



# Thermoforming Quarterly®

A JOURNAL OF THE THERMOFORMING DIVISION OF THE SOCIETY OF PLASTIC ENGINEERS

FOURTH QUARTER 2008 ■ VOLUME 27 ■ NUMBER 4

## Sitting Pretty

## New Aesthetics in Thermoforming



**POST-  
CONFERENCE  
EDITION**

**INSIDE ...**

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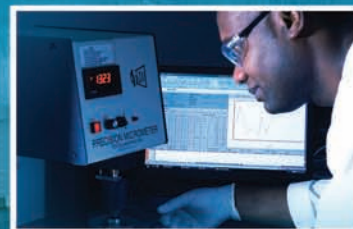
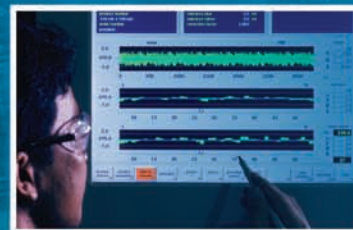
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## Thermoforming Quarterly®

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COVER PHOTO:  
Courtesy of Kal Plastics



The 18th Annual Thermoforming Conference is now a fond memory. The efforts of all those involved does not go unnoticed. I am constantly amazed at the hard work and continued support that the division receives from an all volunteer staff. The board of Directors and Gwen Mathis acting as Conference Coordinator keep the conference on track and running smooth. The unwavering support of our sponsors and exhibitors make this conference and the work it requires worthwhile.

Personally, the conference is a great opportunity to descend on one place for a few days to review new technology in the machinery, material and processing arenas. It is a time to attend technical sessions to learn about industry specific opportunities. I also enjoy the ability to have candid conversations with suppliers, competitors and other supporters of the industry. It is in these conversations that I tend to learn the most. You cannot find a better environment to exchange ideas and have open conversations specific to your business, its challenges, and the opportunities you see going forward. Another aspect I truly enjoy is the interaction with students. I was a student once and in many ways I am always learning. The students offer insight into what is currently being taught in the education system specific to plastics and thermoforming. Their energy is contagious and they will be great additions to the thermoforming industry in the near future.

I would like to thank Bill Carteaux from the Society of the Plastics Industry for his keynote presentation. I have enjoyed working with Bill over the years and I look forward to working with him and SPI in the years to come. I would also like to thank MAAC Machinery and Stopol for the organization of the Casino Night and the subsequent \$4,000.00 donation to the Scholarship fund.

At the Annual Business Luncheon, I reported on several items that the Division has accomplished or has agreed to support:

To date, the Division has provided \$187,750.00 in scholarships since 1999. In addition, we have provided \$213,635.00 in matching equipment grant funds since 2002. Thank you to MAAC Machinery for producing a thermoforming machine that allows schools access to the process with a very reliable piece of equipment. Both numbers are significant and truly show the reach that our division has and the way the funds generated through the conference, Quarterly and Casino Nights have been utilized.

The Thermoforming Center of Excellence at Penn College (see "University News" section) is on track to become a flagship facility with dedicated support for research and development as well as education that is specific to thermoforming. This facility will be open to thermoformers, sheet extruders, resin suppliers, mold builders, equipment manufacturers and any others that need a state-of-the-art facility to conduct testing, analysis or trials. Besides serving industry, curriculum will be developed for the Plastics and Polymer Engineering Technology academic program at Penn College for hands-on instruction in thermoforming. A membership structure has been developed and more information will be published over the coming months. Several companies have already contributed to become Center of Excellence Members and at the conference the Thermoforming Institute of SPI pledged \$10,000.00 toward the program. You can always

visit our division website at [www.thermoformingdivision.com](http://www.thermoformingdivision.com) to get additional information.

The Division has agreed to sponsor a pavilion at NPE. The pavilion itself will be three thousand square feet and will be set up to showcase the benefits of our division. Specifically, it will showcase everything we do to facilitate our mission to advance thermoforming technologies through education, application, promotion and research. Within the pavilion we will have sample parts from prior parts competition winners, we will have information on the matching grant and equipment matching funds, we will have division membership enrollment forms, as well as other marketing and media presentations. We will use the pavilion as a marketing opportunity to reach new individuals and provide sign up sheets for the 19th Annual Thermoforming Conference which will be held in Milwaukee, Wisconsin September 19 - 22, 2009. Across the aisle from the Pavilion will be sixteen 10' x 10' booths that can be secured by companies related to the industry, should they desire to be near the Pavilion. If you want more information on this, you can contact Jennifer Shupe at [jennifer@npe.org](mailto:jennifer@npe.org). These booths are available on a first come, first serve basis.

I want to say thank you again for your support. To be successful, our division requires high energy, thought-provoking members that are not afraid to suggest what we can do to make improvements. In the words of Colin Powell, **"If you are going to achieve excellence in big things, you develop the habit in little matters. Excellence is not an exception, it is a prevailing attitude."** |

Brian Ray  
Chair





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**Thermoforming Quarterly®** is an “equal opportunity” publisher! You will notice that we have several departments and feature articles. If you have a technical article, send it to Barry Shepherd, Technical Editor. All other articles should be sent to Conor Carlin, Editor. Please send in .doc format. All graphs and photos should be of sufficient size and contrast to provide a sharp printed image.

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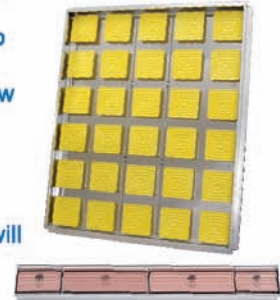


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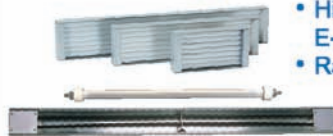
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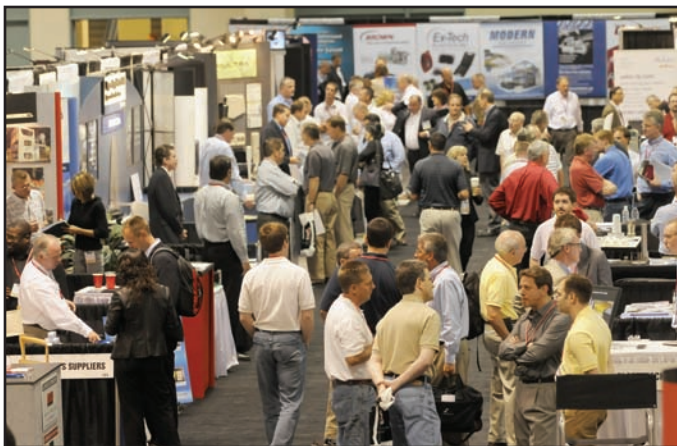
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# 2008 Thermoforming Conference



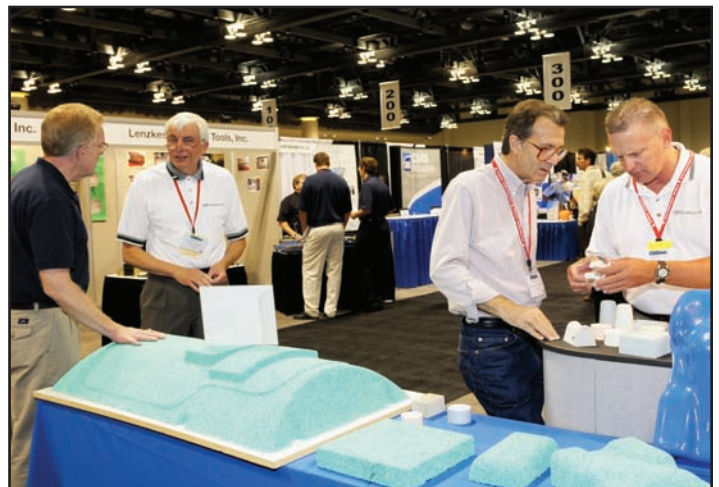
*SPE President Bill O'Connell cuts the ribbon to open the 2008 Thermoforming Conference.*



*A packed exhibit floor suggests another successful Thermoforming Conference.*



*2008 Thermoformer of the Year George Leuken with family and friends.*



*Attendees and exhibitors in the exhibition hall.*



*SPI President Bill Carteaux delivers the keynote address in Minneapolis.*



*Thermoforming Division Chair Brian Ray and SPI President Bill Carteaux.*



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*Exhibit floor activity.*



*Attendees at the technical discussions.*



*Mark Strachan of Global Thermoform Training, Inc. during his thin-gauge seminar, a major draw during the Thermoforming Conference.*



*Local school children learn about the wonders of plastics from the PlastiVan, courtesy of the National Plastics Center.*



*Passing the torch: 2007 Thermoformer of the Year Curt Zamec congratulates the 2008 winner George Leuken.*



*An intrepid student discovers the wonders of scanning systems.*

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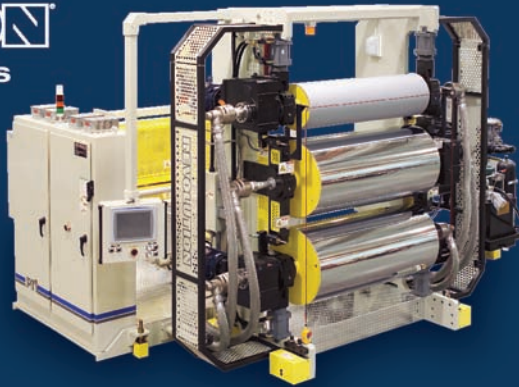
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# Keeping America Competitive: The Manufacturing Challenge

## 2.



This excerpt from the National Association of Manufacturers is the second in our series regarding the importance of operator training.

Manufacturing has long been the engine driving the U.S. economy's growth.

