administration
- ❏ Manufacturing and Engineering
- ❏ Quality Control
- ❏ Research & Development
- ❏ Sales and Marketing
- ❏ Consultant
- ❏ Educator/Student
- ❏ Other _____

❏ **FSCT Member Fee**	Name of FSCT Society _____	$225 US per person	$ _____
❏ **Non-Member Fee**		$295 US per person	$ _____

Hotel Reservations   (Deadline for special group rate is March 31, 1995)

Name of Occupant(s) _____

Arrival Date _____ Arrival Time _____

Departure Date _____

Room Type: ❏ Single - $135 US   ❏ Double - $135 US   ❏ Smoking   ❏ Non-smoking
    ❏ Special needs: Please specify _____

Deposit Information: One night's deposit[1,2,3] is required   **Deposit of $148.50 US** $ _____

Note:
(1)   Deposit includes one night's room rate ($135) plus 10% tax.
(2)   Hotel cancellations received **within seven (7) days** of arrival will incur a penalty of one night's room fee, plus tax
(3)   **No-shows** will incur a penalty of two night's room fee, plus tax

Post Seminar Excursions and Airport Shuttle Transportation

❏	May 19 — Tulum and Xcaret	No. of Persons _____	@ $79 US per person	$ _____
❏	May 20 — Markets to Malls	No. of Persons _____	@ $15 US per person	$ _____
❏	Airport Shuttle Transportation	No. of Persons _____	@ $10 US One-Way	$ _____

    Airline _____   **Flight No.** _____

Note: Excursion and Airport Shuttle cancellations received after **May 9** are non-refundable

Calculate Total Payment Due

Please note choice of payment:

❏   Check enclosed. Make payable to FSCT in U.S. Funds

❏   Please charge to the following card: ❏ MC   ❏ VISA   ❏ AMEX   **Total Payment Due FSCT:** $ _____

card number _____   card expiration date _____

name of card holder _____   signature _____   date _____

Panorama to Assist in NAFTA Certificate of Origin Verification

The Panorama™ MSDS on CD-ROM Retrieval System, developed and produced by the FSCT, has proven to be an effective tool for storing, accessing, and retrieving the Material Safety Data Sheets used by the coatings and associated industries. To provide an even greater benefit to these industries, the FSCT is encouraging companies to send their NAFTA Certificates of Origin (COO) and Harmonized System numbers to be incorporated onto the Panorama CD. There is no cost to the supplier for participation on the System.

For a product to receive preferential tariff treatment under the North American Free Trade Agreement, it must qualify under the NAFTA Rules of Origin. These rules were designed to reward companies using North American parts, raw materials, and labor, and to ensure that goods traded duty-free have substantial North American content. The Rules of Origin are set out in Chapter 4 of the NAFTA agreement.

NAFTA Rules of Origin take into account where goods are produced and what materials are used to produce them. When products meet the rules of origin and qualify for NAFTA tariff preference, they are said to "originate." Exporters must prepare a NAFTA Certificate of Origin to certify that goods originate and provide this certificate to the importer so that the importer may claim NAFTA tariff preference.

The tariff preference cannot be obtained for many types of coatings-related products unless the preference criteria of every raw material contained therein is verified by the supplier. This verification (preferably in the form of a COO) must be updated yearly and records of each must be kept for five years.

This is where the Panorama System can help. Any company who supplies coatings that will be applied to articles which are resold may be asked by their customers to supply a COO for their product. Panorama would provide a unified coatings industry approach to this problem. It will relieve raw material suppliers from the burdensome requests from a multitude of customers for COO.

In addition, Panorama will reduce the time to obtain origin verification from weeks to minutes, and reduce record-keeping for all involved.

The financial incentive to qualify for NAFTA tariff preference is significant. NAFTA provides that all trade between Canada, Mexico, and the U.S. will be duty-free by the end of 2003, provided a COO is presented for goods which pass across the borders. Until that time, duty rates for various products will differ greatly. Each country has prepared duty reduction schedules which are specific to the country of export. These duty reduction schedules are indexed by the HS number. If a COO is not presented for goods imported from another NAFTA country, then the goods will be assessed duties at the Most Favored Nation rate, which can differ considerably from the NAFTA rate.

To participate, send Certificates of Origin c/o Michele Cortopassi, Accu-Mem Systems, 3105 N. Wilke Rd., Arlington Heights, IL 60004.

For additional information on submitting COO, or subscribing to Panorama, contact FSCT Headquarters, 492 Norristown Rd., Blue Bell, PA 19422; (610) 940-0777; or FAX (610) 940-0292.

Society Speakers Program Initiated by Educational Coordinating Committee

A recent survey conducted by the FSCT Educational Coordinating Committee (ECC) determined that the Federation could provide a great benefit to its Constituent Societies by assisting in procuring quality speakers for presentations at monthly meetings. Informative, relevant presentations are seen as a key element to attracting members to local Society meetings.

"One of the complaints of Societies has been that the technical quality of talks has gone down as they have become very commercial," stated Melinda Rutledge, Los Angeles Society member and Chairman of the ECC. "Based on that, we want to get people that are renowned in their area of expertise to give good technical talks."

Acting on this issue, the ECC has initiated the Society Speakers Program. The basis of the program is to maintain a list of coatings technology experts who will give high quality, informative talks at Societies' monthly meetings. FSCT funding for this program will allow all Societies, regardless of their size or finances, to take advantage of these presentations.

Currently, the list of speakers is being developed. Speakers, chosen by the consensus of the ECC, will remain on the list for two to three years and present four or five talks in that time.

This program is designed to benefit local Societies by boosting member participation at the monthly meetings and by providing educational opportunities which will aide in the personal and professional development of their members.

The ECC is planning to begin the Society Speakers Program in 1995-96. For additional details, contact FSCT Headquarters.

Student Papers Invited for 1995 A.L. Hendry Awards Competition

Student authors are encouraged to submit entries in the 1995 Southern Society for Coatings Technology Alfred L. Hendry Award Competition.

This year's award features cash prizes to both the student author (or authors) and the author's sponsoring lab. The student receives a $1,000 cash award and expenses covering attendance at the FSCT Annual Meeting and Paint Industries' Show in St. Louis, MO, on October 9-11, 1995 to receive the honor and a suitably inscribed certificate for the best paper submitted for the competition. The competition is administered by the FSCT Educational Coordinating Committee and several committee members will judge the entries. In addition, the laboratory of the sponsoring school will also receive a grant of $500.

Submitted papers must describe the results of original research on a subject related to coatings technology, or present a significantly insightful, comprehensive review of a field of coatings technology. Work done on coatings related topics as part of an undergraduate research project or as a senior thesis is appropriate for submission.

Those wishing to enter the competition must send a letter of intent, along with the title of the proposed paper and a brief abstract, by March 15, 1995 to: Hendry Awards Committee, c/o FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350. The deadline for receipt of manuscripts is July 3, 1995.

The A.L. Hendry Award is sponsored by the Southern Society for Coatings Technology and commemorates the industry contributions of the late Alfred L. Hendry, president of A.L. Hendry Co. in Tampa, FL. He was a Past-President of the Southern Society and an active participant in many of FSCT's educational activities.

1995 Roon Awards Competition Underway
Entries Invited; Awards Total Up to $4,000

FSCT Roon Awards Committee Chairman Clifford Schoff of PPG Industries, Inc., Allison Park, PA, has announced a Call for Papers for the 1995 competition. Prospective authors have the opportunity to earn up to $4,000 in cash prizes for outstanding papers.

The annual awards are sponsored by the Coatings Industry Education Foundation (CIEF) and were established to honor the late Leo Roon, founder of Nuodex Products Co., with support funds coming from the Roon Foundation. The awards will be presented at the FSCT Annual Meeting, October 9-11, 1995 in St. Louis, MO.

To submit a paper for the competition, the following rules must be observed: (1) The paper must describe original work not previously published or presented; (2) The information must be directly related to the protective coatings industry; (3) It must be of such a caliber that it reflects a step forward in real scientific contribution to the

coatings industry; and (4) It must be accompanied by a clearance for publication. The paper must also be prepared by someone associated with the organic coatings industry, including raw material suppliers and educators.

All of those interested in entering the competition must send a letter of intent, along with the title of the proposed paper and a brief abstract by March 1, 1995 to: Roon Awards Competition, c/o FSCT, Attention: Michael G. Bell, Director of Educational Services, 492 Norristown Rd., Blue Bell, PA 19422.

Entries that arrive after March 1 will be considered for the 1996 competition.

1994 Roon Award Winners

FIRST PLACE—"Epoxy Nucleophile Catalyzed Transesterification," by G.P. Craun, of the Glidden Company

SECOND PLACE—"A Study on the Chemistry of Polyguanidine as Precursors for Polycarbodiimide Crosslinkers in Powder Coatings," by J.W. Taylor, M.J. Collins, and D.R. Bassett, of Union Carbide Corp.

PDC Seminar Schedule Announced for 1995

The FSCT will continue its successful series of programs designed to promote continuing educational opportunities for its members and the industry. Developed by the its Professional Development Committee, the following seminars are scheduled:

"FORMULATING FOR THE NEW CLEAN AIR ACT"—March 21-22, in Cleveland, OH, and November 6-7 in Denver, CO. The seminar will feature updates on the latest Clean Air Act information critical for lab personnel.

"POLYMER CHEMISTRY FOR THE COATINGS FORMULATOR"—June 20-21, in Chicago, IL. This two-day event will feature practical information on a variety of issues concerning polymer chemistry.

The registration fee for each program is $295 for FSCT members and $395 for non-members.

For additional information, contact FSCT at (610) 940-0777.

Principles Governing the Roon Awards

These awards, established in 1957 by the late Leo Roon, founder of Nuodex Products Co., and supported by funds provided through the Roon Foundation, are for the best technical papers (other than those by a Constituent Society of the Federation) submitted for presentation at a Federation Annual Meeting.

Papers to be considered for the competition will be those by individuals associated with the organic coatings industry, including raw material suppliers and educational institutions.

The principles governing the awards are as follows:

(1) The papers will be of such caliber that they will reflect a step forward in real scientific contribution to the coatings industries. The papers shall describe original work which has not been previously published or presented.

(2) Papers must be directly related to the protective coatings industry.

(3) None of the work shall originate from, be guided by, or be any part of, a Coatings Technology Society. These awards shall in no way detract from the cooperative efforts of Societies' Technical Committees and their convention papers.

(4) An Awards Committee, appointed by the President of the Federation, will judge the entries.

(5) The Committee is not obligated to award prizes if in its opinion none of the submitted papers are of a caliber to be worthy of such recognition.

(6) The submitted papers may be presented at the Annual Meeting with the consent of the President of the Federation and the Chairman of the Program Committee. Although it is the intent of the Roon Awards that winning papers will be presented at the Annual Meeting, papers accepted for presentation and papers awarded prizes are separate and distinct. An invitation from the Program Committee to present his/her paper should not be construed by any author as an indication that the Roon Committee has awarded the paper a prize.

(7) Winning papers will be published in the JOURNAL OF COATINGS TECHNOLOGY, which has prior rights to publication of all submitted papers.

(8) The papers shall be concise and informative discussions of up to approximately 6,000 words. Papers greatly exceeding this length should be divided into more than one paper. Multiple entries in the competition from a single author are acceptable. It is requested that manuscripts be prepared in accordance with Journal of Coatings Technology style, as outlined in the Guide for Authors.

(9) A 150 to 200 word abstract shall accompany the paper.

(10) Papers will be rated with emphasis on: (a) Originality – 40%; (b) Scientific Importance – 20%; (c) Practical Value – 20%; and (d) Quality of Composition – 20%.

(11) The Awards will be open to anyone involved in study or engaged in work related to the protective coatings industries, including paint, varnish and lacquer manufacturers, raw material suppliers, research laboratories and universities. (The Committee, however, will not accept papers which involve raw material sales promotion or are self-serving in regard to exploiting a proprietary product.)

(12) The Committee may award any number of prizes, the total of which is not to exceed $4,000.

(13) All papers must be accompanied by company or educational institutional clearance for publication.

(14) Those planning to submit a paper in 1995 must advise the Chairman through FSCT Headquarters (contact Michael G. Bell, Director of Educational Services, Federation of Societies for Coatings Technology, 492 Norristown Road, Blue Bell, PA 19422) by March 1. FSCT must receive 10 publication manuscripts by May 15.

(15) The 1995 Awards and accompanying engraved plaques will be presented during the Annual Meeting in St. Louis, MO, October 9-11.

JCT Interviews: **J.P. Walton**

A conversation with the 73rd President of the FSCT

"When a ship misses the harbor, it's seldom the harbor's fault."

Visitors to the Jamestown Paint Company could hardly fail to notice the pithy "words of wisdom" that are displayed in the office of J.P. Walton. What is not as obvious is how representative these maxims are of the man himself—precise, to the point, encouraging actions over excuses. J.P.'s personal philosophy is more reminiscent of a time when words like "family" and "responsibility" and "giving back" were sincerely valued—representing more than just trendy buzz words.

Joseph P. Walton was named President of the Federation of Societies for Coatings Technology at its Annual Meeting in New Orleans, on October 14, 1994.

He is Executive Vice President for Jamestown Paint Company, a family-run business located in Jamestown, PA. J.P. started with the company in 1973 as Materials Manager in charge of purchasing. Founded in 1885, Jamestown Paint provides coatings to a variety of markets. Quality control and a concern for continuous improvement motivated Jamestown to apply for ISO 9001 certification, which it was recently awarded (see article, page 20).

The importance of family is evident in his professional, as well as his personal, life—his father, Joseph M. Walton, is Chairman and CEO of Jamestown; one brother and an uncle and cousin are employed there. At the same time that J.P. is serving as head of the Federation, his father is President of the National Paint & Coatings Association.

Anyone who spends time with J.P. becomes aware that the focus of his activities is clearly his family, which includes four children and wife of 24 years, Kathy. Pictures of them fill his office. The favorite, though, is their family portrait—a formal sitting in which J.P., Kathy, Joseph (D.), Colleen, Kate, and Brian

are attractively dressed and posed—all making faces at the camera!

The JCT cornered J.P. in his office to learn more about the man and his plans for the coming year.

JCT: What are your main responsibilities as Executive Vice President at Jamestown Paint?

JPW: I'm involved in all of the operations except sales. There are five Waltons here and I'm the only one not involved in sales. *(Laughs)* Maybe they just don't trust me out there with the customers!

I work with all the different department heads— planning—whatever it is required to get the job done. We have, in my opinion, extremely good people involved in every area of the business. One of the projects which occupied a lot of time recently was preparing for the final audit for ISO certification.

JCT: How do you see ISO certification affecting your organization?

JPW: I'm hoping for two things: one, from an internal standpoint, it will make us better at doing our jobs. Everyone has been paying more attention to details and tightening up operations. From the time we have started doing this, we have seen our returned goods dramatically drop. Second, from an external standpoint, we will use the certification to demonstrate we are competitive and concerned about maintaining quality products. We see ISO certification as a positive marketing tool. Our laboratory was recently accredited by American Association of Laboratory Accreditation. These things lend credence to the kind of job we can do.

JCT: How long have you been an FSCT member? Why did you join?

JPW: I joined the Federation in the 1970s. Initially, my involvement was limited to attending some of the local meetings, usually if they had manufacturing topics. I became more involved when additional members were needed on the FSCT Manufacturing Committee and I was asked to represent the Cleveland Society.

I chaired this committee for three years and helped out in later years. I also chaired the NPCA Manufacturing Committee.

We have a philosophy at Jamestown that we should be involved and support the FSCT—that it's important to give back to the industry. So, for the size of our company, we sponsor a lot of members.

JCT: During his tenure as FSCT President, John Lanning emphasized the need for greater involvement of the manufacturing segment of the industry. Will you continue to stress this?

JPW: Yes, we feel very strongly about involving the production people more heavily in the Federation. As you know, the FSCT started as production clubs. Over the course of the years, for whatever reason, it has focused more on the technical areas. I feel that there is a need, not necessarily go back to where we started, but to open up the programming on a local and national level to attract the manufacturing people.

If you are in the coatings industry you know that, without cooperation between the manufacturing and technical people, you won't have as good a product. So it makes good sense to bring those people together, working together, to improve the

"The way I was brought up was to not just think of the bottom line but to consider what the corporation needs to give back to the industry."

"I think the single biggest threat that we face is being legislated out of existence and the way to stop that is to educate people."

"Because the Federation changes administrations each year, there is clearly a need for long-range goals to set a more defined course for the future."

communication between both groups. If we can do something from an educational standpoint to achieve this, it has to be to the benefit of the entire industry. The FSCT needs to do more to represent the operations end, including quality control, production, shipping, and transportation segments.

JCT: *What personal skills/experience will you bring to the FSCT Presidency?*

JPW: My strongest suits are organizational and planning. The FSCT is currently involved in strategic planning and I believe I can be of assistance in that area. Because the Federation changes administrations each year, there is clearly a need for long-range goals to set a more defined course for the future.

Another thing I will do every chance I get is to promote corporate responsibility. The way I was brought up in this industry was to not just think of the bottom line but to consider what the corporation needs to give back to the industry. This philosophy becomes difficult at times because you're trying to walk a tightrope of fulfilling family responsibilities—which come first—your work responsibilities, and your volunteer responsibilities. Yet, I don't think I've missed more than two percent of my kid's sporting events. They were all active in sports! I adjusted my schedule whenever possible to attend those events. That's my number one interest.

JCT: *Since you mentioned goals, what are some of the other things you would like to accomplish in the next year?*

JPW: I think the FSCT committee structure needs some revamping. One of the things I'd like to see accomplished is a "rotation system" for both the chair and personnel on all committees. By bringing in "fresh blood," we encourage new ideas. We can involve more people with the FSCT and they can learn more about the organization. I think that is very important. We're not doing our job if we are not attracting young people to this group, because they are the future of the FSCT.

Term limits can also provide incentive to work on a committee. Individuals may be more inclined to serve if they can see there's a definite goal to accomplish in a definite time period. They know they aren't expected to serve forever!

Now, I'm not advocating that people who have been around a long time shouldn't be involved. If they have served, for example, on the Manufacturing Committee, they can now move to Educational or PDC or some other committee. Sharing their experiences with different committees will be very positive.

I think if we do that on the national level it will help on the local Society level. Many of the locals have the same people

doing the same thing year after year after year. I don't think that's healthy.

JCT: *What in your opinion what is the greatest strength of the Federation?*

JPW: The greatest strengths are the individual members and their volunteer effort. We have close to 7500 members, and many are involved in committee work, not only at the local level, but also at the national level.

If you look at society as a whole, you see that volunteerism is something that has suffered in recent years, whether it be in local politics, church activities, whatever. Yet I still see many examples of volunteerism in this industry, particularly with the FSCT.

JCT: *What incentive is there? Why would you encourage someone to become involved?*

JPW: To insure their future. People can get a lot more out of it than they put in. They meet a lot of people . . . develop contacts that are invaluable.

JCT: *As a paint manufacturer what do you see as the greatest challenge facing your company in the future?*

JPW: I believe that the greatest threat—to all paint manufacturers—is from the legislative arena. I think it is very important for both the FSCT and the NPCA to be involved in this area. That's why I strongly support the state paint councils. All too often legislation that is proposed is not based on scientific facts. Through the working relationship between the NPCA, with their lobbying expertise, and the FSCT, with their technical expertise, we can educate legislators so they can pass regulations that will accomplish the needed goals, based on scientific facts.

The FSCT can assist in providing the information to the NPCA legal people because our tech people and our production people know what technologies are out there to allow things to be accomplished. For example, cleaning up the air can still be done, but the legislation has to be accomplished in a rational, logical manner.

JCT: *Now that you've brought up the subject of NPCA, we noticed that the name of their President is strikingly similar to yours. Is there a sense of competition between you and your father?*

JPW: I'm sure if either group had known that the other group was talking to either one of us, the results would have been different. This is very unusual. I don't think we've ever had two people from the same company heading up both organizations at the same time, let alone two people who are related!

My father and I personally have no problem. Much has to do with what we do here in the company. My responsibilities more closely align themselves with what the FSCT represents and what my father does with the company more closely follows what NPCA represents. So, all of our professional lives we have been working with a corporate structure that has clear delineation. We don't have a sense of competition, we have a sense of cooperation. I think things are much easier, because we can cut through the B.S. and talk with each other in a way that two other individuals might not be able to.

JCT: *From our point of view, though, it would have been easier if you had two different names!*

JPW: When I came to work at Jamestown, they felt the same way! So we went to using initials. A lot of people don't know me as other than "J.P."

JCT: *When you visit the Societies, you stress the importance of education in the FSCT mission. How do you see this role?*

JPW: To me, education is really broad. When I see what the FSCT Educational Committee is planning with the science kits for high school level students and their teachers, I'm very excited. Someone recently asked me about ways to attract college students into the industry. I think you have to go way before that. You get students when they are in high school and let them see that coatings are really neat. Then, maybe they'll go to college and take up polymer chemistry and get a job with a paint company. What the Educational Committee is doing will encourage interest in the coatings industry at an early level.

We are conducting a survey with NPCA to find out where money should best be spent to help people get jobs in the industry when they get out of school, or at least to determine what jobs will need to be filled in the future. In addition, we are talking about broadening the technical programming an the Annual Meeting to attract a wider audience. All of these things are part of education. Not to mention all of the things the Societies do on the local level, such as symposiums, educational programs, etc. That's all part of educating the members. Very positive. Every opportunity I have I will try to stress the continuation and expansion of it.

JCT: *Do you see yourself as the "education president"?*

JPW: No, I don't see myself as THE education president, because I think Past-Presidents of the FSCT, like John Lanning and Colin Penny, stressed this. I think it's something that needs to be continued. (*Laughs*) Maybe I'm just the "ditto President."

T his digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by National Paint and Coatings Association, Washington, D.C. The Regulatory Update is made available as a service to FSCT members, to assist them in making independent inquiries about matters of particular interest to them. Although all reasonable steps have been taken to ensure the reliability of the Regulatory Update, the FSCT cannot guarantee its completeness or accuracy.

Regulatory Update January 1995

Environmental Protection Agency
December 6, 1994—59 FR 62681
National Emission Standards for Hazardous Air Pollutant from Surface Coating Operations; Proposed Standards for Shipbuilding and Ship Repair
Action: Proposed rule and notice of public hearing

The U.S. EPA is proposing standards limiting emissions of hazardous air pollutants (HAPs) from surface coating operations from any new or existing shipbuilding and ship repair facilities at a major source. The proposed standards implement section 112 (d) of the Clean Air Act.

The proposed rule covers toxic emissions form ship painting and coating operations and would impose limits of HAPs contained in 23 types of coatings. The rule would apply to any shipbuilding facility that has the potential to emit 10 tons or more of a hazardous air pollutant, and any facility with the potential to emit 25 tons or more of any combination of hazardous air pollutants. The rule only applies to coating operations and does not cover other shipbuilding activities such as blasting.

The proposals also contain requirements for controlling evaporation during the handling and transfer of substances containing toxic air pollutants, including standards on the handling and transfer of these materials from containers, tanks, vats, vessels, and piping systems.

Comments on the proposal must be received on or before February 6, 1995. Written comments should be submitted in duplicate to Public Docket No. A-92-11 at the following address: U.S. EPA, Air and Radiation Docket and Information Center (6102), 401 M St., S.W., Washington, D.C. 20460. If a hearing is requested before December 27, then a hearing will be scheduled for January

18, 1995 in Research Triangle Park, NC. Contact Kim Teal at (919) 541-5580 for verification of a hearing.

For further information concerning regulatory decisions and the proposed standards, contact Mohamed Serageldin, Coatings and Consumer Products Group, U.S. EPA. (919) 541-2379.

Department of Justice
Drug Enforcement Administration
December 9, 1994—59 FR 63738
Implementation of the Domestic Chemical Diversion Control Act of 1993 (Pub. Law 103-200)
Action: Proposed rule, partial withdrawal

The Drug Enforcement Administration (DEA) has withdrawn parts of its notice of proposed rulemaking to implement the Domestic Chemical Diversion Control Act of 1993 (DCDCA) which deal with mixtures (paint) and the manufacturer reporting requirements. The current proposed requirements regarding chemical mixtures and manufacturer reporting may result in a larger volume of submissions than originally anticipated, or possible duplicative reporting.

In a letter to the Chemical Manufacturers Association, the DEA explained that because of the anticipated burden to both industry and DEA, assessment of the chemical mixtures provisions and manufacturer reporting requirements are warranted. DEA said they will seek the advice of appropriate segments of the chemical industry to identify alternative methods to accomplish the goals of the DCDCA regarding the two issues.

For further information, contact G. Thomas Gitchel, Chief, Liaison and Policy Section, Office of Diversion Control, Drug Enforcement Administration, Washington, D.C. 20537, (202) 307-7297.

Environmental Protection Agency
December 6, 1994—59 FR 62652
National Emission Standards for Hazardous Air Pollutants (NESHAP); Proposed Standards for Hazardous Air Pollutant Emissions from Wood Furniture (Surface Coating) Operations
Action: Proposed rule and notice of public hearing

The U.S. EPA is proposing standards limiting emissions of hazardous air pollutants (HAPS) from existing and new wood furniture surface coating operations located at major sources. The proposed standards implement section 112 (d) of the Clean Air Act Amendments of 1990. The intent of the standards is to protect human health and the environment by requiring new and existing major sources to control emissions to the level attainable by implementing the maximum achievable control technology (MACT), taking into consideration the cost of achieving such emission reductions.

The proposed rule represents the EPA's first comprehensive regulation of the wood furniture surface coating category. No federal rules, such as new source performance standards (NSPS), have previously been promulgated for this industry. In 1990, two titles of the Clean Air Act Amendments affecting wood furniture were added, prompting regulation of this industry.

Written comments must be submitted in duplicate by February 21, 1995, to: Air and Radiation Docket and Information Center (6102), (LE-131), Attention, Docket No. A-93-10, U.S. EPA, 401 M St., Washington, D.C. 20460.

For further information, contact Madeleine Strum, Coatings and Consumer Products Group, U.S. EPA, Research Triangle Park, NC, at (919) 541-2383.

Environmental Protection Agency November 20, 1994—59 FR61432 Addition of Certain Chemicals; Toxic Chemicals Release Reporting; Community Right-to-Know Action: Final rule

The U.S. EPA is adding 286 chemicals and chemical categories, which include 39 chemicals as part of two delineated categories, to the list of toxic chemicals subject to reporting under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and the Pollution Prevention Act of 1990 (PPA). The additions are based on their acute human health effects, carcinogenicity or other chronic human health effects, and/or their adverse effects on the environment. EPCRA section 313 reporting of the newly listed chemicals and chemical categories will be required beginning with the 1995 calendar year. The first reports for the added chemicals and chemical categories must be submitted to EPA and states by July 1, 1996.

For more information on the rule, contact Maria Doa, Project Manager at (202) 260-9592. For further information on EPCRA section 313, contact the EPCRA Hotline at (800) 535-0202.

Environmental Protection Agency November 30, 1994—59 FR61488 Alternate Threshold for Facilities with Low Annual Reportable Amounts; Toxic Chemical Release Reporting; Community Right-to-Know Action: Final rule

The U.S. EPA is establishing an alternative threshold for those facilities with low annual reportable amounts of a listed toxic chemical. These are facilities that would otherwise meet reporting requirements under section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). A facility that meets the current section 313 reporting thresholds, but estimates that the total annual reportable amount of the chemical does not exceed 500 pounds per year, can take advantage of an alternate manufacture, process or otherwise use threshold of 1 million pounds per year for that chemical provided that certain conditions are met.

For further information, contact Tim Crawford, Project Manager, Mail Code 7408, 401 M St., S.W.,

Washington, D.C. 20460 for specific information on this rule, or for more information on EPCRA section 313, the EPCRA Hotline, (800) 535-0202.

Environmental Protection Agency November 22, 1994—59 FR60101 National Emission Standards for Hazardous Air Pollutants for Source Categories; Aerospace Manufacturing and Rework Action: Reopening of the public comment period

On June 6, 1994, National Emission Standards for Hazardous Air Pollutants (NESHAP) for the aerospace manufacturing and rework source category were proposed by the U.S. EPA (59 FR 29216). Since that time, EPA has received information on several aspects of the proposed rule which has led to new amendments proposed for certain sections. These sections deal with definitions, standards for primer and topcoat application operations, standards for chemical milling maskant application operations, compliance determinations, monitoring requirements, and recordkeeping requirements for the NESHAP for aerospace manufacturing and rework facilities.

Because of the new information, EPA has announced the reopening of the comment period for the aerospace NESHAP. However, only comments limited to the following subjects:

◆ Correction of a typographical error regarding a request for comments for commercial exterior primers;

◆ Proposal for more stringent inorganic HAP emission control requirements for new primer and topcoat application operations;

◆ Proposal to eliminate the exemption for chemical milling maskant application operations for use with the Type I chemical milling etchants;

◆ Clarification of the intent of the proposed requirements for control devices used to control emissions from coating application operations;

◆ Proposal of reduced recordkeep-ing requirements to encourage the use of low-VOC primer;

◆ Request for comment on depainting for private, corporate, and small commuter aircraft;

◆ Request for comment on use and efficiency of control devices for

depainting operations using HAP-containing chemicals; and

◆ Request for comment on determining the appropriate length of the rolling material balance period for liquid-liquid material balances for carbon absorbers used as control devices for solvent recovery systems.

For further information, contact Mary Tom Kissell at (919) 541-4516, Standards Development Branch, Emission Standards Division (MD-13), U.S. EPA, Research Triangle Park, NC 27711.

The Republican Environmental Agenda—The new majority is expected to move legislation known, for some reason, as the "Unholy Trinity." The measure will include the following three elements:

(1) Risk assessment: regulations should be levied only if the health and safety risks are pivotal and only if the cost can be justified.

(2) Property rights: private property owners should be compensated for any loss of property value due to restrictions on how that property may be developed or used.

(3) Unfunded mandates: when the federal government shifts a costly program to a local government, financial aid will be provided to assist in implementing those programs.

Complying with this legislation may be a bit difficult in the Senate, as the likely chairman of the Environment and Public Works Committee, Sen. John Chafee (R-RI), is an ally of the environmentalists. It is probably that Sen. Chafee will be pressured by the more conservative members of his committee to advance the party agenda.

Superfund may be the biggest battle of all in this committee. Several members are outspoken opponents to Superfund, including the likely chairman of the subcommittee with jurisdiction over Superfund, Sen. Robert Smith (R-NH). Bipartisan support for quick passage will be a fantasy if Republicans continue to insist on rescinding the retroactive liability of corporate polluters to clean up old contamination. However, expiration of the Superfund tax at the end of 1995 may be a strong enough incentive to advance a compromise.

States Proposed Legislation and Regulations

Alabama

Solid Waste (Regulation)—The Alabama Department of Public Health (DPH) has revised current regulations for the storage, collection, transportation, transfer, and processing of solid waste; for unauthorized dumps; and for the permitting and operational procedures of solid waste collectors and transporters, processing facilities, and transfer stations. The rule went into effect on November 25, 1994. Contact Kimberly R. Rice, DPH, (205) 613-5373.

Arizona

Air Quality (Regulation)—The Arizona Division of Air Pollution Control (DAPC) issued a proposal which incorporates, by reference, the requirements for general conformity of federal actions to a state or federal implementation plan pursuant to the Clean Air Act of 1990. Contact Martha L. Seaman, DAPC, (602) 207-2222.

The Arizona Department of Environmental Quality (DEQ) issued a proposal that would allow the DEQ to set emission limitations by permit that are equivalent to the National Emissions Standards for Hazardous Air Pollutants (NESHAP) in the event that the U.S. EPA has not established the relevant emission limitation. The proposal also establishes requirements for the contents of permit applications for owners and operators of major sources of hazardous air pollutants and adds provisions for the establishment of maximum achievable control technologies (MACT) requirements. Contact Martha L. Seaman, Division of Air Pollution Control, (602) 207-2222.

California

Air Quality (Regulation)—The California Air Resources Board (CARB) adopted an amendment which revises the regulations establishing designation criteria and which designates areas of California as nonattainment, attainment, or unclassified for all pollutants for which state ambient air quality standards are set forth. The amendment changes the requirements for determining complete data—when less than three years of data are available—to exclude data affected by highly irregular or infrequent events before using the maximum pollutant

concentration to determine if the data meets the completeness criteria. The rule went into effect on December 10, 1994. Contact Rich Bradley, CARB, (916) 322-6076.

Hazardous Waste—CA S. 657 (Campbell) exempts from the definition of storage facility a tank used for the purpose of storing hazardous waste which is treated onsite in accordance with the requirements for conditional authorization or conditional exemption. The bill became law on October 1, 1994 without the governor's signature.

Lead (Notice of Petition)—The California Occupational Safety and Health Standards Board (OSHSB) has announced that it has received a petition requesting that current lead standards be revised. The modifications would include the establishment of universal blood lead testing, the lowering of acceptable blood lead levels, and the development of education programs dealing with lead risks. Contact OSHSB, (916) 322-3640.

Packaging (Regulation)—The California Integrated Waste Management Board (IWMB) adopted an amendment which minimizes the amount of additional recordkeeping and fiscal resources devoted to documenting compliance with regulations pertaining to the rigid plastic packaging container program. The rule, which went into effect on December 4, details the responsibilities of product, container, and resin manufacturers to facilitate compliance with the rigid plastic packaging container statutes. Contact Janice Welch, IWMB, (916) 255-2410.

Colorado

Air Quality (Regulation)—A regulation adopted by the Colorado Department of Health (DOH) requires the submittal of state implementation plans (SIPs) for particulate matter of an aerodynamic diameter of 10 microns or less (PM10) to the U.S. EPA. The rule specifies the areas which are in nonattainment for PM10 and which must show attainment and maintenance of the National Ambient Air Quality Standard for PM10. The new rule goes into effect on January 10, 1995. Contact DOH, 4300 Cherry Creek Dr., S., Denver, CO 80222-1530.

The Colorado Commission on Air Quality Control (CAQC) has

announced that it is considering a proposal that would allow additions to the Air Pollution Emissions Notices (APEN) exemption list and additions to the insignificant activities list. Contact CAQC, (303) 692-2000.

The Colorado Air Quality Control Commission (AQCC) issued a proposal that provides an exemption for any facility or equipment constructed, reconstructed, or modified after August 30, 1989, that is designed to burn less than 10 metric tons per day of municipal solid waste. The rule removes the continuous monitoring requirement and the recordkeeping and reporting requirements for municipal incinerators meeting the requirements. A hearing on this issue will be held on January 19, 1995. Contact Joseph Palomba, Jr., AQCC, (303) 692-2000.

The AQCC issued a proposal to continue the suspension of the Total Suspension Particulates (TSP) standard. The rule became effective November 30, 1994. Contact Sara Laumann, AQCC, (303) 692-3180.

The Colorado DOH issued a final regulation which revises the monitoring state implementation plan in accordance with requirements of the U.S. EPA. The rule became effective January 1, 1995. Contact DOH, (303) 692-3180.

Hazardous Materials (Regulation)— A proposed rule of the Colorado Department of Public Safety (DPS) would amend provisions affecting the routing of vehicles transporting hazardous materials and the issuing of hazardous material transport permits. The proposal also revised the list of materials that can be hauled by longer vehicle combinations. Contact State Patrol, Hazardous Pollution Section, (303) 239-4500.

A final rule of the Colorado Hazardous Waste Commission (HWC) amends current hazardous waste management regulations to incorporate federal EPA amendments to the wood preserving standards. The rule became effective on October 20, 1994. Contact Karen Osthus, HWC, (303) 692-3321.

The Colorado HWC announced a continuation of the meeting on a proposed rule that would amend hazardous waste management regulations to strengthen incinerator standards. The meeting is scheduled for January 17, 1995, in Denver, Contact Karen Osthus, HWC, (303) 692-3321.

Connecticut

Air Quality (Regulation)—The Connecticut Department of Environmental Protection (DEP) adopted a final regulation to implement the requirements of Title V of the Federal Clean Air Act Amendments of 1990. The rule established that fees are based on emissions of nitrogen oxides, volatile organic compounds (VOCs), and any pollutants for which an ambient air quality standard has been listed or any pollutant subject to Section 111, 112, or Title VI. The rule also sets procedures for determining and paying the fees. The rule became effective on September 20, 1994. Contact DEP, Bureau of Air Management, (203) 566-2506.

Florida

Air Quality (Regulation)—The Florida Department of Environmental Protection (DEP) proposed amendments to current regulations regarding air emissions monitoring for stationary sources. The changes will modify testing and emissions monitoring requirements. Contact Michael Hewett, DEP, (904) 488-0114.

Hazardous Waste (Regulation)—A proposed rule of the Florida DEP repeals regulations addressing certain requirements for registration of and standards for storage tank systems. The repeal is necessary because the provisions have been superseded by new standards. Contact John Svec, DEP, (904) 488-3935.

Toxic Substances (Regulation)—A proposed rule of the Florida Department of Revenue (DOR) would adopt regulations to levy a $5 per gallon tax on the production, importation, or sale of perchloroethylene. The proposal provides for the collection and enforcement of the tax and includes exemptions for cases when the product is exported from the first storage facility by a licensed producer or importer. The proposal also includes registration and licensing requirements for producers and importers. Contact Charles Strausser, DOR, (904) 922-4719.

Georgia

Air Quality (Regulation)—A rule adopted by the Georgia Department of Natural Resources (DNR) details requirements for facilities from which air contaminants are or may be emitted. The provisions, which became effective on November 17, 1994, include emission limitations and standards, sampling requirements,

ambient air standards, and open burning and source monitoring. The regulation also specifies the requirements for construction permits; operating permits; the revocation, suspension, modification, or amendment of permits; nontransferable permits; combined permits and applications; permit fees; and Title V operating permits. Contact Air Quality Control Branch, DNR, Atlanta, GA.

Illinois

Air Quality (Regulation)—A final rule of the Illinois Pollution Control Board (PCB) defines insignificant activities and emission levels for the purposes of the Clean Air Act permit program. The rule became effective on October 17, 1994. Contact Diane O'Neill, PCB, (312) 814-6062.

Environmental Programs—IL S. 1724 (Mahar) provides a procedure to extend the period for petitioning for certain hearings to contest agency permit decisions from 35 days to 90 days upon written notice by the applicant and the Agency to the Pollution Control Board. In addition, it provides for a legislative privilege for environmental audits. On December 1, both the Senate and the House adopted Conference Committee reports on the bill.

Hazardous Waste—IL S. 1852 (Mahar) amends the Environmental Protection Act to require owners or operators of underground storage tanks to determine if a release of petroleum has occurred and requires the Illinois EPA to propose, and the Pollution Control Board to adopt, regulations on groundwater investigation monitoring. The bill, which was introduced on November 15, was sent to the Senate Committee on Rules.

Transportation (Regulation)—An emergency rule of the Illinois Commerce Commission amends regulations to change the per vehicle certification fee for all intrastate motor carriers of property, except household goods, from $25 to $6. The rule was effective on October 21, 1994 and expires March 20, 1995. Contact Kathy Campbell, Commerce Commission, (217) 785-4869.

Iowa

Air Quality (Regulation)—The Iowa Environmental Protection Commission adopted a regulation which establishes a voluntary operating permit program and

provides an alternative to the Title V operating permit program for small sources able to qualify under these rules. The rule went into effect on December 14, 1994. Contact Christine Spackman, Department of Natural Resources, Wallace State Office Building, 900 E. Grand Ave., Des Moines, Iowa 50319.

Kansas

Toxic Substances (Regulation)—The Kansas Department of Health and Environment (DHE) adopted a regulation which specifically exempts certain chemicals from reporting fees, and it applies right-to-know program reporting and fee requirements to aboveground fuel storage tanks. The rule became effective on November 28, 1994. Contact Jon Flint, DHE, (913) 296-1690.

Louisiana

Air Quality (Regulation)—The Louisiana Department of Environmental Quality (DEQ) has proposed a regulation which revises increments for PM10 and restricts increases in ambient air concentrations of PM10 to established levels. Contact Patsy Deaville, DEQ, (504) 765-0399.

A proposed rule of the Louisiana Department of Environmental Quality would amend air quality regulations to bring state standards of performance for new stationary sources into compliance. Contact Pasty Deaville, DEQ, (504) 765-0399.

Maryland

Air Quality (Regulation)—The Maryland Department of the Environment (DOE) has withdrawn a proposed rule that would have amended the regulations regarding requirements for plastic parts coating and for the applicability level of reasonably available control technology (RACT) for control of VOCs from heatset lithographic web printing presses. The withdrawal is effective November 20, 1994. Contact Dorothy Guy, DOE, (410) 631-3245.

A proposed rule of the Maryland DOE would amend regulations, incorporating by reference prevention of significant deterioration provisions relating to particulate matter increments. Contact Deanna Miles-Brown, DOE, (410) 631-3173.

A proposed rule of the DOE would amend regulations to expand the RACT requirement to include point sources in the serious nonattainment area with VOC emissions of 25 tons or more per year. When adopted, it

will be submitted to the federal EPA as a state implementation plan revision. Contact Deanna Miles-Brown, DOE, (410) 631-3173.

Automotive Refinishing (Regulation)—The Maryland DOE has proposed a rule setting forth reasonable control measures for vehicle refinishing to include the use of lower VOC content coatings, improved application methods, and improved cleanup methods. The proposal, when adopted, will be submitted to the federal EPA as a state implementation plan revision. Contact Deanne Miles-Brown, DOE, (410) 631-3173.

Massachusetts

Graffiti—MA H. 5438 (Local Sponsor) relates to the penalty for the crime of defacing or otherwise destroying property by the use of graffiti. The bill was introduced on November 21 and sent to the Joint Committee on Criminal Justice.

Market Share Liability—MA H. 3976 (Jehlen) authorizes the use of market share liability in civil actions brought against producers or manufacturers of lead constituents used in paint. On November 28, the bill failed—by a vote of 63-83—to advance in the House of Representatives. It is considered dead for this legislative session.

Water Quality—MA H. 124 (Office of Environmental Protection)—reforms the Clean Water Act of the Commonwealth. On December 6, the bill passed the House and was sent to the Senate.

Michigan

Hazardous Waste—MI S. 1293 (Berryman) implements a hazardous waste management plan for the state. The legislation, which was introduced on November 10, was referred to the Senate Committee on Natural Resources and Environmental Affairs.

