Technical Proceedings
36th Annual Conference

REINFORCED PLASTICS/ COMPOSITES INSTITUTE

PREPRINT

of the

THIRTY-SIXTH ANNUAL CONFERENCE

REINFORCED PLASTICS/COMPOSITES INSTITUTE

February 16–20, 1981

TUESDAY MORNING 17 FEBRUARY - 5 CONCURRENT SESSIONS

(Final Schedule—supercedes all previously distributed programs)

(1) SESSION **WASHINGTON ROOM**
SMC/BMC - Material & Fillers

Moderator: Ray H. Miller, ABS Industries
Vice Moderator: George T. Condy, ABS Industries

9:30 a.m. (1-A) **"Improved SMC Systems for Electrical Applications,"** W.D. Luzier, F.J. Howantineck, ICI Americas Inc.

9:55 a.m. (1-B) **"Enhanced Toughness in SMC Moldings Through Urethane Thickened SMC,"** A.T. Hurst, S.A. Smith, J.A. Reitz III, ICI Americas Inc.

10:20 a.m. (1-C) **"Maximizing the Performance of Hollow Microspheres in Low Density Sheet Molding Compound,"** W. Charles Howes, Leonard H. Smiley, The PQ Corporation

10:45 a.m. (1-D) **"'Tough' SMC Resins,"** Steven L. Voeks, Michael Kallaur, Freeman Chemical Corporation

11:10 a.m. **Authors' Panel Discussion**

A FIVE-MINUTE QUESTION-AND-ANSWER PERIOD FOLLOWS THE PRESENTATION OF EACH PAPER.

ALL TECHNICAL SESSIONS ARE ON THE LOBBY LEVEL.

(2) SESSION **NORTH COTILLION ROOM**
The Interface

Moderator: E.P. Plueddemann, Dow Corning
Vice Moderator: Sid Berger, Union Carbide Corp.

9:30 a.m. (2-A) **"The Effects of Resin Variation on the Interlaminar Adhesion of Aramid Reinforced Composites,"** D.J. Vaughan, Clark-Schwebel Fiberglass Corporation

9:55 a.m. (2-B) **"Role of Organo Silanes and Organo Titanates in Promotion of Adhesion Strength of Aluminum Oxide-Polyethylene Joint,"** N.H. Sung, A. Kaul, S. Ni, Tufts University and C.S.P. Sung, I.J. Chin, Massachusetts Institute of Technology

10:20 a.m. (2-C) **"The Structure of an Amino-Silane Coupling Agent in Aqueous Solutions and Partially Cured Solids,"** K.H. Ishida, S. Naviroj, J.L. Koenig, S. Tripathy and J. Fitzgerald, Case Western Reserve University

10:45 a.m. (2-D) **"Comparison of Primary and Secondary Aminosilane Coupling Agents in Anhydride-Cured Epoxy Fiberglass Composites,"** Chwan-Hwa Chiang and Jack L. Koenig, Case Western Reserve University

11:10 a.m. (2-E) **"The Use of Ductile Innerlayers in Glass Fiber Reinforced Epoxies,"** L.D. Tryson and J.L. Kardos, Washington University

11:35 a.m. (2-F) **"Amino Silane Primers for Adhesion Bonding of Iron,"** J.W. Williams and F.J. Boerio, University of Cincinnati

12:00 p.m. (2-G) **"Structure-Property Relationships of Silane Films on Aluminum Substrates,"** C.A. Gosselin and F.J. Boerio, University of Cincinnati

(3) SESSION **SOUTH COTILLION ROOM**
Corrosion Resistance - Pipe, Tanks & Process Equipment I

Moderator: Charles Angell, Consultant
Vice Moderator: Robert Talbot, Ashland Chemical Co.

9:30 a.m. (3-A) **"Failure Analysis of Thin Walled Filament Wound Pipe During Application of Internal Pressure,"** Richard E. Gross and P. Douglas Lyle, Owens-Corning Fiberglas Corp.

9:55 a.m. (3-B) **"Reinforced Plastic Pressure Vessels for Reverse Osmosis Membrane Containment,"** C.E. Kaempen, Kaempen Industries, Inc.

10:20 a.m. (3-C) **"On Site Manufacture of RP Water Tanks,"** Paul Lechner, Fontana Products Pty. Ltd., Australia

10:45 a.m. (3-D) **"Patented Design Will Enable a 5.28 Million Gallon RP Tank to be Air, Highway, Rail and Ship Transportable,"** R.J. Short, and A.V. Kozloff, Tankinetics, Inc.

11:10 a.m. **Authors' Panel Discussion**

12:30 p.m. Sheraton Ballroom. AEROSPACE LUNCHEON. Address by Don Stansbarger, Northrop Corporation. Tickets available until 10:30 a.m.

CONTACT PERIODS: 2:00 to 5:00 p.m. Exhibit Hall, Suites, Function/Hospitality Rooms

TUESDAY MORNING 17 FEBRUARY - CONTINUED

(4) SESSION **VIRGINIA SUITE**
Reinforced Thermoplastics I

Moderator: Jim Best, Market Search, Inc.
Vice Moderator: W.C. Turnier, Owens-Corning Fiberglas Corp.

9:30 a.m. (4-A) **"Characterization of Mineral Fillers Used for Reinforcing Engineering Thermoplastics,"** Richard W. Campbell, General Electric Company

9:55 a.m. (4-B) **"Melt Processible Fluoropolymer Composites,"** Jane Crosby, John Theberge, and K.R. Talley, LNP Corporation

10:20 a.m. (4-C) **"The Influence of Fiber-Matrix Adhesion on the Mechanical Properties of Discontinuous Fiber Reinforced Thermoplastics,"** M.J. Balow and D.C. Fuccella, Thermofil

10:45 a.m. (4-D) **"The Use of Surface Modified Organic Particulate as an Extender for Thermoplastics,"** Scott Willis, Jr., and Tison S. King, Extend-X

11:10 a.m. **Authors' Panel Discussion**

(5) SESSION **WILMINGTON ROOM**
Processing I

Moderator: R.K. Weber, U.S. Peroxygen Div., Witco
Vice Moderator: Steve Walling, Owens-Corning Fiberglas Corp.

9:30 a.m. (5-A) **"Filament Winding Machines, Which Type is Best for Your Application,"** Ronald R. Roser and Dean Hermansen, Engineering Technology, Inc.

9:55 a.m. (5-B) **"A Ring Type Filament Winding Machine with a Dedicated Microcomputer Control System,** David Beck, Goldsworthy Engineering, Inc.

10:20 a.m. (5-C) **"The Filament Winding Market—a Modern Day Review,"** Jeffrey F. Kober, McClean-Anderson, Inc.

10:45 a.m. (5-D) **"Application of Industrial Robots for Processing Fibre Reinforced Plastics,"** Prof. Dr. Ing. G. Menges and Dipl. Ing. W. Ermert, IKV, West Germany

11:10 a.m. (5-E) **"Injection Molded BMC—Influence of Process Limits on Product Performance,"** A. Horner, O. Zaske, Silmar Division of Vistron Corporation and R. Rapp, Amoco Chemical Corp.

11:35 a.m. (5-F) **"Prototype Applications for Compression Molded Fiber Glass Reinforced Plastic Composites,"** W.J. Janosky, and Joe Y. Keller, PPG Industries, Inc.

12:00 p.m. **Authors' Panel Discussion**

WEDNESDAY MORNING 18 FEBRUARY - 5 CONCURRENT SESSIONS

(6) SESSION **WASHINGTON ROOM**
Processing II RRIM-SMC
Moderator: Jim Noonan, Owens-Corning Fiberglas Corp.
Vice Moderator: T. Preisel, Ashland Chemical Co.

9:00 a.m. (6-A) **"International Harvester—SMC Facility Design,"** Tom Greening, SMC Corp.