While not always recognized as such, the manufacturing sector has long been the engine driving and maintaining much of the U.S. economy's growth. Intense competition from the globalization of the manufacturing marketplace, changing demographics and the relentless advancement of technology, however, has challenged U.S. manufacturing. The result has been a dramatic increase in the sector's need for highly skilled, technically savvy employees who can fully exploit the productive potential of advanced technologies and support increased quality and product complexity. This need, in turn, has generated a talent shortage—from engineers and R&D professionals to skilled production workers and plant managers—even in the face of a loss of more than 2 million jobs in the recent recession.

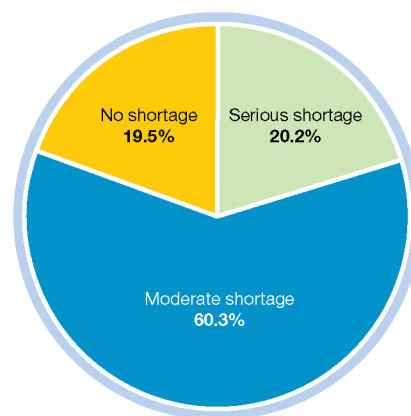
One of the impacts of this issue is clearly seen in the Center for Workforce Success research study *The Skills Gap: Manufacturers Confront Persistent Skills Shortages in an Uncertain Economy*. The central finding of this report, based on a survey conducted at the onset of the recent recession, is that the sector is not effectively competing for highly skilled employees, with more than 80 percent of the large and small manufacturers polled reporting a "moderate to serious" shortage of qualified job applicants.

The most critical shortages of employees identified were in production and the direct support of production, including engineering and skilled crafts. Manufacturers also cited shortages in technical skills;

inadequate basic employability skills; and inadequate reading and writing skills among both job applicants and incumbent workers.

These skill deficiencies impaired manufacturers' ability to maintain production levels to meet customer demand, implement new productivity improvements or deploy quality initiatives. In fact, some manufacturers said they could not accept new orders because they lacked the workers to produce their products. This shortage of skilled workers particularly hampered smaller firms. Some reported that they could not schedule needed second or third shifts for the same reason. Others reported that they had advertised extensively for employees with specific skills—such as welders or electri-

**Figure 1.**  
Availability of Qualified Job Candidates



Source: *The Skills Gap 2001*



cians—and could not find acceptable candidates, or they hired entry-level workers whose skills were barely adequate.

While manufacturing's current situation is difficult, it may soon get worse. A research study conducted by the Educational Testing Service shows that the U.S. economy as a whole will face a growing shortage of skilled workers in the coming decade. The shortage for jobs requiring at least some degree of post-secondary education or training will exceed 10 million in the second decade of this millennium.

This projected shortfall in the skilled-labor force is largely due to the interaction of demographics and technology and the failure of the educational system to keep up with the needs of manufacturing. Unfortunately, the sector's need for technically savvy employees comes at a time when experienced "baby boomer" employees will be retiring in large numbers and are being replaced with a relatively smaller pool of U.S.-based workers who often lack the appropriate technical skills.

This trend is increasingly garnering national attention, with a recent *Time* magazine article stating, "Though the average retirement age is creeping up... demographers say there still will not be enough qualified members of the next generation to pick up the slack. So with 76 million baby boomers heading toward retirement over the next two decades and only 46 million 'Gen Xers' waiting in the wings, corporate America is facing a potentially mammoth talent crunch. Certainly, labor-saving technology and immigration may help fill the breach. Still, by 2010, there may be a shortage of 4 million to 6 million workers."<sup>7</sup>

These factors, when taken together, deepen the concern that many manufacturers did not successfully compete for talent in the 1990s and even in the current recession. Competition will only intensify in the next decade. This means that competent managers, engineers, technicians, skilled craftspeople and front-line workers will be in even greater demand.

### Career Opportunities in Manufacturing

## Electrical Engineer

Engineers are responsible for the design and/or maintenance of products. Most electrical engineers specialize in an area: power generation, transmission or distribution; communications; electrical equipment manufacturing; or a subdivision of these areas such as industrial robot-control systems or aviation electronics. They work with technology to build new communications systems such as broadband or new wireless technology. Others look for new sources of power or ways to make the sources we have more efficient.

**Salary (median annual earnings):** \$64,910 in 2000

**Number Employed:** 288,000 in 2000

**Job Growth:** increasing by 10 to 20 percent through 2010

**Level of Education:** college degree

## Product Marketing Manager

Marketing managers coordinate market research, marketing strategy, sales, advertising, promotion, pricing, product development and public relations activities. They develop the firm's detailed marketing strategy. With the help of subordinates, including product-development managers and market research managers, they determine the demand for products and services offered by the firm and its competitors and identify potential markets (*e.g.*, business firms, wholesalers, retailers, government or the general public). They develop pricing strategy with an eye toward maximizing the firm's share of the market and its profits while ensuring that its customers are satisfied. They monitor trends that indicate the need for new products and services and oversee product development.

**Salary (median annual earnings):** \$71,240 in 2000

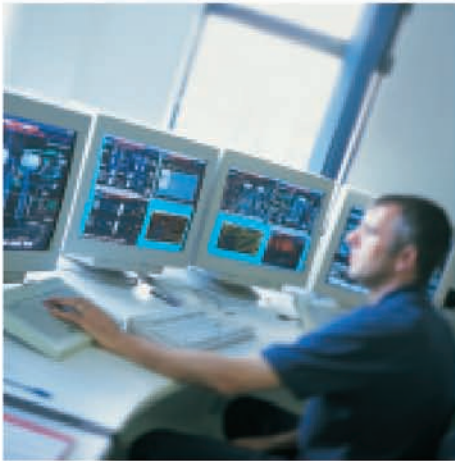
**Number employed:** 190,000 jobs in 2000

**Job Growth:** faster than the average through 2010

**Level of Education:** bachelor's degree in business administration with an emphasis on marketing

Source: Occupational Outlook Handbook, 2002-03 edition, Bureau of Labor Statistics, U.S. Department of Labor

(continued on next page)

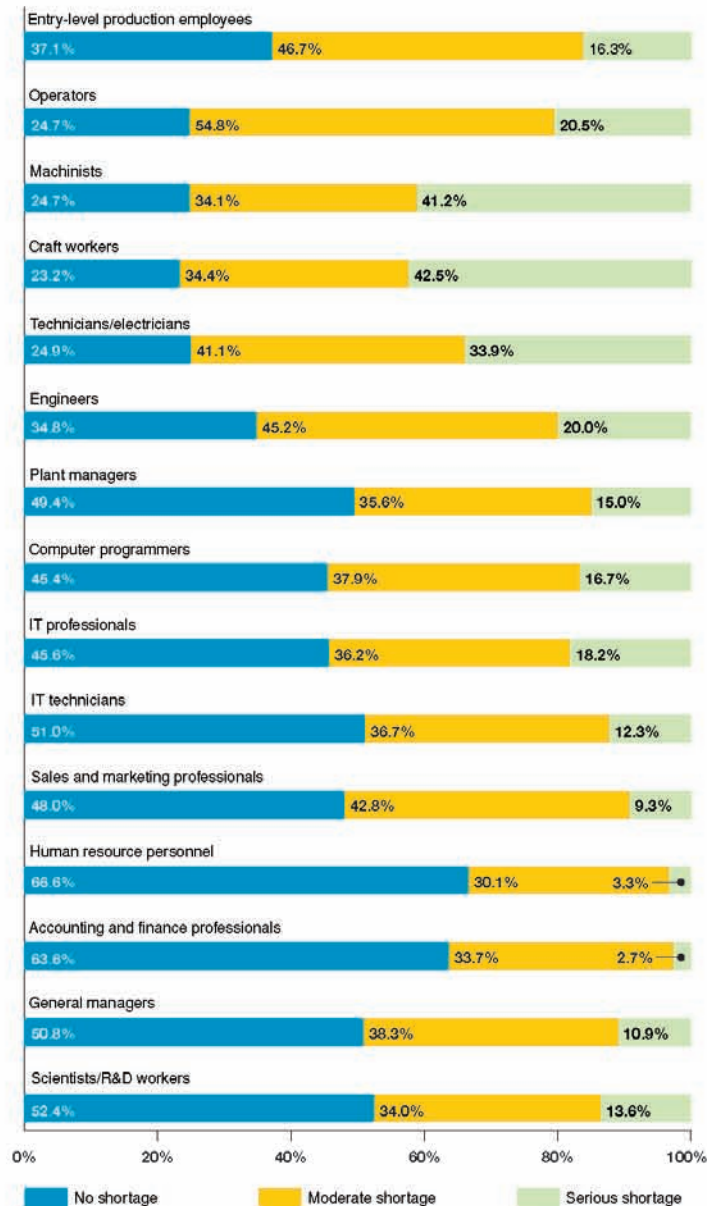


Manufacturers continue to report a lack of qualified job applicants in several key categories. These skill deficiencies impair manufacturers' ability to maintain production levels to meet increasing customer demand, implement new productivity improvements or begin new innovative quality initiatives.

Not surprisingly, the hardest hit regions were the central states—a traditional center of manufacturing—and the West. For all respondents, the most serious shortages specifically identified were in production and direct-support fields (Figure 2): entry-level production employees (63 percent call their need “moderate or serious”); craft workers (77 percent call their need “moderate or serious”); operators (75 percent call their need “moderate or serious”); and machinists (75 percent call their need “moderate or serious”). In addition, 49 percent of respondents said they have a “moderate or serious” need for IT technicians. Larger companies report a greater deficiency of skills in almost all job categories (except in the three categories of operators, entry-level production employees and sales/marketing professionals) in their available workforce.