Occupational Safety and Health (Regulation)—The Michigan Department of Labor and Industry (DLI) proposed a rule incorporating by reference amendments to federal Occupational Safety and Health Administration (OSHA) standards for personal protective equipment for general industry; the retention of certain DOT markings, placards, and labels; hazardous waste operations and emergency response; and confined and enclosed spaces and other dangerous atmospheres in shipyard employment. Contact DLI, (612) 297-3254.

Montana

Air Quality (Regulation)—A final rule of the Montana Department of Health and Environmental Sciences (DHES) amends current regulations in order to keep state air quality standards at least as stringent as federal requirements, to retain state control over the state air quality program, and to implement revised requirements for sampling and data collection. The rule became effective on October 28, 1994. Contact Yolanda Fitzsimmons, DHES, (406) 444-2544.

Nebraska

Air Quality (Regulation)—The Nebraska Department of Environmental Quality (DEQ) proposed a rule which establishes standards for issuing operating permits. The proposal allows the DEQ to approve alternate methods for establishing annual emission rates and to set criteria for the development of insignificant activities for emission reporting requirements. Contact Thomas R. Lamberson, DEQ, (402) 471-2186.

Nevada

Air Quality (Regulation)—The Nevada State Environmental Commission (SEC) proposed a rule which would extend the effective dates of the state's air quality operating permit program. The proposal would extend the date of implementation from November 14, 1994 to a date in the future based on the federal EPA's approval of the program. Contact David Cowperthwaite, SEC, (702) 687-4670.

New Hampshire

Lead (Regulation)—The New Hampshire Department of Health and Human Services (DHHS) adopted a final regulation which establishes licensing and certification requirements for lead abatement workers. In addition, the rule adopts procedures for lead cleanup and inspection requirements. Contact Jean Bergman, DHHS, (603) 271-4492.

New Jersey

Air Quality—NJ A.R. 11 (Corodemus) memorializes President and Congress to enact legislation amending the Federal Clean Air Act Amendments of 1990 to provide flexibility to the state and avoid undue economic hardship.

Lead—NJ S. 1537 (Bassano and Matheussen) requires the screening of children for lead exposure. The legislation was amended and released from the Senate Committee on Health on December 1.

Toxic Substances (Regulation)—A final rule of the New Jersey Department of Health (DOH) establishes the program-implementing requirements of the Worker and Community Right-to-Know Act. The rule codifies the interpretation of "good faith effort" with respect to right-to-know surveys by public employers and the labeling of containers by both public and private employers. The readoption of the rule became effective on September 28, 1994 and the amendments became effective on November 7, 1994. The rule expires on September 28, 1999. Contact Richard Willinger, DOH, (609) 984-2202.

North Carolina

Air Quality (Regulation)—A final rule of the North Carolina Department of Environment, Health, and Natural Resources (DEHNR) amends regulations regarding miscellaneous VOC emissions by clarifying that diacetone alcohol and perchloroethylene are not considered photochemically reactive. The rule became effective on September 1, 1994. Contact Thomas Allen, DEHRN, (919) 733-7015.

Oklahoma

Lead (Regulation)—The Oklahoma Department of Environmental Quality (DEQ) proposed to adopt regulations dealing with lead-paint management. Under the proposal, individuals engaging in lead-based paint activities would be required to undergo an accredited training course and certification procedures. Firms and laboratories that are involved in lead-based paint management or testing would have to register with the state. In addition, the regulation would establish standards for the identification, testing, abatement, and disposal of lead-based paint. Contact Shawna McWaters-Khalousi, DEQ, (405) 271-5220.

Pennsylvania

Hazardous Waste—PA H. 1503 (George) amends the Storage Tank and Spill Prevention Act by providing for underground storage tank program requirements, interim requirements, and discontinued use, as well as the

powers and duties of the Underground Storage Tank Indemnification Board.

PA S. 560 (Shumaker) provides for household hazardous waste collection programs. The bill was sent to the governor for signature on November 23.

Lead—PA H. 1865 (McNally) requires certification of individuals engaged in lead-based paint activities, training by accredited training programs, and the licensure of lead contractors. The legislation establishes minimum training requirements and standards for workers performing lead-based paint activities; interim regulations; fees for accreditation, certification, and licensure; and the Lead-Based Paint Abatement Advisory Committee. The bill was released with amendments from the House Committee on Appropriations on November 14.

Toxics-in-Packaging—PA H. 337 (Vitali) regulates toxic materials used in packaging and components thereof. It prohibits packaging that includes inks, dyes, pigments, adhesives, stabilizers, or any other additives containing lead, cadmium mercury, or hexavalent chromium which has been intentionally introduced as an element during manufacturing.

South Carolina

Air Quality (Regulation)—The South Carolina Department of Health and Environmental Control (DHEC) proposed a rule which would incorporate requirements of the federal general and transportation conformity standards pursuant to the Clean Air Act Amendments of 1990. The proposal also would establish criteria for determining that federal actions conform to the goals of the state implementation plan for maintaining or achieving attainment of national ambient air quality standards. Contact DHEC, Bureau of Air Quality, (803) 734-4750.

Hazardous Waste—SC S. 162 (Leventis and Courson) provides that hazardous waste includes all waste disposed of in a land disposal site permitted to receive hazardous waste.

South Dakota

Air Quality (Regulation)—The South Dakota Department of Environment and Natural Resources (DENR) proposed a regulation addressing the U.S. EPA's changes to the Air Pollution Control program. The regulation will allow interim approval of the state's Title V air quality permit program by the U.S. EPA. Contact Brian Gustafson, DENR, (605) 773-3351.

Utah

Hazardous Waste (Regulation)—The Utah Department of the Environmental Quality (DEQ) issued a proposed rule to clarify situations under which certificates of compliance for underground storage tanks lapse or may be revoked. The proposal provides for the revocation of a certificate of compliance if a tank owner or operator does not satisfy all leaking underground storage tank cleanup requirements. Contact Gary Astin, DEQ, (801) 536-4100.

A proposed rule by the Utah DEQ clarifies coverage and eligibility requirements for the petroleum storage tank fund for leaking petroleum underground storage tanks. The proposal specifies conditions for the waiver of fund assessments, require annual facility throughput to be reported as a specific number, and allow the extension of the 30-day reporting period. Contact Gary Astin, DEQ, (801) 536-4100.

A proposed rule would amend regulations of the Utah DEQ regarding hazardous waste management standards for specific types of facilities. The proposal would replace limits needed to qualify for the Bevill exemption with land disposal restrictions limits. Contact Susan Toronto, DEQ, (801) 538-6170.

Solid Waste (Regulation)—A notice announces a revision by the Utah DEQ of regulations regarding solid waste general requirements. Contact Carl Wadsworth, DEQ, (801) 538-6170.

Toxic Substances (Regulation)—A proposed rule of the Utah Department of Environmental Quality (DEQ) would revise regulations to incorporate by reference federal amendments concerning new test methods associated with pentachlorophenol in wood surface protection. Contact Susan Toronto, DEQ, (801) 538-6170.

Washington

Hazardous Materials (Regulation)—A regulation adopted by the Washington Department of Labor and Industries (DLI) corrects references necessitated by the federal-initiated changes to existing hazard communication rules. In addition, the rule clarifies labeling requirements, and establishes the duty of distributors, manufacturers, and importers to provide material safety data sheets (MSDSs) to employees. Contact Suzanne L. Mager, Division of Consultation and Compliance, Voice Mail (206) 956-5525.

West Virginia

Hazardous Materials (Regulation)—The West Virginia Public Service Commission (PSC) has permanently adopted an emergency amendment relating to uniform registration and permitting program for motor carriers transporting hazardous materials. The regulation went into effect on December 12, 1994. Contact Howard M. Cunningham, PSC, 201 Brooks St., P.O. Box 812, Charleston, WV 25323.

Wisconsin

Air Quality (Regulation)—The Wisconsin Department of Natural Resources (DNR) proposed a rule which changes the major/minor distinction of an indirect source, and states that an indirect source that emits or has potential to emit more than 25 tons of carbon monoxide per year is considered a major source. Contact John Meier, DNR, (608) 267-0869.

Wyoming

Hazardous Materials—WY S. 10 (Joint Committee of Transportation) amends provisions relative to the transportation of hazardous materials on highways. The bill was prefiled on November 28.

Hazardous Waste (Regulation)—The Wyoming Department of Environmental Quality (DEQ) has proposed a regulation which applies to owners and operators of existing and new hazardous waste treatment, storage, and disposal facilities, and generators and transporters of hazardous waste. Contact David Finley, DEQ, (307) 777-7752.

SCM Chemicals Invests $128 Million in Titanium Dioxide Business

During the Third International European Industry Overview Press Briefing, Mr. Donald V. Borst, Chairman, President, and Chief Executive Officer of SCM Chemicals, Baltimore, MD, revealed plans to expand the company's titanium dioxide capacity and environmental upgrades at its two Ashtabula, OH, TiO₂ facilities.

SCM Chemicals' global TiO₂ production capacity will be increased by 11% at a cost of $80 million. The company will invest an additional $48 million in waste treatment facilities in Ashtabula to complete a program to manage its waste products on-site at all of its TiO₂ plants worldwide.

The larger of the two projects is the expansion of the company's global TiO₂ production capacity from 453,000 to 505,000 metric tons per annum (tpa). This project will debottleneck the capacities of each of the company's six chloride-process TiO₂ plants by a total of 52,000 tpa. Therefore, the chloride-process rutile TiO₂ capacity will be increased by 14% to 429,000 tpa or 85% of the expanded total capacity.

According to Mr. Borst, "The 52,000 tpa of additional rutile TiO₂ capacity is scheduled to be commissioned in the first quarter of 1996 and located as follows:

▼ 26,000 tpa in North America to expand the total rutile capacity of the company's U.S. factories at Ashtabula and Baltimore by 12% to 241,000 tpa;

▼ 22,000 tpa in Europe at the company's United Kingdom factory at Stallingborough, where the chloride-process TiO₂ plant will be expanded by 25% to 109,000 tpa; and

▼ 4,000 tpa in Asia/Pacific to expand the company's plant near Bunbury, Western Australia, by five percent to 79,000 tpa."

He continued to say "the company's 76,000 tpa of sulphate capacity remains unchanged."

The second project involving environmental upgrades of SCM Chemicals' two operating sites at Ashtabula will utilize technology developed and employed at the company's TiO2 plant in Western Australia to neutralize process wastes and to recover raw materials from the waste stream.

Alcoa Opens New Center for Alumina Processing

Alcoa Industrial Chemicals Division, Pittsburgh, PA, is operating an alumina chemicals processing and distribution facility in Leetsdale, PA.

Initially, the plant is processing tabular and calcined aluminas used in the manufacture of high-temperature refractories and ceramics. Equipped with material screening and grading equipment along with in-process controls to assure product quality and consistency, the facility will classify, blend, package, and inventory the company's products.

Exxon Increases Neo Acid and MEK Capacity

Exxon Chemical Co., a division of Exxon Corp., Houston, TX, has revealed plans to increase capacity at its Louisiana petrochemical complex.

The Baton Rouge petrochemical complex will undergo two capacity increases. The first expansion will occur in the area of neo acids. This facility will be expanded in two increments with the next increase of 30% expected to be on-stream in 1996.

The second increase will be to the methyl ethyl ketone (MEK) and secondary butyl alcohol (SBA) capacity. The Baton Rouge capacity increment is expected to be on-stream during the first quarter of 1995.

Keystone Center Terminates Reg/Neg After Attempts to Reach Consensus Fail

After almost three years of negotiations between the Environmental Protection Agency and the industry, the Architectural and Industrial Maintenance Regulatory Negotiations Committee (Reg/Neg) has been officially terminated. The Keystone Center, facilitators of the negotiations, cited "... that neither the EPA proposal nor the industry proposal had the potential to form the basis for a consensus agreement. Therefore, EPA has concluded that it is appropriate to terminate the agreement."

Despite the unsuccessful attempts at reaching a consensus, some positive aspects for the coatings industry emerged from the deliberations: (1) they provided an opportunity to educate the regulators and the environmental organization representatives about the industry, its economics, and the present state of technology; and (2) no draconium regulatory measures that could have been proposed and imposed.

While the termination does not remove architectural coatings from the sphere national regulation, it does delay development of a policy and puts it in another form; architectural coatings must now be considered, along with all other consumer and commercial products, subject to regulation under article 183(e) of the Clean Air Act. Now, EPA must submit to Congress a CAA-required report on VOC emissions from those products, divide them into four categories according to the amount of their contribution, and regulate one group every four years. Even if architectural coatings are included in the first group, the earliest they could be regulated would be late 1996 or early 1997.

Rhône-Poulenc Announces Formation of Coatings/Construction Materials Business

Rhône-Poulenc, Cranbury, NJ, recently created the Coatings and Construction Materials business following a merger between the Organic and Inorganic Intermediates (Basic Chemicals) and Specialty Chemicals sectors. Effective January 1, 1995, the new business will market polyisocyanate resins, metal organics, water repellents, silicones, defoamers, dispersants, titanium dioxide, and other technologies.

The Coatings and Construction Materials business will begin marketing new products, such as Manalox® WB water repellent system, Nanolatex™, and Ambicure® emulsions, while continuing to offer Rhône-Poulenc's Tolonate®, Rhodopas®, Colloid®, Manalox®, Pentex®, Manchem®, Alusec®, Zircomplex®, Manomet®, Manosec®, and Jaguar® brands of products.

In North America, the new sector will consist of 14 market or product-oriented businesses. The following will also have access to a variety of technologies and solutions: food ingredients, paper chemicals, textile performance chemicals, tire and rubber, detergents and personal care, pharmaceutical ingredients, environmental services, surfactants and specialties, silicones, phosphorus products, organic intermediates, rare earths, and carbonates.

Jamestown Paint Co. Receives ISO 9001; Eyes Expansion in the Automotive Industry

Jamestown Paint Co., Jamestown, PA, recently achieved ISO 9001 certification. According to Joseph P. Walton, Executive Vice President, "ISO certification, along with A2LA certification, will facilitate new business development, particularly in the automotive industry."

Jamestown pursued ISO 9001, a comprehensive ISO 9000 component, which covers design, manufacturing, installation, and servicing, based on the new 1994 guidelines. The audit was completed by SGS, an auditing firm located in London, England. SGS's New York City office conducted Jamestown's ISO 9001 audit, while Orr & Boss, Detroit, MI served as a consultant.

Last year, Jamestown was certified by the American Association for Laboratory Accreditation. The A2LA certification follows a close, independent review of laboratory testing procedures.

Despite reaching certification in these two areas, Jamestown refuses to become complacent. "Our next step is to pursue the new Big Three quality program, QS 9000 certification," added Mr. Walton. "We're preparing for that audit."

Founded in 1885, Jamestown Paint has been owned and operated by the Walton family since 1945. Today, Jamestown has an annual manufacturing capacity of more than one million gallons and serves the automotive, appliance, office furniture, containers, electrical equipment, metal, wire, wood products, machine tools, building materials, and other industries.
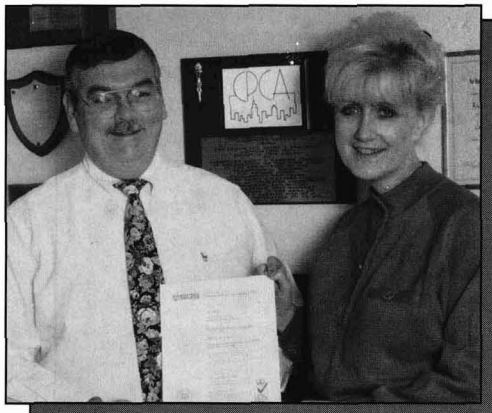
From left: Joseph P. Walton, Executive Vice President and Sandra E. Royal, Quality Assurance Manager Display Jamestown Paint Company's ISO 9001 Certification.

NIPA Harwicke Expands

NIPA Harwicke Inc., Wilmington, DE, has completed the expansion of their Elgin, SC, facilities. This expansion was undertaken to meet the needs for the company's Nipacide® BIT 20 industrial preservative based on 1,2-benziso-thiazolin-3-one.

Nipacide BIT 20 preserves aqueous based materials such as paints and coatings, adhesives, polymer emulsions, etc.

Mexican Chemical Industry Guide Available

Looking for the latest information on the chemical industry in Mexico? The *Kline/Gutierrez New Chemical Guide on the Mexican Chemical Industry* may provide the answer.

According to the authors, chemical production in Mexico reached 26 billion (short) tons valued at roughly $16 billion (U.S. dollars) in 1993. This publication will familiarize the reader with this burgeoning region, since the guide provides trends, future outlook for shipments, end uses, and producers in the Mexican industry.

The *Kline/Gutierrez New Chemical Guide on the Mexican Chemical Industry* is available by subscription only from Kline & Co., Inc., 165 Passaic Ave., Fairfield, NJ 07004 or from Gutierrez Consultores, S.A. de C.V., Oficira Matriz, Liendo No. 614-D4, Col. Obispado, C.P. 64010, Monterrey, N.L. Mexico.

Shell Plans K-1 Rebuild After Fire Destroys Facility

Following a devasting explosion and fire on May 27, Shell Chemical Co., Houston, TX, has revealed plans to rebuild the damaged K-1 facility in Belpre, OH.

The plant produced styrenic copolymers, known as Kraton® D, polymers, which are used to make adhesives, molded parts for automobiles and other consumer products, and roofing and road paving materials.

According to Jim Johnson, General Manager of Shell's Elastomers business, ". . . we have compressed the rebuilding process so it will be completed in 14 months. We will begin making product early in the first quarter of 1996." The new facility will have the same capacity as the previous unit: 100 million pounds annually.

Name Change

Hammond Lead Products, Inc., Hammond, IN, has changed its name to Hammond Group, Inc. Use of the Hammond Lead Products, Inc. name will continue to be used to designate the company's lead oxide division with operations in Hammond, IN, and Pottstown, PA.

There has been no change in the corporate legal structure and all divisions retain their status as operating divisions of Hammond Group, Inc.

Velsicol Buys Hüls Plasticizer and Mil Spec Businesses

Velsicol Chemical Corp., Rosemont, IL, has acquired the Chestertown, MD, plant and certain products of Hüls America Inc.

Under terms of the sale, Velsicol acquires Hüls' Chestertown plant , the Amdex® and Nuoplaz® plasticizer lines and the military specs lubricant businesses.

DuPont Expands Capacity for Teflon® Resins

DuPont, Wilmington, DE, will increase fluoropolymer capacity for its copolymer resins, including the automotive market. Scheduled for completion in 1997, the $150 million program will increase the company's capacity for copolymer fluoropolymer resins about 75%, including the FEP and PFA fluoropolymer resins sold under its Teflon® trademark.

Phase one of the new project is anticipated to be on stream by the end of 1995. Another 50% will be completed in 1996 and the remainder in 1997. The facilities involved in the expansion include the following: Parkersburg, WV; Fayetteville, NC; Dordrecht, The Netherlands; and Shimizu, Japan.

An Additives Approach to Defect Elimination in Thermoplastic Waterborne Industrial Maintenance Coatings

Joel Schwartz and Stephen V. Bogar — Air Products and Chemicals, Inc.*

INTRODUCTION

T he spray application of coatings satisfies the requirement for ease of application, however, it produces its own unique set of problems for the formulations chemist. This high-speed, high-shear application technique can cause air to be entrained in the coating which, during air drying, will rise to the surface and cause surface irregularities. These irregularities are called external microfoam, and will cause loss of gloss. Also, entrained air that has not risen to the applied coating surface will be trapped in the final dried coating. This internal microfoam, as it is referred to in the industry, can cause water sensitivity and loss of corrosion resistance.

Additionally, the airless spray application of a coating coupled with incomplete substrate preparation places a stringent requirement upon the surfactant system. The surfactant package, if not designed properly, will not prevent dewetting, and coating esthetics and substrate protection will not be maximized.

This study utilized an additive package based on a dispersant, a defoamer, and a wetting agent, in a concerted approach to minimize external/internal microfoam and surface dewetting and maximize gloss. The effect of the successful additives on persistence, corrosion resistance, storage stability, and pigment grind characteristics were also studied. Possible mechanisms of microfoam formation and its elimination by additives are given. Model thermoplastic waterborne industrial maintenance coating formulations were chosen that are typically airless spray applied to rail cars, exterior storage tanks, and bridges.

CONCEPTS/THEORY

Airless spray is a hydraulic technique that forces paint to be atomized through a small orifice at high pressure, typically 2500 psi. With working pressures of 2500 psi, a high volume of paint can efficiently be applied over a large area. Conventional spray technique operates typically at 10-40 psi fluid pressures, and air is intentionally injected into the fluid at 30-85 psi to assist in atomization.[1] The microfoam problem oc-

*A*irless spray applied industrial maintenance topcoats can suffer from defects such as microfoam, gloss loss, retraction, and a reduction in corrosion resistance. By careful selection of additives, such as dispersants, defoamers, and wetting agents, the coatings chemist can reduce or eliminate these defects. Basic and empirical data are presented that will demonstrate how these defects were managed in several model industrial maintenance coating formulations.

curs actually in both types of spray operations, but is typically more severe in airless spray.

The variables affecting air entrainment in a spray-applied coating are numerous. Beginning with the spray process,[2-4] the high shear found at the spray nozzle can certainly influence the degree of air entrainment. The size of the atomized droplet may also influence the degree of air entrainment. The question is: Just how does the degree of air entrainment in a droplet track droplet size? As droplets get smaller, will they support less entrained air or will the ratio of entrained air to droplet volume remain the same? The latter can be the case if the entrained air bubbles get smaller as droplet size decreases. The former can be the case if air bubbles tend to form at a fixed size and are therefore reduced in number in smaller droplets. Since the size of the atomized droplet may influence the degree of air entrainment, it is pertinent to address the factors affecting atomization efficiency.

Factors reducing average droplet size during atomization are: (1) increased fluid pressure; (2) decreased fluid flow rate; (3) decreased orifice size in spray nozzles; (4) reduced fluid density; (5) decreased fluid viscosity at high shear; and (6) reduced surface tension of the fluid.

The factors influencing average droplet size or atomization efficiency must be optimized, but within the constraints of all the required performance/application specifications of the
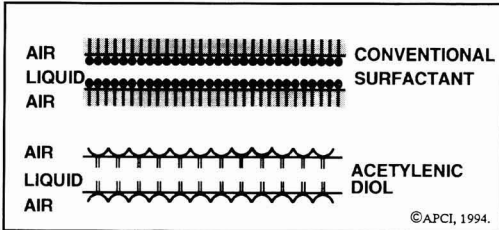
Figure 1 — Mechanism of foam stabilization—surface viscosity.

coating. For example, higher fluid rates and a larger orifice size will allow for spray of more coating per unit time but at the cost of fineness of finish due to larger spray droplets. Finer finishes can be obtained with smaller droplets by increasing fluid pressure and/or decreasing orifice size and fluid rate.

Reduction of coating density by the addition of water or solvent will reduce droplet size, but at the expense of increasing drying time and the volatile organic compound (VOC) level of the coating, respectively. In the attempt to achieve as high a solids level as possible to minimize dry time/VOCs and yet meet the required performance/spray specifications, coating density is one variable that the coating formulator needs to optimize. Additionally, a high coating solids level will affect the high shear viscosity.[5,6] An increased viscosity at high-shear will reduce atomization efficiency. Eliminating thickeners, which can contribute to an elevated high shear viscosity, could be an appropriate measure. Thickeners can be chosen that will predominantly only influence low shear application properties.

A reduction in equilibrium surface tension (EST) will reduce droplet size[3] and will also provide for a more robust coating by allowing for wetting even over improperly treated surfaces. It is speculated that a reduction in dynamic surface tension (DST) may also reduce droplet size.[7,8] Dynamic surface tension, the non-equilibrium value of surface tension, is lowest for surfactants that diffuse rapidly in solution. Whereas a rapidly diffusing surfactant can quickly eliminate high sur-

face tension at a newly created interface such as in a high-speed airless spray coating application, it is speculated that the atomization process can benefit by this process also. Once having determined the effect of atomization efficiency on air entrainment, formulating variables such as density, percent solids, viscosity, surface tension, hardware, and spray conditions need to be optimized. This is contingent upon predetermined performance specifications and cost constraints for a given formulation.

Entrained air that has been introduced into a spray applied coating can be released either during the drying phase or possibly during transit of the atomized droplet. The ability of a spray-applied coating to release its entrained air is related to: (1) bulk viscosity; (2) surface viscosity at the air/liquid coating interface; (3) surface viscosity at the entrained air bubble/liquid coating interface; (4) rate of increase of #1-#3 during drying; (5) size of the entrained air bubbles; (6) variation in dry film thickness (DFT); and (7) temperature and relative humidity.

Air release will be hampered by too high a low shear bulk viscosity and by too high a surface viscosity (many times referred to as just surface skinning but actually more complex) at the coating/air interface. Rapid build-up of these viscosities during drying contributes to the problem. Although the use of rheology modifiers is necessary to have the correct application properties, such as flow and leveling and sag resistance, they must not be overused. The use of slower evaporating solvents to minimize the viscosity build during the critical "time window of opportunity" for air release is more restricted today due to the requirement of lower VOCs. The use of additives can
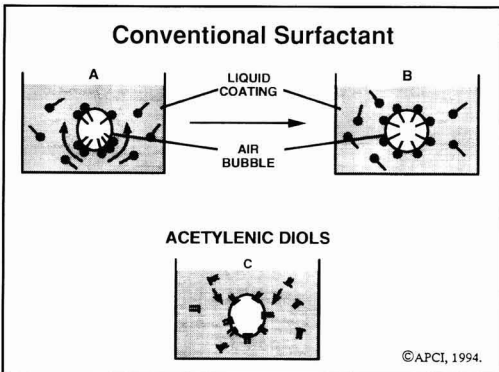
Figure 2 — Mechanism for release of entrained air.
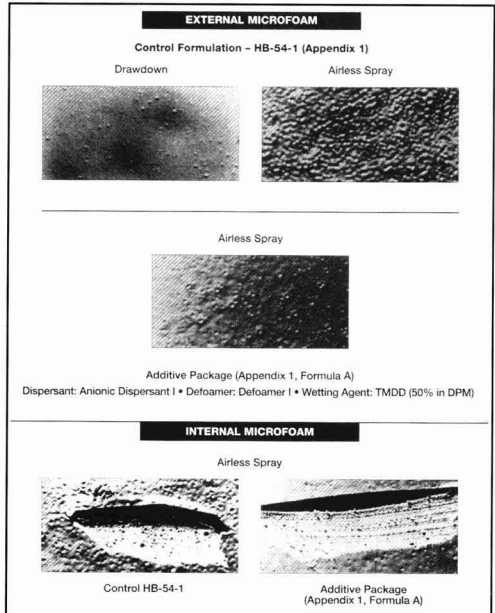
Figure 3 — Maximum reduction of microfoam in airless spray photomicrographs—magnification 15X. (Resin: Acrylic Latex I.)

Table 1—Surface Tension Comparisons — Maximum Bubble Pressure Technique

	Surface Tension (dynes/cm) (Concentration-0.1 wt. % Active in Water)		
	Equilibrium S.T. (1 Bubble/Sec.)	Dynamic S.T. (6 Bubble/Sec.)	ΔST
Linear C12-15 alcohol + 9 moles ethylene oxide 32.5		55.8	23.2
Branched C13 alcohol + 9 moles ethylene oxide 31.5		44.7	13.2
Octylphenol + 10 moles ethylene oxide 33.4		44.6	11.2
Sodium lauryl sulfate 43.8		53.0	9.2
Dioctyl sodium sulfosuccinate 31.7		33.6	1.9
TMDD 32.5		36.5	4.0

keep these viscosities at a minimum. For instance, the use of effective dispersing agents will maintain low bulk viscosity at higher pigment solids loading levels and provide adequate particle size reduction during the grind.

The use of select surface active agents can also minimize surface viscosity. The concept of surface viscosity as a mechanism for the stabilization of foam is well documented.[9-11] The foam stability of shaving cream, fire fighting foam, and meringue is testament to this powerful foam stabilizing mechanism. In *Figure 1*, a conventional surfactant, such as an alkylphenol ethoxylate and an acetylenic diol, are shown adsorbed within the liquid lamella of foam. The orientation of the conventional surfactant, normal to the interface, allows for the intermolecular association of adsorbed surfactant. This structure development, due to surfactant cohesive strength, causes an increase in surface viscosity and will stabilize foam by inhibiting drainage and can be a contributor towards surface skinning. Acetylenic diols, however, have a central hydrophilic group and are branched[12] and orient parallel to the interface. It is speculated that structure development and, therefore, also foam and surface skinning, are minimized. By analogy, the adsorption of additives at the air/liquid interface of a rising bubble (entrained air) should not contribute to a high surface viscosity at this interface, or the resulting drag will also minimize the ultimate air escape from the drying coating.

The retardation of a rising air bubble by Marangoni flow[13] is yet another mechanism to be considered (*Figure 2*). A rising bubble is not rigid and it has been shown that it has an aerodynamic advantage to a rigid sphere.[14] In *Figure 2*, surfactant is shown minimizing this advantage. As coating flows past the bubble, the bubble is elongated and this provides an aerodynamic advantage to the rate of rise. In this scenerio, adsorption of the surfactant at the air/liquid interface occurs preferentially on the downstream portion of the bubble compared to the upstream portion. This concentration gradient, resulting in an interfacial tension gradient, will cause a liquid interfacial flow (Marangoni flow) from the surfactant rich downstream region to the surfactant poor upstream region. This Marangoni flow will reduce the aerodynamic advantage originally setup by the flow of coating past the bubble. If the advantage is completely lost, the bubble rate of rise is that of a rigid sphere given by Stokes law.

Surfactants that diffuse rapidly may minimize this Marangoni flow by minimizing the surface tension gradients, thereby allowing for a more rapid rate of rise of entrained air in an applied coating. One technique used to compare surfactant diffusion of one surfactant class to another is the measurement of dynamic surface tension. *Table 1* identifies comparative EST/DST surfactant performance in deionized water as measured using the maximum bubble pressure technique.[15] 2,4,7,9-tetramethyl-5-decyne-4,7-diol (TMDD) is shown to be a rapidly diffusing surfactant as evidenced by the low dynamic surface tension.

The magnitude of the buoyancy force causing the air bubble to rise is also dependent on the size of the air bubble. Larger bubbles in an applied coating will more rapidly rise to the surface and break than smaller bubbles. To maximize the size of each air bubble, only those surfactants that do not hinder bubble collision and coalescence during the spray processes should be employed. Surfactants such as alkylphenol ethoxylates;

$$R-\langle\hspace{-4pt}\bigcirc\hspace{-4pt}\rangle-O-[CH_2CH_2O]_n-H$$
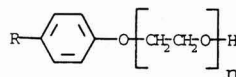
with long hydrophilic groups can entropically hinder effective air bubble collisions that would result in the growth of larger bubbles. Also, a high surface viscosity as previously discussed will have a similar opposing effect on large bubble growth.

Resin: Acrylic Latex I (Appendix 1)

Average Surface Roughness, 147 microinches

Average Surface Roughness, 39 microinches

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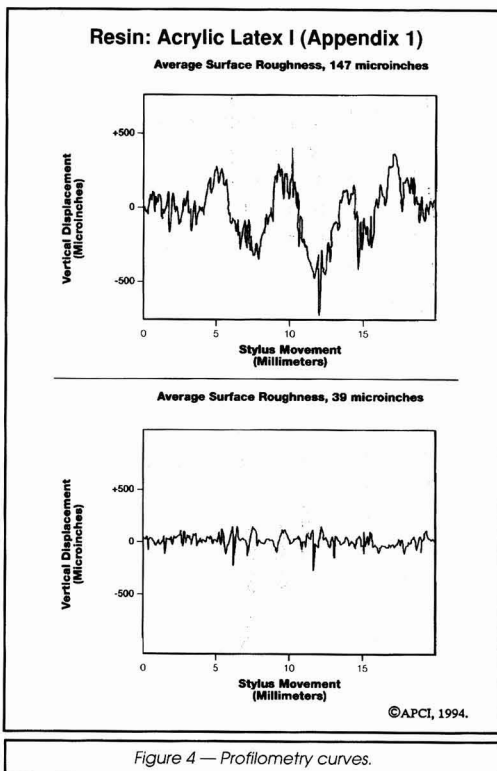
Figure 4 — Profilometry curves.

Table 2—Effect of Additives on Gloss/Microfoam — Initial Test: 24 Hours after Coating Preparation — Resin: Acrylic Latex I

Formula	Control (HB-54-1)	Additive System		
		A	B	C
Dispersant	Polyacrylate Dispersant I	Anionic Dispersant I	Anionic Dispersant I	Polyacrylate Dispersant I
Defoamer	Defoamer II/ Defoamer III	Defoamer I	Defoamer I	Defoamer I
Wetting agent	No recommendation	TMDD (50% in DPM)	3,5-dimethyl-1-hexyn-3-ol	TMDD (50% in DPM)
Performance Properties				
Gloss				
Drawdown				
20°	33.7	33.7	33.6	29.5
60°	78.1	77.3	73.4	74.8
Airless spray				
20°	13.3	31.0	32.3	26.1
60°	54.0	71.7	72.6	70.2
% Microfoam reduction				
Visual				
External	0	75-90	75-90	75
Internal	0	75-90	75	75
From average surface Roughness[a]				
External	0	74	73	63

(a)Tencor P-2 Long Scan Profiler.
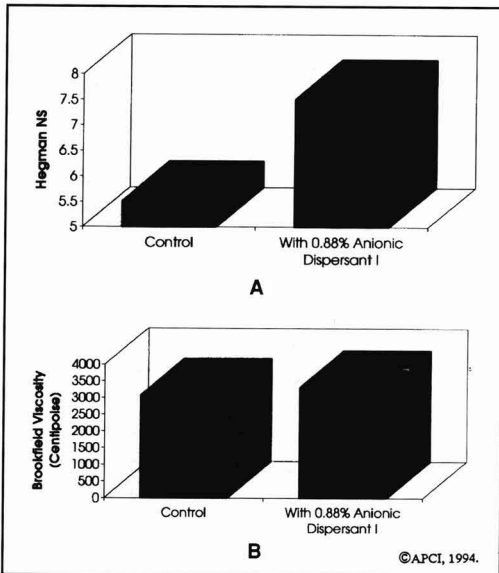
Figure 5 — Comparative grind dispersion/viscosity characteristics. Anionic Dispersant I is more efficient than the control dispersant, with no adverse effect on grind viscosity (Resin System: Acrylic Latex I.)
A–Particle size reduction (5.5 and 7.5 Hegman NS units correspond to 31.25 and 6.25 microns, respectively); B–grind viscosity.
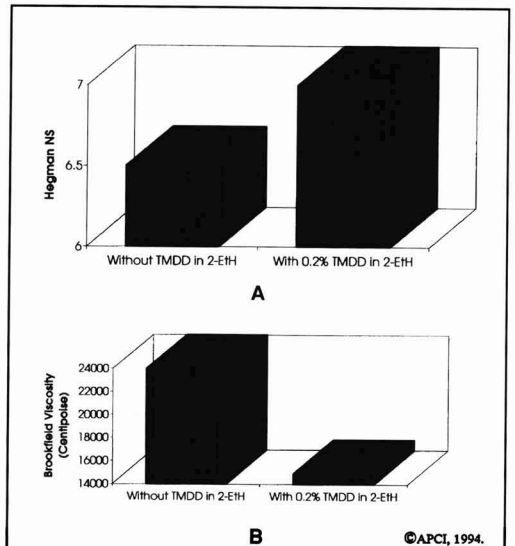
Figure 6 — Comparative grind dispersion/viscosity characteristics. TMDD (50% in 2-ethylhexanol) grind aid improves the grind efficiency and assists the dispersant in grind viscosity reduction. (Resin System: Acrylic Latex III.)
A–Particle size reduction (6.5 and 7.0 Hegman NS units correspond to 18.75 and 12.5 microns, respectively); B–grind viscosity.

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Table 3—Effect of Additives on Gloss/Microfoam Longevity Test: 2 Weeks @ 120°F — Resin: Acrylic Latex I

	Additive System	
Formula	Control (HB-54-1)	1
Dispersant	Polyacrylate Dispersant I	Anionic Dispersant I
Defoamer	Defoamer II/Defoamer III	Defoamer I
Wetting agent ...	No recommendation	TMDD (50% in DPM)

Performance Properties

Gloss		
Drawdown		
20°	28.0	28.5
60°	70.8	68.0
Airless spray		
20°	21.0	26.7
60°	62.8	69.6
% Microfoam reduction		
Visual		
External	0	50-75
Internal	0	50-75

As the DFT of an applied coating increases, the degree of air entrainment remaining in the dry coating and the severity of the surface defects caused by escaping air frequently increases. Also, since the rate of evaporation of an applied air dried coating is related to temperature/relative humidity, it is readily seen that the extreme condition of high temperature and low relative humidity will minimize the "time window" for escape of entrained air.

Given the complexity associated with the variables affecting atomization droplet size and air entrainment stability, this study focused on the use of inherently low foam additives. Additionally, some of these additives exhibit superior EST/DST reduction properties. For those additives or combinations that reduced microfoam, increased gloss, and had a beneficial effect on wetting unclean surfaces, their continued long-term effect in the coating system, effect on air entrainment suppression, high/low shear viscosity, atomized droplet size, and corrosion resistance were studied. Temperature and relative humidity were rigidly controlled during airless spray as to keep constant their effect on the time window.

EXPERIMENTAL DETAILS

All chemical raw materials/manufacturers and equipment used in this study are listed in Appendixes 5 and 6, respectively.

COATINGS PREPARATION: Four model industrial maintenance coating formulas supplied by the resin manufacturers were studied. Acrylic Latex I, Maincote® HG-54, and Acrylic Latex II, Maincote AE-58 (one-component waterborne acrylic and a two-component acrylic-epoxy based formulations, respectively, Rohm and Haas, Inc.), Acrylic Latex III, Aquamac™ 700 (one-component acrylic, McWhorter Technologies), and Acrylic Latex IV, SCX™ 1520 (one-component acrylic, SC Johnson Polymers) were the resin types employed in the model formulations. (See Appendixes 1-4 for general information details supplied by the latex manufacturer.)

A Premier Mill was used for preparing the grind. Grind efficiency and viscosity were measured using the Hegman NS scale on a fineness of grind gauge and a Brookfield Viscom-

eter, respectively. Final coating viscosity, in Krebs units, was adjusted for airless spray per the latex manufacturers recommendation by adding water.

COATINGS EVALUATION: All coatings were aged 24 hr before all evaluations, then Stormer viscosity was checked for drift. Coatings were prepared such that after 24 hr, viscosity was always in specification. Viscosity at low (0.1 rad/sec) and high (10,000 sec⁻¹) shear was measured with a Rheometrics Dynamic Analyzer, RDA II, and an ICI Viscometer, respectively.

The general air release property of the coating was measured by high shear mixing with a Waring Blender for 60 sec at 12,000 rpm followed immediately by determining coating density. The higher the density, the less air has been retained. These density determinations were made on coatings prepared with 1.5% higher level of solids (pigment + resin) by holding out water. This was done since our interest was in the air release property after spray and during the first two hours of drying. It was observed that most of the drying occurred over approximately two hours (Figure 9). A 1.5% higher solids level was arbitrary and is clearly a compromise, since it was beyond the scope of the study to continuously monitor the air release properties during two hours of drying. It would take roughly six minutes of dry time immediately after spray for the solids to increase 1.5%. Interestingly, the airless spray process only increased the solids level approximately 0.3% under the conditions of study (Table 7).

All drawdowns were performed using a Wirecator to deliver 3 mils dry film thickness on metal test panels. Drying rates and gloss were measured on the drawdowns using a Paul N.
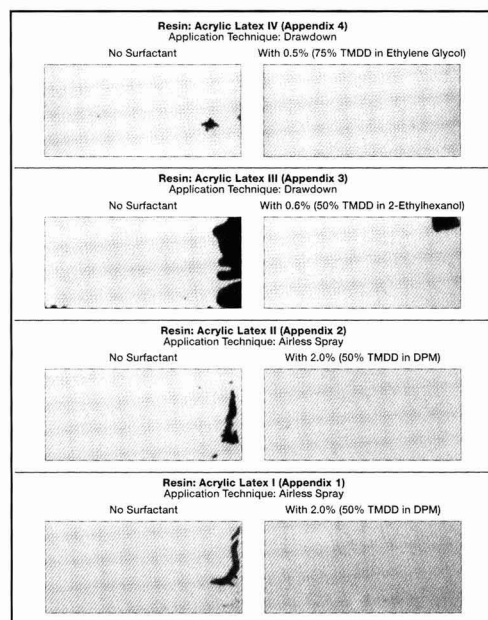

Figure 7 — Effect of TMDD on substrate wetting. Test panels contaminated with lubricant oil.

Table 4—Corrosion Test Results (ASTM B 117) — Salt Spray: 250 Hours — Resin: Acrylic Latex I

	Additive Systems			
Formula	Control (HB-54-1)	1	2	3
Dispersant	Polyacrylate Dispersant I	Anionic Dispersant I	Anionic Dispersant I	Polyacrylate Dispersant I
Defoamer	Defoamer II/Defoamer III	Defoamer I	Defoamer I	Defoamer I
Wetting agent	No recommendation	TMDD (50% in DPM)	3,5-dimethyl-1-hexyn-3-ol	TMDD (50% in DPM)
Corrosion Test Results				
Rust (ASTM D 610)	4	4	5	5
Blisters (ASTM D 714)	2M	6M	4F	4M
Scribe (ASTM D 1654)	6	7	7	7

Abbreviated Key: Rust: 0 = Approximately 100% of surface rusted; 5 = rusting to the extent of 3% of surface rusted; and 10 = no rusting or less than 0.01% of surface rusted.

Blisters: 0-10 Blister size is inversely proportional to number; M = medium; F = few.

Scribe: 0 = Larger than 16m; 5 = between 3 and 5mm; and 10 = no creepage from scribe.

Gardner Bi-Cycle Drying Time Recorder and a HunterLab Glossmeter, respectively.

All coatings were airless sprayed at 71-73° F and 61-65% relative humidity. To eliminate human error, all spray was performed by an automatic spray machine with a five-inch index distance and 1500-1600 in./min traverse speed so as to achieve a 3.5+/– 0.5 mil dry film thickness (DFT) on all metal test panels.

