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JOURNAL OF
COATINGS
TECHNOLOGY

SPECIAL ISSUE

Critical Pigment Volume Concentration

- *CPVC, Critical Pigment Volume Concentration - An Overview*
- *A Critical Look at CPVC Performance and Applications Properties*
- *Measurement of Particle Packing in Dispersed Systems*
- *CPVC as Point of Phase Inversion in Latex Paints*
- *CPVC as a Transition Point in the Properties of Coatings*
- *PVC and its Effect on the Corrosion Resistance Properties of Organic Paint Films*

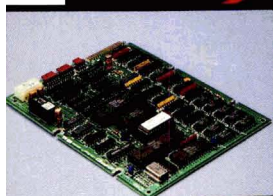


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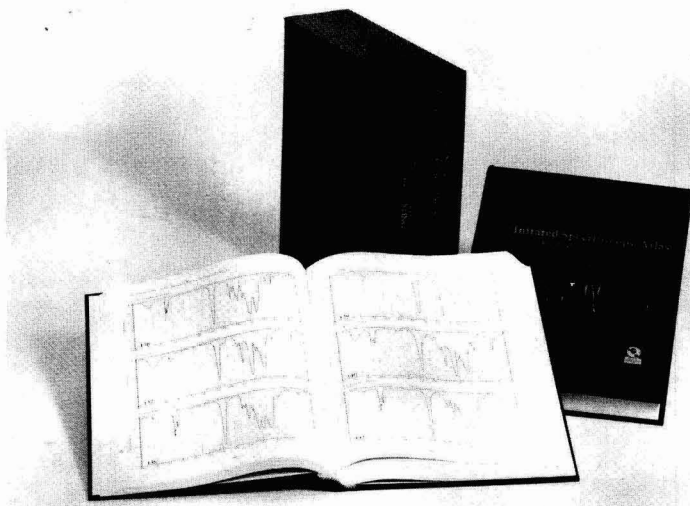
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Comment

CPVC—A Focal Point

CPVC—Critical Pigment Volume Concentration is featured in the papers collected in this issue. They were presented in 1990 at the American Chemical Society's Polymeric Materials Science and Engineering Division Symposium which then honored Dr. Walter K. Asbeck with its prestigious Roy Tess Award. These papers may inspire further researches on this concept which is so central to sound formulations of superior coatings.

Quotations of the Biblical Ten Commandments from Mount Sinai are commonly repeated by contemporary preachers of those dictums. In like manner, we have recurring citations in newer publications of the classic "Asbeck, W.K. and Van Loo, M., 'Critical Pigment Volume Relationships,' *Ind. Eng. Chem.*, 41, 1470 (1949)." A summation of repetitive citations of this 1949 publication would challenge a computer-apt documentalist.

Interim and newer publications around the CPVC focus include, among legions:

—1954: Dr. J.S. Long's Mattiello Memorial Lecture on "Creative Imagination," where "Shorty" distinguished the CPVC concept from the single pigment, PPF, pigment packing factor.

—1967 et seq: Fred Stieg, Jr., in his Mattiello Memorial Lecture and subsequent publications circled about the interplay in the CPVC focus of those two dominant paint components—titanium dioxide and latex film formers. Many other and like authors are cited in this issue's papers.

—1988: The Chicago Society for Coatings Technology presented at the FSCT Annual Meeting "A Review of Methods of CPVC Determination."

—1990: The SVLFC—Working Group II (Analysis and Test Methods) published the "Determination of the CPVC by Measuring the Internal Stress in Paint Films" *Farbe und Lack*, 96, No. 10, 769 (1990). M.V. Kannen et al., published "Effect of Ageing of Alkyd TiO₂ Paints on Adhesion to Mild Steel: Role of PVC," *JOCCA*, 3, 108-114 (1990).

—1990: The Cleveland Society for Coatings Technology's prize winning Annual Meeting paper, "Changes in Hiding During Latex Film Formation: Part II. Particle Size and Pigment Packing Effects," *JOURNAL OF COATINGS TECHNOLOGY*, 63, No. 802, 35-46 (1991); and "Changes in Hiding During Latex Film Formation: Part III. Effect of Coalescent Level and Latex Properties," *JOURNAL OF COATINGS TECHNOLOGY*, 64, No. 804, 79-86 (1992), both circling about the CPVC focus.

—1991: The Cleveland Society again won prizes for Annual Meeting papers: "Changes in Hiding During Latex Film Formation: IV. Effect of Film Thickness and Toning," and "Clear Liquid Separation in Latex Paints Containing Cellulose/Associative Thickener Systems," again both focusing on the PVC contents.

—1992?: The CPVC beat goes on . . .


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Abstracts of Papers in This Issue

CPVC, CRITICAL PIGMENT VOLUME CONCENTRATION—AN OVERVIEW—J.C. Weaver

Journal of Coatings Technology, 64, No. 806, 45 (March 1992)

Critical Pigment Volume Concentration (CPVC) as a theoretical, as well as a practical, concept was evolved into a formal statement in 1949 by Asbeck and Van Loo, following evolution of physical chemistry as a formal branch of science a half-century earlier. Prior to 1920, Coleman studied oil absorption as a specific measure of pigment surfaces. This work has been followed by a dozen or more pigment-binder properties which exhibit inflection points at the CPVC.

A CRITICAL LOOK AT CPVC PERFORMANCE AND APPLICATIONS PROPERTIES—W.K. Asbeck

Journal of Coatings Technology, 64, No. 806, 47 (March 1992)

Critical Pigment Volume Concentration (CPVC) influences the behavior of coatings systems directly or indirectly. Performance, coating applications, production, and storage characteristics are all affected. Although the principles of the CPVC concepts are identical for solution- and dispersion (latex)-type coatings, the details of their causes are not the same. Thus, the CPVC of solution coatings can respond strongly to the degree of dispersion or agglomeration of the pigment particles as a result of the vehicle which may be used. Agglomerated particles will have lower CPVC than systems of well dispersed particles of the same pigment. With latex coatings, the quantity, size, and size distribution of the latex particles, as well as the type and quantity of the coalescing agents used, can result in different values of the CPVC for the same pigment system.

The application properties of coatings are also strongly influenced by relative CPVC. For solution-type coatings, flow and sag can be controlled by lowering of the CPVC from the Ultimate Pigment Volume Concentration (UPVC) due to slight agglomeration of the pigment particles. In contrast, for dispersion-type coatings, the pigment system must virtually always be formulated at the UPVC and flow is controlled by the use of thickeners. The reasons for this behavior are explained.

MEASUREMENT OF PARTICLE PACKING IN DISPERSED SYSTEMS—K.L. Hoy and R.H. Peterson

Journal of Coatings Technology, 64, No. 806, 59 (March 1992)

The exact manner in which small particles are arranged in dispersion is as important to the performance and application properties of liquid coating compositions as the PVC is to the performance of a paint film. Historically, it is assumed that uniform particles approximate hexagonal close pack in most dispersions and there is some evidence to support this view.

Experimental evidence obtained and presented in this work, however, indicates that most probable array is dense random packing as described by Bernal. The effect that boundary condition can have on localized packing is discussed.

CPVC AS POINT OF PHASE INVERSION IN LATEX PAINTS—F.L. Floyd and R.M. Holsworth

Journal of Coatings Technology, 64, No. 806, 65 (March 1992)

In 1949, Asbeck and Van Loo introduced the seminal concept of critical pigment volume concentration (CPVC) as the loading beyond which insufficient polymeric binder existed to encapsulate each filler particle and fill residual interstitial voids in the packed bed. One corollary was that CPVC represented the onset of air voids in filled systems. Subsequent work showed that in latex systems, at least, air voids exist to some extent even down to zero pigment volume concentration. The present work suggests that CPVC might be better thought of as the point at which a phase inversion occurs, from a system in which polymer is the primary phase to one in which air becomes the primary phase. This alternate view explains the anomalies which occur when polymeric fillers are employed, accommodates the porosity which exists below CPVC, explains why properties change in slope at CPVC rather than going to zero or infinity, and offers a view of why different properties exhibit different apparent CPVCs.

Abstracts of Papers in This Issue *(continued)*

CRITICAL PIGMENT VOLUME CONCENTRATION (CPVC) AS A TRANSITION POINT IN THE PROPERTIES OF COATINGS—G.P. Bierwagen

Journal of Coatings Technology, 64, No. 806, 71 (March 1992)

Volume concentration effects in organic coatings are very important in the performance and physical properties of such coatings. The volume concentration or volume fraction of dispersed pigmentary solid phase in the polymeric binder of the coating is normally defined as the pigment volume concentration (PVC). There exists a critical PVC (CPVC) where there is just sufficient polymer matrix to wet and fill the voids between the individual particles. First clearly recognized and characterized in 1949 by Asbeck and Van Loo, the CPVC is a very important transition point in coating performance and properties. A re-examination of the CPVC is presented examining its experimental measurement and error effects in these measurements, the CPVC as a pigment-only determined property vs system effects on CPVC, and interpretation of experimental data in light of percolation theory as applied to composite materials.

PIGMENT VOLUME CONCENTRATION AND ITS EFFECT ON THE CORROSION RESISTANCE PROPERTIES OF ORGANIC PAINT FILMS—B.S. Skerry, C-T. Chen, and C.J. Ray

Journal of Coatings Technology, 64, No. 806, 77 (March 1992)

The effect of the pigment volume concentration (PVC) to critical pigment volume concentration (CPVC) ratio (i.e., Λ) on the corrosion resistance properties of paint films has been investigated by AC impedance and electrochemical noise techniques. Painted mild steel electrodes were studied during exposure to 0.6 M NaCl solution for up to 2,700 hr. Two series of alkyd paints were prepared containing either zinc chromate or barium metaborate as inhibitors. Paints were prepared from similar pigment blends (15 vol% inhibitive pigment, 19% TiO₂, 24% magnesium silicate, 27% calcium carbonate, and 15% barium sulphate) at Λ values 0.0, 0.28, 0.55, 0.83, and 1.1. The results showed that all paints prepared at $\Lambda=1.1$ deteriorated quickly. Panels painted with resin only (i.e., $\Lambda=0.0$) exhibited underfilm rusting and very poor wet adhesion. Only slight differences in corrosion resistance were observed, during the test, for zinc chromate containing paints at Λ values of 0.28, 0.55, and 0.83. In contrast, all barium metaborate containing paints progressively deteriorated. Performance levels also declined steadily in the sequence $\Lambda=0.28, 0.55, 0.83$. In conclusion, for this alkyd resin, corrosion resistance can be affected greatly by the PVC/CPVC ratio. However, the presence of zinc chromate as inhibitor allows considerable flexibility in the PVC/CPVC ratio which can be used.

JOURNAL OF COATINGS TECHNOLOGY—Special Issue Schedule

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The first official listing of the Preliminary Program of Technical Sessions is featured along with the floor plan of show exhibitors, registration forms, housing forms and hotel information, as well as general show information.

October—Paint Show Issue

This special Annual Meeting and Paint Show Issue, which is distributed at the show in addition to our regular circulation, contains Abstracts of Papers to be presented; the final Program of Technical Sessions; floor plan of show exhibitors; an alphabetical list of exhibitors and their booth number; a list of exhibitors classified by product/service categories; and general show/meeting information.

January 1993—Annual Meeting and Paint Show Wrap-up Issue

Featured is information on all exhibitors, with emphasis on exhibitor products and special booth features; photo displays of award-winning booths are presented; and a complete review of important Annual Meeting and Paint Show happenings is highlighted.

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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 repetitious 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 solicited. 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.

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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.

Recent issues of the JOURNAL should be consulted for desired style and technical level.

Metric System

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.

Graphs should be on good quality white or nonphotographic blue-lined 8 1/2 x 11 inch paper. Each graph should be drawn on a separate sheet, numbered, and the captions listed on a *copy* of the original graph. Graph captions and legends should also be typed on a separate sheet from original for typesetting.

Drawings should conform to the guidelines given for Graphs and should be proportioned to fit the height-to-width ratio of the JOURNAL'S pages and columns.

Photographs

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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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.

If special nomenclature is used, include a nomenclature table giving definitions and dimensions for all terms.

Nomenclature of chemical compounds should conform to the style of *Chemical Abstracts* and the IUPAC rules. For oligomeric or polymeric materials, characteristics such as molecular weight, polydispersity, functional group content, etc. should be provided.

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, 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.

Acknowledgment

If used, it should follow the summary.

References

These should be listed in the numerical order in which they are cited in the text, and should be placed at the end of the manuscript. Names of authors may or may not be shown in the text with reference numbers. If possible, include titles of articles referenced in the literature. The following are examples of acceptable reference citations for periodicals,^{1,2,3} books,⁴ and patents.⁵

- (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).

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Resúmenes de Artículos en este Número

CONCENTRACION CRITICA DEL PIGMENTO EN VOLUMEN (CPVC)—UNA REVISION—J.C. Weaver

Journal of Coatings Technology, 64, No. 806, 45 (March 1992)

La concentración crítica del pigmento en volumen como un concepto teórico al igual que práctico se desarrolló gradualmente como una tesis formal en 1949 por Asbeck y Van Loo, siguiendo la evolución de la fisicoquímica como una extensión formal de la ciencia en la primera mitad del siglo. A la absorción de aceite como una medida específica de las superficies de pigmento por R.E. Coleman antes de 1920, ha seguido una docena o más de propiedades pigmento-ligante que muestran puntos de inflexión de la CPVC. Introduciendo escritos contemporáneos en CPVC, la concentración crítica del pigmento en volumen nos brinda la oportunidad de orientar un nuevo trabajo con el arte y la tecnología de recubrimientos desde la época antigua, la época medieval y la moderna.

UNA VISTA CRITICA AL CPVC. COMPORTAMIENTO Y PROPIEDADES DE APLICACION—W.K. Asbeck

Journal of Coatings Technology, 64, No. 806, 47 (March 1992)

La concentración crítica del pigmento en volumen influye directa o indirectamente en el comportamiento de los sistemas de recubrimientos. Se afectan el comportamiento, la aplicación del recubrimiento, la producción y las características de almacenaje. Más aún, los principios en el concepto de CPVC son idénticos para recubrimientos en solución también como dispersiones (latex), pero los detalles de sus causas no son los mismos. De esta forma, el CPVC de recubrimientos en solución puede responder fuertemente al grado de dispersión o aglomeración de las partículas del pigmento, como un resultado del vehículo que pueda ser usado. Las partículas aglomeradas tendrán un CPVC más bajo que las partículas que se encuentran bien dispersadas del mismo pigmento. Con los recubrimientos base latex, la cantidad, tamaño y distribución del mismo en las partículas del latex, al igual que el tipo y cantidad de los agentes coalescentes usados puede resultar en diferentes valores de CPVC para el mismo sistema de pigmento.

Las propiedades de aplicación de los recubrimientos también son fuertemente afectadas por el CPVC relativo. Para recubrimientos del tipo solución, el flujo y el escurrido se pueden controlar bajando el CPVC del UPVC debido a la ligera aglomeración.

En contraste, para recubrimientos en dispersión, el sistema de pigmento debe ser virtualmente siempre formulado al UPVC y el flujo se controla mediante el uso de espesantes. Se explican las razones de este comportamiento.

MEDIDA DE LA PARTICULA DE EMPAQUE EN SISTEMAS DISPERSOS—K.L. Hoy and R.H. Peterson

Journal of Coatings Technology, 64, No. 806, 59 (March 1992)

El camino exacto en el cual las partículas pequeñas son agrupadas en una dispersión es tan importante para el comportamiento y propiedades de aplicación de las composiciones de recubrimientos líquidos, como lo es el PVC en el comportamiento de la película de pintura. Históricamente, se asume que las partículas uniformes aproximadamente hexagonales se empaquetan cercanamente en la mayoría de las dispersiones y existe algo de evidencia para reafirmar este concepto.

Se presenta evidencia experimental dentro de este trabajo, sin emargo, se indica que el agrupamiento más probable esta densamente empaquetado en forma aleatoria tal como lo describe Benal. Se discute el efecto que pueden tener las condiciones frontera en áreas de empaque localizadas.

CPVC COMO PUNTO DE INVERSION DE FASE EN PINTURAS DE LATEX—F.L. Floyd and R.M. Holsworth

Journal of Coatings Technology, 64, No. 806, 65 (March 1992)

En 1949, Asbeck y Van Loo introdujeron el concepto innovador de concentración crítica del pigmento en volumen (CPVC), como la carga donde insuficiente ligante polimérico existía para encapsular cada partícula de relleno y llenar los espacios intersticiales residuales en la cama empaquetada. Un corolario fue que el CPVC representaba, en un inicio, los espacios de aire en sistemas cargados. Subsecuentemente, el trabajo demostró que en sistemas de latex, por lo menos que los espacios de aire existen en alguna forma aunque el PVC sea de cero. El presente trabajo sugiere que la CPVC puede ser mejor descrita como el punto en donde la inversión de fase ocurre, de un sistema en donde el polímero es la fase primaria a otro donde el aire se convierte en la fase primaria. Esta visión alterna explica las anomalías que ocurren cuando se usan rellenos poliméricos, adapta la porosidad que existe por abajo del CPVC, explica porque las propiedades cambian gradualmente en el CPVC en lugar de irse al cero o al infinito y ofrece una revisión del porque diferentes propiedades exhiben diferentes CPVC aparentes.

Resúmenes de Artículos en este Número *(continued)*

LA CONCENTRACION CRITICA DEL PIGMENTO EN VOLUMEN (CPVC) COMO UN PUNTO DE TRANSICION EN LAS PROPIEDADES DE LOS RECUBRIMIENTOS—G.P. Bierwagen

Journal of Coatings Technology, 64, No. 806, 71 (March 1992)

Los efectos de la concentración en volumen en recubrimientos orgánicos son muy importantes en la calidad y las propiedades físicas de varios recubrimientos. La concentración en volumen o la fracción volumétrica de la fase sólida del pigmento dispersa en el ligante polimérico del recubrimiento, normalmente se define como la concentración del pigmento en volumen (PVC). También existe un valor crítico de PVC (CPVC) que es la cantidad suficiente de matriz polimérica justa para humectar y llenar los espacios entre las partículas individuales. En un principio, claramente reconocido y caracterizado por Asbeck y Van Loo en 1949, el CPVC es un punto de transición muy importante en la calidad y propiedades del recubrimiento. Se presenta una re-examinación del CPVC presentando mediciones experimentales y los efectos del error de las mediciones, el CPVC como pigmento sólo determinó el sistema de propiedades vs. efectos en el CPVC, y una interpretación de los datos experimentales—se sintetizan en una teoría depurada para ser aplicada a materiales formulados.

Spanish translations of abstracts were provided by Mexico Society Member, Carlos Urbina, of Instituto Mexicano de Técnicos en Pinturas y Tintas, Mexico

CONCENTRACION DEL PIGMENTO EN VOLUMEN Y SU EFECTO SOBRE LAS PROPIEDADES DE RESISTENCIA A LA CORROSION DE PELICULAS DE PINTURA ORGANICA—B.S. Skerry, C-T. Chen, and C.J. Ray

Journal of Coatings Technology, 64, No. 806, 77 (March 1992)

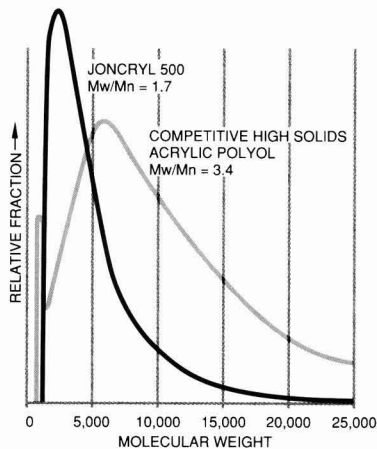
Se ha investigado el efecto de la relación de la concentración del pigmento en volumen (PVC) y la concentración crítica del pigmento en volumen (CPVC) (i.e. Λ) en las propiedades de resistencia a la corrosión de películas de pintura mediante técnicas de impedancia AC y ruido electroquímico. Se estudiaron electrodos de acero ligeramente pintados durante su exposición en una solución 0.6 M de NaCl durante 2700 horas. Se prepararon dos series de pintura alquídica conteniendo cada una cromato de zinc o metaborato de bario como inhibidores. Las pinturas se prepararon con mezclas similares de pigmento (15% volumen de pigmento inhibidor, 19% TiO_2 , 24% silicato de magnesio, 27% carbonato de calcio y 15% sulfato de bario) a valores de Λ de 0.0, 0.28, 0.55, 0.83, y 1.1. Los resultados mostraron que todas las pinturas preparadas a $\Lambda = 1.1$ se deterioraron rápidamente. Los paneles pintados sólo con resina (i.e. $= 0.0$) mostraron corrosión por abajo de la película y muy pobre adhesión en húmedo. Sólo pequeñas diferencias en la resistencia a la corrosión se observaron, durante la prueba, en las pinturas con cromato de zinc a valores de Λ de 0.28, 0.55, y 0.83. En contraste, todas las pinturas con metaborato de bario se deterioraron progresivamente. Los niveles de comportamiento también declinaron pausadamente en la secuencia -0.28, 0.55, y 0.83. En conclusión, para esta resina alquídica, la resistencia a la corrosión puede ser afectada grandemente por la relación PVC/CPVC. Sin embargo, la presencia de cromato de zinc como inhibidor permite una considerable flexibilidad en la relación PVC/CPVC por lo cuál puede ser usado.

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PACIFIC NORTHWEST PAINTMAKING

March 1992

DEFOAMERS IN THE PAINT INDUSTRY

In some industries, such as the beer industry, many scientists are spending years to create foam in their products. In the paint industry, however, foam is a bad phenomenon causing problems such as underfilling, pinholes, and poor substrate wetting.

Causes of Foam Formation

There are many causes facilitating the formation of foam in a paint system (gas in a liquid carrier). Some of the major problems include:

- (a) Poor production methods (whipping air in the system).
- (b) Application methods such as rolling versus brushing or spraying.
- (c) The elasticity of the binder can cause the foam to be stabilized. That is why varnishes should always be brushed-on rather than rolled-on.
- (d) Surfactants (soap-like substances, that are in waterborne coatings for color acceptance, etc.) causing foam.
- (e) Paint conditioners (shakers).

The terms "antifoam" (preventing foam formation) and "defoamer" (destroying foam which has previously been formed) go hand in hand.

A good defoamer for a particular system should also be a good antifoam additive. For the purpose of this writing we'll use the word defoamer.

A characteristic feature of foam is an extremely large interface between the gas (normally air) and the liquid phase—which as a lamella (bubble) separates the bubbles from each other. Physically, foam exists because of a foam stabilizing effect. Pure liquids are not able to foam. Paint, not being a pure liquid, does foam.

Defoamers fall under the category of additives. Additives in the paint industry should be compared to spices in food. A little goes a long way. In general, additives are added at a level not exceeding 1% of the total formulation weight. Here is a case where more is *not* better.

In order for a defoamer to be effective it has to be incompatible with the particular system, but not too incompatible as to create negative effects such as color acceptance problems, fisheyes, craters, and loss of gloss.

The incompatibility of the defoamer within the system causes the continued film of the foam bubble (the lamella) to break and therefore defoam the system.

Because of the incompatibility factor, defoamers are more effective when added in the dispersion phase of production. This will ensure better dispersion of the defoamer and prevent foam from forming. Thus, here the defoamer works as an antifoam. In many cases a silicone is used in the grind charge as an antifoam, and a mineral oil in the let down as a defoamer.

Stability of a defoamer, especially in trade sales paints, is very important. Some of these paints might be on the store-shelf for over a year. The nonionic surfactant in a latex paint system has a tendency to break down some defoamers, particularly the mineral oil based types. Such paints will foam badly after a certain time.

Foaming of solvent-borne coatings was not customarily a problem. In most cases, with the new high solids systems, foaming is more prevalent, and appropriate defoamers are being utilized.

In-plant storage of defoamers is in agitator tanks because some types of defoamers have a tendency to separate. With the silicone types this is not required, however, with the mineral oil types it is essential.

Aliphatic-based defoamers are not carcinogens and do not contribute to yellowing in the paint film.

—Jan P. Van Zelm,
BYK Chemie USA

THE EFFECT OF DISPERSION ON COATING QUALITY. PART I

When a paint doesn't meet specifications, the laboratory has to figure out what went wrong, and how to fix it. If the Hegman grind reading is too coarse the chemist knows that the pigments weren't properly dispersed and the paint will have to be reground. But what if the color isn't fully developed, or the paint has a bad rub-up? Or maybe the gloss is too low, or too high? Or maybe the paint settles badly, or chinks on exterior exposure, or can't pass a water resistance test? These problems are usually thought to be caused chemically through pigment-vehicle incompatibility, poor vehicle selection, or improper use of additives. But all of these problems can also be the result of improper grind—either too coarse or too fine!

The most common tool for checking grind, the Hegman grind gauge, can only show you the size of the largest particles in the dispersion or the paint. It doesn't provide any information as to average particle size or particle size distribution. It doesn't give the answers to all your problems, but it does tell you a lot if you know what to look for.

In this issue we will discuss some of the color problems you might have if the dispersion is not right. In the next issue, we will go into the other performance problems that also can be dispersion-related.

Color Development

The dispersion of any dry pigment, regardless of the type of milling equipment used, is a process to break down agglomerates and aggregates in an attempt to reduce the pigment to its ultimate particle size. It is never possible to completely disperse the small particle size organic pigments, but the closer you can come, the better your paint will be.

Let's say you have a white enamel base dispersed to a 7 N.S. grind, which is sufficient for the required gloss, and you add a predispersed quinacridone violet tinting color. When you make a draw down and rub the wet paint film with your finger the violet color rubs up much stronger and darker. What went wrong? Was the tinting color flocculated before you added it? Did it flocculate when you put it in the paint due to some pigment/vehicle or vehicle/vehicle incompatibility?

There may be a simpler explanation. Dispersions of organic pigments must come as close as possible to the ultimate particle size, about 0.04 to 0.06 microns, to eliminate rub up and achieve maximum color development. With hard to grind pigments like quinacridones, there is a real possibility that the tinting color was not adequately dispersed in the first place.

As an example, we made two dispersions of quinacridone violet in an alkyd dispersing vehicle and used the dispersions to tint white and clear tint bases and a metallic lacquer finish. One dispersion was ground to a Hegman grind of 7 N.S. and the other to a 7 ³/₄ N.S. Average particle size was determined to be 6 microns in the 7 N.S. dispersion. The 7 ³/₄ N.S. dispersion had an average particle size of 0.5 micron, which does not reach, but does approach the ultimate particle size of quinacridone pigments.

In the white enamel, the 7 N.S. dispersion rubbed up badly and was 15% weaker than the 7 ³/₄ dispersion. In a clear base, the 7 ³/₄ dispersion gave much better transparency, and a richer, cleaner color. When the dispersions were used with aluminum powder to make metallic finishes, the results were dramatic. The paint made with the 7 dispersion had a dull, bluish, washed out appearance, low gloss, and poor metallic "flip-flop" (that quality that makes the color seem to change depending on the angle at which light hits the surface). The 7 ³/₄ dispersion gave excellent results in all areas.

Hiding Power

Hiding power of inorganic pigments is also dependent on particle size, but in some cases, finer is not always better. You still want to approach the ultimate particle size range of 1 to 5 microns, but you have to be careful not to over grind and actually fracture the pigment crystals.

For example, manufacturers of synthetic iron oxide pigments have made some grades very easy to disperse to a grind of 6 N.S. or better on a high speed

(Continued on next page.)

(Continued from previous page.)

disperser. This is good enough to get tinting strength and color, but it is often not enough to get maximum hiding power.

In our laboratory we dispersed synthetic yellow iron oxides with a high speed disperser to a grind of 6 N.S., and dispersed the same pigments on a media mill to 7 1/2 N.S. The dispersions at the finer particle size showed up to 15% more hiding.

When we dispersed the pigments further in the media mill we noticed that the color got dirtier and we started to lose hiding. We were actually breaking the pigment crystals, which eventually led to severe discoloration.

Deep red shades of iron oxide show an even more dramatic effect. At a 6 N.S. you get the deep red, maroon color that the pigment is supposed to have, but if you disperse the pigment further you get a surprising change. The hiding power increases and the color, in both tints and masstone, shifts over to that of a typical medium red iron oxide. The dispersion process has cracked the individual pigment crystals and has reduced the pigment particles to the size of the next finer stage of red iron oxide production.

Conclusions

Most paint manufacturers understand that they need good dispersion to get all the available tinting strength from the organic pigments they use. Many are willing to give up 5-10% strength in order to avoid running longer grinding cycles or purchasing better equipment. What they often don't realize is that, along with the value of the pigment, they may also be sacrificing the ultimate quality of the product in terms of rub-up, transparency, clarity, and metallic brightness. Likewise, paint makers must realize that by controlling particle size of inorganic pigments, they will be able to maximize hiding power, and save production costs by developing the right color, the first time, every time.

—*Elio Cohen and Michael C. Frantz,*
Daniel Products Company

The measurement and reporting of particle size is often confusing and contradictory. For example, as Hegman value decreases, the actual size of particles in inks and coatings increases. This upside down relationship, and rightside up relationship of mils vs microns is succinctly exhibited in the Fineness of Grind Conversion Scale.

Reprinted from JOURNAL OF COATINGS TECHNOLOGY, 62, No. 789, 155 (1990).

This scale has been published at the request of one of our readers. If you would like to have something published in the *Pacific Northwest Paintmaking*, please contact Valerie M. Braund, General Paint Ltd., 950 Raymur Ave., Vancouver, B.C. V6A 3L5, Canada.

FINENESS OF GRIND CONVERSION SCALE					
Gauge Depth				U.S. Sieve	
NPIBI	P.C	Hegman	Mils	Microns (µm)	Mesh
	0	0	4.0	100	#140
	1	1	3.5	90	#170
	2	2	3.0	80	#200
	3	3	2.5	70	#230
	4	4	2.0	60	#270
	5	5	1.5	50	#325
	6	6	1.0	40	#400
	7	7	0.5	30	#550
	8	8	0	25	#635
	9	9	0	20	#800
	10	10	0	15	special screens
				10	
				5	
				0	

1 Mil	= 0.001 in	= 25.4 µm
1 Micron (µm)	= 0.001 mm	= 0.03937 mil

A "SLEEPING" GIANT

You are driving home on the interstate after a long hard day and your thoughts are on the events that took place at work and suddenly you are not exactly sure where you are. You can't remember the last few minutes or last few miles. You were daydreaming, on cruise control, or on automatic pilot when you really needed to be awake. If this has happened to you while driving, think how many times this may have happened to you and others while at work.

You've probably seen this, you see an employee who's "out to lunch" when he really needed to be awake and paying attention to the task at hand. When you find employees who exhibit this characteristic, they are usually thinking about something other than their current job assignment. This "sleeping giant" is present at some time in all of us, and we need to awaken him. I believe more accidents occur in manufacturing facilities to employees who forget where they are and what they are doing than all other reasons put together.

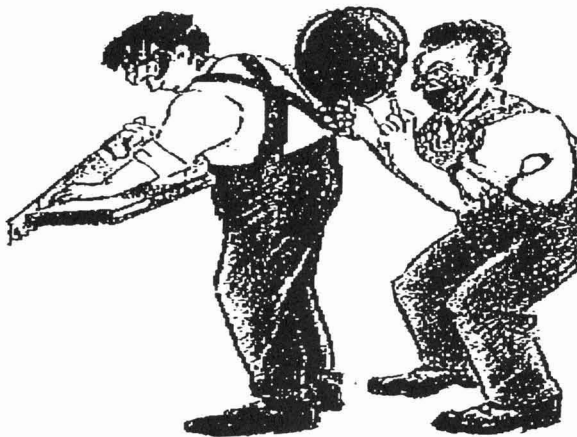
We need to emphasize to employees the need to stay alert at all times; to put it in gear; to pay attention to their movements; to pay attention to what is happening around them; and to be on the lookout for that "sleeper" who is working with them. It may take only a few moments to wake up, but it only takes a second for an accident to occur and for that sleeping giant to emerge and give us a lifetime of nightmares.

STAY AWAKE — STAY ALIVE

—Ed Bish,
Jamestown Paint & Varnish Company

.....

IT MAY NOT BE FUNNY!



REMEMBER

If you see someone fooling about in a dangerous manner get them to stop. If they won't do as you ask, report them to your supervisor—you will be doing everyone a favor, including the culprit.

It is particularly dangerous to fool about with compressed air lines which are found in many factories. Only use compressed air in the way you have been instructed.

If it is not part of your job—leave it alone.

WASTE AVOIDANCE AND DISPOSAL

The affluence of North America during the last two decades has led to what has been popularized as a "disposable society." Manufacturing efficiencies coupled with mass production have reduced the costs of common household items so that disposable commodities are now a lifestyle as well as a convenience. However, as our daily lives and savings accounts are enriched by cheap disposable commodities, the reality remains that these materials must be disposed of in some manner. North American society, through heightened civic and ecological awareness, has realized that the nation's waste problems cannot be cured by simply burying them in the ground. Indeed, acceptable waste landfill sites are diminishing yearly. Concerned consumer awareness is responsible for increased interest in effective waste management and recycling of reusable resources.

We paint manufacturers have an important role in minimizing the generation and subsequent need for treatment, storage, and disposal of hazardous waste. This concept, called "waste minimization," is essential to efficient plant operation and waste management. Minimization and recycling of inplant effluent can represent our dedication to a cleaner environment and substantially reduce the costs of treatment and disposal.

Avoidance and waste minimization must be an active cooperation between corporate management and the on-site production worker. The focus of each must represent a practical goal to avoidance and minimization.

What Can Management Do?

(1) The key to avoidance of waste is the identification of hazardous materials which make a waste stream hazardous or more hazardous. Appropriate choice of paint components in any formulation to reduce or remove hazardous ingredients can significantly reduce hazardous waste volumes and toxicity. Purchase fewer toxic raw materials and substitute nonhazardous for hazardous raw materials.

(2) Implement employee training and management analysis of production operations to identify potential areas of waste minimization. Training programs are ways to generate ideas and establish employees' commitment.

(3) Improve material receiving, storage, and handling procedures. Eliminate sources of leaks and spills.

(4) Introduction of waste handling equipment can be influential in on-site minimization of waste streams. Redesign equipment or processes to produce less waste and facilitate recovery and recycling options.

(5) Install closed-loop recycling systems.

What Can On-Site Production Workers Do?

(1) Segregate waste streams by type. Avoid contamination of one waste stream by another. By segregating key toxic ingredients and isolating hazardous from nonhazardous streams waste handling and disposal can be minimized.

(2) Avoid waste generation through spills and improper storage practices. Store drums on end rather than on their side to prevent seepage. Ensure that liquid containers are thoroughly drained, thus minimizing offsite secondary treatment and waste disposal. Eliminate sources of potential leakage or spills such as corroded drums, faulty valves, and loose pump packings.

(3) Avoid intermixing solvent washes that may prevent reuse or recycling of the mixture. Reduce solvent or water washes by manually washing batch tanks with brushes and the minimum amount of solvent. Alternately use high pressure spray systems to efficiently clean tanks. Cleaning tanks with low pressure systems is inefficient and vastly increases waste generation.

(4) Manufacturing scheduled paint batches in a logical order can often result in minimal waste generation by reuse of compatible washes in the grind of the next batch. Reuse compatible solvents and sludges, in approved formulations, quickly to prevent hard pigment settling and gelation of resinous waste.

(5) Work cleanly, a raw material properly loaded into a batch represents a valuable commodity, on the floor that material often represents a hazardous waste. Thoroughly drain all liquid drums and tote tanks and take extra care that pigment bags are completely empty when loading batches. Recycle paper

(Continued on next page.)

A Newsletter

For the Exchange

Of Ideas On Safety

And Manufacturing . . .



(Continued from previous page.)

packaging whenever acceptable recycling facilities are available. Do not store incompatible materials together. A chemical reaction between two incompatible materials may result in a serious health and safety risk as well as generating large amounts of hazardous waste for treatment or disposal.

(6) Keep chemicals tightly sealed until use and insure that packaging is resealed following use to prevent contamination or chemical reactions which may spoil a material resulting in the necessity to dispose of the commodity.

(7) Segregate halogenated and nonhalogenated solvents and solids. Halogenated wastes are costly to dispose of and may prevent waste minimization, through recycling, by their presence.

(8) Avoid defective batches. Examine the common raw materials, during use, to insure that the materials' physical characteristics are consistent with your knowledge of the product. If the material does not appear correct then CHECK IT OUT, even the best supplier can mislabel a product. Do not use materials that are not properly identified. Avoidance of errors can eliminate unnecessary hazardous waste generation.

(9) When tank scaling becomes necessary use dry cleanup procedures to minimize waste generation. Caustic washes and chemical strippers generate vast amounts of waste which require treatment and disposal.

Waste avoidance and minimization must focus on source reduction or recycling. As in any innovative waste management program, careful planning, creative problem solving, changes in attitude, and often capital investment are necessary to produce an effective response. A real commitment to the program is necessary however to reduce the volume or toxicity of the waste generated.

Waste minimization and avoidance clearly provide industry with opportunities to efficiently and effectively deal with wastes hazardous to human health and the environment. Now is the time to investigate and take practical steps toward waste minimization and avoidance, and by this action significantly reduce the disposal burden borne by industry and the waste disposal community.

—Bill Tapper,
Color Your World

The Pacific Northwest Paintmaking (PNP) is intended for the exchange of ideas on safety and manufacturing. First published and distributed independently by the Manufacturing Committee of the Pacific Northwest Society for Coatings Technology, the newsletter will be published periodically in the JCT. The editors would like your participation. Send your comments, ideas, safety or manufacturing tips, and articles to: PNP Editor, Valerie Braund, General Paint, 950 Raymur Ave., Vancouver, B.C., Canada V6A 3L5.

The PNP is made available as a service to FSCT members. Although all reasonable steps have been taken to ensure the reliability of the PNP, the FSCT cannot guarantee its completeness or accuracy.

Regulatory UPDATE

MARCH 1992

This 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. and edited by members of the FSCT Environmental Affairs Committee.

**Department of Transportation
Research and Special Programs Administration
January 31, 1992—57 FR 3854
Marine Pollutants**

Action: Notice of proposed rulemaking

The Research and Special Programs Administration (RSPA) is proposing to amend the Hazardous Materials Regulations (HMR) by listing and regulating in all modes of transportation approximately 500 chemicals that harm aquatic life.

An annex to the 1973 International Convention for the Prevention of Pollution from Ships is the source of the marine pollutant list. The annex was ratified by the United States in June 1991, and its provisions will become mandatory on July 1, 1992 under the International Maritime Organization dangerous goods code.

The proposal regulates marine pollutants in all modes of transportation because the chemicals are carried over or near bodies of water by air, rail, and highway. The targeted chemicals are those that are environmentally hazardous and do not necessarily cause acute health hazards. The proposal would mandate packaging, markings, labeling, and handling requirements during transportation.

For further information, contact John A. Gale, Office of Hazardous Materials Standards, RSPA, 400 Seventh Street, S.W., Washington, D.C. 20590, (202) 366-4488; or Lt. Cmdr. Phillip Olenik, Office of Marine Safety, Security, and Environmental Protection, U.S. Coast Guard, 2100 Second Street, S.W., Washington, D.C. 20593, (202) 267-1577.

**Environmental Protection Agency
January 16, 1992—57 FR 1984**

Protection of Stratospheric Ozone

Action: Request for data and advance notice of proposed rulemaking

The U.S. Environmental Protection Agency (EPA) has published a notice of proposed rulemaking regarding its preliminary strategy for implementing section 612 of the 1990 Clean Air Act Amendments. The announcement also includes a request to the chemical industry for voluntary information on possible substitutes for ozone-depleting substances.

Under the Clean Air Act, certain chemicals will be banned because of the harm they cause to the ozone layer. The Agency has requested information from chemical manufac-

turers on substances they plan to market as substitutes for those chemicals. The EPA will then make risk characterizations, based on the data received, to begin implementing a Safe New Alternatives Policy (SNAP).

For further information, contact Elaine Haemisegger at (202) 260-9961, or Nina Bonneycke at (202) 260-1496, Stratospheric Ozone Protection Branch, Global Change Division, Office of Atmospheric and Indoor Air Programs, Office of Air and Radiation, ANR-445, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460.

**Environmental Protection Agency
January 15, 1992—57 FR 1733**

Health and Safety Data Reporting; Guidance Availability

Action: Notice

The EPA has released a guidance document entitled "Questions and Answers: Applicability of the Toxic Substances Control Act (TSCA) Section 8 (d) Model Health and Safety Data Reporting Rule (40 CFR part 716) to Modeling Studies."

The Model Health and Safety Data Reporting Rule requires chemical manufacturers, importers, and processors to submit to EPA unpublished health and safety studies on certain chemical substances and mixtures. The purpose of the guidance document is to "clarify the applicability of the TSCA section 8 (d) Model Health and Safety Data Reporting Rule to specific modeling studies.

Copies of the document can be obtained from the Environmental Assistance Division, Office of Pollution Prevention and Toxics, U.S. EPA, 401 M Street, S.W., Room EB-545, Washington, D.C. 20460, (202) 554-1404. Faxed document requests will also be accepted at (202) 554-5603. For further information, contact David Kling, Office of Pollution Prevention and Toxics, U.S. EPA at (202) 554-1404.

**Environmental Protection Agency
January 2, 1992—57 FR 12**

Hazardous Waste Management System; Identification and Listing of Hazardous Waste

Action: Final rule

The EPA has finalized a July 1991 proposed rule reflecting the Agency's intent and consistent interpretation of a

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regulation promulgated in 1980. The regulation implements section 3001 of the Resource Conservation and Recovery Act, which sets forth a series of criteria for listing wastes as hazardous.

For further information, contact the RCRA/Superfund Hotline at (800) 424-9346. For technical information, contact William Collins, Office of Solid Waste, U.S. EPA 201 M Street, S.W., Washington, D.C. 20460, (202) 260-4791.

Resource Conservation and Recovery Act—The Chairman of the House Energy and Commerce Transportation and Hazardous Materials Subcommittee, Rep. Al Swift (D-WA), has indicated he will markup legislation to reauthorize the Resource Conservation and Recovery Act by the end of March.

Rep. Swift plans to hold subcommittee hearings March 10 and 12 on H.R. 3865, the bill he introduced in November. On March 17-19 and March 24-26, the subcommittee is scheduled to markup the bill. H.R. 3865 has been tagged as RCRA lite because it only deals with municipal solid waste issues. Several months ago, Rep. Swift indicated he would offer hazardous waste sections this spring, but to date, even draft language remains elusive.

Among the current provisions are requirements for state solid waste management plans, fees on interstate transportation of waste, and minimum content standards for recycled materials in packaging. Rep. John Dingell, Chairman of the full Energy and Commerce Committee is committed to moving RCRA legislation this year but his schedule will not be determined until after subcommittee action.

In the Senate, Max Baucus (D-MT), Chairman of the Environment and Public Works Subcommittee on Environmental Protection, may have trouble keeping his promise to report his RCRA bill, S. 976, by April 30. The subcommittee has decided to rewrite key provisions of the bill to "emphasize recovery and conservation" rather than hazardous waste regulation. The new language is expected shortly.

Last spring, Sen. Baucus promised Sen. Dan Coats (D-IN) that he would pass an RCRA bill by April 30 if Sen. Coats would hang on to his controversial amendment allowing states to ban out of state waste. Sen. Coats agreed, but has clearly indicated he will offer his amendment as separate legislation if the April 30 deadline is not met. The interstate waste issue has rapidly become a major political issue in the RCRA reauthorization, which has the potential for causing significant problems for certain Midwestern and East Coast Senators running for re-election in November.

Clean Water Act—The Environmental Protection Subcommittee also has jurisdiction over the Clean Water Act, and Chairman Max Baucus has said the Subcommittee

will begin consideration of a reauthorization bill (S. 1801) "early this spring."

Among the provisions in the bill is the continuation of a 1987-appropriated \$18 billion state revolving fund program to pay for sewer treatment facilities. The bill also contains an appropriation of \$3 billion for a new grant program to assist states in dealing with nonpoint source pollution such as urban and agricultural run-off. Two \$2.5 billion grant programs would also be established—one to be used for combined sewer overflow contamination and one to help smaller communities comply with Clean Water Act requirements.

Rep. Gerry Studds (D-MA), Chairman of the House Merchant Marines and Fisheries Subcommittee on Fisheries and Wildlife Conservation and the Environment, introduced a reauthorization bill last April, which the Subcommittee plans to hold hearings on "sometime this spring." The legislation (H.R. 2029) is almost identical to S. 1081.

The House Public Works and Transportation Committee already held hearings on the Clean Water Act reauthorization and plans to introduce its own version of a bill "sometime this spring."

Superfund—The Senate Environment and Public Works Subcommittee on Superfund, Oceans, and Water Protection plans to be very busy this year. After it considers reauthorization legislation for RCRA and the Clean Water Act, it will hold hearings on the reauthorization of Superfund, which is due for new funding in 1994. To date, hearing topics have yet to be determined.

The House Public Works and Transportation Subcommittee on Investigations and Oversight will continue to hold hearings this spring—focusing on specific Superfund sites. Last year the subcommittee heard testimony from a wide variety of witnesses on the effectiveness of the law.

The House Energy and Commerce Subcommittee on Oversight and Investigations has tentatively scheduled two Superfund hearings during 1992. The first hearing will focus on an EPA report filed last October that found contractors charged unjustified expenses in the Superfund alternative remedial contracting system. During the second hearing, the subcommittee will evaluate a report issued by the General Accounting Office (GAO) that determined that the Agency for Toxic Substances and Disease Registry's Superfund health assessments were deficient.

Also addressed at the hearing will be a report issued by the National Research Council that found the Superfund program does not adequately protect human health. The report stated that "the Superfund program has no comprehensive inventory of waste sites, no program for discovering new sites, insufficient data for determining safe exposure levels, and an inadequate system for identifying sites that require immediate action to protect public health."

States Proposed Legislation and Regulations

California

Air Quality—CA A. 2489 (Hayden) requires the California Environmental Protection Agency to prepare a list of CFCs for which substitutes are available and the earliest feasible dates by which their use may be implemented. Requires the agency to develop programs to implement earlier

phase-out dates for CFCs in applications with known, non-hazardous alternatives. Restricts the use of chemicals.

Recycling (Incentive)—CA A. 2446 (Eastin) requires the Department of General Services to give a preference to suppliers of recycled products, such as glass, oil, plastic, solvents, and paint, of up to 5% of the lowest bid or price quoted by suppliers offering no recycled products.

Florida

Recycling (Mercury)—FL S.B. 1528 (Plummer) provides for the recycling of mercury. Prohibits the release of mercury into the environment of this state and also the incineration and the disposal in a landfill of products designated by the Department of Environmental Regulation as proven to release mercury into the environment. Requires posting of warning signs relating to the dangers of mercury poisoning. Provides civil and criminal penalties.

Environmental Marketing—FL H. 1813 (Chinoy) relates to recycling; requires the Department of Environmental Regulation to adopt by rule standardized emblems for the identification of products and packages that are composed of recycled or recyclable materials or that are reusable; provides that the use of the emblems is voluntary, but subject to compliance with department standards; declares misuse a deceptive and unfair trade practice, for which there are penalties; requires development of a public information program to explain the emblems to consumers.

