

## FAILURE ANALYSIS & PREVENTION

### Letter from the Chair — Andy Shah

#### Letter from the Chair:

Welcome to the Failure Analysis and Prevention SIG's Spring 2015 Newsletter! I am happy to report that FAPSIG remains one of the largest special interest groups of the Society of Plastics Engineers with approximately 12% of the total SPE members being affiliated with FAPSIG. Please remember to select your interest in FAPSIG when you renew your membership. Also, a reminder for everyone to register for the SPE's Annual Technical conference, ANTEC 2015 upcoming in May 22-25 in Orlando, Florida. ANTEC 2015 is fast approaching, and it is strategically co-located with NPE2015 to take advantage of the largest plastics trade show and conference of the plastic industry.

In addition to the technical presentations, FAPSIG has also organized an interactive discussion session with a panel of industry experts. I encourage you to read this newsletter for all the details.

FAPSIG will also hold its business meeting at ANTEC. I encourage you to participate and voice your suggestions, ideas, and opinions so that the FAPSIG board can continue to address the needs of our members. Thank you for your support.

I look forward to seeing you all at ANTEC 2015 in Orlando, FL.



Andy R. Shah, M.S., P.E.  
Engineering Systems Inc.  
Chair, Failure Analysis and  
Prevention SIG

#### Special points of interest:

- FAPSIG PRESENTATIONS TO BE GIVEN AT ANTEC 2014
- FEATURED ARTICLE: IMPORTANCE OF CRYSTALLINITY IN PLASTICS PERFORMANCE
- EXPERT PANEL TO BE HELD AT ANTEC TO ANSWER/SOLVE FAILURE AND PROCESSING ISSUE.
- NEW BOOK TO BE RELEASED
- WEBINARS OFFERED BY SPE
- SEMINARS ON PLASTIC FAILURE

#### Inside this issue:

|                                          |    |
|------------------------------------------|----|
| FAPSIG ANTEC PAPERS                      | 2  |
| DID YOU KNOW....                         | 3  |
| FEATURED ARTICLE: BY JEFF JANSEN         | 4  |
| EXPERT PANEL TO BE HELD AT ANTEC         | 6  |
| PLASTIC FAILURE WEBINARS                 | 9  |
| CHEMIR TO GIVE CASE STUDIES AT NPE BOOTH | 12 |

# Failure Analysis and Prevention Presentations at ANTEC

Sponsors of the FAPSIG  
talks at ANTEC:



## Session T25– Understanding and Preventing Failures of Injection Molded Parts

Moderator: Paul Gramann, The Madison Group

Tuesday March 24: 1:30 - 4:30 pm

**1:30 - 2:00 pm**

A Study of Processing Induced Part Failures

Jose Perez, Element

**2:00 –2:30 pm**

Verification of a Structural Analysis of Fiber Reinforced Thermoplastics with Weld Line

Sebastian Kammer, University of Darmstadt - Applied Science

**2:30 –3:00 pm**

Use of Common Six Sigma Tools for Systematic Analysis and Solutions to Plastic Part Failure

**3:00 –4:30 pm**

**Question and Answer Panel with Experts**

Ask your processing, failure, design, etc. questions

**Panel:** Michael Sepe, Jeff Jansen, Vikram Bhargava, Suhas Kulkarni

## Session W6 - Plastic Pipes in Building Construction

Wednesday March 25: 8:30 - 10:30

**8:30 –9:00pm**

Failure Analysis of Cross-Linked Polyethylene Pipes in Residential Plumbing and Heating Systems

Phillip Sharff, Simpson Gumpertz & Heger Inc.

**9:00 –9:30pm**

The Effect of Localized Heating on Polyethylene Tubing

Robert Farina, Exponent, Inc.

**9:30 –10:00pm**

Evaluation of Plastic Pipes for Hot Water Supply and Heating

Hiroyuki Nishimura, Kyoto Institute of Technology

**10:00 –10:30pm**

Degradation Analysis for PE of Raised Temperature Resistance After Long-Term Exposure Tests

Hidekazu, Honma, KRI, Inc.