Average particle size of the spray droplets after atomization was determined by spraying black test paper with the white coatings by allowing only a small fraction of the spray to reach the paper, thereby maximizing the separation of droplets on the test paper. This technique was accomplished by providing for a 1/8-inch opening just in front of the test paper and in the center of the spray pattern and dropping a shutter so as to minimize the amount of spray deposited on the paper. A microscope and image analyzer were used for droplet visualization and ultimate particle size measurement. The field of vision was chosen for the microscope such that approximately 1000 droplets could be analyzed per view. Eight to nine views were made so that the total number (approximately 8000) of droplets being analyzed was high enough to allow for the statistical treatment of the data.

External and internal microfoam was assessed subjectively by visual means and profilometry was used to quantify external microfoam through changes in average surface roughness and to serve as a check on the visual assessment technique.

Salt spray evaluations were performed according to ASTM B 117, D 610, D 714 and D 1654 to determine the effect of additives on corrosion resistance. All coatings were sprayed direct to metal on sandblasted, 3 mil profile, hot rolled steel.

Equilibrium and dynamic surface tension were measured in pure water using the SensaDyne 5000 Surface Tensiometer by operating the instrument at one and six bubbles per second, respectively. The EST/DST of the actual coating could not be reproducibly determined either by the Du Nouy ring[16] or maximum bubble pressure technique unless the coatings were extensively diluted with water. Presumably, this was due to the coating viscosity and/or the nature of the coating/air interface.

Table 5—Effect of Additives on Gloss/Microfoam Initial Test: 24 hr after Coating Preparation — Resin: Acrylic Latex II

	Additive System	
Formula	Control (G-58-1)	1
Disperant	Polyacrylate Dispersant II	Anionic Dispersant I
Defoamer	Defoamer V/ DefoamerVIII	Defoamer IV
Wetting agent	Wetting Agent I	TMDD (50% in DPM)
Performance Properties		
Gloss		
Drawdown		
20°	37.1	20.2
60°	78.5	61.8
Airless spray		
20°	24.6	30.9
60°	71.4	75.1
% Microfoam reduction		
Visual		
External	0	25-50
Internal	0	25-50
From Ra[a], average surface Roughness		
External	0	33

(a)Tencor P-2 Long Scan Profiler.

RESULTS AND DISCUSSION

Defect Control—An Additives Solution.

In this study, microfoam was observed as surface irregularities in the dry applied coating and were approximately 0.1-0.2 mm in diameter. Airless spray application accounts for the microfoam since the dry coating, applied via drawdown technique, microfoam is not present. It is presumed that the high shear/high pressure to which the coating is subjected is responsible for the problem. Possibly, air is dissolved in the coating and is partially released during transit of the atomized droplet to the substrate and during drying.

Additives were evaluated to determine if they will minimize microfoam, maximize gloss, promote substrate wetting on improperly cleaned substrates, not diminish corrosion resistance, and be persistent in airless spray applied waterborne industrial maintenance topcoats. An additive systems approach involving dispersant, defoamer, and wetting agent was taken to achieve our objectives. At the outset, select additives and/or surfactants were chosen for investigation that are inherently low foaming; confer both low EST/DST; minimize surface viscosity due to low coherence at an interface; and do not entropically hinder entrained air bubble coalescence/release.

Acrylic Latex I Based Model Formulation—Results

The control formula based on Acrylic Latex I (Appendix 1) develops external microfoam in airless spray compared to a drawdown as shown in *Figure 3*. Also shown is one additive package (Formula A in Appendix 1) which will reduce both internal/external microfoam by up to 90% in airless spray application compared to control Formula HB-54-1. The new additive package is based on a select dispersant, defoamer, and wetting agent combination. Detailed performance for this additive package and two additional packages, Formulas B and C (Appendix 1), is shown in *Table 2*. The three new additive systems, A, B, and C, based on a select dispersant, defoamer, and wetting agent combinations, provide much resistance to microfoam and gloss loss upon spray application. Subjective visual assessment of external/internal microfoam tracked gloss performance. Depending upon the additive system chosen, as much as 90% of the microfoam can be eliminated. For verification of the subjective assessment of external microfoam, average surface roughness was measured by profilometry and the trends agreed well. *Figure 4* shows the profilometry profiles for airless spray applied Formula A and control HB-54-1.

The additive packages shown in *Table 2* are based on the following chemistries:

Anionic Dispersant I .... ammonia neutralized polycarboxylic acid

TMDD in DPM .... 50% solution of 2,4,7,9-tetramethyl-5-decyne-4,7-diol in dipropylene glycol monomethyl ether

3,5-dimethyl-1-hexyn-3-ol .... acetylenic alcohol

Defoamer I .... nonsilicone organic defoamer

To insure that additive performance longevity is maintained, the data in *Table 3* shows that Formula A will maintain effectiveness in accelerated storage testing at 120°F/two weeks and 140°F/10 days. Although not tested, it is expected that Formulas B and C would perform similarly.

Care must be exercised in the choice of additives since both anionic dispersing agents and surface active agents can reduce the corrosion resistance of the coating. *Table 4* shows the results of corrosion resistance testing for Formulas A, B, and C. All three additive packages were shown not to cause loss of corrosion resistance. Actually, a mild improvement was observed. It needs to be noted that the corrosion testing was

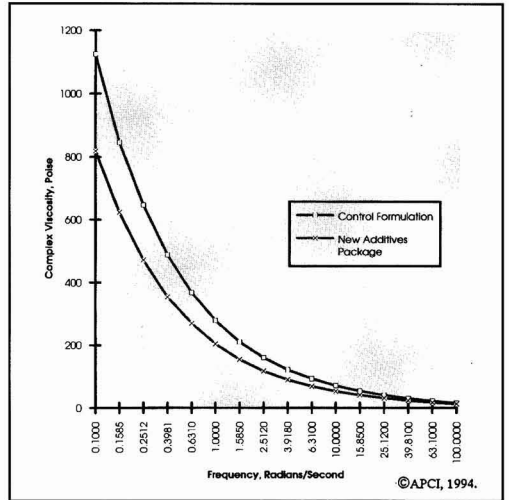Figure 8 — *Comparative low shear viscosity. Effect of the new additive package compared to the control package on the viscosity at low frequency (low shear), measured with the Rheometrics Dynamic Analyzer. (Resin System: Acrylic Latex I.)*
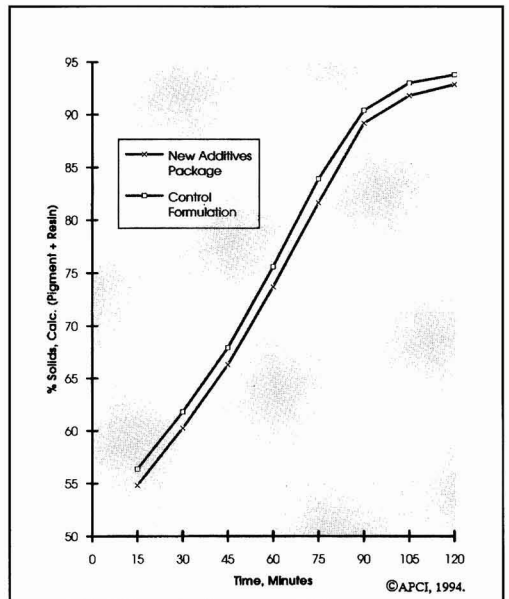

Figure 9 — *Comparative evaporation rates. The new additive package compared to the control package shows no appreciable difference. (Resin System: Acrylic Latex I.)*

performed according to ASTM standards and that even though the formulations are designed as topcoats, they were applied directly to sandblasted, hot rolled steel with a 3 mil profile. In actual practice, the topcoat would be applied over a primer, but this technique would mask most of the additive effect on corrosion resistance.

Although the aforementioned results show that TMDD does not adversely affect corrosion resistance, a formulator can take an alternative approach and employ 3,5-dimethyl-1-hexyn-3-ol, a volatile surfactant, which will evaporate from the air drying film and therefore leave no possible residue to cause either water sensitivity or corrosion resistance problems (Appendix 1, Formula B gives the complete formula description and *Table* 2, Formula B gives the performance data).

As part of the recommended additive package to reduce microfoam, a nonpolyacrylate type dispersant, Anionic Dispersant I, also maintained effectiveness in accelerated storage testing. During the accelerated storage testing previously described, a coating containing Anionic Dispersant I maintained a stable dispersion and comparable viscosity when compared to the control formulation. Additionally, this dispersant improved the grind by more efficiently reducing the particle size with no adverse effect on grind viscosity compared to the Polyacrylate Dispersant I based coating (*Figure* 5).

Acrylic Latex II Based Model Formulation—Results

Similar to the results with Acrylic Latex I, *Table* 5 shows the performance of one additive package based on a select dispersant, defoamer, and wetting agent in an Acrylic Latex II based starting formulation (Appendix 2). Results show that the highest gloss will result after airless spray for the new recommended additive package. The lower gloss on drawdown for the new package compared to the control coating is unexplained. Possibly, improved mixing of the additives occurred upon spray. It needs to be noted that although microfoam was reduced by 29% in the Acrylic Latex II system, the absolute severity of the problem at 3-4 mils was much lower than with the Acrylic Latex I based system. The actual

average surface roughness for the Acrylic Latex II control is 21 microinches versus 15 for Formula A (Appendix 2). The actual average surface roughness for the Acrylic Latex I control is 147 microinches versus 39 for Formula A (Appendix 1). For the Acrylic Latex II system, this improvement in gloss may also be due to improved dispersion characteristics and/or compatibility of select components. For instance, if pigment flocculation occurs at the surface of the drying coating due to incompatible coating components rising to the surface or due simply to a poor choice of dispersant, the gloss will be reduced. It is speculated that the recommended additive package may improve gloss due to some combination of the aforementioned possible mechanisms. Again, no evidence has been specifically developed to support this.

Acrylic Latex II Based Model Formulation—Results

The starting model formulation supplied by the latex supplier recommends the use of a 50% solution of TMDD in 2-ethylhexanol as a surfactant in the grind (Appendix 3). *Figure* 6 shows a small loss of grind efficiency (a half unit on the Hegman grind gauge—6.5 versus 7 Hegman NS units which corresponds to 18.75 and 12.5 microns, respectively) and a large increase in grind viscosity for a 15 min grind, if the TMDD surfactant is left out of the grind. TMDD surfactant is low foaming, hydrophobic, contributes little to water sensitivity and does not detract from corrosion resistance, and is clearly functioning as a grind aid. Presumably, it preconditions the surface of the pigment and thereby maximizes the viscosity reduction effectiveness of the dispersant.

All Model Formulations—Wetting Properties

TMDD (dissolved in either ethylene glycol, 2-ethylhexanol, or dipropylene glycol monomethyl ether) was shown to be an exceptional wetting agent providing much control over dewetting. In all four industrial maintenance coating formulations containing additive packages, dewetting was controlled in either airless spray or drawdowns on lubricant contaminated steel test panels (*Figure* 7). Depending on the level of contaminant, either the complete elimination or a significant

Table 6—Summary Chart

Resin	Problem Addressed	Additive Type	Additive	Percent on Final Coating	
				Grind	Letdown
Acrylic Latex I (Appendix 1)	• External/internal microfoam reduction • Low gloss	Dispersant Defoamer Wetting agent	Anionic Dispersant I Defoamer I TMDD (50% in DPM) or 3,5-dimethyl-1-hexyn-3-ol	0.88 0.24 — —	— 0.24 2.00 1.00
	• Retraction/orange peel	Wetting agent	TMDD (50% in DPM)	—	2.00
Acrylic Latex II (Appendix 2)	• External/internal microfoam reduction • Low gloss	Dispersant Defoamer Wetting agent	Anionic Dispersant I Defoamer IV TMDD (50% in DPM)	0.83 0.06 0.32	— 0.64 1.66
	• Retraction/orange peel	Wetting agent	TMDD (50% in DPM)	—	2.00
Acrylic Latex III (Appendix 3)	• Dispersancy	Grind aid	TMDD (50% in 2-ethylhexanol)	0.20	—
	• Retraction/orange peel	Wetting agent	TMDD (50% in 2-ethylhexanol)	0.20	0.4
Acrylic Latex IV (Appendix 4)	• Retraction/orange peel	Wetting agent	TMDD (50% in ethylene glycol)	—	0.5

reduction of retraction is achieved. TMDD, previously shown to not adversely affect corrosion resistance in the Acrylic Latex I based coating, will provide for a more robust coating. No other surfactants were employed for comparison purposes. TMDD has been shown previously to be an excellent surfactant choice for improved coverage over contaminated surfaces.[7] However, as a primary measure against dewetting, it is recommended that substrate cleaning and preparation be as complete as possible and that surfactant be relied upon only as a secondary measure of protection.

A summary chart (*Table* 6) is provided that lists the resin systems studied, coating defects observed, and select additives and their use levels employed in this study that were effective in minimizing or eliminating these defects.

It is emphasized that the variables that were held constant for the study were the temperature and relative humidity during spray and air dry, at 71-73° F, and 61-65%, respectively. DFTs were kept at 3.5+/- 0.5 mils. The assumption/desire is that at mildly divergent conditions from the previously mentioned, the additive package(s) would still prove useful. The concept of coatings performing under a broad window of use conditions is not new. Additives that provide for robust performance are necessary to the commercial success of the coating. Probably at severely divergent conditions from the aforementioned, no additive package alone could control microfoam.

Microfoam Formation/Elimination—Possible Mechanisms

Topcoat employing Acrylic Latex I, and based on the control and one new additive package (Appendix 1; Control HB-54-1 and Formula A), was studied to reveal information on the mechanism of microfoam formation and elimination. For these coatings systems, the following properties were determined: average atomized droplet size, general air release properties of the coating in a high shear environment, and high and low shear viscosity.

Again, looking first at the atomization process, we found a small reduction of microfoam, 10-25%, in airless spray application of the control formulation resulted if: spray nozzle orifice size is reduced; fluid delivery rate is reduced; and liquid coating spray pressure is increased.

This suggests that for this formulation, improved atomization efficiency (lower droplet size) will influence the degree of air entrainment. We compared the average droplet size for both the control and the new additive based coating and found the control formulation's average droplet size to be 36% larger (*Table* 7). The technique used here (recommended by Kwok and Liu[3]) to measure average droplet size (see Experimental Details section) briefly consisted of allowing a small fraction of the center of the spray pattern to be deposited on black paper followed by measurement with microscopic/image analysis techniques. Ideally, laser techniques[3,4] would actually measure the average droplet size in a very large volume

Table 7—Performance Properties of the Recommended Starting Formulation Compared to the New Additives Based System — Resin System: Acrylic Latex I (Appendix 1)

	Control Formulation	New Additives Package
Additive Package		
Dispersant	Polyacrylate Dispersant I	Anionic Dispersant I
Defoamer(s)	Defoamer II/Defoamer III	Defoamer I
Wetting agent	—	TMDD (50% in DPM)
Properties		
% Microfoam reduction	0	75-90
Wt. % Solids		
Drawdown—experimental	49.5	50.8
After spray—experimental	49.8	51.0
Increase due to spray	0.3	0.2
Calculated—resin + pigment	44.9	44.1
Average particle size,		
μm +/– 3σ	986 +/–54	724 +/–43
High shear foam test	0.86	0.93
Calculated—resin + pigment		
Solids, wt. %	46.4	45.6
Density, g/ml,		
Unagitated	1.14	1.14
Agitated	0.86	0.93
Agitated, no defoamer	0.86	—
Viscosity		
Stormer, KU	99 +/–1	99 +/–1
ICI, @ 10,000 sec^{-1}, poise	0.41	0.41
DMS @ 0.1 rad/sec, poise	1126	819
Dry time, minutes	30-35	25-30

of spray droplets and would be more diagnostic. Nonetheless, these results are encouraging and suggest that air that is incorporated into this coating during the spray process may release more rapidly from a smaller droplet and, therefore, result in a lower air to liquid ratio in the applied coating. It is speculated that surfactants such as TMDD that provide for both a low EST and DST (*Table* 1), may be at least partially responsible for the improvement in atomization efficiency, thereby lessening the inherent air entrainment.

A simple high shear mix test (see Experimental Details section) can reveal much about a coating's propensity to release its entrained air. Air is released in this type of test as a result of a more favorable rate of bubble rise due to: (1) effective collisions of air bubbles during mixing, resulting in larger more buoyant bubbles; (2) low bulk/surface viscosity; amd (3) possibly, low dynamic surface tension.

All additives in the additive packages that were successful in significantly reducing microfoam were low foaming as measured in this high shear foam test. It has been reported that polyacrylate dispersants can cause more foam in coatings than lower foaming nonpolyacrylate dispersants.[17] We observed that the nonpolyacrylate Anionic Dispersant I is much less foamy in the grind than the resin supplier's recommended Polyacrylate Dispersant I. Also, Defoamer I is more effective as a deairentraining agent than the recommended Defoamers II and III. *Table* 7 shows the air release properties (density difference after high shear mixing) of the two coatings with/without the new additive package. It is possible that the new additive based coating allows for more effective bubble collisions in transit immediately after atomization and possibly

also in a reduced surface viscosity at the entrained air bubble/liquid coating interface so that entrained air is released before the drying coating has developed too high a bulk viscosity. It should be noted that the control formulation employs no surfactant. However, in the polymer synthesis of the binder, surfactant is typically introduced which may absorb at an entrained air bubble/liquid coating interface thereby increasing surface viscosity and retarding the rate of air bubble rise. The introduction of TMDD may favorably compete with "surface viscosifiers" thereby reducing this viscosity and improving rate of bubble rise.

Both the control and new additive based formulations were prepared with the same viscosity as per the latex supplier, namely a Stormer viscosity of 99 +/– 1 KU (roughly 1500 sec^{-1}). High shear (10,000 sec^{-1}) viscosity, measured with the ICI viscometer, was the same for both coating systems (*Table* 7). However, using dynamic mechanical spectroscopy (DMS), the complex low shear viscosity (at a frequency of 0.1-100 rad/sec) as measured with the Rheometrics Dynamic Analyzer was different. From *Figure* 8, the new additives based coating had lower viscosity at low shear rates compared to the control based coating, specifically a 307 poise lower viscosity at 0.1 rad/sec. This data is also summarized in *Table* 7. This reduced low shear viscosity had no effect on sag and flow and leveling at 3-4 mils DFT and would be expected to give improved air release properties. Ideally, it would have been instructive to monitor the low shear viscosity during the first two hours of drying, but this too was beyond the scope of the study.

Comparative drying times and evaporation rates were performed to determine if this caused the reduction in microfoam. From *Table* 7 and *Figures* 8 and 9, the drying times and evaporation rates, respectively, are not significantly different.

CONCLUSION

With an understanding of the mechanics of foam/air entrainment (de)stabilization, several additive systems packages, resulting from a concerted additives systems approach, have been found to significantly reduce microfoam and maximize gloss in thermoplastic waterborne industrial topcoats under the conditions of study. The additives, consisting of a dispersant, defoamer, and a wetting agent, were all found to be persistent on accelerated aging with no adverse effect on corrosion resistance. Individually, the additives contributed to improved grind efficiency, lower process or mixing foam, and substrate wetting. No one additive could significantly influence the microfoam/gloss problems but, collectively, they minimized these problems.

Several physical phenomena have been addressed in an attempt to understand the mechanisms associated with microfoam formation/elimination. Of most probable conse-

quence is the surface viscosity at the coating/air interface and at the entrained air bubble/coating interface, low shear viscosity, atomized droplet size, and size of the entrained microfoam. No conclusions can be drawn, however, regarding the quantitative relative importance of each of the proposed mechanisms and this remains fertile ground for future study.

ACKNOWLEDGMENTS

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APPENDIX 1 — High-Build, Gloss, White Topcoat — Acrylic Latex I

Grind Preparation

Grind in Cowles dissolver 15 min then let down at slower speed.

Formula	Control (HB-54-1)	A	B	C
		Pounds		
Ingredients				
Acrylic Latex I	400.0	400.0	400.0	400.0
Pigment dispersant				
Polyacrylate Dispersant I	9.1	—	—	9.1
Anionic Dispersant I	—	8.5	8.5	—
NH₄OH (28% NH₃)	1.0	1.0	1.0	1.0
Grind Defoamer				
Defoamer II	2.4	—	—	—
Defoamer I	—	2.4	2.4	2.4
Titanium Dioxide I	127.6	127.6	127.6	127.6
Allow pigment to wet thoroughly, than add:				
Rheology Modifier I	0.5	0.5	0.5	0.5
Letdown Preparation				
Acrylic Latex I	318.5	318.5	318.5	318.5
Coalescing Agent I	44.7	44.7	44.7	44.7
Letdown defoamer				
Defoamer III	3.5	—	—	—
Defoamer I	—	2.4	2.4	2.4
NH₄OH (28% NH₃)	4.0	4.0	4.0	4.0
Sodium nitrite (15% aqueous solution)	8.2	8.2	8.2	8.2
Water	29.0	29.0	29.0	29.0
Rheology Modifier I	0.5	0.5	0.5	0.5
Wetting Agent				
TMDD (50% in DPM)	—	19.0	—	19.0
3,5-dimethyl-1-hexyn-3-ol	—	—	9.5	—
Total	949.0	966.3	956.8	966.9

APPENDIX 2—Gloss, White, Acrylic/Epoxy Topcoat — Acrylic Latex II

Acrylic Component A

Grind Preparation

Grind the following materials using a high-speed dissolver for 20 min:

Formula	Control (G-58-1)	A
	Pounds	
Ingredients		
Diethylene glycol methyl ether	38.8	38.8
Polyacrylate Dispersant II	13.8	—
Anionic Dispersant I		8.4
NH₄OH (28% NH₃)	1.0	1.0
Wetting Agent I	1.6	—
TMDD (50% in DPM)		3.2
Defoamer V	0.4	—
Defoamer IV		0.6
Titanium Dioxide II	193.7	193.7

Add the following and continue to grind for 2-3 min at lower speed:

Water	19.9	19.9
Total grind	269.2	265.6

Letdown Preparation

Add the following in the order listed and mix thoroughly:

Acrylic Latex II	493.0	493.0
Water	58.5	58.5
NH₄OH (28% NH₃)	2.4	2.4
Grind (from above)	269.2	265.6
ethylene/diethylene glycol 2-ethylhexyl ether	48.2	48.2
Defoamer VIII	2.0	—
TMDD (50 % in DPOM)	—	16.8
Water	14.2	14.2
Rheology Modifier III	8.0	—
Rheology Modifier I	1.2	1.2
Sodium nitrite (15% aqueous solution)	8.8	8.8
Total Acrylic Component A	905.5	908.7
Defoamer V	—	6.5

Epoxy Component B

Epoxy I	94.8	94.8
Total Acrylic/Epoxy Topcoat	1000.3	1010.0

Appendix 3—High Gloss White — Acrylic Latex III — 700 st1

Grind Preparation
Disperse in high-speed dispersator to NS 7 grind. Add to latex under agitation when grind is achieved.

Ingredients	Pounds
Tap water	71.5
Polyacrylate Dispersant I	6.6
TMDD (50% in 2-ethylhexanol)	2.0
Rheology Modifier II	1.0
Defoamer VI	1.0
Titanium Dioxide III	210.0

Letdown

Acrylic Latex III	574.2
Tap water	65.3

Add to adjust pH between 8 and 9.

Aqueous ammonia (28%)	2.0

Add the following:

Coalescing Agent I	71.1
Sodium nitrite (4%)	9.0
	1013.7

APPENDIX 4—High-Gloss White — Acrylic Latex IV — 92-196-U

Grind Preparation
Disperse at high speed to 5-7 Hegman.

Ingredients	Pounds
Acrylic Resin Solution I	126.2
Titanium Dioxide II	141.6
Defoamer VII	1.93
Water	19.9

Letdown

Water	33.8
Acrylic Latex IV	482.2
Ethylene glycol n-butyl ether	43.5
Diethylene glycol n-butyl ether	14.5
10% ammonium benzoate in water	29.1

Premix the following:

TMDD (50% in ethylene glycol)	4.82
Defoamer VII	1.45

Then add as required:

Water	56.8
	955.8

APPENDIX 5—List of Chemicals Used in the Study

Component	Trade Name	Description	Manufacturer
Polymers			
Acrylic Latex I	Maincote HG-54	Waterborne acrylic resin	Rohm and Haas
Acrylic Latex II	Maincote AE-58	Waterborne acrylic resin	Rohm and Haas
Acrylic Latex III	Aquamac 700	Styrenated acrylic emulsion	McWhorter
Acrylic Latex IV	Joncryl SCX-1520	Acrylic latex	SC Johnson
Acrylic Resin Solution I	Joncryl 56	Styrene acrylic polymer	SC Johnson
Epoxy I	Genepoxy 370-H55	Modified epoxy resin emulsion	Daubert Chemical
Dispersants			
Anionic Dispersant I	Surfynol CT-151	Ammonia neutralized poly carboxylic acid	Air Products & Chemicals
Polyacrylate Dispersant I	Tamol 681	Ammonium salt of a copolymeric carboxylic acid	Rohm and Haas
Polyacrylate Dispersant II	Tamol 165	Ammonium salt of a copolymeric carboxylic acid	Rohm and Haas
Pigments			
Titanium Dioxide I	Ti-Pure R-900HG	Titanium dioxide	DuPont
Titanium Dioxide II	Ti-Pure R-900	Ttanium dioxide	DuPont
Titanium Dioxide III	Tiona RCL-535	Titanium dioxide	SCM Chemicals
Defoamers			
Defoamer I	Surfynol DF-210	Non-silicone organic defoamer	Air Products & Chemicals
Defoamer II	Drew L-405	Silicone defoamer	Drew Industrial Div.
Defoamer III	Drew Y-250	Silica/ester derived defoamer	Drew Industrial Div.
Defoamer IV	Surfynol DF-60	Organo-modified, silicone defoamer	Air Products & Chemicals
Defoamer V	Patcote 519	Silicone defoamer	Patco Speciality Chems.
Defoamer VI	Bubble Breaker 3056a	Organic defoamer	Witco
Defoamer VII	BYK 020	Modified polysiloxane copolymer	BYK-Chemie
Defoamer VIII	Patcote 531	Silicone defoamer	Patco Specialty Chems.
Rheology Modifiers			
Rheology Modifier I	Rheology Modifer QR-708	HEUR associative thickener	Rohm and Haas
Rheology Modifier II	Acrysol RM-825	HEUR associative thickener	Rohm and Haas
Rheology Modifier III	Acrysol RM-1020	HEUR associative thickener	Rohm and Haas
Cosolvents			
Coalescing Agent I	Texanol	2,2,4-trimethyl-1,3-pentanediol monoisobutyrate	Eastman
Diethylene glycol n-butyl ether	Dowanol DB		Dow Chemical

APPENDIX 5—List of Chemicals Used in the Study (cont'd)

Component	Trade Name	Description	Manufacturer
Diethylene glycol-n-methyl ether	Methyl Carbitol		Union Carbide
Ethylene glycol-n-butyl ether	Dowanol EB		Dow Chemical
Ethylene/diethylene			
glycol 2-ethylhexyl ether	Ektasolve EEH		Eastman
Wetting Agents			
Wetting Agent I..................................	Triton CF-10	Octylphenoxypoly-ethoxyethyl benzyl ether	Union Carbide
Branched C13 alcohol + 9 moles			
ethylene oxide	Iconol TDA-9		BASF
Linear C12-15 alcohol + 9 moles			
ethylene oxide	Neodol 25-9		Shell Chemical
Octylphenol + 10 moles			
ethylene oxide	Triton X-100		Union Carbide
Sodium lauryl sulfate	DuPonol WAQE		DuPont
TMDD (50 % in DPM)	Surfynol 104DPM	2,4,7,9-tetramethyl-5-decyne-4,7,diol in dipropylene glycol monomethyl ether	Air Products & Chemicals
Dioctyl sodium sulfosuccinate	Aerosol OT-75		American Cyanamid
3,5-dimethyl-1-hexyn-3-ol	Surfynol 61	3,5-dimethyl-1-hexyn-3-ol	Air Products & Chemicals

APPENDIX 6—List of Equipment Used in this Study

Equipment	Manufactuer/Supplier
Airless Spray	
Portable hydra-spray supply pump. Model 224-618 Series A containing a 45:1 ratio King pump. An ARO high presure material regulator (downstream type) model 651780-A2B is used to regulate fluid pressure.	Grayco
Model 550 automatic airless spray gun twist-tip II reversible nozzle cleaner 1/4in. no-wire airless fluid hose.	Binks
Spraymation model 310410 automatic test panel spray machine	Spraymation
Test Panels	
ACT cold roll steel 4X12X032. Unpolished. APR10161. ACT hot roll steel 3u 4X12X071. Blast clean. Unpolished. APR18567.	ACT
Drawdown Bird bar, 3in. film width, to deliver 3.2 mils dry.	
Glossmeter	
HunterLab PRO-3 glossmeter (meets ASTM D 523)	HunterLab
Viscometers	
Stormer viscometer, Krebs-type	BYK-Gardner
Brookfield viscometer model LVTDV-II	Brookfield
ICI cone & plate viscometer	ICI
Rheometrics recap III-dynamic mechanical analyzer	Rheometrics
Corrosion Testing	
Salt-fog chamber model GS-SCH-22	Harshaw/Filtrol
High Shear Foam Tester	
Commercial Waring blendor, with 8 oz. stainless steel cup	Waring
Particle Size Measurement	
Lemont Scientific image analysis, program AC-08251. Line scan image analysis for particles	Lemont Scientific
Fineness of grind gage	BYK-Gardner
Stereomicroscope	Cambridge Instruments
Average Surface Roughness	
Tencor P-2 Long Scan Profiler..	Tencor Instruments
Dry Time	
Drying time recorder	Paul N. Gardner Co.

Thermal and Impact Induced Stress Failure in Painted TPO: The Role of Surface Morphology

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INTRODUCTION

The paintability of thermoplastic olefins (TPOs) is known to vary depending upon the type of TPO utilized and the type (including bake) of topcoat applied.[1] Adhesion failures could manifest themselves as loss of paint adhesion to the substrate or as a loss of cohesive integrity within the painted plastic when the painted substrate is subjected to some external stress. We began to suspect that differences in type of adhesive/cohesive loss of paint and or substrate, respectively, could be attributed to variances in the surface morphology of the TPO material. For that reason, we began to investigate the role of TPO surface morphology on subsequent paint adhesion and the role that external stresses played on resultant adhesive/cohesive properties.

Thermoplastic olefins are blends of polypropylene and rubber with additional fillers and additives. The polypropylene utilized is a semicrystalline polymer that has a very low surface-free energy and is therefore difficult to paint. Rubber, usually an amorphous ethylene-propylene or ethylene-propylene-diene copolymers, is blended with the polypropylene to aid in paintability as well as some physical properties such as low temperature impact. Additives include thermal and process stabilizers, ultraviolet stabilizers, pigments, and fillers.

When TPO is injection molded, a layering of the copolymers within the substrate occurs near the surface due to shearing forces, pressure, and thermal gradients induced during the molding process, much akin to those found in injection molded polycarbonate.[2] The surface morphology of TPO (*Figure* 1) can be depicted as a layering of polypropylene-rich regions of varying crystallinities beneath which lies a rubber-rich layer. If we refer to these layers of varying crystallinity and composition as "boundary" layers, we can begin to ascribe to each of these "boundaries" their influence on the paintability of the TPO and the resulting cohesive strength attained in the substrate once painted.

The polypropylene transcrystalline boundary is created as a result of nucleation generated by porous irregularities in the molding surface. The polypropylene begins to nucleate and

With the introduction of new plastic substrates such as thermoplastic olefins, there is a need to establish a reliable baseline knowledge on stone impact response characteristics under a variety of impact conditions, coating types, coating application conditions, substrate processing, and surface pretreatment conditions.

Dynamic mechanical properties of engineering plastics and polymeric coatings are strong functions of the temperature and strain rate which affect impact response. In injection molded plastics, morphology, crystallinity, composition, and in-plane stresses at the surface can significantly differ from those observed in the bulk. In injection molded TPO layered surfaces, structures exist which consist of varying crystallinities of cohesively weak polypropylene and rubber.

Based on the morphological complexity of the TPO substrate, stone impact response of a painted TPO surface is a complex phenomenon. This work is to present an approach, via numerical simulation based on a physical model developed in our laboratories, to predict the locus of failure within TPO due to stone impact.

crystallize nonideally due to the rapid cooling effects seen at the "cool" mold surface from the injection melt as well as pressure variations from packing. The polypropylene directly beneath the transcrystalline boundary can crystallize in a more ideal fashion, e.g., in larger crystal spherulites, due to the delocalization of rapid "cooling" as exhibited on the molded surface.
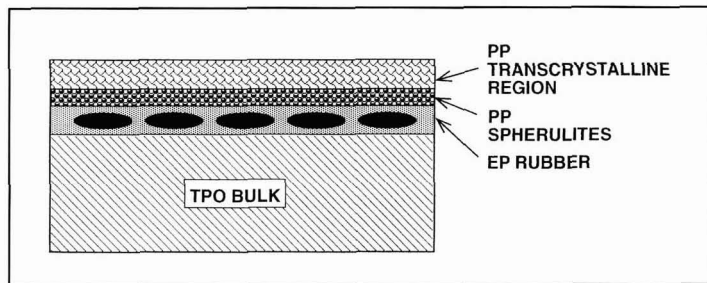
Figure 1—TPO surface morphology.

Rubber-rich areas form directly beneath the polypropylene regions. The rubber is often elongated due to the shear forces present in the injection molding process. It is important that the rubber-rich boundaries lie somewhat near the surface since it is believed that this region accounts for the "paintability" of the TPO. In fact, the same TPO blend when compression molded (no shear forces or thermal gradients are imposed on the substrate in this molding operation) affords no evidence of layering. In compression molded TPO, it is very difficult to attain even initial adhesion of the paint to the substrate since the rubber-rich layer never forms near the surface.

It is postulated that diffusion of adhesion promoter through the polypropylene boundaries with subsequent mechanical interlocking with the rubber accounts for adhesion to the substrate.[3] The composition (including crystallinity) and thickness of these varying boundary layers, therefore, will have a tremendous impact on the paintability of the TPO. Thick highly crystalline boundaries of polypropylene will tend to retard diffusion and therefore result in poor adhesion. Thin amorphous polypropylene boundaries, on the other hand, will aid in swellability and diffusion of the adhesion promoter and its solvents and therefore increase paintability. The impact of rubber distribution within the rubber-rich boundary will play a vital role in initial paint adhesion as well as in the cohesive strength of the painted TPO composite.

Adhesion to TPO substrates is therefore strongly influenced by the type and amount of solvent contained within paint applied. Morphological changes in the TPO substrate are accomplished in the presence of solvent from the topcoat and vary depending upon paint bake times and temperatures. These morphological changes at and near the surface of TPO affect not only the paint adhesion to the substrate but also the cohesive integrity of the painted plastic composite.

When external stresses are imposed upon a TPO substrate (e.g., gravel impact) the possibility for cohesive delamination of the sub-

strate exists. Knowing that layering occurs in the substrate from data obtained thus far,[1] we can propose a mechanism for cohesive delamination of the substrate that involves cavitation of polypropylene crystallites out of the rubber-rich layer. If such interphase delamination does occur, cohesive integrity of the material should be improved through an increase in the interphase miscibility of the polypropylene with the rubber or through dissipation of stresses encountered via a shock absorbing paint layer.

We propose that when a TPO material is exposed to external stress, e.g. impact, cohesive delamination may occur within the substrate if the boundary layers within the substrate are not correctly managed. Incompatibilities between the rubber and polypropylene will lower the amount of energy required to pull the two phases (layers) apart. Also, by increasing the amount of rubber, a more elastic layer will form from which the polypropylene can cavitate before reaching its yield stress and delaminating.

Impact testing of painted substrates has been conducted for several decades. Typical test methods include the standard SAE J00 gravelometer test, the VDA test,[4] the Chrysler steel shot test,[5] and Zroll device,[6] the Zosel device,[7] the Splitt device,[8] the Osterbroek device,[9] and the Nissan diamond shot test.[10] Lack of precision, narrow parameter range, and lack of precise post impact damage estimation were the problems most frequently cited for these methods of measurement.[8] Recently, Ramamurthy and others[11] have described a precision impact device which controls all of the variables that influence stone impact phenomenon. Application of optical image analysis, acoustic imaging, thermal wave imaging, and electrochemical impedance spectroscopy (on metal) for precision post impact damage estimations have been described in literature.[12,13]

Table 1 lists several of the variables that one encounters when attempting to quantify the impact resistance of a painted
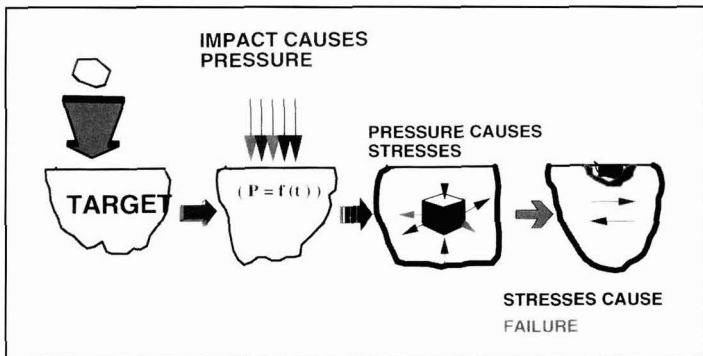

Figure 2—Phenomenology of stone impact damage; impact, stresses, and failure.

substrate. Not only can the type of projectile vary in size and shape, but the way in which it impacts the substrate can have dramatic effects on the chip resistance that is quantified.

It is important to understand the type of impact and the stresses that the impact causes on the substrate (*Figure* 2). The impact from a projectile normal to the target causes pressures to be exerted on the target substrate which are time dependent. These pressures in turn cause compressive stress waves to propagate through the painted composite which can lead to failure of the composite (either as cohesive delamination within the substrate, adhesive delamination between paint layers, fracture, void formation, or internal spallation)[14] if local stresses developed exceed the yield stresses of the material. Therefore, it is important to be able to quantify the pressures exerted on the substrate in order to understand the stresses that will be formed.

Based on the previously mentioned background, it is possible to envision impact response for painted TPO as shown in *Figure* 3. Based on this figure, stone impact response of painted TPO surface can be expected to be a complex phenomenon. The objective of this work is to present an approach to predict the locus of failure due to stone impact on painted TPO via numerical simulation. To the best of the authors' knowledge, this work is the first investigation on the use of mature impact simulation codes to predict locus of failure due to stone impact on painted TPO. Results presented here are preliminary in nature in terms of both material models chosen for impact response and the physical model assumed for TPO and its surface features. This work, however, is a part of a larger effort currently in progress to incorporate advanced material models within the simulation code, a refined physical picture for TPO and also use material constants appropriate to high-strain rates evaluated over a wide temperature range.

This report, in addition to the introduction, is organized into several sections:

(1) Analysis of delamination caused by external stress;

(2) Introduction of phenomenology of the impact process;

(3) Need for numerical simulation in impact studies;

(4) A brief account on the status of current impact simulation codes;

(5) Advantages of numerical simulation;

(6) An overall perspective on numerical simulation in impact studies;

(7) The DYNA 3-D engine;

(8) Numerical simulation of stone impact damage to painted TPO; and

(9) Results and discussions.

ANALYSIS OF DELAMINATION CAUSED BY EXTERNAL STRESSES

In order to efficiently measure the site of delamination within a TPO material exposed to stress, optical birefringence microscopy (optical cross-polarized light) to verify layers within the material was utilized. *Figure* 4 delineates the type of layering within a TPO substrate as viewed under this type of microscopy. In this method, the TPO is cryogenically microtomed (approximately 15 microns thick) and mounted

Table 1—Variables Encountered when Attempting to Quantify the Impact Resistance of a Painted Substrate

Variables	Attributes
Projectile	Size Density Shape Modulus Poisson's ratio
Impact	Velocity Angle of incidence
Environment	Temperature Humidity Solar radiation
Coating	Viscoelastic properties (Density, Poisson's ratio, thickness) Adhesion between layers High strain rate properties
Fixture	Stiffness
Substrate	Type (material properties) Thickness High strain rate properties UV durability Processing conditions

in Canada Balsam on a microscope slide. The sample thus prepared is then viewed under low magnification (ca 100x) under cross-polarized light. A photographic representation of the data is then made (*Figure* 4). The top left quadrant and bottom left quadrant of the figure display the top and bottom of the substrate, respectively, under a red waveplate. The top and bottom right-hand quadrant display the same areas but in the absence of the red waveplate filter. In either case (in the absence or presence of the red waveplate), layering at the top and bottom of the substrate is evidenced by a shift in color. One can view the transitions of thin differently colored lines running parallel to the top surface as one descends deeper into the substrate. It is believed that these parallel lines represent layers of varying orientations and compositions within the substrate due to the temperature and pressure gradients as well as the shear stresses imposed in the material during the injection molding process.

To understand the relationship between the birefringence patterns and the cohesive integrity of the substrate, a painted
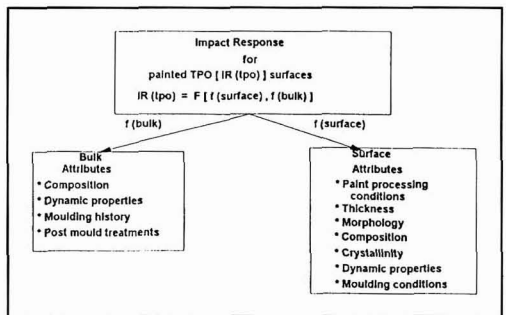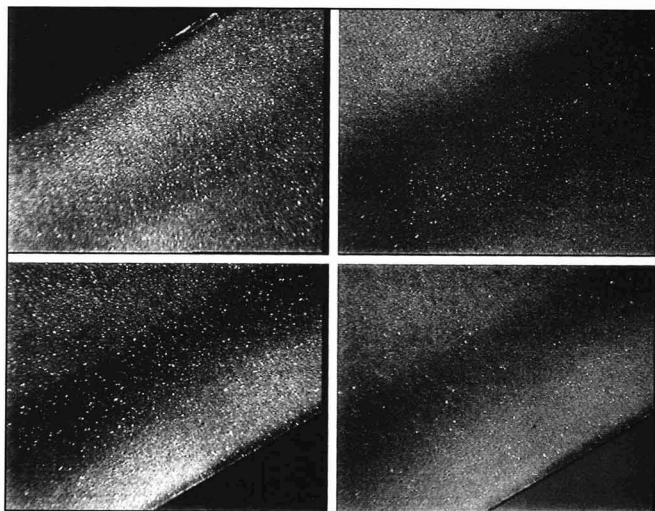

Figure 3—Impact response for painted TPO substrates.