9:25 a.m. (6-B) **"RRIM Technology for Large Volume Production Systems,"** Fritz W. Schneider, PTA-Martin Sweets Co., Inc.

9:50 a.m. (6-C) **"Fiber Glass Reinforced RIM Urethanes: Chopped Strands vs. Milled Fibers,"** James Harvey, B. Das and M.M. Girgis, PPG Industries, Inc.

10:15 a.m. (6-D) **"SMC Paste Metering,"** Joseph Foster, SMC Corporation

10:40 a.m. (6-E) **"Processing of Reinforced Reaction Injection Molding: Paintability Considerations,"** Joseph A. Hulway, G.M. Manufacturing Development

11:05 a.m. (6-F) **"MDI Products For RRIM,"** James Farrarini and Raymond H. Fowler, ICI Americas, Inc., and Nicholas Spatafore, Rubicon Chemicals, Inc.

11:30 a.m. (6-G) **"Design Concepts of a New Generation of Automated Hydraulic Molding Presses,"** Eugene L. Wood, SMC Corp.

11:55 a.m. **Authors' Panel Discussion**

(7) SESSION **NORTH COTILLION ROOM**
Resins
Moderator: Ralph W. Hewitt, Shell Development Co.
Vice Moderator: Ian Grant, ICI Americas, Inc.

9:00 a.m. (7-A) **"100% Reactive Polyester Insulating Varnish for Class 200 Electrical Equipment,"** Robert F. Navin and Michael Kallaur, Freeman Chemical Corporation

9:25 a.m. (7-B) **"The Effects of Temperature and Moisture on the Mechanical Behavior of Reinforced Thermosets: I. Fracture Toughness of Neat Resins,"** J.V. Carisella, Shell Oil Co., R.D. Goolsby, University of Texas at Arlington and Ralph Hewitt, Shell Development Co.

9:50 a.m. (7-C) **"The Effects of Temperature and Moisture on the Mechanical Behavior of Reinforced Thermosets: II. S-N Fatigue of Resin/Glass Laminates,"** J.V. Carisella, Shell Oil Co., R.D. Goolsby, University of Texas at Arlington and Ralph Hewitt, Shell Development Co.

10:15 a.m. (7-D) **"Factors Effecting the Performance and Durability of Clear RP Panels,"** John R. Goglick, Michael Palmer, J.H. Davis, and Paul Von Bramer, Eastman Chemical Products, Inc.

10:40 a.m. (7-E) **"Considerations: Dicyclopentadiene in Polyester Resins,"** D.L. Nelson, The Dow Chemical Company

11:05 a.m. (7-F) **"High Performance Terephthalate Unsaturated Polyester Resins,"** Lloyd Buzbee, Koppers Co. Inc.

11:30 a.m. **Authors' Panel Discussion**

(8) SESSION **SOUTH COTILLION ROOM**
Corrosion Resistance - Pipe, Tanks & Process Equipment II
Moderator: William Holtzclaw, Justin Fiberglass
Vice Moderator: Ian Wilcox, ICI Americas, Inc.

9:00 a.m. (8-A) **"Continuity of Appearance Property Evaluation for ASTM C-581 Chemical Resistance Testing,"** James L. Daughtry, the Dow Chemical Company

9:25 a.m. (8-B) **"Stress Effects on Degradation of Chemically Resistant RP,"** M. Tomikawa, S. Aoki, and K. Kudoh, Chiyoda Chemical Engineering and Construction Co., Ltd., Japan

9:50 a.m. (8-C) **"Elegant Solutions to Crude Problems (Experiences of a Major Oil Company in the Use of Reinforced Plastics),"** K.D. Jeffreys, P.C. Turner, BP Chemicals Ltd., England

10:15 a.m. (8-D) **"Testing and Evaluation of RTR for Corrosion Control Applications,"** W.A. Szymanski, S.J. Scott, and M.J. Duffy, Ashland Chemical Co.

10:40 a.m. (8-E) **"New Resin Transfer Molding (RTM) Resins for Corrosion Resistance and Fire Retardance,"** P.W. Vaccarella, Ashland Chemical Company

11:05 a.m. (8-F) **"Large RP Fabrication for a Municipal Waste Water Treatment Plant Conversion,"** Guy R. Kenny, Glassline Inc. and Walter M. Stark, Stark and Sons Associates, Inc.

11:55 a.m. **Authors' Panel Discussion**

LUNCHEON: 12:30 p.m. **Sheraton Ballroom. The Awards Luncheon—Best Papers; Exhibits Category Winners; and the Clare E. Bacon Executive Award. Address by Mark Russell, political satirist. Tickets available until 10:30 a.m.**

CONTACT PERIODS: 2:00 to 5:00 p.m. **Exhibit Hall, Suites, Function/Hospitality Rooms**

WEDNESDAY MORNING 18 FEBRUARY - CONTINUED

(9) SESSION **VIRGINIA SUITE**
Reinforced Thermoplastics II
Moderator: Mike Whelan, Owens-Corning Fiberglas Corp.
Vice Moderator: Wally Abolins, General Electric/Noryl

9:00 a.m. (9-A) **"Glass Fiber Length Degradation in Thermoplastics Processing,"** Robert A. Schweizer, Owens-Corning Fiberglas Corp.

9:25 a.m. (9-B) **"Low Cost Filler Coupling Agent for Polyolefins,"** O.M. Windrath, R.D. Burge, and D.R. Stevenson, Dover Chemical Corporation

9:50 a.m. (9-C) **"Plastic-on-Plastic Tribological Properties of Thermoplastic Composites,"** Mark Wolverton and John Theberge, LNP Corporation

10:15 a.m. (9-D) **"Reinforced Polypropylene—Versatile High Performance Molding Compounds,"** Richard Wenger, Fiberfil

10:40 a.m. (9-E) **"Physical Characteristics of Molded Reinforced Thermoplastics,"** Stuart Koford, Amphenol North America Division, Bunker Ramo Corporation

11:05 a.m. (9-F) **"Fiber Glass Reinforced Thermoplastics: Effect of Reinforcement Parameters on Composite Properties,"** Edward C. Hsu and Chester S. Temple, PPG Industries, Inc.

11:30 a.m. **Authors' Panel Discussion**

(10) SESSION **WILMINGTON ROOM**
Research and Development I
Moderator: T.T. Serafini, NASA Lewis Research Center
Vice Moderator: R. Proodian, Naval Air Systems Command

9:00 a.m. (10-A) **"Tensile Fatigue Performance of Glass Fiber Dominated Composites,"** J.F. Mandell, D.D. Huang, and F.J. McGarry, Massachusetts Institute of Technology

9:25 a.m. (10-B) **"Effects of Structural Resins and Chopped Fiber Lengths on the Mechanical and Surface Properties of SMC Composites,"** B. Das, S.J. Morris and H.S. Loveless, PPG Industries Inc.

9:50 a.m. (10-C) **"Determination of Principle Stresses in Birefringent Composites by Hole-Drilling Method,"** R. Prabhakaran, Department of Mechanical Engineering and Mechanics, Old Dominion University

10:15 a.m. (10-D) **"Flaw Detection in Composites Using Thermography,"** E.V. McAssey, D.N. Koert, and P.V. McLaughlin, Mechanical Engineering Department, Villanova University

10:40 a.m. (10-E) **"Holographic Evaluation of Disbondings in Sandwich Plates,"** Thees Winkler, F. Erdmann-Jesnitzer, H. Haferkamp, Hanover University, West Germany

11:05 a.m. **Authors' Panel Discussion**

THURSDAY MORNING 19 FEBRUARY - 6 CONCURRENT SESSIONS

(11) SESSION **WASHINGTON ROOM**
Transportation I - Structural Materials
Moderator: Jack Roesly, Owens-Corning Fiberglas Corp.
Vice Moderator: Jeff Selley, Ashland Chemical Co.