Taken together, these skill shortages place the United States at a competitive disadvantage in an increasingly competitive global market.

**Figure 2.**  
Availability of Qualified Candidates by Job Category



Source: *The Skills Gap 2001*

In addition to the services and advocacy provided by the National Association of Manufacturers, thermoforming companies can find resources for workforce development and training via grants and government programs.

The National Institute of Standards and Technology offers a Manufacturing Extension Partnership. This program provides a range of services to enable manufacturing companies to achieve measurable results. Visit [www.mep.nist.gov](http://www.mep.nist.gov) for more information.

For manufacturing companies affected by competition from imports, the U.S. Department of Commerce offers Trade Adjustment Assistance for Firms (TAA). More information can be found at: [www.taacenters.org](http://www.taacenters.org).



# Thermoforming Division's New Website Provides a Wealth of Information



Have you visited the Division's website lately?

Well, if you haven't, you need to go to [www.thermoformingdivision.com](http://www.thermoformingdivision.com) and see the latest in activities and information for thermoforming companies.

The site has been completely revamped and updated with flash technology, an expanded collection of articles, archived editions of *Thermoforming Quarterly* and pictures of our award winners from previous conferences. The latest and greatest in new parts are featured in our header and in the "Conference Part Competition Winner" section.

Looking for a thermoforming machine? Check out our new machinery supplier listings. They have been updated with both domestic and foreign machine manufacturers. It is the most complete listing around and puts all the contact information at your fingertips.

Our material suppliers list has been updated with companies that supply the materials to our industry. This is a listing by material followed by suppliers. The list is being constantly updated so and if you have some additional contacts/materials you would like to see added, please email Richard Freeman at [rfree@freetechplastics.com](mailto:rfree@freetechplastics.com) or Jim Armor at [jimarmor@aol.com](mailto:jimarmor@aol.com). They would be happy to add it to the list.

The Thermoformer of the Year section contains all the winners of this prestigious award. We are in the process of collecting more information on past winners, so if you have some biographical information please forward it to Rich Freeman or Hal Gilham at [halg@productiveplastics.com](mailto:halg@productiveplastics.com). The winners are individuals who have played a significant role in the development of the thermoforming industry. If you think someone should be honored with this award, the qualification requirements and application form are right on the site for your use.

Ever wonder where the money goes? The Division sponsors a matching grant program up to \$10,000 for educational institutions to purchase thermoforming equipment. Our site contains information on the award winners and how to apply for a grant. This a great opportunity for an institution to upgrade their thermoforming capability. Details and qualification criteria are on the site! Go see it! We have awarded over \$130,000.00 in grants so far!

Another important new aspect of the site is the Scholarship Awards section. The division awards four scholarships a year, ranging in value from \$1,000 to \$7,500 in conjunction with SPE. All the information on how to apply and qualifications are right there in one spot. Do you have an employee that would like to attend a higher educational institution?

Interested in becoming a board member? We have all the meeting information on the site as well as the board members and contact information.

The Thermoforming Division's website is designed for our members. It is a great resource for those in the business as well as those looking at going into the industry. Try it out!

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

# Specifying Sheet

**“If we don’t specify what we want in our sheet, they will sweep the floor and dump it in the hopper.”**

Technical Editor’s Note: This was a statement made in a panel discussion at the recent SPE Thermoforming Conference in Minneapolis. While I am sure it was an exaggeration made in the heat of the moment, it certainly opened my eyes to the importance of specifying the ingredients in the sheet we buy from the extruder. Incidentally, the extruder to whom the comment was made was of the opinion that it was not necessary for detailed sheet specifications. In today’s world of recycled content and fillers, I now have a renewed commitment to improve the industry practice of specifying the ingredients and test results for our thermoforming sheet.

The following is an excerpt from Dr. Jim Throne’s book “Understanding Thermoforming.” Some editing has been done to emphasize the points that relate to requirements for recycled and filler content in the newer utility and “greener” grades of sheet.

## INCOMING SHEET QUALITY

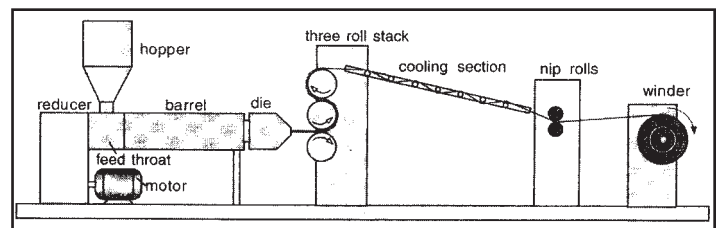
Whether we buy sheet in rolls or flat sheet, to ensure quality parts, thermoformers must have quality sheet. In addition, we must understand enough about the extrusion process to understand its limitations. These limitations may be machinery-driven such as maximum and minimum sheet dimensions or they may be related to the ingredients that go into the extruder hopper.

## THE EXTRUSION PROCESS – WHAT A THERMOFORMER NEEDS TO KNOW

The basic extrusion process is shown in the schematic Figure 1. Solid ingredients ranging from 100% regrind flake to virgin polymer is added to the hopper of the extruder. The barrel of the extruder contains a screw that is driven by an electric motor. The barrel is heated electrically and the ingredients are conveyed by the screw down the barrel while being heated and melted under pressure. The molten polymer is then squeezed through a shaping die. The gap in the die is adjusted to provide the desired sheet thickness. The extruded plastic is laid on the first roll of a multi-roll stack and fed from roll to roll as shown in the illustration. The rolls are temperature controlled and the roll speed is matched to the extruder throughput rate to minimize sheet

orientation (to be discussed later). Heavy gauge sheet is then cooled prior to being cut by way of guillotine or saw cutting and stacking. Thin gauge sheet is fed to a take-up winder and rolled onto fiber cores. Gauge thickness is determined manually for heavy gauge sheet and with nuclear gauges for thin gauge sheet.

There are many variations to the process in the illustration. Twin screw extruders are used for temperature sensitive polymers such as PVC. Multiple extruders are used for co-extruded, multi-layer and laminated sheet. Tandem extruders are used to produce low density foams. Hopper dryers are used on many extruders to remove moisture from pellets and regrind. Certain polymers such as PET and ABS require substantial drying before processing.



*Figure 1. Typical sheet or film extrusion line.*

## THE PURCHASE ORDER

The purchase agreement between the extruder and the thermoformer is as important as it is between the thermoformer and the customer. The following are the main specifications on which they should agree. A more detailed explanation for the need for these specifications follows under the heading, “The effect of non-conformance on the quality of parts.”

### The Ingredients

Since the extruder normally buys his raw material by weight it is important to agree on the yield in terms of the number of sheets or length of the rolls. The extruder determines his price mainly by the weight of the ingredients that go into the hopper. This is very important for thermoformers to understand especially when ordering a grade of material that consists of non-virgin polymers. Recycled or utility grades are obviously cheaper than virgin grades and unless the ingredients are specified the door is left open for the extruder



to make his own formulation. This can lead to inconsistencies in the quality of finished parts.

## **Yield**

Dimensional tolerances can be easily agreed on and are relatively easy to control. The length, width and flatness tolerances must be specified. Thickness tolerances are somewhat harder for the extruder to maintain however these can have a major impact on the yield of a material order and result in a significant loss of margin on the thermoformed parts. Thickness tolerances of minus 2%, plus 0% could be requested but this may be impossible for the extruder to maintain depending on the volume of the order and the type of material. Plus or minus 5% is common but this is considered excessive on a large volume order (truck-load).

## **Other Specifications**

Here is a list of other points that may be quantified on the purchase order.

- Moisture in the sheet
- Irregular and linear surface marks
- Chatter and ribbon marks
- Specks, gels, pits, lumps and holes
- Color uniformity and intensity
- Gloss and texture
- Anti-static content
- Anti-blocking agent content

## **THE EFFECT OF NON-CONFORMANCE ON THE QUALITY OF PARTS**

### **Moisture**

Certain polymers are dramatically affected by moisture. In the presence of even small amounts of moisture, PET, PC and nylons quickly lose molecular weight when heated to processing temperatures. Material property loss can result in excessive sag, extreme thinning during stretching or brittle product failure. Excessive heating and shear degrades RPVC. The first indication is yellowing in color. HDPE degrades to lower molecular weight material. This results in excessive thinning and to some degree, a loss of UV and chemical resistance. Since HDPE's molecular weight is related to viscosity, a simple melt indexer is used to determine the effects of processing and reprocessing HDPE.

### **Recycled Content**

Economically efficient thermoforming depends on the successful reuse of trim. It is imperative that the extruder clearly understands how the thermoformer wants the regrind

to be handled. The purchase order should designate the level and source of regrind stream and the amount of regrind to be used. Regrind is not allowed in certain applications such as medical although these restrictions are being modified as recycling processes become more sterile. Other applications such as dunnage commonly call for 100% regrind however this can be a risky business especially if the dunnage is a returnable tray or pallet that must withstand rigorous and repeated handling. Surface imperfections such as gels, lumps, poor gloss and mottled color can usually be accepted for a material handling part but a word of warning. With these imperfections comes material inconsistency which can create hardships for the thermoformer. It is quite easy to use up the expected savings in material cost on unexpected machine time and bad parts. Today many purchase orders state an acceptable level of 30% regrind by weight, plus or minus 5% and will specify the source of the regrind, i.e. from the purchasing plant itself or the edge trim on the extruder.

### **Orientation**

The thermoformer and extruder should agree on the maximum amount of cross direction and machine direction orientation of the sheet. Excessive orientation can lead to sheet pull-out from clamp frames or pins. The most common test for orientation is to cut 1" by 10" strips from samples of extruded sheet in machine and cross direction, then heat these strips. Strips with no more than 5% orientation are normally considered acceptable but maximum levels depend strongly on polymer and application.

