PUT OUR TOLERANCE FOR STRESS TO THE TEST.

Perfection under pressure is our specialty.

That goes for our products, our process and our people. Slam us with wicked deadlines, shotgun short runs and complex specs. The stuff others won’t touch.

We’ll deliver on time, every time.

KYDEX®
PMC is thrilled to announce a new 20,000 square foot facility expansion to house one of the largest sheet extruders of its kind... "The Beast!"

"The Beast" will increase PMC’s operational capacity and help us to better serve our valued customers... current and new. This monster extrusion line will have the capability to produce one, two and three-ply sheet materials up to 120" wide and gauges up to .375".

Contact PMC today to place your custom plastic sheet order and reserve production time early for "The Beast's" launch in April 2011.

Contact PMC with your custom plastic extrusion needs today!

1-877.BUY.PMC6 (289.7626) | www.buyPMC.com | sales@buyPMC.com
World Class Sheet Extrusion Systems

Complex Co-Extrusion
J-Stack Roll Stands
High Output Co-Extrusion
2-Up Winding Systems
Heavy Gauge Systems
Cut Sheet Solutions
Horizontal Roll Stands
Thin Gauge Co-Extrusion

Inline | Roll Stock | Cut Sheet Solutions

2655 White Oak Circle, Aurora, Illinois 60502 | T: 630.585.5800 | F: 630.585.5855

www.ptiextruders.com
Contents

Departments
Chairman’s Corner | 2
Thermoforming and Sustainability | 22-23
University News | 24-26

Features
Industry Practice | 5
Bonding Solutions for Thermoformed Low Surface Energy Plastics

Thermoforming 2.0 | 12
The Importance of Controlling Sheet Thickness Prior to Forming: A Matter of Quality and Economics

Industry Practice | 16
Performance Products: Bonding LSE Plastics

In This Issue
Save the Date - 2011 Conference | 15
Council Summary | 28-29

www.thermoformingdivision.com
C is for Communication

During our recent board meeting held in Marco Island, Florida in February, we completed a huge undertaking that will have a great impact on how your division will look and operate. Towards the end of 2010, the division was underwriting two applications for awards through the SPE. One of these was the Pinnacle Award, which we won last year. The second was a Communications Award. During the application process for the Communications Award, we realized that a change was needed within our board.

A Communications Committee is perhaps not something you would think our board would need to establish, but what we learned over the past 6 months is that a sound communication strategy is critical to our continued success and advancement.

A communication committee will accomplish several important things for us. For example, it will provide structure and discipline for key areas that cross over all other committees. This will ensure that all groups convey the same message in content, graphics and format. It also provides the means for us to more effectively use our website that will provide our members with new and exciting details in current events, press releases and a running calendar of events, just to name a few. This committee will combine both the website and marketing committees at this time and will directly report to the past chair within our organization chart.

More importantly, the board will operate with more efficiency and provide the membership with new ways of expanding and disseminated thermoforming knowledge.

I would also like to offer an open invitation to anyone who might be interested in attending one of our board meetings. You will be able to see firsthand how hard each one of our groups work and where we explore ways to enhance our conferences and promote educational opportunities for budding young thermoforming experts. Our next board meeting will be held May 12-14, 2011 on the campus of Penn College in Williamsport, Pennsylvania. This is the same school that your board has supported through significant funding and consulting time during its development as a Plastics Center of Excellence.

If you are a machinery builder, processor or materials provider, I invite you to join us. Please feel free to contact me at your earliest so I can arrange the necessary details.

Thank you for your continued support and get the word out – Do Thermoforming!

If you have any viewpoints or comments, please feel free to contact me. I would like to hear from you!

ken@pcmwi.com
New Members

Ted Bickel
amros industries, inc.
Cleveland, OH

Bill Goldfarb
Universal Dynamics, Inc.
Woodbridge, VA

Peter Rye
Brentwood Industries, Inc.
Reading, PA

Jim Dolan
J&J Performance Powder Coating
Carlock, IL

Wendell Gabbard
Stone Plastics, Inc.
Cadiz, KY

Richard L. Partlow
Reading, PA

Marty Rodriguez
Printpack, Inc.
Williamsburg, VA

Greg Hart
Global Tool & Automation Corp.
Laotto, IN

Evan Gilham
Productive Plastics, Inc.
Mt. Laurel, NJ

Mark J. Foster
Mangar Industries, Inc.
New Britain, PA

Tara Moening
Cincinnati, OH

Jeremy Schnulle
MCHenry, IL

Michael Ravizza
CSU Chico
Chico, CA

Violet Stefanovski
Visypak Food Plastics,
Clayton, Victoria, Australia

Thomas Kivisto
Plas-Labs, Inc.
Lansing, MI

Bradley Lovelady
Formation Plastics, Inc.
Quinter, KS

Eduardo Requena
ACS
Houston, TX

Scott J. LaCourse
Big Rapids, MI

Andreas Seefried
Institute of Polymer Technology
Erlangen, Germany

Brett K. Braker
Pennsylvania College of Technology
Williamsport, PA

Dan Birschbach
Bardes Plastics, Inc.
Milwaukee, WI

Kari Malmstrom
Shirlon Plastics, Inc.
Cambridge, ON, Canada

Jeeyoung Choi
Align Technology
San Jose, CA

Bill J. Burke, Jr.
Spring, TX

Tracy C. Wolf
Innovative Plastech, Inc.
Batavia, IL

Kamal Eldin Eisa, Jr.
Octal Petrochemicals
Salalah, Oman

Laurel Graves
INVISTA S.A.R.L.
Spartanburg, SC

Dan W. Leisner
Eberle Manufacturing Co.
Wheeling, IL

John D. Manos
Rochester, NY

Andy Pavlick
Genpak LLC
Hope Hull, AL

Dave Armstrong
Fabri-Kal Corp.
Kalamazoo, MI

Stephen F. Maguire
Tray-Pak Corp.
Reading, PA

Dale A. Hogan
Visy Industries
Campbellfield, Victoria, Australia

Alan Jordan
CPT
Janesville, WI

Perry Engstrom
Arlington Heights, IL

Tom Douglas
Douglas Fabrication & Machine, Inc.

Wendell, NC
Sam Woodford
Piacon Corp.
Madison, WI

Robert D. Ward
Thule Inc.
Franklin Park, IL

William Person
Bloomfield Hills, MI

Varawong Tangitvet
vandapac
Chonburi, Thailand

Daniel J. Hribar
Plastic Ingenuity
Cross Plains, WI

Keith D. Smith
Flight Plastics
Wellington, New Zealand

Suresh Ayyasamy
GDC Inc.
Goshen, IN

Why Join?

It has never been more important to be a member of your professional society than now, in the current climate of change and volatility in the plastics industry. Now, more than ever, the information you access and the personal networks you create can and will directly impact your future and your career.

Active membership in SPE – keeps you current, keeps you informed, and keeps you connected.

The question really isn’t “why join?” but …

Why Not?
PROSPECTIVE AUTHORS

Thermoforming Quarterly® is an “equal opportunity” publisher! You will notice that we have several departments and feature articles. If you have a technical article or other articles you would like to submit, please send 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.
Bonding Solutions for Thermoformed Low Surface Energy Plastics

Shari Loushin, Sr. Technical Service Specialist, 3M Industrial Adhesives & Tapes Division, and Ted Steiner, Corporate Technical Service Scientist, 3M Industrial Adhesives & Tapes Division

Introduction

When seeking to manufacture a plastic-based part, there are more options for attaching parts together than ever before. In the past, Low Surface Energy (LSE) plastics, such as Thermoplastic Polyolefin (TPO), Polypropylene (PP), and Polyethylenes (e.g. HDPE) had to be mechanically attached or solvent welded since true adhesive bonding did not work well with these materials. Mechanical attachments (such as clips, screws, etc.) can be used with virtually any surface but they require additional steps to mold or create features for the attachment, can lead to stress concentrations which may result in plastic cracking and premature failures, and often result in unsightly surfaces. Solvent welding has the disadvantage of relying on the use of hazardous and noxious solvents.