Hawaii

Environmental Marketing—HI S. 2217 (Levin) relates to advertising; reduces confusing environmental marketing claims in Hawaii by regulating and standardizing these claims so that consumers can make purchasing decisions with full knowledge of the environmental consequences of the products they buy; relates to environmental marketing claims; establishes an environmental labeling regulatory program and Independent Advisory Board.

Recycling—HI S. 2221 (Levin) relates to the labeling of recycled materials; adopts rules pursuant to Chapter 91 regarding the labeling of recycled materials, with the object of encouraging the recycling of solid wastes, including identification of recycled solid waste materials that may be labeled; classification of goods or products according to their recycled content; conforms to federal or state guidelines for recycled products.

Iowa

Environmental Marketing—IA S. 2048 (Jensen) relates to the labeling of products as recyclable, recycled, or degradable, and provides a penalty.

Kentucky

Air Quality (Regulation)—The State has proposed a regulation making its clean air program consistent with federal requirements and policies concerning procedures for determining captive efficiency of air pollutants, definitions of organic compounds having negligible photochemical reactivity, classification of ozone nonattainment areas, and application of both CTG and "new source performance standards" for new stationary sources in all nonattainment areas (except marginal nonattainment areas). (18 Administrative Register of Kentucky, p. 2734—February 1, 1992.)

Air Quality—KY H. 386 (Brown) relates to revisions of the state's clean air statute that would authorize the implementation of several features of the Federal Clean Air Act Amendments of 1990. One provision implements the stationary source operating permit fee program which authorizes the collection of not less than \$25.00 per ton of each regulated pollutant. As introduced, the legislation allows the fees to be used for a broad range of clean air activities, not just the administration of the operating permit program. Note—The Kentucky Paint Council is seeking an appropriate amendment to the current language.

Maine

Lead—ME H. 1584 (Office of Mitchell et al.) LD 2234 amends laws governing lead poisoning control so as to make achievable the goal of eliminating lead poisoning of children in the State; establishes the Public Health Lead Poisoning Advisory Committee and outlines the duties and responsibilities of the advisory committee in counseling the Department of Human Services in rulemaking, administrative, and enforcement functions; defines what constitutes a hazard from exposed lead.

Maryland

Packaging—MD H. 1346 (Perry et al.) prohibits, on or after July 1, 1993, a manufacturer or distributor from selling or offering for sale or for promotional purposes any package or packaging component or any product in a package or packaging component to which lead, cadmium, mercury, or hexavalent chromium has been intentionally added during manufacture or distribution; establishes maximum allowable concentration levels for those toxics that are incidentally present in packaging materials.

Lead—MD H. 1265 (Rosenberg and Thomas) establishes the Lead Paint Poisoning Prevention and Compensation Committee for the purpose of preventing lead paint poisoning; establishes the Lead Paint Prevention and Compensation Fund for purposes of funding medical rehabilitation for lead poisoning claimants. The fund will be made up of monies collected from paint retailers who will be taxed in the form of a license fee based on the volume of paint they sell.

Environmental Marketing—MD S. 273 (Garrott) prohibits a manufacturer, distributor, or retailer of retail packaging from imprinting on the package the terms "degradable," "biodegradable," "photodegradable," "environmentally safe," or any other term implying that the packaging is environmentally safe.

Packaging—MD S. 553 (Boozer et al.) requires a manufacturer of rigid plastic containers sold, offered for sale, or used in association with the sale or offer for sale of a product in the state to ensure that the container meets established requirements; specifies exemptions; requires a manufacturer of those plastic containers to submit a certification to the Department of the Environment by October 1, 1993, and on or before March 1 each year thereafter.

Massachusetts

Automotive Paint—MA S. 914 (Durand) relates to illegal use of certain automotive paint and paint by-products.

Paint Recycling—MA H. 313 (Murray) provides for a paint recycling program.

Lead—MA H. 3371 (DiMasi and Magnani) and H. 3724 (Serra) establishes a fund to assist local housing authorities and owners of private property receiving federal or state rental subsidy to remove lead-based paint.

MA H. 3906 (Palumbo and Jajuga) extends the time in which owners of residential premises may remove lead paint.

MA S. 464 (Owens et al.) clarifies governmental responsibility regarding lead paint hazards.

MA H. 1129 (McDonough et al.) prevents lead poisoning through increased lead paint abatement.

MA H. 590 (Fitzgerald) clarifies and establishes a limitation of actions involving lead-based paint; commencing on January 1, 1996, a statute of limitations of six years will be established for any court action related to the presence at any time of lead-based paint, including recovery of costs for encapsulation, containment, removal, and replacement of lead-based paint.

MA H. 2069 (Landers) improves safety and reduces the cost of lead paint abatement.

MA H. 2820 (Clancy) defines testing methods for lead paint.

Packaging—MA H. 2241 (Blute) regulates the use of certain containers.

Minnesota

Lead (Regulation)—Minnesota adopted permanent rules relating to priorities for soil lead abatement. (16 Minnesota State Register, p. 1709—January 31, 1992.)

Missouri

Packaging—MO H. 1331 (Skaggs and Dougherty) requires packaging materials to have reduced levels of toxic materials; packaging material or packaging components containing lead and other minerals will be severely restricted by reducing those minerals in the make-up of the packaging; exceptions are recycled material, those meeting federal health or safety standards, no alternatives, and lead foil purchased and used before January 1993; requires the Department of Natural Resources to review the effectiveness and report findings by January 15, 1994.

New Hampshire

Recycling (Labeling)—NH H.C.R. 21 (Bradley) urges U.S. Congress to adopt uniform recycling product labeling standards based on standards developed by the Northeast Recycling Council.

New Jersey

Packaging—NJ A. 419 creates the Packaging Reduction Act; establishes uniform standards for environmentally acceptable consumer packaging; provides that no person may sell, offer for sale, or offer for promotional purposes in this state any package or packaging material which is not environmentally acceptable; requires the Department of Environmental Protection to establish a system for labeling any package or packaging material that has been certified as environmentally acceptable; defines environmentally acceptable.

NJ S. 2261 (Contillo) requires manufacturers and distributors of packaging or packaging materials to reduce the amounts of toxic substances added to packaging or packaging materials used or sold within the state.

Lead—NJ A. 729 (Kenny) establishes presumption that lead toxicity is due to lead paint in residence. Note—The New Jersey Paint Council obtained a delay in consideration pending a March 20 meeting between the sponsor and the Paint Council.

New York

Graffiti—NY S. 1909 (Mega) prohibits conduct resulting in graffiti on any public transportation facility. Establishes a minimum sentence for violations.

Texas

Air Quality (Regulation)—An amendment has been proposed to the state's clean air new source review (NSR) program so that it will be consistent with new standards established by the Federal Clean Air Act Amendments of 1990. The proposal includes definitions of "actual emissions"

and "de minimis thresholds" which figure importantly in determining the application of NSR program requirements when a facility is constructed or undergoes a major modification. It also establishes offset ratios for reducing overall pollutant emissions that are required by the NSR program. (17 Texas Register, p. 825 and 834—January 31, 1992.)

Utah

Graffiti—UT H. 85 (Short) amends criminal code provisions to include graffiti defacement or damage under criminal mischief and criminal trespass prohibitions; provides for joint liability of minor and parent or legal guardian for minor's intentional damage, defacement, or destruction of property of another; provides exceptions to joint liability; gives court discretion to order community service or alternative restitution as a condition of probation or protective supervision in addition to damage award.

Vermont

Solid Waste (Manufacturer Take-back)—VT S. 400 (McCormack and Ready) prohibits the placement into mixed municipal solid waste, or into landfills, of antifreeze, organic solvents, fluorescent lamps, and motor oil. Proposes to require users of these products to return unused, unwanted, and waste quantities of these products to manufacturer or wholesaler designated collection points. Proposes to require that manufacturers of these products ensure that collection system is available, include the costs of collection in the sales transaction, and publicize the program.

Paint (Deposit and Return)—VT H. 825 and H. 824 (McCormack) establishes a deposit-return system for the retail of sale of paints, paint thinners, paint removers, stains, and varnishes.

Environmental Marketing—VT H. 865 (Schaefer) enacts in conjunction with other states in the northeastern region of the country, standards that would apply to certain representations made on consumer products sold at retail in the state; establishes standards for the use of the term "reusable" for the use of the term "recyclable," and the related symbol, and for the use of the term "recycled materials."

Virginia

Inhalant Abuse—VA H. 385 (Guest et al.) makes technical changes and adds to list of chemical substances it is illegal to inhale with intent to become intoxicated.

Washington

Packaging—WA H. 2678 (Rust et al.) regulates packagers regarding waste reduction and environmental labeling; establishes requirements for a packager using paper, glass or metals, or plastic resins in a package, effective December 31, 1994; requires certification that the package is in compliance with the act; establishes penalties for violation of the act and provides for deposit in the Clean Washington Account; establishes rules for environmental marketing claims.

Hazardous Painting Certification—WA S. 6300 (Oke et al.) requires the licensing of paint or coating applicators; authorizes the department to charge fees; provides for investigation of alleged or apparent violations; establishes monetary penalties for violations; creates the paint and coating applicator account.

WA H. 2400 (Heavey) relates to the education, testing, and licensing of paint or coating applicators.

“New Directions for a Changing World” Is Theme For Annual Meeting in Chicago, October 21-23

The 70th Annual Meeting of the Federation of Societies for Coatings Technology will be held on October 21-23, at McCormick Place, in Chicago, IL. The theme of the event is “New Directions for a Changing World.”

The theme emphasizes that the coatings industry's future depends on changing existing business strategies in formulating products, responding to regulatory and safety demands and managing resources. Addressing the theme, technical presentations will focus on new directions for the industry, including adopting merging and emerging technologies to drive innovation, developing environmentally friendly products and processes, and embracing total quality systems to effectively compete in a global market.

The program will also include the Mattiello Memorial Lecture by one of the technical leaders in coatings research, Room Awards Competition Papers, presentations from Federation Constituent Societies, and Seminars on manufacturing, corrosion, and professional development topics.

Program Committee Chairman John A. Lanning, of Courtaulds/Porter Paints, Louisville, KY, and his committee are developing a schedule of presentations. Assisting on the committee are: Clifford Schoff (Vice-Chairman), PPG Industries, Inc., Allison Park, PA; G. Dale Cheever, GM Corp., Research Laboratory, Warren, MI; Richard J. Himics, Daniel Products Co., Jersey City,

NJ; Louis Holzknecht, Devco Coatings Co., Louisville, KY; Ronda Miles, Union Carbide Corp., Garland, TX; Rose Ryntz, Akzo Coatings America, Inc., Troy, MI; and Roger Woodhull, California Products Corp., Cambridge, MA.

Hotel and Reservations

Eight hotels have reserved blocks of rooms for the Federation event. The Chicago Hilton and Towers will serve as the headquarters hotel for the Annual Meeting and Paint Industries' Show. Other hotels include Essex Inn, Executive House, Hyatt Regency, Fairmont, McCormick Center, Palmer House, and Stouffer Riviere Hotel. All hotel reservations will be processed through the Chicago Housing Bureau. Hotel reservation forms and housing information will be available in April.

Registration Fees

Advance registration forms and information will be sent to all members in April. Advance fees are \$65 for members and \$80 for nonmembers. The fee for spouses' activities is \$50 in advance. Retired members and their spouses may register at the special advance-only fee of \$25 each.

On-site registration will be \$75 for full-time and \$55 for one-day for members. Nonmember fees will be \$95 for full-time

and \$65 for one day. Spouses' activities will be \$60 on-site.

Host Committee

The Chicago Society will serve as the Host for the Annual Meeting. General Chairman of the 1992 Annual Meeting is Ted Fuhs, of Tru-Test Manufacturing Co., Cary, IL. Assisting him are the following sub-committee chairpersons: *Registration Area*—Patricia J. McGrath, of Ashland Chemical, Inc.; *Information Services*—Natu C. Patel, of Ace Hardware Corp., Paint Div.; *Program Operations*—Karl E. Schmidt, of Premier Coatings; *FSCT Exhibit*—Victor M. Willis, of Ace Hardware; *Hospitality Suite*—Thomas P. Yates, of United Coatings, Inc.; and *Spouses' Program*—Cynthia Fuhs.



FSCT Offers Free Ads To Members Seeking Jobs

Unemployed Federation members can find assistance in gaining employment thanks to a new policy recently adopted by the FSCT. Beginning immediately, the JOURNAL OF COATINGS TECHNOLOGY will accept classified advertising, on a no fee basis, for members seeking jobs in the industry.

The offer extends to unemployed members only and includes the publication of six lines of advertising (40-45 characters/spaces per line) in three consecutive issues of the JCT. Included will be the member's name, address, and telephone number (if desired).

To obtain information on this offer, or to place advertising, please contact Lorraine Ledford, Advertising Services Manager, JOURNAL OF COATINGS TECHNOLOGY (Box FB), 492 Norristown Rd., Blue Bell, PA 19422, or telephone (215) 940-0777.

PAINT INDUSTRIES' SHOW

1992 Paint Show Garner's Early Exhibitor Attention; Booths Space Expanded to Almost 100,000 Sq. Ft.

With over seven months to go before the 1992 Paint Show, exhibit space had to be expanded by almost 10,000 sq. ft. to accommodate anticipated increased participation by supplier companies. Currently, 233 companies (*See list of exhibitors in accompanying story.—Ed.*) have reserved over 84,000 sq. ft. of exhibit space, making the 1992 Paint Show the largest ever sponsored by the Federation.

To be held in conjunction with the Federation's Annual Meeting, on October 21-23, at McCormick Place North Hall, the 57th Paint Show will feature the products and services of supplier companies to the international coatings industry.

Exhibit hours will be 10:00 a.m. to 5:30 p.m. on Wednesday, October 21; 9:00 a.m. to 5:30 p.m., on Thursday, October 22; and 9:00 a.m. to 12:00 noon, on Friday, October 23.

1992 PAINT INDUSTRIES' SHOW

Current List of Exhibitors

Aceto Corp.
Advanced Coatings Technologies
Agglo Recovery, Inc.
Air Products & Chemicals, Inc.
Ajinomoto U.S.A., Inc.
Alcan-Toyo America, Inc.
Alcoa Industrial Chemicals
C.M. Ambrose Co.
American Chemical Society
American Cyanamid Co.
Amoco Chemical Co.
ANGUS Chemical Co.
Anker Labelers USA, Inc.
Aqualon Co.
Arco Chemical Co.
Ashland Chemical, Inc. IC&S Div.
Atlas Electric Devices Co.
Aztec Catalyst Co.

B.A.G. Corp.
BASF Corp., Chemicals Div.
Blackmer Pump, Dover Resources
Bohlin Instruments Group
Brookfield Engineering Labs., Inc.
Brookhaven Instruments Corp.
Buckman Laboratories, Inc.
Buhler, Inc.
Bulk Lift International, Inc.
Burgess Pigment Co.
BYK-Chemie USA
BYK-Gardner, Inc.

C B Mills, Inc.
Cabot Corp., Cab-O-Sil & Special
Blacks Div.
Calgon Corp., Div. of Merck &
Co., Inc.
Cappelle, Inc.
The Carborundum Co.
Cardolite Corp.
Cargill, Inc.
Carr-Med Americas, Inc.
Carroll Scientific, Inc.
Celite Corp.
Chemical & Engineering News
Chemical Marketing Reporter
Chemical Week
CIBA-GEIGY Corp.
Coatings Magazine
Color Corp. of America
Colortec Associates
Columbian Chemicals Co.
Consolidated Research, Inc.
Cookson Pigments, Inc.
Coulter Corp.
Cray Valley Products International
Crosfield Chemicals, Inc.
Cuno Process Filtration Products
Cyprus Industrial Minerals Co.

D/L Laboratories
Daniel Products Co.
Datacolor International
Day-Glo Color Corp.
Defelsko Corp.
Degussa Corp.
University of Detroit Mercy
Distil-Kleen, Inc.
Dominion Colour Corp.

Dow Chemical USA
Dow Corning Corp.
Draiswerke, Inc.
Drew Industrial Div.
Dry Branch Kaolin Co.
DSA Consulting, Inc.
Du Pont Co.

Eagle Picher Minerals, Inc.
Eagle Zinc Co.
Eastern Michigan University
Eastman Chemical Co.
Ebonex Corp.
Eiger Machinery, Inc.
Elektro-Physik USA, Inc.
Elmar Worldwide
EM Industries, Inc., Pigment Div.
Engelhard Corp., Spec. Min. &
Colors Group
Epworth Manufacturing Co., Inc.
Etna Products Inc., Specialty
Chemical Div.
Exxon Chemical Co.

Fawcett Co., Inc.
Federation of Societies for
Coatings Technology
Filter Specialists, Inc.
Fischer Technology, Inc.
Fluid Management Ltd. Partners
FMC Corp., Food & Pharmaceuti-
cal Prod. Div.
Freeman Polymers Div./Cook
Composites & Polymers
H.B. Fuller Co.

Paul N. Gardner Co., Inc.
B.F. Goodrich Co., Spec. Polym. &
Chem. Div.
Goodyear Tire & Rubber Co.,
Chemical Div.
W.R. Grace & Co., Davison
Chemical Div.
Guer-Tin Brothers Polymers

Halox Pigments, Div. of Hammond
Lead Products
Harcros Pigments, Inc.
Henkel Corp., Process Chemicals
Heraeus DSET Laboratories, Inc.
Hilton-Davis Co.
Hitox Corp. of America
Hockmeyer Equipment Corp.
Hoechst Celanese Corp.,
Pigments Div.
Horiba Instruments, Inc.
J.M. Huber Corp.
Huls America, Inc.
Hunterlab

ICI Americas, Inc.
ICI Resins U.S.
Ideal Manufacturing & Sales
Industrial Finishing Magazine
Interfibe Corp.
International Compliance Center
International Resources, Inc.
International Specialty Products
ISP Filters, Inc.

S.C. Johnson Wax

K-T Feldspar Corp.
Kenrich Petrochemicals, Inc.
Kent State University
King Industries, Inc.
KRONOS, Inc.

Lawter International
Leeds & Northrup, Microtrac Div.
Liquid Controls Corp.
The Lubrizol Corp., Coatings
Technologies

3M, Industrial Chemicals Div.
Macbeth Div., Kollmorgen Corp.
Malvern Instruments
Malvern Minerals Co.
Matec Applied Sciences
McWhorter, Inc.
The Mearl Corp.
Michelman, Inc.
Micro Powders, Inc.
Micromeritics Instrument Corp.
Miles Inc.
Millipore Corp.
Minnifibers, Inc.
Minolta Corp.
Mississippi Lime Co.
University of Missouri-Rolla
Modern Paint & Coatings
Morton International
Mountain Minerals Co., Ltd.
Myers Engineering

Nacan Products Ltd.
Netzsch Incorporated
Neupak, Inc.
Neville Chemical Co.
New Way Packaging Machinery,
Inc.
Nicolet Instruments Corp.
Nippon Shokubai Co., Ltd.
North Dakota State University
NYCO Minerals, Inc.

Obron Atlantic Corp.
Ohio Polychemical Co.
Olin Chemicals
Ortech International

Pacific Micro Software Engineering
Paint & Coatings Industry
Magazine
Peninsula Polymers
Pfizer Specialty Minerals
Philips Container Co.
Polar Minerals
Pollution Control Industries
Poly-Resyn, Inc.
PPG Industries, Inc., Specialty
Chemicals
PPG Industries, Inc., Silica Products
Premier Mill Corp.
Progressive Recovery, Inc.
Pyosa S.A. de C.V.

The Q-Panel Co.
Quantachrome Corp.

Raabe Corp.
Reichhold Chemicals, Inc.
RHEOX, Inc.
Rhône-Poulenc Inc.
Rohm and Haas Co.
Rosedale Products, Inc.
Charles Ross and Son Co.

Sandoz Chemicals Corp.
Sannor Industries, Inc.
Sartomer Co. Inc.
Schoold Machine Corp.
SCM Chemicals
Scott-Bader
Semi-Bulk Systems, Inc.
Serac, Inc.
Shamrock Technologies, Inc.
Shell Chemical Co.
Sherwin-Williams Chemicals Co.
Shimadzu Scientific Instrument
Silberline Manufacturing Co.
Sino-American Metals & Minerals
Sloss Industries Corp.
South Florida Test Service, Inc.
Southern Clay Products, Inc.
University of Southern Mississippi
Spartan Color Corp.
Startek Chemical Co.
Steel Structures Painting Council
Sub-Tropical Testing Service
Sun Chemical Corp., Colors
Group
Systech Environmental Corp.

Tego Chemie Service USA
Texaco Chemical Co.
Thiele Engineering Co.
Toxide, Inc.
Troy Chemical Corp.

U.S. Borax & Chemical Corp.
U.S. Silica Co.
Unimin Specialty Minerals Inc.
Union Carbide Chemicals &
Plastics Co., Inc.
Union Process, Inc.
United Catalysts, Inc., Rho. &
Perf. Minerals Group
United States Testing Co., Inc.

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R.T. Vanderbilt Co., Inc.
Velsicol Chemical Corp.,
Specialty Chemicals Div.
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Vortli-Siv., Div. of M&M Industries,
Inc.

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FSCT to Offer Quality Management Series in 1992

The Federation of Societies for Coatings Technology will offer four courses in its Quality Management Series for 1992. The Professional Development Committee, which sponsors the courses, has selected Philadelphia and Atlanta as the sites for this year's courses.

The offerings for 1992 are:

"HOW TO IMPLEMENT TOTAL QUALITY MANAGEMENT AND SECURE ISO 9000 SERIES CERTIFICATION"

- **June 8-10, 1992, Philadelphia, PA •**

Over the past three years there has been much discussion in professional quality journals about the value of a broad based quality effort—one which encompasses not only production, but all aspects of providing a product and/or service. Referred to as Total Quality Management (TQM), these discussions have been more general than specific; more theoretical than practical. The practitioner is still asking questions such as "Specifically what are the components of TQM? How have other companies implemented each of these components? Where does Statistical Process Control (SPC) fit into TQM?" "Would you give me step-by-step guidelines on what I must do to implement TQM in my company?" and "Is there a difference between TQM and ISO requirements and what must I do to achieve ISO 9000 series certification?"

This course in implementing TQM and securing ISO certification is an applied, "hands on" approach to specifically answer these and related questions. One by one,

each component of TQM and ISO is explained and discussed, and attendees are given instructions for implementing each component along with useful forms and examples to facilitate understanding.

"GAUGE/MEASUREMENT PROCESS ASSESSMENT AND IMPROVEMENT"

- **June 11-12, 1992, Philadelphia, PA •**

Coatings manufacturers have been living with low reproducibility and excessive variation in their measurement processes. Even when measuring the same thing, agreement between technicians, between laboratories, and between supplier and customer is often unacceptable.

This course is designed to provide participants with an introduction to the nature of gauge/measurement process variation, how to quantify and reduce it, and how to improve its reproducibility. Components of measurement error will be discussed with special emphasis on quality control and research test methods. This course will utilize interactive lectures, coatings industry examples and exercises, and discussion directed toward on-the-job application. The

format is "hands-on" oriented to facilitate implementation.

"STATISTICAL PROCESS CONTROL AND ITS APPLICATION IN THE COATINGS INDUSTRY" (SPC LEVEL I)

- **September 14-15, 1992, Atlanta, GA •**

"PRACTICAL APPLICATION OF INTERMEDIATE STATISTICS IN A TOTAL QUALITY MANAGEMENT SYSTEM" (SPC LEVEL II)

- **September 16-18, 1992, Atlanta, GA •**

The seminars again will be conducted by Dr. Peter Hunt, President of Productivity Management Consultants in Clearwater, FL. Dr. Hunt has over 20 years of experience in Total Quality Management and has conducted numerous seminars on the topic. His courses feature information on SPC and the application of the principles of W. Edwards Deming. Dr. Hunt is a member of the American Society for Quality Control and has authored several management texts.

For more information, contact the Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 or call (215) 940-0777.

Troy Corporation's Fifth Annual Paint Show 5000 Generates \$1,000 Donation to FSCT Scholarship Fund

Troy Corporation's fifth annual Paint Show 5000 Fun & Fitness Run took place in Toronto on November 5, for 100 runners and walkers from the coatings industry. All

proceeds resulting from the individual \$5.00 registration fee were again submitted to the FSCT's Joseph A. Vasta Memorial Scholarship Fund. A supplemental grant from Troy made this year's donation \$1,000. During its five-year history, the run has raised a total of \$4,250 for the scholarship fund.

Bob Ziegler, General Manager of the Paint Show and Executive Vice President of the FSCT, said that Troy's continued sponsorship of the Paint Show 5000 is appreciated by the Federation and the many Paint Show attendees. "The Paint Show 5000 is the most current facet in a long history of support for the FSCT shown by Troy," he said. "In addition to providing an activity which is quickly becoming a tradition at the Paint Show, Troy's contribution to the FSCT scholarship fund assists many students who are working towards a career in the industry," he continued.

The event was held at Coronation Park, Stu Eaton, of Cloverdale Paint, Inc. in Surrey, B.C., was the first to cross the finish line with a time of 18:35. Kay Sanborn, of Rohm and Haas Co., was the first woman to finish, and fifth overall, with a time of 20:05. Runner's Choice of Toronto was the host running club, providing course attendants and equipment to help the run proceed safely and smoothly.

The 1992 Paint Show 5000 will be held in Chicago. Troy recommends that all participants pre-register for the event. Forms will be available in advance.



Dr. Rudi Moerck (right), Vice President, Marketing and Sales for Troy Corp., presents Mr. Ziegler with a \$1,000 donation to benefit the FSCT Vasta Scholarship fund

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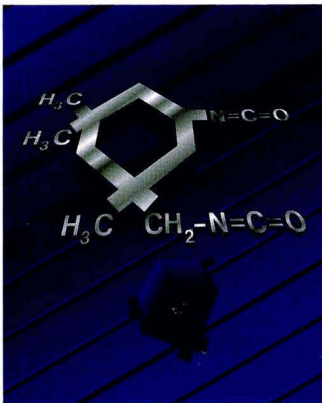
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Boston to Host 1992 Federation Spring Week Activities

The city of Boston will provide a historic setting for the Federation's ninth annual "Spring Week," scheduled for May 17-20. To be held at the Sheraton Boston Hotel and Towers, the event will include the Federation Board of Directors Meeting (Sunday, May 17), the incoming Society Officers Meeting (Monday, May 18), and the annual Spring Seminar (Tuesday, May 19-Wednesday, May 20).

Seminar Program

The theme of the 1992 Spring Seminar is "Understanding Corrosion Protection (How Rusty Are We)." Programming will focus on the role of coatings in inhibiting corrosion. The seminar is designed to provide an in-depth understanding of corrosion basics, along with a review of coating evaluation, and update of formulation technologies. In addition, several open-forum sessions will be held in which speakers will assemble as a panel to respond to questions.

Registration

To register for the seminar, fill out form on the opposite page and return to Federation headquarters. Registration fee is \$175 for FSCT members, and \$225 for non-members. (Payment must be made in U.S. funds, payable on U.S. banks.)

The registration fee includes continental breakfasts, luncheons, coffee breaks, and copies of papers presented, as well as bus transportation to the airport at completion of the seminar. *Please note reference to bus on registration form and check appropriate box.*

Note: If cancellations are received less than five days prior to the seminar, a \$50 charge (per registration) will apply.

Housing

Requests for seminar room accommodations at the Sheraton Boston Hotel and Towers must be made on the official housing form and returned to FSCT headquarters.

"Spring Week" Spouses Tour: In Search of the Stone

The model for the Federation's logo, "Ye Olde Paint Stone," really does exist—and can be found in Boston. The real stone, which the logo represents, is known as the Boston Stone. Originally a paint mill imported from England around 1700 by a painter, Thomas Child, the Stone was used as a landmark or central point from which distances in Boston were measured.

On Sunday, May 17, spouses will gather at the main entrance of the Sheraton to board a motorcoach at 9:00 a.m. for a full day tour of Boston in search of the Boston Stone. Sponsored by the New England Society for Coatings Technology, the tour begins with travel through Copley Square, the Boston

Seminar room rate is \$130, single, and \$145, double (per night). Note that reservations must be received no later than April 15 to assure availability and rates.

Also, if including advance payment for hotel accommodations, please do so on a separate check, made out to "Sheraton Boston Hotel and Towers."

Air Transportation

Special air fares on USAir are available from the Federation's Travel Desk. This service

is provided by Uniglobe Wings Travel. To obtain a discount of 40% on full round trip fares and a 5% discount on published discounted fares, call 1-800-448-FSCT. An agent will make your reservation, write your ticket using your credit card number, and mail the tickets directly to you. Be sure to mention the FSCT Code: Spring Week 92.

Complete information is available from the Federation, 492 Norristown Rd., Blue Bell, PA 19422-2350, (215) 940-0777, FAX: (215) 940-0292.

Federation Publishes "Powder Coatings," by Josef Jilek— 19th Addition to FSCT Series on Coatings Technology

The Federation has announced the publication of "Powder Coatings," the much anticipated 19th addition to its *Series on Coatings Technology*. The monograph, which was authored by Joseph H. Jilek, of Rohm and Haas Austria, examines powder coatings as a viable alternative to conventional liquid coatings.

In the 36-page booklet, Dr. Jilek explores the areas of application and commercial aspects involved with production of powder coatings. Discussions focus on the manufacture and application of powder coatings, as well as on the raw materials which are used. In addition to providing some starting formulations, the monograph describes various methods of testing in powder manufacturing. The most important advantages and the limitations in the use of powder coatings are summarized. Also included is a presentation of toxicological considerations and hazards. Dr. Jilek predicts that, with their ability to meet increasingly stringent environmental regulations, powder coatings will penetrate into other application areas. He concludes with a prediction of the future advances and challenges involved in this

rapidly expanding technology. Emphasis is placed on powder coatings as a nearly pollution free, economical means of coating a wide variety of metal substrates for either decorative or functional purposes.

* * *

The new *Federation Series on Coatings Technology* is intended to serve as an educational resource for the industry. Additional titles in the series include:

"Film Formation," by Zeno Wicks, Jr.
"Introduction to Polymers and Resins," by Joseph Prane

"Radiation Cured Coatings," by J.R. Costanza, A.P. Silveri, and J.A. Vona
"Solvents," by William Ellis

"Coil Coatings," by Joseph Gaske
"Corrosion Protection by Coatings," by Zeno Wicks, Jr.

"Mechanical Properties of Coatings," by Loren W. Hill

"Automotive Coatings," by Bruce N. McBane

"Coating Film Defects," by Percy E. Pierce and Clifford K. Schoff

"Application of Paints and Coatings," by Sidney B. Levinson

"Organic Pigments," by Peter A. Lewis
"Inorganic Primer Pigments," by Alan Smith

"Marine Coatings," by Henry R. Bleile and Stephen Rodgers

"Sealants and Caulks," by Joseph Prane
"Aerospace and Aircraft Coatings," by A.K. Chattopadhyay and M.R. Zentner

"Introduction to Coatings Technology," by Alan Brandau

"Cationic Radiation Curing," by Joseph Koleske

"Rheology," by Clifford Schoff

The monographs are prepared in a standard 8 1/2 x 11 inch format. List price is \$15 for individual copies, \$10 if the existing set is purchased. The member cost is \$7.50 for individual copies and \$5.00 with an order of the full set. Orders may be placed by contacting Meryl Cohen, FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350.

**“UNDERSTANDING CORROSION PROTECTION” SEMINAR
REGISTRATION FORM**

May 19-20, 1992 • Sheraton Boston Hotel and Towers, Boston, MA

Registration fees: \$175 (FSCT members); \$225 (non-members)

Check must accompany registration form. Make checks payable to Federation of Societies for Coatings Technology. (Payment must be made in U.S. funds payable on U.S. banks.)

NICKNAME (For Registration Badge) _____

FULL NAME _____

JOB TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

Name of Federation Society
Of Which You Are a Member _____

I will will not use the Federation bus to the Logan International Airport at conclusion of the seminar.

Return form and check to: FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
492 Norristown Road
Blue Bell, PA 19422-2350

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 Late* Departure Date _____

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*Reservations will be held until 6:00 pm. If arrival is after 6:00 pm, hotel requires deposit for one night's lodging to guarantee availability. Make check payable to "Sheraton Boston Hotel and Towers."

Note: Reservations must be made no later than April 15 to guarantee availability and rates.

Return this form to: FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
492 Norristown Road, Blue Bell, PA 19422-2350

Former Lead Pigment and Lead-Paint Producers Win Round in Lead Lawsuit in New York Court

It has been reported that former producers of lead pigments and lead-based paint won a round in court when a New York state judge dismissed negligence and product-liability claims in a suit filed in New York City.

State Supreme Court Justice Michael J. Dontzin ruled that the city of New York filed its suit too long after the dangers of lead paint became known. The city was seeking more than \$50 million in compensation for lead contamination of city housing projects.

According to information received, Judge Dontzin said, however, that the city could still pursue allegations of fraud on the part of the lead-pigment producers. Those allegations could be based on charges the manufacturers sold the products while concealing the lead-paint dangers from the public.

Attorneys for the defendants said the ruling will boost their defense of similar suits pending in state courts in New York and Massachusetts, and federal courts in

Philadelphia, PA and Boston. The defendants include: The Sherwin-Williams Company; NL Industries, Inc.; Eagle Picher Industries, Inc.; Atlantic Richfield Company; and The Glidden Company.

The defendants' attorneys say the suits were filed too late—most of them in the 1980s, more than a decade after lead-based architectural paint production was discontinued.

Judge Dontzin ordered attorneys for the city and the defendants to investigate when the city should have become aware of any alleged fraud, and then will decide if the statute of limitations should apply to the fraud claim.

In Boston, a ruling is awaited on whether liability can be split among lead paint manufacturers based on their market share.

RadTech International North America Forms Environmental Committee

RadTech International North America, Northbrook, IL, has formed an Environmental Committee to inform and educate American processing industries about the environmental friendliness of UV/EB curing technology.

Jack Weisman, of Energy Sciences, Inc., has been appointed spokesperson for the committee.

The Environmental Committee is made up of UV and EB equipment, ink, coatings, and raw materials suppliers, as well as numerous nationally known end-users. The organization holds meetings bimonthly

throughout the U.S. to discuss recent progress, as well as pending breakthroughs in UV/EB technology. The goal of the committee is to fairly and accurately substantiate and document the environmental benefits of the UV/EB processes versus thermal drying methods.

For more information on the newly formed Environmental Committee of RadTech International or the UV/EB processes, contact: Jack Weisman, Energy Sciences Inc., 42 Industrial Way, Wilmington, MA 01887.

Carl Zeiss Forms Instrument Corporation in Jena, Germany

Following nearly two years of negotiations, Carl Zeiss, Inc., headquartered in Oberkochen, in western Germany, has formed a new corporation to manufacture precision instruments in eastern Germany. The final agreements were signed on November 7, 1991.

Officials at Carl Zeiss and government agencies responsible for reorganizing former East German state-owned companies were involved in the negotiations.

Carl Zeiss Oberkochen holds a majority 51% stake in the new company, Carl Zeiss Jena GmbH. A new state-owned company, Jenoptik GmbH, holds the remaining 49% interest in Carl Zeiss Jena.

According to officials, Carl Zeiss Oberkochen plans to invest more than \$140 million in the next few years to provide the Jena facility with technologies and production techniques. Also, it is expected that Carl Zeiss Oberkochen will assume full ownership of the new company within several years, when Carl Zeiss Jena becomes self-supporting.

Western Fire Chiefs Adopt Higher Limits Of Flammable and Combustible Liquids

The National Paint and Coatings Association (NPCA), Washington, D.C., has announced that the Western Fire Chiefs Association (WFCA) has adopted the higher limits of flammable and combustible liquids that may be kept by retailers and wholesalers as part of the Uniform Fire Code. WFCA officially agreed to these higher limits at a meeting of the International Fire Code Institute in Mesa, AZ.

In late 1991, NPCA and representatives of other affected industries won an increase in the amount of flammable and combustible liquids that may be kept by retailers and wholesalers west of the Mississippi.

The effort by industry was successful in increasing the quantity limits by as much as tenfold, to 15,000 to 30,000 gallons, depending on the type of sprinkler protection and whether minimum one-hour fire-resistant separating walls are present. Earlier in 1991, WFCA had moved to limit retailers and wholesalers to no more than 3,000 gal-

lons of flammable and combustible liquids in their stores.

American Cyanamid to Expand Surfactant Operation

American Cyanamid Company, Wayne, NJ, has announced a multimillion dollar expansion and modernization of its Warners, NJ surfactant operation.

The expansion, targeted for completion in the fourth quarter of this year, will increase the company's Aerosol® surfactant capacity by approximately 10 million pounds.

The multimillion dollar investment is part of a major restructuring effort at Cyanamid's Linden, NJ (Warners) plant. The restructuring will include the relocation of surfactant production to a modern manufacturing facility which utilizes glass-lined reactors.

Major Restructuring Effort Underway at Akzo

Officials at Akzo, The Netherlands, have reported that the company will embark on a major restructuring of its operations in order to increase the effectiveness and efficiency of its operation.

The reorganization will include:

- The merger of the Salt and Basic Chemicals and Chemicals Divisions, which was slated to begin February 1 and be completed by January 1, 1993. The merger will leave four business groups, Chemicals, Coatings, Fibers, and Pharma. The term division will be dropped.

- Efforts to improve lines of communication and give the business units more re-

sponsibility with the institution of one level of authority, to be called Corporate Management Holding, in each business unit.

- The creation of a six-member Board of Management that will include the Chairman, Deputy-Chairman, and the four Group Presidents, effective May 1. The Board of Management will oversee company-wide operations, and the Group Presidents and Directors will oversee operations of individual groups.

- The creation of corporate-policy staff departments and group-specific staff departments as part of a plan to improve efficiency.

An analysis of the company's strengths and weaknesses uncovered that the "strong" business units account for 45% of sales and 80% of operating income, while "weaker" units contributed 15% of sales and, on balance, negative operating income.

According to sources, the analysis indicates that Akzo can boost earnings, and actions taken in 1991 to divest certain operations and concentrate on others will continue.

The company's outlook for 1992 is clouded by political change in Central Europe and the former Soviet Union, falling growth rates in the principal industrial economies, inflationary tendencies in The Netherlands and Germany, and a weak U.S. dollar.

Mergers & Acquisitions...

3M Purchases Zeelan Industries

3M Company, St. Paul, MN, has purchased Zeelan Industries, Inc., St. Paul. Terms of the acquisition were not disclosed.

Zeelan produces two types of ceramic microspheres used by the coatings industry: Zeospheres and Z-Light Spheres.

3M will operate Zeelan Industries as a separate subsidiary of its Industrial Specialties Division. Zeelan's current management staff and its network of North American and overseas distributors will remain in place.

M.A. Bruder Acquires Ohio-Based Paint Manufacturer

M.A. Bruder & Sons, Inc., Broomall, PA, has reported that they have acquired Paint America Company, Dayton, OH.

Paint America is a manufacturer and distributor of paints and coatings. They distribute their products through 36 company operated stores primarily in the Dayton and Cincinnati, OH areas.

Sherwin-Williams Purchases Cook's Protective Coatings Unit

The Sherwin-Williams Company, Cleveland, OH, has acquired the Cook, Kansas City, MO, Heavy Duty Protective Coating business unit located in Kansas City. The terms of the acquisition were undisclosed.

Sherwin-Williams will maintain the Cook brand name and expand the tank linings, rail car, and structural steel coatings business through its dedicated industrial maintenance sales organization.

According to officials of the Sherwin-Williams Paint & Coatings Group, no manufacturing facilities were acquired in the transaction, although a planned nine-month transition of manufacturing from Cook's plant to Sherwin-Williams plants will be undertaken.

Bruning Paint Acquires Sico Divisions

Bruning Paint Company, Baltimore, MD, has announced that they have purchased Sico, Inc.'s Kyanize and NuBrite Divisions. The transaction was completed by a corporation owned by several Bruning shareholders.

Kyanize and NuBrite manufacture architectural coatings and sell to independent paint and hardware stores and building supply centers in the eastern, midwestern, and southern U.S.

Sico, Inc. is a Canadian manufacturer of paints and coatings.

White Color of Choice Among New Car Buyers in 1990

The annual survey of vehicle color popularity, conducted by the Du Pont Company, Wilmington, DE, has revealed that white has been selected as the undisputed color of preference for all classes of vehicles in North America.

The survey reported that an average of 22% of consumers chose white for luxury cars, full/intermediate cars, sport/compact cars, and light trucks/vans. In 1990, white was the color of choice in three of the four categories.

According to the data collected, red came in second place in the sport/compact car category, comprising 19% of the consumers. 1991 marks the first year since 1985 that red was not the consumers' color of choice in this category.

Other colors that retained a high level of motorist popularity include blue, black, and silver.

Colorgen Moves Headquarters; Opens Canadian Subsidiary

Colorgen, Inc., Billerica, MA, has recently relocated their corporate headquarters to One Federal Street in Billerica.

The new facility has larger manufacturing, database development, and in-house laboratory space.

In other news, Colorgen has opened its new subsidiary, Colorgen Canada, Inc., Mississauga, Ont., Canada. The new subsidiary will provide sales, service, and support to company computer color matching systems.

Wesley Stonos has been appointed National Sales Manager of Colorgen Canada. Also, Rob Einarson will administer technical service and support.

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Construction Contracting Falls 4% in Nov. 1991; 1991 Year End Totals Down 8% from 1990

The F.W. Dodge Division, McGraw-Hill, New York, NY, has reported that contracting for new construction dropped 4% in November 1991.

The decline is attributed to nonresidential building down 8%, and public works construction down 6%. Residential building held steady in November, as a small gain in single family homebuilding offset a further decline of multifamily projects.

Through the first 11 months of 1991, construction contracting trailed the previous year's total by 9%.

In December 1991, a 2% gain in the value of newly started construction nudged the fourth quarter's rate of construction contracting to its highest level in 1991, for an annual total of \$226.8 billion.

December's gain did little more than recoup some of the losses of the previous month, when contracting declined 4%. Nonresidential building rebounded 3% in December, as strength in institutional building offset continued weakness in commercial projects. Housing was essentially flat in

the final month of the year. However, public works construction rose 4% with double digit gains in highway and water supply projects.

Despite quarter-by-quarter improvement through 1991, the year's total of new construction starts, at \$226.8 billion, fell short of 1990's value by 8%. It was the second yearly decline since construction contracting reached its peak of \$271.2 billion in 1989.

Nonresidential building, down 11% in 1991, was the weakest of the broad categories. The value of residential building fell 8% last year as the number of housing units hovered around one million, the lowest number in four decades. Contracting for "nonbuilding" construction (public works and utilities) eased back 2% in 1991.

Regional exceptions to the national decline of 8% last year were the South Central (up 4%) and West (down 14%). The Northeast (down 7%), North Central (down 8%), and the South Atlantic (down 8%) were more typical of 1991's circumstances.

S/R Laboratories Unveils New Animation Art Conservation Center

S/R Laboratories, Westlake Village, CA, announced the opening of its animation art conservation center on November 11, 1991. This facility is the only center for the conservation of animation art in the world.

The new conservation center is designed to facilitate the completion of several complex restorations, all taking place at the same time.

The new center is the culmination of over 13 years of research and effort on the part of literally hundreds of paint and coatings professionals who have contributed their knowledge and materials to the center. S/R Laboratories is affiliated with the Los Angeles Society for Coatings Technology, the Association of Official Analytical Chemists, the Western Association for Art Conservation, the Association for the Preservation of Artistic and Historic Works, the Professional Picture Framers Association, and the Inter-Society Color Council.

The heart of the new facility is the color and research laboratory which features an ink and paint making formulary where rainbows of colors are made and matched. Paints are custom-ground in small quantities to the exacting specifications of the art, following traditional formulas and using pigments and ingredients especially researched and gathered to meet conservation needs. Minolta color matching computers that precisely replicate hues and tones for char-

acters are featured in the laboratory. Each color produced is specified with a computer-aided match known as a CAM match number. CAM profiles are stored on the laboratory's computer system along with the character models and previous restoration notes.

Three fully-equipped treatment rooms, a conference/classroom, and full-service framing shop also are part of the laboratory's service areas. Each is outfitted with special lighting fixtures to give the conservator the flexibility to work in the various lights the art may encounter.

The new laboratory also makes possible the training of new conservators, colomen, conservation technicians, and art professionals involved in the handling and management of animation art.

A full paper conservation unit, photographic facilities, and computer video storage systems are featured in the main laboratory.

The conservation center also includes a professional frame shop, fully equipped with high quality moldings and mounting materials. Retail services, offering select conservation materials for clients who choose to care for the conservation needs of their own artworks are available. A research library and conference and teaching facilities are contained in the center.

1990 Membership Survey Of the Federation of Societies For Coatings Technology

Mary G. Brodie

FSCT Professional Development Committee

INTRODUCTION

In March 1990, the Professional Development Committee conducted its second membership survey with the purpose of expanding and refining its knowledge of the membership and their needs. The questionnaire was modified, the correlations were increased, and a section was introduced covering career development. Although the number of respondents was lower than that of the initial (1986) survey, 3385 (46%) vs 3820 (56%), it was still an excellent response for polls of this type.

This report presents a picture of the membership which should be useful to both members and their employers. A later report will cover the Career Development Section of the survey.

It should be noted that not all percentages will add to 100% because a "no answer" or very small category may have been eliminated since it was not significant in the present context.

FSCT MEMBERSHIP

The FSCT membership distribution reported in the 1986* survey was corroborated in this survey. Active members are by far the largest segment (71.6%) but there is also an important segment of associate members (21.9%). Educator/student members (0.6%) and honorary/retired members (5.4%) make up the rest of the membership.

ACTIVE MEMBERS—work largely in technical functions (57.4%) such as research, development, technical service, analytical, engineering, and R/D management. Other smaller but notable functions include general management (12.4%), sales and marketing (10.3%), quality (5.0%), and production (4.6%).

ASSOCIATE MEMBERS—are concentrated in sales and marketing (66.4%), general management (12.6%), technical service (4.9%), and "other" functions (9.4%).

Who Are We?

Member Demographics

The FSCT membership is overwhelmingly male (90.8%) with a very small segment of female members (8.2%). Overall, more than half of the members (52.3%) are 45 years of age or older. However, this differs with sex as described below. (See *Figure 1*.)

Males are broadly distributed across age groups 25 to 65 Plus with the largest concentration in the 35-55 age range (56.7%) and only 17.1% under age 35.

Females, on the other hand, are skewed to the younger side with the largest concentration in the 25-44 age range (74.7%) and essentially half under age 35.

Educational Background

The educational background of the current membership reveals an increase in respondents with college degrees (82.6%). In 1986 this was 76.3%. The key change is an increase in Bachelor's Degrees, the *dominant* category in both surveys, from 55.3% to 60.1%. There was little change in M.S. Degrees (16.5% vs 15.0%) and no real change in the percent (5.9%) who are Ph.D.'s.