## **INCOMING SHEET EVALUATION**

Substantial effort must be expended to assure that the as-delivered sheet meets the highest possible quality standards. Most thermoformed products do not demand excessive incoming testing. Visual and dimensional inspections of the sheet are usually done by the machine operator as the sheet is fed into the forming press. Inspection results are usually recorded only on critical applications. Spot checks of polymer quality are done when product must meet critical design specifications for such things as fire retardency or impact strength.

Thermoformers, especially custom formers who buy a wide range of material types, would be wise to start communicating more with their extruders and setting up some sort of specification sheet that will provide a level of understanding as to what is and what is not acceptable. Our customers are becoming more and more interested in the environmental issues related to their plastic products and as the need for greener plastics increases, the demands on thermoforming processing will get tougher. Knowing what is in our sheet will become even more important. |

# LIFETIME ACHIEVEMENT AWARD

**WALTER J. WALKER  
EXECUTIVE VICE PRESIDENT  
AND CHIEF OPERATING OFFICER  
PRENT CORPORATION  
JANESVILLE, WI**



# W

**alter J. Walker**

is the Executive Vice President and Chief Operating Officer of Prent Corporation, an international manufacturer of custom plastic thermoforming, primarily for the medical and electronics industries.

Walker is responsible for the operations of the company's North American manufacturing facilities and his work recently earned Prent Corporation a prestigious "Manufacturer of the Year" award. Headquartered in Janesville, Wisconsin, Prent plants are located in Wisconsin, Arizona, Puerto Rico, China, Malaysia and Singapore.

A long-time member of the Board of Directors for the Society of Plastic Engineers (SPE) Thermoforming Division, Walt recently served as Chairman from 2006-2008.

Because of Walker's reputation for developing highly skilled workers and his rigid training standards, he was instrumental in creating the first-ever US plastic industry's national skills certification exam and standards for machine operators. In March 1999 he was elected to the Society of the Plastics Industry's (SPI), National Certification in Plastics Board of Governors.



*Walt Walker (left) accepts Lifetime Achievement Award from Brian Ray, Chairman, at the 2008 Thermoforming Conference in Minneapolis.*

Prior to joining Prent, Walker worked for 15 years at the 3M Company in product development, new business ventures, research, and manufacturing.

An active volunteer in his local community with his business expertise, Walker is spearheading the efforts of southern Wisconsin's manufacturers to revamp the math, science and English curriculum of local schools so they may better serve the needs of area industries.

In addition, he is an advisor to the Technical Education Committee of the Janesville Public Schools, as well as the Institute of Supervisory Management at Blackhawk Technical College.

Walker studied Business Administration at the University of Minnesota. He and his wife Barbara are the parents of six grown children and 13 grandchildren who all reside in Janesville, WI. |





# EUROPEAN PLASTICS INDUSTRY ADVOCATE CHOSEN AS SPE'S PRESIDENT-ELECT

Press Release



## KEN J. BRANEY WILL BECOME PRESIDENT OF SPE AT ANTEC 2010 IN ORLANDO

**Brookfield, CT** – The Society of Plastics Engineers (SPE) is pleased to announce that Ken J. Braney was chosen as president-elect of the association during SPE's council leadership meetings recently in Connecticut.

Mr. Braney, managing director of UK-based Thermoforming Solutions Ltd., will begin his term as president of SPE in May of 2010 in Orlando at ANTEC, SPE's annual technical conference and signature event.

"I appreciate Ken's leadership and example as he has been a true champion for SPE and has served as a catalyst for our growth in Europe," explains Susan Oderwald, executive director of SPE. "That combined with his extensive knowledge and understanding of the plastics industry will serve SPE well during his tenure."

### **About Ken J. Braney**

Ken Braney, an SPE member since 1995, currently serves as senior vice president of SPE and recently served as treasurer during the 2007-2008 term. He has been involved with SPE's European Thermoforming Division from its conception, holding the position of chair for 4 years. Mr. Braney has been the chair of SPE Europe (2005-2006) with responsibility for not only registering SPE as a legal entity in Europe, but

also for ensuring the support is in place to nurture and grow all sections and divisions in this area. He was instrumental in the development of SPE's first SPE EUROTEC Conference in Marne la Vallee near Paris, France, which will take place 29th September to 3rd October 2009.

Mr. Braney has been associated with the plastics industry for over thirty years and has held a variety of marketing and general management positions in Europe.

For several years he lived and worked in the USA (Michigan) as general manager and commercial director of two North American divisions of multi national companies. He then returned to Europe when he joined a multi national machinery manufacturer (USA based) and for 13 years held the position of director for Europe, Middle East, Africa and India.

Mr. Braney is currently managing director of Thermoforming Solutions Ltd. based in the UK. |

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- University of Wisconsin
- Michigan State
- Ferris State
- Madison Technical College
- Clemson University
- Illinois State
- Penn College

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# Thermoforming Division

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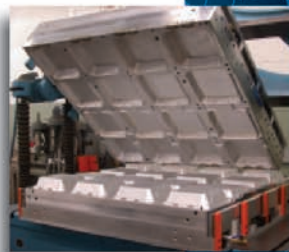
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# Assessing the Thermoformability of High-Performance Polymers for Use in Medical Packaging Applications

T. P. O'Brien, G. M. McNally, W. R. Murphy, B. G. Millar, G. S. Garrett, A. H. Clarke, Polymer Processing Research Centre, Queen's University Belfast, Belfast, Northern Ireland; R. P. McGinley, Perfecseal Limited, Derry, Northern Ireland

## ABSTRACT

A considerable number of polymers are available for use in medical and pharmaceutical packaging applications. Polymers such as polypropylene, glycol modified poly(ethylene terephthalate), polyacrylonitrile, cyclic olefin copolymer and polychlorotrifluoroethylene exhibit different mechanical and thermal properties thereby requiring different processing conditions. The thermoformability of these different polymers can be assessed in order to establish relative performance metrics prior to full scale production trials. This paper presents methods and analyses for assessing thermoformability.

## INTRODUCTION

Extruded, co-extruded and laminated sheet materials can be processed by thermoforming. There is a diverse range of materials, grades and gauges available to choose from for any given application (1,2). Numerous design factors must be considered when choosing a material for a particular thermoformed packaging application. Traditional factors include tensile strength, tear strength and impact strength, while factors of particular importance to medical packaging applications include sterilization capabilities, barrier properties and biocompatibility (3,4).

Thermoforming is a generic technique which in its simplest form is used to shape a flat thermoplastic sheet. First, the sheet is heated to within its rubbery phase, then a mechanical load is applied to the pliable sheet to form or shape it and finally, the formed sheet is allowed to cool and stiffen. Thermoformability is a qualitative term which may be described as the relative ease with which a particular material may be processed using the thermoforming technique. Materials which have good thermoformability include high-impact polystyrene and glycol modified polyethylene terephthalate, while examples of materials with poor thermoformability include polyethylene and polycarbonate. Generally, thermoplastic materials with wide temperature processing windows, low coefficients of thermal

expansion, high melt strengths and moderate specific heat capacities are thermoformable. However, additional properties and characteristics may need to be considered when assessing the thermoformability of a particular material (5).

To establish whether or not a material is thermoformable involves undertaking a thermoforming trial on the material with either a prototype or production thermoformer (6). This can prove to be expensive and time consuming, particularly if the material has poor thermoformability. Substantial experimentation may be required, the thermoforming equipment may need modification, the grades and gauges of available material may be diverse or the available tooling may be unsuitable for the purpose. Laboratory techniques may aid the experimentation process by comparing properties of the material to other materials which have already been qualified for thermoformability (7-10).

The objective of this paper is to present the results of some thermoformability investigations on several different medical packaging materials. Laboratory techniques and a prototype thermoformer are used to assess materials with a view to gaining insight into the performance characteristics of the materials and their relative thermoformability.

## MATERIALS AND METHODS

Five different medical packaging films were assessed during this study and are listed in Figure 1. Three of the materials were extrusions; PETG (glycol modified polyeth-

Material Type	Thickness (mm)
PETG	0.600
PP	0.800
PAN	0.762
PP/COC/PP	0.030 / 0.240 / 0.030
PVC/EVOH/PCTFE	0.250 / 0.070 / 0.100

*Figure 1. The materials under investigation were acquired from various manufacturers as 210 × 300mm sample sheets. The table shows the thickness of each sheet.*

(continued on next page)

ylene terephthalate), PP (polypropylene) and PAN (polyacrylonitrile). One material was a co-extrusion; PP/COC/PP (polypropylene/cyclic olefin copolymer/polypropylene). PETG is a widely used material for thermoforming medical trays. Its main benefits are transparency, sterilization capabilities, toughness and thermoformability. PP has excellent stiffness and high temperature stability but is difficult to thermoform and unsuitable for irradiation. PAN is an excellent oxygen barrier and has good chemical resistance; however, heat degradation of PAN produces dangerous gases therefore the process must be accurately controlled. COC is widely used for pharmaceutical packaging and offers good moisture barrier properties. PVC has good thermoformability but is decreasing as a medical package due to environmental concerns while EVOH is an excellent oxygen barrier. Finally, PCTFE is one of the best available polymeric moisture barriers.

Three different laboratory methods were used to assess material characteristics related to thermoformability. Dynamic Scanning Calorimetry (DSC) was used to investigate the relationship between the endothermic heat absorption with material temperature change and to identify thermally induced phase transition regions for each material. Following the DSC analyses, the materials were strained in a temperature controlled tensile test in order to gain insight into the draw characteristics of the materials at different temperatures. A third laboratory test involved subjecting samples of each material to a certain temperature level to record the resulting centre-point sag from its original position.