In the past decade, new adhesives and bonding tapes have been formulated which allow robust bonding of many of these low surface energy plastics. This allows manufacturers to take advantage of the benefits of using adhesives and bonding tapes including design flexibility, stress distribution, bond dissimilar materials, use lighter/thinner materials as well as clean final bond appearance.

Bonding Fundamentals – Why LSE Surfaces are Hard to Bond

Adhesive bonding of metals, paints and plastics has been common for many years with a wide variety of adhesive technologies available, including structural adhesives (epoxy, acrylic, urethane), non-structural adhesives (hot melt, contact adhesives) and pressure sensitive adhesives (peel and stick bonding tapes). But until recently these adhesives were not used on tougher-to-bond thermoplastic materials including TPO, polypropylene and polyethylene because of their surface characteristics.

For an adhesive to be useful it must achieve adhesion to the substrate surface. Adhesion depends largely upon surface phenomena – the adhesive must flow out on and appropriately interact with the surface of the parts to be joined. The adhesive must be able to make intimate contact with the surface of the substrate. Such intimate contact is called “wetting out” the surface, and refers to the adhesive’s ability to spread over the surface. While adhesives use different mechanisms to flow and achieve contact – structural adhesives are low viscosity liquids before curing, hot melt adhesives are heated to a flowable viscosity at application, and pressure sensitive adhesives make use of their unique viscoelastic nature to flow – in all cases the ability of the adhesive to wet the surface is important. In addition to the chemical make-up of the surface, the texture, porosity, and any contamination or barriers that coat the surface of the substrate (such as mold release agents, process additives which bloom to the surface, or contaminants from handling) can affect the adhesives ability to flow and achieve intimate contact.

Even if cleaned of such barriers and contaminants, some surfaces such as TPO, PP and PE may resist (continued on next page)
being wetted by an adhesive. This is because of a phenomenon referred to as surface energy. Surface energy is the excess energy that exists at the surface (as opposed to the bulk) of a solid. This excess energy exists because molecules at the surface cannot interact with as many like neighbors as molecules in the bulk are able to do. Therefore, they have excess interaction energy.

The surface energy of a solid varies with its chemical make-up as shown in the table below. Note that metals and glass have a high surface energy and are easier to bond whereas plastics have a lower surface energy and are harder to bond. Hardest of all are the low surface energy plastics in the first several rows of the table.

<table>
<thead>
<tr>
<th>Solid Surface</th>
<th>Critical Surface Tension (mN/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polytetrafluoroethylene (PTFE; Teflon®)</td>
<td>18.5</td>
</tr>
<tr>
<td>Silicone</td>
<td>24</td>
</tr>
<tr>
<td>Poly(vinylidene fluoride)</td>
<td>25</td>
</tr>
<tr>
<td>Polyethylene (PE)</td>
<td>31</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>31</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>33</td>
</tr>
<tr>
<td>Poly(vinyl chloride) (PVC)</td>
<td>39</td>
</tr>
<tr>
<td>Nylon-6.6</td>
<td>43</td>
</tr>
<tr>
<td>Poly(ethylene terephthalate) (PET; Polyester)</td>
<td>43</td>
</tr>
<tr>
<td>Aluminum</td>
<td>–500</td>
</tr>
<tr>
<td>Glass</td>
<td>–1000</td>
</tr>
<tr>
<td>Iron Oxide</td>
<td>–1350</td>
</tr>
</tbody>
</table>

**Surface energies of common substances.**


A related concept is the surface energy (or surface tension) of a liquid, which is the amount of excess energy at the surface of the liquid. Surface tension exists because molecules in the bulk liquid are in a lower energy state than at the surface. When a liquid is placed on a solid surface what happens depends on the relative surface energy of the liquid compared to the surface energy of the solid. If the liquid has a higher surface energy than the attractive forces between the liquid and the solid surface, the liquid will prefer to maintain its spherical form. Raindrops bead up on a freshly waxed car because the surface energy of the water is higher than that of the wax. When this phenomenon happens between an adhesive and a substrate the adhesive will not spread and make intimate contact with the surface to be bonded; rather, the liquid molecules will tend to remain associated with themselves rather than the surface. The result is lower bond strengths. In contrast, if the surface energy of the adhesive is less than that of the substrate the adhesive will spread out and wet the substrate thus making the intimate contact necessary for good bonding.

Therefore, high surface energy (HSE) materials such as metals and glasses can be readily bonded with a variety of adhesives which will be strongly attracted to the solid. Medium surface energy (MSE) materials such as Polyester and PVC can be bonded with many adhesives, but low surface energy (LSE) materials are very difficult to bond. “Wet-out” becomes a challenge unless the surface is modified, since the unmodified surface has such a low surface energy. The surface energy of the liquid adhesive is likely to be higher than the surface energy of the solid.

While some adhesives are available to bond LSE materials, another strategy is to use surface modification techniques which can change the chemical composition of the surface to increase the surface energy and allow a broader number of adhesives to be considered. These techniques include **(continued on next page)**
flame, corona or plasma treatment, acid etching or use of solvent based adhesion promoters that contain higher surface energy resins which entangle with the low surface energy substrate when the solvent swells the surface. Once the surface is modified it is easier for the adhesive to flow out on or wet the treated surface and make a suitable bond. While surface modification might be needed in some cases, typically it will add cost, complexity and may present environmental or safety issues.

Increase in surface energy of Polyethylene after several common surface treatment methods.


**New Methods for Bonding LSE Plastics**

Technology has advanced to the point where adhesives are available that are capable of high performance bonding to LSE substrates such as TPO, PP and PE without surface treatment. Easy to use adhesion promoters are also available as a companion to some adhesive product types to increase the strength and broaden the selection.

**Structural Adhesives**

3M™ Scotch-Weld™ Plastic Adhesives DP8005 and DP8010 are uniquely formulated to bond to LSE plastics (as well as high surface energy plastics and metals). These are two-part, solvent-free, room temperature curing adhesives that come in convenient duo-pak format or, for large applications, in bulk. They resist many chemicals, water, humidity and corrosion. Generally surface preparation is limited to solvent cleaning (to remove surface contaminants). Sometimes, light abrasion or a matte finish on the bonded surfaces can increase bond strengths.

Adhesion strength of structural adhesives such as DP8005 and DP8010 is usually characterized using an overlap shear test. Substrates are bonded together with a controlled overlap and the adhesive is allowed to cure. After cure the adhesive bond is pulled in the shear mode at a constant rate and the peak force to break is measured. By convention an adhesive is considered structural if it is capable of achieving greater than 1000 psi break strength in the overlap shear test. To achieve this level of break strength the adhesive must have high adhesion strength to the substrates.

DP8005 and DP8010 create structural (greater than 1000 psi overlap shear) bonds to low surface energy plastics without pre-treatment. Below are some representative overlap shear bond strength data for DP8005 and DP8010 on common plastic substrates including LSE plastics. Note that with several substrates tested the substrate itself was not strong enough to support the 1000 psi load and the substrate failed before the adhesive to substrate bond did.
Bonding strength of DP8005 and DP8010 on some common plastics.

SF: Substrate Failure; CF: Cohesive failure; AF: Adhesive Failure

Bonding strength of DP8005 and DP8010 on HDPE after various environmental challenge conditions.

Hot Melt Adhesives

Hot melt adhesives may also be used to bond lightweight thermoplastic pieces. These adhesives have the advantage of providing quick tack and handling strength, thus speeding production. These adhesives combine high heat resistance with relatively high strength and low creep. These products can provide benefits to manufacturers who can trade off heavy duty bonding for faster production speed in applications such as POP displays; sample boards and tabletop displays; exhibitor booths; foam inserts to carrying cases; fabric or paneling to foam; and molded reinforced plastic to fabric or fascia for furniture and automotive interiors.