The percentage of degreed people is the same for males and females (82.6%). However, males tend to have a slightly higher percentage of graduate degrees (22.8% vs 19.2%).

Comparison of the B.S., M.S., and Ph.D. degree distribution with age categories shows some slight skewing of graduate degrees to older age groups. *Figure 2* exemplifies this while *Figure 3* strongly reflects the preponderance of

*See JOURNAL OF COATINGS TECHNOLOGY, 59, No. 751, 51 (1987).

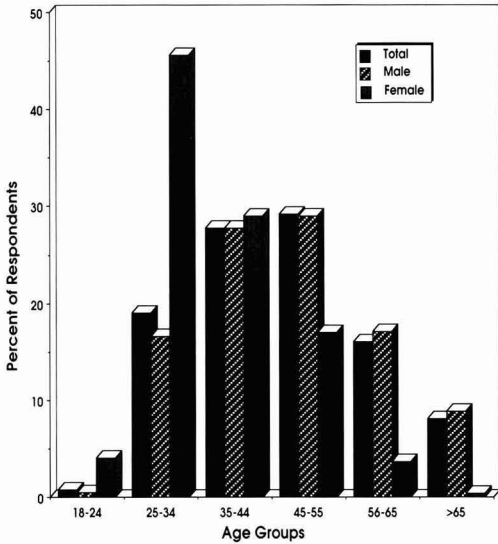


Figure 1—Percent of the Total, Male, and Female Respondents in Each Age Group

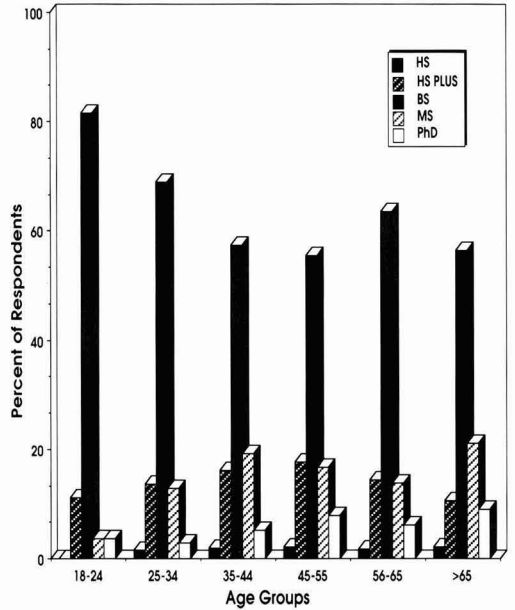


Figure 3—Distribution of Education Levels for Each Age Group

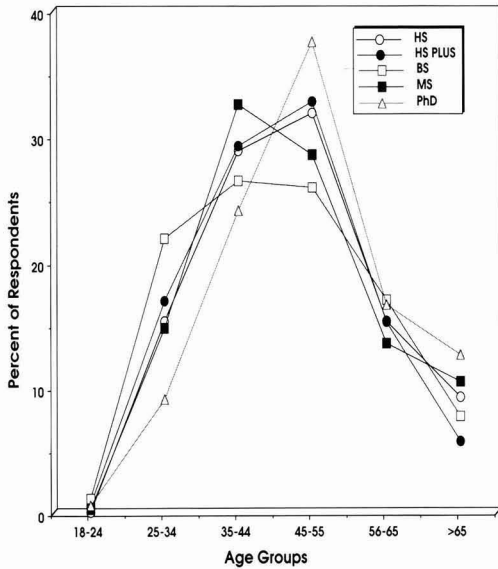


Figure 2—Age Distribution of Respondents from Each Education Level

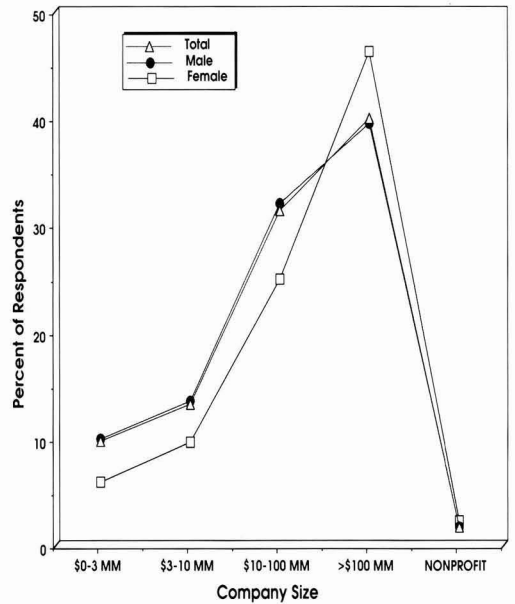


Figure 4—Distribution of Total, Male, and Female Respondents According to Company Size

Table 1—Distribution of Total, Male, and Female Respondents Across Employer Types

	Paint Mfr	RM Supp	Educ Inst	Cons Org	Paint User	Equip Supp	Ret	Other
Female	50.7	32.2	0.4	0.7	2.9	1.1	0.7	10.1
Male	48.5	33.5	0.8	2.6	1.7	0.9	4.6	7.3
Total	48.9	33.2	0.8	2.4	1.8	0.9	4.2	7.6

Table 2—Distribution by Sex of Respondents Associated with Each Employer Type

	Paint Mfr	RM Supp	Educ Inst	Cons Org	Paint User	Equip Supp	Ret	Other
Female	8.5	7.9	3.6	2.5	12.9	10.0	1.4	10.9
Male	90.1	91.6	89.3	97.5	85.5	90.0	98.6	88.3

B.S Degrees in all age categories. Both figures indicate that there are fewer Ph.D.'s in the youngest age groups.

Chemistry (49.3%), Business (10.1%), and Engineering (10.5%) account for a predominant number of degrees (69.9%). Chemistry and its combinations (e.g., Chemistry/Business, Chemistry/Biology, etc.) account for additional degrees (9.7%) making Chemistry and its combinations the principal educational background (59.0%). There are some small differences in degree field between males and females but the overall similarity is quite strong. Females have a higher percentage of Biology degrees than males (6.2% vs 2.6%) but this is not a major category.

The membership is not only dominantly professional in background (82.6%) but a large segment (72.9%) is also interested in *continuing education* and a number of members are active in other professional organizations, e.g., the American Chemical Society, the Steel Structures Painting Council, and the ASTM.

Where Do FSCT Members Work? Employer Type

As reported in 1986, respondents work largely for paint manufacturers (48.9%) and raw material suppliers (33.2%). Paint users, consulting organizations, equipment suppliers, and educational institutions are *small* factors, as are the "other" and retired categories. This is shown in *Table 1*.

Table 1 also shows that the male and female employment distributions are essentially similar and approximate the total distribution. *Table 2* shows the breakdown by sex for each employer type. Females are better represented with paint manufacturers, paint users, equipment suppliers, and "other" employers than their percent of the total FSCT survey population would indicate. The reverse is true with consulting organizations and educational institutions where their percent participation is very low.

If one looks at educational levels vs employer type the picture remains essentially similar. Paint manufacturers and raw material suppliers are still the major employers for all education levels. However, there are differences as education increases to the graduate level, particularly Ph.D., where the percentage employed decreases, especially with raw material suppliers (see *Table 3*). In spite of that, 65% of the Ph.D. respondents work for paint manufacturers or raw material suppliers.

Employer Size and Scope

As might be anticipated based on sheer size differences, more respondents work for large companies (\$10-100 MM

Plus) than for small companies (\$0-10 MM), i.e., 71.2% work for companies of \$10-100 MM Plus, while 22.8% work for companies of \$0-10 MM and 1.6% work for nonprofit organizations. The distribution by company size for males and females indicates that, percentage-wise, females are better represented in \$100 MM Plus companies while males are well represented at all levels of company size. (See *Figure 4*.)

As to the scope of business represented by the FSCT respondents, we find that 39.1% work for companies with international sales scope. National sales companies account for the second largest group at 28.7% followed closely by regional companies at 26%. Local sales companies are a small factor (3.7%) as might be expected. This data shows some changes from the 1986 survey but it is difficult to measure real shifts because of multiple responses to this question by some 1986 respondents.

The fact that a significant percentage of FSCT members tend to come from companies of substantial size and broader sales scope suggests that the members must respond to broader technical interests. This is supported by data that indicates that as education increases, employment shifts to larger companies (or perhaps that larger companies need more educated personnel, and hire them). (See *Figure 5*.)

What Type of Jobs Do FSCT Members Have?

As to job type, Technical Functions (45.7%) constitute the largest category of employment, with Sales a distant second (20.4%) and General Management (12.3%) in third place. Quality (3.9%), Production (3.7%), Marketing (3.0%), Safety/Environmental (1.6%), and "other" (8.2%) are distinctly smaller categories. Among the technical functions, Development (15.6%) is the largest category followed by R/D Management (11.3%), Technical Service (9.1%), Research (7.9%), and Engineering and Analytical (both at 0.9%).

Table 3—Distribution of Education Levels Across Employer Types

	Paint Mfr (A)	RM Supp (B)	[A + B]	Educ Inst	Cons Org	Paint User	Equip Supp	Ret	Other
High School ...	60.6	19.7	80.3	1.5	3.0	1.5	3.0	3.0	7.6
HS Plus	57.6	30.0	87.6	0.4	1.0	1.9	1.5	2.7	4.8
BS	47.2	35.9	83.1	0.2	2.2	1.6	0.8	4.3	7.5
MS	47.5	31.9	79.4	0.4	3.6	2.0	0.5	4.1	9.9
PhD	42.0	23.5	65.5	9.0	5.0	3.5	0	7.5	9.5

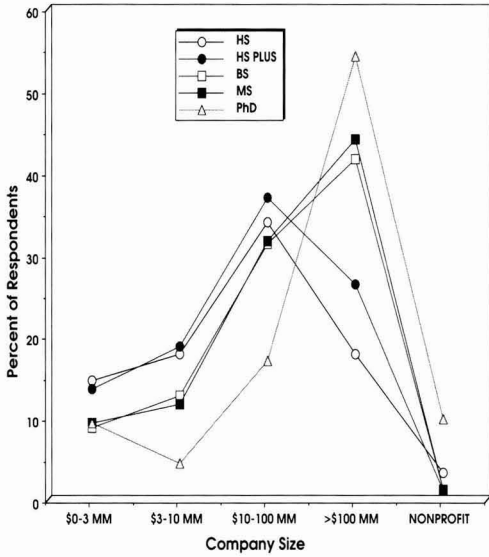


Figure 5—Distribution of Each Education Level According to Company Size

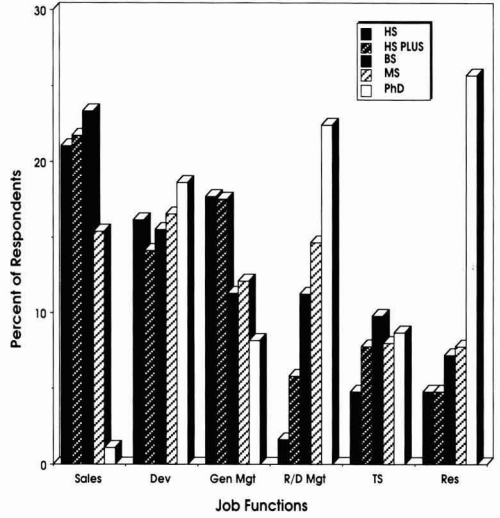


Figure 7A—Distribution of Each Education Level Among Job Functions

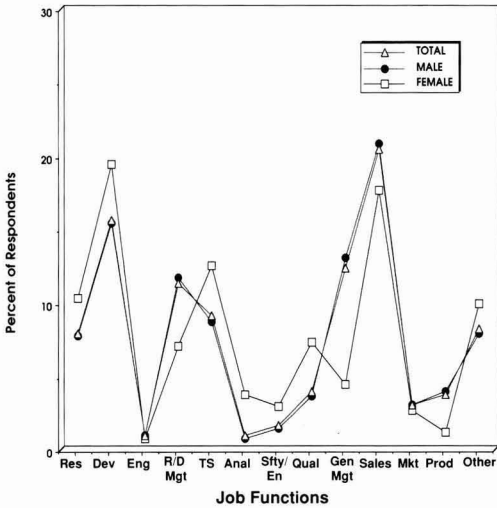


Figure 6—Distribution of Total, Male, and Female Respondents According to Job Function

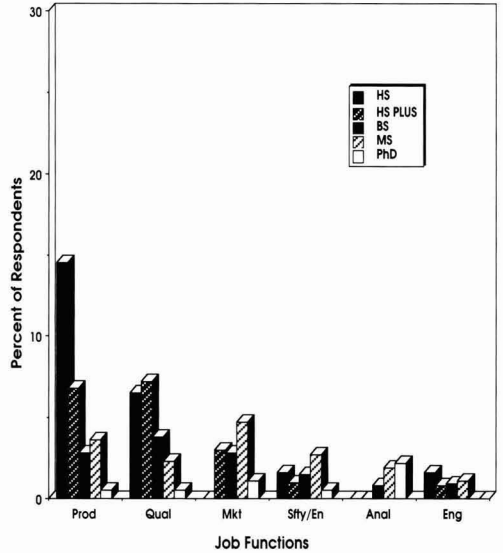


Figure 7B—Distribution of Each Education Level Among Job Functions

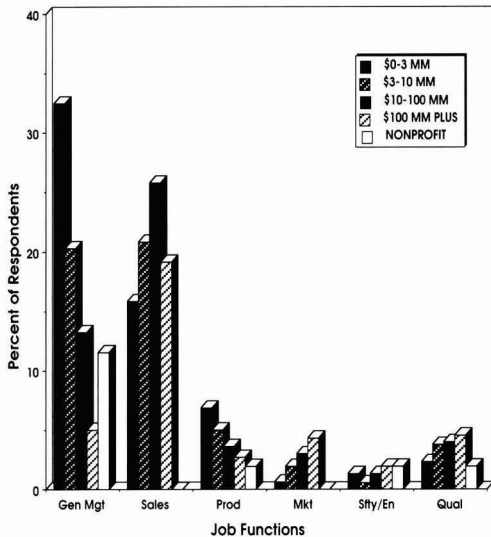


Figure 8A—Distribution of Job Functions for Each Company Size

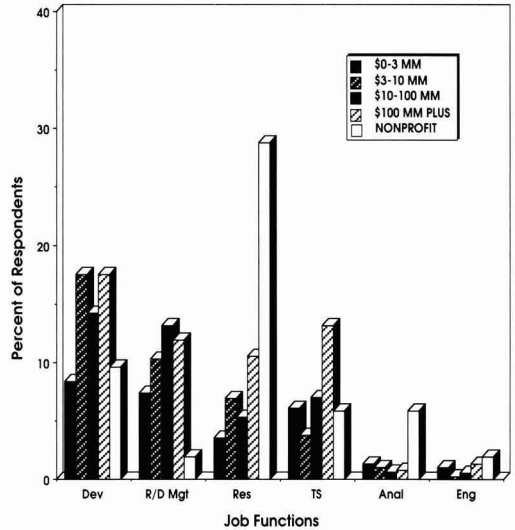


Figure 8B—Distribution of Job Functions for Each Company Size

Do Job Types Differ with Sex or Degree? Employer Type or Company Size?

The survey does indicate differences in the job function of males and females. The highest percentages of females are reported in technical functions, i.e., Development, Technical Service and Research, and in Sales, while the highest percentages of males are reported in Sales, Development, General Management, and R/D Management. Overall, 24.7% of males report their activity as either General or R/D Management while only 11.4% of females report similar activity. In all technical functions except R/D Management and Engineering a higher percentage of the female respondents report activity than do the male respondents (Figure 6).

Job function also varies with level of education. As education increases, the percentage engaged in Analytical, Research and R/D Management functions increases, while the percentage engaged in General Management, Production, Sales and Quality functions decreases. There are some differences in the percentages engaged in Development, Technical Service, Marketing, Safety/Environmental, and Engineering as education changes but these are not distinct trends, nor in some cases, meaningful differences. Interestingly, Development appears to utilize relatively similar proportions of all education levels (14.1-18.5%). Figures 7A and 7B present the picture.

The job functions reported by member respondents for different employer types vary with the nature of the employer's business and its relationship to the coatings industry. This is summarized in Table 4.

The distribution of member respondents according to job function also differs with company size. With the smallest companies (\$0-3 MM), respondents are more likely to be in nontechnical functions (general management, sales, etc.). With larger companies (\$3-100 MM) the nontechnical/

technical distribution of jobs becomes roughly 60/40 and then changes to a heavier concentration in technical functions (roughly 55/45). This occurs in companies of \$100 MM Plus. (See Figures 8A and 8B.)

In What Coating Areas Do FSCT Members Work?

As to coating areas where member respondents are active, three areas account for the bulk of the members, namely

Table 4—Principal Job Functions* Reported for Various Employer Types

Paint Manufacturers	Development	24.4%
	R/D Management	17.2%
	Research	10.7%
	General Management	14.7%
Raw Material Suppliers	Technical Service	14.5%
	General Management	10.1%
	Sales	50.4%
	Marketing	6.9%
Equipment Suppliers	General Management	13.3%
	Sales	50.0%
	Other	13.3%
Paint Users	Research	17.7%
	Development	14.5%
	Technical Service	14.5%
	R/D Management	11.3%
Consulting Organ.	Other	12.9%
	Technical Service	16.2%
	R/D Management	10.3%
	Research	10.3%
Educational Institutions	Other	19.1%
	Research	37.0%
	Other	44.4%

(a) Includes the top categories (10% or greater).

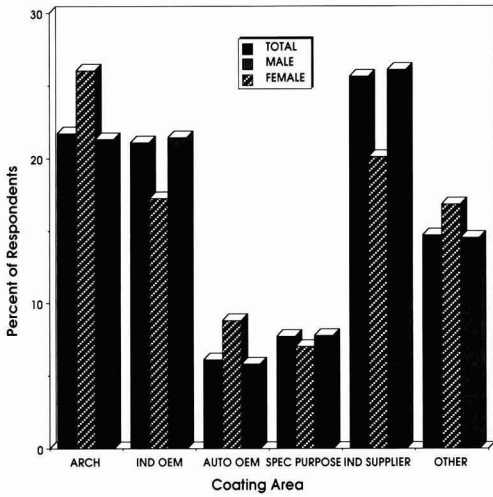


Figure 9—Distribution of Total, Male, and Female Respondents According to Coating Area

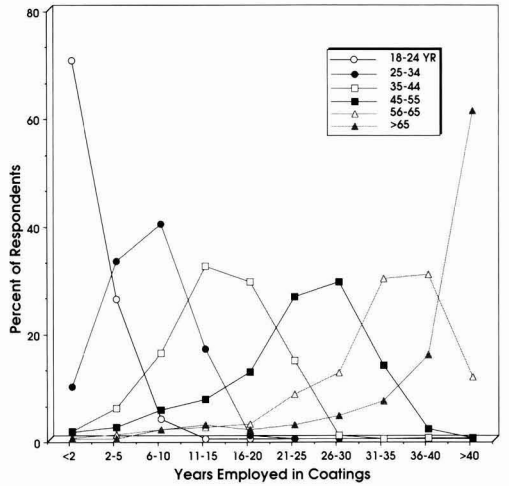


Figure 11A—Distribution of Each Age Group According to Years Employed in Coatings

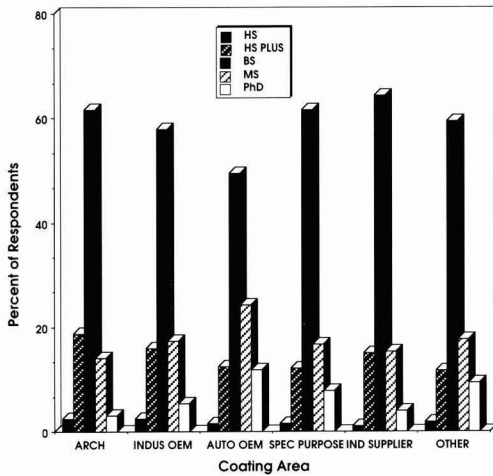


Figure 10—Distribution of Education Levels in Each Coating Area

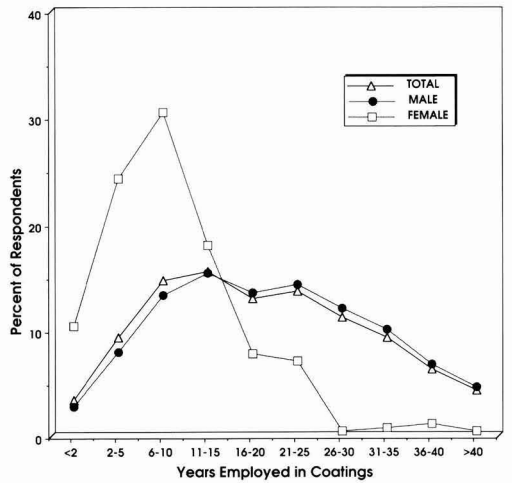


Figure 11B—Distribution of the Total, Male, and Female Respondents According to Years Employed in Coatings

industry supplier (25.6%), architectural (21.7%), and industrial OEM (21.1%). Special purpose and auto OEM are small factors at 7.7% and 6.1%, respectively. "Other" is a notable factor at 14.7%. (See *Figure 9*.)

Are There Differences in the Coating Areas in Which FSCT Members Work Based on Sex or Degree? Other Factors?

The distribution of males and females among coating areas differs somewhat. Larger percentages of the female respondents work in architectural coatings and auto OEM coatings. The reverse is true for the industry supplier and industrial OEM segments where the percentage of male respondents is larger. The special purpose segment is different with nearly equal percentages of males and females active. The position of females in architectural and auto OEM seems to coincide with their position with paint manufacturers, paint users, and equipment suppliers. In all these cases they exceed their total presence in the survey (approximately 8.5-12% vs 8.2%) (*Figure 9* and *Table 2*).

The distribution of education levels in the designated coating areas also shows variability. This is presented graphically in *Figure 10*. Bachelor-degree respondents, the dominant educational category, are well represented in all coating areas. Their best participation is with industry suppliers where they represent 64.3% of employed respondents while their low point of participation is 49.5% in auto OEM. Master-degree and Ph.D. respondents are best represented in the auto OEM area (24.2; 11.9%). Their poorest representation is in the architectural area (14.1; 3.0%). Overall, auto OEM has the highest concentration of graduate degrees (36.1%) and architectural has the lowest (17.1%).

High school and high school Plus respondents, who represent 17% of the total survey population, participate best in the architectural and industrial OEM areas (21.2%; 18.5%). They vary somewhat in their low point of participation: for high school respondents it is industry supplier (1.1%), while for high school Plus respondents it is special purpose (12.2%) or "other" (11.7%).

Considering coating area and employer type, it is apparent that no matter what coating area is involved, respondents tend to work for larger companies and that paint manufacturers and raw material suppliers are the dominant employers. It is also evident that technical functions are predominant in all coating areas except architectural where the split is close to 50:50 and industry supplier where nontechnical functions, mostly sales, predominate.

What Level of Experience in Coatings Does the Membership Reflect?

Examining experience in coatings, we see a broad, relatively even distribution of member respondents, particularly in the six- to 30-year range of employment. This includes 67.6% of the total member respondents, which reflects a relatively experienced group of people. (See *Figure 11A*.)

Separating this by sex, however, shows a different picture. The male distribution which is overwhelmingly dominant mimics the broad even total distribution. Females, however, are strongly skewed to the side of much shorter experience, with 34.5% employed five years or less, 64.9%—10

years or less and 82.8%—15 years or less. The comparable figures for males are 10.5%—five years or less, 25.7%—10 years or less, and 39%—15 years or less, reflecting their greater experience level (see *Figure 11B*).

Comparing age groupings vs years employed in coatings in *Figure 11A* shows us the cyclical nature of the process by which today's membership was formed. Using cumulative peak percentages, it also indicates the likelihood that roughly 50-70% of the respondents joined the industry directly from college. Joining directly from college appears to be a relatively strong trend for the younger age groups (18-24 and 25-34).

Interestingly, females have been coming into the industry at a greater rate over the last decade or more since they equal 40.7% of the 18-24 age group and 19.6% of the 25-34 age group. These percentages significantly exceed the overall survey percentages of females (8.2%) and the percentages of all older female age groups. The 35-44 age group at 8.5% is close to the overall percentage but the older age groups have significantly lower percentages of females, namely 45-55 (4.9%), 56-65 (1.8%), and 65 Plus (0.4%).

All of the above observations indicate a healthy picture for the Federation and the industry.

What Proportion of Members Are in Supervisory Capacities?

The typical pyramid type structure is evident in the supervisory area (i.e., as the number supervised increases the percentage in supervision decreases). Respondents are largely grouped in the "No Supervision" category (26.7%) or as supervising small groups, 1-3 (27.7%), and 4-9 (20.7%). These three categories account for 75.1% of the total respondents. (See *Figure 12*.)

A significantly larger proportion of males (vs females) are in supervisory capacities. The disparity between the male and female percentages in supervision grows significantly as the number supervised increases. For groups over 20 in size female supervisors are almost nonexistent. This, at least in part, reflects the male/female difference in age distribution and number of years in coatings. Refer to *Figures 11B-12*.

Comparison of age vs number supervised generates the expected pattern. Supervisory responsibilities generally peak in the 35-65 age range. As shown in *Figure 13*, the curves for these age groups are essentially similar. The anomalous behavior is more the case with the 18-24 and, to some degree, 25-34 age groups where No Supervision is highest. The No Supervision category remains in a consistent range (20-26%) for all age groups in the 35-65 Plus range.

Advanced degrees appear to have a positive influence on supervisory participation at all levels of supervision, except the highest level (>49 people). Although there are some anomalies, the percentage participation in supervision from each education level is relatively close to the overall percent of that education level in the total survey population. (See *Figures 14-15*.)

Company size does not appear to have a definitive impact on supervisory responsibilities. As could be anticipated, there is an increase in the proportion with no supervisory role as company size increases (>\$10 MM). Other categories of supervision show no clear trend other than the narrowing of the pyramid. The largest concentration of respondents are

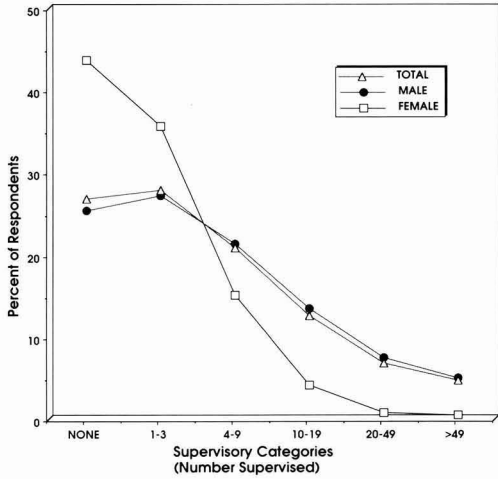


Figure 12—Distribution of Total, Male, and Female Respondents According to Supervisory Categories

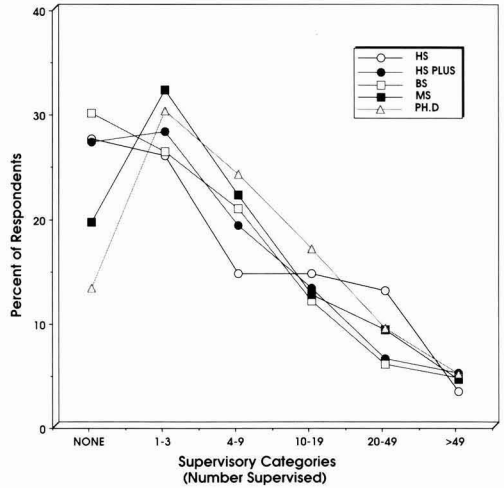


Figure 14—Distribution of Each Education Level According to Supervisory Categories

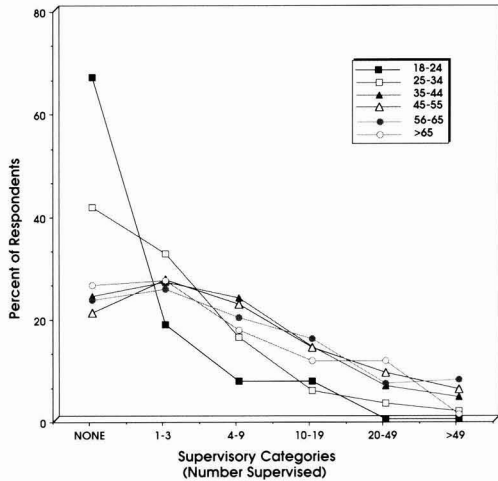


Figure 13—Distribution of Each Age Group According to Supervisory Categories

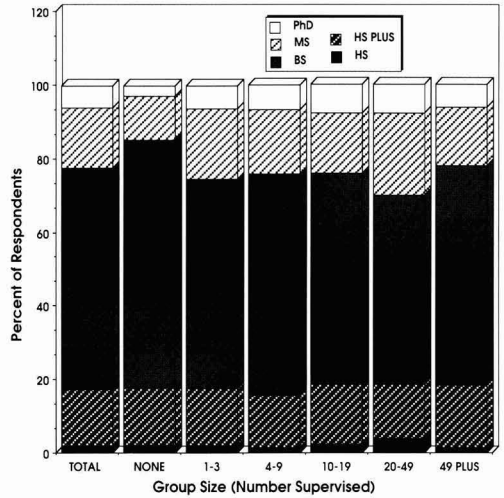


Figure 15—Distribution of Education Levels in the Total Survey and Each Supervisory Category

Table 5—Supervisory Participation of Respondents According to Years Employed in Coatings

Supervision (Number Supervised)	Time Periods of Greater Participation		Participation over Remaining Time Periods	
	Yrs in Coatings	Respondent Percentage ^a	Yrs in Coatings	Respondent Percentage ^a
None	0-10	34.6-57.9	11-40 Plus	17.2-24.5
1-3	2-15	31.0-32.4	0-2 16-40 Plus }	22.0-27.9
4-9	6-40 Plus	18.8-25.9	0-5	7.5-9.1
10-19	16-40 Plus	14.3-17.2	0-15	4.1-11.8
20-49	16-40 Plus	6.9-12.0	0-15	1.9-4.9
49 Plus	16-40 Plus	4.8-7.9	0-15	0.9-3.0

(a) Respondent percentage gives the range of participation for the indicated "years in coatings." The high and low are shown; the percentage may vary up/down within these limits.

engaged in supervision of "none" or small groups, 1-3 and 4-9. (See Figure 16.)

Supervisory responsibility does vary with experience (years in coatings). Table 5 gives a summary picture of the time periods of greater or lesser participation for different levels of supervision. The most likely levels of supervision are again "none" up to groups of nine.

SUMMARY OF KEY CONCLUSIONS

The key information that emerged from this survey included the following:

- (1) The disparity of the male/female membership distribution.
- (2) The older age of the male vs female members.
- (3) The increase in professional members (Degrees).
- (4) The fact that males hold more graduate degrees.
- (5) The skewing of graduate degrees, particularly Ph.D.'s, to older age groups (hinted in 1986).
- (6) The key educational backgrounds, namely, Chemistry (the largest), Business, and Engineering.
- (7) The key employers are still larger companies (\$10-100 MM Plus), most likely, Paint Manufacturers and Raw Material Suppliers.
- (8) Females work more for larger companies (\$100 MM Plus).
- (9) Increased education is more likely to lead to employment with larger companies.
- (10) Technical Functions are the largest category of employment, followed by Sales and General Management.
- (11) Males tend to work in Sales, Development, General Management, and R/D Management.
- (12) Females tend to work in Development, Technical Service and Research, and in Sales.
- (13) Employment with Paint Manufacturers is more likely to be in Technical Functions (including R/D Management) and in General Management (smaller companies).
- (14) Employment with Raw Material Suppliers is more likely to be in Sales-Marketing, Technical Service, and General Management.
- (15) Employment with smaller companies (\$0-3 MM) is heavier in nontechnical functions. This decreases for compa-

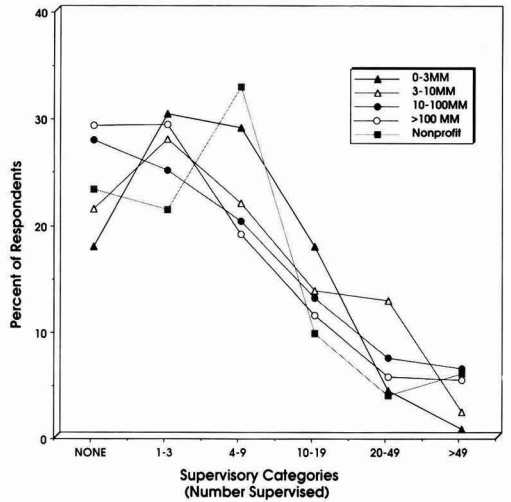


Figure 16—Distribution of Supervisory Categories for Each Company Size

nies \$3-100 MM, and becomes more heavily technical for companies over \$100 MM.

(16) The coating areas employing the most members are Industry Supplier, Architectural, and Industrial OEM coatings.

(17) Larger percentages of females were found in Architectural and Automotive OEM, while larger percentages of males were reported in Industrial OEM and with Industry Suppliers.

(18) Automotive OEM employs the highest percentage of graduate degrees and Architectural the smallest.

(19) Females are coming into coatings at a higher rate in the youngest age groups.

(20) The more likely supervisory role is with small groups 1-9 or "none."

(21) Experience (years in coatings) is related to higher levels of supervision.

(22) Advanced degrees appear to positively influence supervisory participation at all levels of supervision except the highest level.

ACKNOWLEDGMENTS

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CPVC, Critical Pigment Volume Concentration—An Overview

John C. Weaver
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Critical Pigment Volume Concentration (CPVC) as a theoretical, as well as a practical, concept was evolved into a formal statement in 1949 by Asbeck and Van Loo, following evolution of physical chemistry as a formal branch of science a half-century earlier. Prior to 1920, Coleman studied oil absorption as a specific measure of pigment surfaces. This work has been followed by a dozen or more pigment-binder properties which exhibit inflection points at the CPVC.

INTRODUCTION

Introducing contemporary papers on Critical Pigment Volume Concentration (CPVC) allows an opportunity to orient new work with ancient, medieval, and modern coatings crafts and technologies. The elegance and permanence of Japanese and Chinese lacquer ware exemplifies centuries of trial and error in optimally pigmented urushiol, a phenol from the juice of the lac tree, *Rhus Vernicifera*. The master-to-apprentice traditions of pigmentation evolved from those fragile, prehistoric Lascaux cave paintings to the soaring beauty of Michelangelo's Sistine Chapel, and to utilitarian barn and house paints from Thomas Child's ball-and-trough paint mill in 1737. Their common theme of Edisonian trial and error in paint recipes and their field testing cannot be escaped even now.

Chemical analyses of paints and their components to assure conformance to time tested paint recipes were needed by North Dakota farmers and legislators to enforce their 1906 labelling laws and defend and perpetuate native linseed oil along with white lead pigment. They needed the help of young analytical chemists Bolley and Holley, led by Ladd,¹

who founded what we now appreciate as the Polymers and Coatings Department of North Dakota State University. Their classic analytical chemistry is now greatly augmented by the physical and theoretical chemistries of Professors Bierwagen, Glass, and Marek. Rather recent repeal of the 1906 labelling law recognizes new science.

Physical chemistry in paint and varnish research had its origin according to Heckel² at Case School of Applied Science, founded in 1880 in Cleveland, OH. A.W. Smith was professor of chemistry at Case School of Applied Science from 1891 to 1827. Professor Smith's sons founded the Lubrizol Corporation. Another of his colleagues, Herbert H. Dow, (Case, class of 1888) founded what is now the multinational Dow Chemical Company. R.E. Coleman and Max Y. Seaton, who earned his B.S. Degree at nearby Case in 1912, began systematic studies of pigment properties, presumably under the guidance of Professor Smith. Their systematic study of the absorption of linseed oil by a dozen diverse white and inert pigments was reported in 1920 by Gardner and Coleman.³

Coleman's 13 pages of incisive reason and examination of variables resulted in ASTM D 1483, Standard Test Method for Pigments by the Gardner-Coleman Method, which is still in worldwide use. Coleman was one of the dozen founders of the Cleveland Club of Paint Superintendents in 1914. This was the forerunner of the 15 clubs which formed the Federation of Paint and Varnish Production Clubs in 1922 in Cleveland. The group has now grown into the 26 Constituent Societies of the Federation of Societies for Coatings Technology.

PIGMENT-BINDER INTERACTIONS

Oil Absorption

Oil absorption (OA) on pigments as a theoretical concept pioneered by Coleman improved on classical pestle and spatula rubups and led to many variants of the method care-

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fully reviewed by Gardner's career-long colleague, Sward.⁴ He extended these concepts to *free binder and pigment packing* as surface phenomena leading to Walter K. Asbeck's critical pigment volume concepts.

Hydrophile-Lyophile Balance

Hydrophile-lyophile balance (HLB) was conceived and developed in the early 1940s by William C. Griffith, of the Atlas Powder Company. Although he focused mainly on the stable emulsification of diverse immiscible liquids, his application of surface tension concepts naturally impinged on wetting of pigments by both hydrophilic and hydrophobic liquids. Griffith chose an arbitrary HLB scale of 0 to 20 for maximum hydrophilicity. He chose

$$\text{HLB} = 20(1 - S/A),$$

where S=saponification number of an ester and A=acid number of an acid in that ester. Obviously the HLB concept extended Coleman's OA measure of the wetting of pigments toward stable waterborne coatings, but not handily.

In 1962, Gary L. Weidner, of Atlas Chemical Industries, now ICI America, Inc., published a pamphlet, *Application of the HLB System to Selecting Pigment Dispersants for Water Based Paints*. Weidner plotted for diverse pigments the viscosity and sedimentation stability as functions of the HLB.

Flow point for optimum dispersion or milling of pigments was developed in 1946 by Daniels.⁵ He used a spatula rub up method to carry the titration of a pigment by a liquid past Coleman's cohesive point to a *wet point*, and beyond to a *flow point* judged suitable for milling. Elaboration of this concept by him and others, notably T.C. Patton and C.M. Hansen, to encompass all types of mills, diverse surfactants, and various binders beyond Coleman's linseed oil studies, were quantified and summarized by Daniels.⁶ Opportunity continues for quantifying these multidimensional complexities into a unified rheometry design encompassing the low to high shear rates of practical high speed impeller and bead media mills.

CPVC BEGINNINGS

World War II brought many disruptions, urgencies, challenges, and opportunities. The 1990 American Chemical Society's Roy W. Tess Award recipient, Walter K. Asbeck, and his older brother, Hans J. Asbeck, both earned B.S. and M.S. Degrees at Case and Ph.D.s in Berlin. Each contributed to the general theme of pigment/binder relationships.

Hans joined The Sherwin-Williams Company laboratories in Cleveland in 1937 and completed his Sherwin-Williams career upon retirement a dozen years ago from the Sherwin-Williams, Venezaleno, C.A. In the Cleveland laboratories during World War II, Hans mitigated some of the hard settling of zinc chromate primers for military use by combined trial, error, and reason amid benchtop cohorts of 100 mL graduated cylinders for practical settling tests. He mitigated the settling urgency of a 3000-gallon dip tank at

Goodyear Aircraft by adding to the primer formulation one-quarter ounce per gallon of a two percent solution in toluene of either maleic anhydride or phthalic anhydride.

Walter earned the Ph.D. Degree in 1940 at the Technical University in Berlin. War time restrictions kept him there until the 1945 cessation. In Berlin, he and Wachholtz⁷ developed the Band Rheometer which utilizes the gravitational free fall through an accurately designed slot of a weighted ribbon, for example, Mylar™ which carries the test liquid from the top of the slot. Zettlemoyer et al.⁸ used a Paint Research Institute grant to study it in "Carbon Black Deagglomeration During Laminar Shear" while at Lehigh University. This elegantly simple design deserves more study of variations in slot depth and clearance for magnitudes of shear rate applied to diverse pigment/binder compositions in both milling and application of coatings. It deserves a new generation champion for further research.

W.K. Asbeck joined the Sherwin-Williams research laboratories in Chicago, IL, in 1946. He took over from departing W.H. Slabaugh a systematic study of the many variables of the zinc chromate primer compositions and properties. Meanwhile, through the war years, his supervisor, Maurice Van Loo had led the research and development of conserving scarce linseed oil in civilian house paints. Better overall performance by replacing part of the raw linseed oil by a lesser amount of polymerized, refined linseed oil posed questions on the fundamentals of pigment/binder relationships. These questions were pursued by Asbeck and Van Loo under the improved research climate resulting from the 1947 appointment of Arthur B. Holton as the first Sherwin-Williams corporate level Director of Research and Development, less dependent on marketing and local business and production managers. This resulted in the 1949 landmark publication by W.K. Asbeck and Van Loo⁹ of "Critical Pigment Volume Relationships," based mainly on the raw and bodied linseed oil/pigment relationships. It has become almost biblical in frequency of reference by subsequent researchers.

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A Critical Look at CPVC Performance And Applications Properties

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Consultant*

Critical Pigment Volume Concentration (CPVC) influences the behavior of coatings systems directly or indirectly. Performance, coating applications, production, and storage characteristics are all affected. Although the principles of the CPVC concepts are identical for solution- and dispersion (latex)-type coatings, the details of their causes are not the same. Thus, the CPVC of solution coatings can respond strongly to the degree of dispersion or agglomeration of the pigment particles as a result of the vehicle which may be used. Agglomerated particles will have lower CPVC than systems of well dispersed particles of the same pigment. With latex coatings, the quantity, size, and size distribution of the latex particles,

as well as the type and quantity of the coalescing agents used, can result in different values of the CPVC for the same pigment system.

The application properties of coatings are also strongly influenced by relative CPVC. For solution-type coatings, flow and sag can be controlled by lowering of the CPVC from the Ultimate Pigment Volume Concentration (UPVC) due to slight agglomeration of the pigment particles. In contrast, for dispersion-type coatings, the pigment system must virtually always be formulated at the UPVC and flow is controlled by the use of thickeners. The reasons for this behavior are explained.

INTRODUCTION

The Critical Pigment Volume Concentration (CPVC) of a coatings system is a ubiquitous property which directly affects the manufacture, application, performance, and appearance of all coatings.

Consequently, it is imperative that those connected with the coatings industry be aware of what CPVC is and how it works. Those who should be concerned include not only the coatings manufacturer, but also pigment suppliers, resin suppliers, solvent suppliers, and certainly those who vend "additives" to the industry.

What really is the Critical Pigment Volume Concentration? It had been known that if a Pigment Volume Concentration (PVC) ladder of the same pigment or pigment mixture using the same vehicle resin and solvent combination is applied to a substrate and allowed to adequately

dry, the tested performance characteristics are found to change with increasing percentage quantities of the pigment present.¹

These changes with low percentages of pigment in the composition are usually rather gradual. However, above a percentage of the PVC, radical changes in coatings performance usually take place. At low pigment concentrations, for instance, the permeability of the coating to water vapor, other gases, or liquids may be rather low. Beyond a certain pigment concentration the permeability suddenly becomes very high. Similarly, rusting, blistering, gloss, surface roughness, enamel hold-out, hiding, and even such characteristics as tensile strength and elongation usually change radically. Virtually any performance characteristic of the dried coating seems to show this radical change with differences in the PVC.

If such performance characteristics are graphed, a surprising result is found: all these major changes are observed at essentially the same PVC for a given pigment system. This has come to be known as the Critical Pigment Volume Concentration of the system. This is shown

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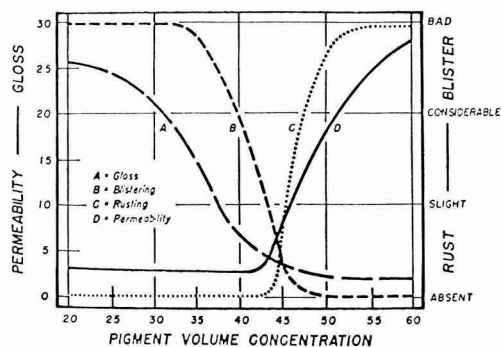


Figure 1 — Effect of CPVC on coatings performance

schematically in Figure 1, where some of the performance characteristics are plotted against the incremental pigment composition of the coatings system.

Figure 2 is a "model" of the situation found in the paint ladder. In the case shown, each step in the composition ladder is a 10% increase in the volume concentration of the pigment. Smaller or larger increments can be used. In general, somewhat smaller incremental changes surrounding the CPVC will result in more accuracy in exactly determining this point.

From the model, we can see that at the CPVC, there is just sufficient binder left in the coatings composition after volatilization of all the solvent to completely fill the voids left between the pigment particles under the specific condition of packing which they have assumed. Below this point, the coating is coherent. Above it, an increasing number of little air voids or holes begin to appear. In other words, the coating becomes increasingly porous above the CPVC.

It is this single fact which influences all other coatings properties which may be tested. Conversely, any test which assesses the onset of porosity in a dried coatings system is capable of defining CPVC of this coating.

Tests for determining the CPVC of a coating must take four points into account. First, since the CPVC represents the densest degree of packing which the pigments can occupy, commensurate with its degree of dispersion, it is necessarily a volume phenomenon.

Second, it is a phenomenon associated with the finished paint. All ingredients of the coatings composition must be present in the formulation including the pigment or pigment mixture, the vehicle or mixture of various resins, the solvent, and any additives which might be required in the paint in order to obtain the true CPVC of this system.

Third, the paint must be dispersed by some method to the equivalent point as it would be found in the finished product.

Fourth, it is a phenomenon associated with the dried coating. All solvent must have evaporated before the classical tests are run.

Some 20 classical tests have been described in the literature in nearly 200 publications.² All tests are carried out on dried films. The more nearly these tests assess the exact point of the initial onset of porosity, the more exact the measured results will be.

Even the fact that high-dry hiding takes place above the CPVC reinforces this concept. Since hiding is directly related to the differences in refractive indices of the vehicle and the dispersed phases, the inclusion of well dispersed air voids with a refractive index of 1 compared to that of vehicles in the range of 1.4 to 1.6, or that of the hiding pigments, which can be as high as 2.7 refractive index.

This, of course, is used to an advantage in the practical formulation of ceiling white paints and other applications, where the added hiding due to the coatings porosity is not a detriment for such properties as scrubability, cleanliness, and dirt absorption.

All these performance property changes can thus be readily accounted for by the knowledge that the pigment in the attached coating becomes progressively more crowded with increasing PVC, and that the coating consequently must become progressively more porous with further increases of PVC above the CPVC.

Any nonclassical tests which emulate these conditions can, of course, also be successful in assessing this point.

Unfortunately, any of the methods utilizing the PVC ladder are necessarily time-consuming, since a number of the paint compositions spanning the expected CPVC must be made up, adequately dispersed, applied to some substrate, dried, and then tested by one or more of the procedures already listed.