9:00 a.m. (11-A) **"Structure/Performance Relationships for Sheet Molding Compound,"** F.A. Myers and Han Nyo, Armco Inc.

9:25 a.m. (11-B) **"High Strength Bumpers for Cars in Series Production with SMC-C,"** Rolf Liebold, FIBRON Wolfgang Mellert GmbH., West Germany

9:50 a.m. (11-C) **"Facelifting the World's First All SMC Clad Truck Cab After 5 Years Production—A Unique Case Study,"** M.J. Seamark, Bifort Engineering Ltd., England

10:15 a.m. (11-D) **"Use of CGHRP in Transport,"** D. Short and J. Summerscales, Plymouth Polytechnic, England

10:40 a.m. (11-E) **"Manufacture of Lightweight Fiberglass Reinforced Plastics from Elastic Reservoir Molding,"** Nippani R. Rao, Composite Technology Corporation

11:05 a.m. **Authors' Panel Discussion**

(12) SESSION **NORTH COTILLION ROOM**
High Performance Composites/Aerospace I
Moderator: G. Lubin, Grumman Aerospace Corp.
Vice Moderator: M. Stander, Naval Air Systems Command

9:00 a.m. (12-A) **"Composite Containment Systems for Jet Engines,"** Gordon T. Smith, NASA—Lewis Research Center

9:25 a.m. (12-B) **"Prediction of Composite Thermal Behavior Made Simple,"** C.C. Chamis, NASA—Lewis Research Center

9:50 a.m. (12-C) **"Thermal and Stress Cracking of C/G Composites,"** John Delmonte and Brian McCrory, Delsen Testing Laboratory

10:15 a.m. (12-D) **"A Significant Role for Composites in Energy-Efficient Aircraft,"** George A. Alther, Composite Aircraft Corporation

10:40 a.m. (12-E) **"The Failure Surface of Graphite-Epoxy Laminates,"** N. Balasubramanian, Wright-Patterson Air Force Base

11:05 a.m. **Authors' Panel Discussion**

(13) SESSION **SOUTH COTILLION ROOM**
Fillers & Additives I
Moderator: S.E. Berger, Union Carbide Corp.
Vice Moderator: J.R. Ritter, Potter's Industries

9:00 a.m. (13-A) **"Thixotropic Properties of New Precipitated Silica in Gel Coats,"** S.K. Wason, J.W. Maisel, J.M. Huber Corporation

9:25 a.m. (13-B) **"On the Use of a Unique Form of Zinc Borate as a Flame Retardant in Fiberglass Reinforced Unsaturated-Polyesters and Vinyl Esters: A Structure-Activity Relationship Study,"** Kelvin K. Shen and Robert W. Sprague, U.S. Borax Research Corporation

9:50 a.m. (13-C) **"A New Surface Treatment for Alumina Trihydrate and its Effect on the Processing and Performance of Filled Thermoset Systems,"** Charles A. Snyder and Thomas Cook, Solem Industries, Inc.

10:15 a.m. (13-D) **"Expansion Molding Compound,"** G.W. Saidla, Whitney and Company, Inc.

10:40 a.m. (13-E) **"Aluminum Trihydrate: A Powerful Additive for Flame and Track Retardancy of RP,"** T.O. Bautista, Protective Plastics Ltd., Canada

11:05 a.m. **Authors' Panel Discussion**

LUNCHEON: 12:30 p.m. **Sheraton Ballroom.**
Address by Donald Stroetzel, Mobil Corp. Tickets available until 10:30 a.m.

THURSDAY MORNING 19 FEBRUARY—CONTINUED

(14) SESSION **VIRGINIA SUITE**
Construction
Moderator: D.J. Bolton, Lucidol Div., Pennwalt Corp.
Vice Moderator: George Condy, ABS Industries

9:00 a.m. (14-A) **"Codes, Standards, and Design Data on Reinforced Plastics for Construction Applications,"** Joseph S. McDermott, The Society of the Plastics Industry

9:25 a.m. (14-B) **"The HAJ Terminal—Permanent Fabric Structures Come of Age,"** Robert P. Mulligan, Owens-Corning Fiberglas Corp.

9:50 a.m. (14-C) **"Stability Behavior of a Double Layer Skeletal/Continuum Glass Reinforced Grid Structure,"** V.G. Ishakian and L. Hollaway, University of Surrey, England

10:15 a.m. (14-D) **"How to Strengthen and Stiffen Composite Panels,"** Ray L. Hauser and Herbert Mund, Hauser Laboratories

10:40 a.m. (14-E) **"Passive Solar Manufactured Buildings for Commercial Applications Using RP/Composites,"** Bruce M. Keller and Victor Sedrick, Kalwall Corp.

11:05 a.m. **Authors' Panel Discussion**

(15) SESSION **WILMINGTON ROOM**
Processing III RTM
Moderator: O. Jacyszyn, Noury Chemical Corp.
Vice Moderator: Earl M. Zion, Owens Corning Fiberglas Co.

9:00 a.m. (15-A) **"Evaluation of Economic and Design Considerations for Production of Business Machine Cabinetry with the Resin Injection RTM Process,"** John Raymer, Venus Products, and Dick Clarke, RISCO

9:25 a.m. (15-B) **"Reinforcement Selection for Resin Transfer Molding,"** Sidney G. Dunbar and T.E. Griffith, Owens-Corning Fiberglas Corp.

9:50 a.m. (15-C) **"Feasibility of Structural Coring in the RTM Process,"** Robert R. Lacovara, Viking Yacht Company and John T. Woehr, Berton Plastics

10:15 a.m. (15-D) **"Resin Transfer Molding of Fiber Glass Preform Reinforced Polyester Resin,"** Robert S. Morrison, Molded Fiber Glass Companies

10:40 a.m. (15-E) **"New Applications of Resin Injection Molding Process in Japan,"** I. Sayama, Sayama Manufacturing Company, Ltd., I. Nomura, Sowa Resin Company, Ltd., K. Tabei and S. Gotoh, Nittoboseki Company, Ltd., Japan

11:05 a.m. (15-F) **"A Continuous Process for Internally Pressurized Tubular Products,"** David Beck and W. Brandt Goldsworthy, Goldsworthy Engineering, Inc.

11:30 a.m. (15-G) **"Vacuum Impregnation Developments for RP Manufacture,"** T.M. Gotch, British Railways Board, England

11:55 a.m. **Authors' Panel Discussion**

SPECIAL SESSION **MARYLAND SUITE**
Quality Assurance Panel
Moderator: Harvey Atkinson, Consultant
Vice Moderator: Tom Priest, Ceilcote Canada

Chemical-resistant equipment for industrial users, such as reinforced plastics processing tanks, have proven themselves in service as valuable materials of construction. Nevertheless, design and product uniformity problems were revealed in a survey conducted by SPI in 1978. This investigation was stimulated by the Materials Technology Institute, an association of users of corrosion-resistant products.

MTI and SPI appointed an equal number of representatives to a joint task force which has worked for nearly two years toward drafting *Quality Assurance Practices and Procedures.*

The joint Committee's report, published late in 1980, will be used during 1981 as a starting point for a code to be administered by the American Society of Mechanical Engineers. Eventually this code will provide criteria for reinforced thermoset plastic equipment which is suitable for use in the processing, storing, and handling of fluids over the pressure range from full vacuum to 15 psig. This code will include requirements for materials, design, fabrication, quality assurance, inspection and testing. It will not include plastic piping, which is covered in ANSI/ASME B 31, or Fiberglass Reinforced Plastic Pressure Vessels, which are covered by Section X of the ASME Boiler and Pressure Vessel Code.