Finally, sheets of the materials were thermoformed using a vacuum thermoformer to establish the relative thermoformability of the materials. Observations and insights gained from the laboratory investigations could then be compared to the actual thermoformed materials.

## DYNAMIC SCANNING CALORIMETRY

A Perkin Elmer DSC 6 was used to perform the analyses. In the investigation, each sample aluminum pan was loaded with  $6.9 \pm 0.1$  mg of material. Analyses were performed at a rate of  $10^\circ\text{C min}^{-1}$  from 30 to  $150^\circ\text{C}$ . Two heat cycles were applied to each sample and results were recorded for the second heat only.

## CONTROLLED TEMPERATURE TENSILE TEST

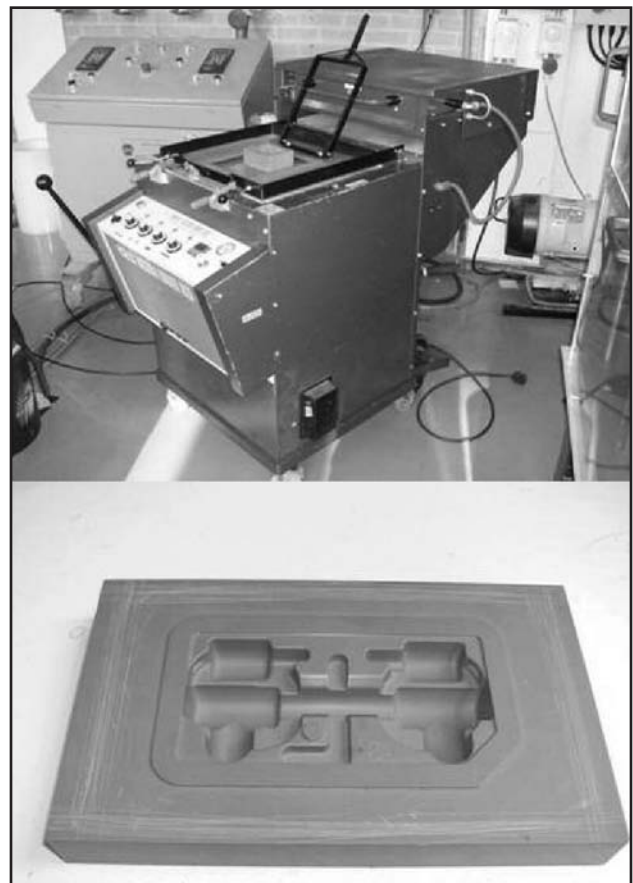
An Instron 5564 Universal Tester equipped with a 5kN load cell was used to perform uniaxial tensile tests. An environmental chamber was used to maintain certain predefined temperatures, namely, 80, 100, 120, 140 and  $160^\circ\text{C}$ . Each sample was cut using a 55mm x 5 mm dogbone cutter and was then mounted in the jaws of the tensile tester. The strain rate was set to  $0.3\text{s}^{-1}$  which corresponded to a crosshead speed of 1000mm/min. This is of a similar order to strain rates found in thermoforming applications (9). The test commenced one minute after the oven had reached the set-point temperature. Two repetitions of the test were performed.

## SAG TEST

Samples of material were cut to  $13 \times 110\text{mm}$  and were screwed onto two screws which were attached to a holding frame. The distance between the two screws was 85mm. The clamped sample was then placed into the convection oven and subjected to a temperature increasing from  $40$  to  $180^\circ\text{C}$  at a linear rate of approximately  $0.75^\circ\text{C/s}$ . As the temperature passed through certain points of interest, the amount of sag in the sample was recorded by measurement against a calibrated steel rule of accuracy 0.5mm.

## THERMOFORMING TRIAL

Standard  $210 \times 300\text{mm}$  sample sheets of material were thermoformed using a modified 1820 model vacuum thermoformer (C. R. Clarke, Ammanford, UK) which incorporated a needle valve for accurate vacuum control and a redesigned clamping plate to hold small sheets. Figure 2 shows pictures of the thermoforming machine and the prototype tray mould



*Figure 2. The prototyping thermoformer used for the thermoforming trials (top) and the prototype mould used to form the sheet (bottom).*

used to form the sheet. Heat was applied to one side of the sheet using a 4-zone bank of ceramic heaters. The heat output was not quantified but remained constant during the trials and the maximum vacuum applied to each sheet was 40kPa below atmospheric. Heating time was varied for each material until a “good” form resulted. As thermoformability is a qualitative attribute of a material, a “good” form was defined as a form

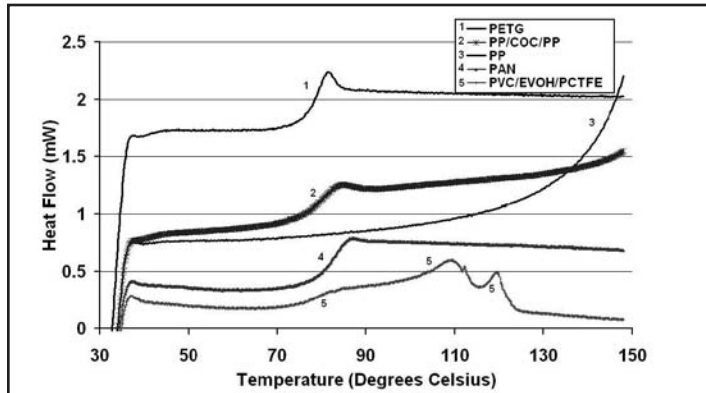


which filled all aspects of the mould (no underforming), did not exhibit webbing (due to excessive sag) and where the structural integrity was not compromised (no melting, tearing or cracking). It should be noted that these three attributes are related to the three laboratory tests described above.

## RESULTS

### DYNAMIC SCANNING CALORIMETRY

Figure 3 shows the results of the DSC investigations. Phase transition regions are indicated in each of the plots by means



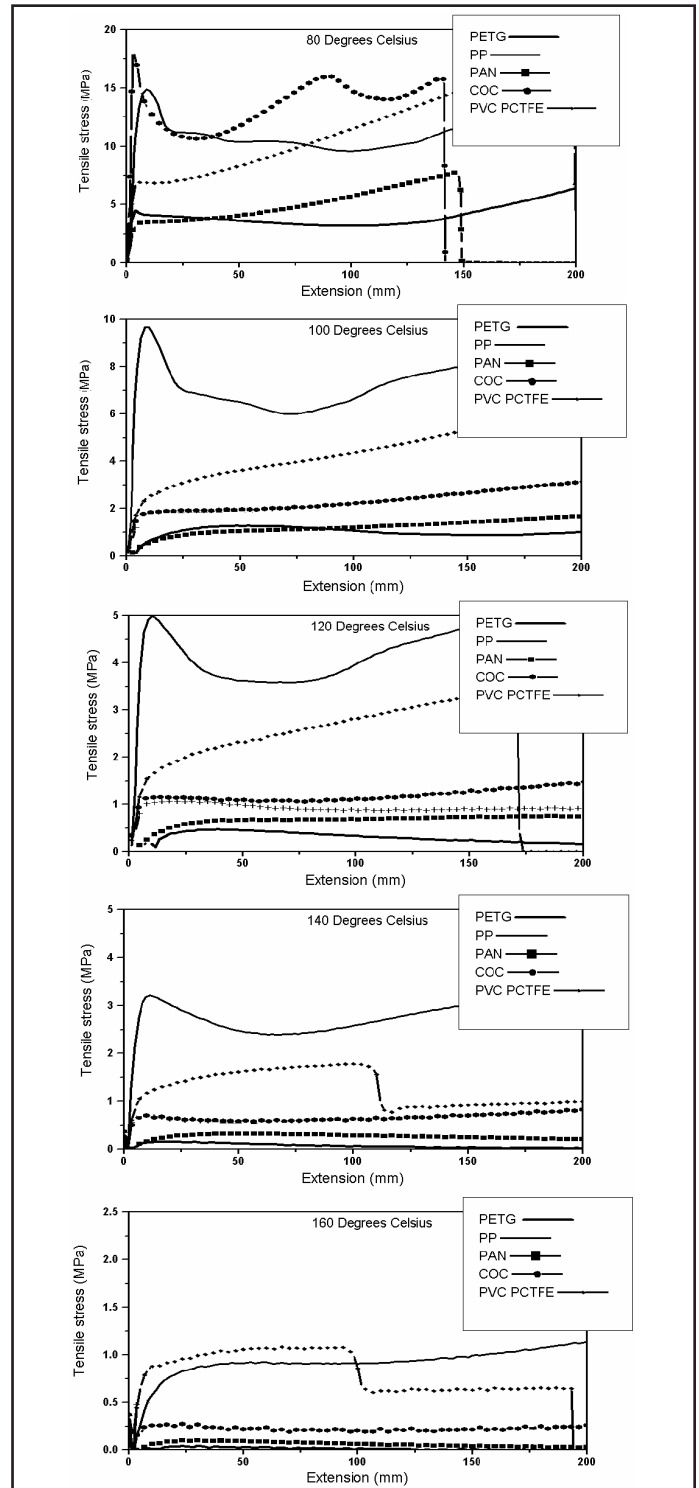
**Figure 3. Second heat DSC results for the five materials. The transition regions are labeled by numerical identifiers.**

of a numerical identifier. Phase transition, or the change from a solid material to a rubbery material, occurs when there is a marked increase in the slope of the graph. By determining the location of the maximum slope in the graph, the temperature step increase which requires the greatest amount of heat input to achieve it may be identified. Considering the amorphous PETG, the transition region occurs around location 1 and the glass transition temperature occurs at 80°C. For PP, the material is entering the crystalline melt region when the test stops at 150°C. It is noted that as the sheet approaches 150°C the material is entering a region of rapidly changing thermodynamic characteristics. PAN is an amorphous material which passes its glass transition temperature and enters the rubbery phase at 83°C. COC is an amorphous polymer, co-extruded with two thin layers of crystalline PP, and the resulting co-extrusion exhibits a glass transition at 80°C. The last material shown is PVC/EVOH/PCTFE. The first transition region occurs at around 80°C which is likely to be caused by one of the three materials while two additional transformation regions occur at 108 and 118°C. This endogram displays the most complex behavior and as a result, does not appear to be particularly thermodynamically stable over the course of this temperature range. These transition regions are likely to be a combination of the effects of the three component materials in the laminate which are all responding differently to the applied heat. In general it can be inferred from the results that a sheet temperature range of 120 to 140°C may be suitable for forming all five materials. The amount of heating time required

would depend on each material's specific heat capacity and the wavelength of radiation it absorbs.