## Session W22– Non-Destructive Testing and Failure Analysis Case Studies

Moderator: Steve MacLean, Exponent

Wednesday March 25: 1:30 - 5:00

**1:30 –2:00pm**

Fast Thermal Tomography for Non-Destructive Testing of Plastic Components

Stefan Kremling, SKZ—German Plastics Center

**2:00 –2:30pm**

CT X-Ray Imaging— A Novel Technique for Non-Destructive Examination of Plastic Products

Anan Shah, Engineering Systems, Inc.

**2:30 –3:00pm**

Non-Destructive Inspection of Plastic Components with Terahertz Time Domain Spectroscopy

Stefan Kremling, SKZ—German Plastics Center

**3:00 –3:30pm**

Failure Analysis of Copolyester Clamps

Tommy Washington, Element

**3:30 –4:00pm**

Failure Analysis of a Fractured Polyamide 6 Shock Absorber Housing

Brian Ralston, Cambridge Polymer Group

**4:00 –4:30pm**

Failure Analysis of a Glass Filled Phenolic Resin Power Steering Pump Pulley

Michael Hayes, Engineering Systems Inc.

**4:45pm**

Best Paper Award

## Did you know...

### Site of ANTEC/NPE 2015 is Powered by PV Rooftop System

The Orange County Convention Center, site of the 2015 ANTEC and NPE, receives some of its power from 1-megawatt and 4-ten kilowatt photovoltaic (PV) rooftop systems. The 1-megawatt system is comprised of 5,808 monocrystalline silicon mod-

ules. At the time of construction, the 1 MW PV systems was the largest rooftop PV system in the southeastern part of the United States.



### 12% of the SPE Membership are FAPSIG Members

According to the December 2014 SPE Executive Committee meeting, FAPSIG membership stands at 1,748. This makes the FAPSIG one of the top four special interest groups within SPE. There are only two SPE divisions with membership above 1,700. The total SPE membership as of December 2014 was 14,613.

You are encouraged to become a member of the FAPSIG. There is no cost to join the FAPSIG. Joining allows you to become more in touch with the Failure Analysis and Prevention Community. Benefits include frequent newsletters, a LinkedIn site for questions/answers, and updates on what is new with the FAPSIG.

### FAPSIG Sponsors Student Travel to ANTEC

The Failure Analysis and Prevention Special Interest Group will be donating \$500 to the SPE Student Travel Fund for graduate and undergraduate students to attend the Society of Plastics Engineers Annual Technical Conference (ANTEC) in Orlando from March 23 - 25.

The FAPSIG has funded this extremely important program for several years. It allows tomorrow's engineers to participate in the industry's premier technical conference. At the same time it allows students to network with possible employers at the many events that take place during ANTEC week.



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# The Importance of Crystallinity in Plastics Performance

By Jeffrey Jansen, The Madison Group

One of the fundamental characteristics of polymeric materials is the organization of their molecular structure. Broadly, plastics can be categorized as being semi-crystalline or amorphous. Understanding the implications of the structure, and specifically the crystallinity, is important as it affects material selection, part design, processing, and the ultimate anticipated service properties.

Most non-polymeric materials form crystals when they are cooled from elevated temperatures to the point of solidification. This is well demonstrated with water. As water is cooled, crystals begin to form at 0 °C as it transitions from liquid to solid. Crystals represent the regular, ordered arrangements of molecules, and produce a distinctive geometric pattern within the material. With small molecules, such as water, this order repeats itself and consumes a relatively large area relative to the size of the molecules, and the crystals organize over a relatively short time period. However,

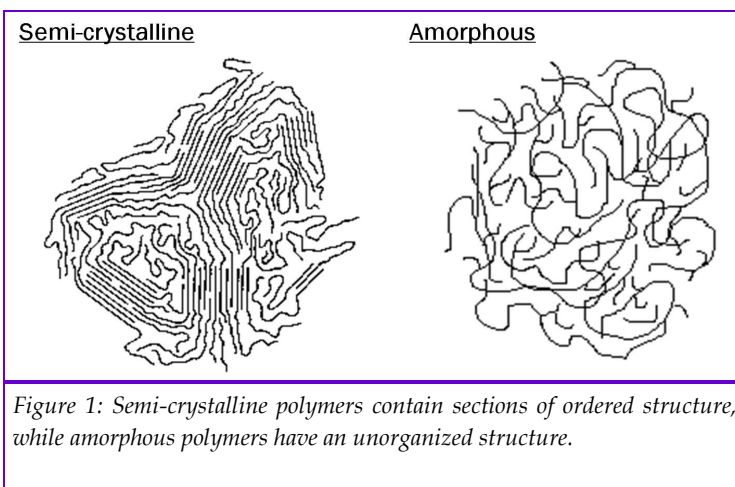


Figure 1: Semi-crystalline polymers contain sections of ordered structure, while amorphous polymers have an unorganized structure.