Pressure Sensitive Adhesives

Pressure sensitive adhesives are unique in that they do not cure or undergo a chemical change when applied. Pressure sensitive adhesives are viscoelastic materials that exhibit both viscous (flow) and elastic (resistance) properties at the same time. When the adhesive is put on the substrate typically in tape form and pressure is applied the adhesive makes immediate contact for initial adhesion but continues to flow onto the surface to achieve increased contact and a higher level of strength over time.

One advantage of pressure sensitive bonding tapes is that the bond is immediate so there is no clamp or cure time. They are also unique in that you do not have to bond the adhesive to both substrates at the same time. The tape can be applied to the first substrate one day and to the second substrate the same day, the next day, or weeks later. This brings added convenience and can be a benefit for many applications including assembly line processes. In particular, acrylic pressure-sensitive adhesives provide the best balance of adhesion and performance properties for many applications, but generally do not bond to LSE plastics.

(continued on next page)
Relatively new acrylic PSA technology now bonds to a wide variety of LSE plastics while maintaining excellent high-temperature and chemical resistance and high-peel strength. This technology is available as an adhesive transfer tape and as a double-coated tape. It works in light to medium-weight bonding applications such as bonding nameplates to LSE plastic parts or bonding carpet onto polypropylene door panels.

Very high strength bonding tapes are available and are used for a variety of applications previously reserved for mechanical fasteners or structural adhesives. These tapes are acrylic foam construction and have viscoelastic characteristics throughout the product. The foam absorbs energy to provide high strength and relaxes stress to protect the bond. The tape allows, rather than fights, movement between parts. A high level of tape to substrate adhesion is required for the foam to allow relative movement of the parts without coming de-bonded at the tape to substrate interface.

While some tapes are available for lightweight bonding on some LSE plastics, generally the acrylic foam tapes do not have high enough adhesion strength to LSE plastics without additional surface modification. Easy to use brush on primer is available to give very high tape to substrate adhesion on some LSE plastics.

Strength of pressure sensitive bonding tapes is typically characterized using a peel adhesion test. Shown below is 90 degree peel adhesion data for 3M™ VHB™ 4952 tape on four grades of TPO with different surface preparation techniques.

High strength bonding tapes are typically used for bonding panels to frames, bonding stiffeners to panels, and bonding decorative overlays, scuff and rub strips. (See chart below.)

**Summary**

New tape and adhesive technologies that bond to LSE plastics offer increased efficiency, reduced costs, and improved design flexibility when using these versatile and popular plastics for manufacturing a variety of products. The use of these materials enables the use of lower cost and thinner plastics. It also allows for joining dissimilar substrates. Examples include bonding thermoformed bumpers to metal; vehicle seats, toppers and accessories; binning strips, architectural panels; plastic lumber; signage; transport cases; protective armament, and many others.
Need help with your technical school or college expenses?

If you or someone you know is working towards a career in the plastic industry, let the SPE Thermoforming Division help support those education goals.

Within this past year alone, our organization has awarded multiple scholarships! Get involved and take advantage of available support from your plastic industry!

Here is a partial list of schools and colleges whose students have benefited from the Thermoforming Division Scholarship Program:

- UMASS Lowell
- San Jose State
- Pittsburg State
- Penn State Erie
- University of Wisconsin
- Michigan State
- Ferris State
- Madison Technical College
- Clemson University
- Illinois State
- Penn College

Start by completing the application forms at www.thermoformingdivision.com or at www.4spe.com.

High Speed Trimming and Modeling

5-Axis CNC Technology...the Next Generation

- High Performance, Fast, Smooth and Accurate Motions
- Next Generation CNC Control Motion Technology
- Advanced Control Communications with On-line Support
- 3-D Laser Volumetric Accuracy Compensation
- Wide Variety of Machine Sizes and Options
- Available with Dust/Chip Containment Systems

Thermwood
First in CNC Routers

P.O. Box 436, Dearl, IN 47523 800-533-6901
www.thermwood.com

REDUCE! REUSE! RECYCLE!

Thermoformer Parts Suppliers

TPS Inc; 3818 Terry Diane; Beaverton, MI 48624

www.thermoformerparts.com

Ph. 800-722-2997
Fax 989-435-3825
tps@ejourney.com
Polymers and Plastics for the Electronics Industry
Monday, May 2
Dr. Young Kim
Samsung Advanced Institute of Technology, Samsung Elec. Co., Ltd.

Innovations in Engineering - SABIC Approach to New Materials and New Applications
Tuesday, May 3
Tom Stanley
Vice President, Technology, SABIC Innovative Plastics

Industry Dynamics Impacting the Resin Supply Chain
Wednesday, May 4
Howard Rappaport
Global Business Director, Plastics, Chemical Market Associates, Inc.

Reasons to attend:
- 3 New Technology Forums
- NEW special sessions on Fundamentals, Regulatory, OSHA and Design
- Hundreds of technical presentations in 40 different areas of plastics
- Networking opportunities and live updates for first-time attendees, SPE Facebook® and LinkedIn® members, and ANTEC Twitter® followers
- Consultants Corner*: Bring your challenge or problem, and consult with an expert in your area—for FREE!

* by appointment only

Visit www.antec.ws for more information and to register.
The importance of pre-thinning for uniform wall thickness and pre-shaping the hot sheet before forming is something many thermoformers understand. However, they do not appreciate how many advantages can be gained if the process is done properly and completely. Where do we begin to discuss such an important subject? Let us start at the beginning with the customer’s design, drawings and software.

The end customer will often include in the title block information, or specifications, their requirement for the material they need, including starting sheet thickness. This is the worst possible thing they can do because one thermoformer, using the indicated material, will form a part with quite variable thicknesses across the part while another will obtain a part with very reasonable uniform thickness. The difference, of course, is the variation in machinery, tooling, and techniques used, and/or a large difference in experience and knowledge between the two companies. Each processor can give the customer what they asked for – the starting sheet thickness as stated on the drawings – though the less-qualified former will deliver a suboptimal part due to thinning, which fails to meet the requirements for part performance. On the other hand, a modern, experienced, quality operation will deliver a part with minimum thickness that exceeds the customer’s need. The part designer should instead indicate the minimum thickness required at specific areas of the part and let the manufacturer decide the starting thickness of sheet.

In this article, I am going to look at some thermoforming problems created in part design, how they were solved and how they saved the customer money while increasing margins for the processors.

Identifying and Classifying Problems

A major problem for formers of refrigerator liners and other similar shaped parts is the formed grooves in the sides and tops of the molds that create the shelf supports inside the finished part. As the material flows over the mold, it first touches the sides and top surfaces of the mold and begins to cool. This increases the hot strength of the material causing it to stretch less and thin more as it flows into the three sides of the recesses. The worst part is where the bottom of the recess meets the platen and now the material must thin even more to cover four surfaces.

The solution is to pre-shape the hot sheet into this configuration before allowing the sheet to be formed onto the mold. In this

(continued on next page)
way we are using hot sheet with less hot strength to cover the area, thus yielding a thicker finish in the part.

In the 1960’s and 1970’s, thermoformers were advised to not stretch the hot sheet over an area greater than 3 times the sheet area. This was due to a lack of ability of the hot sheet to stretch beyond this ratio. Over the last 30 years, new additives that were not previously available have become standard in most thermoformable sheet that allow for greater elongation, hot strength, and impact strength. Today it is not unusual to stretch the hot sheet to 6 or 7 times its starting area. Also, with additional butadiene rubber in the styrene and ABS groups, you will retain higher impact strengths when the additional stretching is needed.

With this information in mind, you can now build the pre-draw box just 1/4 to 3/8 inch higher than the mold and pre-draw the hot sheet all the way up into the pre-stretch box until it hits the top of the box and forms over the inserts. This will give a rectangle shape to the hot sheet more comparable to the shape of the mold and will have pre-formed the areas in the slots on the mold, leaving greater thickness. Without the use of a pre-draw box or if the pre-draw of the hot sheet is only 40-50% of the mold height, the mold will impact the sheet too soon. The material will begin to chill and will be thicker on the top, leaving chill marks on the upper sides while stretching the sheet down the sides which will become too thin in many areas.