Committee members, from whom Panelists will be selected are:

T.F. Anderson	T.G. Priest
H.E. Atkinson	O.W. Siebert
A.H. Ershig	J.H. Van Sciver
R.G. Pistole	R.M. Webster
J.J. Pollock	M. Gutierrez

Each panelist will discuss a section of the joint report with which he is most familiar; then the panel will participate with attendees in discussion of the questions raised.

This session will be tape-recorded and subsequently transcribed, as a step in the procedure by which the ASME Committee will solicit industry comment in transforming the joint report into a code.

THURSDAY AFTERNOON 19 FEBRUARY - 5 CONCURRENT SESSIONS

(16) SESSION **WASHINGTON ROOM**
Transportation II -Structural Materials Testing and Design
Moderator: D.O. Conley, Owens-Corning Fiberglas Corp.
Vice Moderator: David Rigner, General Motors Manufacturing Development

2:10 p.m. (16-A) **"Effects of Processing Variables on the Mechanical Properties of Structural SMC-R Composites,"** Douglas L. Denton, Owens-Corning Fiberglas Corp.

2:35 p.m. (16-B) **"Composite Wheels—Improved Performance with Continuous Fibers,"** M. Dewan and T.N. Coppock, Firestone Tire & Rubber Co.

3:00 p.m. (16-C) **"Curved Pulforming—A New Manufacturing Process for Composite Automobile Springs,"** Glenn W. Ewald, Goldsworthy Engineering, Inc.

3:25 p.m. (16-D) **"Heavy Duty Truck From Steel To RP on Body Panels for 401 & 201 Series Seddon Atkinson Truck,"** Andy Rudy, Premix U.S.A., Norm Trelford, Premix Scotland, and Terry Goodwin, Seddon Atkinson, England

3:50 p.m. (16-E) **"Automotive Body Panels: Composites, Laminates, or Metals?"** James M. Margolis, Margolis Marketing and Research Co.

4:15 p.m. (16-F) **"The Effect of Processing Variables on Curing Time and Thermal Degradation of Compression Molded SMC,"** Mark P. Panter, General Motors

4:40 p.m. **Authors' Panel Discussion**

(17) SESSION **NORTH COTILLION ROOM**
High Performance Composites and Aerospace II
Moderator: C.C. Chamis, NASA Lewis Research Center
Vice Moderator: L.M. Poveromo, Grumman Aerospace Corp.

2:10 p.m. (17-A) **"Fabrication and Test of Integrally Stiffened Graphite/Epoxy Components,"** J.A. Suarez and L.M. Poveromo, Grumman Aerospace Corp.

2:35 p.m. (17-B) **"Advanced Thermoplastic Composite Development,"** Max Stander, Naval Air Systems Command, C.H. Sheppard and E. House, Boeing Aerospace Co.

3:00 p.m. (17-C) **"Design and Evaluation of a Pultruded Hybrid Beam,"** P.K. Mallick, University of Michigan/Dearborn, L.K. Dilauw and D. Fesko, Ford Motor Co.

3:25 p.m. (17-D) **"Application and Testing of Metallic Coatings on Graphite Epoxy Composites,"** C. Staebler, Grumman Aerospace Corp., G. Lubin, Consultant, and M. Stander, Naval Air Systems Command

3:50 p.m. (17-E) **"Moisture Penetration Into Composites Under External Stress,"** L. Broutman and G. Marom, Illinois Institute of Technology

4:15 p.m. (17-F) **"Lower Curing Temperature and PMR Polyimides,"** T.T. Serafini, P. Delvigis and R. D. Vannucci, NASA-Lewis Research Center

4:40 p.m. **Authors' Panel Discussion**

(18) SESSION **SOUTH COTILLION ROOM**
Fillers and Additives II
Moderator: James R. Ritter, Potters Industries, Inc.
Vice Moderator: S.E. Berger, Union Carbide Corp.

2:10 p.m. (18-A) **"Low-Profile Additive for Flame Retardant SMC,"** John Greenzweig and Jay Nielson, Cargill, Inc.

2:35 p.m. (18-B) **"New High Density-Low Viscosity Zinc Stearates for Use in Polyester Molding Compounds,"** Norman Pinkowski, Mallinckrodt, Inc.

3:00 p.m. (18-C) **"A Cost Effective Low Profile Additive for Automotive and Industrial Applications,"** C. Fintelmann, O. Zaske, and A. Horner, Silmar Division, Vistron Corp.

3:25 p.m. (18-D) **"Current Applications of Titanate Coupling Agents in Filled Thermoplastics and Thermosets,"** S.J. Monte & G. Sugerman, Kenrich Petrochemicals, Inc.

3:50 p.m. **Authors' Panel Discussion**

Materials Suppliers' Reception: 6:30 to 7:30 p.m. **Sheraton/Washington Ballroom.**

THURSDAY AFTERNOON 19 FEBRUARY - CONTINUED

(19) SESSION **VIRGINIA SUITE**
Contact Molding Marine/Sanitary
Moderator: R.E. Carpenter, Ashland Chemical Co.
Vice Moderator: Christopher Smith, PQ Corp.

2:10 p.m. (19-A) **"Surface Cracking of RP by Repeated Bending,"** Jardar Malmo, Det norske Veritas, Norway

2:35 p.m. (19-B) **"Continuous Cast Acrylic Sheet Bonding to Glass Reinforced Polyester Resin,"** G. Gillespie and W. McNeil, USS Chemicals - Polyesters

3:00 p.m. (19-C) **"Extending Polyester Resin in Filled Tub/Shower Composites,"** R.A. Weghorst and Samuel A. Folby, Owens-Corning Fiberglas Corp.

3:25 p.m. (19-D) **"A New Low Styrene Emission Laminating Resin,"** Arnold J. Voskamp, Synres International, Netherlands, Joseph E. Studenberg, Synres Chemical

3:50 p.m. (19-E) **"Use of Effective Low Styrene Emission Resins Need Not Lead to Loss of Interlaminar Adhesion,"** R.F. Russell, Scott Bader Company, Ltd., England

4:15 p.m. (19-F) **"Polyceramics—A New Class of Materials,"** Jim Self, Tanner Chemicals Co., Inc.

4:40 p.m. (19-G) **"Recent Advances in Foamed Unsaturated Polyester Technology,"** Paul E. Stott and James Ahnemiller, Uniroyal Chemical Co.

5:05 p.m. **Authors' Panel Discussion**

(20) SESSION **WILMINGTON ROOM**
Electrical/Appliance
Moderator: K. Davis, General Electric Co.
Vice Moderator: E.J. Kerle, Owens-Corning Fiberglas Corp.

2:10 p.m. (20-A) **"EMI Shielding—What You Need to Know and Why,"** James Regan, International Technology Corp.

2:35 p.m. (20-B) **"Impact Modified Phenolic with Unique Heat Resistance,"** M.D. Bertolucci, General Electric

3:00 p.m. (20-C) **"Polyester Molding Compounds for the Electrical and Appliance Industries,"** D.C. Lupton and J.V. Gauchel, Owens-Corning Fiberglas Corp.

3:25 p.m. (20-D) **"Metallized Glass Fiber: The Long and Short of Conductive Plastics,"** Richard H. Warfel, Lundy Technical Center

3:50 p.m. (20-E) **"A Technical Assessment of the Static Decay Properties of Various Conductive Plastic Materials,"** Alan Litman and Norm Fowler, Xerox Corporation

4:15 p.m. **Authors' Panel Discussion**

FRIDAY MORNING 20 FEBRUARY - 4 CONCURRENT SESSIONS

(21) SESSION — **WASHINGTON ROOM**

Transportation III - Weight, Energy, and Design

Moderator: C.H. Luther, PPG Industries, Inc.
Vice Moderator: Ian Grant, ICI Americas, Inc.

9:00 a.m. (21-A) **"Reinforced Plastics to Minimize Energy Consumption over Life Cycle of an Automobile,"** James R. Best, Market Search Inc.