Figure 4—Effect of WBL depth on impact damage TPO.

sample (nominal thickness for adhesion promoter, two-component basecoat/clearcoat baked at 190°F for 30 min part temperature) was exposed to a thermal stress as follows: the painted sample was immersed in a water bath maintained at 38°C for 4 hr, following which it was transferred to a -30°C freezer for a period of at least 3 hr. Within 60 sec after removal from the freezer, the sample was scribed with an "X" with a utility knife, and subjected to a high pressure mix of stream and water from a stream cleaner for a period of 30 sec. The temperature of the steam/water mix was approximately 90°C, at a discharge pressure of a 38 KPa and measured 2.5 cm from the nozzle tip. The stream/water jet contacted the plaque at the intersection of the scribe lines, from a distance of 7 cm and at an angle of 45° to the plaque, on an area of approximately 100 mm². The sample was inspected visually for any delamination of paint or substrate.

The area of delamination was examined by taking a cross-section of the delaminated area and examining it by optical birefringence microscopy (Figure 5). As can be viewed in the top left quadrant of the photograph, the delamination occurs from the X-scribe into the top surface of the TPO substrate. The delamination appears to be cohesive into the top boundary layer (as evidenced by a thin white/blue line running across the top surface) of the TPO. Further analysis of the delamination by differential interference contrast (DIC) microscopy (Figure 6) shows the delamination to be a cavitation of the polypropylene spherulites out of the elongated rubber matrix within the substrate (from left to right, the photo-

graphs represent the scribed area near the top delaminated area, morphology within the scribe, and a top surface away from the scribe). The top of the substrate depicts spherulites of polypropylene pulled out of the rubber-rich (depicted as elongated strings) matrix.

The techniques (differential interference contrast microscopy and optical cross-polarized birefringence microscopy) previously described afforded us the ability to determine the amount and type of layered morphology achieved in a TPO substrate as a function of processing conditions. Polypropylene appears to crystallize at the surface of the plastic when injection molded. The amount and crystallinity of the polypropylene at the surface can be varied by changing conditions such as temperature, pressure, and shear in the molding process, as well as annealing conditions after molding. Rubber, which lies in a layer directly beneath the polypropylene surface, appears to be responsible for paintability of the TPO. The two layers, in conjunction with the paint and its processing parameters, appear to relate more directly to the cohesive integrity of the painted composite.

The data supplied thus far allows us to propose a mechanism for cohesive delamination of the substrate based on surface morphology as a function of painting conditions. The integral strength of the substrate is very important when considering the external stresses that can and will be imposed upon painted parts, i.e., gravel impact.

The effect of impact damage on TPO substrates was studied in relation to their

Figure 5—Proposed mechanism of induced stress failure; cohesive failure within TPO.
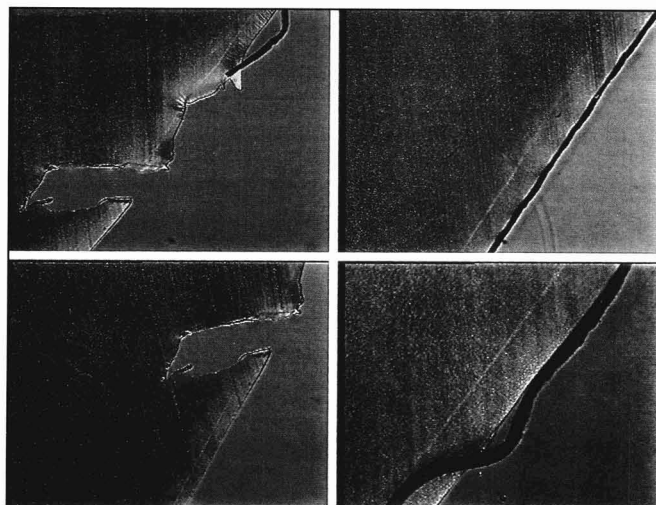
Figure 6—DIC micrographs of cohesive delamination within TPO.
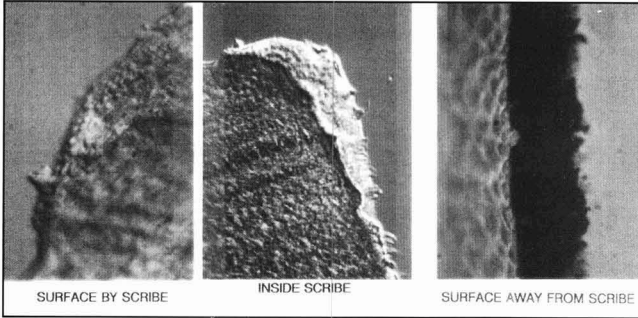
SURFACE BY SCRIBE   INSIDE SCRIBE   SURFACE AWAY FROM SCRIBE
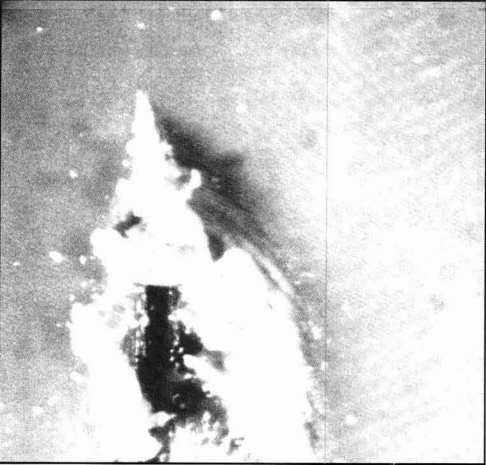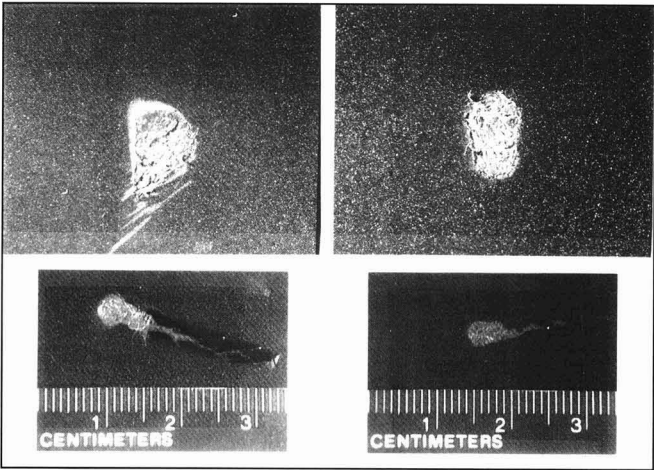

Figure 7—Effect of impact damage on TPO.

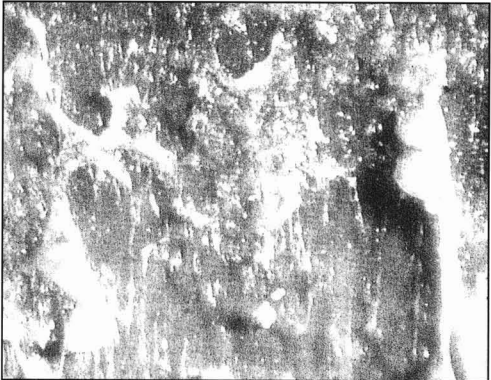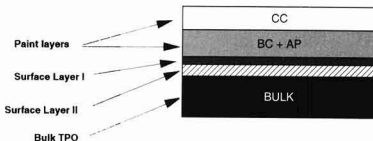Figure 8—Effect of impact damage on TPO (continued).

Figure 9—Effect of impact damage on TPO (continued).

Table 2—Material Constants for Numerical Simulation

Layer	Thickness, nm	Density g/cc	Y Modulus, Pascals	Yield Stress, Pascals	Yield Stress Volume (J/cc)	Poisson's Ratio
Bulk (TPO)	3.0968	0.927	1.3598 E9	1.7 E 7	12.85	0.43017
Surface I (PP)	0.008	0.913	4.13 E 9	3.77 E 7	2.99	0.34
Surface II (Rubber)	0.018	0.85	7.99 E 5	TBD	0.499	TBD
Paint BC	0.2794	1.70	3.428 E 9	5.39 E 8	35	0.433
Paint CC	0.3556	1.18	2.317 E 9	3.64 E 8	21	0.355

surface morphology.[15] The effect of TPO type was studied under the following conditions: varying temperatures of impact, varying angles of impact, rock velocities of 103 and 140 km/hr, varying topcoat types (1K and 2K), varying topcoat bakes, and varying adhesion promoter film thicknesses.

In order to efficiently measure the site of delamination within a TPO material exposed to stress, optical birefringence microscopy (optical cross-polarized light) was utilized to verify layers within the material.[15] When the rock was lofted at the TPO painted substrate, the damage that was incurred can best be described as cohesive delamination within the substrate (see Figures 7-10). If one observes the top two photographs in Figure 7 and the photographs of unpainted TPO damage upon stone impact (Figures 8 and 9), it is evident that the delamination that occurs is a destructive ripping of the substrate. It appears that the TPO melts during impact and then recrystallizes upon cooling (Figures 8 and 9). In the photographs displayed in Figure 8, the impact took place at a 40° angle and

as such the rock skidded across the TPO surface (shown in direction from bottom to top of the pictures). A higher magnification of the delamination is pictured in Figure 9.

The delamination caused by impact (shown in the top two photographs in Figure 7) was then exposed to thermal shock conditions to determine if the locus of failure continued to propagate.[15] The sample was inspected visually for any delamination of paint or substrate (Figure 7, bottom two photographs).

The delamination caused by the thermal shock test was a propagation of the cohesive failure within the substrate caused initially by stone impingement. The propagation of the cohesive delamination was similar in nature to the failure observed on painted plaques under normal thermal shock (Ford test method BI-107-05) conditions when the TPO was painted at low topcoat cure temperatures.

The depth of cohesive failure within the TPO substrate was analyzed by cross-sectioning a stone-impacted painted TPO substrate and observing the failed area under optical cross-polarized microscopy (Figure 10). The failure resulted in depth of cohesive plastic delamination of up to 200 microns.

PHENOMENOLOGY OF STONE IMPACT DAMAGE

In this section, a brief account of the phenomenology of impact is presented. A schematic illustration of impact phenomenon is shown (designated as Figure 2). For impacts normal to the surface, a compressional stress wave propagates through the paint layers and the projectile at approximately the acoustic wave speed in the respective media. This wave will be reflected in tension from free
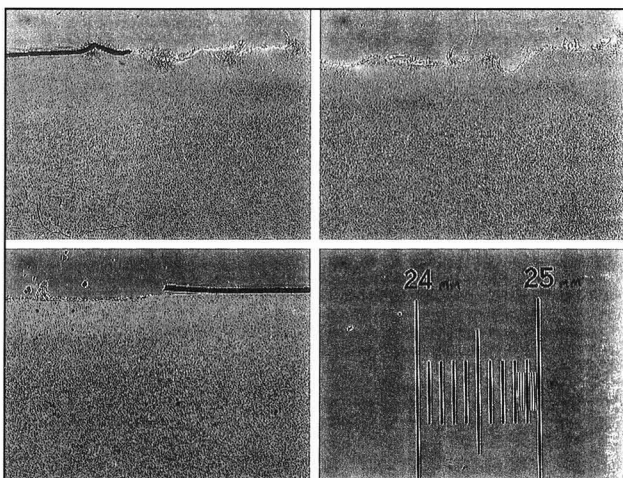

Figure 10—Effect of impact damage on TPO (continued).

surfaces of the target and projectile. When the tensile wave reaches the impact surface, the projectile and target will separate and further reflections occur. This process continues and gives rise to "ringing" in the projectile-target interaction, therefore resulting in a time dependent pressure distribution at the impact surface. This process is significant on the order of tenths of microseconds.

As stress waves propagate through the coated substrate, local stresses which can far exceed the yield stresses develop, thus resulting in fracture, delamination, internal spallation or void initiation.[14] As the projectile-target interaction continues, larger sections of the target may be involved in describing the dynamic responses such as the gross deflection of the substrate. These phenomenon are significant in the order of milliseconds. Eventually, the dynamic response will tend asymptotically to a static response, perhaps involving the entire target.

Most common impact configurations of engineering interest including the current problem are too complex to be satisfactorily treated by plane-wave shock physics and also too inaccessible to permit direct time-resolved measurements of stresses and damage. It is common practice to use wave propagation computer codes (also referred as hydro codes) for understanding phenomenon at the small physical scales and time periods. An initial attempt at such a stress distribution calculation for stone impact damage of painted metal substrate has been described in the literature.[16]

NEED FOR NUMERICAL SIMULATION, NUMERICAL SIMULATION CODES, AND ADVANTAGES OF NUMERICAL SIMULATION

Despite advances in stone impact research experimental techniques, impact phenomenon are inherently very difficult to study due to their transient nature (typically lasting a few hundred microseconds). Assessment of dynamic information via post impact investigations is virtually impossible. Closed-form solutions of impact phenomenon are available but only for a few simple cases. Numerical simulation (NS) of impact events via the use of appropriate wave propagation codes are a major step towards understanding this complex phenomenon.[17]

Numerical simulation involves the application of shock physics principles and material behavior (based on carefully designed experimental data) to describe an impact event. Wave propagation codes such as EPIC, NIKE, and DYNA are very mature today and are available on a variety of platforms such as CRAY, IBM mainframes systems, VAX, SUN, HP, Silicone Graphics, and PCs. Very sophisticated material models are available for both the target and the projectile. For the target, some of the common material models include elastic, elastic-plastic, linear and nonlinear viscoelastic, viscoplastic, rubber-like elastic, to mention a few. For projectiles, several stone types—ceramics and metallic materials with various geometric and physical properties—are also available. Accompanying these material models are the various possible failure criteria that have been built-in to evaluate impact response under conditions of failure. Since all the wave propagation codes evolved over a period of the last 20 years, it is possible to incorporate new material models (physical struc-
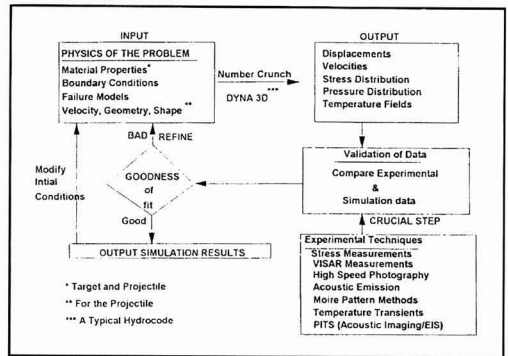

Figure 11—Numerical simulation of impact phenomenon.

tures) and failure criteria based on good laboratory material science practices in combination to observed performance behavior under field conditions.

The integration of NS procedures in stone impact research has several advantages. They are:

➢ For any given model (with or without failure criteria), it is possible to visualize the impact event (e.g, stresses, stains, onset of failure, spallation, and void formation) which include sophisticated animation and zoom mechanisms as a function of time and thickness into the target material.

➢ Plot pressure, stress, strain, and displacement fields as a function of time and thickness for further analysis or experimental validations.

➢ Alter material models, failure criteria, material properties, impose geometric constraints, and change geometry of the system.

➢ Simulate damage for various impact conditions (velocity, angle of impact, and ambient temperature) including different projectile types.

➢ Optimize material properties to minimize damage.

As with any simulation and optimization procedure, garbage inputs produce garbage at the output. Attention to details in material modeling (TPO-paint system) which includes determination of both surface and bulk materials attributes is invaluable to the success of simulation procedures. Choice in failure criteria should be based on carefully designed experiments which closely mimic "real world" performance.

The role of NS can be summarized as follows:

(1) It can provide the materials scientist (substrate/coating system) a specification sheet of material system attributes to derive an optimized impact response;

(2) Predict for the design engineer what the expected impact response would be for the current system and other prototype materials under consideration; and

(3) Rapidly evaluate impact response under a variety of impact conditions and geometry before embarking on a large-scale experimental test evaluation program. This feature is possible only after the simulation approach has been validated

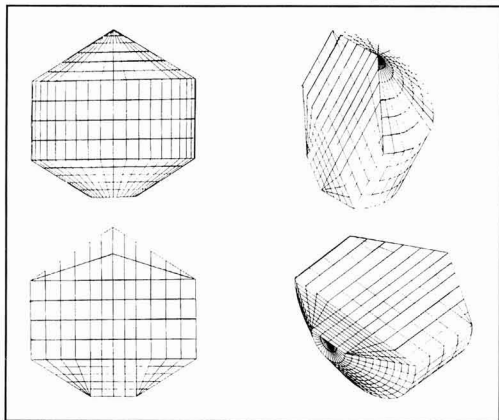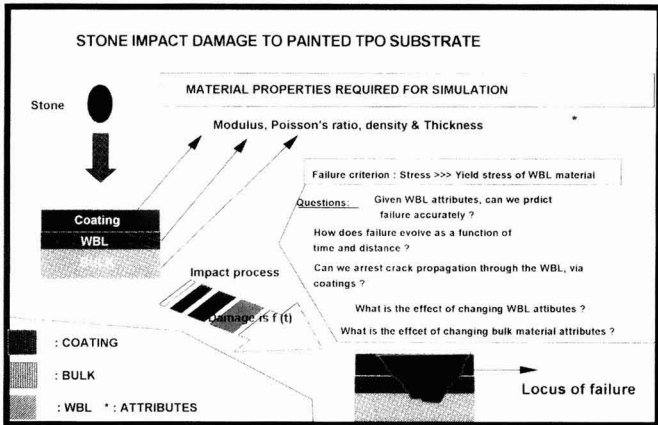Figure 12—Stone impact damage to painted TPO substrate.

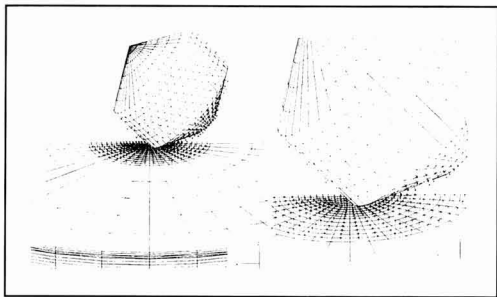Figure 13—Sectioned view of granite mil rock for oblique impacts.

Figure 14—Pictorial vector notation for contacting slide surfaces.
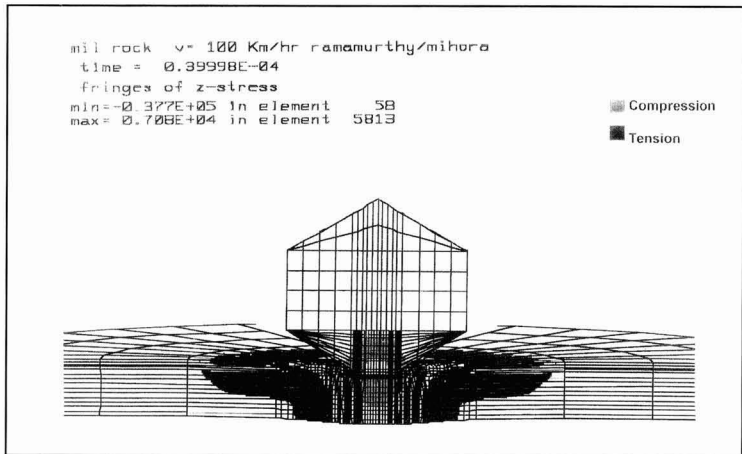

Figure 15—Vertical stresses from impact into painted polymer bumpers.

by observations from both laboratory and field evaluations.

NUMERICAL SIMULATION METHODOLOGY

Figure 11 shows the *modus operandi* for a typical numerical simulation approach that can be implemented for stone impact damage studies. We start by clearly defining the physics of the problem based on intuition and prior knowledge. At this stage, we input all the carefully determined material properties of the substrate/paint system (modulii at high-strain rates as a function of temperature, density, etc.) and the projectile along with the boundary conditions akin to the problem. Other relevant inputs at this stage include size, shape, type, mass, and velocity of the projectile. A failure criteria is not a necessary condition to run a numerical simulation. It is,

Figure 16—Vertical Z-stresses in mil rock and painted TPO bumper 40 μsec after normal impact.

however, necessary to choose a material model from the list of several options as mentioned in the previous section. Once a material model is chosen, the list of inputs required to run the simulation is specified by the code. In practice we use this feature to allow stresses and strains to build up in the system as an overall performance check for the procedure. The ultimate power of NS is in the use of realistic material models based on appropriate data, failure, criteria, and validation experiments and observations. Validation of NS procedures may involve a combination of several experimental observations which can range from high-speed photography, stress measurements during impact to detailed post impact analysis to evaluate area of delamination, determination of locus of failure via microscopy, and observation of subtle features of the failure surface. Based on (experimental) dynamic measurements of the impact event, a goodness of fit criterion for the simulation can be established before beginning to use the procedure for material system optimizations.

NUMERICAL SIMULATION OF STONE IMPACT FOR PAINTED TPO: A PRELIMINARY ELASTIC MODEL WITH NO FAILURE CRITERION

An overview for stone impact simulation for painted TPO substrates is shown in *Figure* 12. In this preliminary work, we assume that "weak boundary layers" within TPO (*Figure* 1) **may** define the locus of failure. Input to DYNA 3-D (elastic model with no failure criterion) requires material properties such as density, Poisson's ratio, Young's modulus along with the thickness for each layer. *Table* 2 shows the various inputs provided for this simulation.* (Note: Not included for this calculation are values akin to the failure process). Young's modulus for bulk TPO was obtained from acoustic data measured at very high frequencies while for the top surface layer
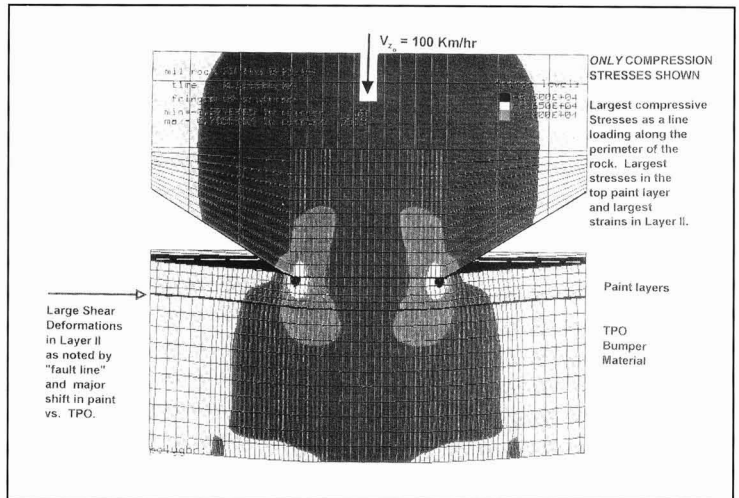
modulus values were provided by Bruce Hartmann (NAVY, Silver Springs, MD) based on an extrapolation from large strain but low strain rate experiments.[§] The modulus of rubber was an estimate based on some preliminary work by Exxon Research Laboratories in Texas. All the data used for paint layers for this simulation were based on moderately high strain rate data, 333%/sec (obtained by VIANOVA Resins, Graz, Austria, courtesy of Elmar Ladstadter). Also, for this preliminary calculation, impact calculations were performed for a fixed geometry which is assumed to be semi-infinite, therefore, ignoring all edge effects.

RESULTS AND DISCUSSION

Some General Observations

The time frame for the impact loads to reach their maximum value is in the first 50 to 100 μsec. The time duration of impact for the 90° impact is shorter than the 45° impact. In the latter case, the mass center of the rock is not aligned directly under the impact center. The added time duration is present as the rock rotates until the full mass of the rock is being decelerated by the bumper. Nominally, the rock rebounds off the bumper in 70 μsec for the 90° impact and around 100 μsec for the 45° impact. The contact times will be longer with plastic flow constitutive relationships.

Distortion of the bumper is very localized as compared to metal plate impact. The cratering is localized to approximately a radius to thickness R/t of about 5. The

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[§]The granite stone projectile is shaped as a cone cylinder with a blunted tip 1.59 mm in diameter. The mass of the projectile was 2g with a density value of 3.2 g/cc3.

At the present moment, work is in progress at the University of Dayton Research Institute, Dayton, OH, to obtain very high strain rate data for painted and unpainted TPO as a function of temperature. Work is also in progress at VIANOVA Resins, Graz, Austria, to obtain high strain rate data for paint layers typically used for painting plastics.

Figure 17—Sectioned view of the X-strain in the bumper 40 μsec after impact with the edge of the mil granite rock.

impact velocity of the rock is low and shock-wave induced damage is not relevant in this impact problem. Rather, the conversion of the rock's momentum by the paint/plate in distortion and flexure introduces the damage. There is a dynamic deflection response of the TPO bumper that introduces large distortions and strains. The shock wave traversal is complete in 10 microseconds by the plate bending and rock rebound is of the order of 100 microseconds.

The very low acoustic wave speed of the rubber layer causes a "trapped" stress region in the paint layer in the first 10 μsec. Even though the large strains have not yet developed, there is academic interest in this surface stress distribution that develops early. In the 20 to 70 μsec time period, the TPO bumper reveals cratering and large distortions together with the large strains. Both the paint layers and the TPO bumper are subject to significant compressive strains. There are also very large shear stresses and moderate in-plane tensile strains in the (rubber) surface layer of the bumper. Because this linear analysis does not include material yielding, it is conjectured that the mode of failure in the rubber is likely to be shear delamination of the paint layers and polypropylene top boundary layer from the TPO bumper. A less likely mode of failure is tensile failure of the rubber layer.
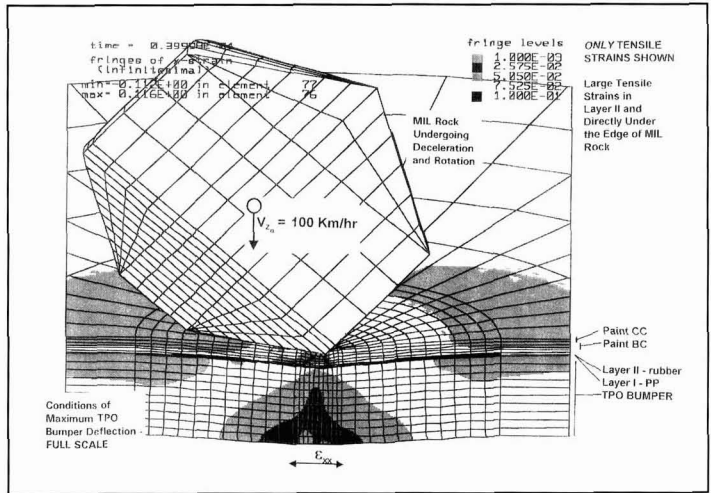
The failure region for both the 45 and 90° impact exceeds well beyond the impact footprint of the rock. It is premature to identify the extent of the delamination area until the materials representation includes yielding and possibly failure simulation. In this conservative modeling, the largest distortions in the rubber layer occur at different times for the 45 and 90° impacts. The axisymmetric failure associated with the 90° impact occurs at about 30 μsec and the maximum principal strain is 2.6. The kidney bean shaped failure region associated with the 45° impact occurs at 50 μsec with a predicted maximum principle tensile strain of 3.1. The damage is predicted to be larger for the 45° impact.

With the 45° oblique impact, the largest stresses at the contact corner occur at about 40 μsec. At this time, the compressive stress in the (linear elastic) paint is -92.3 Ksi. Generally, one does not expect a failure in compression, however, there are substantial gradients and large tensile strains in the rubber layer.

Further development and enhancement of the materials representation is clearly necessary. The linear analysis is only the proper first step, and the modeling of viscoelastic and/or plastic flow is a necessary subsequent step because of the large strains predicted by the linear analysis. The strains introduced in the paint layers are quite large and may be
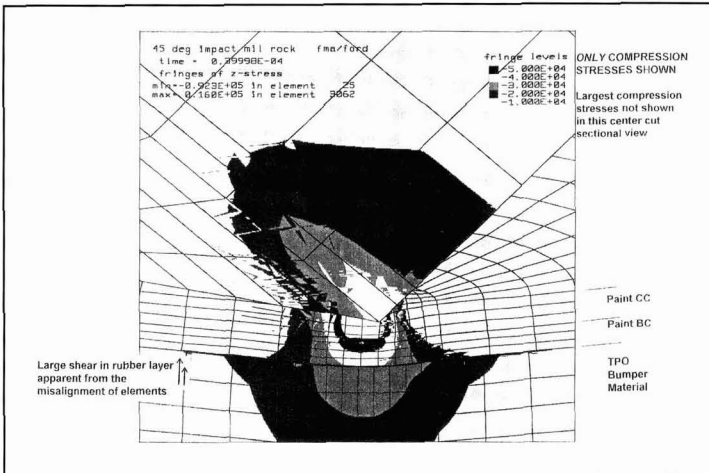
Figure 18—Pseudo "Hertzian" vertical stress at edge of mil-granite rock clearcoat (CC) experienced large compression stresses.
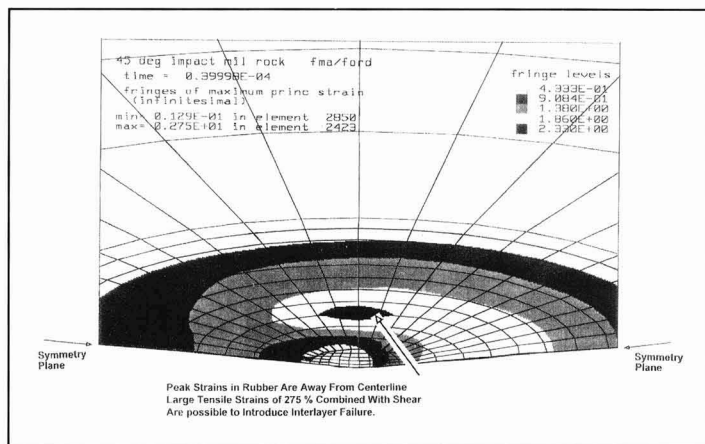
```
45 deg impact mil rock    fma/ford
time =  0.39999E-04
fringes of maximum princ strain
    (infinitesimal)
min= 0.129E-01 in element  2850
max= 0.275E+01 in element  2423
```

```
fringe levels
4.333E-01
9.004E-01
1.300E+00
1.860E+00
2.330E+00
```

Symmetry
Plane

Symmetry
Plane

Peak Strains in Rubber Are Away From Centerline
Large Tensile Strains of 275 % Combined With Shear
Are possible to Introduce Interlayer Failure.

Figure 19—Maximum principal strains in layer II (rubber) from oblique impact

Ksi in the clearcoat is reduced to about -26 Ksi in the bumper. The tension stresses are an order of magnitude lower in the bumper and are not an issue.

Figures 13-19 are specific illustrative examples for normal and oblique angle impact showing the level and extent of stress and strain fields after 40 microseconds. In addition to these perspective plots, it is also possible to obtain a time history plot of any stress or strain component. *Figure 13* shows a typical finite element grid representation for the projectile while *Figure 14* is a pictorial representation for contacting slide surfaces. *Figure 15* shows a pictorial representation for the case of normal angle impact (after 40 microseconds) for 2g mass rock at an impact velocity of 100 Km/hr. Shown in this figure are only the tensile stresses in the Z (vertical direction). Note the type of zoning scheme used at the contacting projectile surface which is significantly different and finer compared to its opposite side. It is clear from this figure that one observes directly beneath the contacting stone surface a zone of significant compression (tensile stresses with a negative sign associated indicate the material in compression) and in the periphery the target is under significant tension. These observations are as expected based on principles of low velocity impact physics.[14] Also seen in this picture is the presence of tensile stress at the substrate surface extending significantly beyond the circumference of the stone. A close-up (zoom) look at this impact condition is shown in *Figure 16*. In this close-up feature, large shear deformations occur both in the clearcoat layer and also subsurface in surface layer II (refer to *Table 2*). *Figures 17* and *18* show a view after 40 microseconds for an oblique angle impact on the painted TPO surface. While *Figure 17* shows strain in the X (in plane) direction, stresses in the Z direction are shown in *Figure 18*. The presence of large subsurface shear stresses, particularly in surface layer II can be seen in both cases. Finally, in any simulation procedure it is possible to view the status of the target by artificially removing the stone in the picture; such a view is shown in *Figure 19*.

even larger when yielding is included in more true-to-life constitutive equations.

Even with linear elastic materials properties, the strains in the paint layers are quite large. The top clearcoat layer experiences a strong crease with the 45° oblique impact case. The maximum surface strain of 0.19 occurs at 55 µsec in the clearcoat. The edge of the granite rock creates a crescent shaped "furrow" in this top protective layer. The top protective layer does an effective job of buffering the severe strains to the surface layer interacting with the rock. The basecoat layer which is under the clearcoat layer experiences less than half the strain as the surface layer. The strains in this surface layer are partially related to the assumed surface friction coefficient of 0.05. The location where the strain magnitude is excessive is at the TPO bumper and undercoat interface and not at the rock or clearcoat interface. Well below the rock/paint friction interface is the problem where the extensional and shear stains are quite large. The material layer #4 (rubber) is subject to a complex 3-D stress field. The most likely failure mode is a debonding of the TPO rubber layer from the paint as the TPO bumper fails in shear. The paint appears to survive within the crude limitations of linear elastic modeling.

The TPO rubber layer experiences the large distortions from 20 to 60 µsec. Over this time period, the TPO is absorbing most of the rock kinetic energy. The TPO distorts substantially more than a sheet metal fender. During this distortion stage, there is a beneficial and large magnitude compressive strain in the paint layer directly under the impact corner of the mil-spec rock. The large compressive strain in the TPO rubber layer is 0.89. With a Poisson's ratio of 0.49, there is imparted a maximum principal strain elongation of 2.9 near the edge of the rock contact area. These tensile values are large but they are not considered to be failure values. However, the shear strains exceed 2.900 at 60 µsec at a location outside the rock content surface. These extreme angular distortions will generally result in a "peeling" delamination.

The compressive stress in the TPO bumper is attenuated by the paint rubber and PP layer. A compressive stress of 92

RECOMMENDATIONS

These numerical simulations have shown the capabilities of modeling impact events with an explicit finite element code. The output presented in this document provides a graphical understanding of the mechanism causing the damage observed in testing. There are additional insights and data that can also be extracted from the output data that has been created. The output of this effort provides direction for the next step in displaying output of this thin layer medium. Future efforts will be directed toward a more refined graphical presentation of interlayer shear

distortions, particularly in the thin, low modulus materials, and the adhesion layer and the eventual prediction of damage (failure modes).

The structural dynamics output will become a useful design tool in addition to the model being a very useful diagnostics tool. Both the normal and the oblique impacts produced different insights relevant to impact damage. The normal or axisymmetric impact predicts a much shorter contact duration than the oblique impact. The 45° impact introduces an interesting dynamic rock motion as the mass center of the rock is not oriented directly above the contact/impact point. The rock experiences a combined deceleration and rotation. The normal impact case only experiences the deceleration. Probably, a slightly higher damage is likely to occur when the rock is impacted into the paint at a 71° angle. In this orientation, the entire kinetic energy of the rock would be reacted along the sharp edge of the rock and minimal rotation would occur. (This is conjectured as the simulation but has not been actually run.)

It is reiterated that the linear modeling is approximate as the future results will utilize a more sophisticated and more accurate materials model. An improved finite element output can provide additional insight as to the likely damage locations. The models will also define the significance of proposed alternations of material properties for both the paint layers and the surface of the TPO bumper. Once acceptable materials modeling fidelity is achieved, a parametric set of cases will be generated. The parametric simulation results will influence both the specification of thickness and the mechanical properties and choices in polymer chemistry. Substantial improvements in survivability can then be expected.

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Bivariate Approach to Viscosity Adjustment

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INTRODUCTION

The manufacture and application of high-solids coatings require good control of the viscosity of oligomer solutions. For a given oligomer-solvent system, temperature and weight fraction oligomer most profoundly affect viscosity. Thus, to control viscosity, one typically brings a wet sample to a standard temperature, and then adds solvent to adjust the weight fraction oligomer to achieve the desired viscosity. Using a model, however, to predict the effect of oligomer concentration and temperature simultaneously, one could reach the desired viscosity without heating or cooling a sample. This would save time and avoid experimental error associated with the temperature adjustment process.

Wicks et al.,[1] were able to predict viscosities, η, of oligomeric butyl and methyl methacrylate solutions over concentrations from 0 to 1 weight fraction oligomer, w_o, and temperatures, T, from 15 to 80°C by regressing parameters from viscosity data using equations (1) and (2) requiring nonlinear parameter estimation to achieve the desired prediction accuracy (see nomenclature for definitions of symbols).

$$\ln \eta = \ln \eta_{T_{ref}} - \frac{c_1\left(T - T_{ref}\right)}{c_2 + \left(T - T_{ref}\right)} - \ln \frac{\rho_{ref} T_{ref}}{\rho T} \tag{1}$$

$$\ln \eta_{ref} = \frac{w_o}{\left(k_1 - k_2 w_o + k_3 w_o^2\right)} \tag{2}$$

In these equations, one must use temperature in Kelvin units.

In the case of the manufacture and circulation of high-solids coatings, however, simpler techniques are more appropriate since this application does not require excellent correlation through such large ranges. Generally, high-solids coatings contain 0.45 to 0.7 weight fraction oligomer and are kept between 15 and 40°C. In this smaller window, one may achieve suitable accuracy using equations that require simple linear regression in concert with carefully chosen data transformations.

The Andrade equation[2] gives a temperature dependence of viscosity that is linear with respect to the fitting parameters A and B.

$$\ln \eta = \ln A + \frac{B}{T} \tag{3}$$

The accuracy of its predictions is quite reasonable for this application.

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This article outlines a method to produce temperature-corrected solvent reduction charts to enable high-solids coating manufacturers and users to simply, quickly, and accurately adjust the viscosity of a coating before application. The method allows accurate control of viscosity without requiring the operator to bring a sample to a standard temperature. Generation of the charts requires minimal and easily obtainable data.

A bivariate strategy is the key to this method. Modeling the kinematic viscosity of the coating, v^2, using an empirical equation (8) enables simultaneous prediction of the effects of temperature, T, and weight fraction solvent reduction, r.

Since equation (8) is linear with respect to the fitting parameters, simple multiple linear regression yields parameter estimates. One typically achieves correlations with R^2 values of 0.99.

We expect that the addition of solvent to a pigmented coating will impact its viscosity by lowering the concentration of both pigment and oligomer. The Mooney equation predicts the change in viscosity as a function of pigment volume fraction. For small ranges of solvent addition, we might ignore the change in viscosity contribution from the pigments and assume a linear form for the oligomer concentration dependence of viscosity.[3] This equation would predict the viscosity of the polymer solution from the weight fraction oligomer, w_o, a proportionality constant, K, and the viscosity of the pure solvent, η_s.

$$\ln \eta = \ln \eta_s + K w_o \tag{4}$$

Since within this small range of temperatures, the log of viscosity of the pure solvent is linear with inverse temperature
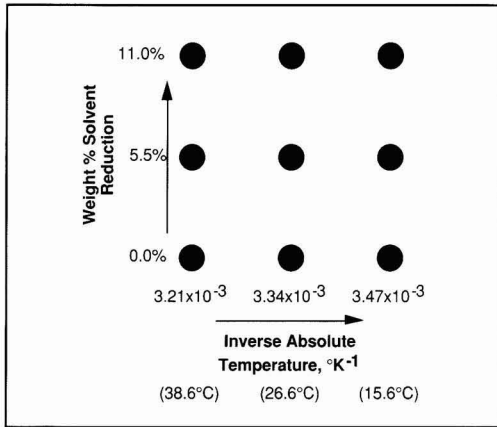
Figure 1 — Orthogonal design space for resolution of main effects of solvent reduction and inverse absolute temperature on viscosity of paint systems. Each circle represents a single data point in the design space.

combining equations (3) and (4) gives a simple bivariate viscosity model of the form

$$\ln \eta = \beta_0 + \frac{\beta_T}{T} + \beta_w w_0 \qquad (5)$$

Note that equation (5) is linear with respect to the fitting parameters, β_0, β_T, and β_w so that common multiple linear regression techniques applied to laboratory viscosity data would give estimates for these parameters.

EXPERIMENTAL

Materials

The three coating samples for this study were fully formulated high-solids enamel automotive finishes which contained full UV protection, catalyst, additive, color pigment, and rheology packages. The samples were: (1) high-solids acrylic/melamine white monocoat; (2) high-solids polyester primer; and (3) high-solids enamel metallic basecoat.

The reduction solvent for the monocoat was a mid-range boiling aromatic hydrocarbon. The reduction solvents for the primer and basecoats were relatively low boiling and polar.

Kinematic Viscosity Determination, *n*

To make this work useful to those working in the field, the determination of viscosity used methods that simulated industrial methods. The ranges of temperature used in this study, 15.6 to 38.6°C, represented normal storage and operating conditions. The efflux time of the coating samples from a #4 Ford viscosity cup were obtained using the method described in ASTM D 1200.[4] Although ASTM D 1200 requires the paint sample to stand for 10 minutes before the efflux time measurement, practitioners in the field often ignore this requirement. Therefore, the standing time was not rigorously controlled so that the results would demonstrate the quality of fit typically realized in the field. Efflux times were measured to

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Nomenclature

A .... Frequency factor constant in Andrade equation.

B .... Activation energy constant in Andrade equation.

c_1 .... Empirical constant in WLF equation for viscosity.

c_2 .... Empirical constant in WLF equation for viscosity.

k_1 .... Empirical constant to predict viscosity as a function of oligomer concentration.

k_2 .... Empirical constant to predict viscosity as a function of oligomer concentration.

k_3 .... Empirical constant to predict viscosity as a function of oligomer concentration.

K .... Empirical constant to predict viscosity as a function of oligomer concentration.

P .... Weight of wet coating.

r .... Percent solvent reduction of wet coating (weight solvent added/weight wet coating).

r_{target} ...... Percent solvent reduction required to achieve desired viscosity.

S .... Solvent required to achieve desired viscosity

T .... Absolute temperature, K.

T_{ref} .... Reference absolute temperature, K.

t .... Time, seconds.

w_0 .... Weight concentration of oligomer.

β_0 .... Empirical constant to predict the natural log of kinematic viscosity in m²/s.

β_T .... Empirical constant to predict the natural log of kinematic viscosity in m²/s as a function of temperature in K.