because of the relatively large size of polymer molecules and the corresponding elevated viscosity, crystallization is inherently limited, and in some cases, not possible. Polymers in which crystallization does occur, still contain a relatively high proportion of non-crystallized structure. For this reason, those polymers are commonly referred to as semi-crystalline. Polymers, which because of their structure, cannot crystallize substantially are designated as amorphous. As illustrated in Figure 1, amorphous polymers have an unorganized loose structure. Semi-crystalline polymers have locations of regular patterned structure bounded by unorganized amorphous regions. While some modification can be made through the use of additives, the extent to which polymers are semi-crystalline or amorphous is determined by their chemical structure, including polymer chain length and functional groups.

The ordered arrangement of the molecular structure associated with crystallinity results in melting when a sufficient temperature is reached. Because of this, semi-crystalline polymers, such as polyethylene, polyacetal, and nylon, will undergo a distinct melting transition, and have a melting point ( $T_m$ ). Amorphous polymers, including polystyrene, polycarbonate, and poly(phenyl sulfone), will not truly melt, but will soften as they are heated above their glass transition temperature ( $T_g$ ). This is represented by the differential scanning calorimetry thermograms included in Figure 2.

The difference between semi-crystalline and amorphous molecular arrangement also has an implication on the mechanical properties of the material, particularly as they relate to temperature dependency. In general, amorphous plastics will exhibit a relatively consistent modulus over a temperature range. However, as the

temperature approaches the glass transition temperature of the material, a sharp decline will be observed. In contrast, semi-crystalline plastics will exhibit modulus stability below the glass transition temperature, which is often subambient, but show a steady decline between the glass transition temperature and the melting point. This is shown in Figure 3.

Due to their viscoelastic nature, time and temperature act in the same way on polymeric materials. Because of this, the changes within the material as a function of time can be inferred from the stability of the material versus temperature.

Aside from the time and temperature dependence, other key properties of polymeric materials are determined by their semi-crystalline\amorphous structure. Some generalizations of characteristic properties are listed in Table 1.

**Jeff Jansen, The Madison Group**

| Table 1                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Semi-crystalline                                                                                                                                                                                                                                                                                                                              | Amorphous                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>Distinct and sharp melting point</li> <li>Opaque or translucent</li> <li>Better organic chemical resistance</li> <li>Higher tensile strength and tensile modulus</li> <li>Better fatigue resistance</li> <li>Better creep resistance</li> <li>Higher density</li> <li>Higher mold shrinkage</li> </ul> | <ul style="list-style-type: none"> <li>Soften over a wide range of temperature</li> <li>Transparent</li> <li>Lower organic chemical resistance</li> <li>Higher ductility</li> <li>Better toughness</li> <li>Lower density</li> <li>Lower mold shrinkage</li> </ul> |

