

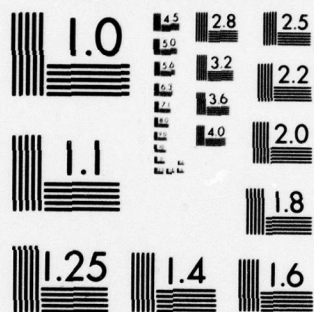
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Lehigh University Bethlehem, Pennsylvania 18015

CENTER FOR SURFACE AND COATINGS RESEARCH

Francis MacDonald Sinclair Memorial Laboratory — Building #7

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HENRY LEIDHEISER, Jr., Director
and Professor of Chemistry

12 29 p1

11 2 Feb 79

February 2, 1979

9 Final Rept. 1 May 78-31 Jan 79

6 Corrosion Control by Coatings.

Dr. Philip Clarkin

Code 471

Metallurgy Division

Office of Naval Research

Arlington, Virginia 22217

A Discussion Held at
Lehigh University

Bethlehem,

Pennsylvania, 13-15

Dear Phil:

November 1978

15

This letter represents the final report on ONR Grant No. N00014-78-G-0029
entitled, "A Discussion - Corrosion Protection by Coatings". The period of this
grant was May 1, 1978 to January 31, 1979.

The grant provided support for a Discussion on Corrosion by Coatings which
was held in the Sinclair Laboratory, Lehigh University on November 13-15, 1978.
There were 82 attendees, the names of which are listed in Attachment #1 and 33
papers were presented. A copy of the program is given in Attachment #2. The
program was arranged in six half-day sessions on the following subjects:

Sacrificial Coatings for Corrosion Control;
Barrier Coatings for Corrosion Control;
Pretreatment Processes and Conversion Coatings;
Inhibitors in Coatings;
Design of Coatings for Other than Corrosion Control; and
Coatings Science.

The full texts 32 of the 33 papers were available to all attendees at the time
of the meeting. Thirty papers were furnished in the form of a bound booklet and
two papers were furnished separately. The full text of the 33rd paper was delayed
because of company policy, but was available about 2 weeks after the meeting.
The proceedings of the Discussion (32 of the 33 papers) are being published by
Science Press in hardback copy and should be available on April 1. Publication
costs are being borne by Lehigh University.

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Each of the six sessions included a chairman and a reporter. The reporter's responsibility was to summarize the major unsolved problems as stated by the speaker or as developed in the discussions following the papers. The reporters from whose notes I draw heavily were:

Ellis Verink, University of Florida
Jerome Kruger, National Bureau of Standards
B. Floyd Brown, American University
Frank Graziano, Pre Finish Metals, Inc.
Howard Lasser, Naval Facilities Engineering Command
Gary W. Simmons, Lehigh University

Summarized below are some of the major problem areas that were recognized during the meeting. This summary is based on information obtained from reporter's notes, from comments made publicly or privately by the speakers, and from my own notes taken during the meeting, and from correspondence and telephone conversations with attendees following the meeting. The comments are limited to questions related to corrosion and are organized under the following major categories:

Sacrificial Coatings for Corrosion Control
Metallic Barrier Coatings for Corrosion Control
Organic Barrier Coatings for Corrosion Control
Pretreatment Processes and Conversion Coatings
Inhibitors in Coatings

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Sacrificial Coatings for Corrosion Control

Galvanized Steel

Galvanized steel has been a commercial product for many years and there is a long experience on its production and service experience. The need to conserve natural resources has increased the pressure to obtain the same protective properties with less zinc. Possible additional applications of galvanized steel in products resulting from coil coating is putting new demands on the product.

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Can the corrosion rate of zinc be decreased for a longer life product, yet the same protection be conferred to steel exposed through the zinc?

The Japanese have reported that the electrodeposition of zinc from a plating bath containing small amounts of cobalt and chromium yields a galvanized steel that has a lower corrosion rate of the zinc. By what mechanism do cobalt and chromium provide such better corrosion resistance?

It has been reported that hot-dipped galvanized steel whose zinc grains have a high degree of (0001) preferred orientation have superior paint adhesion properties. Does this superior performance relate largely to the mechanical properties of the grains, the chemical properties of the surface for the pretreatment process, or both?

Typical hot-dipped galvanized steel has 70% of its grains oriented with the (0001) plane within 15° of the geometric surface? What is the mechanism for this preferred orientation? How can the degree of (0001) preferred orientation be controlled?