β_r .... Empirical constant to predict the natural log of kinematic viscosity in m²/s as a function of percent solvent reduction.

β_{Tr} .... Empirical constant to predict the natural log of kinematic viscosity in m²/s as a function of the product of inverse absolute temperature (K⁻¹) with percent solvent reduction.

β_{rr} .... Empirical constant to predict viscosity as a function of the square of the percent solvent reduction.

β_w .... Empirical constant to predict viscosity as a function of the weight concentration of oligomer.

v .... Kinematic viscosity, m²/s.

ρ .... Density, g/ml.

ρ_{ref} .... Density at reference temperature, g/ml.

η .... Absolute viscosity, mPa•s.

η_{Tref} ...... Viscosity at reference temperature, mPa•s.

η_{rel} .... Relative viscosity (η/η_s).

η_s .... Viscosity of solvent, mPa•s.

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the nearest second which also represented typical precision in the field.

Calculation of the kinematic viscosity from the efflux time is straight-forward using the relation:[2]

$$v = 3.7 \times 10^{-4} t - \frac{0.04}{t} \qquad (6)$$

where n is the kinematic viscosity in m^2/s and t is the efflux time in seconds.

Experimental Design

To produce parameter estimates with the least amount of bias using the fewest number of experiments, experimental design principles were used to choose the nine experiments illustrated in *Figure* 1. For each experiment, the paint was brought to the designated temperature, the designated amount of solvent was added, and the efflux time was measured. The experimental ranges of solvent reductions were somewhat wider than those used in industry in order to eliminate the need for extrapolated predictions outside of the design space. The appendix displays these measured values for all three systems. The design was a two-factor (percentage solvent reduction and inverse absolute temperature), three-level full factorial design capable of resolving both main effects, the two-way interaction, and both quadratics. Estimation of the main effects only leaves six degrees of freedom to evaluate error. Random order execution of the experiments kept experimental error from compromising the parameter estimation.

Statistical Analyses of Data

Authors such as Chau et al.,[5] demonstrate solving the normal equations to fit data by multiple linear regression. The built-in matrix algebra functions of Microsoft Excel® automated the task of correlating the log of the kinematic viscosity as a function of inverse absolute temperature and weight fraction reduction solvent in this study. More easily, one could execute similar analyses using statistical packages designed specifically for multiple linear regression or an experimental design package such as packages from the SAS Institute, BBN, ECHIP, etc.

RESULTS AND DISCUSSION

If the changes in the density of the coating are small with respect to temperature, within the range of experimentation, one can substitute kinematic viscosity for η in equation (5) and run the correlation using a log transform of the kinematic viscosity. Also, below 30% solvent reduction, the weight fraction solvent reduction, r, is virtually linear with respect to weight fraction of dissolved polymer, w_0. This allows one to write equation (5) as:

$$\ln v = \beta_0 + \frac{\beta_T}{T} + \beta_r r \qquad (7)$$

Note that since equation (7) is in terms of weight fraction solvent reduction, one need not know the fraction solids for the paint system to create a correlation for kinematic viscosity, making this form convenient for the paint consumer. This equation also eliminates the inconvenience of measuring the kinematic viscosity of the reduction solvent since it is written

Table 1—Evaluation of Fit for Empirical Models for Three Systems

	Monocoat	Basecoat	Primer
Model	eq. (7)	eq. (8)	eq. (8)
R^2	0.991	0.997	0.997
R^2adjusted	0.989	0.994	0.993
RMS error	1.4 sec	0.7 sec.	1.2 sec.
β_0	−14.9	−18.1	−16.9
β_T	1.84E+03	2.68E+03	2.41E+03
β_r	0.077	0.218	0.385
β_{Tr}	—	−98.8	−202
β_{rr}	—	3.14E−3	9.22E−03
Maximum % solvent reduction	11.0%	15%	41.67%

in terms of an absolute viscosity. Alternatively, one may prefer to write this equation so that it predicts the ratio of the kinematic viscosity of the wet coating to that of the reduction solvent. This would make the fitting parameters in equation (7) less dependent of the selection of reduction solvent. As written, equation (7) gave good fit for the efflux time of the monocoat data shown in the Appendix with a root mean square error of 1.4 seconds and an R^2 of 0.989 when adjusted for the three degrees of freedom used in the model.

In the case of the basecoat and primer data also shown in the Appendix, a step-wise regression method suggested model expansion. Most likely, the larger experimental ranges for the solvent reductions required the addition of these extra terms to improve fit. The data not only indicated the presence of a real statistical interaction term between temperature and fraction reduction, but also a quadratic term for fraction reduction to reflect the curvilinear response of viscosity with respect to fraction reduction alone. The expanded model would then be

$$\ln v = \beta_0 + \frac{\beta_T}{T} + \beta_r r + \beta_{Tr} \frac{r}{T} + \beta_{rr} r^2 \qquad (8)$$

Note that equation (8) conveniently maintains its linear form with respect to the fitting parameters, β_0, β_T, β_r, β_{Tr}, and β_{rr}, while still giving an adjusted R^2 of over 0.99 as indicated in *Table* 1.

Further examination of the literature indicates that others have observed these additional effects as well. The Huggins equation[6] also simulates the quadratic effect of polymer concentration on viscosity. Considering the viscosity effect of the pigment only, the Mooney equation would also require some degree of curvature with respect to solvent addition in order to accommodate fit. From the data in Nakamichi, et al.,[7] one can see that the dependence of the "activation energy for viscous flow" on oligomer concentration is very nearly linear for small ranges of oligomer concentration. This dependence is mathematically identical to the existence of a temperature-concentration crossterm (i.e., interaction).

This interaction effect is especially obvious even from the raw primer data. Note that for the higher-solids systems, viscosity is a strong function of temperature (a change of 23°C yields a viscosity change of over 80 centistokes), but viscosity is independent of temperature for the low-solids systems. This might prompt one to write this activation energy for viscous flow as a mass-weighted average of the activation energies for the pure solvent and the pure polymer. The activation energy

Table 2—Gallons of Aromatic Hydrocarbon Solvent Required to Add to 100 Gallons of White Monocoat So That It Would Have a Viscosity of 28 sec in a #4 Ford Cup if Brought to 80°F

Initial Viscosity	Temperature of Paint									
	60°F	65°F	70°F	75°F	80°F	85°F	90°F	95°F	100°F	105°F
28 sec					0.0	0.7	1.5	2.2	2.9	3.6
30 sec				0.4	1.2	1.9	2.6	3.4	4.1	4.8
32 sec			0.7	1.5	2.2	3.0	3.7	4.4	5.1	5.8
34 sec	0.1	0.9	1.7	2.4	3.2	3.9	4.7	5.4	6.1	6.8
36 sec	0.9	1.8	2.5	3.3	4.1	4.8	5.6	6.3	7.0	7.7
38 sec	1.8	2.6	3.4	4.1	4.9	5.7	6.4	7.1	7.8	8.5
40 sec	2.5	3.4	4.1	4.9	5.7	6.4	7.2	7.9	8.6	9.3
42 sec	3.3	4.1	4.9	5.6	6.4	7.1	7.9	8.6	9.3	10.0
44 sec	4.0	4.8	5.5	6.3	7.1	7.8	8.6	9.3	10.0	10.7
46 sec	4.6	5.4	6.2	7.0	7.7	8.5	9.2	9.9	10.6	11.3
48 sec	5.2	6.0	6.8	7.6	8.3	9.1	9.8	10.5	11.2	11.9
50 sec	5.8	6.6	7.4	8.2	8.9	9.7	10.4	11.1	11.8	12.5
52 sec	6.3	7.2	7.9	8.7	9.5	10.2	11.0	11.7	12.4	13.1
54 sec	6.9	7.7	8.5	9.3	10.0	10.8	11.5	12.2	12.9	13.6
56 sec	7.4	8.2	9.0	9.8	10.5	11.3	12.0	12.7	13.4	14.1
58 sec	7.9	8.7	9.5	10.2	11.0	11.8	12.5	13.2	13.9	14.6
60 sec	8.4	9.2	9.9	10.7	11.5	12.2	13.0	13.7	14.4	15.1
62 sec	8.8	9.6	10.4	11.2	11.9	12.7	13.4	14.1	14.8	15.5
64 sec	9.2	10.0	10.8	11.6	12.4	13.1	13.9	14.6	15.3	16.0
66 sec	9.7	10.5	11.3	12.0	12.8	13.5	14.3	15.0	15.7	16.4
68 sec	10.1	10.9	11.7	12.4	13.2	13.9	14.7	15.4	16.1	16.8

for the polymer should be much higher than for the solvent, so the mass weighting of these energies might adequately describe their behavior.

Armed with a mathematical model for viscosity as a function of temperature and weight fraction solvent reduction, one may now build a useful chart to aid in the viscosity adjustment of a high-solids coating. Frequently, in the automotive industry one wishes to bring a quantity of paint to a desired viscosity when measured at a standard reference temperature. Thus, it would be helpful to have a chart that indicates the amount of solvent necessary to add to this quantity of paint at some nonstandard temperature so that if the chart user were to bring the reduced sample to the reference temperature, the user would find that it has the desired viscosity. To produce such a chart, simply calculate the additional weight fraction solvent required to bring an unreduced paint sample to a standard viscosity, v_{target}, at a reference temperature, T_{ref}, from a measured viscosity, v, and temperature, T. For example, in the case of the white monocoat, one would first solve equation (7) for r, and the target reduction, r_{target} to generate equations (9) and (10).

$$r_{target} = \frac{\ln v_{target} - \beta_0 - \dfrac{\beta_T}{T_{ref}}}{\beta_r} \qquad (9)$$

$$r = \frac{\ln v - \beta_0 - \dfrac{\beta_T}{T_{ref}}}{\beta_r} \qquad (10)$$

Next, for a given weight of paint, P, the weight of additional solvent required, S, could be determined from equation (11).

$$S = P(r_{target} - r) \qquad (11)$$

For convenience, densities of the paint and reduction solvent could be used to determine the volume of solvent required. Also, viscosities and temperatures should be in units familiar to the chart user. In addition, an automated spreadsheet to perform these calculations for a number of combinations of initial viscosities and temperatures might be used. *Table 2* shows such a chart for the white monocoat examined in this study.

An example illustrates this chart's ease of use. For this example, assume that the paint consumer has received 100 gallons of paint at 70°F and determines that this paint has an efflux time of 38 sec in a #4 Ford cup at 70°F. Now, add reduction solvent to this paint so that it has an efflux time of 28 sec at 80°F. Instead of bringing a sample of the paint to the reference temperature, simply read the number at the intersection of the column headed "70°F" and the row headed "38 sec." which is "3.4." Now add 3.4 gallons of reduction solvent to this paint. If brought to 80°F, this paint would now have an efflux time of 28 seconds.

Although this type of analysis provides good predictions for a large number of coatings systems, one might think of

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some systems that may violate some of the assumptions in this analysis such that equation (8) no longer enables suitable statistical fit. Such systems might include some water-based systems in which addition of water creates extra irreversible phenomena that impacts viscosity. For some systems, a high degree of thixotropy might interfere with the measurement of viscosity if standing times are not controlled.

SUMMARY

The empirical modeling of viscosity of a high-solids coating as a simultaneous function of temperature and fraction solvent reduction enables production of solvent adjustment charts to aid in the production and application of these coatings. Since for this application, the ranges of these two independent variables are relatively small in practice, one may use simple model terms merely requiring multiple linear regression techniques to achieve adequate predictions. For the smallest ranges of solvent reduction, the linear effects of fraction solvent reduction and inverse absolute temperature sufficiently describe system behavior. Larger ranges require the interaction and a quadratic term for fraction solvent reduction. Even for these larger models, multiple linear regression yields fitting parameters despite their added complexity.

ACKNOWLEDGMENTS

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APPENDIX — Kinematic Viscosity Data for the Three Coatings Systems in this Study

Monocoat

Temperature, K	% Solvent Reduction	Kinematic Viscosity, m^2/s
288.2	0.0	2.15×10^{-4}
299.4	0.0	1.69×10^{-4}
311.5	0.0	1.30×10^{-4}
288.2	5.5	1.42×10^{-4}
299.4	5.5	9.77×10^{-5}
311.5	5.5	8.51×10^{-5}
288.2	11.0	8.93×10^{-5}
299.4	11.0	7.21×10^{-5}
311.5	11.0	5.87×10^{-5}

Basecoat

Temperature, K	% Solvent Reduction	Kinematic Viscosity, m^2/s
288.2	0.0	1.46×10^{-4}
299.4	0.0	1.02×10^{-4}
311.5	0.0	7.65×10^{-5}
288.2	7.5	7.21×10^{-5}
299.4	7.5	5.40×10^{-5}
311.5	7.5	3.94×10^{-5}
288.2	15.0	4.44×10^{-5}
299.4	15.0	3.94×10^{-5}
311.5	15.0	3.42×10^{-5}

Primer

Temperature, K	% Solvent Reduction	Kinematic Viscosity, m^2/s
288.2	0.0	1.89×10^{-4}
299.4	0.0	1.30×10^{-4}
311.5	0.0	1.06×10^{-4}
288.2	20.8	4.44×10^{-5}
299.4	20.8	3.94×10^{-5}
311.5	20.8	2.88×10^{-5}
288.2	41.7	1.73×10^{-5}
299.4	41.7	1.73×10^{-5}
311.5	41.7	1.73×10^{-5}

Computer-Aided Design and Manufacturing of the Color of Decorative and Protective Coatings

Danny C. Rich — Datacolor International*

Introduction

I t has been approximately 50 years since the first colorant formulation algorithm was reported by Parks and Stearns.[1] Over the last five decades many changes have taken place in both colorimetry and numerical analysis which has allowed the technology of colorant formulation to evolve out of the research laboratory and into a commodity tool, without which no serious manufacturer of coatings can operate. The details of this evolutionary process are beyond the scope of this article, but can be found in the excellent books by Kuehni[2] and by McDonald.[3] Unfortunately, it must be stated that the majority of the evolution of this technology has come from the textile industry, both in the United States and in Europe, and not from the American coatings industry. Nevertheless, the coatings industry has been very quick to pick up the technology developed by others and adapt that technology to their needs.

This review has two goals. First, the technology that has led to the proliferation of commercial colorant formulation systems is covered. The technology, along with assumptions and limitations, is presented. The commercialization of this technology is described along with the application procedures that optimize its utilization. This section is very important. Since the technology was not developed by and for the coatings industry, many of the subtleties of its proper use are not generally understood. To meet this goal, three objectives have been set. First, basic equations and assumptions used in colorant formulation and batch correction are reviewed. Second, effects such as the surface correction, dependent scattering, translucency, and appearance modifying pigments are described and their contribution to the basic equations is highlighted. Finally, through the courtesy of some of the manufacturers of colorant formulation systems, this paper discusses and highlights commercially available colorant formulation packages.

The second goal of this review is to identify other approaches to the colorant formu-

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lation and color matching problem than the traditional methods which have been popularized to date. This goal also has three objectives.

(1) There are spectral methods of matching, both experimental and commercial which are described.

(2) There are "palette" methods which are mainly used in point of sale and ink/printing applications. Palette methods rely heavily on the accurate documentation of standard formulas and on the measurement of specimens of those formulas. In computer jargon, this is often referred to as a "look up table" (LUT) method.

(3) There are methods based on statistical and artificial intelligence formalisms. These are the newest and most daring of the nontraditional approaches. Here, the mathematics are based on the empirically observed stochastic behavior of the coloration process and not on some fundamental principle of the physics of the interaction of light with the matter.

The final goal is to try to pull all of the information together and to project or predict the future directions of commercial implementations of colorant formulation packages.

Technology of Colorant Formulation

REVIEW OF BASIC EQUATIONS OF TRADITIONAL COLORANT FORMULATION

The terminology used in presenting the basic equations of colorant formulation systems will follow the precedent set by Eugene Allen in his chapter in *Optical Radiation Measurements Volume 2, Color Measurement.*[4] The coupled differential equations, originally derived by Kubelka and Munk[5] and further described by Kubelka,[6] are so classical that the reader will be referred to the texts by Kuehni[7] and Kortüm[8] for a description of their origin and solution. The derivation here will begin with the classic two flux solution to the coupled differential equations, first derived by Kubelka and

Munk, which provides an ensemble average coefficient for scattering S and for absorption K. An ensemble average can be used by assuming that, within the film, the individual scattering sites are far enough apart that each site scatters or absorbs the electromagnetic wave independent of all other sites and that the total number of scattering sites is sufficient to provide a completely diffuse "cloud" of radiation within the film. A completely diffuse "cloud" of radiation within the film guarantees that the reflectance will be nearly lambertian in the hemisphere above the film. This is an important assumption. It implies that the predominant mode of interaction between the radiation and the materials is via the phenomenon of scattering. With this basis then, the fundamental form of the Kubelka-Munk solution to the turbid medium problem relates the reflectance R to the parameters K (absorption) and S (scattering) as follows:

$$R = \frac{1 - R_g(a - b \cdot \coth bSX)}{a - R_g + b \cdot \coth bSX} \qquad (1)$$

Here, Rg is the reflectance of the background, X is the thickness of the film, and a and b are given by:

$$a = 1 + (K/S) \text{ and } b = \sqrt{a^2 - 1} \qquad (2)$$

If one assumes that the thickness is infinite, implying the film is opaque, then one obtains the well-recognized form of the Kubelka-Munk equation.

$$R\infty = 1 + \left(\frac{K}{S}\right) - \left[\left(\frac{K}{S}\right)^2 + 2\left(\frac{K}{S}\right)\right]^{\frac{1}{2}} \qquad (3)$$

which can be inverted to yield

$$\frac{K}{S} = \frac{(1 - R_\infty)^2}{2R_\infty} \qquad (4)$$

Having thus established a functional relationship between the apparent reflectance and the absorption and scattering of the medium, one needs only a "mixing" formalism to develop the relationship between the observed ensemble average scattering and absorption and the scattering and absorption of the individual colorants. In optically

thin and moderately thick materials (materials in which the scattering and absorption sites are separated by distances that are several times greater than the wavelength of the light incident on them) the contribution of a single colorant to the total scattering and absorption is linear. Each individual colorant contributes an amount k to the total absorption K and an amount s to the total scattering S. An obvious mixing model is thus,

$$\frac{K}{S} = \frac{c_1K_1 + c_2K_2 + c_3K_3 + c_iK_i \dots}{c_1S_1 + c_2S_2 + c_3S_3 + c_iS_i \dots} \quad (5)$$

where c_i is the concentration of the ith colorant and K_i and S_i are the absorption and scattering due to the ith colorant. This is commonly known as the two-constant model.

Since Kubelka and Munk's original solution was for inter-stellar media, no term for discreet boundaries was included. No such term was added to the textile solution either, as the boundary is composed of very fine, nearly randomly oriented fibers. Any light reflected at the air/fiber interface will be mixed into the diffuse flux from inside the fiber. Such convenient boundary conditions will not generally be observed in an organic coating. Thus, a surface reflection term needed to be added to this very simplistic model. Saunderson[9] is usually credited with deriving this addition in the United States, and it is thus known as the Saunderson correction. The correction takes into account the light that undergoes Fresnel reflection at the air/coating interface. There are two terms, one for directional beams and one for diffuse beams. The directional term describes the reflection of the light incident on the air/coating interface from the external or air side. The diffuse term describes the reflection of the diffuse light, assumed by Kubelka and Munk, incident on the air/coating interface from the internal or coating side. The two terms are given the symbols, k_1 and k_2 respectively. The measured reflectance is the product of the Kubelka-Munk reflectance times the Saunderson correction as given in the next equation.

$$R_\infty = \frac{(R_m - k_1)}{(1 - k_1 - k_2 + k_2R_m)} \quad (6)$$

This equation is true for measurements made with the regular (specular) reflectance component included in the measurement. This is commonly referred to as specular included mode. A similar, but slightly different form of the Saunderson correction must be applied to measurements taken in the specular excluded mode. That equation is,

$$R_\infty = \frac{R_m}{(1 - k_1 - k_2 + k_1k_2 + k_2R_m)} \quad (7)$$

Note the very slight difference between equations (6) and (7). One is often tempted to use equation (6) with $k_1=0$ as the defining equation for specular excluded mode. Such

formalism will not give accurate estimates of the measured reflectance. While the measurement system "excludes" the specular component at some angle or set of angles in the system, the specular component is still present and active in the coating.

It was from the starting point laid by Kubelka and Munk that the researchers at the American Cyanamid Research Laboratory began their search for a method to predict the coloration of textile fibers by dyes. In working with textiles, they were able to make one additional simplifying assumption. All of the scattering came from the textile and the dyes contributed only to the absorption. The mixing relationship then becomes

$$\frac{K}{S} = \frac{c_1K_1 + c_2K_2 + c_3K_3 + \dots}{S_t} = $$
$$c_1\left(\frac{K_1}{S_t}\right) + c_2\left(\frac{K_2}{S_t}\right) + c_3\left(\frac{K_3}{S_t}\right) + \dots \quad (8)$$

Here, S_t is the scattering due to the substrate, in this case the textile. This form of the Kubelka-Munk solution to the general problem of light propagation through or into a nearly opaque material has a very broad application and is known as the single constant model. While it is not generally applied to coatings applications, it has been applied to inks, where the ink is very transparent and most of the scattering comes from the paper. It has also been successfully applied to mid-tone and lighter opaque paints, in which a large percentage of the paint is made from a dispersion of a strongly scattering white pigment such as titanium dioxide. The more general mixing equation is applicable when either the coating is not opaque, or when the "colored" pigments contribute in a significant way to the total scattering. In both cases, scattering is still assumed to be the primary interaction between the light and the colorants.

It is important to try to remember that, in a general sense, the Kubelka-Munk model is an analog to the Beer-Lambert model used routinely in analytical chemistry. Most coatings chemists know that if the relative contribution of a solution is high, the Beer-Lambert relationship between concentration and absorption no longer holds. The same can be true for the Kubelka-Munk model. If the relative concentration is high, the linearity of absorbances may no longer be true. The typical practical solution to this problem is to apply a piece-wise linear approximation to the absorption and scattering versus concentration curves. This may require 5 to 10 known (calibration) mixtures. The logic to select the appropriate set of linear equations can be quite complex and has recently been an application for neural networks.[10] In coatings, two additional complications arise. First, when the relative concentration of absorbing pigments increases, the quantity of scattering sites decreases, and the fundamental assumption of the K-

M model is violated. Second, as the concentration of the absorbing pigment increases, the relative refractive index of the medium begins to change and is proportional to the volume average of the refractive index of the resin and the refractive index of the absorbing pigment. This can contribute two problems. First, the scattering efficiency is proportional to the ratio of the refractive index of the pigment to that of the medium. If the refractive index of the medium changes, then the "calibrated" value of the K and S will no longer be valid. Second, because the pigment is absorbing, the refractive index is complex and it is possible to begin to observe anomalous dispersion in the resin. Anomalous dispersion is similar to the optical effects seen in the phenomenon known as bronzing. The absorption of the medium can undergo a dramatic change in spectral selectivity. Once again, this results in a disagreement between observed optical properties and the stored optical properties of the individual colorants.

At very low concentrations of colorant or at very thin film thickness, the coating is no longer opaque and the basic assumptions of Kubelka and Munk are again not met. Here the linearity of K improves but S must be calibrated absolutely. One must then resort to equation (1) and measurements taken with two different backgrounds (white and black) or with two different measurement modes (diffuse transmittance and diffuse reflectance) to solve for values of S and K at each wavelength. At some point, as the concentration of scattering pigment continues to decline, another assumption is violated, there will not be enough scattering sites to create a perfectly diffuse flux within the coating. Additionally, edge and inter-reflection losses become significant and contribute to systematic errors in the measurements which were not present in the calibration process. Once again, this results in a disagreement between observed optical properties and the stored optical properties of the individual colorants.

At this point, the algorithm for simultaneously determining the concentration of the colorants in the match must be invoked. Because we have postulated a linear system, the algorithm is a system of linear equations and can be solved using linear algebra methods. The notations of Allen[11] are used here also to describe the two-constant match algorithm. The matrix T contain the spectral tristimulus values (standard observer functions), E contains the illuminant energy values, $K^{(a)}$ and $S^{(a)}$ contain the absorption and scattering values for the sample being matched. The matrices D_k and D_s contain partial derivatives showing the change in reflectance with change in K and change in S respectively. Thus an element of D_k would be given as,

$$d_{k,i} = \frac{\partial R^{(a)}}{\partial K^{(a)}} \quad (9)$$

The superscripts refer to the colorants in the mixture. The last two matrices are Φ_k and Φ_s which contain the K and S values at each wavelength for unit concentrations of each colorant. These matrices will be functions of the method used to establish the linear relationship between K and S and concentration. Systems with multiple linear or polynomial approximations will need to determine the correct set of unit K and S to apply. The final solution for the concentration is given by the matrix expression,

$$c = (TE\{D_k[\Phi_k - k^{(4)}u] + D_s[\Phi_s - s^{(4)}u]\})^{-1} \cdot$$

$$TE\{D_k[k^{(a)} - k^{(4)}] + D_s[s^{(a)} - s^{(4)}]\} \quad (10)$$

An initial starting condition is usually set by picking an arbitrary concentration for each colorant. The equation is then iterated until a stopping condition is encountered. The stopping condition may be too many iterations, negative concentrations or convergence to a "good" answer. In the process of iteration, the relative value of the scattering coefficient (S) of the white is adjusted to an empirical estimate. The new value for S is used to adjust the relative concentration in the D matrices. The iteration equation looks like

$$\Delta c = (TE\{D_k[\Phi_k - k^{(4)}u] + D_s[\Phi_s - s^{(4)}u]\})^{-1}\Delta t \quad (11)$$

In these equations, the vector u is the unit vector, containing three ones, and the matrix c contains three concentrations. The concentration of the fourth component is arranged, by convention, to be the difference from 1.0. Various methods for efficient iteration are in use in the literature. Newton-Raphson will work most of the time, but it converges rather slowly. Other forms of optimization can be used, including optimizing on ΔE rather than on the difference in the matrix Δt.[12]

In general, the optimization methods will predict a color difference near zero. In actual practice, one very often finds that when a sample is prepared according to the optimized formula, a zero color difference between the target and the trial is not obtained. Sometimes this difference can be attributed to errors in sample preparation.[13] Often this difference can be traced to systematic errors in either the mixing relationship or in the basic assumptions of the Kubelka-Munk model. Practical implementations of the Kubelka-Munk model always include a "batch correction" module. This module will take the results of a match prediction and a test sample of that recipe and compare the differences in spectral reflectance factor, absorption, and scattering. The exact nature of these calculations are the best kept secrets of the color matching business. The essence of the algorithm involves recalculating the relationship between K, S and concentration. This part of the system of matching programs generally separates the

"good" products from the "average" products.

The correction modules also tend to contribute most directly to the cost benefits of a color matching system. The correction module usually supplies options for adjusting for changes in raw materials between the coating laboratory and the production floor. In some coating systems, the profit margins may be so slim that a few cents a pound savings on a particular colorant type may represent a significant financial improvement. A good correction program will provide an adjustment for colorant substitutions or additions. It may also include adjustments for working waste or excess product off in the current batch. The correction module calculates how much of the waste can be added to the current production batch without significantly affecting the final color. This feature alone can often justify the cost of implementing a colorant formulation system.

While all colorant formulation packages provide correction modules, it cannot be over-emphasized that the efficacy of such modules depends very strongly on the accuracy of the input data. While a colorant file prepared for color cards in nitrocellulose lacquer may give approximate matches for the same pigment classes in a urethane resin using the matching module, the correction module may not give stable predictions. Small differences in the physical, chemical, or optical interactions of the colorants with the resins often result in an oscillatory behavior. Under these conditions, the match will never converge, but will wander randomly around the target with an unacceptable color difference. This oscillatory behavior can also be observed if the calibration series is built away from the line segment best approximating the required concentration. Thus, it is important to keep the colorant database current and accurate. Part of the incoming inspection and qualification of a new or substitute colorant should be the preparation of the necessary samples and measurements to calibrate the colorant for inclusion in the colorant database. Many commercial matching systems allow logical grouping of colorants. This prevents the system from running illogical colorant combinations, such as mixing three green pigments instead of green, yellow, and black to

match a green and it allows all pthalocyanine green pigments to be kept together and a preferred colorant from that group marked for current use. If the K or S versus concentration dependence is curvilinear and the matching module uses a general linear approximation, inconsistent predictions again will be obtained. As in any analytical application, the calibration specimens should be prepared at concentrations near the concentration of normal use.

MULTI-FLUX GENERAL MODEL

It was pointed out in the previous section that Kubelka and Munk made a rather bold and significant assumption in deriving their solution to the coupled differential equations of the turbid medium theory for interstellar radiative transport, namely that the light flux is totally diffuse within the scattering and absorbing region. This turns out to be strictly valid only for a few special cases, such as textiles, low chroma, opaque paint, and highly loaded, opaque plastics.

In the more general case, light within a scattering and absorbing region is both diffuse and directional. The first papers to recognize this were those by Völz,[14,15] followed shortly thereafter by the paper of Beasley, Atkins, and Billmeyer.[16] These two works increased the number of fluxes (constants) in the turbid medium model from two to four. The latter work was applied to translucent plastic sheeting where the light path could be either diffuse up, diffuse down, directional up, or directional down. This four-constant model can handle almost any nonopaque, nonfluorescent film. It does require the calibration of 13 parameters at each wavelength, thus more than doubling the number of calibration samples. In the days before automated dispensing and sampling equipment were available, this was considered too much work for the benefit. Today, there is no justifiable reason for not using a more complex model, except that no one has offered such a model commercially.

Later, Richards,[17] and Mudgett and Richards,[18,19] further generalized the model to include any number of channels. Their work was utilized by Phillips and Billmeyer[20] and by Billmeyer, Chassaigne, and Dubois[21] for ordinary paint films and by Billmeyer

> *By the middle of the 1960s, researchers had begun to search for ways to formulate colors with minimum metamerism by approximating the spectral reflectance factor curves.*

and Carter[22] for paint films containing metallic flake pigments. This general theory provided clear explanations for many empirical phenomena, including the value of k_2, the internal Saunderson coefficient, which Saunderson predicted should be 0.6 but practical experience found values near 0.4 to provide better results. Mudgett and Richards[23] were able to show that if the flux within the paint film was not perfectly diffuse, but spread over only a moderate range of angles, then the amount of light internally reflected dropped from the 60% predicted by Saunderson to the 40% observed in paint laboratories. The relationship between the Kubelka-Munk K and S and the individual pigment particle's scattering and absorption coefficients s and k was also confirmed via the Many-Flux model. The absorption constant K is proportional to twice the single particle absorption coefficient k. The scattering constant S is proportional to the single particle scattering coefficient time the average of the cosine of the scattering angle.

$$K = 2 \cdot k$$
$$S = (1 - \overline{\cos\theta}) \cdot s \qquad (12)$$

This model is so general, that one can start from only the optical constants of an individual pigment particle (complex refractive index, $n+i\kappa$) and the size and shape of that pigment and then develop the ensemble average scattering and absorption of the film made up of a resin binder, and a dispersion of N particles with a specific size distribution. The calculations for generating these numbers are both time consuming and computationally difficult so as to make the application of so general a model of little practical significance. Two recent publications are worthy of note here. In both papers, the authors used some of the latest computer tools for solving differential equations to re-examine the basic radiative transport equations and to resolve them to obtain improved information about the Kubelka-Munk scattering and absorption constants. In the first paper by Latimer and Noh[24] they derived an explicit four flux solution to the transport equations. In the second paper by Marcus and Pierce[25] the same approach is used to quantify the Saunderson equations more exactly. Both of these papers point to the fact that better models than the two flux Kubelka-Munk

model are both available and easily derived with modern mathematical tools.

Other Approaches to Colorant Formulation

LEAST SQUARES CURVE MATCHING

By the middle of the 1960s, researchers had begun to search for ways to formulate colors with minimum metamerism by approximating the spectral reflectance factor curves. This provides what Billmeyer and Salzman[26] describe as an invariant match. The earliest paper of significance on curve matching was that by Gugerli.[27] The technique was published in matrix notation by McGinnis[28] and later expanded by Bridgeman.[29] The goal in this approach to matching is to minimize the spectral differences between the standard and batch reflectance factors by minimizing some parameter of the reflectance curves, such as the sum of squares of the spectral differences. Accordingly, the most common approach is linear least squares or weighted linear least squares minimization. A regular least squares algorithm will treat all wavelengths with equal importance. Yet, visually, we known that wavelengths near the ends of the spectrum generally contribute little to the color of a paint. The weights, in a weighted regression, would reflect the relative importance of each wavelength in the spectral curve. Selecting the weights would seem to be an art in itself. If the matching takes place in a "reflectance space" then tristimulus weights may be the correct weights, but which tristimulus value should be used (x-bar, y-bar or z-bar)? In the "reflectance space" the relationship between reflectance and concentration is not linear and the least squares model must calculate K and S then K/S and finally R for each iteration. A more efficient method would be to do the linear fitting in "K and S or K/S space." Now, the choice of weights is not so clear. It may, in fact, be that the most efficient set of weights could be the K/S values of the standard. This would give importance to spectral regions of high absorption and minimize the contribution of the scattering pigments. Most recently, Walowit, McCarthy, and Berns[30,31] rediscovered the use of linear least squares and published an algorithm for formulation via this method. They mentioned the possibility of using

weighted least squares but did not go into detail about how to generate or apply the weights.

In all of the reports in the literature, the spectral curve fitting method has been shown to be less effective at selecting correct colorant combinations and obtaining the best match to the standard than those obtained from tristimulus matches. However, this method frequently does provide matches with better "balanced" color differences under several illuminants. Thus it can be useful in situations where minimizing metamerism is the ultimate goal.

LINEAR- AND NONLINEAR-PROGRAMMING

An extension to the least squares curve fit is linear-programming. Here, the spectral curve differences are minimized, subject to a set of constraints, by geometric projections in an N-dimensional concentration space. The seminal paper on linear-programming is that of Belanger.[32] At that time, linear-programming required a mainframe computer and much of the system's computational resource. Recently, the algorithms have been ported to personal computers and a renewed interest in the technique has surfaced. Papers by Cogno, Jungman, and Cono,[33] Mendez-Diaz and Cogno,[34] and by Cogno[35] review the earlier work of Bélanger and extended it to use an objective function that includes the tristimulus values in a format very similar to the linear equations set up by Allen. Citing all of the shortcomings of linear-programming, their changes in the algorithm were to overcome the problems and provide a better minimization of ΔE^2. Unfortunately, all of the papers are theoretical and no experimental verification of their algorithm has been published. Implementations of Bélanger's algorithm for linear-programming have yielded similar results to general least squares matching. Often, the correct or "best" colorant combination is not selected, and the formula is often not optimized for the best match under a primary illuminant. It does offer the same advantages, as least squares plus the additional advantage that a large number of pigments can be screened very quickly.

Very recently, a paper by Zeng et al.[36] re-examined the work of Allen and of Bélanger and Cogno et al. In the Allen algorithm, there is an assumption that the spectral curves of the standard and batch will not be widely different, resulting in a minimum amount of metamerism. Zeng identifies this assumption as the Spectral Approximate Matching Condition (SAMC). In the linear-programming algorithms already described, this condition was not constrained directly, but like Allen, it was assumed. However, in a full combinatorial colorant selection procedure or in a multiple colorant filter procedure, the SAMC cannot be assumed. Widely different spectral curves with

identical tristimulus values under the primary illuminant are usually filtered by the metamerism index requirements of traditional formulation systems. In the Zeng algorithm, the objective function is the linear combination of the SAMC and the usual, Allen colorant mixing function based, tristimulus match with a weighting function that favors the tristimulus match function.

This paper analyzed more than 2,000 dyeings of 97 standard colors using one or the other algorithm. They reported that 64% of the Allen algorithm matches were acceptable on the first prediction and 81% of the LP algorithm matches were acceptable on the first prediction. After one correction, the acceptable percentages increased to 87% for the Allen algorithm and 93% for the LP algorithm. Unfortunately, they gave no indication as to the time requirements for the two algorithms. Both algorithms are iterative methods, but the more complex objective function and the innate slowness of the LP algorithm may require substantially more computer resources. Zeng did not report trying this method on Allen's two constant algorithm.

Multi-Dimensional Mapping

With the introduction of computer color matching to the retail paint store another approach to color matching has been gaining popularity. This approach uses a multidimensional mapping technique in which the color coordinates of the target are used to locate "known" formulas that produce colors that are close to the target color. This is not a new technique, but it is one that has not been much utilized until recently, since it requires a large collection of known formulas.

There actually have been two recent developments which have helped to revive interest in this technique. In the past, in large scale production plants, the dispensing of colorants into the mixing system has not been very precise. A single weighing system or volumetric container would be utilized to measure and dispense both large amounts of low strength colorants and small amounts of high strength colorants. Also, the quality or manufacturer of the colorant might change from batch to batch requiring a re-formulation of the product on the production floor. Now, with the new, total quality management philosophy, these old habits are changing and recorded formulas can be quite accurate. Secondly, at the point of sales, formulas are usually well-characterized and the colorants well-maintained, usually by suppliers of universal colorants, so that the repeatability and reproducibility of the color of a known formula is very good. With its large palette of recorded dispensable formulas and color chips, trade sales systems are ideal candidates for a multi-dimensional mapping or palette look-up technique.

The ability to "look up" a known formula is very much faster than running a full combinatorial formulation. If the color of the closest known formula is not acceptably close to the color of the target, then a "batch correction" can usually be applied to the known formula and an acceptable match created. Such formulations are intrinsically much more accurate than original formulations. This is because the batch correction starts with known quantities of colorants that produce known colors in the neighborhood of the target and thus "recalibrates" the colorant behavior on the fly.

Interestingly enough, the most efficient versions of this technology have come not from the coatings application but from the graphic arts. This same palette technique is used in "look-up tables" for video displays, scanners, and electronic color printers. This software is known as a color management system. The total number of colorants is smaller, usually no more than seven, and the concentration levels may be discrete steps and limited in range but the process is the same. Many graphics systems manufacturers, such as Xerox™, Tektronix™, and Apple™ offer color management software as do some third party software systems suppliers such as Pantone™ and EFI™. Because these systems make few or no assumptions about the coloration process, they can

Perhaps the most daring of all of the nontraditional methods of colorant formulation is the one that utilizes a neural network to process a set of tristimulus or CIELAB values of the standard and outputs a set of three or four colorant concentrations.

be very fast and precise. In a 8-bit system which provides a concentration resolution of about one half percent, the upper limit on the color error due to a one step error is still less than 1.0 CIELAB color difference unit. There is no reason to believe that this technique could not be expanded to non-graphic arts applications and applied in coatings applications where the final coating was to be either opaque or of a consistent contrast such as point of sale systems or even in commercial factories for low volume products.

Statistical and Artificial Intelligence Mixture Analysis

Statistical Mixture Analysis

Major chemical firms, such as E.I. du Pont, have been experimenting with a form of response surface methodology known as mixture analysis for more than two decades now. Mixture analysis is a form of statistical modeling in which a linear (in the statistical sense) model is developed to describe the effect of varying the relative concentration of each component on some process dependent parameter. Such mixture models have been successfully applied in several optimization applications including resin composition and co-solvent mixtures. It would seem to be an ideal tool for colorant formulation of opaque coatings since the model predicts relative concentration and the sum of the concentrations of all components is unity, just as it is for colorant concentrations. Such a mixture model defines an N-dimensional concentration space known as a simplex and thus simplex optimization is often applied. This allows one to treat the components as vertices and then project orthogonally through the concentration space until a desired minimum or maximum is obtained.

The paper by Alman and Pfeifer[37] outlines an application of just such a mixture analysis procedure. In their experiment, they "calibrated" one set of colorants: black, white, violet, and magenta. They made 49 mixtures from which to build a model and tested the model on 10 check mixtures. Their model was a polynomial that minimized the differences between the L^*, a^*, b^* of the standard and trial subject to the constraints that the concentrations must be positive and sum to unity. They reported results in terms of the unadjusted standard deviations of the residuals for L^*, a^*, b^*. In those terms, the mixture model actually out-performed the standard Kubelka-Munk model. Still, the 2σ ranges were ±1.0 to ±1.5 units of L^*, a^*, and b^* implying an expected range of color differences on the first "shot" of 2.6 ΔE^*_{ab}. The mixture analysis model required 49 calibration samples while the more traditional Kubelka-Munk model required seven calibration samples. While the statistical model eliminates the need to "know" anything about the interaction of light with the paint

> *Today's major suppliers of commercial systems . . . offer complete systems for color matching and production control in the manufacture of decorative coatings.*

film and pigments it does come at the cost of more laboratory effort to get started.

NEURAL NETWORK MIXTURE ANALYSIS

Perhaps the most daring of all of the nontraditional methods of colorant formulation is the one that utilizes a neural network to process a set of tristimulus or CIELAB values of the standard and outputs a set of three or four colorant concentrations. There appears to be two known schools of study on the application of neural nets to colorants formulation, one in the United Kingdom and one in Japan. The one in the U.K. originated at Reading University and has spread to Keele University with funding from Courtaulds Research in the U.K. and from Color and Appearance Technology in the U.S. The work in Japan seems to be funded mainly by Kurabo Industries. Only three publications are known at this time, two from the U.K.,[38,39] and one from Japan.[40] While everyone has great expectations for this technology, there has been no demonstrations of serious commercial applicability in the formulation of coatings. In the paper of Bishop, et al., the neural net required many hours and samples to "learn" the optical behavior of a two component mix and then it was not very accurate on the first prediction. This is a technology which still has a long way to go.

Commercial Implementations of Colorant Formulation

Beginning in the early part of the 1970s, commercial implementations of colorant formulation systems began to appear. Already, large companies that dealt in the manufacture of colored materials or colorants had developed some type of in-house system for formulation. The small to medium size company usually did not have the resources to fund a software development team and so needed to buy the technology on the outside. Initially, firms offered the programs on a commercial time-sharing computer. A company could then "key in" the spectral data and get the results back over a telephone connection. This was a good way to get an introduction to colorant formulation but it was too slow and expensive for use outside of the formula development laboratory.

