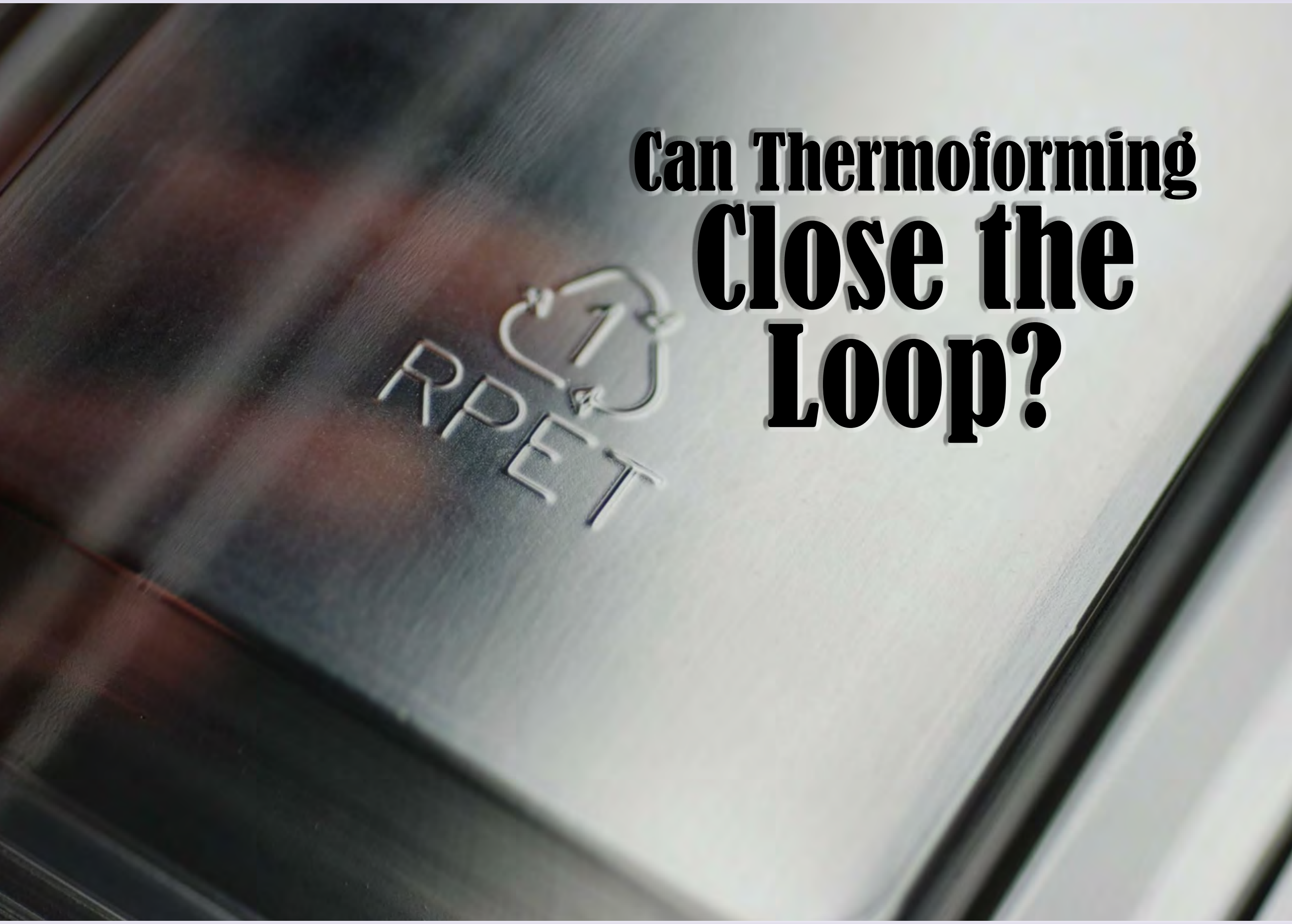
Thermoforming Quarterly®

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

FIRST QUARTER 2015 ■ VOLUME 34 ■ NUMBER 1

NPE Preview Issue



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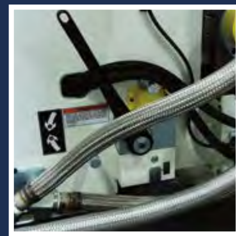
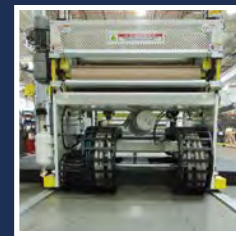