The theory of a platen size of the area of the mold plus a margin of 40 to 50% of the mold height, all around, is not as functional as a smaller platen, and a thicker sheet; using a pre-draw box. A margin of 2 to 4 inches around the mold, depending on the mold height, is preferred.

To prevent webbing at the corners of the mold, it is recommended that a chamber be added in each corner of the pre-draw box. This will cause the hot sheet to spread along the sides during pre-form and be pulled out of the sharp corners of the box.

For any application, the pre-draw box should have large windows on the front and the rear sides. They both will allow light to enter the box and the front will allow a good view of the hot sheet pulling into the box, allowing the processor to monitor the process.

Controlling Vacuum

There is always the question of controlling the vacuum that allows the sheet to be pushed into the pre-draw box to just the right height. The best and most consistent way is to drill a series of small holes (.040” diameter) in the sides and top of the box which will reduce the full vacuum resistance in the box. Set the box up in the machine with a full vacuum, and using a properly heated sheet, test the depth of the pre-draw bubble. If it draws too far, drill a few more holes, and try another hot sheet until it is correct. If the sheet does not draw far enough, cover some of the holes with masking tape, and try again. When it is just right, fill the covered holes with silicone sealer for a permanent seal. Each time you set up the mold and pre-draw box, and properly heat the sheet, you will have the correct setting for the vacuum required to draw the proper bubble every time without changing the vacuum setting.

Addressing Design Challenges

Another problem found in design is a part with a deep
and/or irregular cavity or cavities in the top of the part. Build a plug or plugs close to the size and shape of the cavity or cavities and insert it or them in the proper position in the pre-draw box.

When you pre-draw the hot sheet into the box to its full depth over and around the plugs, then move the mold into the box and draw the vacuum, the cavity or cavities will be formed with maximum possible thickness of material.

When facing the problems of part design of varying heights and irregularities of shape, it is important to use profile heating to create areas of higher and lower temperature in the sheet at time of forming. Create hotter areas where you need greater stretching and cooler areas where you need less.

Combine this heating technique with dividing walls within the pre-draw box to create a hot sheet shape comparable to the mold configuration before forming.

To help maintain the material texture, cover the plugs, walls, and pre-draw box inner top with felt cloth or felt rubber sheeting. These materials will cushion the texture, and draw very little heat from the sheet before you pull the vacuum and form the part.

Using variations of these forming techniques should help any thermoformer to compete for almost all business that comes their way.

Remember, being competitive is not just meeting the other bidder’s price!!

Being truly competitive is meeting the price while being productive enough to build quality parts and retain a fair profit.
20th Annual Thermoforming Conference
September 17-20, 2011
Welcome Back to Chicago!

Renaissance Hotel
Schaumburg, IL
(20 minutes from O’Hare Airport.)
For Reservations: 1.800.468.3571 or 847.303.4100
Request SPE Room Rate of $159.00

Chairman
James Alongi
MAAC Machinery
630.665.1700
jalongi@maacmachinery.com

Conference Coordinator
Gwen S. Mathis
706.235.6298
gmathis224@aol.com

Technical Chairman
Paul Alongi
MAAC Machinery
630.665.1700
paul@maacsales.com

Heavy Gauge Technical Chairman
Jay Waddell
Plastic Concepts & Innovations
843.971.7833
jwaddell@plasticconcepts.com

Roll Fed Technical Chairman
Mark Strachan
Global Thermoform Training, Inc.
754.224.7513
mark@global-tfi.com

Parts Competition
Bret Joslyn
Joslyn Manufacturing
330.467.8111
bret@joslyn-mfg.com

Registration and Exhibitor sign up information is available on our website (www.thermoformingdivision.com)
Check out our plant tours and sign up early to assure yourself an opportunity to be on the limited visitor list.
Performance Products: Bonding LSE Plastics

Michael Merwin, Market Development Specialist, FlexCON, Spencer, MA

Abstract

When working with low-surface-energy materials, it is important to match the durability of the manufactured material with an adhesive that can meet the demanding requirements of the finished product. One of the biggest challenges in bonding to low-surface-energy plastics, specifically thermoplastic polyolefins (TPO), is that in most cases they have traditionally required a pre-treatment for permanent adhesion.

What is Surface Energy?

In liquids, the molecular layer at the boundary where the surface of one material meets a second material (such as liquid to solid or liquid to air) is different than the constituent molecules beneath the surface. This difference is the result of an imbalance between the intermolecular forces. Example: a molecule of water beneath the surface is surrounded by other water molecules in the X, Y, and Z directions. The molecule of water at the very surface has no water on top. This imbalance causes the top water molecules to pull closer together (laterally). This phenomenon is referred to as “surface tension.” Surface tension plays a role in water beading up on a freshly waxed car, water bugs walking on water, and people water-skiing.

A similar effect occurs in solids, but is often referred to as “specific surface energy” and is usually measured as a distortion of a drop of a liquid on the test surface of the solid in the form of a “contact angle” (see Figure 1). For a given liquid with its own surface tension properties, the lower the contact angles, the higher the specific surface energy of the solid material. Conversely, the higher the contact angle, the lower the specific surface energy of the solid material. Pressure-sensitive adhesives are viscoelastic in nature. As such, their degree of surface contact will depend on the specific surface energy of the substrate to which the adhesive is being applied.

Figure 1.

A demonstration of this principle is the ease of removal of the protective liner from a bumper sticker or band-aid. The liners are often silicone-coated. Silicones have very low surface energies, in the 22-24 dynes/centimeter (common units of surface energy) range, compared with most PSAs,
9 MODELS OF THERMOFORMERS

INDUSTRY’S LARGEST THERMOFORMER - A MAXIMUM 65” X 67” MOLD

7 MODELS OF THE VERTICAL & HORIZONTAL TRIM PRESS

• Innovative, Quality Engineering
• Superior Technology Results in Unequaled Performance
• Industry’s Top Service and Support Team
which are between 30 and 36 dynes/cm. The silicone-coated liner presents a difficult surface for the PSA (a viscoelastic liquid) to make surface contact (or “wet-out”). This results in low adhesion to the liner – so low that these protective liners are often referred to as “release liners.” Figure 2 illustrates the “Specific Surface Energies” of some common materials. Materials such as the fluorocarbons and silicone, normally thought of as “non-stick” surfaces, have very low specific surface energies and so are difficult to adhere to. TPO falls in the category of low surface energy. Materials such as copper, aluminum, and tin, which have high specific surface energies, are generally known to be easy to adhere to.

Adhesives for Adhering to LSE Surfaces

High-performance adhesives have become an increasingly important pressure-sensitive bonding solution, responding to market trends that not only include increased use of low-surface-energy plastics, but also:

• Harsher end-use application environments
• Unusual product shapes that require adhesion to curved surfaces

Traditional solutions offered for applying adhesives to TPO included abrading, priming or flame treating. These processes are time consuming and can damage the surface of the plastic. Abrading the surface can require an increase in the thickness of the adhesive. This is necessary in order to get the product to “wet out” into the plastic. The increase in thickness increases the cost of the adhesive and also increases the amount of attention that must be paid to the pressure of application. Priming and flame treating are also intended to “damage” the surface in an effort to raise the level of surface energy. These processes also change the appearance of the TPO area. (See chart below.)

Adhesives designed for use with TPO allow the processor to avoid interim steps. They are required only to wash the area with an IPA/water (50/50 mix) to remove dirt or mold releases. Adhesive designed for TPO can increase the adhesion of the product significantly.