### CONTROLLED TEMPERATURE TENSILE TEST

The results of the tests are shown in Figure 4. In these results, the applied tensile stress in the material is plot-



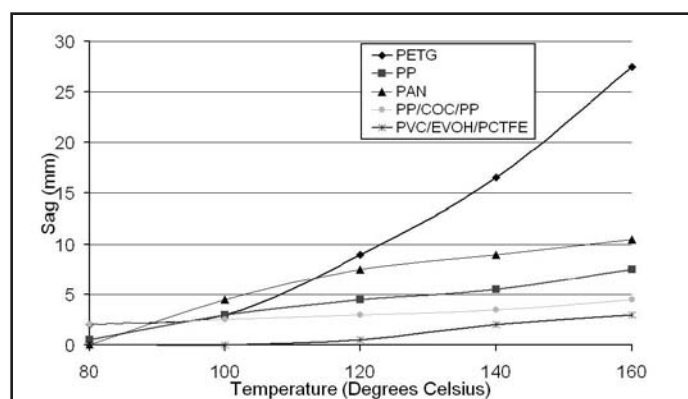
**Figure 4. The results from the controlled temperature tensile tests. The tensile stress is plotted against the extension for each material at the five temperatures of interest.**

(continued on next page)

ted against the resulting extension. As the temperature is increased, the materials soften and the resulting tensile stress decreases. Materials such as PP, PP/COC/PP and PETG display yield points at 80°C; however, as the temperature increases and the materials enter the rubbery phase, these yield points disappear and the materials draw as soon as the load is applied. Some evidence of strain hardening is evident in certain materials, such as PP, PVC/EVOH/PCTFE and PP/COC/PP from 100 to 120°C. In general, in the 120 to 140°C temperature range and 50 to 100mm draw range, it is evident that the rank in terms of ease of draw is [1] PETG, [2] PAN, [3] COC, [4] PVC/EVOH/ PCTFE, and [5] PP. These material temperatures and draws would be similar to those found in thermoforming (5). A final note must be made of the PVC/EVOH/PCTFE lamination. During the tests at 140 and 160°C, delamination and failure of the PVC section was noted to occur at approximately 100mm extension. However, the EVOH/PCTFE continued to extend. This explains the “step” in the respective plot.

## SAG TEST

The results of the sag test are shown in Figure 5. It is clear that PETG and PAN are liable to significant sag. The



**Figure 5.** The results of the sag tests for the materials. PETG is most susceptible to sag.

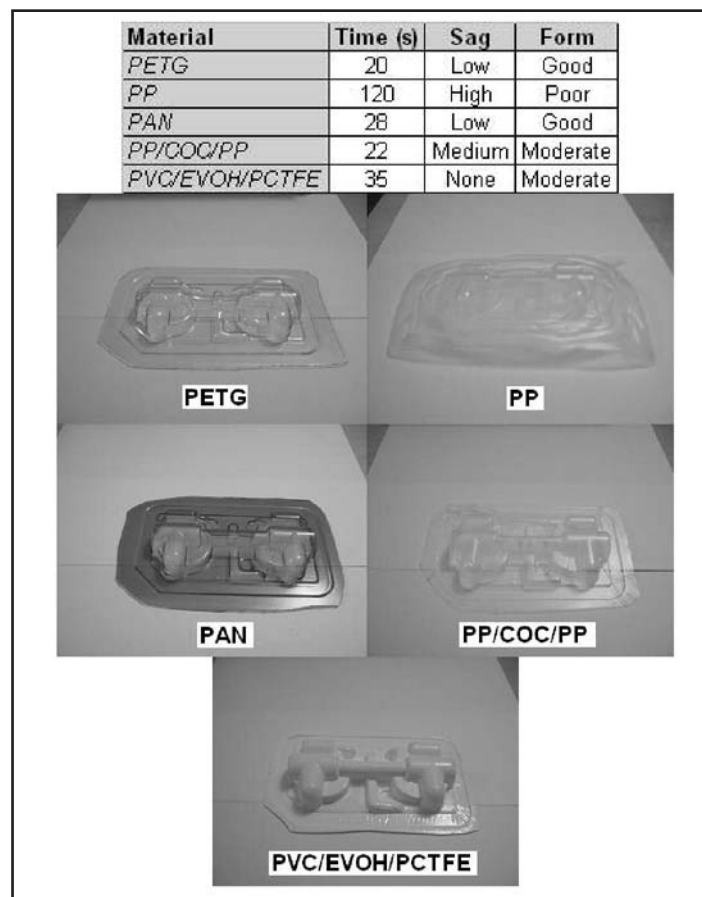
remaining materials exhibited less than 10% sag at 160°C. Little sag was evident in the PVC/EVOH/PCTFE. It should be noted that as the temperature was a ramp input, holding the material at 160°C for a number of seconds would increase the sag of the materials as more heat is transferred to the samples by convection. Nevertheless, the test provides a suitable comparison of the relative amount of sag undergone by each material.

## THERMOFORMING TRIAL

The final stage in the study was to establish thermoformability by means of a thermoforming trial. The laboratory tests have provided useful insights into certain characteristics of the materials. From the DSC tests, it is evident that all materials, except PP, have a transition region beyond which the material can be heated into a thermodynamically

stable rubbery phase. While PP appears to be a stiffer material, heating it to a higher temperature should overcome the draw difficulties. Sag may be an issue with PETG and PAN, particularly at temperatures above 120°C. It now remains to establish if the laboratory derived indicators manifest themselves in the actual thermoforming trial.

The results of the thermoforming trial are shown in Figure 6. The sag and form have been qualified according to



**Figure 6.** Qualitative observations made during the thermoforming trial (top) and images of the formed trays (bottom).

observations. It is clear from the pictures that the PETG and PAN exhibit good thermoformability. All features have been formed, no webbing is present and there is no melting, tearing or cracking. While sag was an issue initially, reducing the heating time helped reduce the degree of sag. PVC/EVOH/PCTFE has moderate thermoformability with the only fault being the presence of a slight rippling and delamination. The hot sheet did not undergo significant sag. PP did not form due to excessive sag and webs caused by the long heating time required to make the sheet sufficiently soft for forming. The PP/COC/PP gave a moderate form with some webbing due to sag. The formed tray also appeared quite brittle when it was being cut from the web.

## CONCLUSIONS

It was suggested from the DSC, sag and tensile test results that PETG and PAN would form well if sag could be kept to



a minimum. It was also expected that PP would be difficult to draw and could have problems due to the temperature dependent thermodynamic characteristics. Delamination was an issue for the PVC/EVOH/PCTFE during the tensile tests while the PP/COC/PP results appeared to suggest thermoformability.

Observations from the thermoforming trial support some of these findings. The PETG and PAN formed well. The thermoformer was unable to process the PP due to excessive sag while COC formed with some webbing and brittleness. Slight delamination was evident in the PVC/EVOH/PCTFE.

In conclusion, laboratory based investigations are useful for comparing the relative performance of different materials under different conditions and can provide insight into how a material may perform in a thermoforming application. |

**KEYWORDS:** *Medical Packaging, Thermoforming, Polymer Analysis*

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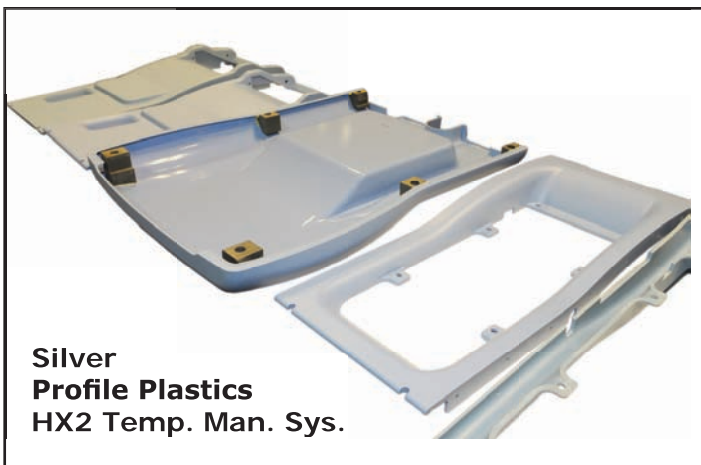