Vertical nip height adjustment


Transfer roll coater for top and/or bottom side coating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Thermoforming Quarterly®

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Departments

Features

In This Issue

Cover Photo: *RPET thermoformed package*
Courtesy of Dordan Manufacturing

Thermoforming Quarterly®

A JOURNAL PUBLISHED EACH CALENDAR QUARTER BY THE THERMOFORMING DIVISION OF THE SOCIETY OF PLASTICS ENGINEERS

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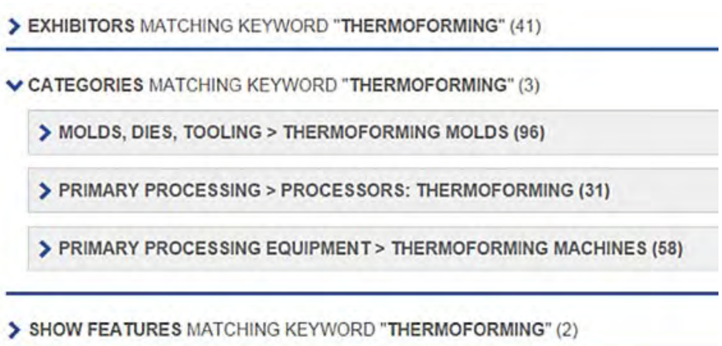
Mark Strachan

Thermoforming Shares the Main Stage

Welcome to the First Quarter edition of *Thermoforming Quarterly*! 2015 is a big year for the plastics industry as NPE rolls into Orlando next month (March 23-27). Billed as "The International Plastics Showcase," NPE is one of the industry's premier events alongside K and Chinaplas. If you look at the list of thermoforming-related companies exhibiting this year, it is truly an international show. The image below from the NPE website illustrates just how many players from our thermoforming industry will be present:



> **EXHIBITORS** MATCHING KEYWORD **"THERMOFORMING"** (41)

⌄ **CATEGORIES** MATCHING KEYWORD **"THERMOFORMING"** (3)

> **MOLDS, DIES, TOOLING > THERMOFORMING MOLDS (96)**

> **PRIMARY PROCESSING > PROCESSORS: THERMOFORMING (31)**

> **PRIMARY PROCESSING EQUIPMENT > THERMOFORMING MACHINES (58)**

> **SHOW FEATURES** MATCHING KEYWORD **"THERMOFORMING"** (2)

Companies from Germany, Canada, China, Taiwan, Italy, Korea and Turkey (see article on page 30-32) will line up alongside many US players. It is interesting to note that 'thermoforming' is categorized several ways, indicating the full depth and breadth of the industry supply chain, i.e. OEMs, processors, suppliers.

ANTEC is being held at NPE this year. As the premier technical conference for the plastics industry, I encourage you to take a look at the papers being presented. Also at NPE, SPE is sponsoring *The Plastics Race*®, a novel event that debuted at last year's ANTEC in Las Vegas. *The Plastics Race* is an app-driven, smartphone-based question hunt in which mixed teams of graduating students, talented young professionals and experienced industry veterans (all active SPE members) compete for prizes by answering questions they can only access by visiting Exhibiting Sponsors' booths. Visit the SPE website for more details including how to sign up to participate as a sponsoring company.

Later this year, Penn College will be hosting their annual thermoforming workshops for both heavy-gauge and thin-gauge processes. I encourage you to take a closer look at the excellent work being done by Chris Gagliano and the team at the Plastics Innovation Resource Center (PIRC). If you are hiring new workers or training current employees, the Penn College programs offer excellent opportunities for companies of all sizes.