9:25 a.m. (21-B) **"SMC—The Second Challenge,"** E.G. Trudeau and M.W. Lindsay, Ford Motor Company

9:50 a.m. (21-C) **"Fiber Glass Seville Project: Discussion of the Innovative Aspects,"** R.H. Grundy, PPG Industries, Inc.

10:15 a.m. (21-D) **"Squeeze Molding Technique as a Means of Simulating SMC Molded Part Performance,"** W.E. Bettac and E. Gray, Owens-Corning Fiberglas Corp.

10:40 a.m. (21-E) **"Design Finite Modeling and Structural Performance of a One-Piece SMC Auto Hood,"** I.J. Bence, E. Gray, Jr., and R.C. Bloom, Owens-Corning Fiberglas Corp.

11:05 a.m. (21-F) **"Reinforced Polyester Material System for Injection Molded Automotive Facia,"** J.T. Englehardt, Owens-Corning Fiberglas Corp.

11:30 a.m. (21-G) **"Designing and Prototyping a European Automotive Door,"** J. Gerard, Owens-Corning Fiberglas Europe, Belgium, J. Keown, Owens-Corning Fiberglas Corp. and B. Loyat, Automobiles Peugeot, France

11:55 a.m. **Authors' Panel Discussion**

The 36th Annual SPI RP/C Conference formally closes with the last authors' Panel Discussion. Thank you for attending. Join us next year, January 11-15, 1982, at the Sheraton Washington.

(22) SESSION — **NORTH COTILLION ROOM**

Reinforced Plastics/Composites in Energy Generation and Storage Systems

Moderator: Oscar Weingart, Structural Composite Industries
Vice Moderator: Roger A. Anderson, Morrison Molded Fiber Glass

9:00 a.m. (22-A) **"Composites in Energy Generation and Storage Systems—An Overview,"** Robert W. Fulmer, Owens-Corning Fiberglas Corp.

9:25 a.m. (22-B) **"Use of Pultruded Reinforced Plastics in Energy Generation and Energy Related Applications,"** Roger A. Anderson, Morrison Molded Fiber Glass

9:50 a.m. (22-C) **"Winding for the Wind,"** Oscar Weingart, Structural Composites Industries, Inc.

10:15 a.m. (22-D) **"Composite Rotor Blades for Wind Turbine Generators."** William D. Weigel, Kaman Aerospace Corporation

10:40 a.m. (22-E) **"Composite Cylinders for CNG,"** Robert Gordon, Structural Composites Industries, Inc.

11:05 a.m. **Authors' Panel Discussion**

(24) SESSION — **VIRGINIA SUITE**

Occupational Health

Moderator: Daniel P. Boyd, D.P. Boyd & Co.
Vice Moderator: Fran Lichtenberg, Society of the Plastics Industry, Inc.

9:00 a.m. (24-A) **"Styrene and Personal Health—Yesterday, Today, and Tomorrow,"** Thomas Anderson, Dow Chemical

9:25 a.m. (24-B) **"An Investigation to Observe the Best Available Technology Applied in Sweden to Reduce Employee Exposure to Styrene,"** SPI Task Force. (This presentation will be a detailed summary of the SPI task force visit to view Swedish technology and work practices.)

9:50 a.m. (24-C) **"Styrene in Regulatory Perspective—An Update in Context,"** Jerome H. Heckman, Esq., Counsel to SPI

10:15 a.m. **Panel Discussion led by the Moderator.** Topics to be covered, in relation to the preceding three papers, will be the SPI Manufacturing Feasibility Study; other non-SPI studies in progress; and the likely future issues to face RP molders and fabricators.

(23) SESSION — **SOUTH COTILLION ROOM**

Research and Development II

Moderator: A.H. Steinberg, Allied Chemical Corp.
Vice Moderator: Ken Marshall, Sikorsky Aircraft

9:00 a.m. (23-A) **"The SPI Thickening Test—A Reproducibility and Improvement Study,"** Oscar C. Zaske, Carl Fintelmann, and Jow-Ching Wuh, Silmar Division, Vistron Corp.

9:25 a.m. (23-B) **"Acoustic Emission Testing of HMC Composites,"** D.L. Sherer, M. Ashley, PPG Industries, Inc.

9:50 a.m. (23-C) **"Flow Testing of Sheet Molding Compound and Its Practical Application,"** Prof. Dr. Ing. G. Menges and H. Derek, IKV West Germany

10:15 a.m. (23-D) **"Evaluation of the Sensitivity of Ultrasonic Detection of Disbonds in Graphite/Epoxy to Metal Joints,"** Scott W. Schramm, Isaac M. Daniel, and Wayne G. Hamilton, IIT Research Institute

10:40 a.m. (23-E) **"Effect of Matrix Toughening on the Strength and Strain Properties of Sheet Molding Compound,"** B.L. Lee, F.H. Howard, The B.F. Goodrich Company

11:05 a.m. (23-F) **"Blister Performance of RP Systems in Aqueous Environments,"** L.S. Norwood, Scott Bader Co. Ltd., D.W. Edgell and A.G. Hankin, Fiberglass Ltd., England

11:30 a.m. **Authors' Panel Discussion**

36th Annual Conference, Reinforced Plastics/ Composites Institute, The Society of the Plastics Industry, Inc. February 16-20, 1981

IMPROVED SMC SYSTEMS FOR ELECTRICAL APPLICATIONS

by

W. D. LUZIER and F. J. HOWATINECK*

INTRODUCTION

At the 1978 SPI conference, ICI Americas introduced a novel polyurethane thickening process and a family of isophthalic and vinyl ester ITP™ resins specifically developed for urethane thickening.[1, 2] Emphasis concerning this new technology was placed on structural sheet molding compound (SMC) applications to confront rapidly increasing demands in the plastics industry. As development work proceeded, the additional potential of urethane thickening and ITP resin in other more diversified types of applications, particularly electrical-grade SMC, became apparent.

Urethane thickening of SMC involves the reaction of a polyisocyanate with a polyol incorporated in the styrenated vinyl ester or polyester resin. This results in the in-situ formation of a polyurethane network which mechanically thickens the system by resin entanglement. This is in contrast to conventionally thickened systems using alkaline earth oxides which thicken SMC formulations by interacting with carboxyl and/or hydroxyl groups of the base resin resulting in polymer chain linkage. The unique properties of ITP resins and the polyurethane thickening utilized provides distinct advantages in structural and non-structural applications. Specifically, this paper deals with the unique water absorption, electrical properties and production practicality exhibited by these materials and their potential in electrical applications. Emphasis is placed on the properties of ITP 1054 vinyl ester resin recently investigated complementing data previously compiled[3] on the isophthalic polyester ITP 1050 resin.

PROPERTIES OF ITP RESINS

A. Electrical Properties

Because of the continuing growth of the plastics industry, the use of SMC in electrical applications has increased. Durable surfaces, dielectric properties and the lightweight nature of SMC moldings have all contributed to this growth.

In many electrical applications, properties such as dielectric strength, volume and surface resistivity, dielectric constant and other electrical requirements exist. Not only are these properties important upon initial measurement, but the retention of electrical properties after long-term humidity exposure must be considered.

Complicated part geometries, elevated temperature resistance needs and good electrical property requirements are some factors which may dictate resin choice. In addition, the presence of magnesium oxide in SMC formulations has been reported to cause high water absorption percentages.[4] Thus, the need for an easily moldable resin designed for a thickening system other than alkaline earth oxides led to an investigation of ITP 1054 vinyl ester resin. Evaluations of water absorption, initial electrical properties and retention of those properties after long-term exposure to high humidity conditions were performed.

Since electrical applications often require a degree of fire retardancy but only moderate strength requirements, SMC formulations studied used 30%, 1" chopped random glass and 40% alumina trihydrate (ATH) formulations. 12"×12"×1/8" plaques were molded and tested according to ASTM standards.