High-performance adhesives are an effective solution where a general purpose, removable, or aggressive adhesive cannot quite meet the demands.
of the application. High-performance adhesive provides performance for a specific function or in a specific environment. It is not necessarily a high performer in all situations. There are high-performing adhesives specifically designed to withstand the service temperature extremes of automotive or electronic components. That same adhesive may not provide high performance in resisting the effects of, for example, long-term UV exposure or chemicals. It is important for the user to ask a series of questions about the product on which the adhesive will be used, the industry it will service, product performance expectations, surfaces receiving adhesives, the size, texture, and shape of the application surface. Other questions can include environmental concerns, temperatures, type of processing equipment, and processing parameters of the customer’s equipment.

PSA Selection and the Ins and Outs of Shear, Tack and Peel

To put the benefits of adhesives to work means a complete understanding of the product design, its intended use and the substrates earmarked for adhesion.

Considerations include the role of key physical adhesive properties – shear, tack and peel – when deciding on the best adhesive system. Within the realm of PSAs, there are four main polymer families: acrylic, emulsion, rubber, and silicone. Each offers particular characteristics for particular applications.

In most cases, acrylic adhesives provide the widest range of performance characteristics, with an operating range of -40°F to more than 450°F.

Any one of the aforementioned adhesive types can be customized to meet virtually any adhesion need. Shear adhesion is the force required to move a PSA from a standard flat surface in a direction parallel to the surface to which it has been affixed with a definite pressure. It is measured in terms of the force required to pull a standard adhesive from a test panel under a standard load. Usually, tack and adhesion performance decrease as shear strength increases.

The ASTM D 3654 Method A (1 hr. dwell, 1 sq. in, 4 lb. load) indicates that low shear is less than 10 hours, while medium shear is 10 to less than 100 hours. High shear is determined by measurements of more than 100 hours.

Tack is a measure of the force required to remove, say, a foam gasket and its adhesive from the substrate. It usually refers to the measure of initial attraction of the adhesive to the substrate. The degree of tack is a function of adhesive components. It can be and is controlled by manufacturers to create different products based upon end user requirements.

According to the ASTM D 2979 standard, very low tack ranges from 0 to 100 grams per square centimeter (g/sq.cm), while low tack is up to 400 per g/sq.cm. Medium- to medium-high tack ranges from 401 to 700 g/sq.cm, while high to very high tack ranges from 701 to more than 801 g/sq.cm.

High tack is equally important with the use of low-surface energy plastics and metal among OEM design and production engineers for a host of products, ranging from automobile components to durable medical devices to sound-damping materials.

Peel is the measure of bond strength between an adhesive and a substrate. The degree of adhesion can be and is controlled by manufacturers to create different products based upon end user requirements.
requirements. Adhesion will continue to increase for a period of time from the moment of application, typically 24 hours.

Peel readings are generally taken at angles of 90° and 180°. Used to measure the force required to overcome an adhesive bond, the peel test is heavily influenced by the targeted surfaces for adhesion. In films, for instance, both caliper and tensile strength will have an impact on the measured adhesion. A peel measurement allows application designers to determine whether an adhesive will be able to resist an anticipated force that may work against the adhesive bond.

According to the ASTM D 903 standard (modified for 72-hour dwell time), very low to low peel is 0 to 34 ounces per inch (oz./in.), while medium to medium-high peel is 35 to 74 oz./in. High to very high peel is 75 to more than 95 oz./in.

Applications

Minimum and maximum tolerances will ultimately determine the right PSA for a given application, which can vary from efficient and cost-effective assembly assist to intricate and fortified disk drive construction to automobile and aerospace components. In fact, in many cases, the use of an adhesive over more traditional bonding and mounting technologies can be more practical, cost-effective and yield a better product.

The Brown Advantage

Poised to serve you better than any other thermoforming company in the continuous and cut sheet markets...from entry level to total turn-key thermoforming systems.

At Brown we’re more than machines. We’re people who love a challenge.

Let our Process Engineering Team and our Machinery & Tooling Group discover the best process and machine combination for you.

Contact us today at www.brown-machine.com or call 989.435.7741

Brown Machine, LLC

REDUCE! REUSE! RECYCLE!
Become a Thermoforming Quarterly Sponsor in 2011!

Additional sponsorship opportunities will include 4-color, full page, and 1/2 page.

RESERVE YOUR PRIME SPONSORSHIP SPACE TODAY.

Questions? Call or email Laura Pichon Ex-Tech Plastics 847-829-8124 Lpichon@extechplastics.com

BOOK SPACE IN 2011!
The End of Life of Bioplastics
Gaelle Janssens, Environmental Affairs Manager, PRO Europe, and Attilio Caligiani, Consultant, Weber Shandwich (Brussels, Belgium)

About Bioplastics
PRO EUROPE (Packaging Recovery Organization Europe), the umbrella organization for the packaging and packaging waste recovery schemes which mainly use the Green Dot trademark, is convinced that waste and resource management is at the forefront of a new economy. This economy is being called upon to answer increasingly wide-spread environmental issues, notably those driven by mainstream concerns over climate change, and the financial crisis.

A few years ago the general opinion about bio-packaging would have meant speaking in terms of biodegradable packaging. Nowadays, the evolution of packaging sees a more focused view on the renewability of resource rather than just on biodegradability. So composting of biopackaging is far from being the only possibility for end-of-life. Many different ends-of-life exist for biopackaging. The choice of a particular option depends on the collection and treatment infrastructure available. Just because many types of biopackaging are compostable, it does not mean that composting is the best option from an environmental, logistic, or economic perspective. Based on environmental study, it is the opinion of PRO EUROPE that bioplastic recovery is better than composting.

End of Life of Bioplastics
Depending on the country, if the bioplastic products comply with the sorting instructions, bioplastics are selectively collected according to type. The possible end-of-life options are recycling, incineration, composting or landfill. Recycling is possible with traditional polymers made from renewable resources, e.g. bio PET, bio PE, etc. For other innovative polymers the prerequisites are adapted sorting equipment, good quantities of high quality homogenous material, an existing and sustainable recycling infrastructure, and end-user outlets. It should be mentioned that blended materials cannot be optically sorted and some polymers might bring a risk of contamination of recycling processes (e.g. if PLA enters the process of recycling PET. Both materials have a similar appearance and automatic sorting as used to sort PP or PVC from a PET recycling stream is not currently installed at all recycling facilities). Another possible end-of-life option is gasification or incineration with energy recovery – for the environment, a better solution than composting. Note that incineration with energy recovery is already used in some countries as a way of treating residuals after sorting. The third end-of-life option in this scenario is organic recycling or composting, a possible solution whenever the packaging is mixed with organic waste (e.g. food waste, kitchen waste, yard waste, etc.) in proper recovery infrastructure. The last end-of-life solution is landfill, which is the least preferable solution.

If bioplastics are thrown into the residual waste bin, they will end their life in landfill (worst option) or be incinerated to provide energy recovery. From the authors’ point of view, incineration is a better environmental option than industrial composting. It is already used in some countries to treat the residual waste. Only a small minority of citizens have access to organic waste
collection. For this scenario, the authors think that composting is not as good for the environment as energy recovery (gasification or incineration). Moreover, new collection and treatment infrastructure is needed to handle organic packaging. A test shows that the quality of the compost (and its end value to the market) would go down because of sorting mistakes made by consumers. There are also implied additional costs in adapting existing infrastructure and to manage residual waste.

**The Sustainability of Bioplastics**

As previously mentioned and based on environmental study, the authors think that bioplastic recovery is better than composting. But even if bioplastics are frequently described as being environmentally superior to traditional plastics, the authors do not agree that this is always the case. As said before, being biodegradable or biomass-based doesn’t automatically mean being ecologically friendly or sustainable. This must be verified on a case-by-case approach.

When considering the problem of litter, we can say that biodegradability does not necessarily resolve this issue. Litter must be dealt with at the source; it is a social problem. Biological degradation can mitigate the problem, but without specific and necessary conditions (micro-organisms, temperature and humidity) it can be very slow.

Furthermore, bioplastics could theoretically add to the problem of litter if supported by a belief that they all just “break down and disappear” after disposal. For this reason, we must take care to educate the consumer properly.