The surface (outer 100 Å.) of hot-dipped galvanized steel is enriched in aluminum. What is the mechanism of this enrichment?

Zinc is often treated with phosphate to form a phosphate conversion coating between the metal and a protective paint coating. The coating appears to form anisotropically. How can advantage be taken of this anisotropic behavior?

What economic method can be developed to prevent wet storage stain?

There appears to be a need for additional basic studies of the anodization of zinc. Can processes be developed, similar to those used with aluminum, for the

preparation of highly protective, sealable, and dyeable anodized zinc?

Aluminum-Zinc Alloys

A relatively new commercial product consisting of 55% aluminum has atmospheric corrosion resistance superior to galvanized steel and provides more galvanic protection to the steel base than aluminum coatings.

What composition of aluminum-zinc alloy for galvanized coatings optimizes corrosion behavior and overall energy cost in production of galvanized products?

What opportunities exist for other alloy additions in combination with aluminum to reduce the content of zinc in galvanized coatings? Consideration might be given to elements such as mercury and tin which have been used effectively in aluminum sacrificial anodes.

What is the detailed character of the corrosion products which develop in the interdendritic spaces of the alloy coatings. What factors influence the crystallographic form and protectiveness of such reaction products. What is the influence of these factors on the long-term ability of the coating to provide cathodic protection to the substrate?

What is the influence of alloy composition on the integrity, protective character, and composition of the intermetallic layer at the interface between the steel substrate and the coating? What is the influence of composition and thickness of the intermetallic layer on the mechanical behavior (formability, etc.) of finished products?

What is the influence of the composition of the alloy on the ability of organic coatings to adhere and provide additional protection to the steel substrate?

Tinplate as a Sacrificial Coating

The major use of tinplate is in the fabrication of food containers. Under the anaerobic conditions existing in the container the tin is anodic to iron.

Why is the grain size of the tin important in determining the corrosion behavior of tin coatings? What is the influence of minor constituents at grain boundaries on corrosion mechanisms for tin coatings?

What are the detailed reactions at the tin and iron electrodes within a food container? What methods are available for further reduction in rate of the rate controlling step?

How can the passive nature of the oxide film on tin be improved?

What methods can be developed to reduce further the amount of tin required to provide satisfactory sacrificial protection for the iron?

Metallic Barrier Coatings for Corrosion Control

Gold Electrodeposits

Gold electrodeposits find wide use in protection of electronic components and electrical connectors from corrosion by the atmosphere. The high cost of gold demands that the corrosion protection be obtained with the minimum quantity of gold.

Can experiments be devised to find independent verification of the proposal made by Morrissey and Welsberg that the porosity of very thin gold deposits is determined to a major degree by the substrate and that the porosity of thicker deposits is determined by the character of the gold deposit itself? Can the transition period between these two regimes be reduced?

Grain size and crystallographic orientation of gold deposits are important variables in determining the degree of porosity. How can the crystallographic orientation be controlled?

Many engineering problems require solution. For example, how can gold be plated selectively only where desired? Can dragout recovery be improved?

Palladium is a possible substitute for gold. How can the cracking of palladium deposits be controlled? What is the mechanism of cracking?

Intermetallic Compounds as Protective Coatings

It has been known for many years that FeSn_2 is important in determining the protection properties of tinplate. The intermetallic NiSn can be formed by electro-deposition and it is finding increased applications as a protective coating.

The oxide coating on NiSn is tin-rich. Is this because of the tin-rich nature of grain boundaries? or does it have a thermodynamic origin?

What is the basic reason for the corrosion resistance of NiSn ? Since its passive oxide is tin-rich, should it not be equivalent to pure metallic tin in its general behavior?

A major problem with intermetallic coatings is their brittleness. What can be done to improve the mechanical properties of intermetallic coating?

It has recently been reported that aging of NiSn results in the formation of crystallinity in the passive film. Is this result not contrary to conventional views which hold that glassy film qualities are desirable? Explain the discrepancy.

Is contact resistance a good method for following changes in the passive film on NiSn as a function of aging?

The chemical properties of the oxide film on NiSn changes with time. Approximately 30 days are required to develop full passivity. It is known that the composition of the outermost layer changes with time. How do these chemical changes relate to the changes in chemical properties ?