Also in this issue, we take a closer look at topics that affect thermoforming companies, both directly and indirectly. Changes in OSHA regulations concerning safety labels for chemicals are addressed on pages 10-12. The Materials Committee of the Thermoforming Board of Directors provides a very informative overview of analytical testing and ASTM methods related to thermoforming materials and processes (see pages 26-28).

I look forward to seeing many of you at NPE next month.

Thermoforming Quarterly® | New Members

Scott Anderson
JELD-WEN
Klamath Falls, OR

Marlon Artis
McClarin Plastics
Hanover, PA

James Goldthorp
Braskem America
Pittsburgh, PA

Andrew Pierce
Skullcandy
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Joe Jones
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Jeffrey Meunier
Berry Plastics
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Adam Liang
GSR Far East Ltd.
Arcadia, CA

Suzan Hamrick
Berry Plastics
Evansville, IN

Peter Greenlimb
Chemagineering Corporation
Rolling Meadows, IL

David Dyke
Creative Foam Corporation
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Cory Christensen
Owens Corning
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Kevin O'Connor
DSM Engineering Plastics
Birmingham, MI

Craig Ekstrum
Michigan Technological Univ.
Negaunee, MI

Mosha Zhao
ExxonMobil Chemical Co.
Baytown, TX

Alan Stachowicz
Seiler Plastics Corporation
Saint Louis, MO

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
- Innovative technologies
- New or expanding laboratory facilities
- New applications
- Industry partnerships
- 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 Conor Carlin, Editor, at cpcarlin@gmail.com or 617-771-3321.

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Guangdong machinery maker adds another plant

By Kent Miller, Correspondent, *Plastics News*

TAIPEI, TAIWAN — Extrusion thermoforming equipment specialist Guangdong Designer Machinery Co. Ltd. plans to open a new 70,000-square-meter factory in Shantou early next year.

The manufacturer anticipates a 25 percent jump this year on 2013 sales of $20 million, marketing director Jameson Chen said at the company's modest Taipei Plas booth.

The facility will more than double the footprint of the company's five existing plants. Guangdong Designer currently employs 240, Chen said.

Sales are split evenly between the Chinese and export markets, Chen said. The bulk of exports go to Southeast Asian buyers, followed by Latin America and the Middle East. In all, the 21-year-old company has shipped to 35 countries.

To fuel penetration of the Middle Eastern market, the company opened a Dubai service office earlier this year. The company has had service centers in Jakarta and Bangkok since the early 2010s. Like other manufacturers showing at the biannual Taiwan show, Chen sees a big move to automated equipment.

"Now people want to cut labor costs," Chen said.

Automated systems also require less training time — a key advantage when coping with today's job-hopping workforce. Guangdong Designer's products include a PET/polylactic acid twin-screw extruder and an extruder connected to a thermoformer for producing cups.

To stand out in a jostling crowd of Pearl River competitors, the company needs to slash turnaround times, Chen said. Typically, it takes four months or longer from the time it takes an order to the time it ships a finished machine.

The company needs to speed up internal parts manufacture and slash the time needed to obtain sourced parts, Chen said. |

From Sustainable Packaging to Sustainable Packaging Machines

By Renee Robbins Bassett, Automation World (online)

December 28, 2014 — Use of sustainable packaging material is an ongoing trend for packaging machine makers. One family-owned maker of thermoforming equipment sought to makes its automation systems more "sustainable" by finding a way to more easily replicate new control system upgrades and enhancements onto other machines. PC-based control was the company's technology of choice.

Fabri-Kal is the company is behind the plastic packages used by some of the largest food manufacturers in the U.S. From packaging for common consumer goods to foodservice products and custom-designed solutions, Kalamazoo, Mich.-based machine builder has a passion to provide innovative and sustainable packaging while ensuring that they manufacture their products in the safest, most environmentally responsible ways possible. Some of their most recent innovations have been for mass-market brands such as Chobani, Yoplait, f'real, General Mills, Nissin, PepsiCo and Vitasoy.