It often happens that consumers are confused by all the different labels printed on bags, boxes and bottles describing packaging as “biodegradable” or “home compostable” or even “biopackaging.” Even if consumers react very favorably to these ideas, most do not associate them with the required actions. There is a need to regulate and provide clear communication on both labels and in the instructions for sorting plastics.

Other important factors are education and instruction. Material producers, converters and retailers that use these new materials have a responsibility and a duty to introduce them in a conscientious and regulated manner, so that previous education programs aimed at promoting recycling and the prevention of waste are not diminished.

*Reprinted with permission from “Bioplastics Magazine.”*
Alliance with Education
Gettysburg High School, Gettysburg, PA
Roger Kipp, McClarin Plastics, Inc.

“A school’s goal is to develop interests and open new avenues for students to explore,” said Dave Snyder, Co-Chair of the Career and Technology Department at Gettysburg High School.

In order to stimulate workforce development in manufacturing, and to further the interest of the next generation in plastics manufacturing jobs, industry must provide the pathway to our technology. Educational facilities including, universities, junior colleges, technical institutes, and high schools all connect to that development. An alliance with those programs is vital to our sustainable growth and success.

In 2008, with support from a SPE Thermoforming Division Equipment Grant, a generous discount from MAAC Thermoforming Machinery, and additional federal funding, a thermoforming work cell was created to expand the school’s Engineering Design course incorporating thermoforming technology into the course content as part of a 6-week group challenge.

Thermoforming is introduced as an application of material engineering and industrial systems engineering. The students explored manufacturing and product development by thermoforming on the MAAC machine, developing design in CAD and creating manufacturing programs for CNC robotic mold machining and part trimming. In the plastics activity they are encouraged to use existing molds to test characteristics of different plastics and explore thermal variables that affect part production. The machine settings, temperatures and results are recorded and used as part of the research and investigation step in the production of prototype parts.

Remote Control Boat
As an independent study course, 2011 senior Kevin Ohler designed and built a remote control boat. The boat hull was modeled after an off shore racing hull. Kevin designed the hull using Autodesk Inventor. He then created the necessary tool paths and machining codes using Master Cam to allow the ShopBot CNC router to cut the mold for thermoforming on the MAAC machine. Kevin then drilled the necessary vacuum evacuation holes in the mold and constructed the vacuum box. Todd Chrismer, Production Manager at McClarin Plastics, assisted Kevin with his hull mold design and provided the students with valuable tips on industry thermoforming practice.

Giant Combination Lock
In another independent study course, Logan Riser and Ryan Dudash reverse engineered a working lock that is 6 times larger than a standard Master lock. The students unassembled several Master locks to understand how a lock functions. Then they created the necessary tool paths and machining codes with Master Cam to complete machining of the thermoforming molds with the ShopBot router. With this project the ShopBot was also programmed for trimming the thermoformed components. The lock’s external body was thermoformed utilizing draw box processing techniques. The giant white hasp was fabricated from PVC pipe. The students built a wooden form to bend the pipe around. They then filled the PVC pipe with sand and heated it using the MAAC oven. Once the pipe softened the students armed with welding gloves removed the pipe from the carriage and bent it around the wooden form.

Remote Control Car
One of the group options for the 6 week program is the popular Penn College Plastics Engineering RC Car competition in Williamsport, PA. The students are challenged to create a 1/18th scale body for a LOSI radio controlled toy race car. In this exciting engineering challenge the students produce...
the vehicle body using the thermoforming process. They are expected to complete the necessary engineering research, CAD drawings and molds, all to be incorporated into their final formal presentation. During production of the car a group of 4 or 5 students assign team member responsibilities, set and evaluate progress to goals, use Auto Cad to design, Master Cam to machine and trim, and develop presentations in PowerPoint. All in addition to the discovery of dealing with sheet thermoforming and the related polymer characteristics. This year, four groups have completed the thermoforming challenge with a focus on competing in Williamsport this spring. This is a unique opportunity for high school students to utilize industrial equipment at a level of technology and competition.

The Thermoforming Division can be proud of the Gettysburg students and the way they have utilized the Division’s grant to trigger their ideas for a future in manufacturing, preferably one that includes thermoformed plastics. The pictures accompanying this article further document the amazing success of these projects.

**Thermoforming Center of Excellence Receives Innovation Grant**

Released January 10, 2011

Pennsylvania College of Technology’s Plastics Manufacturing Center was recently awarded an Innovation Grant from the Pennsylvania Department of Community and Economic Development.

The $100,000 grant will fund the hiring of a thermoforming program manager to help lead the PMC’s Thermoforming Center of Excellence, providing project management to the center’s industry clients and helping to develop curriculum for the college’s plastics program.

The Thermoforming Center of Excellence, opened in April 2010, is an 1,800-square-foot facility dedicated to serve the education, training, and research and development needs of thermoformers, sheet extruders, resin suppliers, mold builders and equipment manufacturers.

It represents the only state-of-the-art Center of Excellence for research and development and education for the thermoforming industry in North America. It greatly enhances Pennsylvania’s infrastructure to serve local industry and its competitiveness for attracting outside companies to locate in the commonwealth Keystone Innovation Zones.

On November 30, Pennsylvania announced 14 Innovation Grants, totaling $1.3 million, to its colleges and research facilities to help bring Pennsylvania-made technologies to market. The investments will leverage an additional $1.6 million in outside funding.

Since the Innovation Grant program began in 2006, the state has invested more than $12.7 million in Pennsylvania’s research institutions. Because of the program, 523 well-paying, high-skilled jobs and 91 startup companies have been created, and more than 1,500 technologies have been developed.

The Innovation Grant and the Keystone Innovation Zone programs are funded through the Ben Franklin Technology Development Authority – one of the nation’s largest and most replicated state technology-development programs that provides a vehicle for investment in economic-, community- and university-based innovation. Its programs are a key component of DCED’s strategy and mission.

The Penn College Plastics Manufacturing Center is one of the top plastics-technology centers in the country. It offers industry access to extensive material-testing laboratories, industrial-scale process equipment, world-class training facilities and highly skilled consulting staff.

See photos on page 26
Alliance with Education ... continued
Gettysburg High School, Gettysburg, PA

Boat hull mold ready for forming.

Chad Love and Todd Chrismer from McClarin Plastics, Inc., Steven Shetter, and Kevin Ohler prepare to form a boat hull.

Master lock outer body shell – side view.

Master lock design and build team – Logan Riser and Ryan Dudash.

Kevin Ohler drills vacuum holes in the hull body mold.

From the Editor

If you are an educator, student or advisor in a college or university with a plastics program, we want to hear from you! The SPE Thermoforming Division has a long and rich tradition of working with academic partners. From scholarships and grants to workforce development programs, the division seeks to promote a stronger bond between industry and academia. Thermoforming Quarterly is proud to publish news and stories related to the science and business of thermoforming:

- New materials development
- New applications
- Innovative technologies
- Industry partnerships
- New or expanding laboratory facilities
- Endowments

We are also interested in hearing from our members and colleagues around the world. If your school or institution has an international partner, please invite them to submit relevant content. We publish press releases, student essays, photos and technical papers. If you would like to arrange an interview, please contact Ken Griep, Academic Programs, at: ken@pcmwi.com or 608.742.7137
Executive Committee
2010 - 2012

CHAIR
Ken Griep
Portage Casting & Mold
2901 Portage Road
Portage, WI 53901
(608) 742-7137
Fax (608) 742-2199
ken@pcmwi.com

CHAIR ELECT
Phil Barhouse
Spartech Packaging Technologies
100 Creative Way, PO Box 128
Ripon, WI 54971
(920) 748-1119
Fax (920) 748-9466
phil.barhouse@spartech.com

TREASURER
James Alongi
MAAC Machinery
590 Tower Blvd.
Carol Stream, IL 60188
(630) 665-1700
Fax (630) 665-7799
jalongi@maacmachinery.com