Organic Barrier Coatings For Corrosion Control

Electrical Measurements as Predictors of Corrosion

DC resistivity, AC resistivity, capacitance, corrosion potential, and polarization behavior are among the electrical measurements used to appraise the protective nature of organic coatings on metals. Capacitance measurements may be used to determine water uptake by the coating and resistance measurements may be used to determine the development of corrosion pathways in the coating.

Can quantitative electrical measurement techniques be developed that will measure corrosion and be able to differentiate between localized and generalized attack? Are changes in resistance determinants for localized attack and changes in capacitance determinants of general attack?

What techniques can be devised to explore the quantitative relationship between changes in capacitance and water uptake of the coatings?

How can the electrical measurements be used to determine the distribution of water in the coating? What information is necessary to determine the amount of water present at the substrate/coating interface?

Can electrical measurement techniques be developed to study the properties of conductive coatings, such as the zinc-pigmented coatings?

Can electrical measurement techniques be applied to determining the quality of the phosphate-based conversion coatings?

Engineering problem. Can the electrical measurement methods be applied in the field for following, and anticipating, changes in the properties of the coating/substrate system?

Organic Electrocoatings

Organic coatings may be electrodeposited anodically and cathodically. The cathodically deposited coatings appear to have better corrosion protection properties.

What is the relative protective behavior of similar coatings formed by electrodeposition, spray coating, dip coating, or roll coating?

How do coatings based on zwitterion polymers perform in corrosive environments compared to anodic and cathodic resins?

Can the galvanic nature of two dissimilar metals be avoided by coating the base metal with an anionic polymer and the noble metal with a cationic polymer?

What is the mechanism of solvent removal from electrocoatings?

What is the chemical composition of the interface between a metal substrate and the organic electrocoating before and after drying? Are there differences between anodic and cathodic coatings?

Organic Coatings - General

How does one determine the actual mode of failure of an organic coating?

It is difficult to distinguish whether a film has failed by (1) loss of adhesion, (2) decohesion, or (3) a mixed mode.

What is the effect of cross-link density on the tendency for corrosion to show up as blister? What mechanical properties should a coating have to "resist" osmotic pressure forces?

What are the effects of pigments (or mixtures of pigments) and Critical Pigment Volume Content (CPVC) on permeation rates of water and oxygen through coatings and on mechanical properties?

Is there any relationship between adhesion of a coatings when exposed to water and corrosion resistance?

More studies, such as those of Koehler, should be carried out in which impurities are purposely put on a surface before coating it. Impurities should be selected.

Why do baked coatings exhibit better corrosion resistance than air-dried coatings? What role does the oxide film at the interface play in adhesion?

What are the chemical changes at the coating/substrate interface when the system is exposed to a corrosive environment?

How can one separate the effects of temperature on coatings performance from factors which depend on the glass transition temperature?

How does oxygen permeability through a coating depend on the water content of the coating? Are oxygen permeability and water permeability through a coating independent of one another?

What effect does water have on the presence of retained solvents and what effect do retained solvents have on water and oxygen permeability?

Does performance of a coating in the salt spray test correlate with service performance? What role do effects of aging play?

Can electrical resistance properties of a paint be used to determine optimum concentrations of resin, pigment, and filler for best corrosion behavior?

What are the chemical and physical factors that affect a scribe mark? What role do these factors play in determining the performance of the coating in the salt spray test?

What role do mechanical properties of a coating play in corrosion behavior?

What can be done to make coating systems more tolerant to applications problems?

Mossbauer spectroscopy has been applied to determining chemical changes at the metal/organic coating interface? What other non-destructive, in situ tests can be devised for following chemical changes at the interface during exposure of the system to a corrosive medium?

What is the relationship between substrate roughness and corrosion behavior of a painted metal in service?

A model has been proposed for mass transport in paint films. Does a model based on one-dimensional mass transfer resistance accurately describe metallic corrosion under paint films? The model contains 15 parameters. Are all of these parameters independent? What are the minimum number of parameters that must be taken into account to describe the mass transfer quantitatively?

An important characteristic of organic coatings is their behavior on weathering. How do mass transport properties of constituents important in corrosion change with weathering? What is the mechanism of weathering? What effect do atmospheric contaminants play in the weathering process? What are the important properties of a coating at the substrate/coating interface that are affected by weathering? How can accelerated weathering tests be improved to reflect more accurately the service performance of a coating/substrate system?

Pigment/matrix, filler/matrix, and matrix/substrate interactions are affected by the acid/base character of the two interacting phases. How does water affect these interactions? How does the quality of the acid/base interaction between the metal and the coating relate to corrosion behavior? Does the corrosion process itself affect the metal surface such that the acid/base interaction is affected? Can the migration of water through a coating be impeded by a high pigment concentration? Can diffusing ions be trapped by proper choice of pigment/matrix character?