"Naturally, these companies expect the best and Fabri-Kal's mission is to provide the best," says electrical engineer Dale Michaels. The reusability of traditional PLC-based manufacturing systems no longer matched that of Fabri-Kal's own plastic products.

Greenware is Fabri-Kal's line of annually renewable drink cups, lids, portion containers and on-the-go boxes made entirely from plant-based materials. During manufacturing, Fabri-Kal can also re-grind any leftover plastic from forming processes and melt it back down for immediate reuse at their plants. But in 2009, the reusability of traditional PLC-based manufacturing systems no longer matched that of Fabri-Kal's own plastic products. So Michaels and his team have been upgrading to a PC-based control architecture.

In early 2010, Fabri-Kal began integrating TwinCAT PC-based control software from Beckhoff Automation into its plastic thermoforming machine lines. The benefit was enhanced overall data collection, easier programming, better machine performance and better product quality, says Michaels.

Since then, Fabri-Kal has been on a mission to integrate PC-based control technology into all of its packaging machine lines at all locations, and the company continues to make improvements to its thermoforming machine lines, says Michaels.

Michaels says that "due to the open architecture and flexibility of Beckhoff PC-based control and EtherCAT [networking protocol], I can easily replicate all the new control system upgrades and enhancements onto other machines." This makes the packaging machines themselves more flexible and any machine design more sustainable. That combination is "making our future goals [of transforming all its machines to PC-based control] more easily achievable," he says.

Moving among different Beckhoff controller types, the TwinCAT software enables an easy migration to higher performance while continuing to use a standard PC-based architecture. Such technology lets Fabri-Kal "intensify our focus on providing best-in-class plastic packaging products for our customers, who are undeniable leaders in the food manufacturing industry." |

ILIP to Launch Recycled PET Food Packaging Line

By *European Plastics News*

Published: February 4, 2015 9:22 am ET; Updated: February 4, 2015 9:26 am ET — Bologna, Italy-based thermoforming plastic packaging company ILIP srl has announced that it is ready to start producing food packaging products made from 100 percent recycled PET.

ILIP is the main division of the ILPA Group, which recently completed the installation of a recycled PET decontamination process. The company states that this system gained the approval from the EFSA (the European Food Safety Authority) in 2014, as a necessary prerequisite for producing packaging products designed for direct food contact compliant with regulations.

The company states that it is one of the first in Europe to have implemented a closed-loop recycled PET process, which means the recovery of the plastic is managed internally: from the washing and grinding of the post-consumer products, to the extrusion of the recycled PET material and the production of the finished products. |

Trienda Poised to Explore New Markets, Products Under New Ownership

By Michael Lauzon, Correspondent, *Plastics News*

Image By: TriEnda Holdings LLC

Published: February 12, 2015 3:01 pm ET; Updated: February 12, 2015 3:05 pm ET — Thermoformer TriEnda Holdings LLC has a new lease on life under new ownership.

The Portage, Wis., company has invested about $2 million on equipment and facility upgrades in the 10 months since it was acquired by Kruger Family Holdings II LLC. It's now poised to explore new markets and products to build on its strength as a producer of reusable industrial packaging such as pallets and shipping containers, according to TriEnda Holdings President David Kruger, also a principal in Kruger Family Holdings.

Kruger Family Holdings was the successful bidder for the Portage business, previously called Lexington Logistics LLC but known for most of its life as TriEnda. Kruger Family Holdings paid $13.5 million last April to lift it out of receivership. Kruger Family Holdings owns most of the company and C3 Capital Partners LP of Kansas City, Mo., mezzanine financier of the deal, is one of the minority shareholders.
"It's a good business but it needed direction," David Kruger explained in a phone interview. "It has blue chip customers so we don't need to worry a lot about getting new orders."