SECRETARY
Mike Sirotnak
Solar Products
228 Wanaque Avenue
Pompton Lakes, NJ 07442
(973) 248-9370
Fax (973) 835-7856
msirotnak@solarproducts.com

COUNCILOR WITH TERM ENDING ANTEC 2010
Roger Kipp
McClarin Plastics
P. O. Box 486, 15 Industrial Drive
Hanover, PA 17331
(717) 637-2241 x4003
Fax (717) 637-4811
rkipp@mclarinplastics.com

PRIOR CHAIR
Brian Ray
Ray Products
1700 Chablis Avenue
Ontario, CA 91761
(909) 390-9906, Ext. 216
Fax (909) 390-9984
brianr@rayplastics.com

2010 - 2012 THERMOFORMING DIVISION ORGANIZATIONAL CHART

2011 Conference
Schaumburg, IL
James Alongi
2012 Conference Grand Rapids, MI
Haydn Forward & Lola Carere

Membership
Haydn Forward
Communications
Clarissa Schroeder
Recognition
Juliet Goff
Green Committee
Steve Hasselbach

OPCOM
Phil Barhouse

Technical Committees

Materials
Roger Jean
Processing
Haydn Forward

Publications / Advertising
Laura Plocin
Newsletter / Technical Editor
Gwen Goflin

Student Programs
Brian Woeste

2012 Conference Coordinator
Gwen Mathis

AARC
Bob Freeman

Antec
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woestre

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Programs
Brian Woeste

2011 Conference Coordinator
Bonnie Woeste

AARC
Rich Freeman

Student Program
The council activities of this “Global Society” have maintained a high intensity focus on the development of a stronger SPE. For SPE to continue the mission of providing and promoting quality plastics education and technical information worldwide, the society first has to regain financial stability. This stability requires the stimulation of membership retention and growth with an understanding and communication of member values to the industry. That includes those involved in plastics engineering and, equally as important, their corporate leadership. The following overview provides some highlights of those council activities and results.

**Financial**

- A positive cash contribution of $120,000.00 to net assets was realized in 2010, bringing total net assets to over $1 million dollars. This is an amazing turn around when you consider that net assets were negative $300,000.00 at year-end 2008.
- The budget approved at the September Council meeting projects a $313,000.00 net contribution for 2011.
- This budget was developed using conservative estimates in all categories.
- Membership is conservatively based on revenues attained in 2010 with no change projected in the base rate of dues and membership at 15,000 members. Again this is conservative and the same as 2010.

Much of the credit for this turnaround goes to Executive Director Susan Oderwald. Long-term contracts for the SPE Journals, contracting the publication of Plastics Engineering to Wiley Subscription Services and negotiating the sale of the 30-year-old headquarters building in 2009 have all made a huge impact on reducing expenses and increasing revenues.

Extensive operations and governance cost-containment further strengthened the results. Staff reductions, staff financial sacrifices, and reduced facilities and operating costs were all contributing factors.

**In order to maintain financial stability, SPE must continue to contain costs while increasing membership and participation in technical conferences and other events.**

**Membership**

- Membership stabilized in 2010 after bottoming out in 2009 with a 15% loss.
- A net gain of 2.2% was realized in 2010 bringing membership to 15,300.
- Retention is at 77% - an increase of 7% over 2010.
- There are 3,680 new members with 14% coming in at ANTEC and 39% through company participation.
- **Membership target for 2011 is 16,000 members.**
- A new extended “Young Professional” membership and a “Retired” membership status as well as possible joint memberships through other organizations are changes being considered to further stimulate growth.

(continued on next page)
• Management system software technology upgrades with new pricing strategies and other features designed toward a “customized” value proposition for members will further support retention and growth.

**Association Management Software (AMS)**

• The 2011 budget includes expenditures to support the replacement of the 1997 system that lacked today’s web-based technology.

• AMS will update and enhance the SPE on presence while providing further office efficiencies.

• This new system will allow the SPE website to more fully interact with members in real time. It will provide payment options including monthly withdrawal, auto renewal, multi currency options and a more efficient event registration process.

• AMS provides improved management of group events, activity calendars and real time availability of member lists.

• AMS will go live by early in the second quarter of 2011.

• **Look for improved member value with**

  **real time information and activity including mobile accessibility via smartphones.**

**ANTEC 2011**

• Mark your calendar for May 1-5, 2011.

• Hynes Convention Center in Boston, MA [www.4spe.org/conference/antec-2011](http://www.4spe.org/conference/antec-2011)

• ANTEC is the largest technical conference for plastics globally with over 700 papers planned for 2011. This paper submittal is up 25% from 2010.

• Papers presented at ANTEC remain in SPE’s online technical library providing a resource to you and your company years after the event has concluded.

**Seminars and the SPE Online Store**

• SPE will no longer produce independent seminars with independent instructors. Revenues have not justified the total costs.

• A new review and licensing model will be introduced where industry seminar providers communicate with SPE members through preferred promotion and market support.

• Licensed providers will be required to meet SPE certification criteria standards.

• The SPE on line store will remain in place to sell SPE proceedings, recordings, and other products.

• SPE will continue to manage agreements with publishers who provide preferred pricing and offerings through the online store with inventory and fulfillment passed through to the publishers. (Amazon model)

**Virtual Council Meeting**

• As council expenses for travel and meeting space have continued to increase, a more efficient method of holding governance meeting has evolved.

• One meeting annually is now a virtual meeting.

• The meeting held on Friday, February 11 included 83 councilors from all around the globe.

• This 3 hour meeting was a great success. The technology worked flawlessly allowing efficient presentations and voting.

The next Council meeting will be held in Boston at ANTEC. As Councilor I request your input and suggestions for continuous improvement opportunities within SPE. Please feel free to e-mail me at rkipp@mcclarinplastics.com.
From the Editor

If you are an educator, student or advisor in a college or university with a plastics program, we want to hear from you! The SPE Thermoforming Division has a long and rich tradition of working with academic partners. From scholarships and grants to workforce development programs, the division seeks to promote a stronger bond between industry and academia. Thermoforming Quarterly is proud to publish news and stories related to the science and business of thermoforming:

- New materials development
- New applications
- Innovative technologies
- Industry partnerships
- New or expanding laboratory facilities
- Endowments