With the introduction of the mini-computer, a new era began to dawn in production control. These new, smaller computers were moderately priced, relatively fast, and had "real-time" operating systems. They could be set up with the instrument interfaced directly to them in a facility near to the production floor. Now the companies offering the color matching system had two new tools to help in the sale of the system. First, the system gave answers to production control problems very quickly. This allowed the system to be used to compensate for changes in raw materials since the formula was originally designed. Second, pigment inventories could be monitored and formulas derived to include only the least expensive colorant combinations. Load options also addressed the cost of production by reducing the total amount of expensive colorants in the mixture to a minimum level where a prescribed contrast ratio was obtained. In short, the return on a capital investment of $50,000 to $80,000 was near 100% in the first year and always well before the term of depreciation.

Three distinct market areas for formulation systems developed during the late 1970s and early 1980s. These areas include retail trade sales coatings, commercial coatings, and automotive coatings. Many small companies were started focused on only one of these markets, usually being able to carve out a small niche. Brand loyalty was very strong in the early years but competition was limited. After all, there were very few suppliers of mini-computers and everyone was using some form of the algorithm documented by Allen. Slowly, the companies began to develop general and then specific philosophies for each of the markets. By the late 1980s competition was beginning to heat up. In their book, Brandau and Brezinski[41] list 11 different commercial packages for colorant formulation for decorative coatings. This list is not even close to being complete today. The ease with which an entrepreneur can get into the computer colorant formulation business is exceeded only by the number of independent consultants available and willing to assist in the startup. This blossoming of offerings has both positive and negative implications. The cost of a formulation system has been halved over the last decade while the sophistication of the programs has increased. This price erosion will force some companies from

the market. In the case of Colorgen Industrial Group this has happened while this paper was being prepared. Other aspects of the system offerings which one has come to expect are also being influenced by the lower prices. Training and education, one of the best "free" benefits of purchasing a system, are being curtailed or offered on a "cost plus" basis.

Today's major suppliers of commercial systems, Datacolor International, Macbeth Division of Kollmorgen Corporation, BKY-Gardner, Inc., Hunter Associates Laboratory, Minolta Corporation, and Davidson Colleagues, offer complete systems for color matching and production control in the manufacture of decorative coatings. Most of these companies offer more than just an instrument, a computer, and a flashy program. Often, they will have special or unique philosophies and products addressed to the particular needs of their customers. Minolta, for example, believes strongly that the foundation of a successful color formulation system is the database—the better the database, the better the matches and corrections. Their *SpectraMatch* software offers multi-level calibration of colorants in their two-constant algorithm, allowing the user to calibrate a colorant over the full range of concentrations in which it will be used. The software also applies extensive data analysis to the colorant database by back-predicting known samples, thus validating and selecting the optimum set of calibration specimens. This can be really important, since any sample preparation errors will dramatically affect the performance of the database. The validation process can quickly identify potential errors in sample preparation, application, contamination, or data entry. Most packages offer some form of laboratory to production scale-up factor and for tinting strength adjustment. Datacolor International offers a slightly different approach with its *SmartMatch* technology. Here, the software applies a form of heuristic algorithm which "learns" from past formulas and batches. In combination with recycling of scrap and excess inventory, this heuristic approach can optimize the production inventory and reduce the number of colorants one needs to keep in the palette. Davidson Colleagues offer many unique tools designed specially for the coatings color technologist. Of particular use are visual guides provided by the combination of spectral and chromaticity plots and an "On-screen" color patch. This allows the user to observe changes to the spectral curve, chromaticity coordinates, and visual color simultaneously.

There are many other vendors of systems and software in both the United States and across Europe. The number increases and decreases annually. Each has something unique or clever to offer to the manufacturer of decorative coatings. Your selection of a vendor should be based on how well the colorant formulation companies unique ca-

pabilities fit with a company's own total quality philosophy. Any of the basic systems will provide good quality matches. The real test of the vendor comes not in matching but in corrections, raw materials handling, waste work off, and ease of use.

Future Trends

There are several trends which are already beginning to become apparent. First, prices are coming down. This price reduction is not because the costs are coming down. In the early days of color matching systems, the computers were very expensive and the vendors made the most of their profits on the computers. Today, the computers are very inexpensive and the vendors must make the most of their profits on the software. Still, the software costs cannot be too much larger than the hardware, especially when programs like Lotus 123® and Microsoft Excel® can be purchased for a few hundred dollars. The more copies a company can sell, the lower the prices are likely to be. The lower prices do have a downside. It is very expensive to send a salesman out to a plant to present the product and then an applications engineer to install the product. In the future, there will be more "shrink-wrap" software and "ship and forget" delivery of instruments and systems. The smaller the company, the more likely one is to get personal service. A company with thousands of customers will have to be more creative in their support and sales efforts. Expect to see more telephone sales, bulletin board systems (BBS), and direct exchanges for service and repair.

Second, performance is going to be improving. In order to reduce the amount of support contact, the programs must become easier to use, and the algorithms more exact on the first predictions. As mentioned previously, the Kubelka-Munk model has some limitations for certain kinds of coatings and certain colors. More fundamental models or more robust algorithms will be developed to handle these limitations. Already, most of the vendors are requiring several "calibration" samples per colorant to characterize the color build from white to mass-tone. The Kubelka-Munk model predicts that the color should build linearly from 0% to 100% pigment. This is rarely the case. Various kinds of nonlinear approximations are being applied to improve the fit between prediction and calibration. Other slight modifications to the basic Allen algorithm can also improve the speed and reliability of predictions by using newer, more efficient mathematical tools.

Third, an increase in the number and quality of empirical fixes to the Kubelka-Munk can be predicted. The area of artificial intelligence is the most frequently seen empirical add-on to K-M theory. Tools such as neural nets, fuzzy logic, and expert systems can all help improve the performance

of the matching algorithm. Newer tools, that are just beginning to move from basic and applied analytical chemistry, such as mixture analysis, principle component analysis, and even partial least squares modeling, could eventually show an improvement for Kubelka-Munk mixture analysis as well. K-M theory predicts that a single colorant should build linearly and yet it does not. K-M theory also predicts that multiple components should build linearly. They most probably do not. The whole field of chemometrics has many tools that have only occasionally been applied to problems in color matching and colorant formulation. Perhaps, a chemometric model will relate colorant concentrations not just to color but other appearance and physical properties as well. Coatings formulation could become a holistic process. The total coating can be accurately formulated on a volume basis and the formula related to both physical and optical properties. There may come a time, when the coatings chemist simply inputs the final product specifications and the computer then picks the optimum set of additives to work synergistically with the colorants to meet those specifications.

Conclusions

What can be concluded about the application of computer color matching to decorative and protective coatings? It is safe to say that the science has evolved through a technology and into a commodity product. It is not a question of whether a coatings plant needs color measurement and colorant formulation but rather one of how many and how much. The costs have come down to the point that only in rare cases does the purchase require a large investment of time to get approval or to justify. Many QC products have already become "shrink-wrap," customer installed software products. Suppliers of this software cannot afford an elaborate system of "free" training and support. As a result, more and more third party support firms will spring up. These small firms will be staffed with experienced formulators and shaders and will offer support and training on a large number of coatings applications and testing.

The final, critical link between the laboratory and production is still the dispensing. No matter how accurate the formula, the product will be of low quality if the colorants and additives cannot be added, mixed, and sampled uniformly. Automated dispensing and mixing systems are a must. With computer controlled pumps, mixers, and testing, the coatings manufacturer can produce many small batches faster and more consistently than one large batch. This will reduce the tank time and the capital cost of tanks and increase the number of colors and batches that can be made in a year. As the dispensing becomes automated, the need for "on-line" or "near-line" measurement increases.

One of the most probable applications for an empirical add-on to K-M model is to relate the properties of a coating in the mixing tank to the finished dry film. This is not a new goal[42] but it is one which had only marginal success using traditional, univariate mathematical tools.

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State-of-the-Art Instruments to Measure Coating Hardness

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Introduction

Over the years, scientists have developed different instruments and procedures to measure the hardness of paint films, i.e., organic coatings. Since test methods result in different numerical values, which one is correct? Rather than answer that question, let us examine some of the state-of-the-art instruments to determine how they compare.

PENCIL HARDNESS

The easiest and cheapest instrument used to measure the hardness of organic coatings is the pencil. Pencil hardness has been utilized for many years. This test uses pencil leads of increasing hardness values which are forced against a coated surface in a precisely defined manner until one lead marks the surface. Surface hardness is defined by the hardest pencil grade which fails to mar the organic coating surface. The hardness of an organic finish according to the hardness of a lead (graphite) pencil that will just scratch it was described by Wilkinson.[1] Gardner[2] studied the test method using pencils sharpened to different shapes—sharp cones, rounded cones, and chisels. ASTM D 3363, Test Method for Film Hardness by Pencil Test,[4] lists 14 different grades of hardness, ranging from the softest, 6B, to the hardest, 6H, that can be used in this test method. Pencil leads are blends of graphite, clay, and binders, and range in hardness from softest to hardest as follows: 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, and 6H. Over the years certain features of this test method have been standardized.

Variations in the test method have occurred with respect to how the test is actually carried out. Smith[3] made a study in 1956 and used the following test method: (1) strip the wood from the lead for a distance of approximately $1/4$-in. using care not to nick the lead; (2) square the exposed lead by a gentle rotary motion against No. 400 carbide abrasive paper; (3) hold the pencil in a writing position, that is, at approximately 45°, and push forward against the

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Table 1—Knoop Indentation Hardness Values of Pencil Leads[5]	
Pencil Lead	Knoop Hardness Numbers[a]
5H	51.5
4H	47.0
3H	45.3
2H	38.7
H	31.7
F	27.0
HB	24.0
B	12.7

(a) Mean KHN with a 200-g load.

film. Use pressure short of breaking the lead. By turning the pencil after a test, a new edge is available for use, and three or four trials may be made with one dressing of the lead; and (4) clean the marks with a soap or "artgum" eraser. Any marring of the surface, visible at an oblique angle in strong light, indicates that the pencil is harder than the film. The hardness is expressed as the grade of the next softer pencil.

In developing this test method, Smith[3] determined the pencil hardness of 14 different organic finishes that varied widely in hardness. Five different brands of pencils were used and the results published.[3] The results indicated that there were variations in the hardness between different brands of pencils and that it was necessary to use only one brand to obtain reproducibility.

Smith[3] also compared the Knoop hardness and Sward rocker hardness versus pencil hardness of the 14 organic finishes. These results showed that the pencil hardness rated the various organic finishes in the same order of hardness as the two other more elaborate test methods. According to Smith, three widely different mechanisms were involved.

They are: Sward rocker, deformation within the elastic limit; Knoop hardness, deformation beyond the elastic limit; and pencil, deformation beyond the elastic limit and tearing away of material.

In 1974, ASTM adopted Test Method D 3363,[4] a quick test method to check the cure of coil coatings as they exited from the curing oven. With its limitations, Test Method D 3363 is useful and practical for laboratory use, for use on a production line, or in the field to assess quantitatively the rigidity or firmness (elastic modulus) of organic coatings applied to rigid substrates such as metal or plastic. Hardness values may define requirements for particular coating applications, or may be used to evaluate state-of-cure or aging of a coating.

W.W. Walker[5] evaluated the Knoop hardness of three organic coatings using a Model LR Tukon microhardness tester in accordance with Test Method A of ASTM D 1474, Test Methods for Indentation Hardness of Organic Coatings,[6] except he calibrated the instrument at a 100-g load and ran the tests at a 200-g load. His paper showed pencil lead hardness in terms of Knoop hardness numbers (KHN). The KHN values made with a 200-g load are shown in Table 1.

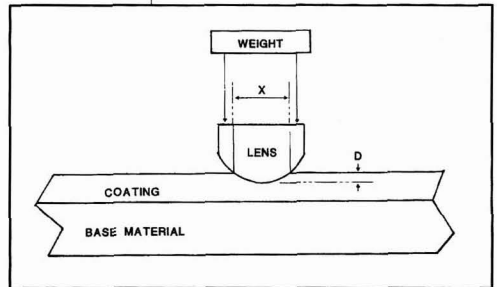In addition, he tested the pencil hardness of three different organic coatings in

Figure 1—Diagram of Gardner-Pfund hardness indenter.

Table 2—Comparison of Pencil and Knoop Hardness Numbers of Selected Coatings[5]

Paint	Pencil Lead No.	Lead Hardness, KHN	Paint Hardness, KHN
Epoxy powder	5H	51.5	30.2
Polyurethane	3H	45.3	22.7
Solvent epoxy	H	31.7	8.9
Metal panel.........	—	—	195 ± 1

accordance with ASTM Test Method D 3363. Data are shown in *Table 2*. Walker concluded a useful correlation exists between the 200-g Knoop indentation hardness and pencil hardness of thick paint films but added a statement indicating further work is needed. To date, no one has verified his work by continuing with a study.

PFUND HARDNESS NUMBERS (PHN)

After numerous unsuccessful attempts to grade the hardness of varnishes with a graded pencil scratch test, A.H. Pfund, an associate professor of physics from Johns Hopkins University, Baltimore, MD, modified the Brinell indention test.[7] In this test method, the measurements are made on the organic coating while the loaded indenter is in contact with the coating. At first, a 1/16-in. diameter steel ball was forced under load into the varnish, and the diameter of the resultant circular impression was measured under the microscope. This ball was soon changed to a quartz cylinder terminating in a hemisphere 1/4-in. in diameter. The results are expressed as the load on the indenter, in grams, necessary to achieve a specified diameter of indent. The device consists of a counterbalanced brass beam containing the indenter. Illuminating light is reflected into the indenter by the clear glass and reflected back up to the microscope where the

Figure 2—Gardner-Pfund hardness tester.

planar diameter of indent is measured by means of a filar eyepiece.

The essential difference between the Pfund and Knoop test methods is the Pfund hardness measurement is made when the indenter is under load, while the Knoop hardness measurement is made on the indentation impression remaining after both the load and indenter have been removed. This remaining Knoop impression is typically smaller than the original made while under the loaded indenter, because all of the elastic and substantially all of the viscoelastic (creep) recovery occur in the indentation impression once the load is removed.

The operation of the Pfund[7] and Knoop test methods rests on two entirely different principles. E.M. Corcoran[8] stated that each measurement represents a completely and substantially different point on a viscoelastic creep-creep recovery curve for any given material or organic coating. Yet, the amazing aspect is that, coincidentally, the numerical results can be quite similar. This similarity in numerical results (PHN ≈ KHN) with organic coatings could never have been achieved deliberately. How fortunate for the paint industry that this is so.

As this test method was rather tedious and time consuming, Corcoran[8] reported that the instrument and method were modified in the early l950s by the Bell Telephone Laboratories. The indenter, a transparent, colorless synthetic quartz or sapphire hemisphere whose spherical radius was 0.125 in. (1/4 in.) diameter with a maximum spherical eccentricity of 0.002 in., was mounted in a holder weighing 1,000 g so that the indenter was always under a load of 1,000 g when making measurements. Hence, this test method kept the load constant and the resultant diameter of indent was recorded. This was exactly opposite to the original Pfund test method.

In operation, the test panel was brought into contact with the loaded indenter and after 60 sec (while still under load) the diameter of the circular impression was measured by means of a filar micrometer mounted in the eyepiece of the microscope. Each filar division represents 0.1 mm, and the diameter of the impression was converted into a Pfund hardness number (PHN), expressed in kg/mm² units, shown in equation (1):

$$PHN = \frac{L}{A} = \frac{L}{\frac{\pi d^2}{4}} = \frac{1.27}{d^2}$$

where: L = load in kilograms (1 kg) applied to the indenter, A = planar or projected area of indention in square millimeters, and d = diameter of the indentation in millimeters. The PHN was the load, in kilograms, divided by the planar or projected area of indentation. The planar or projected area of indent deserves some explanation. A hard-

Table 3—Comparison between Sward, Pfund, Vickers, and Pencil Coating Hardness Values

Coating	Sward	PHN	HU[a]	Pencil
10-7311	11.2	21.5	225	4H
30-7008	10.8	21.5	201	H
20-7163	34.0	17.8	156	H
Control	9.4	5.8	83	3H

(a)HU (H/mm²), obtained by the Fischerscope® H100V Microhardness Tester, divided by 10 is approximately equal to Vickers hardness number.

ness measurement is taken when the spherical indenter is under load and in contact with the coating. Initially, the hardness or PHN was reported as l0d. The reason for changing it to the load divided by the planar area of indentation was to make the reported PHN results have the same units of measurement as the Knoop hardness number (KHN) in Test Method A of ASTM Test Method D 1474. Surprisingly, the PHN and KHN values come very close numerically.

In 1990, Maynard R. Euverard looked at the Pfund hardness instrument and realized improvement could be made which he subsequently described.[9] The classical test method of measuring hardness is by indentation. An object of known form and dimensions is pressed into the test material. The load for a given depth of indentation is measured on the test material. Measurement of coating hardness by indentation presents two unusual problems. Only the top 10 to 15% of the coating thickness can be considered in the measurement without the influence of the surface on which the coating is applied. In addition, the depth of the indentation must be determined with the load of the into the surface of the coating by a known weight. With the weight in place, the diameter of the spot formed where the lens is in contact with the coating is determined by a microscope with a measuring lens. Although the concept of penetration hardness of coatings is simple, the following elements are necessary for the measurement: (1) means for positioning the coating on its supporting base material in proper registry with the lens; (2) means for accurately load-
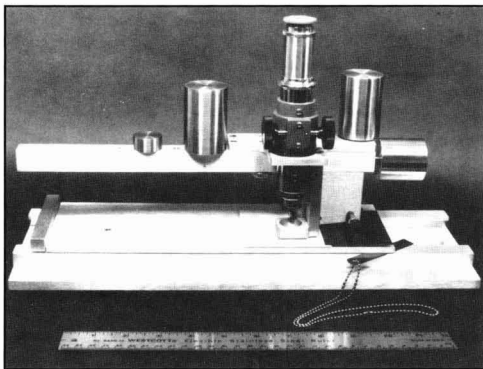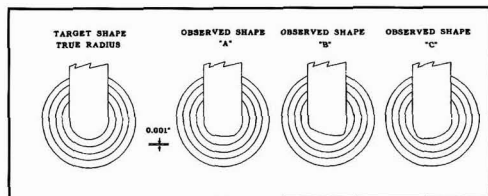
Figure 3—Diagram of Sward rocker hardness rings.

ing the lens with any weight within the possible range of interest; (3) a suitable mechanism for lowering or raising the lens with respect to the test surface; (4) a lens of known radius with suitable lens holder; (5) a measuring microscope for determining the spot diameter of the lens in contact with the coating; and (6) a light source for illuminating the spot where the lens is in contact with the test material, either through the lens or in the plane of the coating. The balanced beam tester served as an excellent mechanism for holding and loading the modified Pfund hardness measuring components. A picture of this tester is shown in Figure 2. This tester consists of a beam and tool holder which is balanced by a counterweight. The beam has ten positions for receiving two 500-gram or one 50-gram weight. These weights can be placed in any combination in any of the ten numbered positions. Weights used and their positions on the beam are the weights placed by the tool against the test surface. A locking mechanism is provided to hold the tool in an elevated position. The improved Pfund gage provided an extremely accurate means of measuring penetration depth and thus resulted in better precision and accuracy.

SWARD ROCKER HARDNESS

George Gilbert Sward was awarded a patent for his coating hardness tester developed when he was associated with the National Paint, Varnish, and Lacquer Association. Further work[11] improved upon its usefulness. It is perhaps the best known and most widely studied instrument for measuring the hardness of organic coatings. ASTM Committee D-20 on Plastics wrote a standard using the Sward hardness tester, D 2134, Test Method for Softening of Organic Coatings by Plastic Compositions. Committee D-20 turned over the responsibility of D 2134 to Committee D-1 in 1991. Test Method D 2134 was rewritten and retitled (Test Method for Determining the Hardness of Organic Coatings with a Sward-Type Rocker). It is printed in the 1994 *Annual Book of ASTM Standards*. Interlaboratory and intralaboratory testing, i.e., a round-robin, will begin to develop data needed for the precision and bias statement required by ASTM.

The Sward rocker operates on the same principle as does the swinging beam and other pendulums. However, it is self-contained and requires no separate scale. Some models also have their own circular level. It consists of two flat, 4-in. diameter, chromium-plated bronze rings, spaced one inch apart. Amplitudes of oscillations are indicated by two tube-style levels in the lower half. The level at the left is for marking the start of a test; the one on the right is for marking the end.

In 1991, Maynard R. Euverard looked at the Sward rocker hardness instrument and realized it too could be improved. Using an optical comparator, he saw that the radius of the rings of existing instruments were not truly round. One side was higher than another, as seen in *Figure 3*. Observed shapes "A," "B," and "C," shown in *Figure 3*, are profiles of the rings of three different, commercial Sward rocker hardness instruments. Knowing that a combination of conventional and electrical discharge machining would produce a truly round and reproducible radius of the rings, he had a new instrument fabricated. Besides providing a better radius of the rings, he replaced the assembled parts with a single frame machined from a solid metal bar. The new Gardner/Sward instrument is pictured in *Figure 4*.

Another problem with existing Sward rockers was the demand they placed on the operator to observe bubble position and to count cycles during the testing procedure. Mr. Euverard replaced the two bubble levels for determining the high and low limits of swings with an electronic device containing miniature mercury switches which, through electronic circuitry, automatically register the swings on a large character liquid display digital counter. These changes made the Sward rocker hardness gage "user friendly." The operator simply rotates the rocker past the angle where count starts and releases the instrument. This motion resets any digits showing on the display to zero. Automatically, the instrument starts registering cycle counts at the high set angle and stops at the low set angle. This cycle count between the high and low set

angles is held on the display until further action is taken by the operator.

DYNAMIC HARDNESS TESTERS

The Fischerscope® H100V, shown in *Figure 5*, is one of the dynamic microhardness testers which can be used on a variety of materials, including organic coatings, to measure hardness under load. It works with very small test loads up to 256 mN. Determination of hardness based on the plastic and elastic deformation of a material is the direct result of measurements under load. Hardness measurement is expressed in N/mm^2, corresponding to the quotient of Load P over Area of Impression A (whereby A can be derived directly from the depth of indentation). This definition of hardness is physically meaningful by providing a measurement of hardness with an uncertainty of $\pm 1\%$. This requires exact measurement of load and indentation depth which is possible with this instrument. High reproducibility of results because of subjective errors traceable to operating personnel (e.g., microscope readings) are eliminated. Since the load is applied (or reduced) in steps, a measurement is taken at each intermediate load. All test and evaluation procedures are preprogrammed. The operator needs only to position the test specimen and select a test or evaluation sequence. The entire testing
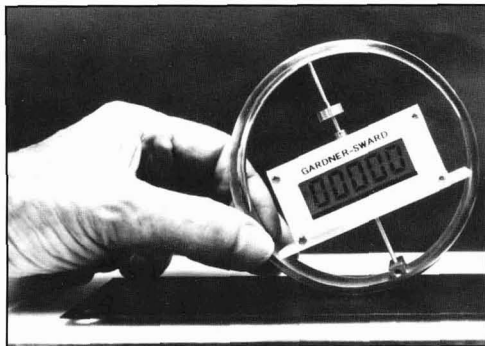

Figure 4—Gardner/Sward rocker hardness tester.

cycle takes (depending on application) between 20 and 120 seconds. At the end of this period, the instrument logs the result. The software offers graphics of hardness versus load or indentation depth, differential hardness, indentation depth versus load or time.

Using this Fischerscope H100V microhardness tester, W.W. Weiler developed a dynamic, non-destructive test method to measure the microhardness of surface layers, coatings, and homogeneous materials in the ultra-low load range of 0.025 to 1 N.[12] The test method was based on using a conven-
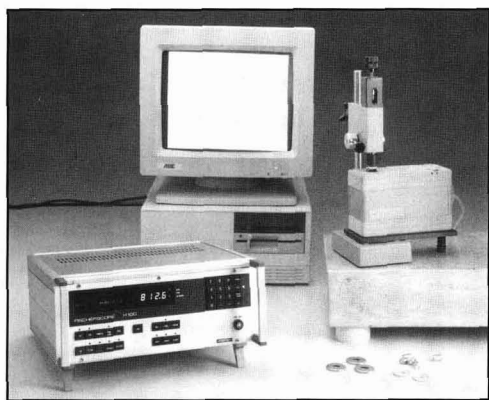
Figure 5—Fischerscope H100V dynamic hardness tester.

tional Vickers indenter coupled to a displacement measuring device. Typically, these testers are fitted with the Vickers indenter. However, they can accommodate the Knoop or any other similar indenter. The Vickers indenter is a diamond pyramid with equal angles of 136°. The Knoop indenter is a diamond-based pyramid with included longitudinal angles of 172° 30′ and an included traverse angle of 130° 0′. It produces a diamond-shaped (rhomb) indentation having long and short diagonals of an approximate ratio of 7 to 1. The depth of indentation is about l/30th of its length. Frederick Knoop et al.[13] published hardness data that showed his Knoop hardness values were essentially similar but not identical to Vickers Hardness Numbers. Task Group D01.23.20 Exploratory Research has a study underway which is investigating several dynamic hardness testing instruments.

Experimental

Three unplasticized black powder coatings from Morton International, Inc. were se-

Figure 6—Comparison of coating hardness tests.

lected for testing: Covel® 10-7311 (a semi-gloss epoxy), Covel® 20-7163 (a high gloss hydroxyl terminated polyester/urethane), and Covel® 30-7008 (a low gloss carboxyl terminated polyester). The powder coatings were spray applied to 4 in. × 12 in. cold-rolled steel panels and given the appropriate cure by Morton International. The coating thickness on each panel was approximately 2 mils over the whole panel.

The three powder coated panels were shipped to Paul N. Gardner Co. A fourth panel, a red acrylic/melamine control panel from ACT Laboratories, was added. The Paul N. Gardner Co. has used this control for several years as a benchmark standard when conducting tests on new instruments. Hardness tests were conducted at 77°F (25°C) and 50% relative humidity using the new, advanced/automatic Gardner/Sward hardness rocker. ASTM Test Method D 2134 was used. Averages of three or more Sward hardness readings are shown in Table 3.

Hardness tests were then conducted at 77°F (25°C) and 50% relative humidity using the Paul N. Gardner modified Pfund hardness gage. The Pfund hardness measurements were made using a modification of Test Method B of ASTM Test Method D 1474. Instead of starting with a 1.0-kg load, the weight was started with a 0.5-kg load and increased up to 5.0 kg at 0.5 kg increments.

The panels were then shipped to Fischer Technology Inc. for hardness measurements using their Fischerscope H100V microhardness tester. A Vickers indenter was used for the dynamic hardness testing. The instrument was set to ultimately apply a load of 25-kg over 15 steps with one second between steps. The instrument recorded the indention depth (µm) and the computer calculated the hardness (N/mm²) at the operating temperatures, 72°F (22°C). The results of single measurements are shown in Table 3. Besides microhardness, the test method yields information

on elastic material properties such as the modulus of elasticity and relative elastic recovery following load removal.

Pencil hardness measurements in accordance with ASTM Test Method D 3363 were made on the three powder coated panels at Morton International. The results were averaged and are shown in Table 3. Pencil hardness measurements in accordance with ASTM Test Method D 3363 were made on the red control panel at the Paul N. Gardner Co.

Discussion and Results

The averaged Sward hardness results using the automatic Gardner/Sward hardness rocker are summarized in Table 3. The Sward hardness values, while consistent, are higher than values obtained using other Sward rocker hardness instruments as the radii of the new instrument is more precise and has less dampening qualities.[14] There is no apparent explanation for the significantly higher Sward value for Covel 20-7163 when the ranking is compared to the hardness values for the other coatings using other instruments.

The averaged Pfund hardness numbers (PHN) using the Paul N. Gardner modified Pfund hardness gage are summarized in Table 3. The Pfund lens penetrated no deeper than about 15% of the coating thickness to avoid any anvil effect. PHN values did not approach a constant level until coating penetration was more than about the coating thickness, a load of 3.0 kg or more. Pfund hardness value ranking closely approximated the hardness value ranking obtained using the Fischerscope H100V microhardness tester.

The 25-kg load values obtained using the Fischerscope H100V microhardness tester and the Vickers indenter are shown in Table 3. The 25-kg load is identical to the load specified in Test Method A of ASTM Test Method D 1474 which uses a Knoop indenter.

HU values were converted to approximate a Vickers Hardness Number (VHN), and the pencil hardness values were converted to numerical values using the data obtained by Walker (Table 1). Tabulated data were plotted as shown in Figure 6. There was an excellent correlation between the hardness data using the modified Pfund hardness gage and hardness data using the Fischerscope H100V microhardness tester microindention system. As this study was a feasibility study with a few coatings, additional studies are needed to explore the relationships further.

Pencil hardness values for the Covel powder coatings were determined by Morton International. Control pencil hardness value shown in Table 3 was determined by Paul N. Gardner Co. It is possible pencils from different manufacturers were used. Since Covel
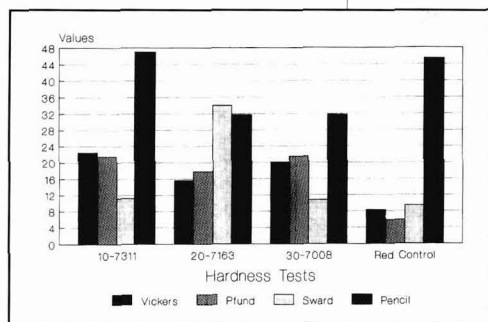
20-7163 and 30-7008 have identical pencil hardness values but different Pfund and Vickers hardness values, the value of pencil hardness values can be questioned.

Acknowledgment

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BALTIMORE—OCTOBER

"Water-Based Zinc Silicate Coatings"

The meeting featured a visit from FSCT Executive Vice President Robert F. Ziegler and FSCT President-Elect Darlene R. Brezinski, of Consolidated Research Inc.

Mr. Ziegler relayed the success of the 1994 Annual Meeting and Paint Industries' Show in New Orleans and revealed that FSCT and NPCA will meet concurrently beginning in 1996, however, it will remain two separate meetings.

Mr. Ziegler also stated that FSCT will cooperate with NPCA in its Industry Outreach Program, a public relations effort to defend the industry against adverse publicity.

President-Elect Darlene R. Brezinski addressed the current activities of the Publications and Professional Development Committees of FSCT. She also stated that the Federation will host two seminars on the Clean Air Act and VOC regulations.

The evening's technical speaker was Michael Sfirri, who spoke on "WATER-BASED ZINC SILICATE COATINGS: AN ALTERNATIVE FOR THE FUTURE."

Since environmental issues, increased worker safety awareness, and requirements for improved performance have altered coatings manufacturers approach to business, a modification in coatings must occur. Ac-

The speaker provided an alternative to these new technologies.

Mr. Sfirri urged the industry to look at the technology of water-based zinc silicate coatings, which has existed and been proven over the past 50 years. Water-based zinc silicates produce a chemically bonded coating which adheres to the substrate and can withstand environmental exposure without degrading. The speaker also noted that uncontaminated waste can be used by other industries, so the environmental impact is minimal.

There are applications of water-based zinc silicates that are 50 years old and show no signs of degradation or evidence of failure, he said. This technology may resolve some of the problems facing the coatings industry in the 90s and beyond.

CONNIE SAUER, Secretary

CDIC—NOVEMBER

"Associative Thickeners"

Ohio Paint Council Representative, Hugh Lowery, of Perry & Derrick Co., updated the membership on recent developments in national and state legislation and regulations concerning the paint industry.

AIM VOC Regulations—U.S. EPA officially ended the attempt to reach a consensus on a national regulation to control VOCs emitted by architectural and industrial maintenance paints, declaring no consensus. EPA

CDIC Society Officers for 1994-95 (from left) — Treasurer—Steven Prodromo; Society Representative—William M. Hollifield; President—Alan Machek; Vice President—John C. Avery; and Secretary—William Jelf, III.

cording to Mr. Sfirri, compliance has concentrated on the reformulation of existing generic coating types and new technology attempting to address changing regulations in the industry. Both reformulation and new technology have led to confusion and controversy regarding specification, inspection, application, and performance of coatings.

is proceeding to formulate a regulation with the initial proposal expected no earlier than mid-1995.

Meanwhile, several states are going ahead with their own AIM VOC regulations, because they assumed VOC reductions under the national rule when they filed revised implementation plans. The tardiness of the

national rule has left them with no way to meet deadlines for ozone reduction.

Lead Hazards in Existing Structures—U.S. EPA published a proposed regulation which would implement, in part, the new federal lead law which has become part of TSCA. It deals with contractors, not with homeowners. The regulation establishes the following: requirements for training and certification of individuals and firms engaged in lead abatement; recordkeeping requirements for testing of surfaces in structures for the presence of lead paint; and requirements for states which administer their own lead abatement regulations.

In Massachusetts, the legislation that apportions lead abatement costs according to market share of companies which sold lead pigment and paint may still come to a vote in the House depending on whether the Massachusetts legislature is called back from recess before the session ends in January.

Ohio's new lead law established an Advisory Committee on Environmental Lead Abatement. The potential threat to the state's paint industry lies in the question of financing of whatever expansion of the law may be recommended. The committee is to recommend a method of financing.

British Columbia Paint Recycling Legislation—Efforts are being made by environmental activists to persuade some states to imitate the new paint recycling law in British Columbia. It has made the paint industry responsible for compliance with a very short deadline, has enacted heavy fines for noncompliance, and has prohibited the sale of paint in British Columbia by companies that do not participate in the industry compliance scheme. There is controversy over whether this is in conflict with NAFTA, since it restricts access to the British Columbian market.

Environmental Crimes Legislation—Following the defeat of Lee Fisher for Ohio Attorney General, the reintroduction of his environmental crimes bill will not take place.

Paul R. Guevin Jr., of P.R. Guevin Associates, reported on the Cleveland Symposium, which has been renamed the Cleveland-Pittsburgh-CDIC Symposium. Mr. Guevin informed attendees that a theme has not been selected yet. The symposium is tentatively scheduled for May 12, 1995 in Akron, OH.

Environmental Committee Chairman Kenneth Pendleton, of K.A. Pendleton Co., Inc., reported on the Waste Environmental Exposition.

Nominating Chairman James E. Flanagan, of Flanagan Associates, Inc., announced that Treasurer Steven Prodromo,

Serving as Houston Society Officers for 1994-95 are (from left) — Society Representative—Joseph Caravello; Vice President—Edward E. Boss; President—Thomas Fitzgerald; Secretary—Guy Sullaway; and Treasurer—Ken Munoy.

of Hilton-Davis Co., is unable to complete his term of office due to a change in work responsibility. Teresa L. Case, of Fiberglass Evercoat Co., has accepted the nomination.

William Mirick, of William Mirick Inc., presented plans for the 75th anniversary celebration. The program layout was discussed, and Mr. Mirick requested help in determining the status of past presidents.

Philadelphia Society member C. Warren Vanderslice, of Aqualon Co., Wilmington, DE, delivered the evening's presentation "THE INTERACTION OF ASSOCIATIVE THICKENERS WITH SURFACTANTS IN LATEX PAINTS."

Mr. Vanderslice began by discussing cellulosic chemistry, including its vegetable source, six-membered ring, and tri-hydroxy functionality. He stated that the lack of solubility in both water and organic solvents is due to the hydrogen bonding between molecules, primarily from cotton linters. To prepare the cellulose derivatives, the cotton linters should be treated with sodium hydroxide to form alkali cellulose.

According to Mr. Vanderslice, associative thickeners have both a hydrophobic group and a hydrophilic group. These thickeners are associative because networks are formed between thickener molecules. Depending upon the structure of surfactants and dispersants used in the formulation, the addition of surfactants to coatings made with associative thickeners can either enhance or degrade the thickener performance.

The speaker stated that proper surfactants act as network crosslinkers. The concentration of an enhancing surfactant can be optimized to maximize network formation and minimize the thickener demand. Excess surfactant will disrupt the network formation and increase the thickener demand. The following are enhancing surfactants: sulfosuccinates, low hydrophilic-lipophilic-balance (HLB) nonionics, and alkylphenols.

Formulating notes for associative thickeners were outlined by Mr. Vanderslice. He said that they are adsorbing species, which partition themselves between water, latex, and resinous phases. The acid functionality of latex, surfactant, or other component can interact and affect the thickener demand. The speaker also stated that changes due to interactions are less dramatic in coatings and may occur more slowly.

WILLIAM E. JELF, III, Secretary

CHICAGO—NOVEMBER

Federation Officer Visit

The meeting featured a visit from FSCT Secretary-Treasurer Jay Austin, of Halox Pigments and FSCT staff member, Michael G. Bell, Director of Educational Services. Their presentation highlighted the FSCT's future plans and programs for membership growth and increased educational services. The theme for the 1995 Annual Meeting and Paint Show, "Creativity + Adaptability = Gateway to Success," was announced.

During the business meeting, President

Natu Patel, of Ace Hardware—Paint Division, displayed the Union Carbide Technology Award presented to the Chicago Society at the 1994 Annual Meeting for the Panorama™ MSDS on CD-ROM Retrieval System develped by the Chicago Society Technical Committee chaired by Darlene R. Brezinski.

The evening's speaker was Eric Nowicki, of Henkel Corp. Mr. Nowicki discussed the "EVALUATION OF DISPERSANT TYPES IN PIGMENT/RESIN HIGH-SOLIDS SYSTEMS."

Dispersion was carried out in glass containers with glass grinding media. Comparisons were made through grind, gloss, color, and viscosity tests. Results showed dispersant type to be very significant, especially in viscosity.

VICTOR M. WILLIS, Publicity

DETROIT—OCTOBER

"Stanostats"

The meeting began with a tour of the Eastern Michigan University Emissions Evaluation Center. Members were shown how the Emissions Center evaluates odor emitted by paints, adhesives, sealants, and other various components. Individuals were invited to participate in becoming a panelist in the Devlin olfactometer. A data review showed how panelist responses are translated into a projection of the odor potential any test material possesses.

Gus Munoz, of Magnesium Elektron, Inc., was the evening's speaker. His presentation focused on the characteristics, application, and processing of a new family of conductive fillers called "STANOSTATS." According to Mr. Munoz, stanostats are ideal for the paint and coatings manufacturer and the user of conductive paints and electrostatic primers.

The speaker discussed general and distinctive characteristics as well as how these fillers

Golden Gate Society Officers for 1994-95 (from left) — Treasurer—Eve Blackburn; Society Representative—Timothy J. Donlin; President—Donald Nolte; Vice President—Richard Cooper; and Secretary—Don Mazzone.

allow the economics of high yield, with reduced raw materials and operating cost.

JAN SPALDING, *Secretary*

GOLDEN GATE—OCTOBER

"High-Solids Technology"

Gordon Pioch, of Eureka Chemical Co., reported on the progress of the Western Coatings Societies' Symposium and Show. Mr. Pioch received 20 new potential exhibit reservations at the Society-sponsored booth during the 1994 Paint Industries' Show in New Orleans, LA. He is also seeking volunteers to staff the registration booth.

The technical presentation entitled "NEW DEVELOPMENTS IN HIGH-SOLIDS TECHNOLOGY" was delivered by Rich Johnson, of McWhorter Technologies.

Mr. Johnson noted that environmental concerns have resulted in new government regulations. To meet these regulations, while maintaining high coating performance, formulators must rely on new technologies.

Two high-solids resin technologies were developed to meet these requirements. The first is an air dry, nonaqueous dispersion that can be formulated into air dry coatings at 340 grams per liter. The second is a baking polyester that requires little or even no solvent in a coating formulation.

DON L. MAZZONE, *Secretary*

LOS ANGELES—OCTOBER

"High-Solids Technology"

A moment of silence was observed in memory of Martin Fischer.

Jan Van Zelm, of Byk-Chemie USA, acknowledged those who had won awards at the FSCT Annual Meeting and Paint Show in New Orleans, LA. Robert J Skarvan, of McWhorter Technologies, was awarded the Society Secretaries Award at the 1994 FSCT Annual Meeting.

Mr. Van Zelm also announced that the Los Angeles Society won first place in the A.F. Voss/APJ Awards for the paper "VOC Testing Comparison: EPA 24 Versus the Cal Poly Method," and that Max T. Wills, of Cal-Poly SLO, received the Society Speakers Award for his presentation of this paper. The Society received $500 that will go toward the Technical Committee's 1995 activities.

Environmental Committee Chairman Dave Muggee, of E.T. Horn, gave the environmental report.

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Martin's West, Baltimore, MD). CONNIE SAUER, Duron, Inc. 10460 Tucker St., Beltsville, MD .

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). DAVID C. MORRIS, PPG Industries (UK) Ltd., P.O. Box 359, Rotton Park St., Birmingham, B16 OADS, England.

CDIC (Second Monday—Location alternates between Cincinnati, Columbus, Dayton, and Indianapolis). WILLIAM JELF, III, Akzo Nobel Coatings, Inc., P.O. Box 147, Columbus, OH 43216-0147.

CHICAGO (First Monday—Sharko's Restaurant, Villa Park, IL). C. DAVID STROMBERG, Standard T Chemical, 290 E. Joe Orr Rd., Chicago, IL 60633.

CLEVELAND (Third Tuesday—Brown Derby, Independence, OH). RICHARD A. MIKOL, Tremco Inc., 10701 Shaker Blvd., Cleveland, OH 44104.

DALLAS (Second Thursday following first Wednesday—Radisson Hotel, Dallas, TX). CHIP NEWCOMB, 1448 N. Joe Wilson Rd., Cedar Hill, TX 75104.

DETROIT (Second Tuesday—meeting sites vary). JAN SPALDING, BASF Corp., 26701 Telegraph Rd., Southfield, MI 48086-5809.

GOLDEN GATE (Monday before third Wednesday—alternates between Francesco's in Oakland, CA, and Holiday Inn in S. San Fransisco). DON MAZZONE, Dowd & Guild, Inc., 14 Crow Canyon Ct., #200, San Ramon, CA 94583.

HOUSTON (Second Wednesday—Medallion Hotel, Houston, TX). GUY SULLAWAY, Courtaulds Coatings, P.O. Box 4806, Houston, TX 77210.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). RANDALL L. EHMER, Walsh & Associates, Inc., 500 Railroad Ave., N. Kansas City, MO 64116.

LOS ANGELES (Second Wednesday—Steven's Steakhouse, Commerce, CA). JOSEPH B. EVANS, Trail Chemical Corp., 9904 Gidley St., El Monte, CA 91731.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). DAN FORTNEY, American Dispersions Inc., P.O. Box 11505, Louisville, KY 40211.