Plaques made from ITP 1054 were conditioned in a Blue M Humidity Chamber under the following conditions:

48 hours, 50% Relative Humidity (RH), room temperature
2 weeks, 100% RH, 100°F
4 weeks, 100% RH, 100°F
8 weeks, 100% RH, 100°F
12 weeks, 100% RH, 100°F

At the end of each conditioning period, the plaques were wiped dry, weighed and tested for the following properties:

1) water absorption
2) dissipation factor
3) dielectric constant
4) dielectric strength (1/16" thick plaques were used)
5) surface and volume resistivity
6) arc resistance

The property measurements after the 48 hours conditioning were used as initial data points. This data is graphed in Figures 1 through 7. Comparisons are given of a conventional thickened (MgO) vinyl ester resin as well in order to indicate the degree of property improvement.

Water absorption properties are very important in a variety of applications. This importance is magnified where retention of electrical properties of molded parts exposed to humid conditions is concerned. Figure 1 graphically shows the water absorption properties of plaques molded for urethane thickened ITP 1054 and a conventional vinyl ester using magnesium oxide thickener. A distinct difference between the two systems is readily apparent. While ITP 1054 absorbed water at a decreasing rate during the first two to three weeks, and then absorbed no more water over the remaining nine-week study period, the conventional vinyl ester absorbed water at a constant rate. The water absorption of ITP 1054 leveled off at approximately 0.42%. The magnesium oxide thickened system on the other hand, absorbed 0.50% water after only six weeks and exhibited a trend of significant additional absorption.

Water absorption can drastically affect electrical property retention. Figure 2 illustrates this for the dissipation factor. This is a measure of the ratio of the electrical energy lost to the total energy stored by a material. A very significant difference in the retention of this property after humid aging between the ITP system and the MgO thickened vinyl ester is clearly shown. The dissipation factor of ITP 1054 increased at a decreasing rate and showed little change after four weeks of humid aging. At the end of the twelve-week period, the dissipation factor was 0.0233 MHz. In constrast, the conventional vinyl ester system's dissipation factor increased at a very high rate between two and six weeks. In fact, a measurement of 0.0530 MHz made at the end of six weeks represents a change of 458% from the initial value.

The dielectric constant is the ratio of a material's ability to store a charge (i.e. capacitance) to that of a vacuum. Figure 3 shows the relationship between dielectric constant and long-term aging. The ITP formulation showed only a 10% change over the entire twelve-week study leveling off after about three weeks and possessed a dielectric constant of 5.126 MHz at the end of the test period.

The dielectric strength of a material is a measure of the voltage required for electrical breakdown of an insulating material. ITP 1054 exhibited a dielectric strength of 494 V/mil after eight weeks' exposure to high humidity conditions as shown in Figure 4.

Surface and volume resistivity are important parameters in some electrical-grade SMC applications. These properties are measures of the material's resistance to conducting an electrical charge along its surface and through its volume. As shown in Figures 5 and 6, surface and volume resistivity of ITP 1054 appeared to level off after about three weeks of humidity exposure.

Another electrical property frequently of significance is arc resistance. This is a measurement of a material's resistance to a conducting

*ICI Americas, Inc.
P.O. Box 900
Woodbury, N.J. 08096

path formed by the action of a high-voltage arc close to the material's surface. As shown in Figure 7, the arc resistance of ITP 1054 was 128.5 seconds and showed no signs of deterioration upon long-term humid aging.

The product of the dielectric constant and the dissipation factor is the dielectric loss index. This represents the amount of electrical energy lost in the material. Figure 6 graphically depicts the loss index of ITP 1054 and clearly shows the leveling off trend after humid aging.

Emphasis has been place on the ITP 1054 vinyl ester resin system and associated electrical property retention advantages were pointed out. These advantages are believed to be a function of the resin system and, particularly, the urethane thickening used. Some evidence of this is indicated by the fact that the ITP 1050 isophthalic resin system in electrical-grade SMC urethane thickened formulations exhibited the same trends as ITP 1054 in humid aging studies. A summary of these data and data on MgO thickened isophthalic resin given in a previous paper[3] are shown in Table I. These electrical property retention values of the urethane thickened resin were superior in every long-term humid aging test performed.

To further investigate the effect of urethane thickening on SMC formulations for electrical applications, castings of four systems were subjected to a four-hour boil in water. The resultant water absorption of the neat 1054 resin, 1054 resin urethane thickened, neat conventional vinyl ester resin and MgO thickened vinyl ester resin was calculated. These results are shown in Table II. Addition of a polyurethane thickening network to ITP 1054 was beneficial to the system in terms of water absorption. However, addition of MgO thickener to the conventional vinyl ester system increased the water absorption properties by 16.1%.

Another experiment eliminating resin differences was performed which further demonstrates urethane thickening advantages in terms of electrical properties. Electrical-grade SMC (i.e. 30% glass/30% resin/40% ATH) was made, molded and tested for water absorption and electrical properties. Two formulations were tested based upon ICI Americas' developmental polyester resin, XPL 1061. They differed in the thickener type used in that one system was thickened by the in-situ formation of a polyurethane network and the other with MgO. Results of these evaluations are shown in Table III. With the exception of surface and volume resistivities, the retention of the measured properties was greater for the urethane thickened system than the MgO thickened formulation. This significant difference appeared after only one week of humid aging. These data clearly demonstrate the advantage of using an in-situ formed urethane to thickened SMC as compared to MgO where water absorption and electrical properties are concerned.

B. Mechanical Properties

In most electrical applications, mechanical property requirements exist in addition to the electrical properties mentioned. SMC moldings based on urethane thickened ITP resins have mechanical properties equal or superior to conventionally thickened formulations. Table IV shows physical property measurements on an electrical-grade formulation. These values, the electrical properties and the processing and molding properties of urethane thickened ITP systems which follow, suggest meaningful improvements in electrical-grade SMC formulations.

PROCESSING AND MOLDING CHARACTERISTICS OF ITP 1054

In order to capitalize on the previously described benefits of urethane thickened ITP resins, production-practical formulations are a necessity. The preparation of ITP 1054 electrical-grade formulations are readily adaptable to satisfy both batch and semi-continuous operations. The same reinforcements and fillers commonly used to prepare electrical-grade compounds are also used in the preparation of ICI Americas' urethane thickened SMC. A uniform and stable maturation rate is consistently obtained for a given formulation. Urethane thickening of ITP resins results in a finite and stable viscosity plateau thereby yielding improved SMC quality and consistency. Molding viscosity and initial maturation rate may be varied by adjusting the amount of urethane thickener. Table V shows maturation rates for two systems of identical composition but different total urethane contents. As expected, the increased urethane maturates faster and to a higher ultimate viscosity. The percent rate of increase, however, is quite uniform throughout the first hour and from one to three days. Ultimate viscosity of electrical-grade formulations are infinitely stable with shelf-life being a function of the care taken to prevent styrene loss and base resin polymerization.

Compounds used in electrical applications normally require pigmentation in a variety of colors. Actual field molded parts as well as laboratory configurations have shown ITP compounds to accept a wide variety of pigments. Pigments from various suppliers have been evaluated and found to be acceptable in a variety of formulations. The ability of ITP resins to maturate, maintain a desired rate of viscosity and accept pigments enhances their potential for use in electrical applications.

The molding of electrical-grade compound based on ITP resins offers advantages to the electrical part molder not available from MgO thickened material. One of these is its low pressure molding properties which results from the unique rheology of the urethane thickened ITP resin. ITP electrical-grade resin systems have been molded at periods of up to eight months of age using pressures of 300 psi and mold coverages as small as 22%. These materials have exhibited excellent glass and filler carry, even in boss and ribbed tooling. Diagram 1 shows an experimental box tool with the percent of glass, filler and resin reported from the extremities and center of charge area when only 22.3% mold coverage was used. These numbers are from compound that originally showed 27% glass, 42% filler and 31% resin in flat plaques at 56% mold coverage. This uniformity-over-time characteristic allows the part molder to hold inventory of material to be molded over an extended period of time if necessary. The age of ITP 1054 electrical compound has little effect on its ability to mold at low pressures. Of course, routine precautions must be taken to avoid styrene evaporation and vinyl polymerization of compounded materials. This ability to mold at low pressure effectively allows for larger and more complex geometry tooling without increasing press tonnage requirements.