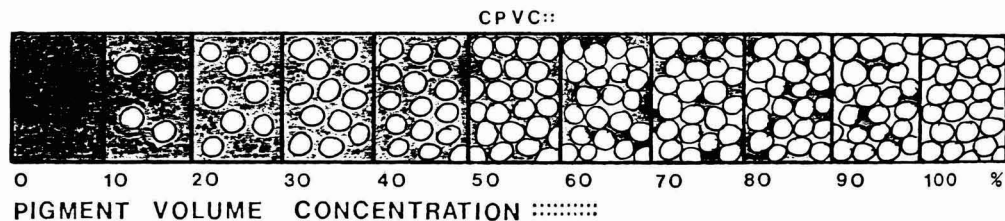


Figure 2 — PVC ladder with CPVC (arbitrarily) at 50%

In order to reduce this time and expense, a relatively fast and simple method was developed early in the original studies, which can be used with any solution-type coating.

CPVC CELL METHOD

The CPVC cell simulates in bulk the packing of the specific paints in question at the CPVC.³

The cell as shown in *Figure 3* consists of a standard 30 mL tall-type fritted glass Gooch filter crucible with medium fritted glass plate. The top edge of this crucible is ground plane with fine emery paper or carborundum on a glass plate. A special glass or stainless steel lid with a flat bottom, as shown, is placed over the top to allow measurement of the volume of the cell. This is conveniently done by "plugging" the frit with a light oil and measuring the total volume of the empty cell with the lid in place by means of water from a burette. The frit is then freed of the oil by sucking this out with a vacuum.

To make a measurement, an exact volume of the paint to be tested is introduced into the cell by means of, for instance, a calibrated syringe. The liquid portion of the paint is filtered out by applying a vacuum on the bottom of the Gooch crucible in the usual manner.

The exact volume of the resulting filter cake is then measured by filling the cell completely with the lid in place from the burette. The difference between this volume and the empty volume of the cell is the volume which the packed pigment cake occupies.

Dividing this volume into the true volume of the pigment known from the formulation and the quantity introduced into the cell is then the CPVC of the paint system.

Some precautions and means of accelerating the filtration and paint making processes can be employed, and these are described more fully in the original publication.¹

The results so obtained correspond closely to those obtained on the same coatings composition as found by the PVC ladder tests.

It is interesting to note that any air voids introduced into the system at the specific packing of the pigment particles after adequate filtration are immaterial in the testing process. This is due to the fact that the water does not penetrate any surface voids in the "oily" surface of the filter cake due to the effect of surface tension. Consequently, the total volume of the packing is measured, regardless of the number of air voids which may be present.

Besides providing a relatively fast test method, the procedure illustrates that the packing behavior of a coatings system only several mils thick is essentially duplicated in a packing system which can be many hundreds of times thicker. It confirms that any adsorption effects of vehicle molecules at the substrate or air interfaces are negligible in the packed pigment system of a practical paint film.

The method works quite well with virtually all solution-type coatings systems. However, it cannot effectively measure the CPVC of a conventional dispersion (latex) system since the soft latex particles plug the frit, disallowing the filtration step.

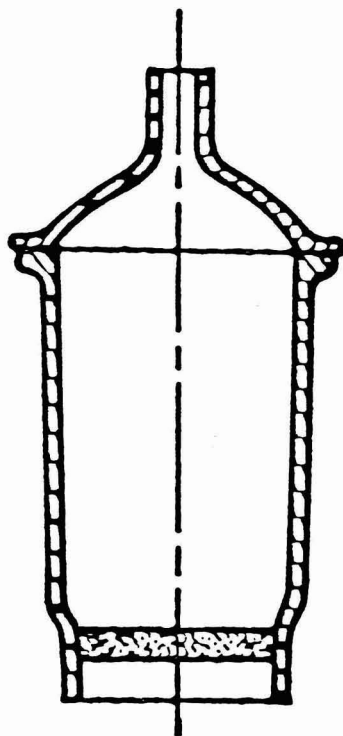


Figure 3 — CPVC cell



Figure 4 — Differences in flow properties due to degree of dispersion for the same pigment

A rather close approximation to this can be achieved, nevertheless, by measuring the packing characteristics of the pigment alone, without the addition of the latex phase, but with the use of all the additives in the aqueous carrying phase. Although the reading will not necessarily be the exact value of the CPVC since it is known that latexes of different particle sizes can yield different measured values with a given pigmentation,⁴ the results should be adequate enough to give the formulator a reasonable starting point.

OIL ABSORPTION

Oil absorption (OA) methods have been suggested to quickly determine the CPVC of given coatings systems. However, despite this desirability, unfortunately there are numerous reasons why these must be dismissed.

Chief among these reasons is the fact that the OA methods do not emulate the conditions found in the dried coating at the CPVC. Usually single pigment, rather than the combination of pigments employed in a formulated coatings composition, is used. Instead of the formulation vehicle, linseed oil is substituted. No high energy grinding step is used, and the pigments are not allowed to pack in the same free manner as in an applied film.

From a practical point of view, further complications arise. End points are difficult to determine and extensive studies have demonstrated that different operators utilizing the same OA method may differ in the results obtained by ratios as high as 2:1. The use of one of the many OA methods described utilizing a different manner of testing such as the Barber-Coleman or Spatula Rub-Up methods may cause even greater deviations in the results obtained.⁵

Thus, although the various OA methods mix pigments and linseed oil into a paste by various strategies, they do not approximate closely enough the conditions found in the dried manufactured coatings films to be reliably considered as a measure of CPVC.

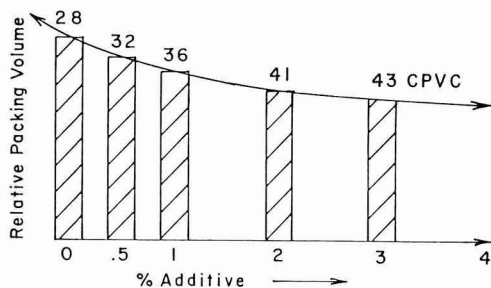


Figure 5 — Packing of the same pigment system due to differences in dispersion

Whereas any one of the OA methods which may be used can give only a single reading for the result, CPVC methods can distinguish clearly the degree of dispersion or agglomeration which may take place and which may give substantially different results for the same pigment, but using different vehicles of various dispersive capacity.

Also, the OA methods are not amenable to the aqueous dispersions encountered in latex coatings. Indeed, if OA methods had given the true value of the CPVC, all the subsequent work on this process would have been superfluous.

CALCULATIONS

Some considerable successes have been achieved in calculating the CPVC values of latex coatings by use of the particles' size distributions and quantities used of the pigment mixtures and latexes.⁶ However, this requires computers and sophisticated programs which may not always be readily available to formulators.

DISPERSION VS AGGLOMERATION

It had been found early in the original work on CPVC¹ that the same pigment ground in different solution-type vehicles can give substantially different values of the CPVC. This is true whether the measurements are made by the traditional PVC ladder methods or with the use of the CPVC cell.

Thus, the same TiO₂ pigment prepared in bodied linseed oil gives a value of the CPVC of 38%, while the same pigment ground in raw linseed oil gives a lower value of only 26%. Similarly, a given magnesium silicate pigment in bodied oil has a CPVC of 46%, whereas the same pigment in raw linseed oil has 41%. Many other pigment systems, as well as mixtures, show this difference.

One of the major fallacies which has crept into the literature is that the CPVC is considered a characteristic of only the pigment. In fact, the CPVC of a given pigment system or pigment mixture can have a number of different measured values depending upon the specific vehicle into which the pigment is dispersed. Additives, such as wetting agents, or even the presence of excess moisture, or



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the degree of grind, can influence the CPVC of a given pigment system.^{1, 3}

This difference in solution-type coatings has been found to be due to the degree of dispersion or agglomeration of the pigment system due to the dispersive capacity of the vehicle.

A simple laboratory experiment has been carried out to clearly demonstrate the effects of dispersion vs agglomeration on the CPVC.⁷

MODEL SYSTEM

A model system of TiO₂ pigment dispersed in a white mineral oil is ground, for instance, in a three-roll mill set at tightest clearance. This assures complete removal of any hard aggregates and assures complete replacement of the air at the pigment/vehicle interface.

This master batch is then divided into five aliquot parts. One sample is retained "as is," whereas 0.5%, 1%, 2%, and 3% of a commercial flow agent are added to the other four. These samples are then simply stirred or shaken for a short time with no further grinding of the pigment.

A dramatic visual change results. The sample with no flow agent addition appears to be puffy, and shows a high rheological yield value. With increasing addition of the flow agent, the samples show increasing amounts of flow. The dramatic differences between the "no added surfactant" and the 3% additions are shown in Figure 4.

It should be recalled that this difference is a purely physico-chemical one. No additional energy input is re-

Table 1 — TiO₂ in White Mineral Oil

Additive (%)	CPVC (%)	Relative Packing Volume
0	28	1.5
0.5	32	1.35
1.0	36	1.2
2.0	41	1.05
3.0	43	1.0

quired to achieve it, apart from distributing the surfactant molecules reasonably well within the vehicle.

Measurement of the CPVC with the CPVC cell gives the results shown in Figure 5. This shows the relative packing values of the same true volume of pigment caused by the addition of the various quantities of dispersant. The packing values and concomitant CPVC values are shown in Table 1.

It is most interesting to find that the highly agglomerated system packs about 50% larger than the most dispersed system for exactly the same quantity of pigment, leading to a CPVC difference of 15%. This is more clearly illustrated in Figure 6, where the relative packing volumes of the system with 3% added wetting agent, and that with no wetting agent, are shown.

DISPERSION AND AGGLOMERATE SIZE

The reason small additions of a flow agent or other surfactant cause this large difference in CPVC and concomitant relative packing volume was already explored in

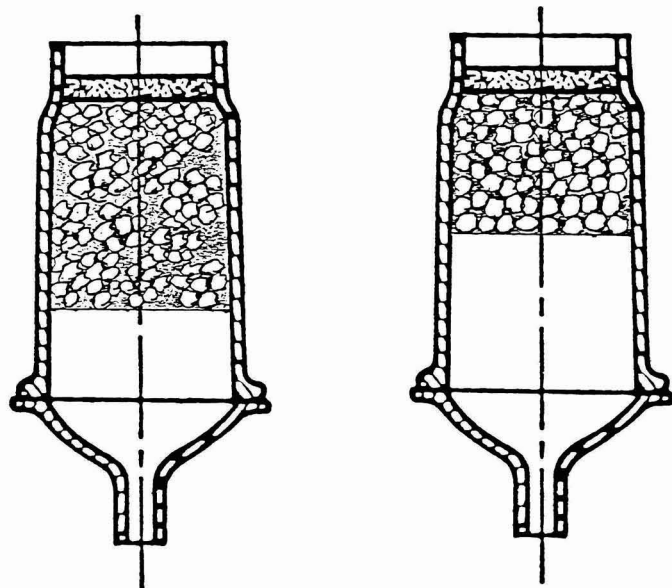


Figure 6 — Differences in packing volume of a given pigment in the dispersed (CPVC = 45%) and agglomerated (CPVC = 28%) state

Table 2 — TiO₂ in White Mineral Oil

Additive (%)	CPVC (%)	Relative Packing Volume	Relative Agglomerate Size	No. of Primary Particles
0	28	1.5	13	~2000
0.5	32	1.35	5.8	200
1.0	36	1.2	3.4	40
2.0	41	1.05	1.3	2
3.0	43	1.0	1.0	1

previous papers.^{1,7} Lack of surfactant causes severe agglomeration of the pigment particles under the specific set of experimental conditions employed. As more dispersant is added, the agglomerated particle size becomes progressively smaller, achieving complete dispersion of the individual pigment particles as sufficient dispersant is added (3% in the earlier example). Addition of more surfactant does not increase the degree of dispersion.

Agglomerate size can easily be determined in a number of ways, the simplest being, perhaps, by permeation methods utilizing the CPVC cell, or by hindered sedimentation. These methods are adequately described in the literature, where the equations to be used and precautions to be observed are listed.⁸

The permeation method was employed in the present case utilizing the CPVC cell with the results shown in Table 2.

An additional, rather surprising fact can be observed when sedimentation methods are used with a homogeneous pigment type. The agglomerate size is found to be remarkably uniform in each individual case. Large agglomerates show no individual particles present; conversely, when the particles are well dispersed, no large agglomerates are observed (provided there are no large, aggregated hard particles left after the "grinding" step). The basic reasons for this behavior are predicated on surface energy and entropic considerations.

However, a much more simplistic point of view can be employed to adequately describe the gross physico-chemical conditions that prevail in the equilibrium established between pigment particle, surface active agent, and liquid. This may allow the coatings formulator a

more simple and direct method to predict (or outguess) in which of several possible directions his formulation should be changed to obtain optimum performance for this paint product.

THREE-DIMENSIONAL SOLUBILITY PARAMETER

The three-dimensional solubility parameter has been recognized as an important theoretical and practical means of predicting which solvent or solvent combination is effective in dissolving a given vehicle polymer.^{9,10} Those concepts were extended by Hansen to apply to the dispersion of pigments as well.

Thus, when components of the vehicle liquids and solvents match the quantitative energy requirements of the pigment surfaces, dispersion of the pigment particles results. If there is a deficiency of these elements, the pigments will clump together as agglomerates, even if they may have been temporarily well dispersed in the rheological high shear field of the dispersing equipment.

Thus, the experimental conditions of the cited model of the TiO₂ pigment in white mineral oil were deliberately chosen to give a considerable mismatch to the dispersion and solubility parameters between pigment and vehicle. The TiO₂ has a crystalline and highly polar surface, whereas the white mineral oil is highly hydrocarbon-like. As a consequence, a considerable degree of agglomeration was expected, and, of course, found.

ROLE OF WETTING AGENTS

It has long been known that a prime method for dispersing a highly agglomerated pigment system is by use of surface active materials—the wetting, dispersing, or flow agents. Unfortunately, this has been accomplished by trial-and-error methods, since no scientifically valid method has, so far, been found where the type and quantity of surface active agent can be predicted and calculated for any arbitrary pigment particles or vehicles which might be chosen.

The use of the three-dimensional solubility and dispersion parameter concepts will allow considerable insight into this perplexing problem.

What is required of the surfactant molecule is obviously that:

- (1) The "head" must match the dispersion parameter of the solid surface.
- (2) The "tail" must match the solubility parameter of the vehicle.
- (3) The two molecular ends, head and tail, must be held together by physico-chemical forces such as chemical, ionic, or other reasonably strong bonds.

Since the three-dimensional solubility parameter for organic molecules can now be more or less accurately calculated from their structure alone,¹⁰ it is obvious that much progress may be possible in reducing the time-consuming, trial-and-error methods presently required to find the "proper" surfactant molecule or the combination of molecules to effect efficient and controlled dispersion of pigment particles in coatings vehicles.

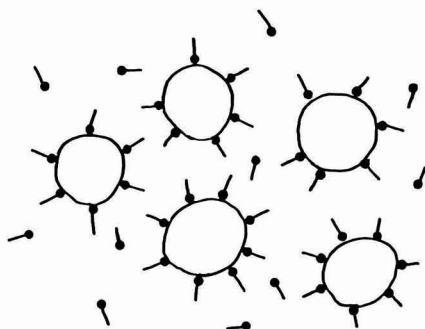


Figure 7 — Pigment particles with dispersing molecules

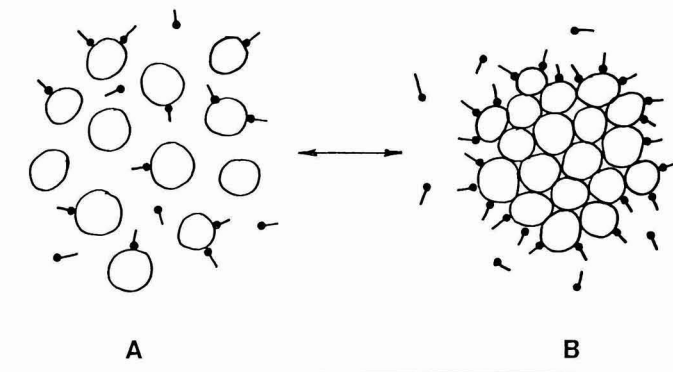


Figure 8 — Pigment particles with insufficient dispersing molecules

The concepts would also, of course, apply to foaming, anti-foaming, flotation, etc., where surfactants play a major role in the success or failure of the process.

The previous data is predicated on rather complicated surface energetic concepts. The overall results, however, can be described in a rather simple model.

WETTING AGENT MODEL

Dispersions of fine particles in a liquid have a tendency to cluster or agglomerate unless they are stabilized by molecules which satisfy the energy requirements of the solid/liquid interface. When such a match is not present, the special wetting agents, one end of which matches the values of the pigment surface, the other the liquid, can be effectively employed. These amphoteric molecules adsorb on the pigment surface in such a way that the original antagonistic surface has been transformed into a compatible one.

This may be thought of simplistically as the dispersing agent molecules "hiding" the pigment from the surface energy requirement of the liquid.

When enough of such surface active molecules are adsorbed on the surfaces of the solids, the particles will be completely dispersed in the liquid in a monodispersed manner.

The situation can be depicted as shown in *Figure 7*. The dispersing molecules substantially cover the surfaces of the particles, which are then free of attracting forces. The situation might be described as the liquid "not knowing" that the particles are present, and that the particles actually may repel each other through electrical interaction or through steric hindrance.

When no such stabilizing molecules are present, or when the surfaces are incompletely covered, the situation as shown in *Figure 8A* results. Here some portions of the pigment particle surfaces are covered with the surfactant molecules, whereas other portions are not. Under the high shear conditions of "grinding," the particles are momentarily substantially separated from each other due to the intense shear field of the dispersing process. As soon as the process ceases, however, Brownian motion has a

tendency to move the particles statistically and haphazardly toward each other, to the point where they may touch. If two particles approach each other with the surfaces having the dispersing molecules facing each other, they will repulse each other. Where these molecules are absent, the particles may become permanent pairs and then become larger agglomerates.

It is known that the adsorbed molecules are not permanently bound to any particular spot on the pigment surface. Rather, there is a dynamic equilibrium between those molecules which are adsorbed and those which are suspended in the liquid.

When the agglomeration process due to the Brownian motion has reached an equilibrium, a situation as depicted in *Figure 8B* will result. The particles which do not have the stabilizing molecules on their surfaces will be crowded into the interior of the particle agglomerate, whereas those which have the molecules adsorbed will show that portion to the vehicle. The resulting agglomerate can be considered to have a "skin" on the surface of the adsorbed molecules which segregates the cluster of particles from the carrying vehicle liquid.

This simple concept leads to a number of interesting insights into the behavior of agglomerated pigment particles.

A given true volume of pigment particles must necessarily pack to a larger volume, since the agglomerated particles displace not only the liquid contained within the interstices of the particles participating in the body of the agglomerate, but, also, all that liquid between the agglomerates themselves. Consequently, agglomerated particular systems must always have a lower CPVC than the same pigments packed as a monodisperse phase.¹

The high degree of agglomerate size uniformity found in sedimentation experiments also becomes apparent. Because of the principle of energy conservation, monodisperse particles existing in the presence of agglomerates would require a disproportionately larger quantity of the scarce dispersing agent molecules compared to those required by the agglomerated particles. They would "rob" the larger agglomerates of their share of these molecules. The equilibrium condition then tends toward a uniform

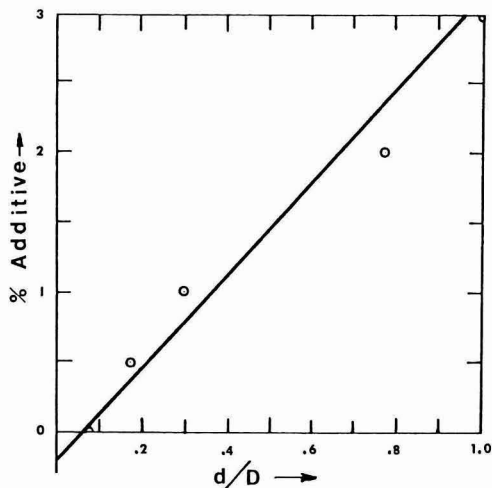


Figure 9 — Agglomerate size dependence on added surfactant

agglomerate size, where each has its share of the dispersant molecules available proportional to the total area which these molecules can cover.

The lack of color development in the “rub-up” tests requiring hiding, extender, and colored pigments can also be readily explained by variations of these concepts. The surface requirements of these three groups of pigments need not necessarily be the same. The surfaces of the hiding pigments (such as TiO_2) and the extender pigments are usually polar in nature, whereas those of the colored pigments, particularly the organic types, can often be more nonpolar or hydrocarbon in nature.

The three-dimensional solubility parameter concept indicates that it is very possible that a sufficient number of compatibilizing molecules may be present in the vehicle to disperse the hiding and extender pigments, but not to disperse the colored pigments. These will consequently have a tendency to cluster together as agglomerates, thus resulting in poor color development. Because of the very high shear field induced, the rub-up process would disperse these colored pigments much more effectively, resulting in more color development in the coating. The more the pigment surfaces deviate from each other in the three-dimensional dispersion parameter, the more likely this phenomenon will occur.

The solution to this problem is, of course, to add the proper dispersing aid to the coating system such that the head of the molecule will adsorb to the agglomerated pigment particles, and the tail be compatible with the vehicle, similar to the tail which makes the hiding and extender pigments compatible.

Furthermore, the concept indicates that pigment systems with smaller particle sizes will generally require more of the dispersing molecules, since they have a larger surface area per unit volume. This requirement will be proportional to the sum of all the pigment surface areas or to the reciprocal of their diameters.

From a practical point of view, a pigment in a given paint formulation may be well dispersed. A pigment system with the same surface characteristics but a smaller particle size may, in contrast, show agglomeration, since there will no longer be a sufficient number of dispersing molecules present to give monodispersion.

Pigments used as flow control agents to increase rheological structure are typical of this phenomenon. They must be very small with very large surface area per unit volume to “rob” the system of dispersant, and thus cause partial co-agglomeration of the primary pigment system and a concomitant reduction in the CPVC.

A direct relationship should exist between the quantity of dispersing agent present and the relative surface area of the agglomerate and the agglomerate size. The surface area covered should be directly proportional to the amount present, and the reciprocal of the agglomerate size, for a given concentration of total pigment volume. Reasonably good fits in this relationship are found in Figure 9, which shows the reciprocal of the agglomerate size plotted against the percentage of wetting agent added to the dispersion.

It is interesting to note that about 0.25% of wetting agent was already present in the TiO_2 /white mineral oil composition of the earlier “model” example despite the fact that surface requirements of pigment and vehicle were chosen to be as different as possible.

AGGLOMERATE SIZE AND CPVC

It was found in the original work on the CPVC that the same pigment system dispersed in various solution type vehicle resins could result in materially different values of the CPVC.¹ This was found to be due to the fact that the pigment particles would be dispersed or agglomerated more or less. Those pigment systems dispersed to a monodisperse condition invariably gave lowest packing commensurate with the highest CPVC. In contrast, agglomerated systems always resulted in more expanded packings and concomitant lower CPVC.

Obviously, when the particles are all completely dispersed where no agglomeration is present, the packing will assume its densest configuration commensurate with the particle size distribution. The particles cannot pack more tightly. This is the Ultimate Pigment Volume Concentration (UPVC)—the limiting or maximum value of the CPVC. For a given pigment system or pigment mixture, it is the highest CPVC that may be attained. The UPVC is significant since it is the only value of a pigment system which can presently be calculated from the particle size distribution and shape alone.

If the pigment particles are agglomerated, however, the packing volume per unit volume of pigment is found invariably to be higher, and the CPVC of the system is correspondingly lower. A simple model elucidates how the relationship between agglomerate size and CPVC can be reconciled. It is based on the concept of the relative expanded volume occupied by the agglomerate above and beyond that occupied by the well dispersed particles alone.⁷ Figure 10 shows a more or less spherical agglomerate of a number of individual particles. The hydraulic

volume occupied by the agglomerate is not that of the spheroid D , but it is that shown by the dotted line drawn through the approximate center of the outside layer of particles, $D-d$.

The relative reduced hydraulic volume is thus:

$$V_h = k \left(\frac{D}{d} - 1 \right)^3 \tag{1}$$

where D is again the average outside diameter of the agglomerate, and d is that of the average individual particle.

The hydrodynamic increase in the volume beyond that occupied by the individual particles alone at the UPVC is then the ratio of the apparent volume of the agglomerate to the true volume or:

$$\frac{U - C}{U} = k \left(\frac{D}{d} - 1 \right)^3 / \left(\frac{D}{d} \right)^3 \tag{2}$$

$$= k \left(1 - \frac{d}{D} \right)^3 \tag{3}$$

If it can be further assumed that the packing of the particles in each of the agglomerates is nearly equal to or is equal to the UPVC, the constant k becomes the UPVC and the very simple relationship that results is:

$$k \approx U \tag{4}$$

$$\frac{U - C}{U} = U \left(1 - \frac{d}{D} \right)^3 \tag{5}$$

The validity of this relationship can be readily tested with the data of *Table 2*. A plot of one minus the reciprocal of the relative agglomerate size quantity cubed against the CPVC of the tested samples should result in a straight line with the intercept being the reciprocal of the UPVC on the Y axis, and UPVC on the CPVC axis. *Figure 11* shows that this is very nearly true, well within experimental error.

The results are sufficiently accurate to allow a good assessment of the agglomerate sizes in systems with incomplete dispersion of the particles due to insufficient wetting capacity of the vehicle and to make ready use of this relationship.

There is also one apparent contradiction which is actually anticipated by the model. This is the fact that the relationship does not accurately hold for the measurement of the smallest of the agglomerated sizes. This was measured to be statistically about 1.3 times the primary particle size. It is of course obvious that there can be only either a single particle or particle pairs present in the dispersion, so that the derived relationship would not hold here.

For the larger measured agglomerates, there are a sufficient number of particles present to effectively average out the measured fractional agglomerate diameters.

LATEX COATINGS

It is perhaps pertinent to note that latex coatings were in their very infancy when the original work on CPVC was carried out. Styrene-butadiene latex resins using casein as the thickener were just beginning to be marketed. Consequently, latex coatings were not yet considered in

these studies. In the meantime, of course, latex systems have become an important portion of the coatings market.

The theoretical considerations described for solution coatings also apply to latex coatings. Thus, the CPVC of latex coatings can be determined by any of the classical methods already described. As with solution coatings, the CPVC is again a measure of the onset of porosity in the dried coating.

A rather important difference exists, however, between solution coatings and latex coatings, which materially affects the theoretical, as well as the practical considerations of CPVC. This is due to the fact that agglomeration of the pigment particles may not generally be permitted in latex systems, whereas partial agglomeration may be an important formulating tool for regulating application properties for solution-type coatings, as will later be described.

This is due to the fact that latex coatings require complete stabilization of the latex particles. This means that any pigment added to the latex particles must not allow "robbing" of the surfactant already employed to stabilize the latex. Since the latex particles are generally designed to coalesce at room temperature, the absence of complete coverage of the resin particles by dispersing molecules would allow them to touch and become permanent pairs. This would permit subsequent agglomeration and premature coagulation of the latex particles in the paint during the manufacturing process or during storage.

To avoid the coagulation of the latex particles, enough dispersant is provided that the addition of pigment to the formulation (or the reverse) does not deplete the dispersant molecules already adsorbed on the latex particle

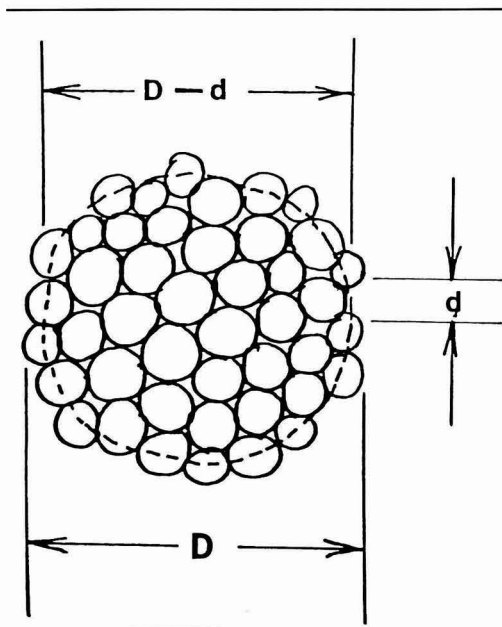


Figure 10 — Relative hydraulic volume

surfaces. This means, however, that the pigment particles must also be essentially monodisperse, equivalent to the condition found at the UPVC for solution-type coatings. As will be shown subsequently, this also influences the application properties of latex coatings. The rheology for latex and solution coatings systems is consequently different.

Since all the particles in the paint, including both pigments and latex, are essentially monodisperse, it has become possible, as already mentioned, to accurately predict the CPVC of these systems with the use of rather sophisticated mathematical calculations.⁶

The same is not necessarily true for solution-type coatings except where these are completely deflocculated at the UPVC, since there is as yet no theoretically valid means of predicting the degree of agglomeration of these systems where the CPVC may often be substantially lower than the UPVC for the reasons already explained.

RHEOLOGY OF COATINGS AS RELATED TO CPVC

Solution Coatings

A review of *Figure 4* demonstrates clearly that the model dispersion of the TiO₂ in white mineral oil shows extreme differences in flow properties. Whereas the sample with the 3% dispersing agent added demonstrates rather good flow properties, the sample with no dispersant added is puffy and stiff, and does not flow at all. The three samples having 0.5%, 1%, and 2% additive show visual differences commensurate with the amount of agent added. If the viscosities of these samples are measured over a large range of shear rates, these will also show extreme differences, as expected. Whereas the 3% additive sample shows nearly Newtonian behavior, the sample with no added flow agent shows viscosities many orders of magnitude higher, when measured at low shear rates.

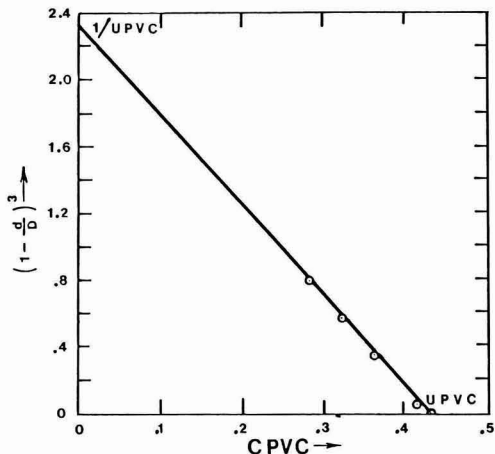


Figure 11 — CPVC dependence on agglomerate size

Obviously, these measurements confirm the visual expectation that there is indeed a major difference in flow properties due to the dispersion or agglomeration of the pigment particles and the concomitant lowering of the CPVC from the UPVC value. There is then a direct relationship between flow properties of a given solution-type paint system and the relative CPVC of that system.

The lower the CPVC is than the UPVC, the “puffier” the rheological qualities of that paint will be, and the more rheological structure will be present.

The quantitative relationships derived⁷ can shed considerable light on flow properties, agglomerate size, and the CPVC of coatings systems.

It has been shown by Casson¹² in his semi-quantitative derivation that a relationship in the rheological properties of solution paint systems and printing inks exist such that:

$$\eta^{1/2} - \eta_{\infty}^{1/2} = (\tau/\dot{\gamma})^{1/2} \tag{6}$$

where η is the viscosity of the system, τ is the shear stress, and $\dot{\gamma}$ is the shear rate. η_{∞} is the viscosity of the system at “infinite shear rate.”

If the viscosity data on the TiO₂/white mineral oil is graphed, the Casson plot in *Figure 12* is obtained. Good straight line relationships result, as is the case with most pigment dispersions in more or less Newtonian vehicles.

The results are most interesting. The “X” coordinate is quite distorted, being plotted as $(1/\dot{\gamma})^{1/2}$. The value of infinite shear rate is equivalent to 0 on the X axis, whereas the lower the shear rates, the disproportionately further along the X axis the values lie.

The well-dispersed system with a UPVC that is 43% is almost horizontal, indicating that when the pigment particles are completely dispersed, the viscosity of the system is essentially Newtonian. The viscosity is very nearly the same at all shear rates.

As the CPVC decreases because of increasing agglomeration of the pigment, the rheological structure also increases materially. For the 28% CPVC system, it is over 100 times higher than the well dispersed system at a shear rate of about one reciprocal second. At close to zero shear rate, this sample, of course, shows extreme puffiness and does not flow at all. The most striking fact to be gleaned from this Casson plot, however, is that as the shear rate approaches infinity, the viscosities of all these samples are essentially the same.

This means that when very high shear rates are applied to agglomerated type coatings (approaching infinite shear rate), the viscosity of these systems becomes essentially the same as a well-dispersed system of the same type where all the particles are in a monodispersed condition.

An agglomerated coating remains well dispersed as long as the shear field is maintained. When the shear stress imposing this high shear rate is discontinued, the system almost immediately reverts to its agglomerated state with the concomitant higher viscosities. This has practical significance in several areas.

During the high shear grinding stage of manufacture, such as with the three-roll mill and high shear dispersers, the pigment particles are momentarily almost completely separated, and aggregated clumps are broken down. In paint systems which have sufficient dispersive capacity to

completely cover the pigment particles with the dispersing molecules, the pigments will remain in their well-dispersed state after cessation of the grinding process. Those systems which have insufficient dispersing molecules available to cover the total pigment surface areas will agglomerate. The degree of agglomeration will be according to the concepts previously discussed.

Consequently, the sag or flow of applied solution-type coatings systems can be conveniently controlled by regulating the degree of dispersion or agglomeration of

Coatings application is also strongly affected by this phenomenon. The shear rates achieved in the brush application of coatings is in the range of 10,000 to 20,000 reciprocal seconds, much higher than can be measured by most of the older type viscometers. With the advent of such simple instruments as the Band Viscometer¹³ and later the Brushometer,¹⁴ the practical laboratory assessment of the brushability and other high shear application of coatings could be effectively determined.

It was found that master painters¹⁵ desired the brushing viscosity of most solution-type coatings to be in the range of one to two poise. The value could range up to three poise, but paints with this brushing viscosity are generally considered to have poor application properties. It is interesting to note that the brushing viscosities of latex paints are usually preferred to be somewhat lower than solution paints, in the range of about 0.7 to 1.5 poise.

The Casson plot of the TiO₂/mineral oil dispersions of Figure 12 demonstrates this explicitly. The brushing shear range of about 10,000 reciprocal seconds lies very close to the value of the viscosity at infinite shear rate on the graph. This means that all the dispersions would have satisfactory brushing characteristics in the range of about 1.5 poise despite the very great differences in their viscosities at lower shear rate.

Brushing tests of these materials have substantiated that the "flowing" sample and the "stiff" sample brush out with about the same ease. Thus, it is imperative that the rheological properties of coatings be measured at the shear rates of their application in order to achieve meaningful results. Measurements at low shear rates will be misleading in determining brushing characteristics and measurements at high shear rates will not determine leveling and flow characteristics.

LATEX SYSTEMS

The viscosity characteristics of latex paints will generally not follow the Casson relationship. Whereas solution coatings almost invariably show straight lines as Casson plots, those of latex coatings will usually be curved, showing major diversion. Application of the previously described concepts will clearly show why this must be so.

As already described, latex paints must have enough wetting agent present to effectively disperse both the latex and the pigment. An insufficient amount could lead to premature coagulation of the latex during production or storage. However, well-dispersed particles, whether latex, pigment, or their combination, will always show

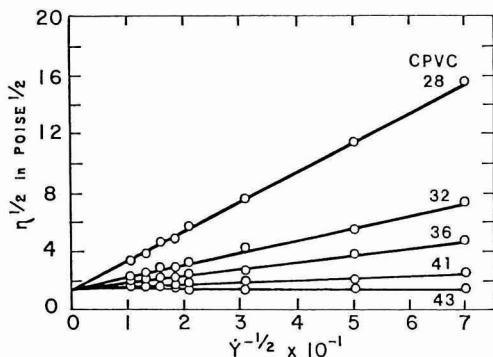


Figure 12 — Rheological structure dependence on shear rate and CPVC

essentially Newtonian behavior when well dispersed in a Newtonian liquid such as water.

The latex paint composition in this condition can be formulated to show rather good brushing (or roller) application characteristics in the range of about 0.7 to 1.5 poise. But such a system has low viscosity at low shear rates, so it generally drips excessively and sags from vertical surfaces. Small amounts of thickening agents (such as casein in the earliest formulations) alleviated this problem. These materials are usually high molecular weight special polymers which show very high rheological structure at low shear rates and low structure at high shear rates when dispersed (dissolved) in a carrying liquid such as water.

It is thus the thickeners which impart the required structure to latex paints and prevent drip and sag as opposed to the method generally used for solution coatings of creating slight agglomeration. The thickeners are a part of the vehicle and do not significantly contribute to the packing characteristics of the latex and pigment particles.

Thus, latex paints, because of the monodisperse condition of their particles, usually have the highest packing density commensurate with the highest CPVC. They are essentially always at the UPVC. It must be remembered that the latex particles behave similarly to pigment particles, both in the rheological and packing behaviors of the system. Consequently, both the flow properties, particularly at high shear rates, and the packing properties will be dependent on both the particle size and particle size distribution of the latex system employed in the paint as well as the pigments. Thus, the use of the same pigment combination with different latexes may give different CPVC values and different brushing application characteristics.

CONCLUSIONS

Since its publication over 40 years ago, the concept of Critical Pigment Volume Concentration (CPVC) of coatings systems has been confirmed to directly or indirectly affect all coatings properties.

Although the original work was concerned only with solution-type coatings, the concepts apply equally well to latex coatings. The details between the two systems, however, are substantially different.

The CPVC is characterized by the onset of porosity in the PVC ladder of a dried coatings system. Thus, any method which measures this break can be utilized to specify CPVC.

The use of the CPVC cell for solution coatings often hastens the reliable measurement of this point. In contrast, the use of oil absorption methods is not acceptable to reliably establish the CPVC of a given pigment system, and should consequently be employed only with extreme caution.

CPVC is not a property of the pigment alone as has been repeatedly suggested in the more recent literature. Rather, as originally concluded, it is an interaction parameter between pigment and vehicle. Thus, the same pigment system may have substantially different values of the CPVC. This depends upon the ability of the vehicle to disperse or agglomerate the pigment in solution-type coatings and upon the latex particle size and distribution and other properties in dispersion-type coatings.

The flow properties of coatings systems are also strongly affected by their relative CPVC values. Application properties are influenced by the degree of dispersion of the pigment particles in solution-type coatings and the use of thickening agents in latex systems.

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Measurement of Particle Packing In Dispersed Systems

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The exact manner in which small particles are arranged in dispersion is as important to the performance and application properties of liquid coating compositions as the PVC is to the performance of a paint film. Historically, it is assumed that uniform particles approximate hexagonal close pack in most dispersions and there is some evidence to support this view.

Experimental evidence obtained and presented in this work, however, indicates that most probable array is dense random packing as described by Bernal. The effect that boundary condition can have on localized packing is discussed.

INTRODUCTION

A liquid coating material is a complex mixture of pigments, fillers, binders, and other additives dispersed and/or dissolved in a liquid. When applied to a surface, the liquid is changed by a film forming process to a solid composite film. In the final coating, pigments and fillers are dispersed in an amorphous glass-like polymer binder matrix. The manner in which solid particles are arranged in the matrix is extremely important to the understanding of many physical properties and processes with which the coatings technologist must deal. The coating's properties are directly related to the volume occupied by the particulate material (pigments and fillers) per element of volume of the system (matrix volume + particulate volume). This basic concept of pigment volume concentration (PVC) was introduced to the coatings industry by Asbeck and Van Loo.¹ They were able to identify a certain PVC

at which nearly all of the coating properties underwent a dramatic transition. This unique property was termed the critical pigment volume concentration (CPVC), and has successfully explained many performance properties. Similarly, many of the properties of dispersions (rheology, film coalescence, residual film stress, etc.) are related to the critical packing of the particles in dispersions.

CRITICAL PACKING OF LATEX AND DISPERSION POLYMERS

Classically, the colloid scientist considers the packing arrangement of uniform latex particles to be rhombohedral or hexagonal close pack which has a packing constant (K_c) of 0.7405. Indeed, there is a body of evidence for this arrangement. Krieger and Hiltner² have described latexes which, upon standing, form iridescent colors characteristic of their particle size. These latexes were carefully prepared with a minimum of electrolyte and are reported to have very uniform particle sizes. Bragg scattering data suggest that the particles of these unique latexes have assumed the hexagonal close pack geometry, although it is not clear if the repulsive forces in conjunction with an induced surface orientation by the sample cell wall did not create the pentagonal di-pyramid structure described by Bagley³ ($K_c=0.72457$). Bagley has observed that the pentagonal di-pyramid structure, once initiated, can theoretically exist throughout a packing array and is often observed in metallic crystalline materials (spherical molecules) which have been grown at or near a surface.

Bernal et al⁴ have modeled the packing of spherical particles. In their classical experiment,⁵ a large balloon is filled with small ball bearings. Black paint is introduced into the balloon, and the balloon is then kneaded to simulate generating the most favorable geometric ar-

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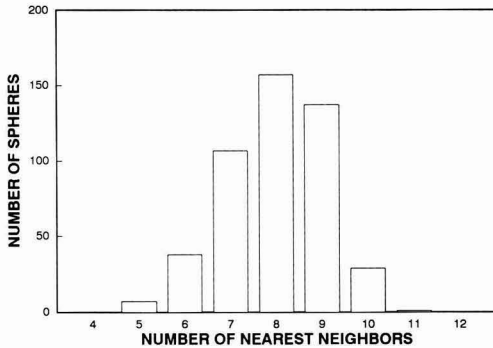


Figure 1—Number of nearest neighbors in dense random packing (after Bernal et al.)

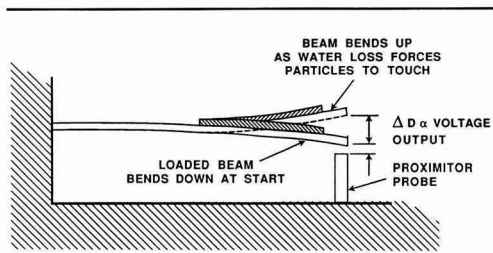


Figure 2—The Cantilevered Gravimetric Beam (CGB) packometer

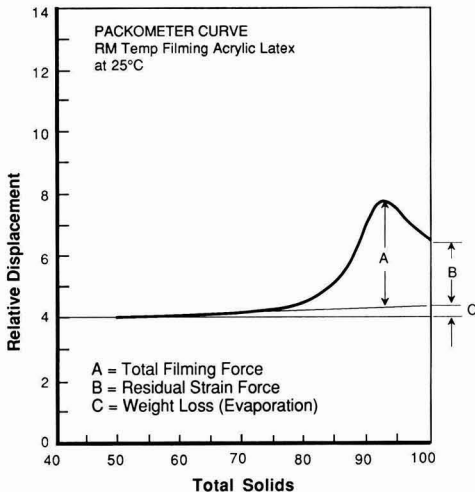


Figure 3—CGB packometer recording from room temperature filming acrylic latex. Deflection of beam follows filming process and records residual film stress

rangement (lowest energy state) and uniformly coat each ball bearing. The balloon is then inverted and the surplus paint allowed to drain from the balloon. Upon drying, the volume of the balloon and the void volume inside is determined to obtain a packing constant of 0.634. Subsequently, the balloon was stripped from the assembly of spheres. Upon disassembly of the coherent spheres (Figure 1), they determined the distribution of nearest neighbors in the assembly from the marks produced by the dried paint. The mean value of nearest neighbor was found to be 8.5 rather than 12, as was predicted from geometrical considerations.

METHODS OF DETERMINING THE PACKING CONSTANT OF DISPERSIONS

Asbeck and Van Loo describe the measurement of CPVC of a pigmented solventborne paint system by a quantitative filtration followed by a volumetric determination of the filter cake. The method, although somewhat time consuming, is difficult to reproduce, but suffices for pigment and fillers. Because of long filtration times and coalescence forces acting on polymeric particles during filtration, the method is not suited for determining the packing constant of very fine dispersions, for example, nonaqueous dispersions, polymer emulsion, and latexes.

Hiemenz⁶ determined packing of polystyrene latexes by measuring the solids contents of centrifugally produced sediments. Two disadvantages are apparent in this method: the nonuniform settling of different sized particles and possible deformation of the particles under the < 2000 G field used. Neither of these methods is capable of determining the packing constant of particles in the range of 0.1 to 1 micron routinely and reproducibly.

Because of the possible surface induced orientation, the suppression of double layer repulsion by buffers, ionic catalysts by-products, and surfactant, and the problems of classification in a gravimetric field, the exact packing arrangement of uniform latex remains in question. Even more complex is the packing arrangement of bimodal and multi-modal systems, mixtures of different species, and distribution of different shapes.

It is an object of the present work to report a relatively simple, direct method of measuring the packing constant in which the surface orientation, particle shape, and/or classification is minimized. The method is based on the observation that when a thick liquid film of a dispersed solid in a volatile liquid is subjected to evaporative volume losses, it shrinks. The shrinkage invariably causes the resulting composite to "mud crack" and "curl," often to the extent that a thin substrate is distorted. The Cantilevered-Gravimetric Beam (CGB) instrument capitalizes on this phenomena and provides an effective means of determining the packing constant of uniform particles as well as mixtures and distributions.

APPARATUS

In essence, the CGB Packometer instrument (Figure 2) consists of a thin metal strip (beam) which is cantilevered from a supporting bracket. A sample of the particles

Table 1—Properties and Packing Results of Experimental Lattices and Dispersions

Sample Number	Type Latex/ Disper.	Non-volatile Percent	MFT °C	Particle Size Microns	Critical Packing Constant
1	Acrylic	50.4	33.5	.97	0.658
2	Acrylic	49.5	51.0	.23	0.637
3	Acrylic	50.2	49.0	.12	0.611
4	Acrylic	52.1	26.0	bimodal dist.	0.756
5	Pigment	74.9	—	inorg. mix.	0.456
6	Acrylic	67.0	—	broad dist.	0.735

dispersed in a volatile liquid is placed in a flexible sample boat which is affixed to the cantilevered beam. The whole assembly is placed on a balance and the quantitative loss of weight is recorded as the liquid is allowed to evaporate. As the liquid evaporates and as the concentration approaches the critical packing concentration, the liquid surface forces acting on the particles contained in the dispersion and on the wetted wall of the sample boat create a stress which causes the beam to bend. When the strain acting on the beam exceeds the strength of the sample, the sample cracks and the stress is relieved, allowing the beam to return to a lower position. The displacement of the beam is detected by a proximity gage placed at the opposing end of the cantilevered beam. From the knowledge of the concentration of the initial dispersion and the concentration of the dispersion just as the beam is stressed, the packing coefficient can be calculated providing the densities of the particles and liquid are known.

EXPERIMENTAL RESULTS AND DISCUSSION

Approximately 0.5-0.7 g of a dispersion of known solids and composition are accurately weighed in to the sample boat. The initial response of the instrument is a negative deflection due to the load placed on the beam. As the volatile liquid evaporates from the dispersion, the liquid phase volume is reduced and the particles are crowded ever more closely together. Below critical packing an excess of fluid maintains the fluidity of the dispersion, and there is a linear positive deflection with weight loss. The rigid particles cannot move more closely together once critical packing has been reached. Thereafter, continued evaporative volume losses cause retreat of the liquid phase into the particle voids, and surface tension now exerts a tensile stress upon the bed of particles causing a rapid, pronounced deflection of the supporting beam.