MEXICO (Every fifteen days—Gabriel Mancera, Mexico City, Mexico). SERGIO ROJAS, Pinturas International, S.A. De C.V., Ganaderos 234, Col. Granjas Esmeralda, 09810 Mexico, D.F., Mexico.

MONTREAL (First Wednesday—Le Bifthèque Steakhouse, St. Laurent, Quebec). LUC MILLETTE, Frank E. Dempsey & Sons Ltd., 2379-46nd Ave., Lachine, Que., H8T 3C9, Canada.

NEW ENGLAND (Third Thursday—Sheraton Lexington Hotel, Lexington, MA). GENE C. ANDERSON, Chemcentral Corp., 38 Spindlewick Dr., Nashua, NH 03062.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). JOHN W. DU, Hüls America, Inc., P.O. Box 365, Piscataway, NJ 08854.

NORTHWESTERN (Tuesday following frist Monday—Jax Cafe, Minneapolis, MN). JOSEPH J. MILLS, Milsolv® Corp./Minnesota, 2340 Rose Pl., Roseville, MN 55113.

PACIFIC NORTHWEST (PORTLAND SECTION—Tuesday before third Wednesday—Tony Roma's, Mall 205, Portland, OR; SEATTLE SECTION—Third Wednesday—Wyndham Garden Hotel, Sea-Tac, WA; VANCOUVER SECTION—Thursday after third Wednesday—Abercorn Inn, Richmond, B.C.). EDWARD LINTON, Cloverdale Paint Co., 6950 King George Hwy., Surrey, B.C., V3W 4Z1, Canada.

PHILADELPHIA (Second Thursday—Williamson's Restaurant, GSB Bldg., Bala Cynwyd, PA). THOMAS G. BROWN, Consultants Consortium, 209 Fox Ln., Wallingford, PA 19086.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). ROY MODJEWSKI, Akzo Nobel Coatings, Inc., 1431 Progress St., High Point, NC 27261.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). JAMES REDISKE, Miles Inc., Mobay Rd., Pittsburg, PA 15205.

ROCKY MOUNTAIN (Monday following first Wednesday—Zangs Brewery, Denver, CO). CHARLES SHROEDER, Fel-Pro Inc., 6120 E. 58th Ave., Commerce City, CO 80022.

ST. LOUIS (Third Tuesday—The Salad Bowl Restaurant, St. Louis, MO). MICHAEL P. HEFFERON, Walsh & Associates, Inc., 1801 S. Hanley Rd., St. Louis, MO 63144.

SOUTHERN (GULF COAST SECTION—third Thursday; CENTRAL FLORIDA SECTION—third Thursday after first Monday; ATLANTA SECTION—third Thursday; MEMPHIS SECTION—bi-monthly on second Tuesday; and MIAMI SECTION—Tuesday prior to Central Florida Section). WALTER R. NAUGHTON, JR., Scott Paint Corp., 7839 Fruitland Rd., Sarasota, FL 34240.

TORONTO (Second Monday—Meeting sites vary). NATALIE JANOWSKY, Degussa Canada Ltd., 4261 Mainway Dr., Burlington, Ont., L7R 3Y8, Canada.

WESTERN NEW YORK —MARKO MARKOFF, 182 Farmingdale Rd., Cheektowaga, NY 14225.
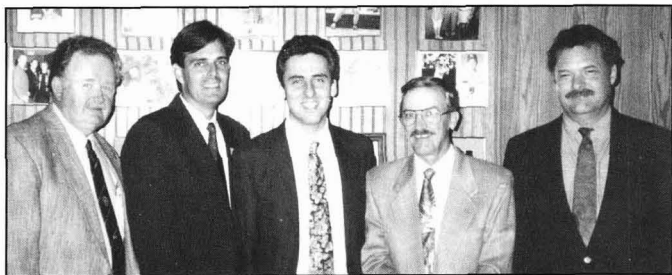
Kansas City Society Officers for 1994-95 are (from left) — Vice President—Lawrence J. Murphy; Secretary—Randall L. Ehmer; President—William T. Porter; Treasurer—Curry D. Sanders; and Society Representative—Mark D. Algaier.

Serving as Louisville Society Officers for 1994-95 are (from left) — Secretary—Daniel R. Fortney; Society Representative—Larry F. Pitchford; Vice President—William Leightner; President—Mike Moilanen; and Treasurer—Andres Traister.

Mexico Society Officers for 1994-95 include — Seated from left: Alicia Olasconga, Society Representative—Martha Colin; Raquel Cortez, and Ana M. Elizalde. Standing: Publicity—Mariano Saucedo; Treasurer—Mauricio Misdrahi; President—Jorge Hijuelos, Jr.; Vice President—Marcelo Herrera; and Program—Gustavo Vera.

Mr. Muggee mentioned that EPA has proposed that acetone releases would no longer be reportable on the TRI. EPA is also proposing to exclude acetone as a VOC from the U.S. Clean Air Act.

In addition, he reported that the National Toxicology Program's Seventh Annual Report on Carcinogens lists fiberglass, new substances ceramic fibers, glycidol, hexachloroethane, tetranitromethane, and vinyl cyclohexane as chemicals reasonably anticipated to cause cancer. Radon is listed as a known carcinogen.

Mr. Muggee stated that EPA has proposed electronic cleaning HCFC 225 and precision cleaning HCFC 225 as acceptable replacements for chlorofluorocarbons.

In conclusion, Mr. Muggee noted that EPA has given advance notice of proposed rulemaking on certain significant new uses (SNU) of lead, such as the following: (1) lead in water system; (2) household lead dust; (3) lead containing objects that could be mouthed by children; (4) lead that can be released to the environment by weathering (sheet lead, lead caulk, traffic paint); and (5) nonresident lead releases to the environment (combustion of lead motor fuel additives, lead sinker, lead shot) is subject to SNUR.

Scholarship Committee Chairman Johnny A. Gordon, of Pacific Technical Consultants, introduced the following members of the Scholarship Committee: Denese R. Crick, of Specialty Finishes Co.; Sandra L. Dickinson, of Synergistic Performance Corp.; Jim C. Harmon, of H. M. Royal of California, Inc.; Joseph King, of Pacific Coast Chemicals Co.; and Gary W. Van Otten, of Lipscomb Chemicals.

The meeting's guest speaker was Mehrdad Emami, of McWhorter Technologies, Inc., who spoke on "NEW DEVELOPMENTS IN HIGH-SOLIDS TECHNOLOGY."

According to Mr. Emami, environmental concerns have resulted in governmental regulations. In order to meet these regulations while maintaining coatings performance, the formulator must turn to new technologies. The speaker then offered an air-dry, non-aqueous dispersion that can be formulated into air-dry coatings at 340 gm/l and baking polyesters that require little or no solvents in coating formulations to meet these requirements.

A high-solids acrylic alkyd (non-aqueous dispersion) which is 75% solids and has a U-X viscosity cut in MIAK and MPK was developed. A white coating enamel with methyl isoamyl ketone (MIAK) was formulated for the high-solids acrylic alkyd, but 340 or less gm/l VOC using exempt solvents was not achieved. A black enamel was then made with cobalt, zirconium, and active-8 as the drying system. MPK was substituted for MIAK. The 340 gm/l VOC and 20 seconds in a #4 Zahn cup was achieved. The
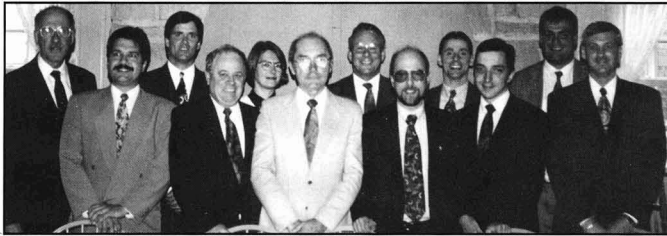
Montreal Society Officers for 1994-95 are (from left) — Horace Philipp; Sylvain Belisle; Vice President—Alain Charbonneau; Robert Benoit; Society Representative—Suzanne Richardson; Membership—Gilles Bélisle; Jean Brunet; President—Jason G. Hart; Ralph Weberbauer; Secretary—Luc Millette; Michael Montagano; and Treasurer—Luc Pépin.

drying properties were similar to the white acrylic enamel.

The next step involved formulating a red aerosol base from the high-solids acrylic resin and placing it in a can. The dryer level and combination for the red aerosol base was the same as in the black and white high-solids acrylic enamels. The solvent system for the aerosol base involved MIAK and butyl cellosolve was added to prevent popping. VOC compliance was attained.

Using this high-solids acrylic modified alkyd, a two-component urethane was formulated. The high-solids alkyd has hydroxyl functionality and will react with isocyanate. This object was applied with a high volume low pressure gun and yielded a viscosity of 22 seconds in a #4 Zahn cup. The film properties consisted of three hours dry time, 2B to HB pencil hardness with direct impact of 80 inch pound.

Research done on the second high-solids resin entailed a 100% nonvolatile polyester with a polyol that breaks up heating. By using the ASTM method, a lower theoretical VOC was achieved. After 10 minutes at 350°F, differences were noted. A new product that retains solids at bake temperature was formed.

In conclusion, Mr. Emami summarized the characteristics and expected results of formulations featuring high-solids polyols. He also described the formulation process for high performance products.

JOSEPH B. EVANS, Secretary

LOUISVILLE—OCTOBER

"Industrial Cleaning"

Technical Commitee Chairman Ilona Nemeth, of Red Spot Paint and Varnish, discussed the "Spectrum of Coatings Science" Spring Symposium. Ms. Nemeth is recruiting speakers and exhibitors.

John Lanning, of Courtaulds Coatings, and Past-President of FSCT, informed the

members on the happenings at the Annual Meeting and Paint Show in New Orleans, LA. In addition, Mr. Lanning thanked everyone for their support while he was President.

Rob Luerson, of CB Mills Co., was the speaker for the evening. Mr. Luerson discussed "INDUSTRIAL CLEANING."

Mr. Luerson began by stating that tank cleaning used to be done by either dedicating a tank or hosing down the tank. Thanks to new developments, there are many methods available now, such as the following: (1) mechanical agitation-brushing type; (2)

Serving as New England Society Officers for 1994-95 are (from left) — Vice President—Charles Shannen; President—Joanne Monique; Treasurer—Michael Iannuzzi; and Secretary—Gene Anderson.

spray nozzle type; (3) portable cleaning units that are brought to the tank; (4) closed loop type of system; and (5) vapor recovery system.

The speaker stated that some of the most frequent cleaning types are CFCs, aqueous and semi aqueous spray jets, and hydrocarbons and chlorinated solvents.

Mr. Luerson concluded with areas that should be addressed prior to purchasing a

cleaning system: have the manufacturer test your cleaning needs; installation; maintenance; safety; regulations; effectiveness of the equipment; and price.

DAN FORTNEY, Secretary

LOUISVILLE—NOVEMBER

"Polyurethanes"

Ilona Nemeth, of Red Spot Paint and Varnish updated the members on the upcoming Spring Symposium "Spectrum of Coatings Science." Ms. Nemeth mentioned that almost all of the speakers are confirmed for the April 19, 1995 symposium.

Educational Chairman Paul Baukema, of Akzo Nobel Coatings Inc., stated that the LSCT Executive Committee has requested the maximum of $400 from the FSCT Educational Grant Fund. This amount, combined with the $800 the LSCT will contribute, will total $1200 in grant money for the recipient.

The technical speaker of the evening was Valentino J. Tramontano, of King Industries Inc. Dr. Tramontano discussed "POLYURETHANES BY NONISOCYANATE ROUTES AND DERIVED POLYURETHANE DISPERSIONS."

According to Dr. Tramontano, polyurethanes have been used in the coatings industry for approximately 35 years. However, concern on the safe use of isocyanates is prompting investigations into alternative nonisocyante processes to polyurethane coatings.

The speaker stated that waterborne polyurethanes are used in many coatings applications because of their mechanical properties. The crosslinking of a hydroxyl/carboxyl functional low molecular weight polyurethane dispersion prepared by a nonisocy-anate process with melamine-formaldehyde resins was explored. Crosslinked films were analyzed for typical mechanical properties, such as impact resistance and hardness development.

Dr. Tramontano said that stress-strain studies and solvent swelling experiments were used to characterize network formation, determine crosslink density, and the amount of elastic network chains in the crosslinked polymers.

New York Officers for 1994-95 are (from left) — Treasurer—Robert W. Schroeder; Vice President—Cary Grobstein; President—George M. Amrich, Jr.; Secretary—John W. Du; and Society Representative—Michael Frantz.

In conclusion, the speaker stated that surface analysis by FTIR ATR indicates the presence of higher melamine levels at the surface of the cured high molecular weight PUR dispersion, thereby, providing further evidence for the presence of a second phase of self-conducted melamine-formaldehyde resin.

Q. Are you finding adequate bonding of the new system versus the common type, primarily with intercoat adhesion?

A. Yes, we are finding good results with acid functionality which provides for aggressive bonding in the system.

DAN FORTNEY, *Secretary*

NEW YORK—SEPTEMBER

"Acetylenic Glycols"

The Society Officers for 1994-95 were announced as follows: President—George M. Amrich Jr., of Benjamin Moore & Co.; Vice President—Cary Grobstein, of LBL Sales; Secretary—John W. Du, of Hüls America Inc.; Treasurer—Robert W. Schroeder, of Daniel Products Co.; and Society Representative—Michael C. Frantz, of Daniel Products Co.

Mike Granito, substituting for Fred Holtxman, presented George Amrich with the Hüls gavel.

Mr. Amrich presented the Past-President's Pin to Mr. Armand Stolte, of Rheox, Inc.

Irwin Young, of Jesse S. Young Co., Inc. presented President Amrich with a copy of *Robert's Rules of Order.*

Sam Morell, of SP Morell Co., delivered the evening's presentation "THE ROLE OF ACETYLENIC GLYCOLS IN WATER-BASED COATINGS."

Through the use of computer screen slides and demonstrations, Mr. Morell described the chemistry and benefits of acetylenic glycols, a class of unique nonionic surface active agents. The benefits of acetylenic glycols include foam control, low dynamic surface tensions, and lower water sensitivity. They also provide excellent coverage over wet substrates, and improved color development when used in the grind stage of pigment dispersion. According to Mr. Morell, comparisons were also made to a nonylphenol ethoxylate and a sodium octyl sulphosuccinate.

In conclusion, demonstrations of the defoaming and pigment wetting benefits of the acetylenic glycols were carried out with the help of a volunteer from the audience.

Q. What is the inhalation hazard of acetylenic glycols?
A. These materials have FDA approval.
JOHN W. DU, *Secretary*

NEW ENGLAND—OCTOBER

Joint Meeting with NECA

The evening's program began with Jim Sell, of NPCA, updating members on current happenings in governmental regulations.

The 1990 Federal Clean Air Act has completely overhauled programs of most interest to the coatings industry. According to Mr. Sell, the Act controls Hazardous Air Pollutants (HAPS) and establishes a program to regulate VOC emissions.

In addition, a new facility operating permit program has been implemented and the area of ozone noncompliance has expanded to include the entire Northeastern Corridor. The speaker also stated that the federal government is concentrating on establishing new regulations for architectural and industrial maintenance coatings, while Reg-Neg has been terminated.

Mr. Sell also informed the attendees on NPCA's latest activities. A Steering Committee has been formed to deal with EPA during the establishment of national regulations scheduled for the summer of 1995. A model rule has been developed, but has not been introduced to the states.

Finally, EPA is about to introduce new regulations for wood furniture coatings.

The evening's next speaker was Vance Starker, of NECA. Mr. Starker provided an overview of Massachusetts State Regulations.

House Bill 3976—Market Share Liability: this bill goes after Labor and Liability Costs involved with cleaning up lead paint. Massachusetts Paint Council has a list of representatives in all areas to contact to voice concerns.

The final speaker of the evening was Frank Pagliula from OSHA. Mr. Pagliula stated OSHA's charter is to monitor all companies to insure each employer is furnishing a hazard-free workplace.

Mr. Pagliula then outlined OSHA's inspection priorities and procedures. To insure worker safety, OSHA's inspection priorities include: imminent danger, fatality/catastrophe notification, complaints, referrals, high hazard, and special emphasis on asbestos removal and lead in construction.

Next, Mr. Pagliula stated that OSHA's inspections are unannounced to the company and the inspection begins with a conference with both management and labor. Once the opening conference is completed, a walk-through tour of the complaint area is conducted. OSHA also takes samples from the work area and conducts interviews with employees. Photos and videos are also taken. At the inspection's conclusion, analysis is done and recommendations are made. If the

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Errata

The Mexico Society Officers appeared incorrectly in the October 1994 issue of the JCT (see page 14). The correct names are as follows:

President—Jorge Hijuelos, Jr., Hi Fil Pinturas, S.A. de C.V.
Vice President—Marcelo Herrera, Du Pont, S.A. de C.V.
Secretary—Alvaro Camarena, BASF Pinturas, S.A. de C.V.
Treasurer—Mauricio Misdrahi, Pinturas Contimex, S.A. de C.V.
Society Representative—Martha Colin, Colin y Lozano, S. de R.L.

We are sorry for any confusion this error may have caused—Ed.

inspector sees other health hazards not on the complaint, the inspector must report it.

Despite the citations, some companies elect to take the fines instead of correcting the problems. As a deterrent, Congress has just increased the amount of each fine. OSHA bases the fine on several conditions: (1) the size of the company; (2) is the company a "good faith" company; (3) the severity of the offense; (4) the frequency of the offenses; and (5) is the company a repeat or first-time offender.

In conclusion, Mr. Pagliula noted that if a company receives a citation, they have the right to contest it; however, the company should have a strong case for defense.

Q. Is the coatings industry now on the high hazard list.
A. Yes.

<div align="right">GENE C. ANDERSON, Secretary</div>

NORTHWESTERN— NOVEMBER

"Non-Pigmentary Inorganic Materials"

The members were informed that Harold Christhilf, of The Valspar Corp., has resigned his position of Vice-President due to a job transfer.

Society Representative Larry Brandenburger, of Valspar, reported that Joseph P. Walton was elected as FSCT President.

Mr. Brandenburger also noted that FSCT headquarters is purchasing a new computer system and software.

Environmental Committee Chairman, Mark Uglem, of Hirshfield's Paint Mfg. Inc., updated members on the State Affairs Committee Meeting, where concern regarding the Canadian Paint Stewardship legislation, which calls for the collection of post-consumer paint, was voiced.

Mr. Uglem also noted that NPCA has joined the A.L.S.C., which is lobbying congress for uniform lead paint legislation.

Ed Ferlauto, of The Valspar Corp., reported that the Northwestern Society paper "A Study of the Effect of Acid Rain on Alkyd, Polyester, and Silicone Modified High-Solids Coating" took third place in the A.F. Voss/APJ Awards competition at the 1994 FSCT Annual Meeting.

The first speaker of the evening, Clemens Aderhold, of Sachtleben Chemie, presented "DO WE NEED NON-PIGMENTARY INORGANIC MATERIALS IN OUR PAINTS?"

Dr. Aderhold began by discussing the benefits of blanc fixe (barium sulfate) in solid dispersants—pigments, fillers, and extenders.

According to the speaker, there are three factors which influence the use of blanc fixe in a coating: They are:

(1) The surface area/particle size of the blanc fixe;

(2) The use of blanc fixe as opposed to titanium dioxide can result in thousands of dollars in savings in a particular formulation; and

(3) Blanc fixe will have a bodying effect on the coating, thus reducing sag.

Blanc fixe also provides economic advantages in the formulation. Dr. Aderhold noted that it improves the hiding of titanium dioxide by having an observed spacer effect which aid in the distribution of titanium dioxide. Also, less titanium dioxide is needed in the formula to obtain the same hiding.

The second speaker of the meeting was Maureen Jensen, of the Minnesota Department of Transportation. She discussed "CURRENT TRAFFIC MANAGEMENT SYSTEMS AND THE FUTURE."

<div align="right">JOSEPH J. MILLS, Secretary</div>

BALTIMORE

Active

Gandhi, Chan I.—Dynasurf Corp., Baltimore, MD.

Associate

Miller, Michael D.—Chusei (USA), Inc., Frederick, MD.
Patterson, Thomas R.—Hilton-Davis Co., Clarksburg, NJ.
Pupa, Michelle R.—Kemira Pigments, Bel Air, MD.
Steward, Scott E.—Brush Masters, Owings Mills, MD.

BIRMINGHAM

Active

Knight, Graeme M.—Weilburger UK Ltd., Runcorn, Cheshire.
Knowles, Christopher D.—Skylow Coatings Ltd., Smethwick, W. Midlands.
Roberts, Bryn D.—Kemira Coatings, W. Bromwich, W. Midlands.

Associate

Knowles, Richard I.—Silberline Ltd., Leven Fife, Scotland.
Rich, Deborah M.—TH Goldschmidt Ltd., Kingston, Milton Keynes, Buckinghamshire.

CDIC

Active

Carter, Randy A.—The Sherwin-Williams Co., Columbus, OH.
Everhart, Rebecca A.—PPG Industries, Delaware, OH.
Hoock, Barry R.—Ashland Chemical Co., Columbus.
Krempasky, Louis J.—The Sherwin-Williams Co., Columbus.
Renner, Stephen A.—Ashland Chemical, Columbus.
Wang, Jin-Liang—Great Lakes Chemical Corp., West Lafayette, IN.

CHICAGO

Active

Franke, David R.—Tru-Test Manufacturing, Cary, IL.
Gallagher, Kathleen H.—Tru-Test Manufacturing, Cary.
Johnson, Anita L.—Color Corp., Rockford, IL.
McCarthy, Monica D.—Finishes Unlimited Inc., Sugar Grove, IL.
Smelyansky, Pyotr—Finishes Unlimited Inc., Sugar Grove.
Trzupek, Karmen M.—Union Carbide, Alsip, IL.

Associate

Cole, John A.—Halox Pigments, Hammond, IN.

Cornille, Chris K.—Cabot Corp., Bartlett, IL.
Druffner, Ann M.—ANGUS Chemical Co., Buffalo Grove, IL.
Leppla, Lesley A.—Chemcentral, Bedford Park, IL.

CLEVELAND

Active

Khatib, Karim—PPG Industries, Inc., Cleveland, OH.
Mackulin, Peter J.—Lilly Industries, Inc., Westlake, OH.

Associate

McEwen, Terry D.—Wacker Silicones, Cranberry Township, PA.

DETROIT

Active

Church, Douglas A.—Seibert Oxidermo, Romulus, OH.
Heldt, Betty J.—Morton Powder Coatings, Rochester Hills, MI.
Henchel, Jeffrey A.—BASF Corp., Detroit, MI.
Kelbel, John M.—Guardsman Products, Grand Rapids, MI.
Patterson, David L.—Betco Corp., Toledo, OH.
Qureshi, Aslam N.—Maple Roll Leaf, Windsor, Ont.

Associate

Ash, Frank M.—Ebonex Corp., Melvindale, MI.
Chidley, Roland H.—The Chidley and Peto Co., Arlington Heights, IL.
Toenniges, Shelly M.—Ebonex Corp., Melvindale.

KANSAS CITY

Active

Bogle, John A.—Rich Paint Manufacturing, Inc., S. Hutchinson, KS.
Kytasaari, John F.—Tnemec Company Inc., Kansas City, MO.
Teachout, Larry R.—Pratt & Lambert, Wichita, KS.
Womack, Doug R.—American Concepts, Lawrence, KS.

Associate

Fletcher, Wilma J.—Kerr McGee Chemical Corp., Lees Summit, MO.
Smith, Jerry L.—Rheox Inc., Chanmahon, IL.
Todd, Michael W.—Abner Hood, Riverside, MO.

MONTREAL

Active

Lavallee, Simon—Epoxy Tech, Montreal, Que.

NEW YORK

Active

Alda, Alan—Hüls America, Inc., Piscataway, NJ.
Anderson, Lea L.—Akzo Nobel Chemicals, Dobbs Ferry, NY.
Jencik, John—Tenax Finishing Products, Newark, NJ.
Lamy, Alfred A.—Tego Chemie Service, Chestnut Ridge, NY.
Lateef, Ahkeer A.—Troy Chemical Corp., Newark.
Robinson, David P.—American Safety Tech, Roseland, NJ.

Associate

Telford, Valerie—Dynepco Inc., Henryville, PA.

Retired

Friedman, Charles—Westfield, NJ.

NORTHWESTERN

Active

Brown, Orville E.—Diamond Vogel Paints, Orange City, IA.
Homme, Dean A.—McWhorter Technologies, Inc., Minneapolis, MN.
Lundahl, Stephen L.—The Valspar Corp., Minneapolis.

Associate

Lighthart, Lane S.—Luzenac America, Galena, IL.
Matera, Michael—Hüls America, Inc., Chicago, IL.
Wrobel, Elizabeth A.—SC Johnson Polymers, Chicago.

PIEDMONT

Active

Avramidis, Kostas S.—Union Carbide Corp., Cary, NC.
DeFusco, Andrew J.—Union Carbide Corp., Cary.
Giles, Fred Jr.—Union Carbide Corp., Cary.
Kaminski, Victor V.—Union Carbide Corp., Cary.
Olesen, Keith R.—Union Carbide Corp., Cary.
Prior, Rocky A.—Union Carbide Corp., Cary.
Vandezande, Gerald A.—Union Carbide Corp., Cary.

Associate

Deutscher, Andy K.—Lomas International, Pineville, NC.
Hoover, Charles E. Sr.—Hoover Color Corp., Hiwassee, VA.
Kendall, William M.—ChemSolv Inc., Charlotte, NC.
Mann, Deena—Southeast Pigments and Resins, Tucker, GA.
Marchand, Melanie A.—Air Products and Chemicals, Philadelphia, PA.

PITTSBURGH

Active

Carberry, Marybeth—The Valspar Corp., Pittsburgh, PA.
Gross, Robert S.—PPG Industries, Inc., Springdale, PA.
Klepser, Robert J.—PPG Industries, Inc., Springdale.
Longhini, Debra M.—PPG Industries, Inc., Springdale.

McGuire, Kathleen A.—PPG Industries, Inc., Springdale.

Mlatnik, Timothy S.—Washington Penn Co., Washington, PA.

Puglisi, Samuel E.—Atomized Materials, Cecil, PA.

Rice, David E.—Degussa Corp., Cleveland, OH.

Rich Larry, J.—Seal-Master Manufacturing, Hillsville, PA.

Rich, Mariellen—Seal-Master Manufacturing, Hillsville.

Robey, Adrienne D.—The Valspar Corp., Pittsburgh.

Szalkowski, Norm—Neville Chemical, Pittsburgh.

Von Deuton, Klaus—Miles Inc., New Martinsville, WV.

Warfel, David R.—Washington Penn Co., Washington, PA.

Associate

Lipsitz, Mel S.—Harvey Lipsitz Co., Pittsburgh, PA.

McEwen, Terry—Wacker Silicones, Cranberry Township, PA.

Scheeser, Gary F.—Neville Chemical, Pittsburgh.

ROCKY MOUNTAIN

Active

Kubica, Gary L.—Dunn Edwards Corp., Tempe, AZ.

Messmer, David J.—Messmer's Inc., W. Jordon, UT.

Pomp, Paul R.—Bravura Corp., Chandler, AZ.

Tafoya, Chris—Kwal Howells Inc., Denver, CO.

Wright, Winfield S.—Preferred Coatings Inc., Phoenix, AZ.

Associate

Dammann, Max C.—Ashland Chemical Corp., Tempe, AZ.

Hertz, Sanford L.—Luzenac America, Englewood, CO.

Moore, Jarry V.—Ribelin Sales, Inc., Tempe.

Von Thaden, John—Arizona Oxides Inc., Phoenix, AZ.

Wilson, Kenneth D.—Arizona Oxides Inc., Phoenix.

ST. LOUIS

Active

Avery, Mike R.—Marsh Co., Belleville, IL.

Barnes, Nile R.—Marsh Co., Belleville.

Koeltz, Ted E.—U.S. Paint Corp., St. Louis, MO.

Lewis, Randall D.—Marsh Co., Belleville.

Schatz,David M.—Marsh Co., Belleville.

Snow, Damon L.—Carboline, St. Louis.

Sokolowski, Sam—Brod-Dugan, St. Louis.

Zucca, Dawn R.—Marsh Co., Belleville.

Associate

Cwik, James E.—Rheox, Inc., Schaumburg, IL.

Dwyer, Andrew J.—American Paint Journal Co., St. Louis, MO.

Fuller, Gregory C.—Dow Corning Corp., St. Charles, MO.

Jones, Thomas J.—I.T. Bauman Co., St. Louis,.

Reitter, Charles A.—IDS Financial Service, Crestwood, MO.

Smith, Jerry L.—Rheox, Inc., Channahon, IL.

Wallenberg, Scott A.—Wacker Silicones Corp., Wheaton, IL.

CDIC

(Mar. 13)—Manufacturing Program.

(Apr. 10)—CDIC 75th Anniversary.

(May 8)—"EVALUATION OF NEW GENERATION COALESCING AGENTS FOR INDUSTRIAL ACRYLIC LATEXES"—Thomas M. Larson, Exxon Chemical Co.

Chicago

(Feb. 6)—"DESIGNING FOR QUALITY"—Laura J. Hansen, Orr & Boss.

(Mar. 6)—"SOLVING PRACTICAL ADHESION PROBLEMS IN COATINGS WITH FUNDAMENTAL STUDIES IN SURFACE AND BULK EFFECTS OF ADHESION"—Krishan C. Sehgal, Union Carbide Chemical & Plastics Co., Inc.

(Apr. 4)—"NEW TECHNOLOGY IN SMALL MEDIA MILLING"—Harry Way, Netzsch, Inc.

(May 12)—Annual Awards Banquet.

Cleveland

(Feb. 21)—"FOAM & FOAM CONTROL AGENTS"—Andrew Romano, Drew Division/Ashland Chemical.

(Mar. 21)—"USING KAOLIN PIGMENTS TO REPLACE CRYSTALLINE SILICA"—Thad T. Broome, J.M. Huber Corp.

(Apr. 11)—Manufacturing Symposium.

(Apr. 18)—Annual Meeting. "UNIQUE WETTING & DISPERSING ADDITIVES"—Edward Orr, BYK-Chemie.

(May 4-5)—Educational Symposium.

(May 16)—Awards/Past-Presidents'/Spouses' Night.

Golden Gate

(Mar. 13)—"USE OF SMECTITE CLAY MINERALS IN WATERBORNE COATINGS"—Dwayne Siptak and Bob Briell, Southern Clay Products.

(Apr. 17)—"EASILY DISPERSIBLE, LOW OIL ABSORPTION, OPACIFYING ORGANIC PIGMENTS ENCAPSULATING TITANATED LITHOPONE"—Michael Issel, Sino American Pigments.

(May 15)—"HIGH-SPEED DISPERSION TECHNIQUES"—Rocky Courtain, Morehouse Industries, Inc.

(June 19)—Manufacturing Committee Seminar.

Los Angeles

(Feb. 20-22)—Western Coatings Societies' Symposium and Show, San Francisco, CA.

(Mar. 8)—Past Presidents' Night. "USE OF SMECTITE CLAY MINERALS IN WATERBORNE COATINGS"—Dwayne Siptak and Bob Briell, Southern Clay Products.

(Apr. 12)—Bosses' Night. "EASILY DISPERSIBLE, LOW OIL ABSORPTION OPACIFYING ORGANIC PIGMENTS ENCAPSULATING TITANATED LITHOPONE"—Mike Issel, Sino American Pigments.

(May 10)—Awards Night. "HIGH-SPEED DISPERSION TECHNIQUES"—Rocky Courtain, Morehouse Industries, Inc.

(June 14)—Annual Meeting.

Montreal

(Feb. 2)—Mini Symposium.

(Mar. 1)—"ACCELERATED TESTING"—Dwight Weldon, KTA-Tator.

(Apr. 5)—"RHEOLOGY MODIFIERS"—Bob Briell, Southern Clay Products.

(May 3)—"EPOXY TECHNOLOGY"—Elizabeth Wrobel, Air Products/Pacific Anchor.

New England

(Feb. 16)—"THE EFFECT OF ASSOCIATIVE THICKENERS ON THE PROPERTIES OF WATER-BASED COATINGS"—David Bryant, Rheox.

(Mar. 16)—Past-Presidents' Night. "NEW LATEX TECHNOLOGY FOR SEMI-TRANSPARENT STAINS"—Arthur Leman, Rohm and Haas Co.

(Apr. 20)—Joint Meeting with New England Paint and Coatings Association. "NEW COALESCING SOLVENTS FOR WATERBORNE COATINGS"—Peter Doty, Dow Chemical Co.; and "COATINGS IN FORENSICS"—James Corby, FBI.

(May 25)—"NEW CHEMISTRIES IN DEFOAMERS AND WETTING AGENTS"—Fred Lewchik, BYK-Chemie.

New York

(Feb. 9)—Joint Legislative Update with New York Paint and Coatings Association.

Pacific Northwest (Puget Sound Section)

(Mar. 15)—"USE OF SMECTITE CLAY MINERALS IN WATERBORNE COATINGS"—Dwayne Siptak and Bob Briell, Southern Clay Products.

(Apr. 19)—"EASILY DISPERSIBLE, LOW OIL ABSORPTION OPACIFYING ORGANIC PIGMENTS ENCAPSULATING TITANATED LITHOPONE"—Mike Issel, Sino American Pigments.

(May 4-6)—48th Annual Spring Symposium, Portland, OR.

(May 17)—Joint Meeting with Puget Sound Paint and Coatings Association. "HIGH-SPEED DISPERSION TECHNIQUES UPDATE"—Rocky Courtain, Morehouse Industries, Inc.

Piedmont

(Jan. 18)—"REACTIVE DILUENTS"—Tom Johnson, ANGUS Chemical Co.

(Feb. 15)—"ADDITIVES FOR COATINGS"—Chuck D'Amico, Ultra Additives Corp.

Pittsburgh

(Feb. 13)—"NATURAL VS ARTIFICIAL WEATHERING AND THE EQUIPMENT AVAILABLE"—Atlas Electric Corp.

(Apr. 10)—Joint Meeting with SSPC, PDCA, NACE, and PSCT.

(May 8)—"COLOR TRENDS FOR THE COMING YEAR"—PPG Industries, Inc. Past-Presidents' and Spouses' Night.

Toronto

(Feb. 13)—"POWDER COATINGS—YESTERDAY, TODAY, AND TOMORROW"—David Barlow, The Valspar Corp.

(Mar. 6)—"RADIATION CURING TECHNOLOGY FOR THE 90S AND BEYOND"—Robert A. Lie Berman, Henkel Corp.

(Apr. 10)—Technical Symposium.

(May 8)—"Non-Toxic Anticorrosive Pigments in Aqueous Media"—Robert E. Snyder, A.R. Monteith (77) Ltd. (Toronto Society Technical Committee Presentation).

Marek Urban, Associate Professor of Polymers and Coatings at North Dakota State University, Fargo, ND, has been named Chairman of the Department of Polymers and Coatings. Dr. Urban joined the department in 1986.

Dr. Urban, a member of the Northwestern Society, is the author of more than 150 research publications, two patents, several book chapters, and three books. He also serves on the Editorial Board of two international journals and is the Editor-in-Chief of the book series entitled "Polymer Surfaces and Interfaces," published by the American Chemical Society.

M. Urban

Red Spot Paint and Varnish Co., Inc., Evansville, IN, has completed personnel changes within its Automotive Marketing Group, based in Plymouth, MI. **Jerry Brown**, who has been employed with Red Spot since 1981, has accepted the newly created position of Interior Marketing Manager. **Tom Hughes** has been appointed to Ford Marketing Manager. He has been with the company since 1993. **Kevin Wylie**, Red Spot's Sales Representative in Metro Detroit since 1989, has been promoted to General Motors Marketing Manager.

ARCO Chemical Co., Newtown Square, PA, has announced that the regional structure of the company has been realigned by creating an office with worldwide responsibility for all commercial activities of the company. This position, Chief Operating Officer, was conferred to **Marvin O. Schlanger**, who was also appointed Executive Vice President.

In other news, **Jack E. Oppasser**, Senior Vice President and President of ARCO Chemical Europe, has announced his plans to retire during 1995. Prior to his retirement, Mr. Oppasser will work with **Alan R. Hirsig**, President and Chief Executive Officer, and Mr. Schlanger to ensure an orderly transition.

Charlotte Stripling was named Administrative Manager for the American Filtration and Separations Society, Nashville, TN. In this position, she will coordinate all administrative activities, providing conference coordination and serving as a point of reference for inquiries on the society's projects and membership.

Dennis L. Barbee has been appointed Manager, Regulatory Affairs, of Buckman Laboratories International, Inc., Memphis, TN. Mr. Barbee will be responsible for compliance issues associated with the manufacture, sale, and use of Buckman's specialty chemicals worldwide.

Eric H. Erenrich has accepted the position of Manager, Coatings Market Development, for the Performance Additives business unit of Allied-Signal Inc., Morristown, NJ. In this capacity, he will be responsible for the development of new products, applica-

E.H. Erenrich

tions, and markets in the coatings industry for the company's performance additives product lines. Mr. Erenrich is a member of the New York Society.

Cytec Industries, West Paterson, NJ, has appointed **Gordon M. Ruhf** to Vice President, Sales and Marketing for Process Chemicals. Mr. Ruhf assumes responsibility for marketing and sales of the company's process chemicals and specialty monomers in North America and for the development of new business and process chemicals sales in Latin America and Asia/Pacific.

The company also promoted **Jeanne M. Burnell** to General Manager, Surfactants. Dr. Burnell will oversee the company's North American surfactants business, including marketing and manufacturing.

Obituaries

Carroll M. Scholle, Past-President of the Federation of Societies for Coatings Technology, died on November 30, 1994. He was 80 years old.

Mr. Scholle received the B.S. Degree in Chemical Engineering from the University of Dayton in 1936. He

C.M. Scholle

also completed one year of graduate work in Applied Physics at Loyola University in 1939.

Mr. Scholle began his career in the coatings industry in 1936 as Assistant to the Technical Director of the Jewel Paint and Varnish Co., in Chicago. He retired in 1979 from the Sherwin-Williams Co.

Having served in the U.S. Army's Chemical Warfare Corps during World War II, Mr. Scholle retired from the U.S. Army Reserves as a Lieutenant Colonel in 1964.

A 50-year member of the Federation, Mr. Scholle served as the Chicago Society President in 1963 and Federation President in 1965-66. He received the Chicago Society's Outstanding Service Award in 1963 and the Federation's Distinguished Service Award in 1967.

In addition, Mr. Scholle was a member of the Federation's Board of Directors and the National Paint and Coatings Association's Safety and OSHA Task Force Committee.

He is survived by his wife, Margaret.

Edward T. Ryan, of the Pittsburgh Society, died suddenly on September 8, 1994. Mr. Ryan was a passenger on USAir Flight 427, which crashed outside of Pittsburgh. He was 36 years old.

He was employed by PPG Industries, Inc., which he joined as a Chemist in 1980. Mr. Ryan received the B.S. Degree in Chemistry from the University of Pittsburgh in 1980 and the M.S. Degree in Polymer Chemistry from Carnegie-Mellon University in 1984.

Thomas V. Mammano, a long-time member of the Cleveland Society, died on November 19, 1994. Mr. Mammano was last employed by Seegott Corp.

He is survived by his wife, Constance; three sons; a daughter; and a grandson.

Terry Sherban, of the Harry Holland Co., passed away on July 31, 1994. He was a member of the Detroit Society.

Short Courses Scheduled for 1995 at University of Southern Mississippi

The Polymer Science Department of the University of Southern Mississippi (USM), Hattiesburg, MS, will conduct five different short courses throughout 1995.

The first course offered by USM is "INTRODUCTION TO COATINGS SCIENCE," to be held on April 24-27. This course covers the basic principles of synthesis, design, testing, and performance evaluation of solvent, waterborne, high-solids, and powder coatings. Curing techniques and methods to lower VOCs are also highlighted.

The course includes the following topics: introduction to polymer synthesis including chain-growth, step-growth, and ring-opening polymerizations; pigment types and selection; mechanism of action; and role of additives and crosslinking agents in coatings; equipment for pigment dispersion; introduction to color science and color matching; surface pretreatment processes; ASTM testing protocols for wet and dry film testing of industrial and architectural coatings; paint film defects and solutions; and demonstration and data interpretation using state-of-the-art equipment for specific testing of polymers.

"COATINGS SCIENCE FOR COATINGS TECHNICIANS" short course is scheduled for May 22-25. This program is designed to provide coatings technicians with lectures and hands-on laboratory instruction. The lectures will focus on basic principles of coatings design, synthesis, testing, and performance evaluations of industrial and trade sales coatings. The laboratory sessions highlight on the use of instrumentation, and techniques to identify, evaluate, and test coating performance. Laboratory sessions offer participants hands-on experience in evaluating and testing of coating performance of solvent, waterborne, and high-solids as per ASTM and industry standards.

Short course topics include: introduction to polymer chemistry; polymer structure-property relationships; pigment properties and selection criteria; introduction to color science and color matching; standard testing procedures for coatings evaluation; and modern instrumentation in coatings characterization. Laboratory sessions include: the discussion of ASTM and standard industrial protocols for coatings evaluation, wet paint testing of previously prepared coatings, dry film testing of previously coated panels, color matching experiments, and instrument demonstration and data interpretation.

The third course, "COATINGS SCIENCE FOR COATINGS CHEMISTS," will be held June 5-8, and emphasizes both the theory and practical aspects of the principles dictating coatings selection, design, formulation, testing, and performance evaluation. Contemporary VOC lowering technologies to develop environmentally friendly coatings are explored and include waterborne, high-solids, powder, and UV-curable coatings.

Items to be discussed include: the principles of polymer chemistry, such as step-growth, chain-growth, and ring-opening polymerizations; the design, synthesis, and selection of emulsion polymers; the mechanism of action of associative thickeners; principles of surfactant science; the introduction to rheology in polymeric materials; pigment selection for industrial/trade sales coatings; introduction to color science and color matching; solvents for the 21st century; converting organic soluble polymers to waterborne systems; and the modern methods in coatings characterization.

"COATINGS SCIENCE FOR COATINGS FORMULATORS," is the fourth course to be offered. Scheduled for June 12-15, this program covers formulation techniques, principles, and equipment for coatings manufacture, as well as performance testing of industrial and trade sales coatings. Polymer design and formulating strategies to reduce VOCs are highlighted. Coatings performance criteria of waterborne, high-solids, and traditional solvent-based coatings are emphasized.