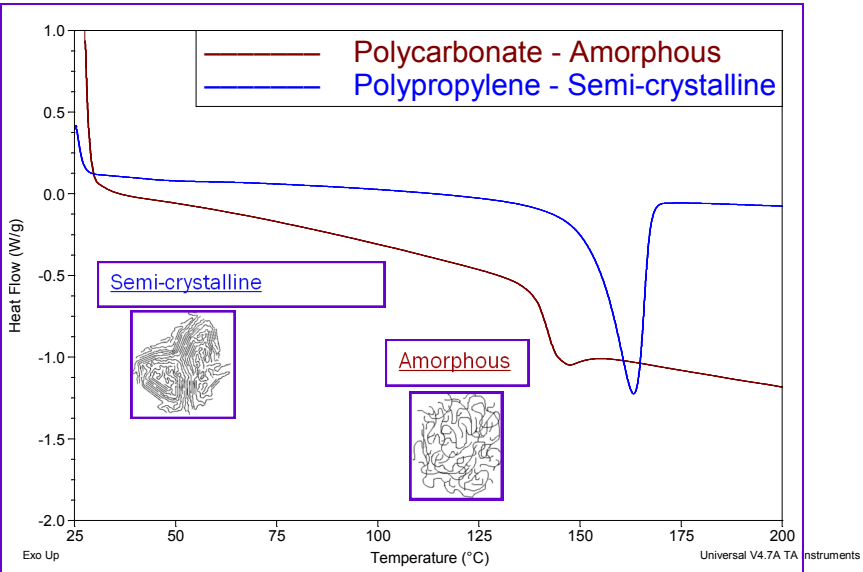


Figure 2: Differential scanning calorimetry thermogram showing a melting transition of a semi-crystalline polymer and a glass transition for an amorphous polymer.

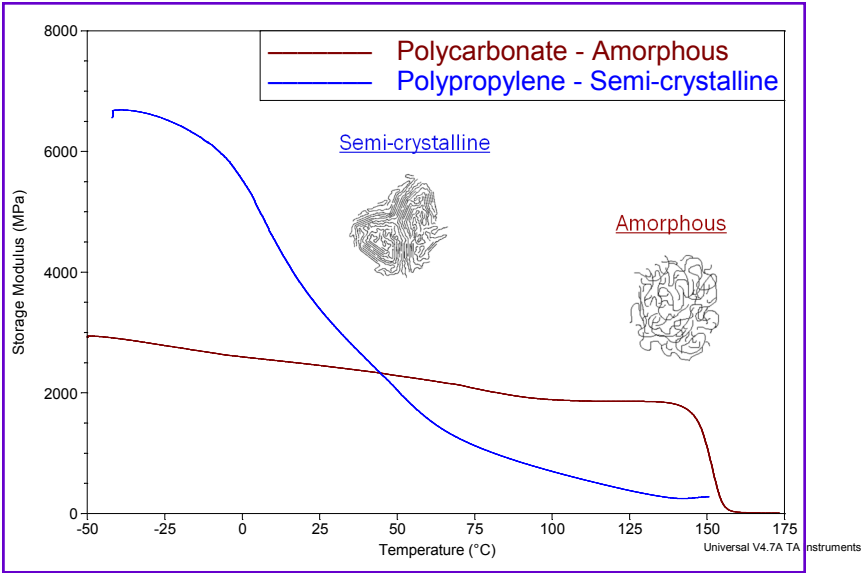


Figure 3: Dynamic mechanical analysis thermogram showing the storage modulus as a function of temperature for semi-crystalline and amorphous polymers.

## Panel to be Held at ANTEC to Solve Your Plastic Failures and Molding Issues “Understanding and Preventing Failures of Injection Molded Plastics”

**Do you have parts that are cracking, do not look good, are not molding correctly?**

**Are you looking for input on what material to use, how to fix a design or how to modify your process?**

If you are attending the ANTEC conference during NPE week in Orlando, Florida this is the one event that you must attend. A panel of the top experts in design, material behavior, injection molding and failure analysis has been assembled to answer your questions. These experts will give you advice that may solve an issue that you have been struggling with for years – and it is free! Participants are encouraged to ask as many questions as they would like and bring parts for the panel to examine – whatever is needed to solve your issue.

Given by: Injection Molding Division and Failure Analysis/Prevention SIG

When: Tuesday, March 24<sup>th</sup>, ANTEC Session: T25

Time: 3:00 – 4:30pm

***First 30 People get a \$5 Starbucks Gift Card***

### Experts on the Panel



Mike Sepe, The Material Analyst  
Mike Sepe Consulting



Jeff Jansen, Partner  
The Madison Group



Vikram Bhargava, Retired  
Director of Engineering— Motorola



Suhas Kulkarni, President  
FIMMTEC

# Fractography in Failure Analysis of Polymers

A New Volume in the Plastics Design Library Series

## Description

*Fractography in Failure Analysis of Polymers* provides a practical guide to the science of fractography and its application in the failure analysis of plastic components. In addition to a brief background on the theory of fractography, the authors discuss the various fractographic tools and techniques used to identify key fracture characteristics.