Visible changes during the drying process follow what is happening during these rather dramatic changes. The initially glossy surface dulls* noticeably as drying proceeds. The first signs of dulling are seen just as the deflection changes rapidly. Very fine cracks are detected in the sample just after the deflection has peaked and begun to drop.

Figure 3 illustrates the results obtained from room temperature acrylic film forming latex using the CGB

*Loss of gloss has been used previously to detect critical packing in plastisol systems; see *J. Appl. Polymer Sci.*, 10, 1871 (1966).

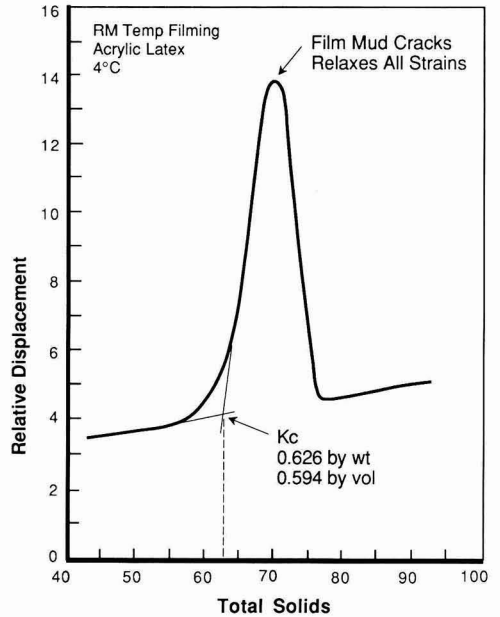


Figure 4—CGB packometer recording of acrylic latex of Figure 3 measured at 4°C. The deflection peak is much more narrow and the beam returns to baseline

instrument; while Figure 4 describes the results obtained from the same latex below its minimum filming temperature. Note that under nonfilming conditions, the beam after an initial deflection returned to the baseline after the stresses were relieved by film cracking. Under filming conditions, the beam did not return to the baseline, and the remaining deflection is indicative of residual stress which is inherent in the coalesced polymer and not re-

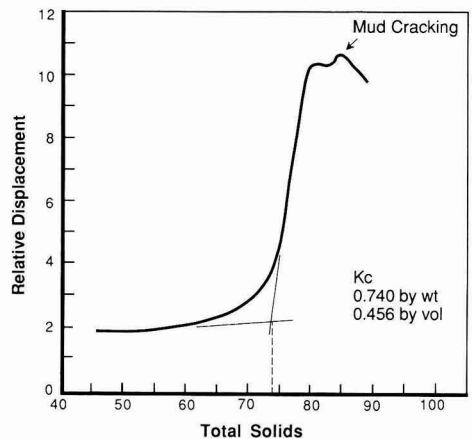


Figure 5—CGB packometer recording from a pigment grind used in manufacturing a latex paint

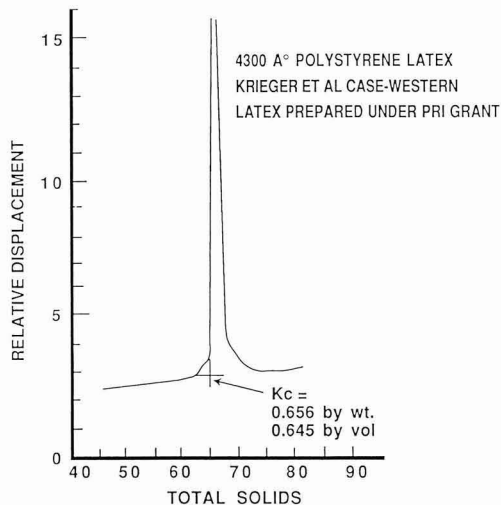


Figure 6—CGB packmeter results from a 4300 A° polystyrene latex obtained from Krieger et al.

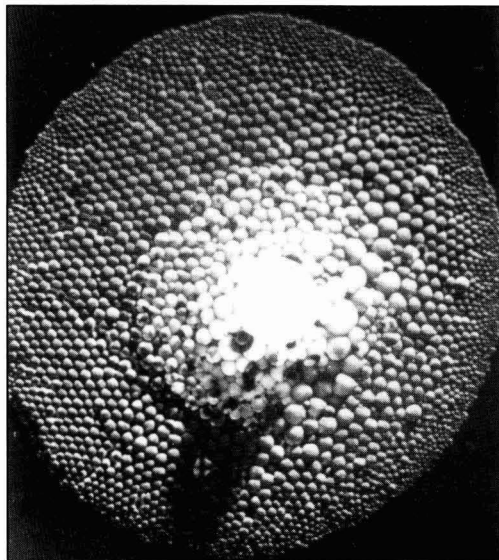


Figure 7—Electron micrograph of single latex droplet

lieved by relaxation of the polymer within the time frame of the experiment.

The results of a number of determinations are recorded in Table 1. Samples 1 to 3 are experimental methyl methacrylate/butyl acrylate latexes produced using a mixed surfactant and a persulfate initiator; sample 4 is made by blending a large particle seed and a small particle seed, reinitiating the polymerization, and feeding the monomer until the solids have reached nearly 75%; sample 5 is an aqueous pigment grind of a mixture of TiO₂ and Duramite ASP-170 (Duramite Chemical Company, Winston-Salem, NC) (see Figure 5); and the last sample is a latex with a very broad distribution. It is made by a semi-continuous batch process⁷ in which, following particle nucleation, a part of the growing particles is continuously removed from the polymerization zone and later systematically returned to complete the polymerization. In this manner, extremely broad distributions can be prepared by altering the withdrawal rate and the return rate during the process.

The data from latexes 1 to 3 reported in Table 1 support Bernal (0.635) rather than hexagonal close packing (0.7405). However, these lattices contain the ionic species that result from initiator by-products, which are known to suppress the extent of any double layer that might be present. But what of the rather carefully prepared latexes of Krieger? To answer this question the Case Western Reserve University Group was kind enough to prepare and send four samples of their latexes.[†] The physical properties of these polystyrene latexes are listed in Table 2 along with the results obtained on the CGB instrument. Figure 6 is the CGB packmeter recording

obtained from the 4300 A° latex and is typical of the results obtained from the remaining latex samples.

Again, even these rather carefully prepared lattices favor Bernal packing rather than the hexagonal close pack reported by the Krieger Group. These data lend support to the idea that the wall of the container together with the repulsive forces of the double layer of the particles causes a local orientation of the particles and results in the iridescent diffraction patterns observed.

Alternatively, collapse of the double layer (decrease in repulsive forces) caused by the increasing concentration of the few ionic species remaining as the latex dries cannot be ruled out, although the estimated double layers

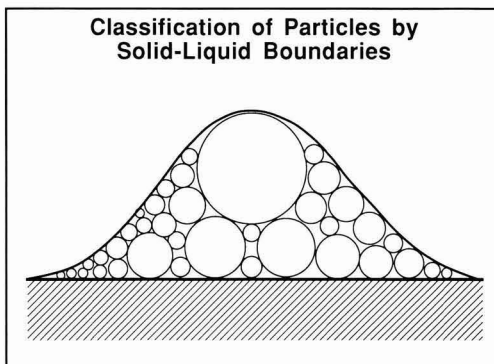


Figure 8—Diagram of single latex droplet and mechanism of classification of particles in a latex with very broad distribution of particles

[†]A description of the procedure for the preparation of uniform particle size lattices appears in Papir, Y. S., Woods, M. E., and Krieger, I. M., "Monodisperse Lattices III: Crosslinked Polystyrene Lattices," JOURNAL OF PAINT TECHNOLOGY, #2, No. 550, 571 (1970).

Table 2—Physical Properties of Polystyrene Lattices from the Laboratory of I.M. Krieger et al.

Reported Particle Dia. A ^a *	Non-volatile Percent ^b	Measured Core Dia. A ^c	Std. Dev. A ^c	Hydrodynamic Dia. A ^d	Double Layer Dia. A ^e *	Critical Packing Constant ^f
1800	43.93	2150	9	2249	50	0.629
2150	46.66	2410	18	2486	38	0.663
2800	52.68	2720	17	2779	30	0.644
4300	54.14	4530	8	4562	16	0.644
blend ^g . . .	—	—	—	—	—	0.674

(a) Received from I.M. Krieger, of Case Western Reserve University.

(b) Evaporated to dryness @ 100°C, then 30 min at 150°C; average two determinations.

(c) Average of 50 particles from electron micrographs.

(d) Hydrodynamic volume from viscometric determinations.

(e) Estimated, double layer = (core-hydrodynamic)/2.

(f) CGB Packometer determination of critical packing constant.

(g) 86% 4300 A^g/14% 1800 A^g by weight.

of the original lattices do not seem unusually large and would tend to belie this postulate.

Some idea of the effect that boundaries both solid and liquid can have on the packing arrangement of particles during film formation is given by *Figure 7*. *Figure 7* is an electron micrograph of a single droplet of a very dilute sample of the latex number 6 of *Table 1*.** The unusual arrangement of particles, that is, a large particle in the center and the progressively smaller particles aligning themselves towards the perimeter of the droplet, can be attributed to the manner in which the droplet was formed and the surface forces acting on the particles as water is subsequently removed by vaporization. Since the particles are well stabilized, the energy to alter the packing arrangement is much less than the energy required to cause dewetting of the particles; hence, the particles

**The single droplet technique is a means of evaluating particle size and distribution of emulsion polymers without resorting to replicate samples.

move to accommodate the loss of liquid volume and maintain the "wetted" condition of the stabilized surface of the particles. Ultimately, the effect is the arrangement of particles as depicted in *Figure 8*, which results in the rather unusual arrangement of particles in the electron micrograph.

SUMMARY AND CONCLUSIONS

The Cantilevered Gravimetric Beam is a reliable and facile means of determining particle packing of a dispersion of solids in a volatile liquid. It can be helpful for understanding the properties of polymeric dispersions, paint, and pigment grinds. The method is capable of measuring packing of bimodal, multi-modal, and broad distributions. The CGB Method is not impeded by particle shape or size.

The preferred packing arrangement of uniform spherical particles is dense random packing (Bernal Packing). It is believed that under certain conditions the container walls in concert with the repulsive forces can orient uniform particles into quasi-lattice arrangements that display unusual iridescence diffraction patterns, probably of the Bagley type, which were described earlier.

The constraints that boundaries can have on the arrangement of particles in a dispersion during film formation can play a role in the ultimate performance of the film.

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CPVC as Point of Phase Inversion In Latex Paints

F.L. Floyd and R.M. Holsworth
The Glidden Company*

In 1949, Asbeck and Van Loo introduced the seminal concept of critical pigment volume concentration (CPVC) as the loading beyond which insufficient polymeric binder existed to encapsulate each filler particle and fill residual interstitial voids in the packed bed. One corollary was that CPVC represented the onset of air voids in filled systems. Subsequent work showed that in latex systems, at least, air voids exist to some extent even down to zero pigment volume concentration. The present work suggests that CPVC might be better thought of as the point at which a phase inversion occurs, from a system in which polymer is the primary phase to one in which air becomes the primary phase. This alternate view explains the anomalies which occur when polymeric fillers are employed, accommodates the porosity which exists below CPVC, explains why properties change in slope at CPVC rather than going to zero or infinity, and offers a view of why different properties exhibit different apparent CPVCs.

INTRODUCTION

In 1949, Asbeck and Van Loo introduced the concept of critical pigment volume concentration (CPVC).¹ Working with paints employing liquid binders (oil based), they observed that any such liquid binder has a finite capability to "bind" particulates (pigments). This limit was shown to correspond to the filler concentration of a randomly close packed bed of particles. Thus, they developed the concept that at CPVC just enough binder existed to encapsulate each pigment or filler particle with a van-

ishingly thin shell, plus filling the remaining voids left by the randomly close packed pigment bed.

They further showed that the CPVC was the point at which most paint properties undergo a significant change in magnitude, which was thought to be due to the onset of air voids in the film. For example, opacity, porosity, and permeability all increase sharply, while tensile strength, holdout, and scrub resistance all decrease sharply beyond CPVC. As a result, CPVC became somewhat of a barrier beyond which most paints were not formulated, in order to retain a good balance of film properties.

Asbeck and Van Loo proceeded to refine their concept by noting that the identity of the binder plays a role in the CPVC by influencing the packing which occurs at CPVC.¹ They suggested that different binders impart differing degrees of colloidal stability to the pigments in the liquid state. This in turn influences the density to which the particles could pack before becoming irreversibly attached to their neighbors. Thus, CPVC could be seen to be directly related to the colloidal stability of the liquid paint from which the films were cast, in addition to the inherent packing characteristics of the pigmentation. While they did not deal explicitly with latex paints, they alluded to the effects subsequently seen by others.

Many others have built on Asbeck and Van Loo's original concept, by offering numerous refinements in both concept and measurement. One good review is that by Toussaint.² Most of the subsequent work has centered around latex paints, and their presumed deviations from the principles expounded by Asbeck and Van Loo. In fact, however, Berardi,³ among others, showed that latex paints follow the same principle, but exhibit CPVCs offset to lower values by some fixed amount, which was characteristic of the specific latex involved. The measured CPVC divided by that predicted from oil absorption became known as the binder index for a given latex.

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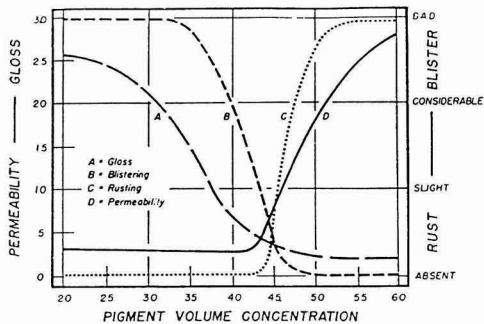


Figure 1—Effect of CPVC on paint characteristics [from reference (1)]

The present authors, while studying the distribution of pigment particles in dried paint films, from both an economic and physical property viewpoint, have developed an alternate view of the phenomenology of CPVC. The authors are indebted to Walter K. Asbeck for the stimulating discussions which led to the development of this paper.

VIEW OF CPVC

In their original paper, Asbeck and Van Loo¹ illustrated the change in various paint properties as a function of pigment volume concentration (PVC) (Figure 1). While this is somewhat oversimplified, it does demonstrate the essential features of CPVC. A typical profile for latex paints is shown in Figure 2 [constructed from reference (4)]. Like Asbeck's original figure, this illustrates that most properties show a significant change in a narrow range which is typically labeled as CPVC. It is interesting to note that a few properties, such as gloss and corrosion resistance, appear to be sensitive to other transitions,

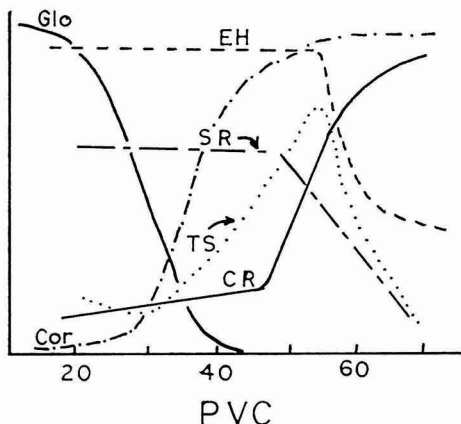


Figure 2—Behavior of latex paints as a function of PVC [constructed from reference (4)]. Glo—gloss, EH—enamel holdout, SR—scrub resistance, TS—tensile strength, CR—contrast ratio, and Cor—corrosion

perhaps the onset of percolation, as suggested in the text to follow.

CPVC with Polymeric Fillers

A particularly troublesome set of observations was introduced by Ramig and Floyd in 1975⁵ with their use of polymeric fillers as microvoid precursors. As seen in Figure 3 [constructed from reference (5)], opacity measurements yield CPVC values consistent with the conventional view. However, the other properties have inflections in different regions, suggesting that they each have their own unique sensitivity to the changing morphology of the film. In this case, the conventional view of CPVC appears to fail to some extent.

Although the p-styrene latex they used was non-film-forming in the classic sense, it was shown to sinter at points of contact with other particles.⁵ This introduced elements of mechanical integrity well above the PVCs at which resistance properties normally decline (conventional CPVC). It was also noted that scrub resistance showed a broad transition, rather than an abrupt one, which is characteristic of bicontinuous systems, such as polymeric interpenetrating networks.^{6,7} On the other hand, surface porosity measurements still showed an abrupt transition, but displaced to higher PVCs relative to that for the opacity transition.

This behavior succinctly pointed up a limitation in the historical definition of CPVC, viz., that the inflection in properties now occurs at widely separated PVC values, rather than within a narrow band. The authors at that time explained this as merely accentuating the differences in sensitivity of various properties to CPVC. The present

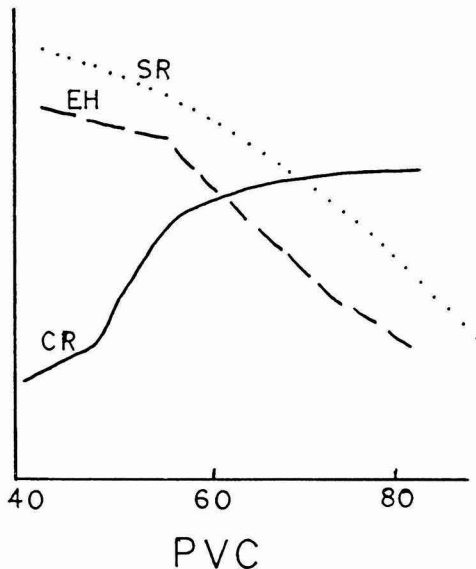


Figure 3—Behavior of latex paints employing polymeric fillers [constructed from reference (5)]. SR—scrub resistance, EH—enamel holdout, and CR—contrast ratio

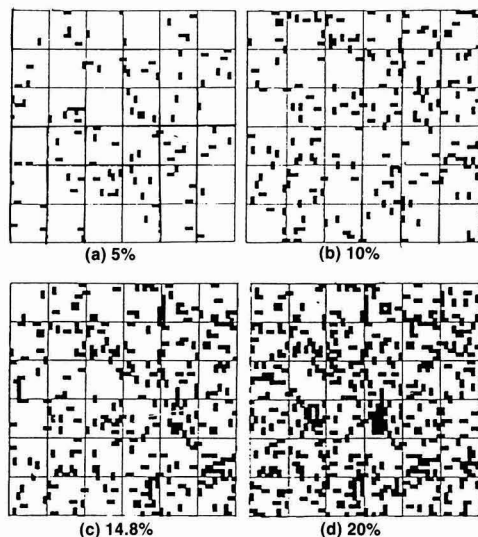


Figure 4—Simulation of pigment particle distribution in a paint film [from reference (9)]

authors believe that something more fundamental is involved, namely the concept of CPVC itself.

ASSOCIATIONS IN DISPERSED PHASES

Clustering

As one increases the concentration of a dispersed phase in a continuous matrix, a point is reached where particle-particle contact will be encountered. Surprisingly, the onset of multiplet formation occurs at quite low volume fractions, typically less than 5%⁸⁻¹⁰ (Figure 4). As the concentration of pigment increases further, the frequency of occurrence of singlets decreases, while the frequency of doublets and higher multiplets increases⁹ (Figures 4-6). Such associations can occur from random packing behavior, unrelated to the phenomenon of flocculation which results from a colloiddally unstable system. We prefer to refer to this random process as clustering, to differentiate it from true flocculation.

Percolation

As one further increases the concentration of the dispersed phase, another point is reached where a cluster of particles grows big enough to span the dimensions of the film. This point is called the onset of percolation or percolation threshold.⁸ Both experiments and theory suggest that this will broadly occur in the vicinity of 20-30 PVC, depending on the specifics of the system in question.⁸ An example can be seen in Figure 7.

We speculate that the onset of percolation is the cause of changes in such barrier-related properties as permeability and corrosion resistance which occur at relatively low PVCs with latex paints. Our thought is that such

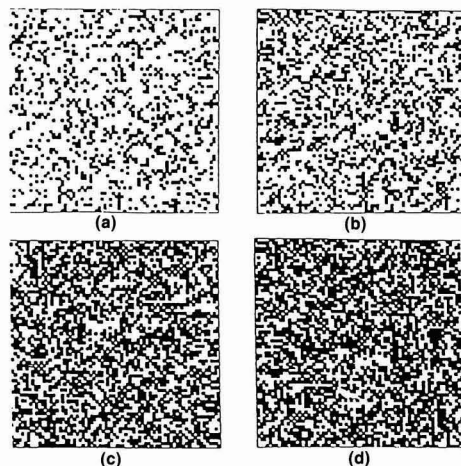


Figure 5—Similar cluster of monosized pigment fine particles at various pigment loadings [from reference (9)]. (a)—20 PVC, (b)—30 PVC, (c)—45 PVC, and (d)—50 PVC.

percolation will introduce continuous (though probably contorted in shape) pathways through the film, which allow materials to migrate more readily. Percolation may also be the cause of declining gloss at low PVCs, due to the introduction of light scattering at the surface of the paint film by optical heterogeneities.

The concept of percolation necessarily implies that the film becomes bicontinuous at that time, with continuous phases of both polymer and filler spanning the dimensions of the film. However, the primary matrix is still polymer, with the secondary one being pigment. A simplified analogy would be the punching of a hole in a sheet of paper. Further increases in pigment concentration above the percolation threshold will result in an increase in the concentration of percolating clusters, analogous to punching additional holes in the paper.

CPVC

At some higher concentration, this percolating phase rivals that of the polymeric phase for primacy in the film. This can be thought of as analogous to the formation of an open-cell sponge. One can conceive of a phase inversion point (or region) in which the primary phase changes from polymer-rich to pigment-rich. This can be argued to correspond to critical PVC, although the present authors feel a further refinement in viewpoint is needed (see following).

Latex Paint Anomalies

With latex paints, another process is active during this sequence. Since the polymer is particulate in nature, it too participates in the packing process which occurs during drying prior to the onset of film formation. In our view, the concept of polymer encapsulating each pigment particle plus filling all remaining voids is probably inaccurate. Density measurements by others¹¹ have clearly

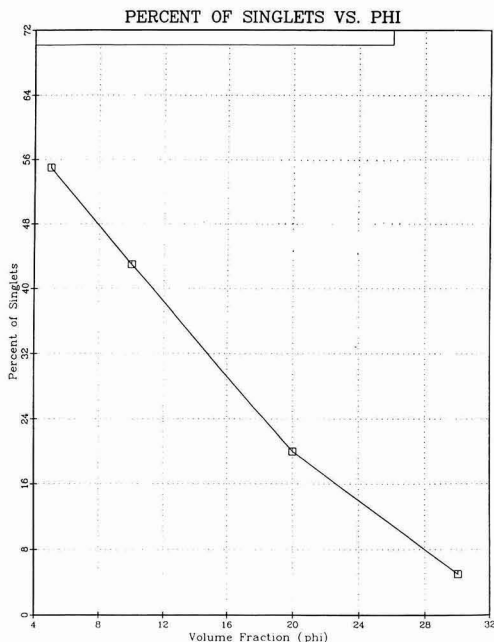


Figure 6—Rapid decline in singlets occurring even at modest concentration of filler

shown that air voids exist in latex paints at virtually all PVCs. These voids probably arise from imperfections in the random packing process which occurs during film drying.¹² While this packing density can be influenced by the colloidal stability of the particles in the wet state, we believe that voids are an inescapable reality in films cast from even the most stable of latex paints. To date, no report has been seen in the literature to the contrary.

Air Voids as Dispersed Phase

Cole¹³ first demonstrated the use of density measurements to detect the CPVC of solventborne paints, reasoning that such measurements would be particularly sensitive to the onset of air voids. Pierce and Holsworth¹¹ showed by a similar technique that latex paints possess some air voids at all PVCs, which increase slowly in concentration as CPVC is approached. Above CPVC, the concentration increases rapidly, as expected. (See Figures 8 and 9 for current examples.)

Since the latex particles deform and flow to some extent during film formation, it may be argued that they are self-healing to some extent, which will minimize residual voids in unpigmented films. However, Balik, Said, and Hare¹² confirmed that even unpigmented latex films contain residual porosity due to packing defects during drying, which persists long after further gradual coalescence has occurred. Since pigments cannot participate in the film formation process, they aggravate the

retention of air voids in the dried film. Density measurements show a linear increase in void content as PVC increases, up to CPVC, at which point a further linear increase in voids occurs, but with a much higher slope.¹¹

One may view the air voids, therefore, as a third phase in a paint film, and may apply to them the same arguments developed previously for pigments. For example, at quite low filler levels, air voids might exist as single entities, dispersed in the polymeric matrix. As PVC increases, the packing imperfections increase, with the result that the air voids increase in concentration. At some point, the air voids would experience the onset of clustering, followed by the onset of percolation analogous to the filler phase. We suggest that such properties as permeability and corrosion resistance would experience a noticeable change at the onset of percolation of the void phase, which would probably correspond closely to the onset of percolation of the filler phase.

Our view is that pigment particles without attendant air voids should cause a net increase in barrier behavior, provided that they are properly dispersed in and encapsulated by the polymeric binder. This is because they should have virtually zero permeability themselves. The only way they can cause a decrease in performance is to be incompletely bound by the polymeric binder. This could be either through a weak or incomplete boundary layer, or via imperfect packing which introduces nonwetable voids into the matrix. In either case, it is the air void, rather than the pigment particle per se, which should cause the decline in properties. The pigment particle is merely the precursor for the voiding which occurs in the film.

PHASE INVERSION VIEW OF CPVC

As the concentration of the void phase increases, the concentration of percolating voids will increase. At some point, this void phase will rival that of the polymeric phase for primacy in the film. It is our view that this coincides with the phenomenon of critical PVC. Thus,

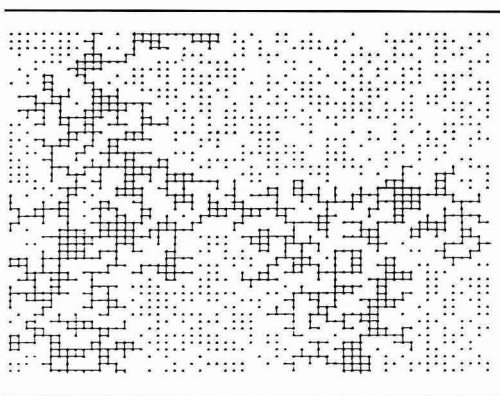


Figure 7—Simulation of a percolating cluster which spans the dimension of the object [from reference (8)]

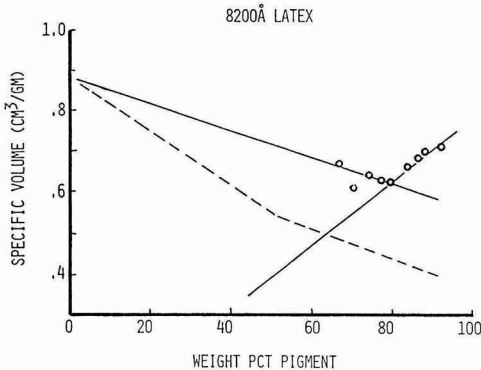


Figure 8—Experimental density measurements made by the technique described in reference (11). Gap between the theoretical (dashed) line and measured (solid) line represents the porosity of the paint film at each pigment loading. Paints are 20 PVC, 40 volume solids, using only TiO_2 as pigmentation. Latex is acrylic copolymer (BA/MMA) with a T_g of 0°C . Additives are conventional

CPVC is related *indirectly* to filler loading rather directly, although we expect the relationship to be quite close. While this distinction may be subtle, we believe that it can have a substantial impact on how we design paints in the future.

Beyond CPVC, there would still be regions rich in polymer-bound pigment, but they would be discontinuous islands in nature. There would be a distribution of pigment particles between the polymer-rich and air-rich phases, with the ratio declining as one proceeds further above the CPVC. While a film would lose mechanical integrity, it would do so at a controlled rate as one effectively decreases the concentration of polymer-bound domains in the film.

This phase inversion view of CPVC not only accounts for the anomalous behavior of paint systems containing polymeric fillers, but also is quite consistent with the behavior of more conventional systems. We therefore propose this as a more general description of the phenomenon of CPVC.

PRACTICAL IMPLICATIONS

Historically, it was accepted that while paints formulated above the CPVC would have increased opacity from the air voids introduced into the films, they would suffer from significant reductions in most other properties. By viewing paint films as co-continuous networks, and by considering nontraditional ingredients such as polymeric fillers, one can start to conceive of tuning individual properties independently of one another.

This means that the historical consequences of formulating to high PVCs need no longer apply. For example, higher opacity can be obtained through the introduction of controlled air voids, without the historical penalty of reduced holdout and scrub resistance [see reference (5) for example].

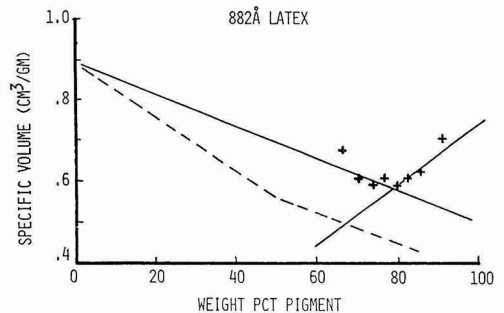


Figure 9—As in Figure 8, but for a smaller particle size latex. This illustrates the universality of the phenomenon

CONCLUSIONS

It is our view that the CPVC (of at least latex paints) is not simply the onset of air voids, but *represents the point of phase inversion of a co-continuous structure from one whose primary continuous phase is polymeric to one whose primary continuous phase is air*. This view not only accounts for the deviations observed with polymeric fillers, but better explains similar phenomena with more conventional paints. The phase inversion view also accounts for why properties only alter in slope at CPVC, rather than going to zero or infinity. This view also accounts for why different physical properties exhibit different apparent CPVCs. Such an alternate view of the micro morphology of paint films suggests that much fertile ground exists for future research and development, both from the performance and economics viewpoint, by suggesting that it is possible to manipulate various paint film properties independently of one another.

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Critical Pigment Volume Concentration (CPVC) As a Transition Point In the Properties of Coatings

Gordon P. Bierwagen
North Dakota State University*

Volume concentration effects in organic coatings are very important in the performance and physical properties of such coatings. The volume concentration or volume fraction of dispersed pigmentary solid phase in the polymeric binder of the coating is normally defined as the pigment volume concentration (PVC). There exists a critical PVC (CPVC) where there is just sufficient polymer matrix to wet and fill the voids between the individual particles. First clearly recognized and characterized in 1949 by Asbeck and Van Loo, the CPVC is a very important transition point in coating performance and properties. A re-examination of the CPVC is presented examining its experimental measurement and error effects in these measurements, the CPVC as a pigment-only determined property vs system effects on CPVC, and interpretation of experimental data in light of percolation theory as applied to composite materials.

INTRODUCTION

The Critical Pigment Volume Concentration (CPVC) was first clearly defined and experimentally measured in the seminal work of Asbeck and Van Loo of 1949.¹ Since that time, the CPVC concept has been the basis of much work, including that of Walter Asbeck, examining the performance of coatings as affected by variations in the level of pigmentation. It is especially crucial in those coatings in which there is an incentive to have a high pigment volume concentration (PVC) for performance or economic reasons. In those classes of coatings, among

them corrosion protective primers, magnetic tape coatings, and trade sales flat coatings, considerable effort has been expended in its characterization and prediction.

In the terms of the physicist, the CPVC is "critical point" in behavior, analogous to a concentration or temperature where a phase change occurs. In terms of modern material science, a pigmented coating is a random composite,² and for PVC the term "heterogeneous (discontinuous) phase volume concentration" would be consistent with present usage. The CPVC is then a critical heterogeneous (discontinuous) phase volume concentration. At PVCs below the CPVC, a dry coating film is polymer continuous, a composite consisting of pigment particles randomly embedded in a continuously connected matrix of polymer. Above the CPVC, there are void structures in the film due to insufficient polymer, but the pigment particles can still be thought of as continuously connected. The polymer is still continuously connected globally, but voids will cause the polymer to lose local connectivity, and thus the sharp drop-off in mechanical properties of the coating just above the CPVC. Ideally, at the CPVC, the system is a bicontinuous network similar to interpenetrating polymer networks or microemulsions,³ both the polymer and pigment being continuously connected. Above the CPVC, a new fluid phase, air, is now present in the film and its properties drastically affect those of the film, especially in density, transport (barrier and electrical), mechanical, and optical properties.

CPVC, FLOCCULATION, AND FILM FORMATION

From this viewpoint, the CPVC is determined by the point at which all pigment particles can be connected to all of its nearest neighbors in the packing of these particles. If all of the particles can act individually, that is, not flocculated prior to or during film formation, and the

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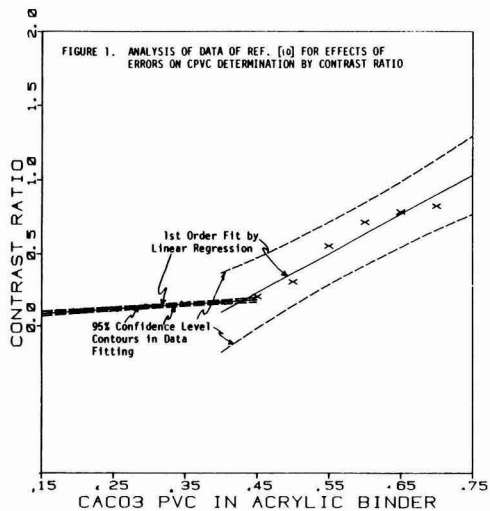


Figure 1—Analysis of data of reference (10) for effects of errors on CPVC determination by contrast ratio

polymer matrix acts as a continuous fluid in film formation, that is, in a latex coating, after coalescence is complete, the CPVC is determined by the pigment content of the film. This is the "Ultimate" CPVC or "UCPVC" of Asbeck,⁴ as well as a summary of the assumptions of this writer in his model for computing the CPVC from the random densest packing of pigment particles.⁵ There has been much discussion of whether the CPVC is a coating system (polymer + pigment) property, or solely a pigment determined property.⁶ Functionally, the performance changes due to the presence of air voids in the coating at the CPVC are system determined, but the ideal random packing of the pigment in its ultimate state of dispersion is a pigment property. All events in the film that cause permanent structure in the pigment particles which will not allow each of them to act independently of the others during film formation, such as flocculation, phase separation, etc., will cause the film to act as if it had a lower CPVC than is ultimately achievable in a stable, well-dispersed system.

Huisman and co-workers, in several papers,^{7,8} have clearly recognized this issue, but seem to take the viewpoint that the purely operational definition of the CPVC previously discussed is the appropriate one to consider when dealing with "real" systems. The danger in this interpretation and use of the CPVC concept is that one is accepting ill dispersed or manufactured systems, and/or poor film formation, and thereby accepting less performance than can be attained with the pigment and polymer present in the coating. If the CPVC of a given coating system really varies with the degree of dispersion, and the reproducibility of pigment dispersion quality is that much of a problem in the system in question, one will have a significant problem in controlling the reproducibility of the quality of a coating and its properties. If this is

acceptable to the formulator, so be it, but in most highly pigmented systems, one seeks as high a concentration of pigment in the system as possible, or as high an operational CPVC as possible. Further, it would place into difficulty any quality program designed to use Statistical Process Control (SPC) techniques⁹ on the manufacture of that coating if the properties of the coating were extremely sensitive to coating manufacturing conditions.

Similarly, there can be events occurring in the liquid state that set up permanent structure in the dry film that interfere with the random densest packing of the pigment particles, and these events can be caused or influenced by the conditions of film application and film formation. This situation also makes the "effective" CPVC a probabilistic issue, that is, the functional CPVC can be changed by conditions not under the control of the formulator, but those at application. Since so much of the coating's performance has been shown to be determined by its CPVC, accepting the CPVC as a variable of coating production, film application, and film formation can be a very dangerous thing to do. The system will not be "robust" or "user-friendly" in the eyes of the customer, especially in coatings formulated near the CPVC. Therefore, film formation and film application conditions must be monitored and controlled carefully for their effects on the coating functional CPVC. Schaller¹⁰ has treated film formation issues relative to the CPVC as measured in latex systems quite well, and illustrates how this basic property of a coating system can get lost in film formation and related issues. These effects, and the problems they cause in latex coatings, have also been reviewed.¹¹

ERROR EFFECTS IN THE MEASUREMENT OF CPVC

The effect of "errors" in coating preparation and in measurements on coatings on the CPVC of a coating is a very important issue to consider when making measurements to determine the CPVC in a coating. There has been much work done on various methods of CPVC determination and many arguments on their implications and validity. A specific example of this is the work that indicates that various aspects of the porosity induced in the film structure can be controlled about the CPVC by materials and film formation characteristics of individual coating formulations.¹² However valid the data of reference (12) might be, the measurements are made in regions of PVC near the CPVC where problems in sensitivity to small errors of preparation or local fluctuations in concentration are severe. Unfortunately, this work has drawn coating designers to focus on designing coatings right at the CPVC, a point which is very hard to control and reproduce exactly, as previously described.

A further issue of some importance that must be very carefully considered in analyzing the end-point of CPVC measurements is the experimental errors in the measurements above and below the CPVC end-point and the manner of determining the end-point. The effects of data analysis techniques and error effects on the determination of the CPVC end-point in latex coatings have been studied and the results indicated that there was always quite a large statistical scatter in the end-point due to the experi-

mental errors in the measurement of the individual property measured.¹¹ In many cases, the end-point is determined by an intersection on two linearly changing property vs PVC curves, as shown in *Figure 1*, and the error range in determining the end-point is determined in the accuracy of the slopes of the two lines (see also *Figure 1*). As *Figure 1* and *Figure 2* show, these errors can be quite large, and are almost never considered carefully when CPVC determinations are made. A question that might be posed here is to whether anyone has ever reported a CPVC value with error limits to the accuracy of the number. No such data has been seen by this author, but many discussions about the importance of 0.05 PVC differences in determinations of CPVC values exist in the literature, not recognizing the differences are often meaningless because of overlapping error levels in the numbers being compared. Even optical measurements of the CPVC have significant error levels, especially above the CPVC (see *Figure 1*). Before differences in CPVC values are given any significance, the statistical significance of the data upon which they are based must first be established. This is often hard to do, especially for notoriously bad data such as scrub tests and certain other performance tests.

“SCATTER” IN CPVC MEASUREMENTS

“Scatter” of measurement data may be an unavoidable feature of the CPVC, especially when it is considered a “critical point” in coating behavior. It is well known that near a phase change or analogous critical point, the properties of a system begin to locally fluctuate between values characteristic of the system at either side of the critical point. An example of this is the turbidity onset in a solution near a phase separation due to concentration

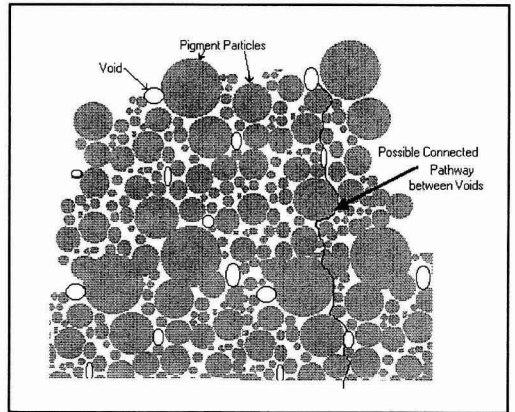


Figure 3—Schematic of proposed percolation transition in pigmented coatings near CPVC

change or temperature change. Another example of this type of behavior is the electrical conductivity fluctuations near the inversion temperature for a (water + salt)-in-oil emulsion to an oil-in-(water + salt) emulsion.¹³ The transition here is from oil-continuous (low conductivity) to (water + salt) continuous (high conductivity) system. Just at the temperature of phase inversion, the conductivity fluctuates considerably with time, but it may fluctuate as well with location within the system. This latter situation is probably characteristic of the CPVC. Those property measures that are performed on a macrostructure scale will probably detect an average property characteristic of the entire system. Those coating property measures that are sensitive on a microstructure scale will probably detect the fluctuations and give values which may vary in a random manner from place to place in a coating or from sample to sample in a laboratory study.

POSSIBLE PERCOLATION TRANSITION EFFECTS

Further aspects of the statistical nature of the CPVC transition point must also be considered. Related problems in composite materials have been studied recently under the heading of Percolation Theory.¹⁴ As has been shown in many areas of materials behavior, within the vicinity of a critical point where physical properties can change discontinuously, properties can be described by functions involving $(x-x_c)^{-b}$ where x is the critical parameter in question, x_c is its critical value, and b is a “critical exponent” for the transition. For example, the dielectric constant of a random composite made up of silver particles embedded in a KCl matrix gives a percolation threshold of $x_c = 0.20$ to 0.22 volume fraction of Ag, and a critical exponent of 0.72 - 0.74 .² In composite media, where there is a very large difference in some physical property between the continuous phase and the discontinuous phase, such as electrical conductivity of an insulator/conductor composite, locally connected pathways between highly conductive particles grow to infinite

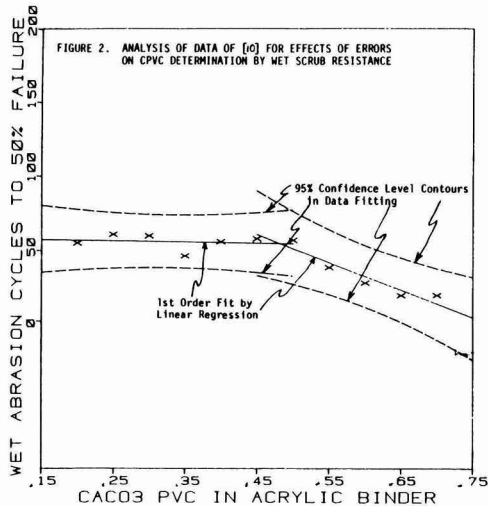


Figure 2—Analysis of data of reference (10) for effects of errors on CPVC determination by wet scrub resistance

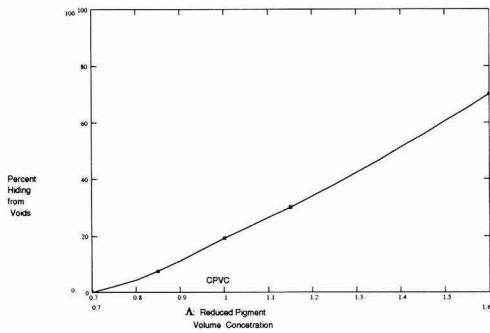


Figure 4—Void hiding vs lambda

length below the discontinuous phase concentration at which all particles touch (the CPVC). This can give high conductivities and the so-called percolation threshold for onset of a sharp conductivity increase at relatively low volume fractions of conductive phase.¹⁵ The dispersed phase of considerably different properties that one must consider to apply the arguments of percolation theories to the CPVC would seem to be the voids in the film above the CPVC. In a standard percolation model, it is this phase that becomes “connected” below the critical point due to the statistics of the alignment/connectivity of the discontinuous phase. The question for us to answer is how voids, their formation in coatings about the CPVC, and their connectivity or interaction give the rapid changes in properties at the CPVC. A possible diagram of such a transition is given in Figure 3. When the voids interconnect over the complete thickness of the film by a pathway such as shown in Figure 3, transport properties will increase drastically through the film.

Can we model a coating system near the CPVC as a percolation system, with the onset of connected void formation being the percolation effect that we observe? Some of the material in the physics literature^{2,16} suggests that using an optically transparent insulating material such as KCl or KBr as the matrix for composite formation gives a useful experimental model system for measurements of these effects. These composites are formed under pressure in a manner similar to sample preparation for IR measurements of organic solid powders. This sample preparation offers some unique advantages over polymer as the matrix of the coating in terms of electrical and optical measurements. This technique may offer some unique measurement insight to the transitions in a system near the CPVC and offer also IR measurements of pigment clustering (due to the IR transparency of the KCl or KBr). It may also offer some insight into the manner in which voids form near the CPVC and possibly how they may interconnect or “percolate” in a manner which drastically alters the transport properties of a pigmented coating. Do “voids” formed in film formation of a coating connect on a molecular level, and thus give an immediate transition above the CPVC in transport properties? Connectivity of voids in porous media has been discussed,¹⁷ but the case of small voids constrained between fixed solid particles is not covered. There seems to be a concen-

tration of voids effect on staining and optical properties¹⁸ and a low detectable concentration of voids below the CPVC. This effect is given in Figures 4 and 5. The volume concentration of voids can be predicted above the CPVC¹¹ and this effect relative to the CPVC for the data of Culhane, et al.,¹⁹ is given in Figure 6. The major problem is this methodology only deals with the average void properties of the coating system, while there remains a need to describe void distribution and void sizes. Acoustic characterization methods may help accomplish this.²⁰

POSSIBLE APPLICATIONS

A specific coating situation to consider with respect to percolation effects would be Zn-rich paints. These coatings function by providing sacrificial protection of a ferrous substrate via the zinc particles in the coating. The Zn particles, according to the proposed mechanism,²¹ must be in contact with each other and the ferrous substrate to provide galvanic, sacrificial protection. They are thus formulated above the CPVC to insure that the particles are connected electrically. In view of percolation theory, there should be an onset in corrosion protection at the concentration of the conductivity percolation threshold (circa 30% volume conductive pigment²²). Some performance should maintain as the PVC of zinc is reduced from the CPVC of the Zn pigment to the conductivity percolation threshold. Also, these effects will have to be taken into account in the analysis of the performance of these coatings as the Zn is oxidized to hydrated zinc oxides and zinc carbonate complexes in the coating. These compounds will be resistive, and would interfere with the conductive pathways of the Zn particle percolation network, and inhibit conductivity required for cathodic protection. Recent work on the partial substitution of a conductive extender pigment for zinc in this class of coating has indicated maintenance of the conductive pathway between Zn particles is important, but the polymer of the coating must be considered also. A more complete analysis of this type of coating based on percolation concepts is recommended.

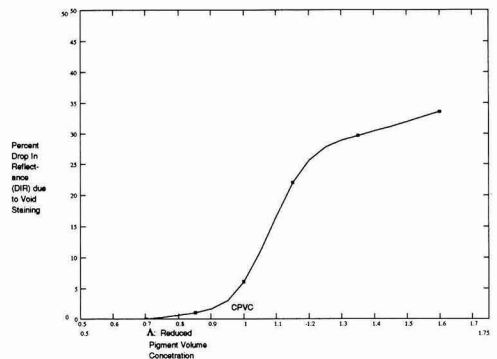


Figure 5—Plot of estimated percent void hiding vs lambda (PVC/CPVC) for typical latex coating

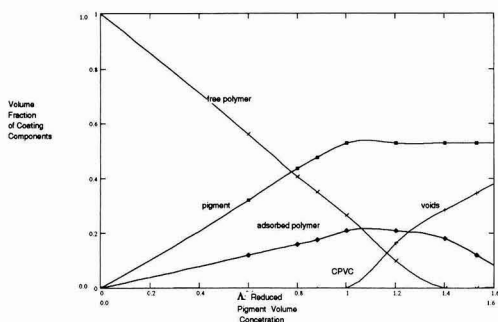


Figure 6—Normalized film volume fractions vs lambda; system of Culhane, Smith, and Chiang¹⁹

LOCAL FLUCTUATIONS IN CONCENTRATION OF PIGMENT OR POLYMER

There also exists the possibility of local fluctuations of the relative volume fractions of polymer and pigment.²³ If these fluctuations occur near the CPVC, there can be local areas above the CPVC and others below the CPVC while there is still a statistically homogeneous coating on average. Torquato and Liu¹⁸ give a "coarseness" measure which provides an estimate of the pigmented dispersion phase volume concentration fluctuations and their length scale. The key issue here will be the size of these local fluctuations (the correlation length for this statistical fluctuation), and how these fluctuations are measured by coating tests and performance measures.