Kruger praised TriEnda Holdings' employees, who are highly focused on customer service. With a strong staff, the business only needs adjustments in material costs and production methods, David Kruger indicated. The staff will become even stronger, David Kruger explained, as numerous operators receive training in robotics to more effectively run machinery filling long production run orders. The company employs about 185.

"The customer-first mentality that is ingrained in the culture here was a motivating factor in purchasing the operating assets," stated David Kruger.

TriEnda Holdings recorded sales of $41 million last year, fairly evenly split between custom thermoforming and proprietary production. Automotive is its biggest single market but it is diverse, producing heavy gauge items, including twin-sheet products, on its 12 thermoforming lines.
The firm mostly forms high density polyethylene sheet supplied by in-house sheet extrusion lines operated by compounder and sheet extruder PolyOne Corp.

PolyOne's four sheet lines in house "help make us more competitive, we're very happy with them," David Kruger said. The sheet lines and TriEnda Holdings's thermoformers are housed in a 297,000-square-foot building.

David Kruger's father, Warren Kruger, has corporate turnaround experience and an extensive plastics background — two factors that helped convince the family to invest in the Portage operation. Warren Kruger is TriEnda Holdings' chairman but isn't active in day-to-day running of the company. John Brown, who has a background in plastics compounding, is TriEnda Holdings' CEO and a minority shareholder. David Kruger's background is in the financial industry.

"This acquisition reflects our commitment to the material handling industry, and our belief in the renewal of North American manufacturing," Brown stated in a news release.

The TriEnda business has undergone numerous gyrations in the past 20 years. Problems began in the mid-1990s when the U.S. Postal Service delayed a large order of hundreds of thousands of thermoformed plastic pallets. Ironically, the postal service is now a key customer.

In 2012, TriEnda's officers were replaced by Boston Finance Group after TriEnda's owner, Spara LLC defaulted on loans. In 2013 Spara regained control of the company, which had been renamed TriEnda/Lexington Logistics LLC. Officials then hired an investment bank to help sell the business but those efforts failed and TriEnda/Lexington Logistics went into Wisconsin Chapter 128 receivership in February 2014. Kruger Family Holdings beat out seven other bidders in auction and completed the sale in April.

Not included in the sale was a former plant in Marion, Ind., that TriEnda bought in 2008 and in which it sank $20 million in retrofits before the facility closed in 2011 after Spara skipped lease payments. The Marion equipment was subsequently sold. TriEnda was founded 40 years ago.

Have an idea for an article?

Submission Guidelines

- We are a technical journal. We strive for objective, technical articles that help advance our readers' understanding of thermoforming (process, tooling, machinery, ancillary services); in other words, no commercials.
- Article length: 1,000 - 2,000 words. Look to past articles for guidance.
- Format: .doc or .docx

Artwork: hi-res images are encouraged (300 dpi) with appropriate credits.

Send all submissions to Conor Carlin, Editor

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The Challenges of Labeling for OSHA's Revised Hazard Communication Standard