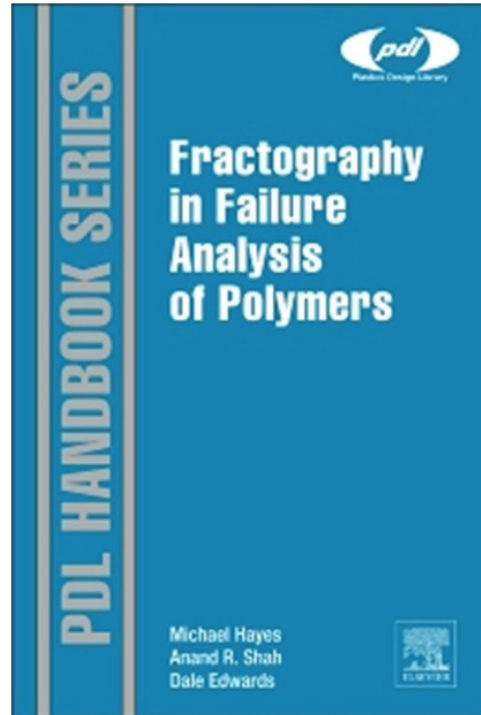
Case studies are included for a wide range of polymer types, applications, and failure modes, as well as best practice guidelines enabling engineers to apply these lessons to their own work. Detailed images and their appropriate context are presented for reference in failure investigations.

Michael D. Hayes Engineering Systems Inc.

Dale B. Edwards Engineering Systems Inc.

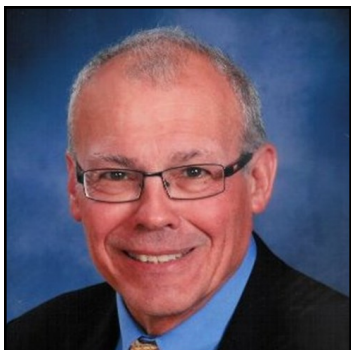
Anand R. Shah Engineering Systems Inc

Pub. Date: June 2015



## Announcements

**Element New Berlin is pleased to welcome Mark Wolverton.**



Mark P. Wolverton has joined the New Berlin office of Element Materials Technology. Mr. Wolverton comes to Element from Flint Hills Resources, where he served as a senior technical service engineer performing trouble-shooting, material confirmation, root cause failure analysis, and process engineering support across multiple industries. Mr. Wolverton brings a strong history of accomplishments in failure analysis, application development, materials technologies, part design, mold design, FMEA implementation and process engineering. His diverse product history includes medical disposables, closures, sporting goods, packaging, consumer products, and products from numerous other industries. Mr. Wolverton earned his Bachelor of Science in Materials Engineering from Drexel University. He is an active SPE member, and will be receiving the Honorary Service Member Award at ANTEC 2015.

**Engineering Systems is pleased to announce the addition of Dr. Pierce Umberger as Staff Consultant.**



ESI is pleased to announce that Dr. Pierce Umberger has joined their Polymers & Composites practice as a Staff Consultant. Pierce works in ESI's Georgia office. He has experience with a variety of lab equipment, including MTS/Instron load frames, DMA/TMA (Dynamic Mechanical Analysis/Thermo-Mechanical Analysis) rheology equipment, and SEM/ESEM microscopes. Pierce joined ESI from Virginia Tech, where he earned a Ph.D. and M.S. in Engineering Mechanics, and a B.S. in Mechanical Engineering. While at Virginia Tech, Pierce worked as a Graduate Research Assistant for the Materials Response Group, where he predicted ultra-high strain rate constitutive properties, developed progressive damage models to predict axial composite response at selected strain rates, and created a constrained punch-shear test to measure through-thickness shear properties of low-modulus composite laminates.

**The Madison Group is pleased to announce the addition of Matt Dachel to its plastics consulting team.**



Matt Dachel joined The Madison Group in June of 2014 after receiving his B.S. in Plastics Engineering from the University of Wisconsin—Stout. Matt gained work experience from internships with Phillips-Medisize and Callaway Golf. At Phillips-Medisize, he gained experience as a project engineer. At Callaway, Matt worked in the golf ball research and development department and used Moldflow simulation software to improve their injection molding and simulation processes. As a teacher's assistant for the Process Simulation class, Matt helped the students learn how to use Moldflow and assisted with the development of new projects for the class. Matt has passed the Moldflow exam to become a certified Moldflow consultant.