SUMMARY AND CONCLUSIONS

To meet industry demands, improved SMC systems based on ITP resins and a urethane thickening process have been introduced. Major emphasis was placed on the potential of these systems in electrical applications with production-practical R30 F40 formulations.

ITP resins, with specific emphasis on ITP 1054 vinyl ester resin, were evaluated in electrical-grade formulations. The testing included water absorption measurements and effects of humid aging on electrical properties. As illustrated, the water absorption and retention of electrical properties of urethane thickened ITP systems are superior when compared to metallic oxide thickened resins. The deleterious effect of MgO thickener on water absorption and electrical properties was shown and contrasted to the effect of urethane thickening. Experiments using castings and a polyester resin thickenable with MgO and urethane were performed to demonstrate these thickener characteristics.

After characterizing the mechanical properties of the ITP 1054 system, the processing and molding properties of electrical-grade ITP systems were discussed. Many advantageous characteristics in terms of electrical properties were pointed out. These included the stable ultimate viscosity of urethane thickened compound, pigmentation, low pressure molding and excellent glass carry.

The uniqueness of urethane thickening in conjunction with ITP resins in terms of electrical properties, processing and molding characteristics suggest considerable potential in electrical-grade SMC applications.

REFERENCES

1. Ferrarini, J., Longenecker, D. M., Shah, N. N., Feltzin, J., Greth, G. G.; "Development of a Unique Method for the Preparation of High Quality SMC", 33rd Annual Conference, 1978, RP-C Institute, SPI.
2. Ferrarini, J., Magrans, J. J., Reitz, J. A., III; "New Resins for High Strength SMC", 34th Annual Conference, 1979, RP-C Institute, SPI.
3. Magrans, J. J., Ferrarini, J.; "Unique Electrical and Mechanical Properties of ITP™ SMC", 34th Annual Conference, 1979, RP-C Institute, SPI.
4. Grunewald, R., Walter, O.; "Fifteen Years' Experience with Sheet Molding Compound", 30th Anniversary Technical Conference, 1975, RP-C Institute, SPI.

TABLE I

Summary of Electrical Property Advantages of ITP 1050 Resin in 30% Glass/30% Resin/40% ATH SMC Upon Humid Aging

Property	Time (weeks)	ITP 1050 (urethane thickened)	Conventional Isophthalic Resin (MgO thickened)
% Water Absorbed in Humidity Chamber	2	0.34	1.11
	8	0.43	1.74
Dielectric Strength (v/mil)	initial	427	342
Surface Resistivity (Ω/square)	initial	7.66×10^{15}	1.45×10^{15}
	8	1.05×10^{14}	1.64×10^{10}
Volume Resistivity (Ω-cm)	initial	1.05×10^{15}	1.32×10^{15}
	8	1.58×10^{14}	1.13×10^{12}
Arc Resistance (seconds)	initial	181	181
	8	162	135
Dielectric Constant (MHz)	initial	5.020	5.100
	8	5.512	>10.80
Dissipation Factor (MHz)	initial	0.0098	0.0115
	8	0.0490	>0.2235
Loss Index	initial	0.0492	0.7868
	8	0.2712	>2.4138

TABLE II

Water Absorption of Castings After Immersion in Four-Hour Water Boil

Resin/Thickener	% Water Absorbed After Immersion	Increase by Thickener Addition
ITP 1054/none	0.97	
ITP 1054/urethane	0.91	-6.2%
Conventional Vinyl Ester/none	0.93	
Conventional Vinyl Ester/MgO	1.08	16.1%

TABLE III

Effect of Thickening Agent in Electrical-Grade SMC Formulations on Electrical Properties

Property	Time of Humid Aging (weeks)	Urethane Thickened XPL-1061 Polyester	MgO Thickened XPL-1061 Polyester
% Water Absorbed in Humidity Chamber	1	0.29	0.41
	2	0.60	0.97
Surface Resistivity (Ω/square)	initial	2.37×10^{16}	1.24×10^{16}
	1	4.61×10^{14}	5.59×10^{11}
	2	4.87×10^{14}	1.37×10^{15}
Volume Resistivity (Ω/in.)	initial	8.18×10^{14}	7.33×10^{11}
	1	1.72×10^{14}	1.05×10^{11}
		1.08×10^{14}	8.77×10^{15}
Arc Resistance (seconds)	initial	138.8	140.2
	1	136.4	132.0
	2	132.6	134.0
Dielectric Constant (MHz)	initial	4.729	4.741
	1	4.941	5.218
	2	5.138	5.814
Dissipation Factor (MHz)	initial	0.0096	0.0099
	1	0.0167	0.0281
	2	0.0280	0.0567
Loss Index	initial	0.0454	0.0469
	1	0.0825	0.1466
	2	0.1439	0.3297

TABLE IV

Physical Properties of ITP 1054 Resin in 30% Glass/30% Resin/40% ATH SMC

Flexural Strength (psi)	26,900
Flexural Modulus (10^6 psi)	1.27
Tensile Strength (psi)	13,500
Tensile Modulus (10^6 psi)	1.51
Tensile Impact	
total energy (ft.-lbs./in.^{2})	39.1
stress at initial fracture (psi)	1,167
Short Beam Shear (psi)	2,518
Compression (psi)	27,100
Oxygen Index	42.5
Barcol Hardness	50-56
Flammability Class	UL94V-O at 1/8"

TABLE V

Maturation Profiles of ITP 1054 Electrical-Grade Formulations

Time	Viscosity	
	% Urethane = 8.2 NCO/OH Ratio = 1.5/1.0	% Urethane = 9.3 NCO/OH Ratio = 1.5/1.0
0 minutes	9,600	8,800
10 minutes	17,400	39,500
20 minutes	34,000	75,000
30 minutes	46,000	101,000
60 minutes	91,000	202,000
1 day	1.8×10^6	10.6×10^6
2 days	2.6×10^6	17.8×10^6
3 days	2.7×10^6	13.4×10^6

FIGURE 1

Water Absorption vs. Time in Humidity Chamber (100% RH, 100°F)

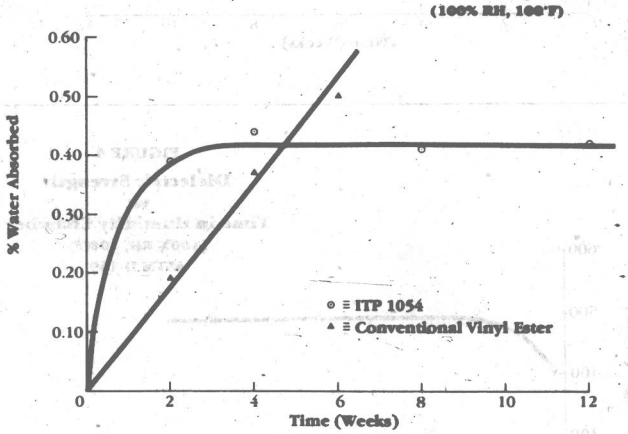


FIGURE 2
Dissipation Factor
vs.
Time in Humidity Chamber
(100% RH, 100°F)
ASTM D-150