By Daniel Levine, CHMM

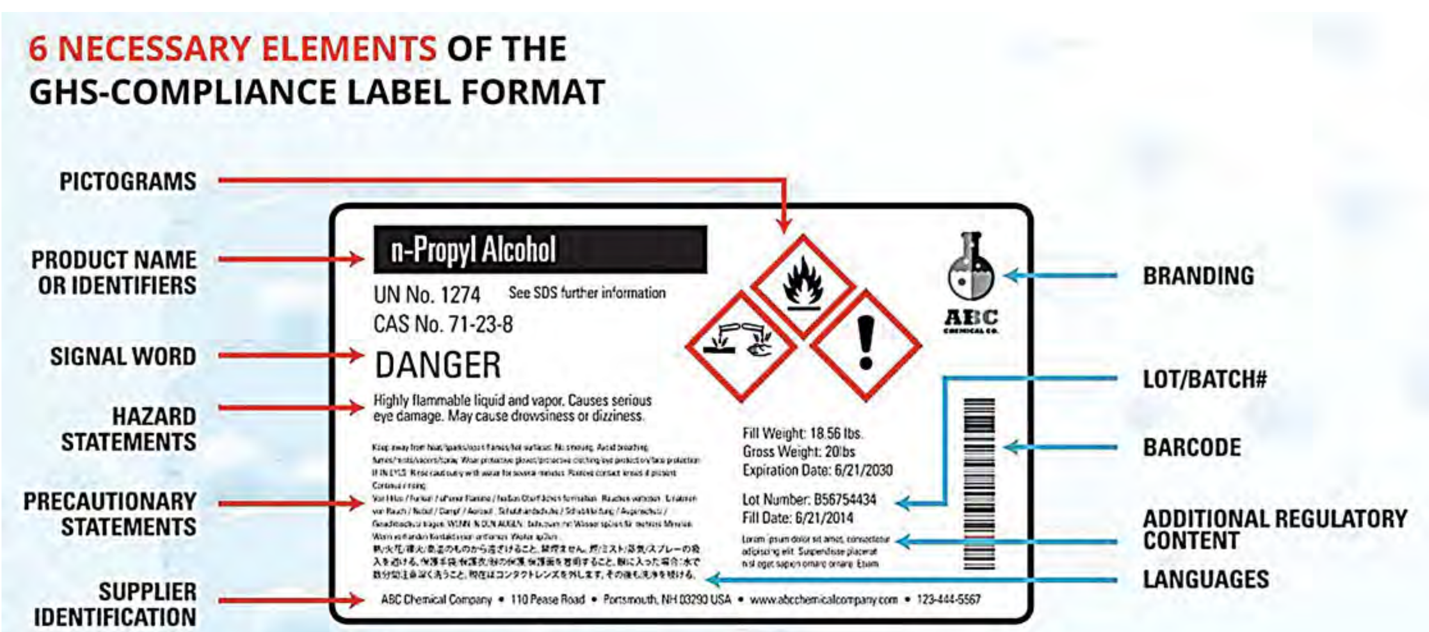
What is the GHS?
As a response to the multiple definitions of hazard and multiple ways of communicating these hazards, the United Nations adopted the Globally Harmonized System for Classification and Labeling of Chemicals (GHS) in 2003. OSHA's revised Hazard Communication Standard has presented manufacturers, formulators and distributors with the challenge of revising their Safety Data Sheets (SDSs) and the product labels by June 1, 2015. These changes are based upon the third revision of the GHS. The GHS system is gradually being adopted on a worldwide basis. This paper will explore the background of the regulation, some of the issues raised in adopting it, and some of the challenges that chemical producers and shippers will encounter in complying with the GHS.

These challenges include the mandatory use of red color, the potential need for multiple languages if shipping to other countries, various U.S. state issues like New Jersey's "Right to Know"* that go beyond OSHA's requirements, and many other regional regulatory requirements for compliance in the global marketplace. The reality is that virtually every label for a hazardous chemical product is subject to change, and will in many cases require changes on an ongoing basis into the unforeseeable future.

Complicating the environment in which these regulations will go into effect, the chemicals industry is faced with a major challenge due to the fact that many large companies have decentralized their hazard communication work processes. In addition, many medium- to smaller-sized companies don't have the internal resources to create their own Safety Data Sheets and must use outside resources. Because of the additional requirements in the 2012 OSHA and GHS regulations to be implemented starting June 1, 2015, regardless of how or where a Safety Data Sheet is created, automated systems will need to be capable of pulling the information from Section 2 of the SDS onto labels. In addition, the current complex nuances of labeling range from having many different products of various shapes and sizes, the need to respond to customer requirements, the need to access transactional data, languages, branding information, and more.