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# SPE Offers Variety of Webinars on Failure/Prevention

The Society of Plastics Engineers offers educational webinars that are directly related to failure analysis and prevention of plastic parts. These webinars provide a cost-effective way to expand your knowledge of plastics, how and why they fail, and what preventive techniques can be put in place to avoid failure. Below are a list of upcoming failure analysis/prevention webinars, along with ones that have been previously given and are available as a recorded DVD from SPE.

## **Plastic Failure Prevention**

Thursday, March 12, 2015 10:00 a.m. Central Time; Speaker: Jeff Jansen, The Madison Group

## **The Effects of Impact and Other Rapid Loading Mechanisms on Plastics**

Wednesday, April 15, 2015 10:00 a.m. Central Time; Speaker: Jeff Jansen, The Madison Group

## **Ductile to Brittle Transitions in Plastic Materials**

Thursday, May 21, 2015 10:00 a.m. Central Time; Speaker: Jeff Jansen, The Madison Group

## **Understanding Wear of Plastics**

Wednesday, September 16, 2015 10:00 a.m. Central Time; Speaker: Jeff Jansen, The Madison Group

## **Fourier Transform Infrared Spectroscopy in Failure and Compositional Analysis**

Wednesday, October 7, 2015 10:00 a.m. Central Time; Speaker: Jeff Jansen, The Madison Group

## **Dynamic Mechanical Analysis of Plastics**

Thursday, November 12, 2015 10:00 a.m. Central Time; Speaker: Jeff Jansen, The Madison Group

## **Prerecorded Webinars on DVD**

**Plastic Material Selection; Speaker: Niles Stenmark, Element**

**Non-Destructive Analysis of Plastics Parts using CT Imaging; Speaker: Paul Gramann, The Madison Group**

**Weldlines: The Good, The Bad, and The Ugly; Speaker: Erik Foltz, The Madison Group**

**Lifetime Prediction of Plastic Parts - Creep Failure; Speaker: Paul Gramann, The Madison Group**

**Opening up Injection Molding with Virtual Design of Experiments; Speaker: Jeff Jansen, The Madison Group**

**Failure Analysis of Plastics — 3 Parts; Speaker: Jeff Jansen, The Madison Group**

**Introduction to Plastics; Speaker: Jeff Jansen, The Madison Group**

**Degradation Failure of Plastics; Speaker: Jeff Jansen, The Madison Group**

**Understanding Failure Rate in Plastic Components; Speaker: Jeff Jansen, The Madison Group**

**Creep Rupture Failure of Plastics; Speaker: Jeff Jansen, The Madison Group**

*For more information contact SPE's Scott Marko at 203-740-5442 or [smarko@4spe.org](mailto:smarko@4spe.org)*

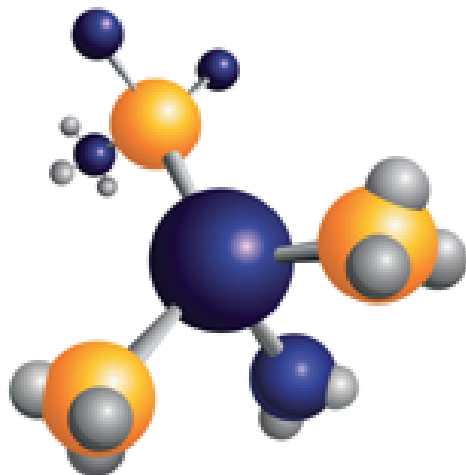
# UW Stout, The Madison Group and RTP to Give Free Seminar: “Environmental Stress Cracking and Injection Overmolding”