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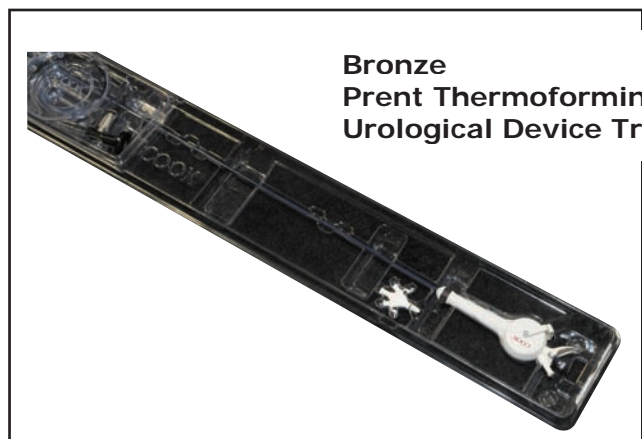
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(continued on next page)

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- Entries must include a brief description of the photo including photographer name, company name and address.
- Images will be judged on originality, technical excellence, composition, overall impact and artistic merit.
- The judges will be a panel of editors and SPE board members.
- Only one winner will be chosen. Based on the number of eligible entries, the criteria may be modified in the future to award multiple prizes.
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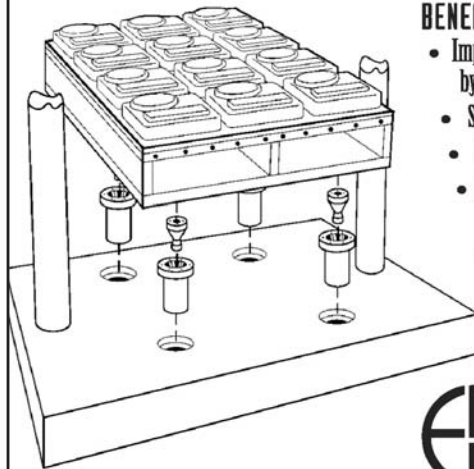


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- (2) Advanced theory development of mold temperature control and its effects.
- (3) Optimization of vacuum/air to allow faster forming, better part definition, and faster cycles.

- (4) Documentation and evaluation of the impact of recycling material properties, as well as processing to optimize material recycling capability.
- (5) Research on the development of biodegradable and/or composite materials for thermoforming.

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**The SPE Thermoforming Division contributed \$60,000 to the Thermoforming Center of Excellence. These funds will be used for project development and continuing research in the thermoforming sector.**

### Carbon and Environmental Footprint of PLA Products

Editor's Note: There is a great deal of work going on around the world in the field of sustainability. This article contributes to the increasing level of knowledge required for plastics processors when measuring the effects on the environment of various materials used in our industry. A growing number of companies are being asked to benchmark their own carbon footprint. We thank *Bioplastics Magazine* and author Ramani Narayan of Michigan State University for allowing us to reprint this article.

**B**ioplastics like PLA use renewable (bio) carbon, and therefore provide an intrinsic reduced carbon footprint depending on the amount of renewable carbon in the product. This fundamental principle and concept behind the use of bio(renewable) feedstocks for reducing the carbon footprint is not captured or calculated in the many LCA's reported or if it is, then it is lumped together with other related carbon emissions and the "intrinsic value proposition" is lost.

The intrinsic "zero carbon" value proposition is best explained by reviewing and understanding Nature's Biological Carbon Cycle (see bM 01/2007). Nature cycles carbon through various environmental compartments with specific mass, rates, and time scales (see Figure 1).

Carbon is present in the atmosphere as CO<sub>2</sub>, essentially as inorganic carbon. The current levels of CO<sub>2</sub> are around 380 ppm. CO<sub>2</sub> is a life sustaining, heat-trapping gas, and needs to be maintained at or around current levels to maintain life-sustaining temperature of the planet. While one may debate the severity of effects associated with this or any other target level of CO<sub>2</sub>, there can be no disagreement that uncontrolled, continued increase in levels of CO<sub>2</sub> in the atmosphere will result in global warming and with it associated severity of effects affecting life on this planet as we know it. It is therefore prudent and necessary to try and maintain current levels – the "neutral or zero carbon" approach. This can best be done by using annually renewable biomass crops as feedstocks to manufacture our

carbon based products, so that the CO<sub>2</sub> released from the end-of-life of the product after use is captured by planting new crops or biomass in the next season. Specifically the rate of CO<sub>2</sub> release to the environment at end-of-life equals the rate of CO<sub>2</sub> fixation photo synthetically by the next generation biomass planted – a "neutral or zero carbon" footprint. In the case of fossil feedstocks, the rate of carbon fixation is in millions of years while the end-of-life release rate into the environment is in 1-10 years. The math is simple: using fossil feedstocks is not sustainable and results in more CO<sub>2</sub> release than fixation, resulting in an increased carbon footprint with its associated severe environmental impacts.

Thus, for every 100 kg of polyolefin (polyethylene, propylene) or polyester manufactured from a fossil feedstock, there is an intrinsic net 314 kg CO<sub>2</sub> (85.7% fossil carbon) or 229 kg of CO<sub>2</sub> (62.5% fossil carbon) released into the environment respectively at end-of-life. However, if the polyester or polyolefin is manufactured from a biofeedstock, the net release of CO<sub>2</sub> into the environment is zero because the CO<sub>2</sub> released is fixed immediately by the next biomass cycle. This is the fundamental intrinsic value proposition for using a bio/renewable feedstock and is totally lost or ignored during LCA discussions. Incorporating biocontent into plastic resins and products would have a positive impact – reducing the carbon footprint by the amount of biocarbon incorporated, for example incorporating 30% biocarbon PLA content into a fossil based polypropylene resin would intrinsically

reduce CO<sub>2</sub> emissions by 42%. These are significant environmental value gains for the biobased product.

It is equally important to note that in the conversion of the feedstock to product and in its use and ultimate disposal, "carbon" in the form of energy is needed and releases CO<sub>2</sub> into the environment. Currently, in the conversion of biofeedstocks to product, for example corn to PLA resin, fossil carbon energy is used. The CO<sub>2</sub> released per 100 kg of plastic during the conversion process for biofeedstocks as compared to fossil feedstock is in many cases higher, as in the case of PLA. However, in the PLA case, the total (net) CO<sub>2</sub> released to the environment taking into account the intrinsic carbon footprint as discussed in the earlier paragraph is lower, and will continue to get even better, as process efficiencies are incorporated and renewable energy is substituted for fossil energy (see Figure 3, these are actual data from Vink et al, [www.natureworksllc.com](http://www.natureworksllc.com) and the APME database). For PLA and other biobased products, it is important to calculate the conversion "carbon costs" using LCA tools to ensure that the intrinsic "neutral or zero carbon" footprint is not negated by the conversion "carbon costs."

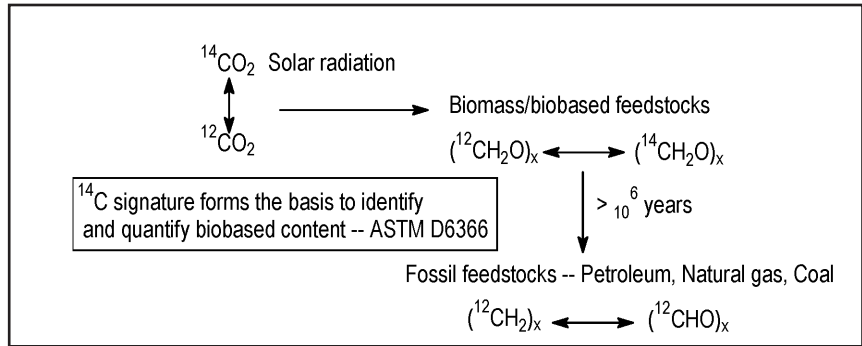
#### BIOCARBON CONTENT DETERMINATION

In order to calculate the intrinsic CO<sub>2</sub> reductions from incorporating biocarbon content, one has to identify and quantify the biobased carbon content.

As shown in figure below, <sup>14</sup>C signature forms the basis for identifying and quantifying biobased content. The CO<sub>2</sub> in the atmosphere is in equilibrium with radioactive <sup>14</sup>CO<sub>2</sub>. Radioactive carbon is formed in the upper atmosphere through the effect of cosmic ray neutrons on <sup>14</sup>N. It is rapidly oxidized to radioactive <sup>14</sup>CO<sub>2</sub>,



and enters the earth's plant and animal lifeways through photosynthesis and the food chain. Plants and animals which utilize carbon in biological foodchains take up  $^{14}\text{C}$  during their lifetimes. They exist in equilibrium with the  $^{14}\text{C}$  concentration of the atmosphere, that is, the numbers of C-14 atoms and non-radioactive carbon atoms stays approximately the same over time. As soon as a plant or animal dies, they cease the metabolic function of carbon uptake; there is no replenishment of radioactive carbon, only decay. Since the half life of carbon is around 5,730 years, the fossil feedstocks formed over millions of



years will have no  $^{14}\text{C}$  signature. Thus, by using this methodology one can identify and quantify biobased content. ASTM subcommittee D20.96 has codified this methodology into a test

method (D 6866) to quantify biobased content. D6866 test method involves combusting the test material in the presence of oxygen to produce carbon dioxide ( $\text{CO}_2$ ) gas. The gas is analyzed to provide a measure of the products.  $^{14}\text{C}/^{12}\text{C}$  content is determined relative to the modern carbon-based oxalic acid radiocarbon standard reference material (SRM) 4990c, (referred to as HOxII).

### END-OF-LIFE OPTION

PLA, PLA blends and similar biobased plastics end-of-life scenarios involve recycling, waste to energy plants or biological disposal systems like composting or anaerobic digestion. In each case, the biocarbon conversion to  $\text{CO}_2$  is fixed by the next season's biomass plantation giving it the intrinsic value proposition as discussed in detail earlier. However, many LCA studies show landfills as an end-of-life option for PLA and similar biobased plastics. The studies assume breakdown of the biocomponent anaerobically to methane with its attendant negative global warming effect. However, landfills are not the preferred end-of-life option for any waste, and efforts at all levels are underway to divert waste from landfills to making more useful product.