Further, near the CPVC, locally efficient (FCC or HCC) packing may occur in one area with corresponding local areas of very inefficient pigment particle packing, and a resultant creation of a void to local insufficiency of resin. These void areas would be locally above the CPVC, whereas the entire film may, on average, be at or below the CPVC. These local fluctuations would increase toward the CPVC and at that point become significant. If the film were annealed after film formation in a thermoplastic system, this type of fluctuation would probably disappear. This would be similar to the type of imperfections noted in latex coating films cast with insufficient coalescent.

SUMMARY AND CONCLUSIONS

Further analysis of the CPVC as a transition point in coating behavior indicates that care must be taken in use of the CPVC. Poor dispersion or film formation always decrease CPVC values from those attainable in a well prepared system. Problems in error propagation in the determination of the CPVC are discussed. Right at the CPVC, scatter in property data is to be expected because of the statistical nature of the endpoint, and the fact that this is the point of greatest sensitivity to errors in preparation and measurement. This also means that producing coatings at the CPVC will tend to give reproducibility problems. Considerations of the CPVC in light of Percolation Theory are given, and some work is recommended in zinc-rich coatings. The effects on the CPVC of local

fluctuations in pigment concentration or packing efficiencies are also considered. In general, ongoing work in materials science on the statistics of random composites bears consideration with respect to improved interpretation and use of the CPVC in organic coatings.

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Pigment Volume Concentration and Its Effect on the Corrosion Resistance Properties of Organic Paint Films

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The effect of the pigment volume concentration (PVC) to critical pigment volume concentration (CPVC) ratio (i.e., Λ) on the corrosion resistance properties of paint films has been investigated by AC impedance and electrochemical noise techniques. Painted mild steel electrodes were studied during exposure to 0.6 M NaCl solution for up to 2,700 hr. Two series of alkyd paints were prepared containing either zinc chromate or barium metaborate as inhibitors. Paints were prepared from similar pigment blends (15 vol% inhibitive pigment, 19% TiO₂, 24% magnesium silicate, 27% calcium carbonate, and 15% barium sulphate) at Λ values 0.0, 0.28, 0.55, 0.83, and 1.1. The results showed that all paints

prepared at $\Lambda = 1.1$ deteriorated quickly. Panels painted with resin only (i.e., $\Lambda = 0.0$) exhibited under-film rusting and very poor wet adhesion. Only slight differences in corrosion resistance were observed, during the test, for zinc chromate containing paints at Λ values of 0.28, 0.55, and 0.83. In contrast, all barium metaborate containing paints progressively deteriorated. Performance levels also declined steadily in the sequence $\Lambda = 0.28, 0.55, 0.83$. In conclusion, for this alkyd resin, corrosion resistance can be affected greatly by the PVC/CPVC ratio. However, the presence of zinc chromate as inhibitor allows considerable flexibility in the PVC/CPVC ratio which can be used.

INTRODUCTION

It has been known for many years that the physico-chemical properties of a paint are affected by its pigment volume concentration (PVC). Further, as was originally explained by Asbeck and Van Loo,¹ there is a critical pigment volume concentration (CPVC) above which, many such properties change abruptly. These authors demonstrated that blistering and gloss decrease markedly as the CPVC is approached, whereas permeability and rusting increase dramatically at or above the CPVC. More recently, Bierwagen and Hay² noted 20 paint properties affected by the PVC/CPVC ratio (Λ). One group of these properties encompasses transport phenomena such as permeability, blistering, electrical resistance, and corrosion (i.e., salt-spray) resistance.

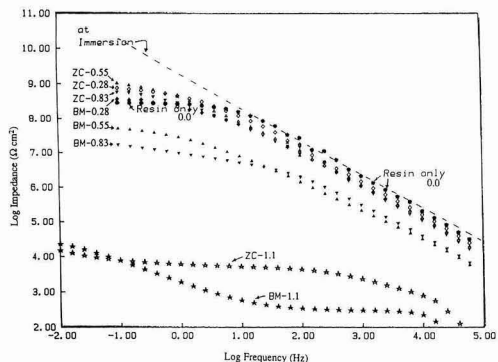


Figure 1 — Electrochemical impedance responses after 1,000 hr immersion in 0.6 M NaCl for steel electrodes coated with unpigmented alkyd resin (i.e., $\Lambda = 0.0$) or with paints containing either zinc chromate (ZC) or barium metaborate (BM) at Λ values 0.28, 0.55, 0.83, and 1.1

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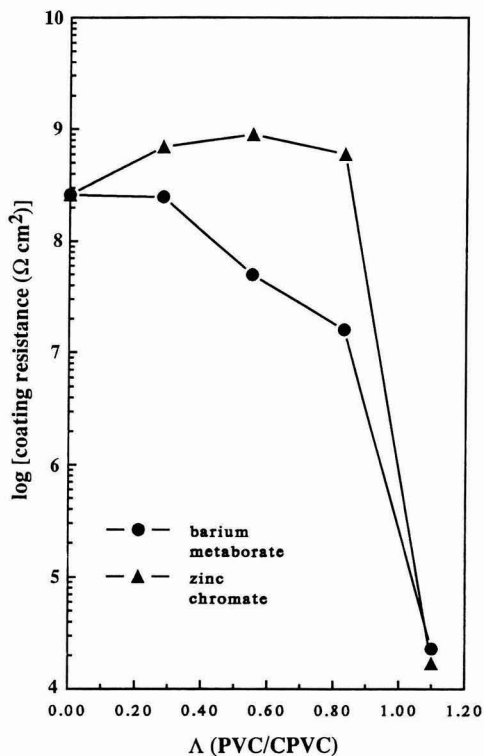


Figure 2 — Coating resistance vs Λ after 1,000 hr immersion testing

In virtually all studies of the effect of PVC on coating performance properties, corrosion resistance has been assessed by traditional salt-spray testing methods.^{3,4} The ASTM B117-85 standard (i.e., 5 wt% NaCl spray, 95% relative humidity, 35°C) would be representative of such tests.⁵ However, the relevance of this approach to testing paints for their corrosion resistance properties has been extensively criticized in recent years.⁶⁻⁹

During the last decade or so, significant progress has been made in attempting to apply electrochemical techniques to assess the corrosion properties of organic coatings when applied to metallic substrates. The most successful of these methods has undoubtedly been wide frequency scan AC impedance, often referred to as electrochemical impedance spectroscopy.¹⁰ More recently, studies of the spontaneous fluctuations in electrochemical voltage and current measured on painted electrodes in freely corroding conditions has also proved effective in assessing corrosion resistance properties of paints.^{11,12}

With the advent of these electrochemical techniques, the present work has been conducted primarily with the objective of applying quantitative electrochemistry, particularly AC impedance and electrochemical noise analysis to determine the effect of varying the PVC/CPVC ratio of an alkyd based coating system on the corrosion resistance properties of the cured paints. The relative effects

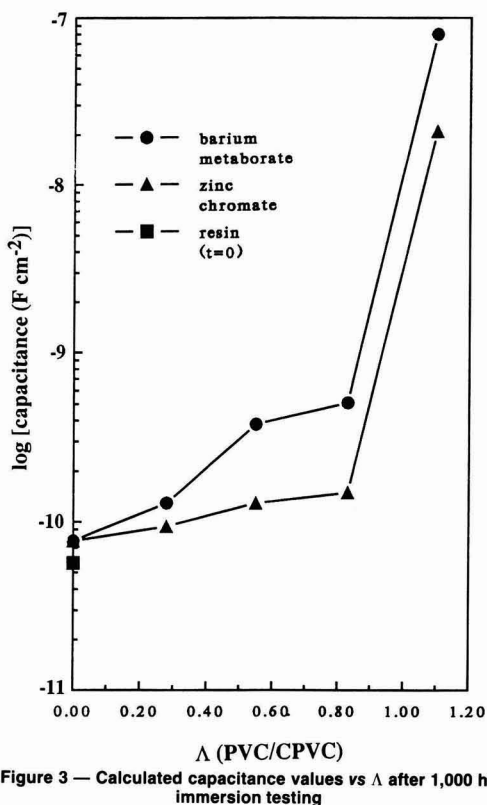


Figure 3 — Calculated capacitance values vs Λ after 1,000 hr immersion testing

of two corrosion inhibitive pigments (zinc chromate and barium metaborate) at the same PVC levels have been compared directly. Unpigmented resin samples were also tested with the additional aim of assessing the role of the binder barrier properties in comparison with the anticipated electrochemical activity of the inhibitive pigments in controlling corrosion.

EXPERIMENTAL

Paints

Two series of alkyd paints using linseed glycerol phthalate resin were prepared containing either zinc chromate ($4ZnO \cdot K_2O \cdot 4CrO_3 \cdot 3H_2O$) or barium metaborate ($2BaO \cdot B_2O_3 \cdot H_2O$) as the inhibitive pigment. From a single batch of the alkyd resin, two pigment blends were made at a Λ value of 1.1. The Λ values used in this work were obtained by the procedures developed by Bierwagen.¹³ Using this methodology, CPVC values were calculated from pigment properties according to the following relationship;

$$CPVC = \Phi / \left[\sum_{i=1}^p X_i (1 + u_i^a) \right]$$

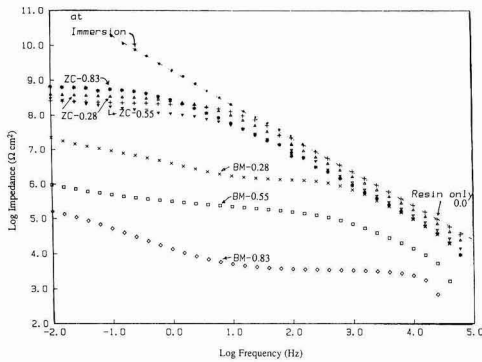


Figure 4 — Electrochemical impedance responses after 2,700 hr immersion in 0.6 M NaCl for steel electrodes coated with unpigmented alkyd resin (i.e., $\Lambda = 0.0$) or with paints containing either zinc chromate (ZC) or barium metaborate (BM) at Λ values 0.28, 0.55, and 0.83

where Φ = random densest packing factor for dry paint; i = subscript describing increments of particle size 1, 2, ..., m ; p = number of pigments in the paint; X_i = volume fraction of pigment i ; and u_i^n = adsorbed volume of oil on pigment i .

Each of these two blends had the following pigment composition: 14.8 vol% inhibitive pigment, 19.3% TiO_2 , 24.2% $Mg_2O_8Si_3$ (magnesium silicate), 27% $CaCO_3$ (calcium carbonate), and 14.7% $BaSO_4$ (barium sulphate). These blends were then mixed with the alkyd resin to produce paints with nominal Λ values of 0.28, 0.55, 0.83, and 1.1. The pigmented paints were mixed by high speed dispersion (20 min - Hegman 5). Thus, by using the unpigmented resin also, two sequences of paints were made at five Λ values ranging from 0.0 to 1.1.

Substrates

Prewashed cold rolled steel test panels (Q-Panel, R612) were used in order to ensure uniform substrate surfaces for testing purposes.¹⁴ All test panels were pre-cleaned using a liquid detergent with a plastic abrasive

pad, subsequently washed with deionized water, dried, and used the same day. Paint test films were cast with a Bird bar applicator onto each substrate and were allowed to cure under ambient air conditions (21°C, 45% relative humidity) for 16 weeks prior to testing by electrochemical methods. Paint dry film thicknesses were maintained within the range $85 \pm 15 \mu m$.

Electrochemistry

AC impedance measurements were conducted using a Schlumberger 1250 frequency response analyzer (FRA) operated under microcomputer control (HP-85). Experiments were carried out in a 3-electrode potentiostatic mode using a Thompson 251 potentiostat. Measurements were made in the nominal frequency range 65 kHz to 0.01 Hz. Current output from the potentiostat was measured using appropriate resistors from a range varying from $1 \times 10^2 - 1 \times 10^7 \Omega$.

Electrochemical noise data were collected on a second series of electrodes. Current noise fluctuations between two nominally identical electrodes, coupled electrically and electrolytically via an agar salt bridge, were made using a low noise zero resistance ammeter interface coupled to a digital voltmeter (DVM). Voltage noise between these coupled electrode pairs and a reference (Ag/AgCl) was monitored using a second DVM. Voltage and current were measured simultaneously during 23.5 min time periods at selected times of immersion during the test. Noise data obtained were studied either as direct plots of the voltage and current fluctuations, or by analyzing the transient data in terms of their simple statistics. Specifically, mean and standard deviation (σ) calculations were made. Noise resistance (R_n) values were calculated using an Ohm's Law analogy (i.e., $R_n \sim \sigma V / \sigma i$). More comprehensive details concerning these procedures have been described previously.^{11,12,15}

Electrochemical cells were made by attaching acrylic (polymethyl methacrylate) cylinders onto the painted test panels using a silicon adhesive. In all cases, painted panels were exposed to 0.6 M NaCl solution under ambient aeration as the corrosive electrolyte. All immersion experiments were of 2,700 hr duration. Working electrode areas were 32 cm².

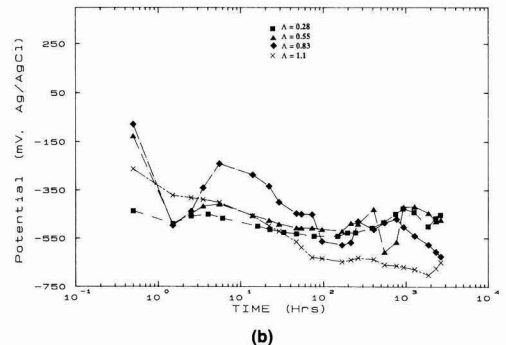
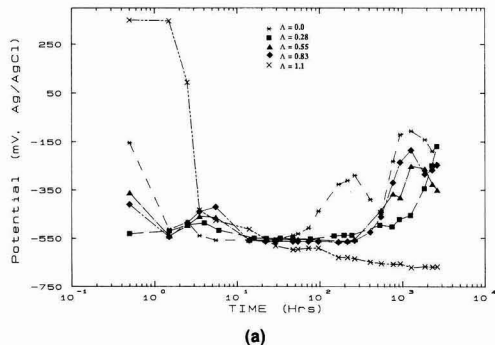


Figure 5 — Mean potential data vs time of immersion in 0.6 M NaCl for steel electrodes. (a) Coated with unpigmented resin ($\Lambda = 0.0$) and with zinc chromate containing paints at Λ values of 0.28, 0.55, 0.83, and 1.1. (b) Coated with barium metaborate containing paint at Λ values of 0.28, 0.55, 0.83, and 1.1

RESULTS AND DISCUSSION

AC Impedance

Electrochemical impedance responses obtained from the painted electrodes after 1,000 hr immersion in the sodium chloride electrolyte are shown in *Figure 1*. These Bode plot data (plotted in $\log |Z|$ vs $\log f$ format) exhibit several important features. The first of these is that for the resin only and for all the pigmented versions at all PVC levels below CPVC, the curves obtained at 1,000 hr show

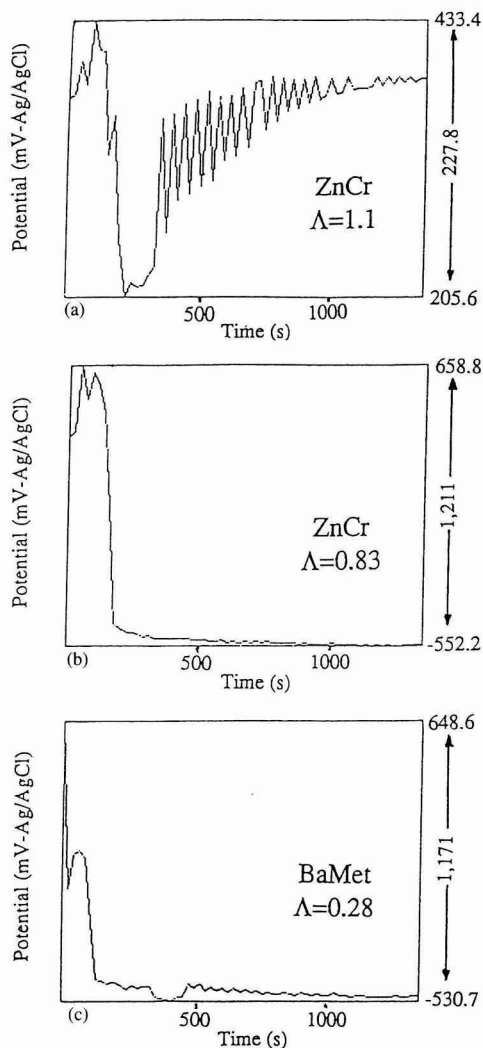


Figure 6 — Voltage noise transients vs time during the initial 0.5 hr immersion period in 0.6 M NaCl for electrodes coated with: (a) zinc chromate containing paint at $\Lambda = 1.1$; (b) zinc chromate containing paint at $\Lambda = 0.83$; and (c) barium metaborate containing paint at $\Lambda = 0.28$

two distinctive segments. The high frequency part of each curve exhibits a linear increase of $\log |Z|$ with decreasing values of $\log f$. This relationship can be considered to be the response expected of a pure capacitor. However, at the lower frequencies, a transition towards constant $\log |Z|$ vs $\log f$ values occur. Where $\log |Z|$ is invariant with frequency, this is indicative of the response expected of a pure resistor. Overall, these two segments of the plot can be considered as representative of the response due to the coating and can be modelled in terms of a simple parallel resistance-capacitance (RC) electrical equivalent circuit. In practice, as the coatings degrade, the coating capacitance increases and the paint film resistance (R_f) decreases. These effects are thought to be caused by the formation of ionically conducting paths due to the transport of electrolyte through the coating to the metal substrate.

From *Figure 1*, very little difference in impedance response is apparent after 1,000 hr for either the clear resin or the zinc chromate pigmented paints at $\Lambda = 0.28$, 0.55, and 0.83. R_f values at the lowest frequencies ranged only between 10^8 - $10^9 \Omega \text{ cm}^2$. The paint pigmented with barium metaborate at $\Lambda = 0.28$ also was included in this group of data plots. However, the paints pigmented with barium metaborate at $\Lambda = 0.55$ and 0.83 exhibited progressively lower low frequency R_f values of approximately 5×10^7 and $2 \times 10^7 \Omega \text{ cm}^2$ respectively, indicative of progressively reduced corrosion protection compared with the equivalent paint formulated at $\Lambda = 0.28$.

All paints formulated above the CPVC (i.e., $\Lambda = 1.1$) resulted in different behavior patterns in that the coating capacitance/resistance transition was displaced towards significantly higher frequencies (i.e., $>10^4$ Hz) and at the lower frequencies (<0.1 Hz for the zinc chromate case and <10 Hz for the barium metaborate case); a further curve component again displayed a linear relationship between $\log |Z|$ and decreasing values of $\log f$. This additional low frequency component of the impedance response suggests that substrate corrosion under these paints formulated above the CPVC was quite significant after 1,000 hr testing.

Plotting the low frequency R_f values as a function of PVC for these coatings gives a clear indication as to the relative corrosion resistance properties at the different PVC loadings. From the data shown in *Figure 2*, it is apparent that, below the CPVC, the measured paint film resistance values are little affected by the PVC level of the formulation when using zinc chromate as the inhibitive pigment in this linseed glycerol phthalate resin. Conversely, PVC loading significantly affects the measured R_f values if barium metaborate is the inhibitive pigment. Highest R_f values were obtained at the lower PVC levels, with progressively decreasing values being obtained as the PVC was increased to $\Lambda = 0.83$. For both the zinc chromate and barium metaborate containing paints, drastic reductions in R_f values were observed once the CPVC was exceeded.

From these impedance data, it is also possible to calculate values of capacitance according to the following relationship;

$$C = 1/(2\pi fZ_{imag})$$

where Z_{imag} is the imaginary component of the impedance in a region of the spectrum where $Z_{imag} \sim Z$ and $Z_{imag} \propto \omega^{-1}$. Increasing capacitance values are indicative of increased uptake of water (electrolyte). In this work, capacitance values were calculated at 10 kHz. For the paint systems formulated below CPVC, the required conditions are clearly met at this frequency, Figure 1. However, the calculations have less precision for the paints formulated above the CPVC.

Capacitance results thus obtained are shown in Figure 3, plotted as a function of PVC. From these data, it can be seen that, again, for the zinc chromate pigmented paints below the CPVC, the PVC loading makes relatively little difference to the extent of water uptake in the paint. In contrast, for the barium metaborate pigmented paints below CPVC, progressively increasing capacitance values were obtained as the PVC loading increased. These results are consistent with the trends observed for the R_f data shown in Figure 2, since an increased uptake of electrolyte would lead to decreased paint film resistance values. Above CPVC, irrespective of pigmentation, electrolyte uptake was clearly extensive. This is not surprising considering that, above the CPVC, the paint structure is relatively open and porous.

Impedance responses obtained from the painted electrodes after a longer period of immersion (2,700 hr) are shown in Figure 4. As for the 1,000 hr immersion data (Figure 1), the response for the paints containing zinc chromate are very similar at Λ values of 0.28, 0.55, and 0.83. Again, these data are similar to the results obtained for the clear (unpigmented) alkyd resin ($\Lambda = 0.0$). Overall, for these paints, the similarity of the results compared with the data at 1,000 hr immersion indicates considerable stability in the electrochemical impedance responses which is probably indicative of good corrosion resistance properties. Furthermore, since the capacitance values (calculated at 1 kHz) vary only from $70 - 172 \times 10^{-11}$ F cm^{-2} , this indicates that the clear resin and chromate containing coating systems (formulated below the CPVC) absorbed only a moderate amount of electrolyte during the entire 2,700 hr test period.

These data trends contrast sharply with equivalent data from the barium metaborate containing paints after 2,700 hr immersion as may be noted also in Figure 4. For these paints, a clear trend towards progressively decreasing resistance values at the low frequencies can be observed in the sequence $\Lambda = 0.28, 0.55,$ and 0.83 . At frequencies below approximately 10 Hz, it is apparent that the impedance responses for these systems are not of a simple resistance, but rather, they are of a resistance/capacitance combination. These results suggest that considerable degradation of the paints has occurred and a simple parallel RC circuit model involving only coating capacitance and paint film resistance terms is no longer appropriate. A more complex model including additional circuit elements for substrate capacitance, polarization resistance, and diffusion terms due to electrochemical dissolution of the underlying substrate is now necessary in order to develop an understanding of the electrochemical interface.

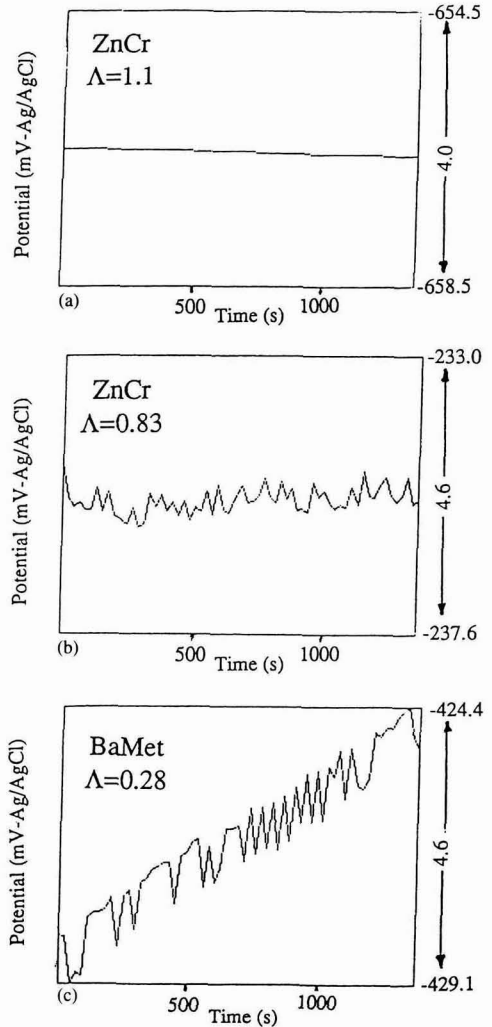


Figure 7 — Voltage noise transients vs time after 920 hr immersion in 0.6 M NaCl for electrodes coated with: (a) zinc chromate containing paint at $\Lambda = 1.1$; (b) zinc chromate containing paint at $\Lambda = 0.83$; and (c) barium metaborate containing paint at $\Lambda = 0.28$

Electrochemical Noise Analysis

Mean values of electrode potential data obtained during the electrochemical noise measuring experiments are shown for the zinc chromate pigmented paints, and also for the unpigmented resin, in Figure 5(a). Two data trends are apparent. First, during the 2,700 hr immersion period, the results were very similar for all zinc chromate containing paints formulated below CPVC. Furthermore, these results were not substantially different from those for the unpigmented resin which suggests that the zinc chromate pigment had no significant influence on the

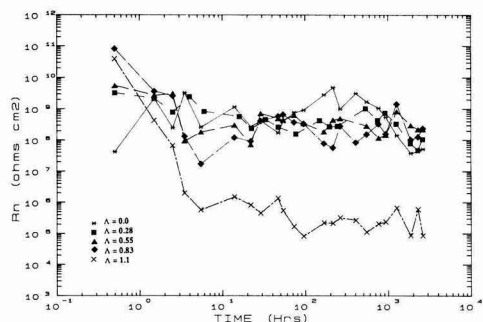


Figure 8 — Resistance noise data for steel electrodes coated with unpigmented alkyd resin (i.e., $\Lambda = 0.0$) and with zinc chromate containing paints at Λ values 0.28, 0.55, 0.83, and 1.1

measured electrode potential. Second, if formulated above the CPVC, the electrode potential data are very different. On immersion, the zinc chromate causes a substantially more noble electrode potential (approximately 700-900 mV displacement in the positive direction) when compared with the equivalent values for the chromate pigmented paints formulated below the CPVC. This result may indicate a degree of substrate surface passivity induced by the oxidizing activity of the chromate anion as this paint absorbed electrolyte. However, the effect is rapidly lost, as the electrode potential decreases (becomes more active) reaching a value comparable with the other paints after only 3.5 hr immersion. Thereafter, the electrode potential for this paint also exhibited a different trend in that the values obtained drifted steadily towards a limiting value of the order of -650 mV (vs Ag/AgCl), whereas the paints pigmented below CPVC and the unpigmented resin drifted to more noble values with increasing time of immersion.

Equivalent data for the barium metaborate pigmented paints are shown in *Figure 5(b)*. In this sequence, the trend is one of progressively decreasing electrode potentials with time. From these data, no specific electrochemical activity can be attributed directly to the barium metaborate.

Plotting the voltage transients as a function of time provides a mechanistic insight into how these pigments function. *Figure 6* shows the transients measured during the initial 0.5 hr immersion period for three paints: zinc chromate pigmented at $\Lambda = 1.1$ and 0.83 [*Figures 6(a)* and *(b)*], respectively; and barium metaborate pigmented at $\Lambda = 0.28$ [*Figure 6(c)*]. These time plots reinforce the view that the zinc chromate functions differently above CPVC since the measured potential transients at $\Lambda = 1.1$ indicate stabilization at the relatively noble potential of ~ 400 mV vs Ag/AgCl [*Figure 6(a)*]. Below CPVC, the zinc chromate at $\Lambda = 0.83$ exhibits a transient pattern similar to the barium metaborate at $\Lambda = 0.28$.

Further mechanistic insights were apparent at various stages of the test. For example, after 920 hr testing (*Figure 7*), the zinc chromate paint formulated at $\Lambda = 1.1$ exhibited no discernible voltage transients superimposed on a mean potential value of ~ -656 mV vs Ag/AgCl

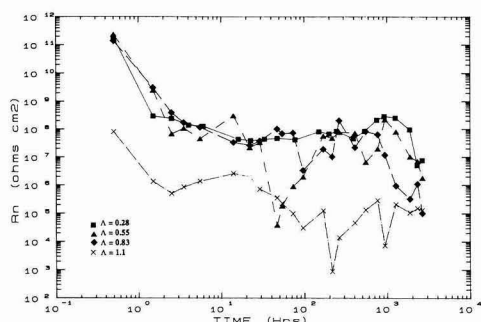


Figure 9 — Resistance noise data for steel electrodes coated with barium metaborate containing paints at Λ values 0.28, 0.55, 0.83, and 1.1

[*Figure 7(a)*]. This pattern of behavior is considered to be consistent with a relative lack of protective capability.¹² Of significance is that clear similarities in the voltage transient patterns were observed between the paint with zinc chromate formulated at $\Lambda = 0.83$ [*Figure 7(b)*], and the paint containing barium metaborate formulated at $\Lambda = 0.28$ [*Figure 7(c)*]. In these cases (superimposed on the general background drift of the data), the voltage transients were of the same general magnitude and frequency, thus suggesting the possibility that these paints may be functioning somewhat similarly mechanisms at this stage of the test.

The general electrochemical trends described were mirrored by the noise resistance (R_n) values obtained from the statistical analysis of the data (i.e., the standard deviation calculations of the voltage and current transients). R_n values for these painted electrodes are shown in *Figures 8* and *9*. Results for the unpigmented, clear resin ($\Lambda = 0.0$) and for the zinc chromate containing sequence at Λ values of 0.28, 0.55, 0.83, and 1.1 are given in *Figure 8*. These data illustrate the changes with time observed during the course of the immersion test (0-2,700 hr). It is clear that the derived resistance value trends are set during the early stages of the test (substantially within the first 10 hr). There is relatively little difference in the results obtained at $\Lambda = 0.28$, 0.55, or 0.83. Further, these results are similar to those obtained for the clear resin. The noise resistance values for these systems fall consistently within the approximate range 10^8 - $10^9 \Omega \text{ cm}^2$. In contrast, the data for the paint containing zinc chromate above the CPVC (i.e., $\Lambda = 1.1$) exhibit considerably reduced R_n values of the order of $10^5 \Omega \text{ cm}^2$ after the first 10 hr of testing. These results reinforce the conclusions from the impedance data in suggesting first, that these systems are relatively stable with respect to time in terms of their electrochemistry, and second, that the PVC level of the formulation does not greatly affect the results providing that the CPVC is not exceeded. Above the CPVC, a much reduced level of performance is apparent.

Equivalent noise resistance data for the paint sequence incorporating barium metaborate are given in *Figure 9*. In this case, the data trends are, in general, less stable with

time. Again, the lowest resistance values are observed for the samples formulated above the CPVC ($\Lambda = 1.1$). The paints formulated at $\Lambda = 0.55$ and 0.83 exhibit considerable variations in noise derived resistances during the course of the immersion test suggesting that these paints are less electrochemically stable than is the case for the paint formulated at $\Lambda = 0.28$. In fact, the paint formulated at $\Lambda = 0.28$ gave noise resistance values approaching those of the paints containing zinc chromate formulated below the CPVC.

Of considerable significance is the close correspondence between the derived resistance (R_n) values obtained by the electrochemical noise technique and the equivalent data obtained at the lowest frequencies (i.e.,

R_f values) by electrochemical impedance analysis. Considering the quite different principles on which these procedures are based, this close correspondence provides valuable evidence as to the validity of these methods. In essence, the derived noise resistance value represents the DC limit of AC impedance for electrochemical systems.

Visual Inspection of the Electrodes

Assessment of the electrochemical data can be made easier by visually inspecting the condition of the electrodes at the conclusion of the immersion test. Electrodes coated with resin in the absence of pigments ($\Lambda = 0.0$) gave paint film surfaces almost entirely covered with a rash of very small blisters (of diameter approximately 1-

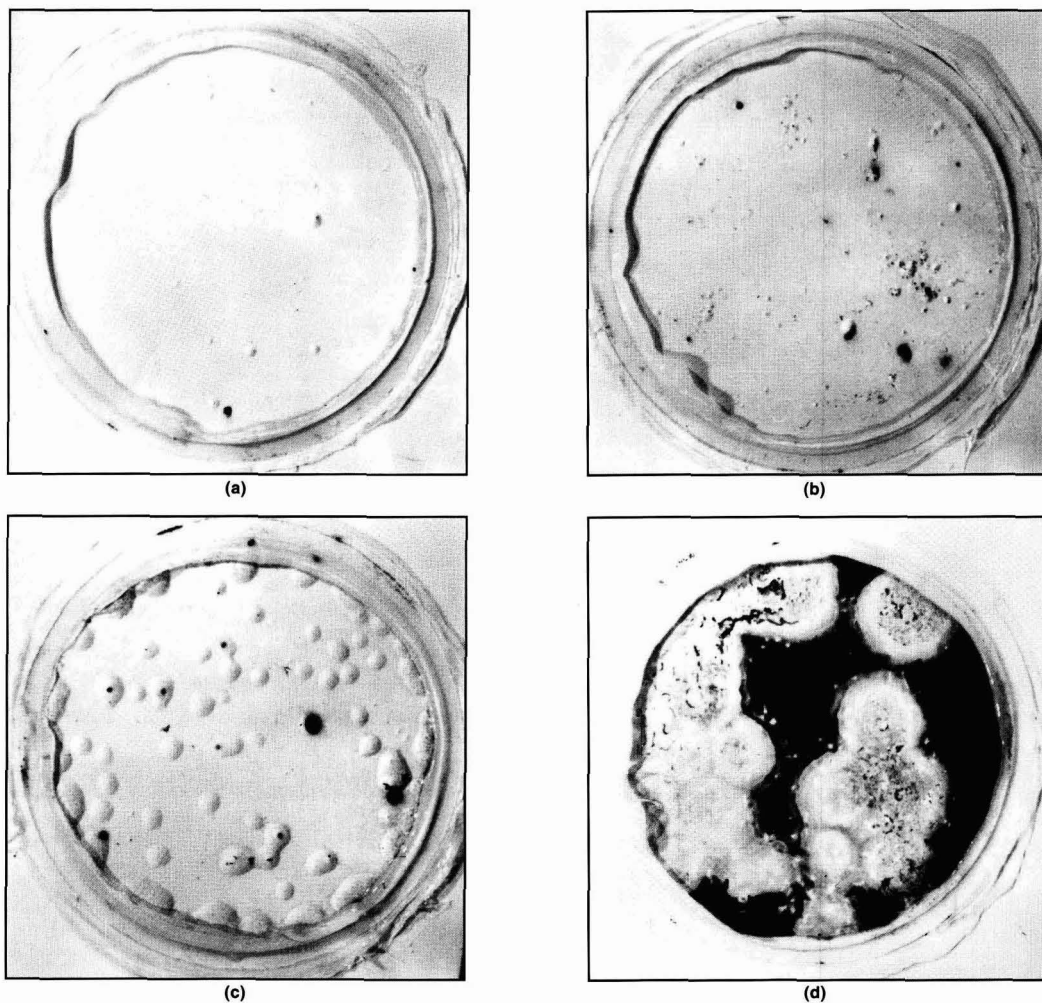


Figure 10 — Visual appearance of electrodes coated with barium metaborate containing paints after 2,700 hr immersion testing. (a) $\Lambda = 0.28$, (b) $\Lambda = 0.55$, (c) $\Lambda = 0.83$, and (d) $\Lambda = 1.1$

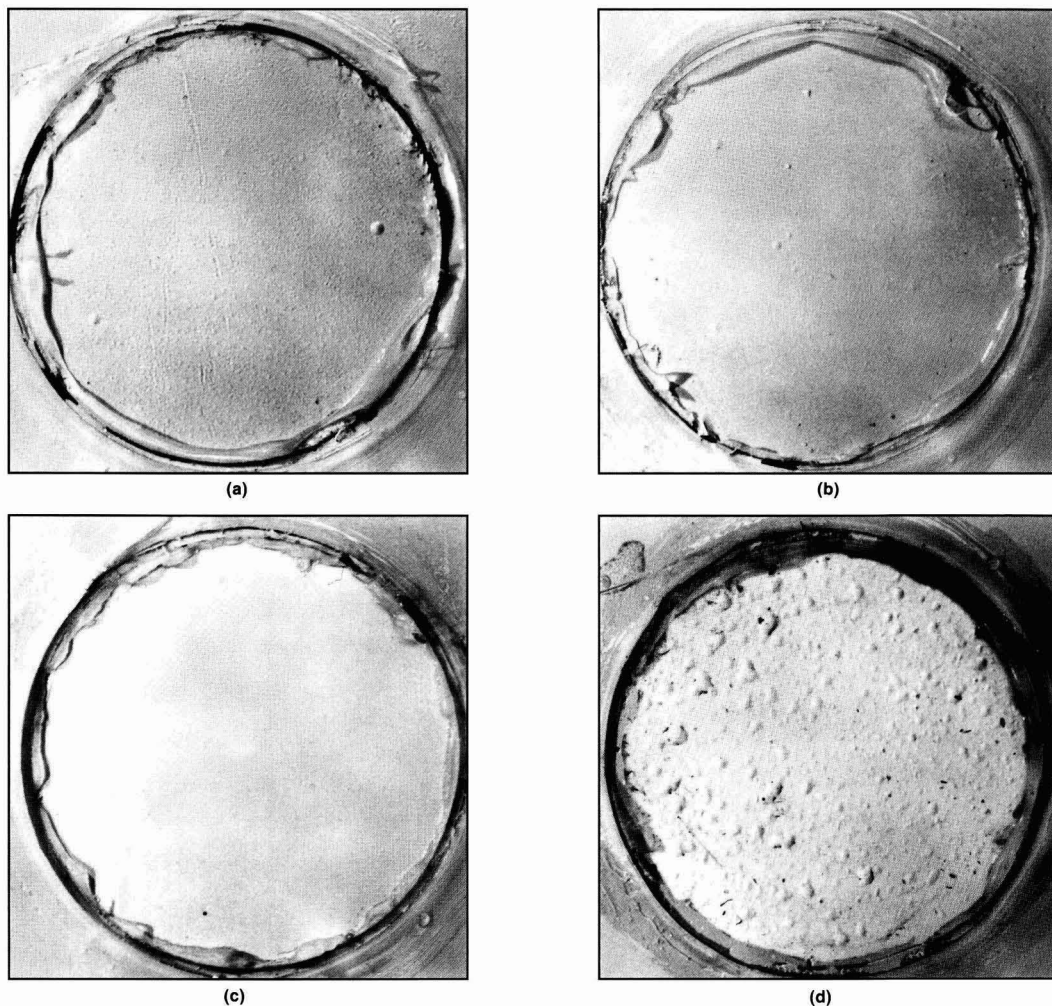


Figure 11 — Visual appearance of electrodes coated with zinc chromate containing paints after 2,700 hr immersion testing. (a) $\Lambda = 0.28$, (b) $\Lambda = 0.55$, (c) $\Lambda = 0.83$, and (d) $\Lambda = 1.1$

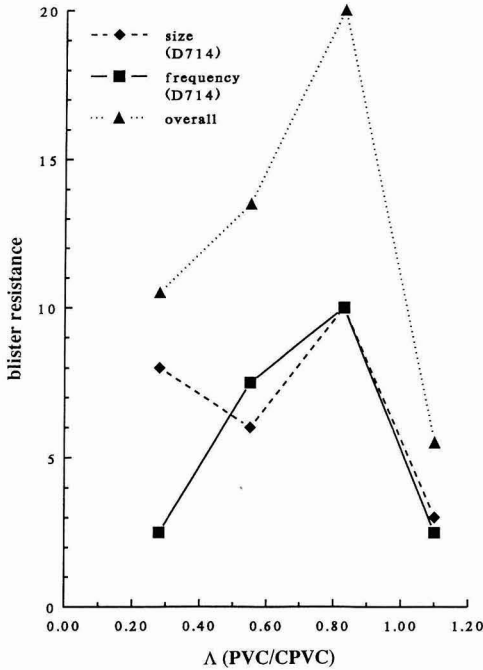
2mm). Associated with this blister pattern was the underfilm formation of green, black, and orange colored corrosion products.

Below the CPVC, for electrodes coated with paints containing barium metaborate, the severity of blistering and though film rusting decreased progressively in the sequence $\Lambda = 0.83, 0.55$, and 0.28 . These progressive effects are shown in *Figure 10* (a-c). Essentially, the reverse trend was observed on the samples coated with zinc chromate containing paint (*Figure 11*). Indeed, in the latter case, almost perfect, defect free results were obtained for the electrodes coated with zinc chromate containing paint at $\Lambda = 0.83$ [*Figure 11(c)*]. Overall, these differences were smaller which, again, may suggest

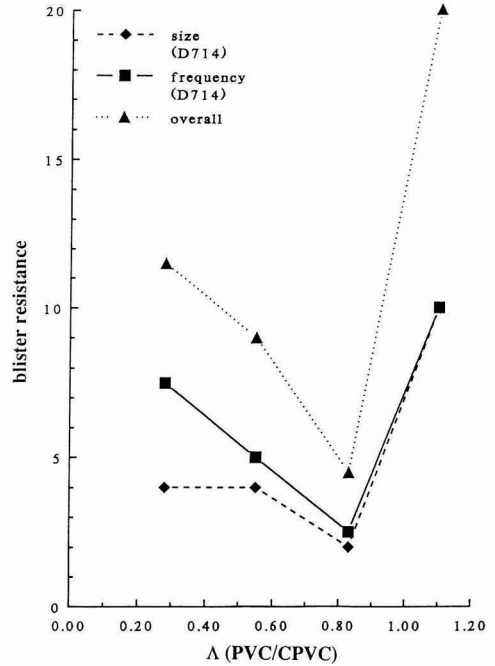
that this pigment allows some greater flexibility in the formulation PVC without significant performance variations than is the case for the barium metaborate pigment.

For all paints formulated above the CPVC, extensive visual degradation and discoloration of the electrodes was apparent. In the case of the zinc chromate containing paint, severe blistering of the paint occurred and the discoloration suggested a loss of leachable chromate from the paint [*Figure 11(d)*]. For electrodes coated with barium metaborate containing paints formulated at $\Lambda = 1.1$, the discoloration suggested extensive underfilm corrosion [*Figure 10(d)*].

Using these electrodes, an attempt was made to plot blister resistance as a function of Λ in a semi-quantitative



(a)



(b)

Figure 12 — Paint film blister resistance vs Λ by ASTM method D714-87 after 2,700 hr immersion testing. (a) Zinc chromate pigmented paints; and (b) barium metaborate pigmented paints

way. It should be noted that blistering in this work refers to blistering induced in the presence of the relatively concentrated 0.6 M NaCl electrolyte, and is likely to be quite different to the blistering phenomena which would occur in immersion testing or in high humidity test chambers when using distilled or deionized water. Blister ratings are according to ASTM D714-87⁵ for size and frequency. An overall assessment was made by arithmetic addition of the size and frequency ratings. The results thus obtained are shown in Figure 12(a) for the zinc chromate containing paints and in Figure 12(b) for the barium metaborate containing paints. From these plots, as is also clear from Figures 10 and 11, it can be seen that optimum blister resistance occurs at $\Lambda = 0.83$ for zinc chromate containing paints, but at $\Lambda = 0.28$ for the barium metaborate paints (discounting the case above CPVC which exhibited extensive underfilm corrosion).

At the conclusion of the electrochemical testing program, and immediately after photography, the painted electrodes were tested for their wet adhesion ratings by using ASTM method D3359-87.⁵ Wet adhesion of the unpigmented resin coatings was observed to be particularly poor giving 100% removal of the coating. The results obtained are illustrated graphically in Figures 13(a) and (b) for the zinc chromate and barium metaborate paints, respectively. For the zinc chromate containing paints, it appears that the wet adhesion tended to improve with increasing PVC even beyond the CPVC [Figure

13(a)], whereas for barium metaborate pigmented paints, wet adhesion appeared better at the lower PVC levels.

SUMMARY

A general conclusion from the present work is that the PVC level can significantly affect the corrosion resistance characteristics of a coating as determined by electrochemical impedance and noise transient measurement methods, and by subsequent visual inspection of the electrodes.

For the alkyd resin/inhibitive pigment combinations as tested, the following specific conclusions can be drawn:

(1) Optimization of corrosion resistance properties does not occur universally at Λ values of approximately 0.83. Whereas the optimum electrochemical corrosion resistance/permeability and physical adhesion results were obtained at $\Lambda = 0.83$ when zinc chromate was used as the inhibitive pigment, when barium metaborate was substituted for the zinc chromate, optimum results were achieved at $\Lambda = 0.28$.

(2) The unpigmented linseed glycerol phthalate alkyd resin used is an effective barrier to the uptake of electrolyte. As the PVC increases, the barrier property decreases.

(3) When formulated above the CPVC, poor performance was observed in terms of: blistering (during immersion in 0.6. M NaCl) for the zinc chromate containing

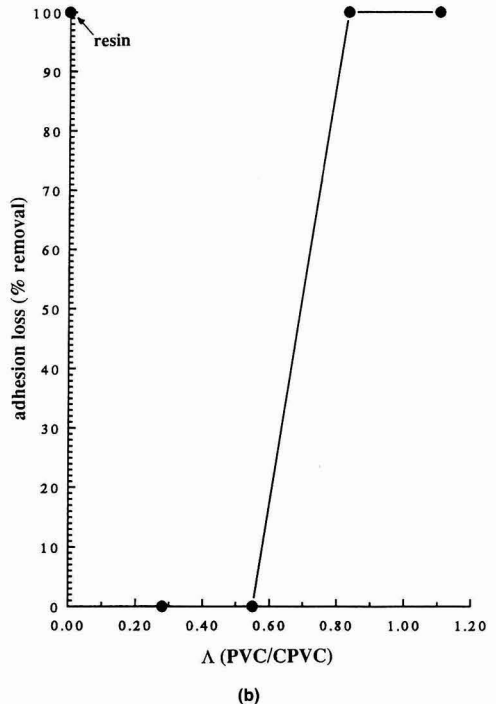
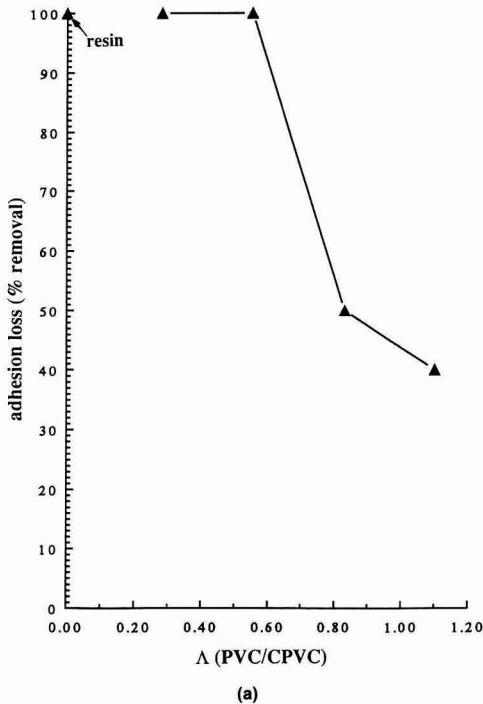


Figure 13 — Paint film wet adhesion vs Λ by ASTM method D3359-87 after 2,700 hr immersion testing. (a) Zinc chromate pigmented paints; and (b) barium metaborate pigmented paints

paint, and permeability and corrosion resistance (i.e., exhibiting coating resistance values of $<10^7 \Omega\text{cm}^2$ within 24 hr of immersion testing) for all the paints.