Complete characterization of the thin oxide present at the metal/organic coating interface is important. What novel techniques can be devised for better characterization? How does the metal oxide change when a coating is cured by thermal treatment? How rapidly does the composition of the thin oxide change with time? Does the composition of the outermost layer change with time? How does aging of the oxide affect the substrate/organic coating bond?

In summary, the areas of research that appear to offer the greatest promise for improvements in the corrosion protection of metals by organic coatings are:

- (1) The development of laboratory tests that predict service performance.
- (2) Studies of the metal/coating interface during exposure to a corrosive environment.
- (3) The chemical factors that govern the strength of the substrate/coating bond.
- (4) The critical factors that govern mass transport through organic coatings.
- (5) An understanding of the relationship between mechanical properties of a coating and its ability to provide protection to a substrate.
- (6) A better understanding of the relationship of the glass transition temperature to corrosion protective qualities of organic coatings.

Pretreatment Processes and Conversion Coatings

Passive Films

Passive films are obtained by means of an applied potential and by immersion of the metal in the proper electrolyte.

The stability of passive films is predictable from thermodynamic considerations, but why is the film protective in some cases and non-protective in others?

What atomistic processes account for the film growth kinetics? Is the rate-controlling process one based on field-assisted cation diffusion or is it a place exchange of metal-oxygen pairs in a row normal to the metal surface?

Certain constituents of the electrolyte become incorporated in the oxide under certain conditions. The incorporation of boron in the oxide film on iron

during anodic treatment in borate solution is an example. What is the mechanism of this incorporation? Is the protective nature of the film dependent on this incorporation?

What is the mechanism by which certain inorganic inhibitors maintain the protective nature of the passive film?

Chromate Conversion Coatings on Aluminum

Adhesive bonding to aluminum requires the development of a surface, prior to the application of the adhesive, that resists corrosion and deterioration of the aluminum/adhesive bond during exposure to the atmosphere.

What is the relationship between the topography of the surface and the quality of adhesive bonding?

A conversion coating for aluminum is based on CrO_3 and phosphoric acid. The coating that is formed is generally referred to as a chromium phosphate coating. Such coatings are prone to a phenomenon known as "mud cracking". What is the cause of "mud cracking"? What is the relationship between degree of "mud cracking" and the protective nature of this conversion coating? How does "mud cracking" relate to the chemical composition of the bath used in forming the conversion coating? What is the effect of aluminum build-up in the bath on "mud cracking"?

Chromate conversion coatings are commonly used for the protection of aluminum from corrosion. Does hexavalent chromium occur in the film? Present information is conflicting. A polysulfide primer has been shown to give good corrosion resistance to aluminum. Does the same primer work as well with steel or galvanized steel?

Anodic Coatings on Aluminum

Can thick anodic coatings on aluminum be developed that are ductile ?
How are mechanical properties of the anodic oxide affected by crystallinity and the degree of hydration ?

What is the optimum method for forming an anodic oxide with the minimum number of flaws that act as nucleation sites for cracks in environments leading to stress corrosion cracking ?

What current waveform yields the anodic oxide on aluminum with the best chemical properties ?

Conversion Coatings and Paint Delamination

Paint delamination in an accelerated laboratory test is caused primarily by the accumulation of an alkaline solution beneath the paint film. This alkaline solution is generated by the cathodic reaction involving the reduction of oxygen. Carbon on the surface is responsible for the poor quality conversion coating and the resulting area available for the cathodic reaction.

What is the mechanism by which carbon interferes with the phosphating process ?

What is the source of the carbon ?

Where does the adhesive bond break ? In the phosphate at the paint/phosphate interface ? at the phosphate/metal interface ? or elsewhere ?

What is the mechanism of bonding of paint to a phosphated surface ?

What role do pits and grain boundary trenches, both of which may serve as reservoirs for contaminants, play in controlling the quality of the phosphating process ?

Inhibitors in Coatings

Inhibition of Stress Corrosion Cracking

That is the fundamental mechanism for stress corrosion cracking (SCC)?

Does the same mechanism apply with all metals under all circumstances?

What is the rate controlling chemical step in SCC?

How does a paint film inhibit SCC? Can paint films under some circumstances accelerate SCC? Can SCC inhibitors be incorporated in a paint film?