This course features laboratory sessions designed to provide instruction in the use of instrumentation and techniques for manufacture, evaluation, and testing coatings performance. Emphasis is placed on the formulation, testing, and reformulation of solvent, waterborne, and high-solids coatings as per ASTM and industry standards.

On August 7-10, the final course being offered, "INTRODUCTION TO POWDER COATINGS" will be held. Lectures emphasize powder coatings markets, chemistry of thermo-

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Sandra Skommesa To Present Keynote Address at WCSSS

The Western Coatings Societies' Symposium and Show (WCSSS) has selected Sandra Skommesa to deliver the Keynote Address. The President of Ellis Paint Co., Los Angeles, CA, Ms. Skommesa will discuss how to make the theme of the symposium "New Opportunities—Challenges and Solutions" a reality in business and community relationships.

A biennial event sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies, the 22nd WCSSS will be held on February 20-22, 1995 at the Hilton Hotel and Towers, San Francisco, CA.

"Compliant Coatings for 2000" Theme for 1995 FOCUS Conference

Compliance is undeniably a hot topic in the coatings industry right now. With the turn of the century rapidly approaching, and further changes in regulations and standards anticipated, the questions on everyone's mind are: "How is this going to affect my company? How is this going to affect the coatings industry? What will it take to survive and compete in the future?"

There are strategies to tackling these problems, however, and some of them will be available at the Detroit Society for Coatings Technology's 20th Annual FOCUS Conference. To be held on April 4, 1995, at the Michigan State University Management Center in Troy, MI, the conference is themed "Compliant Coatings for 2000 and Beyond."

Fourteen experts on coatings technology are currently scheduled to present talks at this "all-day educational and scientific conference," according to Rosemary Brady of Akzo Coatings, Inc. and the Detroit Society. The speakers will address such issues as formulating concepts, experimental strategies, roadmaps for the information superhighway, regulatory issues, troubleshooting, and application technology.

Challenges facing the coatings industry into the next century will be addressed in a two-track format, in which concurrently running sessions will provide the attendee with a choice of topics. Last year, around 160 participants were present at the DSCT event, with a similar number expected this year.

For more information on the FOCUS Conference, please contact DSCT, P.O. Box 2454, Riverview, MI 48192.

Bridges and Steel Structures Congress Slated for Feb. 1-3

The Marriott Airport Hotel, St. Louis, MO, will be the site of the Fourth World Congress on Coating Systems for Bridges and Steel Structures.

Slated for February 1-3, 1995, the conference applies to industrial painting contractors, paint manufacturers, testing laboratories, consultants concerned with protective coatings and the environment, material and equipment suppliers, educators, and others who have an interest in protective coatings for bridges and other structures.

Discussions will focus on new developments in research, manufacturing, and application and evaluation of new coating systems and practices for bridges and steel structures.

For more information on the congress, contact Norma Fleming, UMR Continuing Education, 103 ME Annex, Rolla, MO 65401-0249.

USM Releases Schedule for 1995 Short Courses

(Continued from previous page.)

plastic and thermosetting powders, advantages and limitations of powder coatings, equipment used in the formulation, application, and curing of powders, quality control of powder coatings, and trends and new developments in powder coatings.

The laboratory sessions include demonstrations of equipment used in the manufacture, application, evaluation, and testing of powder coating performance. The lab sessions will also provide hands-on experience in applying, evaluating, and testing powder coatings as per ASTM and industry standards.

The courses will be held in the Polymers Science Research Center at USM. Dr. Shelby F. Thames, Professor of Polymer Science, will be the Course Director for all five courses.

For more information, contact Debbie Ballard or Dr. Shelby Thames, USM, Box 10037, Hattiesburg, MS 39406-0037.

"Chemistry for the Changing Times"

Mini-Symposium Sponsored by the Montreal Society for Coatings Technology

February 2, 1995

Contact: Alain Charbonneau, Miles Canada Inc., 7600 Trans-Canada Hwy., Pointe-Claire, Que., Canada H9R 1C8

SSPC Announces Upcoming Events for 1995

The Steel Structures Painting Council (SSPC), Pittsburgh, PA, will present the Eighth Annual Lead Paint Abatement and Removal Conference at the Palmer House Hilton, in Chicago, IL, on March 13-15.

SSPC has designed its 1995 conference to highlight corporate facilities. Attendees will gain practical insight on regulations for compliance—including worker safety and environmental protection—legal issues, and alternative abatement strategies.

"Supervisor/Competent Person for Deleading of Industrial Structures" will precede the conference on March 9-12. This course will serve as both a primer on industrial deleading issues and an in-depth workshop.

In other news, SSPC is inviting all prospective authors to submit an abstract or proposal for SSPC 95. Slated for November 10-16, 1995, in Dallas, TX, the major focus of this conference is on the technology and regulations affecting use of coatings for protecting industrial structures. Deadline is February 1, 1995

For more details, contact SSPC, 4516 Henry St., Ste. 301, Pittsburgh, PA 15213.

Cleveland SCT and PCA Host Manufacturing Seminar

The Cleveland Society for Coatings Technology in conjunction with the Cleveland Paint and Coatings Association will conduct "Manufacturing Principles to Survive the 90s" on April 11, 1995, at the Cleveland Hilton South.

The morning session will feature tutorials on subjects such as dispersion, filtration, tank cleaning, etc. Discussions on waste prevention, product stewardship, and safety will occur during the afternoon session.

Another feature of the seminar is the table top exhibits that will display the latest in manufacturing equipment.

For more information, contact Joseph P. Walton, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134; (412) 932-3101.

Washington Paint Group Hosts Spring Symposium

Focusing on the environment is the theme of the 35th Annual Washington Paint Technical Group Spring Symposium. The meeting is scheduled for April 18-19, 1995 at the Ramada Hotel—Tyson's Corner, Falls Church, VA.

Additional information may be obtained from Mark Padow, NPCA, 1500 Rhode Island Ave., N.W., Washington, D. C. 20005.

UMR Coatings Institute Announces Coatings Short Course Schedule

The Coatings Institute at the University of Missouri-Rolla (UMR), Rolla, MO, has released the schedule of coatings short courses for the upcoming year.

The first short course, "Basic Coatings for Sales, Marketing, and General Personnel," will be offered on both February 20-22, 1995 and July 17-19, 1995, in St. Louis, MO. This course is designed especially to aid sales, marketing, and general personnel

Corrosion/95 Slated for March 26-31 in Orlando, FL

NACE International, Houston, TX, is hosting its 50th Annual Conference and Exhibition—Corrosion/95—at the Orange County Convention Center in Orlando, FL, on March 26-31, 1995. Corrosion/95 will feature exhibits at the Materials Performance and Corrosion Show, 35 technical symposia, panel discussions, special lectures, topical discussions, a student poster session, and a plastics education program.

The Materials Performance and Corrosion Show is just one event scheduled during this busy week of activities. Slated for March 27-30, this show is expected to feature more than 300 companies showing a range of corrosion control products and services.

Complementing the show is the technical symposia and panel discussions, which feature Alan V. Levy, a retired researcher from Lawrence Berkeley Laboratory, Berkeley, CA, as the plenary lecturer. Mr. Levy will discuss how erosion-corrosion occurs on metal, ceramics, and coatings.

For additional information on Corrosion/95, contact NACE International, P.O. Box 218340, Houston, TX 77218.

SCAA Conference and Exhibition Slated for July

The 1995 Conference and Exhibition of the Surface Coatings Association Australia (SCAA), Melbourne, Australia, is scheduled for July 20-22, 1995 at the Southern Cross Hotel, in Melbourne, Australia.

The theme of the event is "A Focus on Quality, Technology, and Safety." The exhibition is designed to give suppliers the opportunity to promote products and services to a technical and commercial audience. Over 30 exhibit booths have already been reserved.

For additional information on the SCAA's 1995 Conference and Exhibition, contact Kahren Giles, The Meeting Planners, 108 Church St. Hawthorn, Victoria 3122.

in the coatings industry to have a better understanding of the composition of coatings. Course subjects include composition of coatings, relationships between composition and performance characteristics, customer's specifications and testing techniques as related to formulation criteria, and business aspects of coatings.

"Basic Composition of Coatings" is designed to introduce the newcomer, as well as those involved in raw material manufacture, sales and service, to the technical aspects of paint manufacture, testing, and use. Topics to be discussed include the history of paint, materials used in manufacture, simple formulating techniques that can be put to immediate use, introduction to the equipment used to make and test modern protective coatings, modern chemical instrumentation as applied to coatings, and simple cost accounting that allows beginners to start on a stable economic basis. This course will be held at the UMR campus on March 20-24 and September 11-15.

The third course provided by the UMR Coatings Institute is "Paint Formulation." This intensive five-day course will take the attendee through the basic steps of paint formulation, from understanding the process to an actual laboratory formulation. Through study and work in a laboratory, the participant will learn to formulate paints to meet specific requirements. This course provides an opportunity to study and experiment with basic raw materials and their influences on the performance of the finished coating, formulation and testing of coatings in the laboratory to meet the special demands of the job, limitations of plant production equipment and formulation variables for moving from the lab to the plant, and modern chemical instrumentation as applied to coatings. This course will be presented at the UMR Rolla campus on April 24-28, May 15-19, and September 25-29.

The course fee for "Basic Coatings for Sales, Marketing, and General Personnel is $745. The cost for "Basic Composition of Coatings" is $845 and the fee for "Paint Formulation" is $945. The fee includes classroom materials and instruction, coffee breaks and refreshments, and get-acquainted dinner.

For more information on these courses, contact Cynthia N. Campbell, UMR Coatings Institute, 236 Schrenk Hall, Rolla, MO 65401.

Institute of Materials Science Releases Schedule for 1995 Spring/Summer Events

The Sixth Annual three-day course "Introduction to Polymer Colloids/Emulsion Polymers" will be held on March 6-8, 1995, at the Grosvenor Resorts, Orlando, FL. Conducted by the Institute of Materials Science, the course will emphasize waterborne synthetic latexes because they can be used in nonpolluting paints, adhesives, printing inks, floor polishes and other applications.

The Institute of Materials Science has announced domestic and international programs for the upcoming year. The list of programs is as follows:

"Pigment Dispersions: Science and Technology"—March 5-8, Orlando, FL;

"Fundamentals of Adhesion"—March 6-8, Orlando, FL;

"Advances in Polymer Colloids/Emulsion Polymers"—March 6-8, Orlando, FL;

"Polymer Blends and Alloys: Phase Behavior, Characterization, Morphology, and Alloying Technology"—March 8-10, Orlando, FL;

"Computer Modeling of Polymer and Solid Interfaces"—March 8-10, Orlando, FL;

"Second North American Research Conference on Stabilization and Degradation of Polymers"—March 13-15, Hilton Head, SC;

"17th Annual International Conference on Advances in the Stabilzation and Degradation of Polymers"—June 12-14, Luzern, Switzerland; and

"21st Annual International Conference on Organic Coatings Science and Technology"—July 10-14, Athens, Greece.

Contact A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561, for more information on any of these events.

ISCC Issues Call for Papers

The Inter-Society Color Council (ISCC), Reston, VA, has issued a call for papers for the ISCC Annual Meeting slated for April 23-25, 1995, in Greensboro, NC.

The contributed papers session is designed to provide a vehicle which could be used by all ISCC members to share state-of-the-art color information in oral form. Topics are open.

Contact Ron Oldchurch, 1680 N. Hwy. 101, #11, Leucadia, CA 92024, if you are interested in submitting an abstract for the contributed papers session. The deadline is February 1, 1995.

New Products

Paints/Coatings

Water-Reducible Primer

Sherwin-Williams introduces a one-component, 2.3 VOC complying acrylic latex water-reducible primer, designed for the metal finishing and business machine markets. Polane® W2 reportedly offers adhesion to a range of structural foam plastics and corrosion resistance to iron phosphated metal surfaces. This primer can be air- or force-dried and is lead and chromate free.

Circle No. 30 on Reader Service Card

Multicolor Paints

A line of water-based, multicolor paints which may be roller- or spray-applied is introduced. These paints, which are dispersed with multicolor flecks, are capable of providing the look of wallpaper, granite, stone, or other textured wallcoverings. These Surface Protection Industries International products can be applied over any color latex paint.

Circle No. 31 on Reader Service Card

Polyurethane Coatings

Chemical-resistant polyurethane coatings for the protection of concrete floors and secondary containment structures exposed to harsh materials and wear are available. Miles Inc.'s Desmolith aqueous polyalcohol emulsions and Mondur MRS aromatic polyisocyanates are featured in these elastomeric membrane paint systems, which are designed for durability and a hard surface.

Circle No. 32 on Reader Service Card

Powder Coatings

Primerless powder coatings are obtainable from Elf Atochem North America, Inc. Rilsan® ESY powders can be applied using all types of equipment, including negative polarity electrostatic and tribo-charge spray guns. Some applications include automotive interior and under-the-hood components, display racks, outdoor metal furniture, office furniture, and bicycle wheel rims.

Circle No. 33 on Reader Service Card

Non-Skid Coating

Cote-L presents Durabak, a single-part non-skid/protective coating. This coating is constructed with polyurethane and includes recycled tire crumbs as grit to prevent skidding. It reportedly binds to metal, wood, concrete, painted surfaces, epoxies, and itself for easy damage repair, and is designed to be waterproof and chemical and UV resistant.

Circle No. 34 on Reader Service Card

Baking Finishes

Shell Chemical Co. has published information on baked coatings for coatings formulators who are concerned with VOC reduction. This guide contains details on the manufacturing of epoxy resins and the chemistry of epoxy resin baking finishes cured with phenolic and amino resins. Selection of raw materials, formulation and application procedures, and handling precautions are also covered.

Circle No. 35 on Reader Service Card

Testing Equipment

Flash-Point Tester

A mini flash-point tester which performs flash-point tests automatically in a closed-cup chamber without operator intervention is available. Stirring is possible and test data can be transferred to a printer or computer. This Petrolab Corp. instrument also features the ability for entering and storing multiple testing programs and storing previous test data.

Circle No. 36 on Reader Service Card

Accelerated Weathering

The Ci3000 Xenon Weather-Ometer® for lightfastness and weathering testing of textiles, plastics, paints, coatings, inks, elastomers, building products, and other materials, is available. The controlled irradiance xenon arc light system delivers constant levels of light energy to test specimens in this Atlas Electric Devices Co. equipment, and microprocessors are designed to continuously measure and maintain specified exposure conditions for repeatability.

Circle No. 37 on Reader Service Card

Software

Color Formulation

ProPalette, a Windows®-based color formulation system designed for the plastics, inks, paint and coatings, and textile industries, has been introduced by Macbeth. This system allows for formulating colors with white to formulating without white—without switching databases. This software is also reportedly capable of matching transparent, translucent, or opaque colorants.

Circle No. 38 on Reader Service Card

Raw Materials

Toners

Two new organic products for water-based liquid flexographic and gravure printing inks are introduced by Engelhard. One of these is RX 1309, a water stable calcium 2B red toner pigment made without barium; the other, RX 1319, is a transparent blue shade toner with gloss-promoting properties for water-based ink applications.

Circle No. 39 on Reader Service Card

Titanium Dioxide

A rutile white pigment which features fast wet-in, easy dispersion, low binder demand, high whiteness, and a blue undertone is detailed by DuPont. In this pigment, a thin coating of silica encapsulates the TiO_2 particles to provide durability while particle size distribution results in high gloss.

Circle No. 40 on Reader Service Card

Aluminum Pigments

A comprehensive formulating guide for Aquasil™ inhibited aluminum pigments for aluminized aqueous coatings has been published. Included are starting point formulations and sections on ingredient selection, blending procedures, and stability testing. This reference publication is released by Silberline Manufacturing Co., Inc.

Circle No. 41 on Reader Service Card

Allyl Propoxylate

News has been released by ARCO Chemical Co. on an allyl propoxylate reportedly found to lower VOC levels in high-solids alkyd bake formulations. Guardsman Products, Inc., reported these research findings on Arcal® allyl propoxylate 1375 (AP 1375). Due to the novel nature of this proprietary technology, production is currently limited to laboratory quantities.

Circle No. 42 on Reader Service Card

Specialty Waxes

The Drew Industrial Div. of Ashland Chemical Co. has introduced a line of specialty waxes. Drewax specialty waxes are designed for such applications as waterborne coatings, paints, printing inks, lacquers/stains, and leather treatments. None of the waxes contain surfactants or emulsifiers based on alkylphenol ethoxylates.

Circle No. 43 on Reader Service Card

Aliphatic Amine

A new aliphatic amine epoxy curing agent for waterborne systems has been developed. Reported benefits of Anquamine™ 401 curing agent include low VOC, low odor, high gloss, chemical resistance, and corrosion resistance on steel or concrete substances. This agent from Air Products and Chemicals, Inc., is designed to be resistant to alkalis, certain organic solvents, water, and dilute mineral acids.

Circle No. 44 on Reader Service Card

Photoinitiators

Sartomer Co. has introduced two new photoinitiators for cationically cured resin systems. CD-1010 and CD-1011 are for use in metal, paper, wood, and plastic coatings and inks. These products are designed to offer fast cure speeds in vinyl, epoxy, ether, and other cationically cured resin systems.

Circle No. 45 on Reader Service Card

Sealants/ Caulks

Fluoroelastomer Caulks

A line of fluoroelastomer caulks/sealants formulated with a fluorine-containing synthetic rubber is introduced. Pelmor Laboratories, Inc.'s Pelseal® and Pelseal PG caulks/sealants are designed for use in harsh environments with severe temperature conditions, and are reportedly resistant to such corrosive chemicals and liquids as oil, gasoline, hydraulic fluids, hydrocarbon solvents, and sulfuric acid, as well as sunlight, UV radiation, salt spray, and fungal growth.

Circle No. 46 on Reader Service Card

Books/ Publications
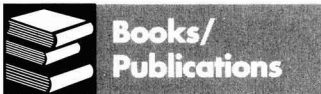
Coating Inspection

Protective coating inspection standards for field and shop applications are the topic of a new ASTM publication. This volume contains 34 standards that are commonly used by coatings inspectors, covering such areas as measurement of wet and dry film thickness, adhesion, hardness, degree of cure, film continuity, surface preparation, and cleanliness. Guidance is provided for the qualification of journeyman painters and certification of coating inspection personnel.

Circle No. 47 on Reader Service Card

Metal Media Guide

Porous metal media used in the manufacture of Pall Corp.'s filters is illustrated in a 20-page guide. Tables, color photographs, and schematics describe a variety of metallic media; criteria for selection of the most suitable metal medium for specific applications are presented. The guide, which includes seven tab-coded sections offering descriptions of different types of metallic media, also illustrates characteristics of sintered metal filler media.

Circle No. 48 on Reader Service Card

Chemical Solutions

A brochure entitled "The Man-Gill Success Formula for the Container Industry" details chemical solutions for the two-piece aluminum beverage can industry. Information is presented on controlling chemical costs, selecting appropriate products, and implementing a chemical management program.

Circle No. 49 on Reader Service Card

Glycol Ether Solvents

A newsletter entitled "News on Glycol Ether Solvents" has been printed. This Dow Chemical Co. publication is intended to provide technical information, industry news, and regulatory highlights to those who work with glycol ethers. The focus is on regulatory issues for coatings solvents in general, but particularly glycol ethers.

Circle No. 50 on Reader Service Card

Services

Pumping Applications

Watson-Marlow Inc., a manufacturer of peristaltic pumps, has released a capabilities brochure. This eight-page color brochure provides an overview of the company's product line and applications in such industries as chemical processing, laboratory, OEM, and industrial. Products for fluid metering, transfer, and dispensing are featured.

Circle No. 51 on Reader Service Card

Data Systems

A new product information system integrates facsimile and voice mail technologies to allow remote access to any document in the system. This service is operational 24 hours a day, seven days a week, and includes the ability to fax oneself information on certain products. GE Silicones' fast fax system will transmit up to seven data sheets per inquiry.

Circle No. 52 on Reader Service Card

Laboratory Apparatus

Electron Microscope

The EM 906 zoom transmission electron microscope provides continuous control in real time of kV, magnification, diffraction camera length, and image orientation. The microscope also performs user-defined, computer-controlled operation sequences. Electromagnetic image orientation in all magnification ranges is also featured in this Carl Zeiss, Inc. instrument.

Circle No. 53 on Reader Service Card

Process Viscometer

The Model 300 PIC process viscometer, an addition to the Viscoliner® series, is available. The sensor has no moving parts in order to facilitate cleanup and lessen maintenance needs. A flow-through mounting cell is included and current output for viscosity is standard in this Nametre Co. instrument.

Circle No. 54 on Reader Service Card

Capillary Rheometer

An automated high-shear capillary rheometer is introduced. The Paar HVA6 rheometer is designed to permit the use of capillaries, slits, and dies to provide rheological information under production, processing, and application conditions where high shear rates occur. Paar Physica's instrument provides determination of structural viscosity, dilatancy, thixotropy, and rheopexy under controlled temperature conditions.

Circle No. 55 on Reader Service Card

Humidity Transmitters

Vaisala's new series of humidity/dewpoint transmitters is introduced. These include the HMP 235 duct-mount unit for high-temperature industrial process applications, the HMP 234 for pressurized spaces, the HMP 233 for small areas and general-purpose duct applications, and the HMP 231 for high performance wall-mount applications. These are all capable of being customized before or after purchase.

Circle No. 56 on Reader Service Card

Electrochemistry

A seven-page, black and white brochure highlights features and applications of a line of electrochemical instrumentation. The publication describes the instrumentation recommended by EG&G Instruments/ Princeton Applied Research for research electrochemistry, corrosion measurement, voltammetry, and impedance applications.

Circle No. 57 on Reader Service Card

Vacuum Degasser

Information is available on Perkin-Elmer's Series 200 Vacuum Degasser, an on-line module for the removal of dissolved gases from HPLC solvents. The instrument's design is compatible with any reservoir size and with isocratic, binary, and quaternary pumping systems for degassing of up to four different solvents or buffers. Solvents are passed through the vacuum chamber multiple times to permit higher flow rates.

Circle No. 58 on Reader Service Card

Crystallizer

Dedert Corp.'s new mobile cooling disc crystallizer (CDC) pilot unit, which is designed for forming pure, uniform crystals from aqueous and organic solutions or melts, is announced. The Dedert/Gouda multi-stage CDC generates crystals by means of controlled cooling and residence time in each stage, promoting crystal growth and purity as opposed to new crystal production. Low-speed rotating-disc agitators maintain constant concentration and temperature.

Circle No. 59 on Reader Service Card

Spectrophotometer

A portable spectrophotometer with a 25 mm aperture is introduced. Minolta Corp.'s CM-525i offers an optional RAM card with 555 shade sort capability. This spectrophotometer, which does not require a computer, features d/8 geometry that conforms to ISO and DIN standards.

Circle No. 60 on Reader Service Card

Recirculating Mill

An ECM recirculating mill that is capable of full automation has been developed. CB Mills' Dyno-Mill features a new disc type, the Dyno-Accelerator, which creates a high-energy media cloud with a flow characteristic minimizing bypassing and wormholing in order to facilitate high flow recirculation applications.

Circle No. 61 on Reader Service Card

Used Equipment

A complete list of used laboratory and product plant equipment is available from Western Equipment. Machinery used in the coatings and ink industries, such as horizontal or vertical media mills, high speed dispersers, physical test equipment, ovens, balances, dispersators, or mixing tanks, are available. Equipment is bought, sold, and traded.

Circle No. 62 on Reader Service Card

Industrial Training

Video industrial training programs on vacuum system materials, sputter deposition and ion beam processes, and capture pumping are available. These videos, produced by the American Vacuum Society, feature renowned instructors and provide six to eight hours of instruction each. The videos present theory, demonstrations, and práctical applications.

Circle No. 63 on Reader Service Card

Powder Coating Resins Kit

Application reports and product data reviews are featured in Cytec Industries' Powderlink® powder coating resins kit. Information is provided on this resin as a powder crosslinking agent in durable wrinkle finishes and its use in lighting fixture and appliance applications. Film properties and formulation data are provided.

Circle No. 64 on Reader Service Card

FEDERATION MEETINGS

 For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292.

1995

(Mar. 21-22)—"Formulating for the New Clean Air Act." Seminar sponsored by the Professional Development Committee. Cleveland Airport Marriott, Cleveland, OH.

(May 17-21)—FSCT Spring Week. Spring Seminar on the 17th and 18th; Board of Directors Meeting on the 20th; Incoming Society Officers Meeting on the 21st. Fiesta Americana, Cancun, Mexico.

(June 20-21)—"Polymer Chemistry for the Coatings Formulator." Seminar sponsored by the Professional Development Committee, Chicago, IL.

(Oct. 9-11)—73rd Annual Meeting and 60th Paint Industries' Show. Cervantes Convention Center, St. Louis, MO.

(Nov. 6-7)—"Formulating for the New Clean Air Act." Seminar sponsored by the Professional Development Committee. Denver, CO.

1996

(Oct. 23-25)—74th Annual Meeting and 61st Paint Industries' Show. McCormick Place North, Chicago, IL.

1997

(Nov. 5-7)—75th Annual Meeting and 62nd Paint Industries' Show. Georgia World Congress Center, Atlanta, GA.

SPECIAL SOCIETY MEETINGS

1995

(Jan.10-May 16)—"A Course in Coatings Technology." Sponsored by the Chicago Society and Chicago Paint and Coatings Association. Course held every Tuesday evening at DePaul University. (Alison Azar, Seegott, Inc. (708) 468-0400; or Kevin Murray, Applied Polymer Systems, (708) 882-3194).

(Feb. 2)—"Chemistry for the Changing Times." Mini-symposium sponsored by the Montreal Society. (Alain Charbonneau, Miles Canada Inc., 7600 Trans-Canada Hwy., Pointe-Claire, Que., Canada H9R 1C8).

(Feb. 9)—Legislative Update. Meeting sponsored by the New York Society and New York Paint and Coatings Association. (Sid Rubin, Empire State Varnish Co., 38 Varick St., Brooklyn, NY 11222; (718) 388-5450).

(Feb. 20-22)—Western Coatings Societies' 22nd Biennial Symposium and Show. Sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies. Hilton Hotel and Towers, San Francisco, CA. (Gordon Pioch, WCSSS Chairman, Eureka Chemical Co., P.O. Box 2205, S. San Francisco, CA 94083; (415) 761-3536).

(Feb. 22-24)—22nd Annual Waterborne, High-Solids, and Powder Coatings Symposium. Sponsored by the Southern Society and The University of Southern Mississippi (USM). New Orleans, LA. (Robson F. Storey or Shelby Thames, Co-Organizers, WBHS&PC Symposium, Dept. of Polymer Science, USM, P.O. Box 10076, Hattiesburg, MS 39406-0076).

(Mar. 8)—"Process Safety." Chicago Society Manufacturing Seminar/Workshop. Marriott Hotel, Oak Brook, IL. (Stephen Brauer, Mozel Incorporated, 1110 Lake Cook Rd., Ste. 250, Buffalo Grove, IL 60089-1968; (708) 285-0065).

(Mar. 15)—"Clean Air & Technology." Mini-Trade Show and Symposium sponsored by the Piedmont Society. Showcase on the Park, High Point, NC. (Richard Chodnicki, Van Horn, Metz & Co., 320 Towsontown Blvd., Ste. 205, Baltimore, MD 21204).

(Mar. 29-31)—Southwestern Paint Convention. Sponsored by Houston and Dallas Societies. Airport Hyatt Regency, Dallas, TX. (Benny Puckett, Kelly-Moore Paint Co., Inc., 301 W. Hurst Blvd., Hurst, TX 76053; (817) 268-3131).

1995 FSCT SPRING WEEK TECHNICAL SEMINAR

"COATINGS IN THE AMERICAS: REGULATORY AND TECHNOLOGICAL ISSUES"

MAY 17-18, 1995

FIESTA AMERICANA CORAL BEACH CANCUN, MEXICO

(Apr. 4)—"Compliant Coatings for 2000 and Beyond." Sponsored by the Detroit Society. Michigan State University Management Center, Troy, MI. (Joe Lesnek, DSCT, P.O. Box 2454, Riverview, MI 48192; (812) 428-9200).

(Apr. 11)—"Manufacturing Principles to Survive the 90s." Seminar sponsored by the Cleveland Society and the Cleveland Paint & Coatings Association. Cleveland Hilton South, Cleveland, OH. (J.P. Walton, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134; (412) 932-3010 or fax: (412) 932-5147).

(Apr. 19)—"Spectrum of Coatings Science." Sponsored by the Louisville Society. Executive West Hotel, Louisville, KY. (Ilona Nemeth, Red Spot Paint Co., P.O. Box 418, Evansville, IN 47703-0418; (812) 428-9200).

(Apr. 19-21)—Southern Society Annual Meeting. Hyatt Regency, Savannah, GA. (Wayne West, Thompson & Formby, Inc., 10136 Magnolia Dr., Olive Branch, MS 38654).

(May 3-4)—"Recent Advances in Modifiers for Modern Coatings." Symposium sponsored by the New York Society. Holiday Inn North, Newark Airport, Newark, NJ. (Larry Waelde, Troy Chemical Corp., c/o NYSCT Office, 520 Westfield Ave., Elizabeth, NJ 07208; (908) 354-3200).

(May 4-5)—"Focus on the Future." 38th Annual Technical Symposium sponsored by the Cleveland Society. Quaker Square Hilton, Akron, OH. (Sharie Moskaluk, The Sherwin-Williams Co., 601 Canal Rd., Cleveland, OH 44113-2498; (216) 566-3661).

(May 4-6)—48th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. Red Lion Lloyd Center, Portland, OR. (Ken Wenzel, Chemical Distributors, Inc., P.O. Box 10763, Portland, OR 97210; (503) 243-1082).

OTHER ORGANIZATIONS

1995 — North America

(Jan. 22-25)—Meeting of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications. Hyatt Regency Hotel, San Antonio, TX. (ASTM, 1916 Race St., Philadelphia, PA 19103-1187).

(Feb. 1-3)—"Bridging the Environment." The Fourth World Congress on Coatings Systems for Bridges and Steel Structures. Sponsored by the University of Missouri-Rolla (UMR). St. Louis Marriott Airport Hotel, St. Louis, MO. (Michael R. Van De Mark or Norma Fleming, UMR, 119 ME Annex, Rolla, MO 65401).

(Feb. 4-6)—"Interiors Decor Showcase '95." Cosponsored by the Canadian Decorating Products Association (CDPA). Exposition Place, Automotive Bldg., Toronto, Ont. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Feb. 4-6)—18th Annual Meeting of The Adhesion Society. Crystal Sands Resort, Hilton Head, SC. (Joseph W. Holubka, Ford Motor Co., MD 3198, P.O. Box 2053, Dearborn, MI 48121).

(Feb. 20-22)—"Basic Coatings for Sales, Marketing, and General Personnel." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(Feb. 24-26)—"Spring Decor 1995." Sponsored by the National Decorating Products Association (NDPA). Georgia International Convention Center, Atlanta, GA. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Mar. 5-8)—"Pigment Dispersions: Science and Technology." Orlando, FL. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 6-8)—"Advances in Polymer Colloids/Emulsion Polymers." Orlando, FL. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 6-8)—"Fundamentals of Adhesion." Orlando, FL. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 6-8)—"Introduction to Polymer Colloids/Emulsion Polymers." Grosvenor Resorts, Orlando, FL. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 8-10)—"Computer Modeling of Polymer and Solid Interfaces." Orlando, FL. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 8-10)—"Polymer Blends and Alloys: Phase Behavior, Characterization, Morphology, and Alloying Technology." Orlando, FL. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 9-12)—"Supervisor/Competent Person for Deleading of Industrial Structures." Course sponsored by the Steel Structures Painting Council (SSPC). Palmer House, Chicago, IL. (Dee Boyle, SSPC, 4516 Henry St., Ste. 301, Pittsburgh, PA 15213-3728).

(Mar. 13-15)—Eighth Annual Lead Paint Abatement and Removal Conference. Sponsored by the Steel Structures Painting Council (SSPC). Palmer House, Chicago, IL. (Dee Boyle, SSPC, 4516 Henry St., Ste. 301, Pittsburgh, PA 15213-3728).

(Mar. 13-15)—"Second North American Research Conference on Stabilization and Degradation of Polymers." Hilton Head, SC. Sponsored by the American Chemical Society, Polymeric Materials: Science and Engineering (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 20-24)—"Basic Composition of Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(Mar. 26-31)—"Corrosion '95." Annual conference sponsored by National Association of Corrosion Engineers (NACE) International. Orange County Convention Center, Orlando, FL. (NACE International, P.O. Box 218340, Houston, TX 77218-8340).

(Apr. 2-7)—38th Annual Technical Conference sponsored by Society of Vacuum Coaters (SVC). Chicago Marriott Downtown, Chicago, IL. (SVC, 440 Live Oak Loop NE, Albuquerque, NM 87122-1407).

(Apr. 5-7)—10th Annual Conference sponsored by Architectural Spray Coaters Association (ASCA). Doral Ocean Beach Resort, Miami, FL. (ASCA, 230 W. Wells St., Ste. 311, Milwaukee, WI 53203).

(Apr. 18-19)—35th Annual Washington Paint Technical Group Spring Symposium. Ramada Hotel—Tysons Corner, Falls Church, VA. (Mark Padow, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-6272).

(Apr. 23-25)—ISCC Annual Meeting. Sponsored by Inter-Society Color Council, Greensboro, NC. (Ron Oldchurch, ISCC Poster Papers Committee, 1680 N. Hwy. 101, #11, Leucadia, CA 92024).

(Apr. 24-27)—"Introduction to Coatings Science." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(Apr. 24-28)—"Applied Rheology for Industrial Chemists." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(Apr. 24-28)—"Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(May 8-12)—"Dispersion of Pigments and Resins in Fluid Media." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(May 15-19)—"Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(May 15-20)—"Interpretation of IR and Raman Spectra: Lectures, Interpretation Workshops, and FTIR Laboratories." Course sponsored by the Fisk Infrared Institute. Vanderbilt University, Nashville, TN. (Clara D. Craver, Fisk Infrared Institute, 1000 17th Ave. North, Nashville, TN 37208-3061).

(May 22-24)—Eighth International Symposium on Polymer Analysis and Characterization (ISPAC-8). Sanibel Island, FL. (ISPAC Registration, 815 Don Gaspar, Sante Fe, NM 87501).

(May 22-25)—"Coatings Science for Coatings Technicians." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS.

(Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(May 22-26)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(June 5-8)—"Coatings Science for Coatings Chemists." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(June 5-9)—"Advances in Emulsion Polymerization and Latex Technology." Short course sponsored by Lehigh University, Bethlehem, PA. (Mohamed S. El-Aasser, Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18015).

(June 12-15)—"Coatings Science for Coatings Formulators." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(June 25-29)—"Coating Work in Nuclear Facilities." Symposium sponsored by The National Board of Registration for Nuclear Safety Related Coating Engineers and Specialists. Marriott Hotel, Philadelphia, PA. (Dean M. Berger, Executive Secretary, NBR, P.O. Box 56, Leola, PA 17540).

(July 17-19)—"Basic Coatings for Sales, Marketing, and General Personnel." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(Aug. 7-10)—"Introduction to Powder Coatings Technology." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(Sept. 11-15)—"Basic Composition of Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(Sept. 19-22)—"New Horizons '95." Conference jointly sponsored by the American Oil Chemists' Society (AOCS) and the Chemical Specialties Manufacturers' Association (CSMA). Omni Sagamore Resort, Bolton Landing, NY. (Rebecca Richardson, AOCS, P.O. Box 3489, Champaign, IL 61826-3489).

(Sept. 20-22)—"Accelerated and Natural Weathering Techniques for Coatings and Polymers." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(Sept. 25-29)—"Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(Sept. 26-29)—"Introduction to Coatings Technology." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(Sept. 29-Oct. 1)—"Fall Decor 1995." Sponsored by the National Decorating Products Association (NDPA). McCormick Place North, Chicago, IL. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Nov. 10-16)—1995 International Conference and Exhibition. Sponsored by the Steel Structures Painting Council (SSPC). Dallas, TX. (Dee Boyle, SSPC, 4516 Henry St., Ste. 301, Pittsburgh, PA 15213-3728).

Asia

(May 23-24)—First Pacific Coating Forum. Sponsored by the Japan Coating Technology Association. Shonan Kokusai Village, Kanagawa, Japan. (Secretariat, Japan Coating Technology Association, Daiichi Naka-Bldg. 4F, 3-4 Nihombashi-Kobunacho, Chuouku, Tokyo 103, Japan).

Australia

(July 20-22)—Surface Coatings Association Australia Conference and Exhibition. Southern Cross Hotel, Melbourne, Australia. (Kahren Giles, Conference Manager, SCAA Conference and Exhibition, The Meeting Planners, 108 Church St., Hawthorn, VIC 3122).

Europe

(Mar. 14-16)—"European Coatings Show '95." Congress and Exhibition. Exhibition Centre, Nuremberg, Germany. (Vincentz Verlag, Postfach 62 47, D-30062, Hannover, Germany).

(May 15-18)—"Recycle '95." Forum and Exposition. Sponsored by Maack Business Services. Swissôtel, Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(June 12-14)—"17th Annual International Conference on Advances in the Stabilization and Degradation of Polymers." Luzern, Switzerland. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(June 12-14)—"21st Annual International Conference in Organic Coatings Science and Technology." Luzern, Switzerland. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Sept. 19-21)—"Eurocoat '95." Congress-Exhibition organized by AFTPV. Eurexpo Conference Center, Lyons, France. (E. Andre, UATCM, 5 rue Etex, F-75018 Paris, France).

(Sept. 26-28)—"Surcon '95." Biennial International Conference sponsored by the Oil & Colour Chemists' Association. London, Heathrow. (Chris Pacey-Day, 967 Harrow Rd., Wembley HA0 2SF, United Kingdom).
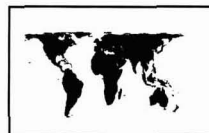
1996 — Australia

(Jan. 18-25)—International Schools and Conference on X-ray Analytical Methods—AXAA '96. Sponsored by the Australian X-ray Analytical Association (AXAA), Inc. Sydney, Australia. (The Secretariat, AXAA '96, GPO Box 128, Sydney, NSW 2001, Australia).

Sid Lauren, a dear friend and one who knows whereof he cooks, writes:

"In a reach for a new record for idiocy, some anonymous careerist in the Environmental Protection Agency has announced the discovery that what normal people consider the delicious aroma of baking bread is actually a dangerous air pollutant, consisting of unacceptably high levels of (*gasp!*) volatile organic compounds. The result is that commercial bakeries (*I'd always go out of my way to drive past one of them for the pleasure of it*) may now be required to install the same fuel burners that were forced down the throat of the coatings industry years ago. Perhaps we should be fair and admit that processing alkyds doesn't make one's mouth water as bread being baked does."

Sid goes on to say that he advised his friend, Joe Reckers, a bread baking enthusiast, that if a stranger who might look like an EPA person approaches his house, to first eat the evidence and be sure to wipe the crumbs off his chin before opening the door.

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Past Prez Colin Penny was invited to present a paper at last fall's Australian-New Zealand conference.

While passing through Sidney, he picked up a copy of *The Bulletin*, from which he sent me a copy of the "Humour" page, most of which was a bit racy or vague for Humbug. These, though, are quite appropriate:

A wealthy and unusually idealistic banker was pottering (sic) around the backyard of his mansion one day when an itinerant handyman came around and asked for a bit of casual work. Feeling sorry for the fellow, the banker produced five litres of enamel paint and a brush and told the handyman he would like him to go and paint the front porch.

An hour later the handyman was around the back again to collect his earnings. The banker commended him on the speed of his work and handed him $10. As he was leaving, the handyman remarked, "By the way, it's not a Porsche, it's a Mercedes."

Two wharflies (longshoremen) are unloading a container. One checks a consignment document, scratches his head and asks, "What's a cubic foot?" His mate frowns, then replies, "Dunno. Reckon we can claim compo (compensation) for it though."

An arrogant red rooster was giving chase to a fluttery little hen. To escape him, she scrambled to the highway and was promptly run over by a truck.

Two old maids on a nearby porch witnessed the accident. "You see," said one, with an approving nod. "She'd rather die."

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Bob Athey noticed the following "terms of venery" (see April 1994 Humbug) in the September 1994 *Chemical & Engineering News*:
A hive of allergists
A rash of dermatologists

A plague of epidemiologists
A pool of geneticists
An outbreak of infectious disease specialists
A nest of obstetricians

To which Bob adds his own:
A dispersion of pigment chemists
A floc of latex chemists
A rainbow of paint chemists

✪ ✪ ✪ ✪ ✪ ✪

I must confess that Humbug's files are in a constant mess. Today's confession is called for because I'm not sure that the following was sent to me by Bob Athey. If so, thanks Bob. If not, forget it Bob and thanks, whoever you are:

When (and if) health care reform goes into effect, you will want to know the meaning of all the technical medical terms. Here are just some "official" definitions:

Artery .... Study of paintings
Bacteria .... Back door to a cafeteria
Barium .... What doctors do when treatment fails
Bowel .... Letters like A,E,I,O,U
Caesarian Section .... A district in Rome
Cauterize .... Made eye contact with her
Colic .... A sheep dog
Congenital .... Friendly
D & C .... Where Washington is
Dilate .... To live long
Enema .... Not a friend
Fester .... Quicker
Fibula .... A smaller lie
Genital .... Not Jewish
Impotent .... Distinguished, well-known
Nitrate .... Cheaper than day rate
Pap smear .... Fatherhood test
Postoperative .... Letter carrier
Prostate .... Flat on your back
Rheumatic .... Amorous
Seizure .... Roman Emperor
Tablet .... A small table
Terminal illness .... Getting sick at the airport
Tibia .... Country in North Africa
Tumor .... More than one
Urine .... Opposite of "you're out"
Varicose .... Near by
Vein .... Conceited

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Some short bits from the *Yetter Letter*, always so kindly sent by Jeff Sturm. More later.

—You can't please everyone and you should never tell anyone your problems. Twenty percent don't care and 80% are glad you got'em.

—It's easy to identify people who can't count to 10. They're in front of you at the supermarket express lane.

—Herb Hillman, Humbug's Nest,
P.O. Box 135, Whitingham, VT 05361.

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