(4) When zinc chromate was used as the inhibitive pigment, corrosion resistance and delamination susceptibility improved only slightly in the sequence $\Lambda = 0.28, 0.55, \text{ and } 0.83$. This suggests that considerable flexibility exists in the PVC levels which can be used for the formulation. However, the converse was true and the differences were greater when barium metaborate was substituted in the same resin system at the same PVC levels.

(5) The clear resin ($\Lambda = 0.0$), zinc chromate containing paints at low PVCs ($\Lambda < 0.55$) and barium metaborate containing paints at high PVC ($\Lambda = 0.83$) exhibited relatively poor wet adhesion properties. This suggests that substrate/paint interface regions are affected by the choice of inhibitive pigment used and by the PVC level of the formulation.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the management of The Sherwin-Williams Company for permission to publish this paper. They would also like to thank C.H. Simpson for assistance during the course of the work.

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Society Meetings

BIRMINGHAM JAN.

"Nonautomotive Electropaint Technology"

A moment a silence was observed in memory of Birmingham Club founder member Ken Cooke, and former Club member David Yates, who both passed away recently.

Mr. Cooke had been a member of the Club since its inception in 1930. He served as Club President in 1938 and 1954.

Club member Peter I. Hope, of L.V.H. Coatings Ltd., gave a talk on "NONAUTOMOTIVE APPLICATIONS OF ELECTROPAINT TECHNOLOGY."

The basic electrochemical reaction of water at the anode and cathode and its effect on electropainting were reviewed. An explanation of electrochemical painting processes followed.

Mr. Hope discussed "pseudo gold," a gold dyed lacquer used on aluminum for door and light fittings.

In conclusion, the speaker stated that people prefer yellow metals, gold, brass, etc., and that, environmentally, electropainting offers a less harmful approach since cyanides and other metal solutions are not used, as in traditional finishes.

Q. What types of polymer systems are used in electropainting?

A. Epoxy/blocked isocyanates, which provide good performance, and are used for automotive box sections; acrylic/aliphatic urethanes, which display good color, and are used for white box sections; and acrylic/blocked isocyanates which are suitable for decorative finishes.

Q. What are the differences between anodic and cathodic electrodeposition?

A. Anodic systems produce a passive chromate layer to give good performance with less gases given off. Cathodic systems will do almost anything, however, they produce double the level of gases given off during the process.

TERRY WOOTTON,
Publicity

CDIC JAN.

"Driers"

Environmental Affairs Committee Chairman Kenneth Pendleton, of K.A. Pendleton Company, reported on the problems between the state of Ohio and the Cin-

cinnati Metropolitan Sewer District (MSD). He stated that Cincinnati may have been putting more hazardous waste into the sewer system than some of the other areas. Numbers appear to suggest that this is the case. MSD and the State arrived at a settlement of \$160,000. Mr. Pendleton said that the six companies that were cited may be discussing paying the fine.

MSD was found guilty of not enforcing the requirements that they were supposed to have been enforcing against the companies that they do business with.

A presentation on "DRIERS FOR HIGH SOLIDS APPLICATIONS" was delivered by Marvin Landau, of Hüls America, Inc.

The substantial increase in price of cobalt and cobalt related products was reported. The speaker attributed this price increase to the turmoil in Zaire.

Mr. Landau reflected back to April 1990, when laws were placed on the books regarding VOC regulations in California, New York, New Jersey, Houston and Dallas, TX, and Arizona. The Clean Air Act and how it involved the coatings industry was discussed.

According to the speaker, the U.S. Congress never put any of the legislation regarding the coatings industry into the law. The Environmental Protection Agency (EPA) was appointed to enforce law.

The NPCA-published benefits of dealing with Regulatory Negotiations (Reg-Neg) were stated. These benefits include: dealing with the EPA policy makers directly; allowing good, reasonable less-stringent rules to be adopted on an area by area basis; reducing the likelihood of aggressive rulemaking by the States since they get credit from the Federal government; and disrupting the process if not being treated fairly.

The opposite side of the coin when dealing with Reg-Neg is: rules would give emission standards to areas that presently do not have them; preemption cannot be guaranteed in some of the areas and rules would be more stringent than they were before; and information could be used against the coatings industry.

Mr. Landau advised formulators to look into using manganese as a replacement for some of the cobalt presently used. He said for baked finishes, the drier would be based on iron or cerium. A polymerizing or through dry catalyst would be lead or zirconium based. An auxiliary drier would be zinc or calcium. The speaker reported that the anion portion of the driers would be derivatives of naphthenic acid, 2-ethylhexoic acid, or some of the new synthetic acids.

The problems resulting from using these driers in lower VOC alkyds at the levels normally used for higher VOC alkyds (wrinkling, discoloration, soft films, and tackiness) were discussed.

Mr. Landau said sunflower oil acts differently with driers than linseed oil and soy oil based alkyds.

In conclusion, he recommended using higher metal content driers, which provide cost savings, especially in terms of warehousing costs.

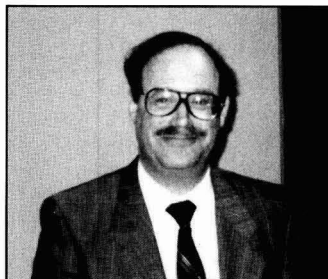
Q. Have you looked at other driers?

A. Yes, we have looked at driers containing lithium and aluminum. They work and you solve one problem, but they create other problems.

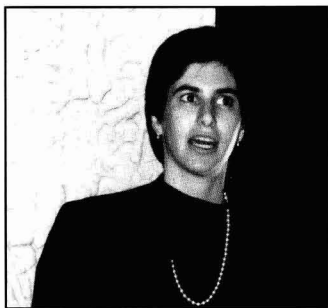
We have focused on properties such as discoloration, cost, and dry time, however, you have viscosity stability to worry about. You do not really have to get that exotic. The resin people have to come out with the approved resins in order for us to start working with these materials to find out what is needed to get them to dry properly.

The Educational Program speaker was Robert Hellebush who spoke on how to maximize returns on investments and how to minimize interest payments on mortgages.

He reported that home mortgage rates are the lowest they have been in 22 years. He stated that it is time to remortgage if your interest rate is 9 or 10%. He recommended a long term mortgage, for example, 30 years. He said with Certificate of Deposit (CD) interest rates dropping and a 2% inflation, a CD paying 6% is really a 4% return. He advised looking into annuities.



CDIC TECHNICAL SPEAKER—Marvin Landau presents "Driers for High Solids Applications" during the January Society meeting



POLYURETHANE COATINGS—Dr. Sherri L. Bassner speaks at the Chicago Society January meeting

According to Mr. Hellebush, another alternative to the low CD interest rate is to invest in real estate and provide a positive cash flow.

PAUL R. GUEVIN, JR., *Secretary*

CHICAGO JAN.

"Polyurethane Coatings"

A talk entitled "EXPERIMENTAL DESIGN IN HIGH SOLIDS POLYURETHANE COATINGS" was presented by Sherri L. Bassner, of Air Products and Chemicals, Inc.

The talk focused on the use of multi-component mixture design studies in the area of high solids polyurethane coatings. Dr. Bassner said the experimental approach was used to optimize the processing and performance properties of coatings prepared from a series of unique isocyanate-terminated prepolymers with low viscosity and low monomeric isocyanate content.

The development of a new line of prepolymers was discussed. In addition, the speaker demonstrated an Expert System formulating program built from the results of the design studies.

A calculation of a blend of prepolymers which will produce a coating meeting desired performance requirements was demonstrated possible within acceptable limits.

CLIFFORD O. SCHWAHN,
Publicity

CLEVELAND NOV.

"Federal EPA"

Technical Committee Chairman Freidun Anwari, of Coatings Research Group, Inc., presented the A.F. Voss/American Paint and Coatings Journal Awards, won by the Society Technical Committee at the 1991 Annual Meeting and Paint Show in Toronto,

Ont., Canada, to President Ben Carlozzo, of Tremco, Inc.

The papers, entitled "Changes in Hiding During Latex Film Formation. Part IV. Effect of Film Thickness Toning," and "Clear Liquid Separation in Latex Paints Containing Cellulosic/Associative Thickener Systems," tied for First Prize in the competi-

The meeting's speaker was Richard Winkhofer, Chief of the Eastern District Office, Region V, the U.S. Environmental Protection Agency (EPA). Mr. Winkhofer gave a brief overview of the Federal EPA.

The speaker said the EPA was established by executive order in 1970. Currently, the EPA employs 16,000 people. According to Mr. Winkhofer, the EPA must implement all or portions of approximately 24 laws, including the Clean Water Act, Clean Air Act, and RCRA. He said the EPA has an operating branch which functions through 10 regional offices and a research branch with about 15 research centers. According to the speaker, legislation is pending to make the EPA a cabinet position.

Mr. Winkhofer stated that the EPA controls a budget of approximately \$6.3 billion broken down as follows: \$2 billion for construction, \$1.8 billion for Superfund, and \$2.5 billion for funding state and local agencies.

The speaker discussed the main purposes of the EPA, including: writing regulations to implement laws; providing financial assistance to state and local agencies; and overseeing the activities assistance to state and local agencies.

In conclusion, Mr. Winkhofer said the future challenge of the EPA is to change attitudes. He said technical processes must be changed to reduce waste generation rather than using "end-of-the-pipe-technology" to treat waste that has already been generated. The speaker emphasized that this approach reduces the actual cost of manufacturing instead of increasing cost. Also, a unified "Eco-Systems" approach must be sought to reduce pollution rather than treating the air, soil, and water as separate entities.

Q. How does the Federal Government put pressure on delinquent states?

A. If a state does not take actions to comply, a formal notice is given. After this, federal funding can be withheld or even called back. However, our objective is to be nonconfrontational.

Q. Do you think there will be a "backlash" to current environmental regulations?

A. Currently, public support is high, but it will take a long time for the public to adjust to regulations that have been enacted. This could take some time.

Q. What steps can the EPA take to make the public aware of actual vs perceived dangers?

A. When policies are drafted, there is a time period during which the public can comment on the proposed policy. All comments are then considered; a very difficult process.

FREIDUN ANWARI, *Secretary*

HOUSTON NOV.

"Multifunctional Polyols"

A moment of silence was observed in memory of former Society members Joe Rench and Bryan Seller who passed away recently.

Gary A. Weaver, of Hüls America, Inc., presented the Nuodex Gavel to President Joseph Caravello, of Guardsman Products Company.

Mr. Caravello presented a plaque (from the Houston Society) and the Society Speaker Award won at the 1991 Annual Meeting and Paint Show, in Toronto, Ont., Canada, to Technical Committee Chairman David Siller, of Kenrich Petrochemicals, Inc.

The presentation, "Variable Characteristics of Titanium Dioxide Pigments Using SEM and Particle Size Analyses," was awarded Second Prize in the competition.

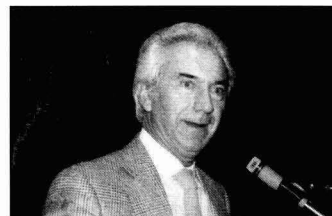
The meeting's technical speaker was Delano Eslinger, of Cook Composites & Polymers, Freeman Polymers Division. Dr. Eslinger's presentation was "HIGH SOLIDS MULTIFUNCTIONAL POLYOLS."

RICHARD W. RYAN, *Secretary*

HOUSTON DEC.

"Powder Coating"

A moment of silence was observed in memory of former Society member Don Leive who passed away recently.



FEDERATION OFFICER VISIT—FSCT President-Elect Colin D. Penny addresses the Los Angeles Society January meeting

It was announced that Arthur McDermott, of Champion Technologies Company, is replacing James W. Judlin, of Devco & Reynolds Company, Inc., as the Society Representative to the Federation's Board of Directors.

New York Society member Vipul Joshi, of CIBA-GEIGY Corporation, was the meeting's technical speaker. His talk was on "DEVELOPMENTS IN POWDER COATING CHEMISTRY."

RICHARD W. RYAN, *Secretary*

LOS ANGELESJAN.

"Color Machines"

A moment of silence was observed in memory of Bob Dorsett, retired partner of Dorsett & Jackson, who passed away recently.

Federation guests in attendance included President-Elect Colin D. Penny, of Hampton Paint Mfg. Company, and Executive Vice President Robert F. Ziegler.

Mr. Penny addressed the membership, discussing the direction of the Federation's Educational Committee efforts. He described the duties of the Educational and Professional Development Committees, and reviewed the status of the Coatings Industry Education Fund and the Educational Coordinating Committee.

Mr. Ziegler praised the efforts of Society members who had supported Federation programs.

Also, he reported on Federation's Spring Week, slated for May 17-20, in Boston, MA, and the 1992 Annual Meeting and Paint Show, scheduled for October 21-23, in Chicago, IL.

Mr. Ziegler concluded his presentation with a slide presentation of the 1991 Annual Meeting and Paint Show, held in Toronto, Ont., Canada, and the new Federation headquarters building, in Blue Bell, PA.

Environmental Affairs Committee Chairman Dave Muggee, of E.T. Horn Company, reported that the Department of Transportation is asking for comments on the 1990 Emergency Response Guide Book, prior to May 15.

Mr. Muggee predicted toxic substance listing for diethanolamine and dimethylformamide based on recent National Toxicity Program studies.

Also, he noted that U.S. Sugar pleaded guilty to eight counts of illegal disposal of hazardous materials; three of these counts involved disposal of lead subacetate used in the laboratory. Mr. Muggee said that filterpapers were thrown in the trash and

lead contaminated filtrate was poured down the laboratory sinks.

"HISTORY AND FUTURE OF COLOR MACHINES," was presented by James T. DeGroff, of Colortec Company Associates, Inc.

The developments in color measurement devices were reviewed. He described sphere as well as 0/45° type instruments.

Mr. DeGroff pointed out that early colorimetric calculations were based on a color coordinate approximating visual color. He said that current software may be used with a variety of color instruments and several mathematical models. In addition, he stated that batch data analysis is possible with the most recent software.

The speaker explained that with more accurate and precise scales, reproducible color measuring devices, and standards which accurately represent today's colorants and paint formulae, quick and dependable matches are possible with controlled batch to batch correlation.

Mr. DeGroff predicted lower cost color measuring devices and much more variety in software in the next five years.

Q. On dark colors (reflectance of less than 10%), we find FMCI more discriminating than CIELAB. Please comment.

A. Looking at colors with small color differences such as in those you describe, FMCI should perform better than CIELAB.

Q. How do I know what numbers represent a good commercial color match?

A. First, establish a standard which all can see. Second, determine the variation from that standard which is acceptable visually by normal observers, and measure those limits.

PHILIP C. BREMENSTUHL, *Secretary*

LOUISVILLENOV.

"Silicone Technology"

Rich Powell, of Argus Company, Inc., presented the Hüls Gavel to President Kris Grauer, of Ashland Chemical Company.

John A. Lanning, of Courtaulds Coatings, Inc, was honored for his election to Secretary-Treasurer of the Federation of Societies for Coatings Technology.

Educational Committee Chairman Paul Baukema, of Akzo Coatings, Inc., announced the establishment of an Educational Grant Program. The program is being established to provide funding for the continuing education of the coatings industries' employees. The grant is designed to provide funding to cover the tuition expenses for an acceptable short course in coatings technology. Notices were distributed to members.



LOS ANGELES SPEAKER—James T. DeGroff talks about "History and Future of Color Machines" at the January meeting

Eligibility requirements established dictate that a nominee be a member of the Society, be a full or part-time employee of a company within the geographic boundaries of the Society, and be willing to pursue a career in coatings technology.

The deadline for completing the application package was January 1.

Dipak Narula, of Dow Corning Corporation, gave a presentation entitled "SILICONE TECHNOLOGY FOR COATINGS IN THE 90s."

The chemistry of silicone resins, highlighting the fact that silicone resin systems can be useful for a wide variety of applications, was discussed. Mr. Narula noted that resins containing high methyl content exhibit films with fast cure times, high weatherability, and gloss retention.

An explanation that low solids silicone resins (50-60%) are only silanol functional, but high solids varieties can be alkoxy or silanol functional, followed.

Mr. Narula pointed out that these polymers are totally new and not just emulsified versions of existing programs.

Coating system comparisons of silicone-organic hybrids to typical solvent based systems, containing white and aluminum pigments, were demonstrated.

In conclusion, it was stated that low VOC, high performance waterborne technology is available. The speaker emphasized that current mechanical emulsions commonly contain some cosolvent content, however, the next generation will be emulsion polymerized and totally solvent free.

MIKE MOILANEN, *Secretary*

NEW YORKNOV.

"Dispersants for High Solids Coatings"

The meeting featured a visit by Federation Secretary-Treasurer John A. Lanning, of Courtaulds Coatings, Inc., and members of the Federation staff, Executive Vice President Robert F. Ziegler, and Director of Educational Services Michael G. Bell.

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Willow Grove Restaurant, Linthicum, MD). JOHN KURNAS, Mineral Pigments Corp., 12116 Conway Rd., Beltsville, MD 20705.

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). D.C. MORRIS, PPG Industries (UK) Ltd., P.O. Box 359, Birmingham, B16 0AD, England. CDIC (Second Monday—Location alternates between Columbus, Cincinnati, Dayton, and Indianapolis). PAUL R. GUEVIN, JR., P.R. Guevin Associates, P.O. Box 811, Westerville, OH 43081-0811.

CHICAGO (First Monday—Sharko's Restaurant, Villa Park, IL). GREGORY E. McWRIGHT, ANGUS Chemical Co., 2911 Sanders., Northbrook, IL 60062.

CLEVELAND (Third Tuesday—Brown Derby, Independence, OH in Sept., Oct., Nov., Dec., Feb., March; Jan. and Apr. meetings, Landerhaven, Mayfield Heights, OH). FREIDUN ANWARI, Coatings Research Group, Inc., 2340 Hamilton Ave., Cleveland, OH 44114.

DALLAS (Thursday following second Wednesday—The Harvey Hotel, Dallas, TX). MIKE EVANS, J.M. Huber Corp., 803 Pleasant Valley, Richardson, TX 75080.

DETROIT (Second Tuesday—meeting sites vary). RON ANDRUS, BASF Corp., 5935 Milford Ave., Detroit, MI 48210.

GOLDEN GATE (Monday before third Wednesday—alternates between Francisco's in Oakland, CA, and Holiday Inn in S. San Francisco). DONALD NOLTE, John K. Bice Co., 280 Missouri St., San Francisco, CA 94107.

HOUSTON (Second Wednesday—Sonny Look's Sirlion Inn, Houston, TX). RICHARD W. RYAN, Exxon Chemical Co., P.O. Box 5200, Baytown, TX 77520.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). YVONNE D'ARCY, Cook Paint & Varnish Co., P.O. Box 419389, Kansas City, MO 64141.

LOS ANGELES (Second Wednesday—Steven's Steakhouse, Commerce, CA). V.C. BUD JENKINS, Consultant, 3366 Somis Dr., Riverside, CA 92507.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). MIKE R. MOILANEN, United Catalysts, Inc., P.O. Box 32370, Louisville, KY 40232.

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 Biftheque, Ville St. Laurent, Quebec). JACQUES BROUILLETTE, BAPCO, 1470 Nobel St., Boucherville, Que., J4B 5H3, Canada.

NEW ENGLAND (Third Thursday—Sheraton Lexington Hotel, Lexington, MA, alternate meetings twice a year in Sturbridge, MA and Providence, RI). JOANNE E. MONIQUE, Ashland Chemical Inc., 400 Main St., Tewksbury, MA 01876.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). ARMAND J. STOLTE, RHEOX Inc., P.O. Box 70, Hightstown, NJ 08520.

NORTHWESTERN (First Tuesday after first Monday—Jax Cafe, Minneapolis, MN). SARAH OEBSER, H.B. Fuller Co., 3530 Lexington Ave., N., St. Paul, MN 55126.

PACIFIC NORTHWEST (PORTLAND SECTION—Third Tuesday; PUGET SOUND SECTION—Third Wednesday; VANCOUVER SECTION—Third Thursday). FLORA WONG, Saguaro Ltd., 106-150 E. Fifth St., N. Vancouver, B.C., V7N 1L5, Canada.

PHILADELPHIA (Second Thursday—Williamson's Restaurant, GSB Bldg., Bala Cynwyd, PA). BRIAN O'CONNOR, McWhorter Resins, Inc., 7600 State Rd., Philadelphia, PA 19136.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). DENNIS GILLESPIE, Lomas Minerals and Chemicals, P.O. Box 605, Indian Trails, NC 28079.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). TIMOTHY ZEFFIRO, J.M. Gillen Co., P.O. Box 588, Bridgeville, PA 15017.

ROCKY MOUNTAIN (Monday following first Wednesday—Zangs Brewery, Denver, CO). LOUIS HARTNELL, Herr & Hartnell Co., 791 Chambers Rd., #555, Aurora, CO 80041.

ST. LOUIS (Third Tuesday—Salad Bowl Restaurant, St. Louis, MO). MICHAEL SCHURMAN, Kop-Coat, Inc., 328 Henley Ind. Ct., St. Louis, MO 63144-1599.

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). MARY G. FINNIGAN, Unocal Chemicals Div., 8901 Research Dr., Charlotte, NC 26845.

TORONTO (Second Monday—Cambridge Motor Hotel, Toronto). DAVID JACK, Technical Coatings Co Ltd., 1164 Walkers Ln., Burlington, Ont., L7M 1V2, Canada.

WESTERN NEW YORK (Third Tuesday—meeting sites vary). MARKO MARKOFF, 182 Farmingdale Rd., Cheektowaga, NY 14225.

Mr. Lanning talked about the Federation-sponsored educational and technical programs that are available to the Societies.

Mr. Bell briefly reviewed the activities of the Educational Coordinating, Technical Advisory, Professional Development, Corrosion, and Planning Committees.

Mr. Ziegler reported on the recently concluded 1991 Annual Meeting and Paint Show which was held in Toronto, Ont., Canada. Also, he gave a slide presentation of the new Federation headquarters building in Blue Bell, PA.

Technical Committee Chairman Larry Waelde, of Troy Chemical Corporation, estimated that the Society should be able to produce two technical papers from work being completed by the subcommittees. In addition, planning for an educational video on proper paint testing has begun.

The meeting's technical speaker was Marvin J. Schnall, of Troy Chemical Corporation. Mr. Schnall reported on "CHOOSING THE MOST EFFECTIVE DISPERSANTS FOR HIGH SOLIDS COATINGS."

The speaker explained that with the current emphasis on low VOC technology, new raw materials are being used which are selected more for their acceptability to environmental conditions than to their compatibility with the coating, and are therefore in need of dispersants because of their poor wettability.

The discussion covered a number of common pigments in VOC compliant systems such as acrylics and high solids air-dry alkyds. The pigments included carbon black, titanium dioxide, quinacridone red, phthalocyanine green, and carbazole violet.

According to Mr. Schnall, in all cases, a newly developed amphoteric dispersant outperformed the many competitive dispersants that were used for purposes of comparison.

In conclusion, it was pointed out that pigments with high oil absorption required more dispersant (10-15%) than low oil absorption pigments (0.5-1.0%) on a pigment weight basis.

Q. Does the amphoteric dispersant work over a wide range of pigment types?

A. Yes. Because it is amphoteric, it can act as a cationic or anionic dispersant depending on the system being used and this characteristic enables it to be effective over a very wide range of different pigment types.

Q. Does this dispersant work in both high solids and low solids systems?

A. Yes, it works well in both types. In the high solids systems, smaller resin particles are present and therefore there is less steric hindrance with a greater tendency for pigment flocculation so that the proper dispersant is more critical than in the low solids systems.

ARMAND J. STOLTE, Secretary

Elections

BALTIMORE

Active

Asarawala, Arun D.—The Valspar Corp., Baltimore, MD.
Kalfian, Charles R.—Mineral Pigments, Beltsville, MD.
Lisby, Alva C.—The Valspar Corp., Baltimore.

Associate

Rossello, Patrick V.—Aqualon Company, Wilmington, DE.
Williams, Kenneth K.—Lenape Chemical Inc., Bound Brook, NJ.

CDIC

Active

Bussell, Leonard J.—Borden Coatings, Cincinnati, OH.
Hastie, John F.—Akzo Coatings Inc., Columbus, OH.
Van Kuren, Thomas A.—Akzo Coatings Inc., Columbus.

CLEVELAND

Active

Figoli, Andrew N.—Man-Gill Chemical, Bedford, OH.
Mecca, Sam V.—Alliance Paint & Coatings, Alliance, OH.
Ditucci, Al J.—Rohm and Haas Co., Westlake, OH.
Graham, Cynthia J.—Interstate Chemical, Hermitage, PA.
Nelson, Gregory A.—Palmer Supplies Co., Cleveland, OH.
Nortz, William H.—Maroon Inc., Rocky River, OH.

Educator/Student

Nowak, Richard—Edinboro University of PA, Edinboro, PA.
Philistine, Maureen T.—John Carroll University, Wickliffe, OH.

Retired

Wiegmann, J. Robert—Erie, PA.

NEW YORK

Active

Boboye, Adebayo—Cookson Pigments Inc., Newark, NJ.
Crossland, Bonnie L.—Troy Corp., Newark.
Grumski, Deborah A.—Akzo Coatings Inc., Somerset, NJ.
Igbokwe, Edward O.—Hoboken Paint Co., Lodi, NJ.

Inigo, Rosario M.—Advance Foils Inc., Elizabeth, NJ.
Karouna, Kir G.—E.A.O., New York, NY.
Lee, Sharon—Minwax, Montvale, NJ.
Michalewicz, Leo W.—William Zinsser & Co., Somerset.
Santiago, Renier—Hoboken Paint Co., Lodi.

Associate

Alampi, Lorraine M.—Advance Foils Inc., Elizabeth, NJ.
Lefelar, Robert A.—Clifton Adhesive Inc., Wayne, NJ.
Oxley, James William—Spectra Colors Corp., Kearny, NJ.
Smerak, Lance P.—Cookson Pigments Inc., Newark, NJ.

LOS ANGELES

Active

Alkhas, Sargon A.—Old Quaker Paint Co., Carson, CA.
Dertlich, Valerie—Advanced Systems Technology, Inc., San Diego, CA.
Nucup, Amelia M.—Morton International, Los Angeles, CA.

Plouff, Jamie S.—Ameritone Paint Corp., Long Beach, CA.

TORONTO

Active

Andres, Margie G.—St. Clair Paints, Concord, Ont.
Cimbron, Helder M.—Tremco Ltd., Toronto, Ont.
Kershaw, John W.—Home Hardware, Burford, Ont.
Malone, Shaun F.—Du Pont Canada Inc., Ajax, Ont.
Nadarajah, Sivakumar—Reichhold Ltd., Weston, Ont.
Olesen, Keith R.—Nacan Products Ltd., Brampton, Ont.

Associate

Bodendistel, Kenneth T.—Henkel Canada Ltd., Mississauga, Ont.
Howes, Gord J.—Folio Instruments, Kitchener, Ont.
Letvenuk, John L.—Henley Chemicals Ltd., Scarborough, Ont.
Papanikolaou, Vasiliki V.—Du Pont Canada Inc., Mississauga.
Vriesinga, Roland—Klieverik Dispensing Systems, Toronto, Ont.

Solution to February's "CrossLinks"

Future Society Meetings

Birmingham

(Apr. 2)—“POWDER COATING—A RESIN PRODUCER'S APPROACH”—Yves Merck, U.C.B. Ltd.

(May 7)—63rd Annual General Meeting.

Cleveland

(Mar. 17)—“DRIER SYSTEMS FOR HIGH

SOLIDS COATINGS”—Marvin Landau, Hüls America, Inc.

(Apr. 21)—“THE ADVENTURES OF A CHEMIST-COLLECTOR”—Dr. Alfred Bader, Aldrich Chemical Co.

(May 19)—“ADVANCES IN RESIN TECHNOLOGY FOR WATERBORNE STAINS”—Al Heitkamp, Cargill Inc.

Detroit

(Apr. 14)—“POLYVINYL CHLORIDE RESINS”—Speaker from ICI Chemicals, Inc.

(May 12)—“COLOR THEORY”—Speaker from Byk-Gardner, Inc.

Golden Gate

(Mar. 16)—“SMOOTHNESS OF CLEAR FLAT FINISHES”—Sam Maskery, Crosfield Chemicals Co.

(Apr. 13)—“WATERBORNE RESINS”—Rich Johnson, Cargill, Inc.

(May 18)—“STATISTICAL PROCESS CONTROL”—Dan Baker, McWhorter, Inc.

(June 15)—Manufacturing Committee Seminar.

Los Angeles

(Mar. 11)—Past-Presidents' Night. “SMOOTHNESS OF CLEAR FLAT FINISHES”—Sam Maskery, Crosfield Chemicals Co.

(Apr. 8)—“WATERBORNE RESINS”—Rich Johnson, Cargill, Inc.

New York

(Mar. 10)—“THE EFFECT OF A NOVEL CLASS OF THIXOTROPIC AGENTS ON RHEOLOGICAL PROPERTIES OF LOW VOC COATINGS”—Speaker to Be Announced, King Industries.

(Apr. 14)—“POWDER COATINGS IN THE 90s”—Charles Danick, Cargill, Inc.

(May 12)—Past-President's Night—PaVaC Awards Night—“WATERBORNE COATINGS: RETROSPECT AND PROSPECT”—Robert M. Fitch, Fitch & Associates.

Philadelphia

(Mar. 12)—“WAX EMULSIONS IN AQUEOUS POLYMERIC COATINGS: CONTRIBUTIONS AND MECHANISMS”—Marty Reihemann, Michelmann Inc.

(Apr. 24)—Awards Night.

(May 14)—“THE MALCOLM BALDRIDGE PROCESS—A FRAMEWORK FOR IMPROVEMENT”—Ross C. Loeser, E.I. du Pont de Nemours & Co., Inc.

Piedmont

(Apr. 15)—“THE INFLUENCE OF EQUILIBRIUM AND DYNAMIC SURFACE TENSION ON WOOD COATINGS SURFACE DEFECTS”—David Wanke, Air Products & Chemicals, Inc.

(June 17)—Past-Presidents' Night. PSCT Technical Committee, Sara Robinson.

Pittsburgh

(Apr. 13)—Title and Speaker to Be Announced.

(May 11)—Title and Speaker to Be Announced.

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People

Virginia E. Bayer has joined the Electronic Optics Division of Carl Zeiss, Inc., Thornwood, NY, as Senior Applications Specialist for transmission electron microscopes. In this position, Dr. Bayer will work primarily with the company's biomedical electron microscopy customers to optimize the performance of Zeiss microscopes for their specific applications.



V.E. Bayer

The promotion of **Kenneth Richardson** to Laboratory Manager at Avecor, Inc.'s, Vancouver, WA plant has been announced. An employee of the company since 1982, Mr. Richardson previously held the position of Liquid Color Supervisor at Avecor's San Fernando, CA facility.

Don Dell has been appointed to spearhead the new Consumer Specialties Division of American Colloid Company, Arlington Heights, IL. The division, which has been created through a restructuring of the company's Industrial Chemical Division, will focus on marketing American Colloid's Magnabrite®, Polargel®, and Hectabrite® specialty clay lines for applications in the cosmetic, pharmaceutical, and household products industries. Mr. Dell will be based at the company's Belle Fourche, SD operation.

In addition, **Mark Steward** has been named Industrial Chemical Division Manager. Under Mr. Steward's leadership, the division will focus on its traditional markets which use American Colloid's Volclay® products in industrial manufacturing, wine clarification, ceramics, and asphalt emulsions. He will be based in Arlington Heights.

Christopher Gantz has been named Branch Manager of the Salt Lake City office of Van Waters & Rogers Inc., a subsidiary of Univar Corporation, headquartered in Kirkland, WA. Mr. Gantz has held a variety of sales and managerial positions within the company over the past 11 years. Most recently he served as Branch Manager at the company's Riverside, CA office.

The following appointments have been announced by Du Pont Chemicals, Wilmington, DE: **Jeffrey L. Keefer**—Manager of Special Projects and Global Market Coordinator/White Pigment and Mineral Products; **Fred J. Michels**—Regional Manager/Pulp and Paper (East); **John J. Pritchard**—Plastics Industry Manager/White Pigment and Mineral Products; and **David M. Lundquist**—Regional Manager/Coatings and Plastics (East).

James Y. Oldshue, Vice President/Mixing Technology for Lightnin, Rochester, NY, has announced his retirement. Dr. Oldshue's various positions throughout his 42-year career with Lightnin include: 1950-1959—Manager/Development Engineering; 1960-1963—Director of Research; 1963-1970—Technical Director; and 1970-1992—Vice President/Mixing Technology. In addition to his accomplishments with Lightnin, Dr. Oldshue has lectured throughout the world and has taught several courses through the American Institute of Chemical Engineers. His broad experience in chemical engineering process design has greatly influenced the manner in which many materials are produced today.

Kemira, Inc., Savannah, GA, has appointed **George L. (Rob) Roberts, III** to the position of Vice President of Marketing. Formally Marketing Director for Cyanamid BV, The Netherlands, Mr. Roberts was responsible for the marketing of chemicals in both Eastern and Western Europe. Prior to his European stint, Mr. Roberts managed Cyanamid's Canadian Division.



G.L. Roberts, III

Spraylat Corporation, Mount Vernon, NY, has announced the appointment of **Brewster Barclay** as European Product Manager/Conductive Coatings. In this capacity, Mr. Barclay will be responsible for establishing a Belgium-based office to market the company's copper and silver-based conductive coatings. He most recently was a consultant for New York-based BPA (Technology & Management), Inc.

The newly created post of Business Director/Chemicals for Quantum Chemical Corporation's USI Division, Cincinnati, OH, has been accepted by **Jerry W. Parker**. In this position, Mr. Parker will oversee the company's ethyl alcohol, ethyl ether, vinyl acetate monomer, acetic acid, methanol, ethylene glycol, and ethylene oxide businesses. He previously served as Director/Sales for Polyolefins.

Richard M. Rompala has been named Group Vice President/Coatings and Resins, of PPG Industries, Pittsburgh, PA. Mr. Rompala who had been Group Vice President/Chemicals, since 1987, succeeds **Eugene B. Mosier**, who has left the company to pursue other interests. Mr. Rompala will also continue to have responsibility for PPG's instrument and systems business, which he assumed in 1988.

Benjamin Moore & Company, Montvale, NJ, has announced the retirement of **Michael C. Quaid** as Executive Vice President. **Benjamin M. Belcher, Jr.** has been elected to replace Mr. Quaid in that position.

Mr. Quaid joined Benjamin Moore in 1953 and rose to the position of Divisional Vice President/Eastern Division in 1973. He was subsequently named Assistant to the President, Vice President/Subsidiaries, Senior Vice President, and Vice President/Marketing. Mr. Quaid will continue to serve on the company's Board of Directors.

Mr. Belcher started with Benjamin Moore as a Sale Representative with the company's Canadian affiliate, Benjamin Moore & Company Ltd. He held a succession of positions with Moore's corporate and eastern division organizations.

The National Decorating Products Association (NDPA), St. Louis, MO, has elected its slate of officers and Board of Directors for 1992 at its national convention and trade show. Officers elected are the following: President—**Norman Thomas**; Vice President—**Robert Perschon**; and Treasurer—**Jan Satrom**.

Elected directors include: **Rick Cronin**; **Gary Fahndrich**; **Dan Gould**; **David Morris**; and **Richard Rickard**.

Obituary

Thomas R. Mitchell, President and Chief Executive Officer of Reichhold Chemicals, Inc., Research Triangle Park, NC, has announced his retirement from the company, effective April 1. Mr. Mitchell will be succeeded on an interim basis by **Hiroshi Maeda**, Senior Managing Director of Reichhold's parent company, Dainippon Ink and Chemicals, Inc., of Tokyo, Japan until a permanent successor is appointed.

Mr. Mitchell joined the company in 1957 as a Laboratory Technician and held positions of increasing responsibility until his appointment as President and CEO in 1988. He also served as Chief Executive and Chairman of the Board of several domestic divisions, foreign subsidiary companies, and joint ventures. During his four-year tenure as President and CEO, Mr. Mitchell relocated the company from White Plains, NY to its current location in Research Triangle Park. He will continue to serve Reichhold as a consultant.

Darren R. Gilbert has joined the staff of ANGUS Chemical Company, Northbrook, IL, as a Sales Representative/Northeast. Prior to joining ANGUS, Mr. Gilbert was an Account Representative for ARCO Chemical Company.

Research-Cottrell, a subsidiary of Air & Water Technologies Company, Branchburg, NJ, has announced the addition of **Stephen R. Wilson** as Vice President/Sales and Marketing for the Custodis Division. At this position, Mr. Wilson will be responsible for directing the sales program for the division's line of chimneys, steel stacks, and silos. He will also manage the Custodis regional sales offices in Somerville, NJ; Birmingham, AL; Chicago, IL; and Salt Lake City, UT.

The position of Plant Superintendent for Preservative Paint Company, Seattle, WA, has been filled by **Kevin Hudson**, in bringing 25-years experience in the paint industry to this position. Mr. Hudson will be responsible for production, maintenance, safety, and regulatory compliance at Preservative Paint.

James J. Gambino has been appointed to the newly created position of Business Director/Specialties for the Marketing Group of RHEOX, Inc., Hightstown, NJ. Mr. Gambino will oversee the organizing and managing of the inks, grease, cosmetics, adhesives, oil drilling, plastics, and environmental systems groups. He most recently served as Manager of Corporate Development for Rohm and Haas Company, Philadelphia, PA.

The position of Product Manager/Biocides for Troy Corporation, E. Hanover, NJ, has been accepted by **Irving Gottlieb**. Under this title, Mr. Gottlieb will have marketing responsibility for Troy's complete line of Troysan® bactericides, fungicides, and algacides. Prior to joining Troy, he was a Marketing Manager for Lonza, Inc.



I. Gottlieb

The following appointments have been announced by the Packaging Products Division of The Dexter Corporation, Waukegan, IL: **Randy V. Johnson**—Manager of Business Planning; **Peter Winner**—Director of Research and Development, Asia Pacific, Ltd., Singapore; **Thomas M. Daly**—Vice President of Marketing; **John W. Ramler**; Vice President of Operations; and **Kurt E. Marhoefer**—Vice President of Finance.

Matthew D. Dustin, former counsel with the State Affairs Division of the National Paint and Coatings Association, has been named Executive Director of the California Paint Council, located in Sacramento, CA. Mr. Dustin's responsibilities will include working with state regulatory agencies; maintaining a comprehensive information system; and continuing effective communications among the council, the Southern California and Golden Gate Paint and Coatings Association, and their respective lobbying groups.

Kenneth G. Cooke, co-founder of the Birmingham Paint, Varnish & Lacquer Club, died January 2, 1992. He was 87 years old.

Mr. Cooke spent most of his working life with Arthur Holden & Sons, Ltd. in Birmingham, England, overseeing technical and quality control in addition to production. At the time of his retirement in 1972, he served as Works Director.

Mr. Cooke was the last surviving member of the three who founded the Birmingham Paint, Varnish & Lacquer Club (a Constituent Society of the Federation of Societies for Coatings Technology). He served as Club Secretary/Treasurer, and then became President of the Club, first in 1938-39 and again in 1953-54. Mr. Cooke attended The Paint and Varnish Production Club Annual Meeting in 1935 and 1944.

Many of the original aims of the Club laid down in 1930 by Mr. Cooke are still in existence today: social contact, cooperation, and the interchange of noncompetitive information by members of the paint industry.

Dexter Tight, pioneer in the furniture and automobile paint industry, died September 13, 1991. He was 101 years old.

Mr. Tight joined the Glidden Varnish Company in Cleveland, OH, then moved to California where he was Vice President and General Manager of Glidden Company from 1919 to 1921. Mr. Tight was President of the R.H. Nason division of W.P. Fuller and Company, from 1921 until his retirement in 1946 and continued to serve as a technical advisor for an additional 10 years.

Mr. Tight is a former member of the Golden Gate Paint, Varnish and Lacquer Club.

FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY

Presents

SPRING WEEK '92

May 17-20

Sheraton Boston Hotel and Towers • Boston, MA

Featuring FSCT Seminar on

"Understanding Corrosion Protection"

Spring Week Schedule

May 17—FSCT Board of Directors Meeting

May 18—FSCT Society Officers Meeting

May 19-20—FSCT Spring Seminar

XXIst FATIPEC Congress Slated for RAI Congress Centre In Amsterdam, The Netherlands, June 14-18, 1992

The XXIst FATIPEC Congress, held in conjunction with the European coatings exhibition "Euroformula 92," will take place June 14-18, 1992 at the RAI Congress Centre Amsterdam and the International Congress and Exhibition Centre RAI, respectively. The theme of this year's event is "Safety, Health, and Environment (SHE)."

As the theme indicates, the program will demonstrate a complete generation of new pigments, binders, solvents, and other raw materials, together with production methods and measuring techniques adapted to reduce pollution. Speakers will present the latest developments of the industry which will include: emission reduction; waterborne systems; high solids coatings; powder coatings; durability of coatings; pigmentation of coatings and inks; measuring and testing; and production of coatings.

Speakers scheduled to appear include:

Monday June 15

PLENARY LECTURES

J. DeWit, of Akzo Coatings bv; and H. Kastien, of Siegfried Keller AG

EMISSION/WASTE DISPOSAL

F.R.J. Willems, of TNO Centre for Coatings Research; L. van Dalen, of Akzo Coatings bv; E.J. van Beem, of Shell Nederland Chemie B.V.; P.G. de Lange, of Teodur N.V. Breda; E.W.F. van Biemen, of Akzo Coatings bv; and F. Rivetti, of Enichem-Synthesis

WATERBORNE

M. Slinckx and M. Sonderman, of Shell Louvain la Neuve; R.Q.F. Janssen, of TU Eindhoven; A. Wegmann, of CIBA-GEIGY AG; J.E. Lawniczak, P.J. Greene, and K. Middleton, of Eastman Chemical Co.; M. Hulden, E. Sjöblom, and P. Boström, of Institute for Surface Chemistry; and G. Ostberg, B. Bergenstahl, and M. Hulden, of Institute for Surface Chemistry

PIGMENTATION

U. Gesenhues, of Sachtleben Chemie GmbH; O.J. Schmitz, L. Dulog, and R.

Fischer, of Forschungsinstitut für Pigmente und Lacke E.V.; A. Kimura, of Shiseido Basic Research Laboratory; L. Elfenthal and M. Klwig, of Kronos International Inc.; L. Cutrone, of Tioxide Europe; and J. Hajas, of Byk-Chemie GmbH

Tuesday, June 16

PLENARY LECTURES

F. Pellaschiar, of Avisia-Federchimica; and K.-D. Vellemann, U. Rothe, and H. Wagner, of Bayer AG.

WATERBORNE

G. Hardeman, of DSM Resins bv; L.G. Curtis, P.M. Cook, and K.R. Walker, of Eastman Chemical Co.; S.J.M. Lemmers, of DSM Resins bv; A. Arcozzi, of Enichem Synthesis; H. Hofland, of DSM Resins bv; H. Affeldt and G. Koppey, of Synthomer Chemie GmbH; K. van der Kolk, of Sigma Coatings; H. Kossmann, of BASF Aktiengesellschaft; and A. Overbeek, of ICI Resins

PIGMENTATION

R. Glausch, J. Dietz, and R. Maisch, of E. Merck; E. Berarducci and G. Medaglia, of Casco Nobel Srl; P.R. Willemsen and G.M. Ferrari, of TNO Centre for Coatings Research; and C. Ugeux, of Roland Chemicals

PRODUCTION

R. Vitelli and L. Colombo, of Mirodur spa; Z. Mihalko, of AKZO-TVK RT.; H.-J. Adler, of Akzo Coatings GmbH; and N. Borghetti, of Max Meyer Duco s.p.a.

DURABILITY

A. Kovacs-Stahl, M. Ovari, and J. Bognar, of Res. Inst. Paint Ind. Budalakk Ltd.; J. Schmelzer and R. Schwindt, of Kronos International Inc.; M. Leclerc, of

Veille-Montagne; Dr. Kahl, Dr. Halpaap, and Dr. Wamprecht, of Bayer AG; and I. Font and A. Alexandru, of Unitate a Institutului Central de Chimie

MEASURING/TESTING

Mrs. Marold, of Institut für Technische Chemie der Universität Stuttgart; K. Hartmann and H. Berlin, of BASF Lacke + Farben AG; M. Hoeflaak, F. Molenaar, and J.M.G. Junen, of TNO Centre for Coatings Research; A. Bartelt, of BASF Lacke + Farben AG; and B. Varkonyi and L. Santha, of Jozsef A. Universität

Wednesday, June 17

PLENARY LECTURES

P. Schutyser and D. Perera, of CORI; A. Vertes, of Eötvös University; and H. Jotischky, of Paint Research Association

WATERBORNE

M. Tudose, N. Moga, R. Mtez, and C. Calina, of Unitate a Institutului Central de Chimie; R. Metz and R. Cristofor, of Unitate a Institutului Central de Chimie; H. Schönfelder and H. Bock, of Bayer AG; and J. Zwinselman, of Dow Europe SA

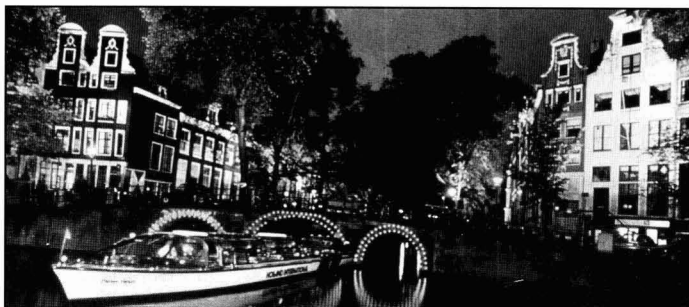
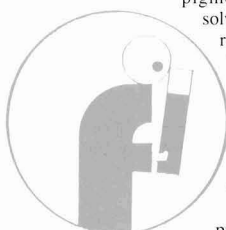
MEASURING/TESTING

R. Novak and M. Bradac, of Vyzkumny ustav naterovych hmot Praha; R. Herzog, of Kronos International Inc.; K. Süvegh, E. Talas, and M. Ovari, of Budalakk Ltd.; and A. Panescu and E. Stöckel, of Unitate a Institutului Central de Chimie

HIGH SOLIDS

O. Andre and C. Gerets, of Shell Louvain la Neuve; S. Simpson, C.J. Coady, R.R. Engelhardt, and J. Klais, of Amoco Chemical (Europe) S.A.; K. Hentschel, E.

(Continued on next page.)



United Kingdom Surface Coatings Week Gets Underway March 16-20, in Harrogate, North Yorkshire, UK

The first United Kingdom Surface Coatings Week, organized by the Oil & Colour Chemists' Association (OCCA), is scheduled to begin on March 16th and run through March 20th in Harrogate, North Yorkshire, United Kingdom. The week will include three technical symposia and the Surfex 92 Exhibition.