We are also interested in hearing from our members and colleagues around the world. If your school or institution has an international partner, please invite them to submit relevant content. We publish press releases, student essays, photos and technical papers. If you would like to arrange an interview, please contact Ken Griep, Academic Programs, at: ken@pcmwi.com or 608.742.7137
<table>
<thead>
<tr>
<th>MACHINERY COMMITTEE</th>
<th>MATERIALS COMMITTEE</th>
<th>PROCESSING COMMITTEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>James Alongi</td>
<td>Jim Armor</td>
<td>Haydn Forward (Chair)</td>
</tr>
<tr>
<td>MAAC Machinery</td>
<td>Armor &amp; Associates</td>
<td>Specialty Manufacturing Co.</td>
</tr>
<tr>
<td>590 Tower Blvd.</td>
<td>16181 Santa Barbara Lane</td>
<td></td>
</tr>
<tr>
<td>Carol Stream, IL 60188</td>
<td>Huntington Beach, CA 92649</td>
<td>6790 Nancy Ridge Road</td>
</tr>
<tr>
<td>T: 630.665.1700</td>
<td>T: 714.846.7000</td>
<td>San Diego, CA 92121</td>
</tr>
<tr>
<td>F: 630.665.7799</td>
<td>F: 714.846.7001</td>
<td>T: 858.450.1591</td>
</tr>
<tr>
<td><a href="mailto:jalongi@maacmachinery.com">jalongi@maacmachinery.com</a></td>
<td>jimarмор@aol.com</td>
<td>F: 858.450.0400</td>
</tr>
<tr>
<td>Roger Fox</td>
<td>Phil Barhouse</td>
<td>Richard Freeman</td>
</tr>
<tr>
<td>The Foxmor Group</td>
<td>Spartech Packaging</td>
<td>Freetech Plastics</td>
</tr>
<tr>
<td>373 S. Country Farm Road</td>
<td>Technologies</td>
<td>2211 Warm Springs Court</td>
</tr>
<tr>
<td>Suite 202</td>
<td>100 Creative Way</td>
<td>Fremont, CA 94539</td>
</tr>
<tr>
<td>Wheaton, IL 60187</td>
<td>PO Box 128</td>
<td>T: 510.651.9996</td>
</tr>
<tr>
<td>T: 630.653.2200</td>
<td>Ripon, WI 54971</td>
<td>F: 510.651.9917</td>
</tr>
<tr>
<td>F: 630.653.1474</td>
<td>T: 920.748.1119</td>
<td><a href="mailto:rfree@freetechplastics.com">rfree@freetechplastics.com</a></td>
</tr>
<tr>
<td><a href="mailto:rfox@foxmor.com">rfox@foxmor.com</a></td>
<td>F: 920.748.9466</td>
<td>Ken Grieb</td>
</tr>
<tr>
<td>Hal Gilham</td>
<td><a href="mailto:phil.barhouse@spartech.com">phil.barhouse@spartech.com</a></td>
<td>Portage Casting &amp; Mold</td>
</tr>
<tr>
<td>Productive Plastics, Inc.</td>
<td>323.581.6194</td>
<td>2901 Portage Road</td>
</tr>
<tr>
<td>103 West Park Drive</td>
<td>Julian Goff</td>
<td>Portage, WI 53901</td>
</tr>
<tr>
<td>Mt. Laurel, NJ 08045</td>
<td>Kal Plastics, Inc.</td>
<td>T: 608.742.7137</td>
</tr>
<tr>
<td>T: 856.776.4300</td>
<td>2050 East 48th Street</td>
<td>F: 608.742.2199</td>
</tr>
<tr>
<td>F: 856.234.3310</td>
<td>Vernon, CA 90058-2022</td>
<td><a href="mailto:ken@pcmwi.com">ken@pcmwi.com</a></td>
</tr>
<tr>
<td><a href="mailto:halg@productiveplastics.com">halg@productiveplastics.com</a></td>
<td>T: 323.581.6194</td>
<td>Steve Hasselbach</td>
</tr>
<tr>
<td>Don Kruschke (Chair)</td>
<td></td>
<td>CMI Plastics</td>
</tr>
<tr>
<td>TME</td>
<td></td>
<td>222 Pepsi Way</td>
</tr>
<tr>
<td>31875 Solon Road</td>
<td></td>
<td>Ayden, NC 28416</td>
</tr>
<tr>
<td>Solon, OH 44139</td>
<td></td>
<td>T: 252.746.2171</td>
</tr>
<tr>
<td>F: 440.498.4000</td>
<td></td>
<td>F: 252.746.2172</td>
</tr>
<tr>
<td>F: 440.498.4001</td>
<td></td>
<td><a href="mailto:steve@cmiplastics.com">steve@cmiplastics.com</a></td>
</tr>
<tr>
<td><a href="mailto:donk@allthingsthermoforming.com">donk@allthingsthermoforming.com</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mike Sirotnak</td>
<td></td>
<td>Roger Kipp</td>
</tr>
<tr>
<td>Solar Products</td>
<td></td>
<td>McClarin Plastics</td>
</tr>
<tr>
<td>228 Wanaque Avenue</td>
<td></td>
<td>15 Industrial Drive</td>
</tr>
<tr>
<td>Pompton Lakes, NJ 07442</td>
<td>2040 Industrial Drive</td>
<td>PO Box 486</td>
</tr>
<tr>
<td>T: 973.248.9370</td>
<td></td>
<td>Hanover, PA 17331</td>
</tr>
<tr>
<td>F: 973.835.7856</td>
<td></td>
<td>T: 717.637.2241</td>
</tr>
<tr>
<td><a href="mailto:msirotnak@solarproducts.com">msirotnak@solarproducts.com</a></td>
<td></td>
<td>F: 717.637.2091</td>
</tr>
<tr>
<td>Brian Ray</td>
<td></td>
<td><a href="mailto:rkipp@mcclarinplastics.com">rkipp@mcclarinplastics.com</a></td>
</tr>
<tr>
<td>Ray Products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1700 Chablis Drive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario, CA 91761</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T: 909.390.9906</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F: 909.390.9984</td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="mailto:brianr@rayplastics.com">brianr@rayplastics.com</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brian Winton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modern Machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO Box 423</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beaverton, MI 48612</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T: 989.435.9071</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F: 989.435.3940</td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="mailto:bwinton@modernmachineinc.com">bwinton@modernmachineinc.com</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eric Short</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mytex Polymers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1403 Port Road</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jeffersville, IN 47130-8411</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: 248.705.2830</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F: 248.328.8073</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:eric_short@mytexpolymers.com">eric_short@mytexpolymers.com</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dennis Northrop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Akzo Nobel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1872 Highway 9 Bypass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lancaster, NC 29720</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: 803.287.5535</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:dnorthrop@paintfilm.com">dnorthrop@paintfilm.com</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robert G. Porsche</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General Plastics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2609 West Mill Road</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Milwaukee, WI 53209</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: 414.351.1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F: 414.351.1284</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:bob@genplas.com">bob@genplas.com</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mark Strachan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Global Thermoforming Technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1550 SW 24th Avenue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ft. Lauderdale, FL 33312</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: 754.224.7513</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:globalmarks@hotmail.com">globalmarks@hotmail.com</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jay Waddell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plastics Concepts &amp; Innovations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1227 Queensborough Road</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suite 102</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mt. Pleasant, SC 29464</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: 843.971.7833</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F: 843.216.6151</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:jwaddell@plasticoncepts.com">jwaddell@plasticoncepts.com</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clarissa Schroeder</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auriga Polymers, Inc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Film &amp; Sheet Division</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1551 Sha Lane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spartanburg, SC 29307</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: 864.579.5047</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F: 864.579.5288</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:Clarissa.Schroeder@us.indorama.net">Clarissa.Schroeder@us.indorama.net</a></td>
</tr>
</tbody>
</table>

|      |                      |                    |
|      |                      |                    |
|      |                      |                    |

THERMOFORMING QUARTERLY 31
Sponsor Index

- Allen ........................................ 30
- ANTEC 2011 .......................... 11
- Brown Machine .................... 20
- CMT Materials .................... 14
- CMG ...................................... 30
- GN Plastics .......................... 4
- GPEC 2011 ............................. 21
- Kiefel .................................. 30
- KMT ..................................... 21
- Kydex .................. Inside Front Cover
- MAAC Machinery ................. 21
- McClarin Plastics ................. 4
- PCI ................................... 27
- PMC .................................. Inside Back Cover
- Portage Casting & Mold .......... 4
- Primex Plastics ................... 14
- Productive Plastics .............. 30
- Profile Plastics Corp. ........... 30
- PTI .................................. Back Cover
- Ray Products ...................... 30
- Solar Products ..................... 4
- Temuco .............................. 32
- Thermoforming Machinery & Equipment Inc. .......................... 27
- Thermwood ....................... 10
- TPS .................................. 10
- TSL .................................... 17
- Zed Industries .................... 30

Thermoforming Division Membership Benefits

- Access to industry knowledge from one central location: www.thermoformingdivision.com.
- Subscription to Thermoforming Quarterly, voted “Publication of the Year” by SPE National.
- Exposure to new ideas and trends from across the globe.
- New and innovative part design at the Parts Competition.
- Open dialogue with the entire industry at the annual conference.
- Discounts, discounts, discounts on books, seminars and conferences.
- For managers: workshops and presentations tailored specifically to the needs of your operators.
- For operators: workshops and presentations that will send you home with new tools to improve your performance, make your job easier and help the company’s bottom line.

JOIN D25 TODAY!

32 THERMOFORMING QUARTERLY