How can one identify SCC under a paint film?

What is the mechanism by which some inorganic ions inhibit SCC?

Corrosion Inhibition

Is chelation capability related to the quality of corrosion inhibition for some organic compounds?

The efficiency of chemisorption-type organic inhibitors in acid solution is a function of the molecular structure of the inhibitor, the structure of the electrical double layer, the presence of adsorbed water molecules at the interface, competitive or cooperative adsorption with surface active anions, and the degree of hydrophobicity of the aliphatic tail or aromatic ring. How can these various factors be prioritized and evaluated quantitatively?

Is competitive adsorption between chromate and chloride ions the critically important issue in determining if crevice corrosion and pitting occur in iron and its alloys?

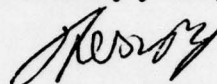
Dr. Clarkin

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February 2, 1979

Can phase transfer catalysts such as the crown ethers and quaternary ammonium salts be used as means to solubilize inhibitors ions in non-aqueous phases?

Sincerely yours,

A handwritten signature in cursive script, appearing to read "Henry".

Henry Leidheiser, Jr.

Enclosures
HLJ/rf

A DISCUSSION - "CORROSION CONTROL BY COATINGS"

Lehigh University
Bethlehem, Pennsylvania 18015

November 13-15, 1979

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CORROSION CONTROL BY COATINGS

A Discussion

to be held at:

**Lehigh University
Bethlehem, Pennsylvania**

November 13-15, 1978

Sponsored by: Office of Naval Research

Condensed Schedule

Monday, November 13

8:00 a. m.	Registration, Sinclair Laboratory Conference Center
8:45	Welcome, W. Deming Lewis, President, Lehigh University
9:00	H. S. Preiser, Overview Lecture
9:45 - 12:05	Session I, "Sacrificial Coatings for Corrosion Control"
12:15 p. m.	Lunch, University Center
1:45	Howard Gerhart, Overview Lecture
2:30 - 5:15	Session II, "Barrier Coatings for Corrosion Control"
5:30	Hospitality Hour
7:00	Dinner, University Center
8:00 - ?	Discussion (as determined by chairmen and attendees)

Tuesday, November 14

8:30 a. m.	Jesse Lumsden, Overview Lecture
9:15 - 12:05	Session III, "Pretreatment Processes and Conversion Coatings"
12:15 p. m.	Lunch, University Center
1:45	Zeno Wicks, Jr., Overview Lecture
2:30 - 5:30	Session IV, "Inhibitors in Coatings"
5:45	Hospitality Hour
7:00	Dinner, University Center
8:30	Discussion (as determined by chairmen and attendees)

Wednesday, November 15

8:30 a. m.	W. Funke, Overview Lecture
9:15 - 12:05	Session V, "Design of Coatings for Other than Corrosion Control"
12:15 p. m.	Lunch, University Center
1:30 - 4:30	Session VI, "Surface and Coatings Science"
5:00	Conclusion of Discussion

Monday, November 13

Session I

Chairman: Henry Leidheiser, Jr., Lehigh University

Reporter: Ellis Verink, University of Florida

Overview Lecture

9:00 a. m. H. S. Preiser, Naval Ship Research and Development Command
(co-authored with S. D. Rodgers)

"Coatings - The Promise and the Challenge for Enhanced Naval Ship
Performance"

Session Title: "Sacrificial Coatings for Corrosion Control"

9:45 "Galvanized Steel and Zinc Pigmented Paints", A. R. Cook,
International Lead Zinc Research Organization

10:10 "Aluminum-Zinc Alloys as Sacrificial Coatings", James Horton,
Bethlehem Steel Corporation

10:35 Break

10:50 "Tinplate as a Sacrificial Coating", Ronald Beese, American
Can Company

11:15 Discussion

12:00 Lunch

Monday, November 13

Session II

Chairman: Raymond Myers, Kent State University

Reporter: Jerome Kruger, National Bureau of Standards

Overview Lecture

1:45 p. m. Howard Gerhart, Carnegie-Mellon University

"Prophetic Imperatives in Corrosion Control"

Session Title: "Barrier Coatings for Corrosion Control"

2:30 "Some Further Studies on Porosity In Gold Electrodeposits",
Ronald Morrissey, Technic, Inc., (co-authored with A. M. Weisberg)

3:00 "Corrosion Control with Tin Nickel and Other Intermetallics",
Morton Antler, Bell Laboratories