The University of Wisconsin - Stout and The Madison Group will be offering its fourth annual educational seminar on plastics. This yearly event, which is sponsored through the Society of Plastics Engineers, is given at UW - Stout and the Waukesha County Technical College. The seminar is given by Dr. Adam Kramschuster (UW– Stout), Jeff Jansen (The Madison Group) and Erik Foltz (The Madison Group). This year the RTP Company from Winona, MN will be joining the team to give this free event to plastic professionals at the following locations, dates and time:

| Thursday - May 14, 2015                                                                                                                      | Wednesday - May 20, 2015                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <b>University of Wisconsin - Stout</b><br>Menomonie, Wisconsin<br>9:00-12:00 Presentation<br>12:30 - 1:30 Tour of UW-Stout Plastics Facility | <b>Waukesha County Technical College</b><br>Waukesha, Wisconsin<br>9:00-12:00 Presentation<br>12:30 - 1:30 Tour of WCTC Plastics Facility |

An Educational Outreach Sponsored by:

- Society of Plastics Engineers
- UW– Stout SPE Student Chapter
- Waukesha County Technical College
- The Madison Group
- The RTP Company



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## 3-Day Course on Analysis/Prevention of Plastic Part Failure to be Given at UW Milwaukee

The University of Wisconsin—Milwaukee School of Continuing Education will be holding its Annual 3-day course entitled, **“Plastic Part Failure: Analysis, Design & Prevention”** taught by The Madison Group engineers Antoine Rios, Erik Foltz, Javier Cruz, and Jeffrey Jansen. The course will cover a broad range of topics essential to understanding and preventing plastic failure. Receive continuing education units/credits. Get introduced to the strategies behind analysis, design and prevention with course material that includes:

- Essential knowledge of why plastic components fail
- The five factors affecting plastic part performance
- The process of conducting a failure investigation
- Ductile-to-brittle transitions and their role in plastic component failure
- Methods for understanding how and why a product has failed
- Approaches to more quickly respond to and resolve plastic component failure
- Methods and techniques to avoid future failures

Get 2.0 CEU and 20PHs

For more information contact:  
Murali Vedula UW-Milwaukee  
mvedula@uwm.edu, p:414-227-3121

**October 12 — 14, 2015**



## The Madison Group Completes Move to New Headquarters

After a year of planning and construction The Madison Group officially moved into its new headquarters this past October. The new building, which is approximately 13,000 square feet, was custom designed to The Madison Group's specifications. The building was constructed to satisfy a huge need to house the rapidly expanding company. The new facility has a number of new labs, offices, conference and meeting rooms, a library and a recreational area for the employees. The Class A steel structure building has a unique brick exterior design with large sections of glass to maximize the use of natural light. The building is situated on two acres of land to accommodate future expansion.



## Engineering Systems Inc. to Hold Seminars: “Plastics Failure Analysis Workshop & Prevention”

A unique series of seminars that highlight the principles of failure analysis and failure prevention in plastic products. These seminars will benefit FAPSIG members who are involved in plastic design, production, quality control, or quality assurance functions:

- Understand how to determine the cause of fracture of plastic products through analysis of the fractured part.
- Analyze failures of plastic products through testing and how to prevent failures through quality control/testing through the application of proper stress analysis and design methods.

### SEMINARS

June 8 – 9: Plastics Fracture Analysis Workshop & Seminar

June 10 – 11: Plastics Failure/Analysis Prevention & Testing Seminar

June 12: Failure Analysis of Plastic Products through Stress Analysis Method Seminar

Attendees are encouraged to bring questions and samples from actual experience for discussion and review.

*For more information contact:*

*Gail L. Karim, ESI*

*glkarim@esi-il.com, p:630-851-4566*

## CHEMIR to Give Case Study Presentations on Investigative Analytical Chemistry at NPE

Plastic material problems solved by analytical chemistry will be presented by CHEMIR at NPE2015 (March 23 - 27). CHEMIR's chemists will present 15-minute case studies twice a day, explaining analytical laboratory techniques, data interpretations and solutions. Topics include extractables and leachables, failure investigations, contamination studies and reverse engineering. Christopher Andren, John Newman, and Aaron Cassely will be presenting. To view the full schedule, visit [www.chemir.com/npe2015](http://www.chemir.com/npe2015).

Participants are welcome to bring questions investigating problems associated with their plastic, polymer or packaging products to CHEMIR's booth S19047.



[www.chemir.com](http://www.chemir.com)

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