Starting the week off will be a two-day symposium cosponsored by OCCA and the Paint Research Association (PRA) on "Creative Advances in Surface Coatings: The Impact of the Environment." This program will take place on March 16-17 and will be held at the Moat House International Hotel.

Scheduled presentations include:

"Advances—What Advances?: An Overview of Industrial Waterborne Coatings"—John Nicholson, of Laboratory of the Government

"Whither Nonaqueous Coatings?"—Stephen Rees, of Cray Valley

"The Coloration of Advanced Coatings"—Adrian Abel, of Hoechst UK, Pigments Dept.

"Dispersion and Resins for Waterborne Inks and Coatings"—Stanley Jones, of Foscolor, and Paul Bass, of IGP

"Regulations and Practice in Waste Water Disposal: A 400m Hurdle Race and How to Win It"—W.J. Ferguson, of E&A West

"Intrinsically Intumescent Polymers: Environmental Safety Without Environmental Hazards"—David Aslin, of Prometheus Developments

"Meeting the Compliance Agenda: Are You Ready?"—Helma Jotischky, of PRA

"Barriers to Using New Technology—Radiation Curing"—Richard Holman, of PRA

"The Use of Borate Compounds in Waterborne Coatings"—K. Quill, of Borax Consolidated

"Harnessing Product Innovation to Environmental Care in Waterborne Paints"—Jeremy Lane and Jeff Ulyatt, of Vinamul

"Additives and Innovations"—Lionel Morpeth, of BYK-Chemie

"How Green is (My) Ink?"—Gerry Burdall, of Usher Walker

"Advantages of Catalytic IR Curing for Effective Emission Control"—John Sullivan, of Teknikat, and Grahame Kitchin, of Juna Products

On March 17 and 18, Surfex 92 will open. This is the exhibition portion of the

conference. With its approximately 107 exhibitors, Surfex 92 will be located in Halls A, B, and C of the Harrogate Exhibition Centre.

A one-day seminar on "The Implications of Information Technology," sponsored by OCCA is scheduled. This program will take place March 18 at The Imperial Hotel, in Harrogate.

On March 19 and 20, The Institute of Corrosion will be sponsoring a program entitled "Blast Clean 92." This will be held at the Cairns Hotel, in Harrogate.

For further information on the UK Surface Coatings Week—1992, contact Chris Pacey-Day, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex, England HA0 2SF.

Golden Gate Society to Host "Ideas for the Future" Conference

"Ideas for the Future" will be the theme for the annual conference of the Manufacturing Committee of the Golden Gate Society for Coatings Technology. The conference will be held at the Holiday Inn in S. San Francisco, CA, on June 15, 1992.

Featured at the seminar will be a presentation of four papers in the morning session by the Program Advocating Responsible Legislation for the Environment (PARLE). PARLE is composed of Northern California coatings manufacturers and related industries. Their talks will feature rules and regulations pertaining to recycling and emission control and other related issues.

The afternoon sessions' speakers will present ideas for recycling of materials and emission control in addition to discussing possible cooperation by individual companies in solving common problems. This part of the conference will be in the form of a panel discussion.

In the evening, a speaker from the law firm of Fitzgerald, Abbot and Beardsley will present a paper on legal responsibilities. The firm is involved in matters related to litigation, permitting, and compliance, and they have considerable expertise in the technical aspects of investigation and remediation including groundwater and soil contamination. The firm also provides counseling regarding characterization, treatment, disposal of hazardous waste, and recycling and minimization of hazardous waste.

The cost of the conference is \$70.00 which includes lunch and dinner. More information is obtainable by contacting Louie Sanguinetti, Jasco Chemical Corp., P.O. Drawer J, Mountain View, CA 94042 or Ron Hughes, Ashland Chemical Co., 8600 Enterprise Dr., Newark, CA 94560.

XXth FATIPEC Congress Slated for June 14-18

(Continued from previous page.)

Jürgens, and W. Wellner, of Bayer AG; and M. Motoiu and G. Nicolescu, of Unitate a Institutului Central de Chimie

Thursday, June 18

HIGH SOLIDS

C. Robu, R. Gardu, and D. Dobre, of Unitate a Institutului Central de Chimie; P.J.A. Geurink, of Akzo Coatings bv; J.R. Tuebols and J.T. Subirats, of Oficina Technica de Estudios y Controles; E. Vos de Wael and J. Serdijn, of Sigma Coatings; and C.J. van Hoolwerff, of Foundation for Paint Application

POWDER COATINGS

C. de Cock and M. Godts, of Shell Louvain la Neuve; G.C. Hewitt, W. Jacobs, and S. Ramesh, of Dyno Cyanamid C.V.; and A. Koopmans, of Teodur N.V.

ELECTRODEPOSITION

F. Heinrich and H. Gebhard, of BASF AG; C. Zimbran, C. Robu, and M. Mateescu, of Unitate a Institutului Central de Chimie; R. Serban and M. Rosetti, of Unitate a Institutului Central de Chimie; and C. Robu and R. Serban, of Unitate a Institutului Central de Chimie.

MISCELLANEOUS

J.J. Trescol, of Akzo Coatings SA; D Pappie, of Shell Nederland Chemie B.V.;

H. Gebhard, of BASF; P. Koenders, and E.M. van Acker, of Koninklijke/Shell-Laboratorium; W. Henning, K. Sirinyan, and B. Benda, of Bayer AG; and R. Crevecoeur and H. Claessens, of Rijksdienst Monumentenzorg Zeist.

In addition to the program sessions, a technical exhibition will be held in conjunction with the congress. The exhibition will be located in the Deltahall and Randstadhall of the RAI International Congress and Exhibition Centre.

A social program for congress participants and their accompanying persons will include a reception at the famous "Rijksmuseum," a candlelight boat tour through the canals, or a visit to the Joseph Lam Jazzclub and a dinner dance in the restaurant of Shell Research Laboratories overlooking the waterway "t IJ."

A full afternoon excursion to "Floriade" is scheduled. Floriade is a large exhibition of flowers, plants, trees, vegetables, and fruit, which is held every 10 years.

More information on the FATIPEC Congress and "Euroformula 92" may be obtained by writing RAI Organisatiebureau Amsterdam B.V., Europaplein 12, 6078 GZ Amsterdam.

Chicago Society for Coatings Technology Cosponsors SYMCO '92, "Sharing Technology," on January 23

SYMCO '92, cosponsored by the Joint Educational Committees of the Chicago Society for Coatings Technology and the Chicago Paint and Coatings Association, was held January 23, 1992, at the Holiday Inn Crowne Plaza, Lisle, IL. The theme for SYMCO '92 was "Sharing Technology."

The symposium featured eight presentations focusing on trade sales and industrial coatings. The program's papers and speakers included:

"EPA Regulations and Their Impact on the Coatings Industry"—Ed Doty, of U.S. EPA Region 5;

"HEEU for Waterborne Coatings"—Fred Giles, of Union Carbide;

"New Vinyl Polymers and Monomers"—Ollie Smith, of Union Carbide;

"Water-Based Exterior Paints—Past, Present, and Future"—Walt Gozdan, of Rohm and Haas Company;

"The Effects of CCA-Treated Wood on the Performance of Surface Finishes"—William Feist, of U.S. Department of Agriculture Forest Service, Forest Products Laboratory;

"The Future of Aerosol Paint: Conventional High-Solids Versus Waterbase"—Patrick S. Gieske, of Seymour of Sycamore;

"Selecting the Best Approach to VOC Compliance in Epoxy Coatings"—George

Roy, of Rhone-Poulenc, Inc.; and
"Two Component Waterborne Polyurethanes"—Richard Hergenrother, of Mobay Corporation, a Bayer USA Company.



SERVING ON THE SYMCO '92 COMMITTEE ARE: (from l-r)—Bill Heiden, Ace Hardware, Paint Div.; Jim Salesbury, UCAR Emulsion Systems; Michael Beland, Halox Pigments; Steve Hodges, Halox Pigments; P.J. McGrath, Ashland Chemicals; John Devaney, Cabot Corp.; John Hanacek, Ace Hardware, Paint Div.; and Dave Stromberg, Standard T Chemical Co. Not present for photo, Lori Hilson-Gaede, T.H. Hilson Co.

35th Annual Cleveland Society Conference on Advances in Coatings Technology

*"Advances in Environmentally Compliant
Coatings Technology"*

Thursday, May 28, 1992

NASA, Lewis Research Center, Cleveland, OH

Meet the Speaker Social Hour, Banquet, and After Dinner Speaker to Follow at:
The Sheraton Airport Hotel, Cleveland, OH

Member of



Since 1922

Conference Registration:

Name: _____

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City/State/Zip: _____

Telephone Number: _____

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Send registration to:

James A. Miller
3057 Kent Road
Cuyahoga Falls, OH 44224
Phone: (216) 352-0218

FSCT Member Conference Registration	()	\$ 90.00
Member Registration with Banquet	()	115.00
Retired Member—Conference Only	()	45.00
Full Time Student—Conference Only	()	45.00
Retired/Student—Conference & Banquet ...	()	70.00
Non-FSCT Members, Add	()	10.00
Registration after May 10, Add	()	10.00
Speaker Social and Banquet Only	()	30.00

Banquet Dinner Choice:

Prime Rib _____ Chicken Piccata _____ Vegetarian _____

Accommodations:

Sheraton Airport Hotel Cleveland
5300 Riverside Drive
Cleveland, OH 44135
Phone: (216) 267-1500 or (800) 362-2244

Please make your reservation directly with the Sheraton Hotel. Use I.D. #GA8223 for CSCT Conference Rate of \$70.00 for Standard Room.

Kent State University to Present Three Short Courses Featuring Rheology, Dispersion, and Adhesion

The Rheology and Coatings Laboratory of Kent State University will be offering three short courses this spring. These programs are designed for research and development personnel who have interest in coatings, adhesives, elastomers, inks, and composites.

The first course, "Applied Rheology for Industrial Chemists," is scheduled for April 27-May 1. During the class, fundamentals will be presented followed by a discussion on instrument selection and meaningful measurements.

The "Rheology" program is as follows:

Monday, April 27

"Rheometry"—Irvin M. Krieger, of Case-Western Reserve University; "Fundamentals of Linear Viscoelasticity"—Irvin M. Krieger; "Rheology of Dispersion"—Irvin M. Krieger; and "Instruments and Selection"—Edward A. Collins, of E.A. Collins, Inc.

Tuesday, April 28

"Meaningful Rheological Measurements"—Edward A. Collins; "Application of Rheology to Processing Problems"—Charles L. Rohn, of Rheometrics, Inc.; "Application of Rheology to End-Use Performance Problems"—Charles L. Rohn; and "Characterization of Coatings and Other Dispersions by Viscoelastic Measurements"—Nancy Phillips, of Pen Kem, Inc.

Wednesday, April 29

"Rheology of Fluid Coatings: Application, Flowout, and Defects Formation"—Clifford K. Schoff, of PPG Industries, Inc.; "Stress Rheometry in the Coatings Industry"—Richard R. Eley, of The Glidden Co.; "Thermal Mechanical Properties of Coatings"—Daniel J. Skrovanek, of Miles Inc.; and "Physical/Chemical Characterization of the Cure Process by Thermal/Mechanical/FTIR Analysis"—Theodore Provder, of The Glidden Co.

Thursday, April 30

"Application of Rheology to Engineering Problems"—Donald Bigg, of Battelle-Columbus Laboratories; "Correlation of Film Morphology with Drying Behavior"—John W. Vanderhoff, of Lehigh University; and "Chemorheology of Thermosetting Coatings"—Richard R. Eley.

Friday, May 1

"Control and Rheological Measurement of Crosslink Density in Films"—Loren W. Hill, of Monsanto Chemical Co.; and "Rheological Additives for Flow Modification"—Sharad Thakkar, of Eastman Kodak.

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The second course, slated for May 11-15, is entitled "Dispersion of Pigments and

Resins in Fluid Media. This program introduces the chemistry of the dispersion process, dispersing agent selection, dispersion quality by rheological means, and particle size analysis.

Programming for the "Dispersion" class is as follows:

Monday, May 11

"Fundamentals of Surface and Colloid Chemistry—I"—Richard J. Ruch, of Kent State University; "Dispersant Selection Based on Pigment Functionality"—Robert F. Conley, of Mineral and Resource Technology; "Fundamentals of Surface and Colloid Chemistry—II"—Richard J. Ruch; and "Mineral Pigment Processing Parameters and Their Influence on Polymer Properties"—Robert F. Conley.

Tuesday, May 12

"White Pigments—Processing and Rheology"—Robert F. Conley; "Pigment Dispersion"—Theodore Vernardakis, of Sun Chemical Corp.; "Carbon Black Dispersion in Liquid Systems"—Elizabeth Sims, of Cabot Corp.; and "Wetting and Dispersing Agents in Aqueous and Nonaqueous Systems"—Robert W. Vash, of BYK-Chemie USA.

Wednesday, May 13

"Introduction to Dispersion Rheology"—Richard R. Eley; "Determining Dispersion Quality by Rheological and Related Methods"—Richard R. Eley; "Dispersion of Oil-Soluble Coatings Systems: The Inseparable Roles of Art and Science"—George R. Pilcher, of Akzo Coatings Inc.; and "Particle Size Analysis of Coatings Systems"—Theodore Provder.

Thursday, May 14

"Primary Mixing and Blending"—Leo Dombrowski, of Gibraltar Chemical; "High Viscosity Dispersion and New Dispersion Techniques"—James White, of White Chemical Equipment Co.; "Small Media Milling and Dispersion Technology"—Leo Dombrowski; "Principles of Ball and Pebble Milling"—Barry Fuller, of Paul O. Abbe, Inc.; and "Attritor Grinding and Dispersing Equipment"—Arno Szegevari, of Union Process, Inc.

Friday, May 15

"Dispersing Fine-Particle Material"—David G. Bosse, of Maginet-Projects; "Determining Equipment Requirements (And Choices Based on the Ingredients)"—David G. Bosse; and "Evaluating Processing Results Via Optical Microscopy"—David G. Bosse.

* * * * *

"Adhesion Principles and Practice for Coatings and Polymer Scientists," is the title

of the third course. This class is scheduled for June 1-5, and discussions will focus on surface chemistry related to adhesion, tack and fracture mechanics of glassy and elastomeric adhesives, surface preparation, plasma treatment, and adhesion promoters.

Topics to be discussed during the "Adhesion" session include:

Monday, June 1

"Interfacial Energies and Their Role in Adhesion"—Richard J. Ruch; "Principles of Elastomer Tack"—Gary R. Hamed, of The University of Akron; "Deformation and Fracture of Elastomeric Adhesives"—Alan N. Gent of The University of Akron; and "Deformation and Fracture of Glassy Adhesives"—Alan N. Gent.

Tuesday, June 2

"Fracture Mechanics and Bond Durability Considerations"—James Koutsky, of University of Wisconsin; "Etching and Cleaning of Polymer and Other Surfaces"—James Koutsky; "Plasma Technology and Surface Treatment of Plastics"—Peter W. Rose, of Plasma Science, Inc.; and "Organofunctional Silanes as Adhesion Promoters"—Bruce A. Waldman, of Union Carbide.

Wednesday, June 3

"Improved Durability of Adhesive Bonds to Metal Using Silanes"—F. James Boerio, of University of Cincinnati; "Microscopic/Spectroscopic Studies in Adhesion of Metals and Composites"—John G. Dillard, of Virginia Tech; "Application of Surface Science to Adhesion of Coatings"—Larry Salvati, of Perkin-Elmer Physical Electronics Laboratories; and "Bonding and Chemistry of Structural Adhesives"—Kurt C. Frisch, Jr., of 3M Co.

Thursday, June 4

"Surface Chemistry of Release"—Michael J. Owen, of Dow Corning Corp.; "Corrosion Aspects of Paint Adhesion and Adhesive Bond Durability"—Ray A. Dickie, of Ford Motor Co.; "Formulation, Application, and Evaluation of Adhesives in Web Form"—James A. Miller, of Chemsultants International Network; and "Fundamental and Practical Aspects of Pressure Sensitive Adhesives, Caulks, and Sealants"—Krishan C. Sehgal, of Union Carbide.

Friday, June 5

"Bonding Plastics and Elastomers"—Edward M. Petrie, of ABB Power T&D Co.; and "Adhesive Application Methods"—Edward M. Petrie.

Additional information can be obtained from Program Chairman, Carl J. Knauss, Kent State University, Chemistry Dept., P.O. Box 5190, Kent, OH 44242-0001.

Tank Gauging System

A tank gauging system which allows an unlimited number of tanks to be remotely monitored from either a personal computer or controller has been introduced. Tanks can be monitored from distances up to 4,000 feet (1,200 m) from a central monitoring location. For more information on the TS1100FX tank gauging system, write Unisonyx, Inc., 14255 N. 79th St., Ste. 6, Scottsdale, AZ 85260.

Microscope

The reintroduction of a microscope utilized for education and clinical applications has been made through literature. The microscope rests on a small-footprint three-point base, and coarse and fine focus controls a low-mounted for convenient and comfortable use. For more information on the Carl Zeiss, Inc. "Classic" Standard 16 Microscope, contact Audrey Smith, Bulk Mailing Service, 325 N. MacQuesten Pkwy., Mt. Vernon, NY 10550.

Waxes

A brochure introducing a complete line of polyethylene and copolymer waxes formulated as performance additives for polishes, color concentrates, printing inks, plastics, and in other applications has been printed. The six-page fold-out bulletin contains a 12-column table detailing the typical properties of the waxes and providing information on a broad spectrum of the products' characteristics. For a free copy of the brochure, "Luwax™ Polyethylene Waxes and Copolymer Waxes," contact BASF Corp., Performance Chemicals, 119-2 Cherry Hill Rd., Parsippany, NJ 07054.

Propylene Glycol Tertiary Butyl Ether

A brochure describing a propylene glycol tertiary butyl ether in the formulation of waterborne and water reducible coatings has been released. Data are presented on the use of the product, either alone or in blends, and as a coalescent in waterborne latex systems. For a copy of the brochure "PTB in Coatings," write ARCO Chemical Co., c/o ADH Sales Support, Attn: Jeanine Walentine, Rm. #P008, 114 Mayfield Ave., Edison, NJ 08837.

Combination Drier

A combination drier, which is based on a combination of cobalt, calcium, and lithium, is the subject of literature. The drier reportedly reduces drying times, and promotes better through-drying, and minimizes wrinkling. Write Rhone-Poulenc Inc., Specialty Chemicals Div., CN 5266, Princeton, NJ 08543 for more information on Manosec® CD44 Drier.

Weathering Device

A eight-page technical brochure on an ultraviolet condensation weathering device (UVCON) has been issued. Technical features, physical specifications, and relevant test methods are discussed in the literature. For a free copy of the UVCON brochure, write Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613.

Pretreatment Programs

Non-chrome, no-rinse pretreatment programs for the coil coatings industry is highlighted through literature. The pretreatments can be applied by spray, dip, or roll-coating. For information on Betz Norinse II™ pretreatment programs, contact James S. McNeill, Director of Technical Marketing, Betz MetChem, 200A Precision Dr., Horsham, PA 19044.

Diaphragm Check Valves

A series of molded diaphragm check valves, which reportedly provides bubble-tight sealing in any position, has been introduced through a data sheet. Designed for use with corrosive or ultra-pure liquid applications, the valves are available in the following sizes: 1/2, 3/4, and 1 inch NPT. Contact Jack Leonard, Plast-O-Matic Valves, Inc., 430 Rte. 46, Totowa, NJ 07512 for more details on the Series CKM valves.

Curtain Transvectors

Information is obtainable on new curtain transvectors which reportedly use a small amount of compressed air to deliver a high velocity laminar sheet of air for blowoff, cleaning, drying, and cooling of large parts, moving webs of plastic, paper, sheet metal, and fabric or objects moving on a conveyor. The transvectors are designed to be used in the plastics, chemical, food, and drug industries. For further details on the curtain transvectors, write Vortec, 10125 Carver Rd., Cincinnati, OH 45242.

Zinc Silicate Coating

A water-based inorganic zinc silicate coating with no volatile organic compounds and no flash point has been introduced through a product release. The coating is a two-package, high-zinc content water-based coating designed for protecting steel surface from corrosion. Recommended uses include as a primer for steel in atmospheric and select immersion service exposures. All inquiries for additional information should be identified as "Zinc Clad XI," and sent to The Sherwin-Williams Co., c/o HKM Direct, 5501 Cass Ave., Cleveland, OH 44102.

Hybrid Polymers

A technical data sheet on a new line of aqueous urethane hybrid polymers has been released. Coatings and adhesive applications include graphic arts polymers for overprint coatings and ink vehicles, textile and vinyl coatings, leather coatings and finishes, plastic and industrial coatings, and film lamination. Write Air Products and Chemicals, Inc., Polymer Chemicals Div., 7201 Hamilton Blvd., Allentown, PA 18195-1501 for more details on the Flexthane™ EXP polymers line.

Radiation Curing Bulletin

The Paint Research Association (PRA) has announced the publication of a new quarterly technical bulletin dedicated to the radiation curing industry. This publication will provide information on technical developments and new legislation as well as company and market news. It will also offer a forum for people involved in this growing area. The first issue will be distributed free of charge. Anyone wishing to subscribe to this publication may do so by contacting the PRA, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD England.

Thermal Analyst

A controller/data analyzer, based on an IBM PS/2 Model 90SX 486 computer, has been introduced through a product release. The thermal analyzer, with a 4 megabyte RAM memory and 160 megabyte hard disk, is designed for laboratories which require state-of-the-art analysis speed and large data storage capability. More details on the Thermal Analyst 2200 can be obtained by writing TA Instruments, Inc., 109 Lukens Dr., New Castle, DE 19720.

Aluminum Paste

Product information is available on a new aluminum paste product for metallic-finish paints and coatings used for trade and maintenance applications. The paste is comprised of a very fine leafing aluminum flake in a mineral spirits base. Samples and further details on Super Fine "P" aluminum paste are obtainable from Silberline Mfg. Co., Inc., Samples & Literature Dept. Lincoln Dr., P.O. Box B, Tamaqua, PA 18252-0420.

Spectrocolorimeter

A portable spectrocolorimeter for color measurement of metallic, pearlescent, and solid paints has been introduced through literature. The rechargeable, battery powered AC/DC unit provides QC information at three key angles, 15, 45, and 110° from gloss. Further information on the Dataflash™ 200M Spectrocolorimeter is obtainable by contacting Datacolor International, 5 Princess Rd., Lawrenceville, NJ 08648.

TiO₂ Pigment

A product sheet describing a TiO₂ pigment which combines high gloss, durability, and dispersion in one grade for architectural exterior and interior emulsion paints has been issued. The pigment may also be used in auto refinish and general industrial coatings applications. Further information on "Ti-Pure" TiO₂ pigment can be obtained by writing Du Pont External Affairs, Wilmington, DE 19898.

Solvent Recovery

A data sheet highlighting an on-site solvent recovery system for large and small generators of waste solvents has been printed. The system is microprocessor controlled which monitors the oil, vapor and sludge temperatures, while a built-in fault detection system shuts the unit down if a series of parameters falls beyond acceptable boundaries. For a free brochure on Red Head Still solvent recovery systems, write CB Mills, 1225 Busch Pkwy., Buffalo Grove, IL 60089.

Meters

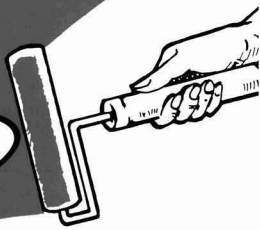
A 16-page brochure highlighting a company's full line of positive displacement flowmeters and related equipment has been released. The full-color bulletin provides equipment illustrations, specification data, and user features for the company's equipment. For a copy of the catalog, "Product Overview," write Liquid Controls Corp., Wacker Park, N. Chicago, IL 60064.

Monomer

The introduction of a new monomer which reportedly provides low odor, low irritation, and high adhesion properties for ultraviolet and electron beam curing has been made through literature. The caprolactone acrylate monomer can be formulated as a replacement for NVP in coating formulations. For more technical information on SR-495 monomer, contact Sartomer Co., Inc., Oaklands Corporate Center, 468 Thomas Jones Way, Exton, PA 19341.

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Coming Events

FEDERATION MEETINGS

For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (215) 940-0777, FAX: (215) 940-0292.

1992

(May 17-20)—Federation "Spring Week." Board of Directors Meeting on the 17th; Incoming Society Officers Meeting on the 18th; Spring Seminar on the 19th and 20th. Sheraton Boston Hotel and Towers, Boston, MA.

(June 8-10)—"How to Implement Total Quality Management and Secure ISO 9000 Series Certification." Sponsored by Professional Development Committee. Adam's Mark Hotel, Philadelphia, PA.

(June 11-12)—"Gauge/Measurement Process Assessment and Improvement." Sponsored by Professional Development Committee. Adam's Mark Hotel, Philadelphia, PA.

(Sept. 14-15)—"Statistical Process Control and Its Application in the Coatings Industry" (SPC Level I). Sponsored by Professional Development Committee. Atlanta, GA.

(Sept. 16-18)—"Practical Application of Intermediate Statistics in a Total Quality Management System" (SPC Level II). Sponsored by Professional Development Committee. Atlanta, GA.

(Oct. 21-23)—70th Annual Meeting and 57th Paint Industries' Show. McCormick Place, Chicago, IL.

1993

(Oct. 27-29)—71st Annual Meeting and 58th Paint Industries' Show. World Congress Center, Atlanta, GA.

1994

(Oct. 12-14)—72nd Annual Meeting and 59th Paint Industries' Show. New Orleans Convention Center, New Orleans, LA.

SPECIAL SOCIETY MEETINGS

1992

(Mar. 11-13)—Southern Society Annual Meeting. Grosvenor Resort Hotel, Orlando, FL. (Billy Lee, Kemira, Inc., P.O. Box 368, Savannah, GA 31402).

(Mar. 29-31)—Houston and Dallas Societies. Southwestern Paint Convention. South Shore Harbour Resort & Conference Center, League City (Houston), TX. (Dennis Crozier, Crozier-Nelson Sales, Inc., 2505 Collingsworth, Houston, TX 77026).

(Apr. 30)—Detroit Society. 17th Annual FOCUS Conference. Mercy College, Detroit, MI. (Valerie E. Gunn, FOCUS Chairperson, Akzo Coatings Inc., P.O. Box 7062, Troy, MI 48007-7062).

(Apr. 30-May 2)—Pacific Northwest Society. 45th Annual Spring Symposium. Portland, OR. (John Westendorf, Lipscomb Chemical Northwest, 2627 N.W. Nicolai St., Portland, OR 97210).

(June 15)—Golden Gate Society. "Ideas for the Future." Manufacturing Committee Conference. Holiday Inn, S. San Francisco, CA. (Louie F. Sanguinetti, Jasco Chemical Corp., P.O. Drawer J, Mountain View, CA 94042).

OTHER ORGANIZATIONS

1992

(Mar. 16-18)—"Polymer Blends and Alloys: Phase Behavior, Characterization, Morphology, Alloying Technology." Short course

sponsored by State University of New York (SUNY). Orlando, FL. (Institute of Materials Science, CSB 209, SUNY, New Paltz, NY 12561).

(Mar. 16-18)—"Lead Paint Removal from Industrial Structures." Fifth Annual Conference sponsored by Steel Structures Painting Council (SSPC), Pittsburgh, PA. Hyatt Regency Hotel, Reston, VA. (SSPC, Meetings Dept., 4400 Fifth Ave., Pittsburgh, PA 15213-2683).

(Mar. 16-20)—United Kingdom Surface Coatings Week—1992. Symposia and Exhibition sponsored by Oil & Colour Chemists' Association and the Paint Research Association (PRA). Moat House International Hotel, Harrogate, England. (Avril Henn, Conference Secretary, PRA, Waldegrave Rd., Teddington, Middlesex TW11 8LD, United Kingdom).

(Mar. 17-18)—Electrocoat'92. Sponsored by *Products Finishing* magazine. Drawbridge Inn, Ft. Mitchell, KY. (Greater Cincinnati Airport Area). (Cindy Goodridge, Gardner Management Services, 6600 Clough Pike, Cincinnati, OH 45244).

(Mar. 17-18)—Polyacrylates and Initiators Symposium. Sponsored by Akzo Chemicals Inc., Contemporary Resort in Walt Disney World, Lake Buena Vista, FL. (Ginger Myers, Technical Development Manager, Akzo Chemicals Inc., One Livingston Ave., Dobbs Ferry, NY 10522).

(Mar. 17-18)—"Introduction to Plastics Technology." Seminar sponsored by the Canadian Plastics Institute (CPI), Toronto, Ont. Holiday Inn, Montreal, Que. (CPI, 1262 Don Mills Rd., Ste. 48, Toronto Ont., M3B 2W7 Canada).

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(Mar. 22-27)—35th Annual Technical Conference of the Society of Vacuum Coaters (SVC). Hyatt Regency on the Inner Harbor, Baltimore, MD. (SVC, 440 Live Oak Loop, Albuquerque, NM 87122).

(Mar. 23-26)—WESTEC '92—29th Exposition & Conference. Sponsored by Society of Manufacturing Engineers (SME), ASM International, American Machine Tool Distributors' Association, and The Association for Manufacturing Technology. Los Angeles Convention Center, Los Angeles, CA. (SME Customer Service Center, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(Mar. 24-26)—Surface Coating '92. Conference and Trade Show sponsored by Chemical Coaters Association International (CCAI). Indianapolis Convention Center, Indianapolis, IN. (CCAI, P.O. Box 54316, Cincinnati, OH 45254).

(Mar. 27-28)—Western Decorating Products Show. Long Beach, CA. (Tameila Adamson-McMullen, Public Relations Director, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Mar. 30-Apr. 3)—24th Introductory Short Course, "Paint Formulation." Sponsored by University of Missouri-Rolla (UMR), Rolla, MO. Rolla Campus. (Norma Fleming, Sr. Coordinator, UMR, Continuing Education, 119 M.E. Annex, Rolla, MO 65401-0249).

(Mar. 31)—"Plastics Technology and the Environment." Seminar sponsored by the Canadian Plastics Institute (CPI), Toronto, Ont. Airport Hilton, Toronto, Ont. (CPI, 1262 Don Mills Rd., Ste. 48, Toronto Ont., M3B 2W7 Canada).

(Apr. 1-8)—Surface Treatment '92 Exhibition. Hannover Fairs, Hannover, Germany. (Hannover Fairs USA Inc., 103 Carnegie Ctr., Princeton, NJ 08540).

(Apr. 5-10)—"Water-Based Coatings" Symposium. Sponsored by American Chemical Society, Division of Polymeric Materials: Science and Engineering. San Francisco, CA. (F. Louis Floyd, The Glidden Co., 16651 Sprague Rd., Strongsville, OH 44136, or John L. Massingill Jr., The Dow Chemical Co., Bldg. B-1603, Freeport, TX 77541).

(Apr. 7-10)—Davos Recycle '92—International Forum and Exposition. Congress Centre, Davos, Switzerland. (Horst Maack, Presi-

dent, Maack Business Services, Moosacherstrasse 14, CH-8804 AU/ZH, Switzerland).

(Apr. 26-30)—RadTech '92 Biennial Conference. Hynes Convention Center and Sheraton Boston Hotel & Towers, Boston, MA. (Chris Dionne, Executive Director, RadTech International North America, 60 Revere Drive, Suite 500, Northbrook, IL 60062).

(Apr. 27-29)—"Flexible Packaging Technology." Course sponsored by Center for Professional Advancement. Chicago, IL. (Center for Professional Advancement, P.O. Box H, East Brunswick, NJ 08816).

(Apr. 27-May 1)—"Applied Rheology for Industrial Chemists." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education-Chemistry, KSU, P.O. Box 5109, Kent, OH 44242-0001).

(Apr. 29 and 30)—"Paint Technology—Surviving the 90s." 46th Annual and 39th "Back to Back" Symposium. Sponsored by The Chemical Institute of Canada, Protective Coatings Division. The Old Mill, Toronto, Ont., Canada; and Hélène de Champlain Restaurant, Montreal, Que., Canada. (For Toronto, contact: Steve Balmer, Bapco, Inc., P.O. Box 7000, 8200 Keele St., Concord, Ont., Canada L4K 1B6; for Montreal, contact: Gordon Simpson, Sico, Inc., 41 Bates Rd., Outremont, Que., Canada H2V 1A6).

(May 4-6)—"Advances in Polymer Colloids/Emulsion Polymers: Polymerization, Characterization & Applications." Short course sponsored by State University of New York (SUNY), New Orleans, LA. (Institute of Materials Science, CSB 209, SUNY, New Paltz, NY 12561).

(May 4-6)—"Fitting the Package to the Product." Course sponsored by Center for Professional Advancement. Chicago, IL. (Center for Professional Advancement, P.O. Box H, East Brunswick, NJ 08816).

(May 11-14)—Powder & Bulk Solids '92 Conference/Exhibition. O'Hare Exposition Center, Rosemont (Chicago), IL. (Cahners Exposition Group, Dept. Powder & Bulk Solids '92, 1350 E. Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060).

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(May 11-15)—"Dispersion of Pigments and Resins in Fluid Media." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education-Chemistry, KSU, P.O. Box 5109, Kent, OH 44242-0001).

(May 11-15)—"Physical Testing of Paints and Coatings from Classical Methods to Modern Instrumental Techniques." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. Rolla Campus. (Norma Fleming, Sr. Coordinator, UMR, Continuing Education, 119 M.E. Annex, Rolla, MO 65401-0249).

(May 11-15)—"Coatings Science for Coatings Technicians." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Deborah Theisen, PSC Coatings Short Course, USM, Southern Station Box 10076, Hattiesburg, MS 39406-0076).

(May 11-16)—"Interpretation of IR and Raman Spectroscopy." Course and workshops sponsored by Fisk University, Vanderbilt University, Nashville, TN. (Fisk Infrared Institute, P.O. Box 15, Fisk University, Nashville, TN 37203).

(May 13-15)—"Adhesion Science and Technology." Course sponsored by Center for Professional Advancement, East Brunswick, NJ. (Center for Professional Advancement, P.O. Box 1052, East Brunswick, NJ 08816).

(May 18-22)—International Automation Conference and Training Course. Cosponsored by Instrument Society of America (ISA) and International and Scientific Computing and Automation, Montpellier, France. (ISA, 67 Alexander Dr., P.O. Box 12277, Research Triangle Park, NC 27709).

(May 19-21)—PaintCon '92. Conference and exhibition sponsored by *Industrial Finishing Magazine*. O'Hare Expo Center, Chicago (Rosemont), IL. (PaintCon '92, 2400 E. Devon Ave., Des Plaines, IL 60018).

(May 19-21)—"Additives for Coatings." Course sponsored by Center for Professional Advancement, East Brunswick, NJ. (Center for Professional Advancement, P.O. Box 1052, East Brunswick, NJ 08816).

(May 25-29)—"Coatings Science for Coatings Chemists." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Deborah Theisen, PSC Coatings Short Course, USM, Southern Station Box 10076, Hattiesburg, MS 39406-0076).

(June 1-4)—Fifth International Symposium on Polymer Analysis and Characterization. Inuyama Hotel, Inuyama City, Japan. (Howard Barth, Du Pont Co., Experimental Station, P.O. Box 80228, Wilmington, DE 19880-0228).

(June 1-5)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education-Chemistry, KSU, P.O. Box 5109, Kent, OH 44242-0001).

(June 2-6)—"Advances in Emulsion Polymerization and Latex Technology." Short course sponsored by Emulsion Polymers Institute, Lehigh University, Bethlehem, PA. (Mohamed S. El-Aasser, Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18105).

(June 8-12)—"Environmentally Compliant Coatings." Short course sponsored by North Dakota State University (NDSU), Fargo, ND. (Jeanette Shaw-Lynch or Deborah M. Shasky, Dept. of Polymers and Coatings, NDSU, Fargo, ND 58105).

(June 8-12)—"Water Based Polymers." Course sponsored by Center for Professional Advancement, Chicago, IL. (Center for Professional Advancement, P.O. Box 1052, East Brunswick, NJ 08816).

(June 14-18)—XXIth FATIPEC Congress. RAI International Congress Centre, Amsterdam, The Netherlands. (General Secretary Francis Borel, 34 Chemin du Halage, La Bonneville, Mery sur Oise, France).

(June 15-17)—Euroformula '92. International Trade Fair. RAI International Exhibition and Congress Centre. Amsterdam, The Netherlands. (RAI, Europaplein, 1078 GZ, Amsterdam, The Netherlands).

(June 15-26)—"Coatings Science." Short course sponsored by North Dakota State University (NDSU), Fargo, ND. (Jeanette Shaw-Lynch or Deborah M. Shasky, Dept. of Polymers and Coatings, NDSU, Fargo, ND 58105).

(June 16-18)—"Radiation Curing: Ultraviolet Light and Electron Beam Technology." Course sponsored by Center for Professional Advancement, Chicago, IL. (Center for Professional Advancement, P.O. Box H, East Brunswick, NJ 08816).

(June 21-24)—ISCC 61st Annual Meeting and AIC 25th Anniversary. International symposium on "Computer Color Formulation."

Princeton University, Princeton, NJ. (Danny Rich, ISCC Secretary, ACS Datacolor, 5 Princess Rd., Lawrenceville, NJ 08648).

(July 13-17)—International Symposium on Surface Phenomena and Latexes in Water-Based Coatings and Printing Technology. Sponsored by Fine Particle Society. Riviera Hotel, Las Vegas, NV. (M.S. El-Aasser, Emulsion Polymers Institute, 111 Research Dr., Iacocca Hall, Lehigh University, Bethlehem, PA 18015).

(July 22-24)—"Basic Coatings for Sales and Marketing Personnel." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. Airport Marriott Hotel, St. Louis, MO. (Norma Fleming, Sr. Coordinator, UMR, Continuing Education, 119 M.E. Annex, Rolla, MO 65401-0249).

(Aug. 16-21)—"Polymer Chemistry: Principles and Practice." Seminar sponsored by The American Chemical Society (ACS), Washington, D.C. Marriott Inn, Blacksburg, VA. (ACS, Dept. of Continuing Education, Meeting Code VPI9203, 1155 Sixteenth St., N.W., Washington, D.C. 20036).

(Aug. 17-21)—"Formulating Coatings." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Deborah Theisen, PSC Coatings Short Course, USM, Southern Station Box 10076, Hattiesburg, MS 39406-0076).

(Sept. 14-18)—65th Introductory Short Course, "The Basic Composition of Coatings." Sponsored by University of Missouri-Rolla (UMR), Rolla, MO. Rolla Campus. (Norma Fleming, Sr. Coordinator, UMR, Continuing Education, 119 M.E. Annex, Rolla, MO 65401-0249).

(Sept. 28-Oct. 2)—25th Introductory Short Course, "Paint Formulation." Sponsored by University of Missouri-Rolla (UMR), Rolla, MO. Rolla Campus. (Norma Fleming, Sr. Coordinator, UMR, Continuing Education, 119 M.E. Annex, Rolla, MO 65401-0249).

(Oct. 5-8)—"Introduction to Coatings Technology." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education-Chemistry, KSU, P.O. Box 5109, Kent, OH 44242-0001).

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'Humbug' from Hillman

The New Year found me somewhat nonplussed, a condition, I confess, that is not unusual for Humbug. To add to my perennial confusion, however, 1991 ended with the receipt of two letters—one from Tom Miranda containing some new frightening observations from Humbug's favorite closet sage, Bob Ahlf. The second was a note from the Federation's well known Dean of Confusion, the lovable Frank Borrelle.

Get a grip on yourselves, dear readers, as we first turn to Sage Ahlf:

—If you wait for appreciation, you wait.

—What if, when you get rid of phosphates, it turns out silicates are worse.

—Before you send me away—the others are even worse.

—Being old is as confusing as being young.

—Don't plant tomatoes. Your neighbors will bring them to you. (Vermonters: read "zucchini.")

—Good is nice. Lucky pays better.

—It's better to give, but receiving isn't bad.

—In this great country you can say what you think without thinking.

—Opportunity knocked, I was in the shower.

Prepare yourselves, there'll be more in future issues.

Before we foist Borrelle on you, digest these poetic words from Doris Platt, who keeps up with Humbug, courtesy of her spouse, my OLD associate, Dave Platt.

Accent on Youth

Youth everlasting, the new modern craze.
Staying thin is "in," we can't show a bulge.
So obsessed are we with stopping the clock,
We'd die before our age we'd divulge.

The sweet old fashioned grandma is gone.
She now has a face lift to keep her good looks.
We cringe at the sight of the first gray hair.
"Keep fit, stay young," say all the books.

All the money that's spent on creams and bleaches,
All kinds of equipment, reducing machines,
Hair styles and facials for both of the sexes
To ever look regal like kings and queens.

Such wisdom and character those added years bring.
Yet our energies go in the wrong direction.
That wealth of experience is like precious gold,
But we're all too busy seeking perfection.

True, old folks get weary, their minds not as quick.
When asked a question, they might even blow it.
Youth, on the other hand, has all the advantage.
There's only one problem. They're too young to know it.
—Doris Platt

Thank you dear Doris, for as my joints creek and moan, I think your final words wind up with a comforting tone. But here's a second problem: When I do "blow it," I'm afraid that I'll be too old to know it.

Bill Passeno, impressed with some of Humbug's "more exotic formulae," has contributed a formula suggestion from the *Detroit Free Press* that is nothing short of explosive: SOFIA, Bulgaria—"Make paint, not war" is the slogan of Bulgarian scientist Radi Ganev, who says that he's developed a way to make paint from gunpowder.

"Several paint factories could run for years processing just the explosives from former East Germany and the Soviet Union alone," Ganev said, calling his method cheap and ecologically sound. —No formula was included.

And now for Borrelle, as your patience and our space will allow. Frank writes that he has started work on some original poems for Humbug. His efforts have brought him just this far:

"Mary had a little lamb"

Well, we have a lot to look forward to, but I think I can help a little:

Mary had a little lamb

The obstetrician had a hell of a shock.

To be on the safe side, Frank quoted from Bennett Cerf:

Q. *What did Adam say when his wife had fallen out of the apple tree for the third time?*

A. "Eavesdropping again, eh?"

Q. *Why isn't ten cents worth what it once was?*

A. Dimes have changed.

Q. *What happens when you submerge a body in warm water?*

A. The telephone rings.

Q. *What do you get when you cross a movie house with a swimming pool?*

A. A dive-in theater.

Q. *What do you call a Chinese maid who inherited ten million yen?*

A. A fortunate cookie.

—*The Sound of Laughter*, 1970

Shall we blame Borrelle or Cerf?

—Herb Hillman
Humbug's Nest
P.O. Box 135
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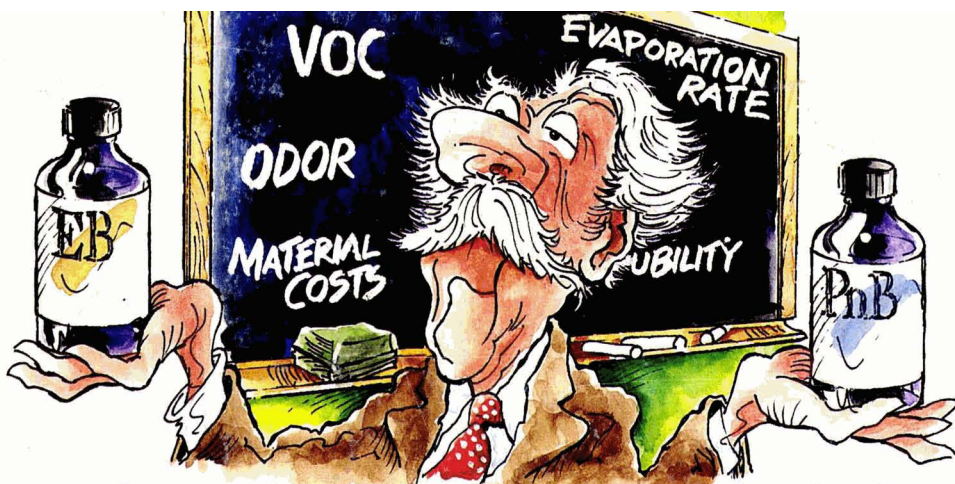
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Considering Alternatives to E-Series Glycol Ethers? DOWANOL PnB and DPnB Reduce Handling Concerns and Deliver Comparable Solvent Performance.

There are no such things as drop-in replacements for familiar E-series glycol ethers. However, DOWANOL® PnB and DPnB P-series glycol ethers can offer surprisingly similar performance in both industrial and architectural formulations.

DOWANOL PnB: Fast Hardness Development Like EB in Industrial Formulations

When you want fast evaporation, DOWANOL PnB (propylene glycol n-butyl ether) performs almost identically to EB glycol ether. The efficiencies of PnB and EB in lowering minimum film formation temperatures (MFFT's) are in the same range. And as the example in Figure 1 shows, their hardness development rates in typical industrial latexes are very similar.

Also, blends of DOWANOL PnB with other P-series glycol ethers and/or C₄ alcohols yield organic phase coupling behavior comparable to EB.

DOWANOL DPnB: High Efficiency, Easier VOC Compliance, and Lower Odor

DOWANOL DPnB (dipropylene glycol n-butyl ether) is a good alternative to DB glycol ether. While their evaporation rates are similar, DOWANOL DPnB can offer better MFFT-lowering efficiency

than DB (Figure 2). And since DOWANOL DPnB has much lower water solubility, it's less likely to cause compatibility

problems with associative thickeners.

In addition, DOWANOL DPnB often provides greater coalescing efficiency than popular ester-alcohols in acrylic-based architectural latex formulations. So for about the same formulated cost, you can reduce both VOC's and odor levels.

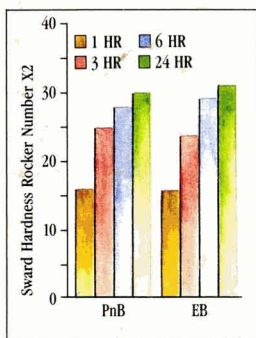


Figure 1 – Hardness Development Rates in Typical Acrylic-Based Latex

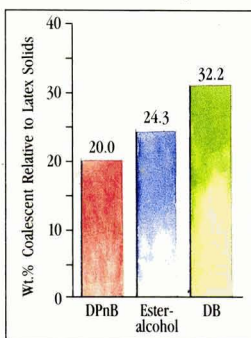


Figure 2 – Coalescent Levels Required for 50°F MFFT in Typical Acrylic-Based Latex

Answers to Reformulating Questions

With our extensive reformulating database, we can help make your switch to P-series alternatives easier. If you need to fine-tune solvent performance to address specific temperature and humidity considerations, we can offer unmatched assistance.

Call Today For Literature and Samples

It's easy to learn more about DOWANOL PnB or DPnB and how they may be ideal alternatives in your current formulations. Our 20-page brochure provides comprehensive information, and we'll be glad to provide samples for your evaluation.

Just circle the reader service number below. Or call us toll-free at: 1-800-447-4369.



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