3:30 Break

3:45 "Corrosion Resistance of Paint Films from Anodic and Cathodic Resins",
George Brewer, Coating Consultant

4:15 "Electrical and Electrochemical Measurements as Predictors of Corrosion at
the Metal-Organic Coating Interface", Henry Leidheiser, Jr., Lehigh University

4:45 Discussion

5:30 Hospitality Hour

6:30 Dinner

Tuesday, November 14

Session III

Chairman: A. C. Zettlemoyer, Lehigh University

Reporter: B. F. Brown, American University

Overview Lecture

8:30 a. m. Jesse Lumsden, Rockwell International Science Center

"Surface Analysis of Passive Films on Metals"

Session Title: "Pretreatment Processes and Conversion Coatings"

9:15 "Anodic Coatings for Aluminum", William C. Cochran, Aluminum Company of America (co-authored with Donald O. Sprowls)

9:40 "Characterization of Chromic Acid Anodized Aluminum Alloy Surface", William Russell, ARRA DCOM (co-authored with Carolyn Westerdahl)

10:05 "Conversion Coatings - Chromate and Non-Chromate Types", Nelson Newhard, Jr., Amchem Products

10:30 Break

10:45 "Important Correlations Arising from the Scribe Test for Appraising Paint/Pretreatment/Substrate Systems", R. W. Zurilla, Ford Motor Company

11:10 "Aspects of Substrate Surfaces Influencing Industrial Coating Systems Corrosion Performance", Ralph E. Pike, Consultant

11:35 Discussion

12:15 Lunch

Tuesday, November 14

Session IV

Chairman: W. Funke, University of Stuttgart
Reporter: Howard Gerhart, Carnegie-Mellon University

Overview Lecture

1:45 p. m. Zeno Wicks, Jr., North Dakota State University

"Principles of Formulating Corrosion Protective Coatings"

Session Title: "Inhibitors in Coatings"

2:30 "Mechanisms of Corrosion Control By Inhibitors", Edward McCafferty,
Naval Research Laboratory

2:55 "Control of Stress Corrosion Cracking by Inhibitors", B. F. Brown,
American University (co-authored with C. S. O'Dell)

3:20 Break

3:40 "A New Method to Solubilize Inhibitors in Coatings", K. Clark, Naval
Air Development Center

4:05 "The Role of Chromates in Sealants and Coatings", Robert N. Miller,
Lockheed-Georgia Company

4:30 "The Mechanisms of Corrosion Prevention by Inhibitors in Paints",
J. D. Scantlebury, University of Manchester

4:55 Discussion

5:45 Hospitality Hour

7:00 Dinner,

Wednesday, November 15

Session V

Chairman: John W. Vanderhoff, Lehigh University
Reporter: Howard Lasser, Naval Facilities Engineering Command

Overview Lecture

8:30 a. m. W. Funke, University of Stuttgart

"Corrosion Tests for Organic Coatings - Usefulness and Limitations"

Session Title: "Design of Coatings for Other than Corrosion Control"

9:15 "Optical Properties of Coatings", Eugene M. Allen, Lehigh University

9:40 "Ultraviolet Curing Coatings", Robert W. Bassemir, Sun Chemical Corporation

10:05 "Coating Underwater Surfaces", Richard W. Drisko, Civil Engineering Laboratory, U. S. Navy

10:30 Break

10:45 "Antifouling Coatings", Nadim Ghanem, National Research Center, Egypt (co-authored with Mounir M. Abd El-Malek)

11:10 "Intumescent Coatings", D. Pulley, Naval Air Development Center

11:35 Discussion

12:15 Lunch

Wednesday, November 15

Session VI

Chairman: Robert Frankenthal, Bell Telephone Laboratories

Reporter: G. W. Simmons, Lehigh University

Session Title: "Surface and Coatings Science"

- 1:30 p. m. "Mechanism of Drying of Latex Coatings", John W. Vanderhoff,
Lehigh University
- 2:00 "Model for Mass Transport in Paint Films", Robert Ruggeri,
Electrochemical Technology Corporation
- 2:30 "Weathering of Organic Coatings", R. M. Holsworth, Glidden
Coatings and Resins, (co-authored with T. Provder)
- 3:00 "Pigment-Matrix Interactions", Frederick M. Fowkes, Lehigh
University
- 3:30 "The Composition of Metal Surfaces After Atmospheric Exposure",
James Castle, University of Surrey
- 4:00 Discussion