It is also important to note that biodegradability is many times erroneously assumed for all biobased plastics. Not all biobased plastics are biodegradable, and not all biodegradable plastics are biobased. Furthermore, the use of the term biodegradability is very misleading and deceptive if one does not define the disposal environment and the time to be completely assimilated by the microorganisms present in the

(continued on next page)

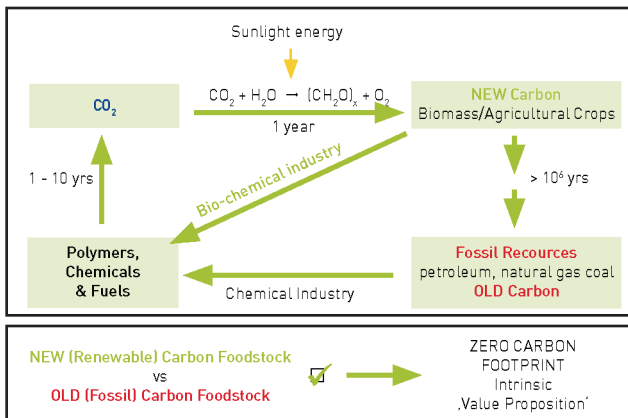


Figure 1. Global Carbon Cycling Carbon Management Nature's Way.

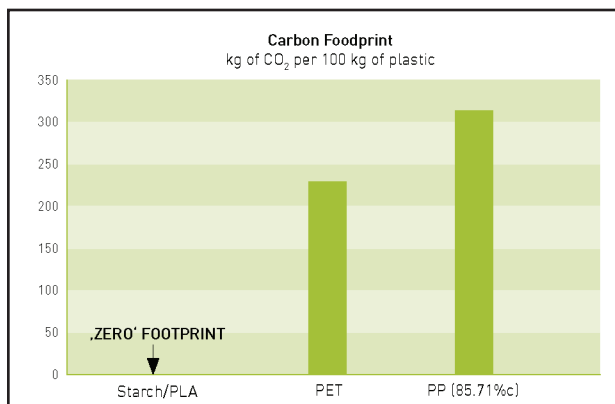


Figure 2. Intrinsic value proposition for "Bio" feedstock.

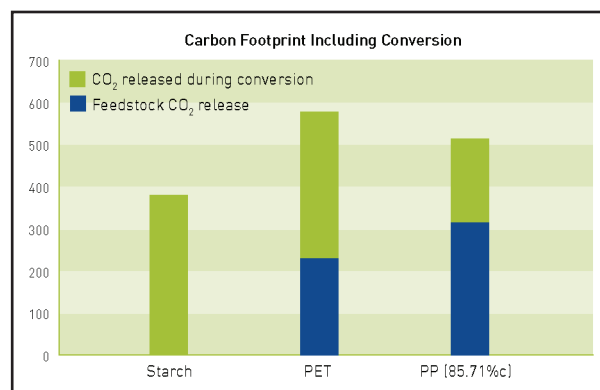


Figure 3. Intrinsic value proposition for "Bio" feedstock. (Source: E. Vink et al.)

disposal environment. Harnessing the power of microorganisms present in the disposal environment to completely (the keyword being completely) remove the plastic/product from the environment via microbial assimilation (essentially food for the microorganisms) is a safe, efficacious, and environmentally responsible way to handle our waste products – the concept of biodegradable plastics. However, one must demonstrate complete removal in one year or less via microbial assimilation in the selected disposal environment as codified in any of the ASTM D6400, EN 13432, and ISO 17088 standards. As reported by us, and clearly documented in literature, there is serious health and environmental effects if there is not complete removal (biodegradation) of the plastic from the environmental compartment.

In summary, reporting the carbon and environmental footprint of PLA, PLA based products, and similar bioplastics and biodegradable plastics requires a clear understanding of the intrinsic carbon value proposition, the use of biocarbon content to quantify this value proposition and the appropriate use of LCA tools to report on the total environmental footprint. |

*(Excerpted from a presentation at the 1st PLA World Congress, 9-10 Sept. Munich, Germany)*

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### References:


1. Ramani Narayan, *Biobased & Biodegradable Polymer Materials: Rationale, Drivers, and Technology Exemplars*; ACS (an American Chemical Society publication) Symposium Ser. 939, Chapter 18, pg 282, 2006; *Polymer Preprints* (American Chemical Society, Division of Polymer Chemistry) (2005), 46(1), 319-320
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3. R Narayan, *Proceedings "Plastics From Renewable Resources" GPEC 2005 Global Plastics Environmental Conference - Creating Sustainability for the Environment, February 23-25, 2005*



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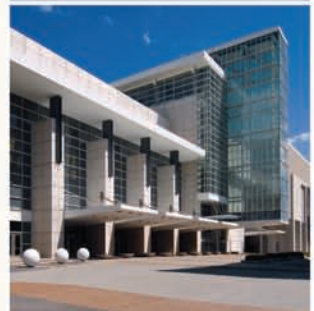
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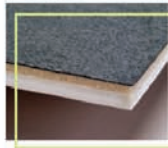
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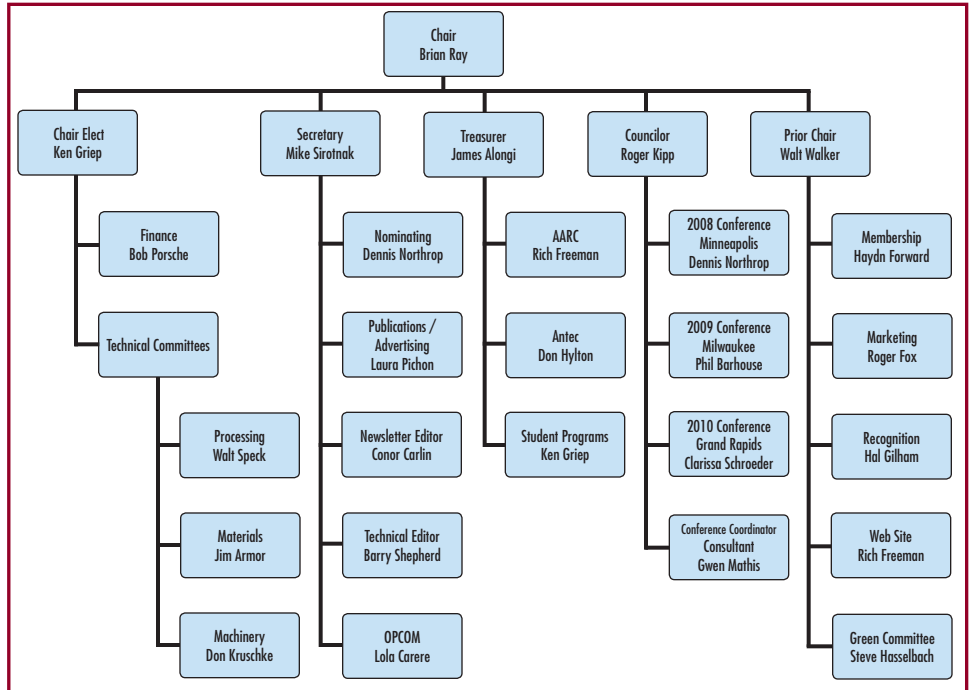
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# PlastiVan™

*Plastics Education on the Move!*



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**WONDER**



**&  
WOW!**

## **Sponsor the PlastiVan™ in Your Community**

Since 2000, the SPE Thermoforming Division has contributed approximately \$120,000 to the PlastiVan™ program.

For more information about the PlastiVan Program, contact:

Betty Coleman  
Outreach Director  
Phone: (781) 337-7127

National Plastics Center  
210 Lancaster Street  
Leominster, MA 01453  
Phone: (978) 537-9529  
Fax: (978) 537-3220  
[www.PlasticsCenter.org](http://www.PlasticsCenter.org)



The PlastiVan™ is a great way to WOW and excite young people about science and the vast opportunities the plastics industry has to offer. PlastiVans travel to schools and companies throughout North America, educating people of all ages about plastic's chemistry, history, processing, manufacturing, sustainability and application.

Plastics industry companies and other organizations are encouraged to introduce school children in their community to the marvels of plastics by sponsoring a visit from the PlastiVan. If the company chooses, time will be allotted for a company representative to address the students about their products, processes and career opportunities.

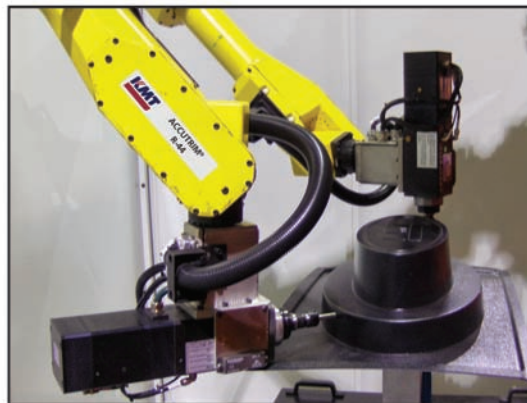
Sponsoring companies nurture the development of their future workforce by opening children's minds to careers in sciences, engineering and the plastics industry. In addition, PlastiVan benefits the sponsoring company by increasing the company's visibility in the community and often garnering local media coverage, changing the public's perception of the industry, and positively affecting the lives and minds of young people. Plus, sponsorship of a PlastiVan visit is a tax-deductible donation to the school.

For more information about the PlastiVan™ Program, please contact Betty Coleman, Outreach Director at (781) 337-7127.

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