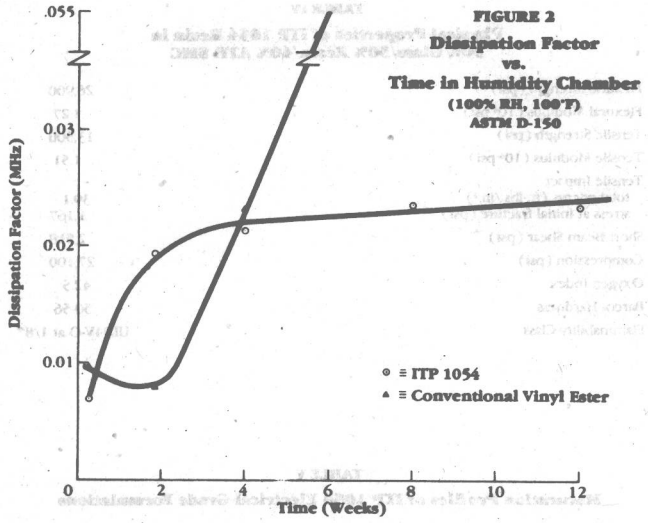


FIGURE 3
Dielectric Constant
vs.
Time in Humidity Chamber
(100% RH, 100°F)
ASTM D-150

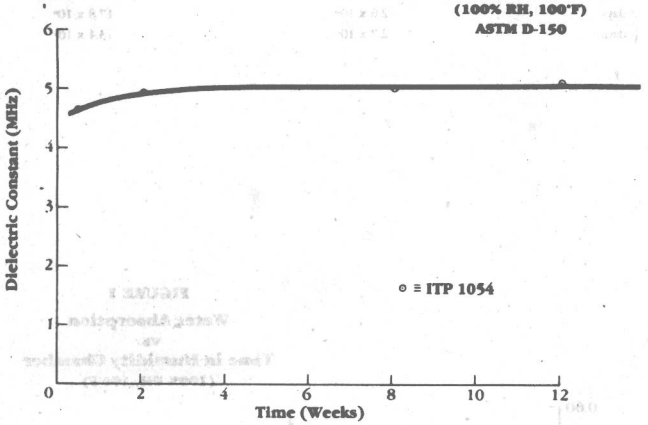


FIGURE 4
Dielectric Strength
vs.
Time in Humidity Chamber
(100% RH, 100°F)
ASTM D-149

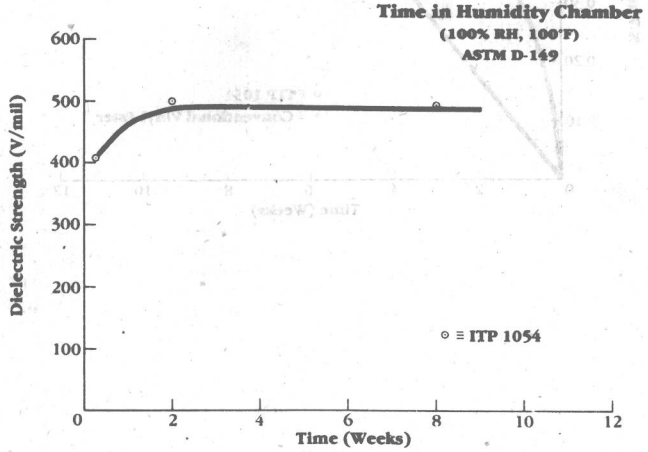


FIGURE 5
Surface Resistivity
vs.
Time in Humidity Chamber
(100% RH, 100°F)
ASTM D-257

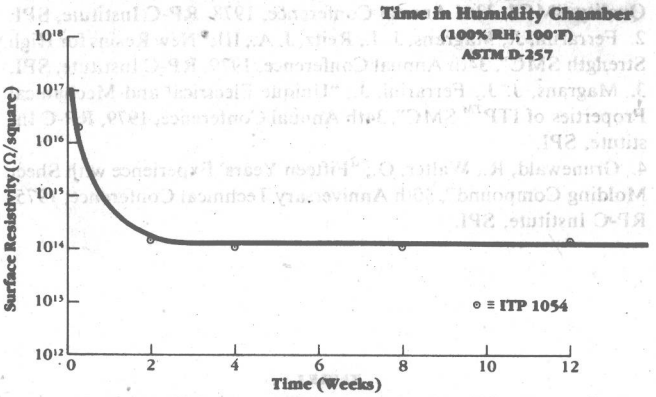


FIGURE 6
Volume Resistivity
vs.
Time in Humidity Chamber
(100% RH, 100°F)
ASTM D-257

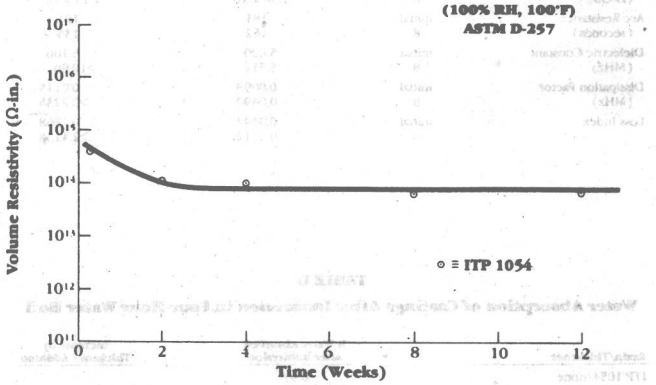


FIGURE 7
ARC Resistance
vs.
Time in Humidity Chamber
(100% RH, 100°F)
ASTM D-495

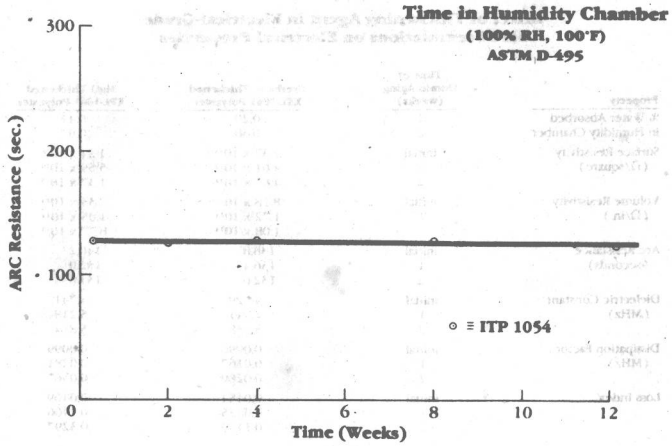


FIGURE 8

Loss Index
vs.
Time in Humidity Chamber
(100% RH, 100°F)

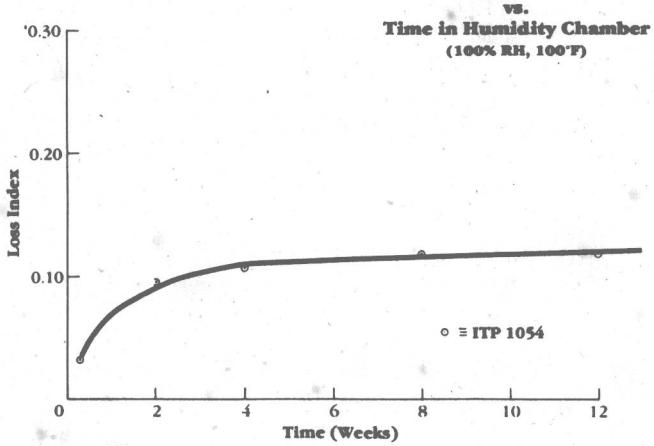
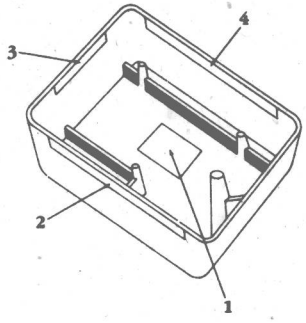


DIAGRAM 1



Area #	% Glass	% Resin	% Filler
1	28.7	27.0	44.3
2	26.0	27.0	47.0
3	26.0	27.5	46.5
4	27.6	26.3	46.1