Why the GHS?
Before adoption of the GHS, multiple systems and definitions of hazard were the rule. Even here in the United States there have been—and to some extent still are—different definitions of various physical and health hazards presented by chemical substances. Looking at just two hazards such as flammability and oral toxicity, Charts 1 through 3 below show the disparity in definitions, and how the GHS has created a common basis for these two frequently encountered hazards. These hazards were compared based upon 2009 regulations because many countries have already adopted, or are in the process of adopting, GHS definitions.

For instance, the European Union (EU) adopted GHS for substances in 2010 and the classification and labeling of mixtures is scheduled to become mandatory by June 1, 2015, which is the same day as OSHA's mandatory implementation date. Canada is actively working on the institution of GHS but will not be able to complete implementation for industrial products by 2015.



Accordingly, they are trying for mandatory implementation by manufacturers by June 1, 2016, and a complete implementation by June 1, 2017 where stock on shelves can no longer be shipped with older formatted labels. Therefore, between June 1, 2015 and June 1, 2016, shippers in the U.S. may need to create a separate label for Canadian shipments.

This difference in implementation timelines is an example of why a single product might need two different labels depending upon its final destination. For the time being, industrial and consumer labels in the U.S. and Canada will continue to differ, while by next year, European industrial and consumer labels will follow the same classification and communication scheme.

Oral toxicity is even more complicated, and the scope of this paper does not have the space to show all the conflicting definitions that existed in 2009, but here is the unified definition developed under GHS. There are different GHS tables for dermal toxicity and three for inhalation, one each for gases, vapors, and dusts and mists. All would have to be examined in creating a new label.

Also, the various shapes of symbols and graphics used for hazard communications are being unified into a single shape and graphic that will be used for both transport and for workplace notification. This will require a change for all EU labels for mixtures—both industrial and consumer—beginning June 1, 2015, and will change Canadian industrial labels by June 1, 2016. The new graphic will be mandatory (see opposite page).

Some Things Change While Others Don't

HCS 1994	HCS 2012
Hazard Determinations	Hazard Classifications
Labels (3 elements)	Labels (6 elements)
MSDSs – any format	SDSs – 16 sections
Training required	Training required
Written program required	Written program required
Trade secrets allowed	Trade secrets allowed
Formulators rely on supplier safety data sheets	Formulators responsible for data if the identity of the substance is known

Labels will now have more information on them, and will have to be revised to include symbols, standard signal words, and standard phrases. Other text, such as contact phone numbers and statements about ingredients with unknown toxicity will also be required. Because of the regional challenges presented by a widening global supply chain, signal words and phrases must be translated into multiple languages, making labels more efficient instruments for global hazard communication.

And Some Things Are Changing a Lot…

HCS 1994	HCS 2012
Performance standard	Specification standard
Floor of hazardous chemicals	No floor of hazardous chemicals
One study rule classifies substance	Weight of evidence from many studies
Standard mixture with 1%, 0.1% cut-offs (bright lines)	Each hazard calculated based on ingredients and criteria tables

Before 2015, as a performance standard, manufacturers could meet the OSHA requirements by methods of their own choosing. Now as a specification standard, manufacturers must follow methods of compliance outlined by OSHA. From 2015 onward, manufacturers will have to examine all available information and make a scientifically based determination where conflicting toxicity information is found. Also, formulators will now have a greater degree of responsibility for deter- mining the correct hazards associated with ingredients supplied by others where the identity of the ingredient is known. Definitions have expanded, especially for physical hazards. OSHA used to talk about flammability, pressure, explosively and reactivity. It is now more finely defined by GHS into these categories:

- Explosives
- Flammable gases
- Oxidizing gases
- Pressurized gases
    - Compressed gases • Liquefied gases
    - Refrigerated liquefied gases • Dissolved gases
- Flammable liquids
- Flammable solids
- Self-reactive substances
- Pyrophoric liquids
- Pyrophoric solids
- Self-heating substances
- Water Reactive producing flammable gases
- Oxidizing liquids
- Oxidizing solids
- Organic peroxides
- Corrosive to metals
- Explosive dusts

OSHA regulates all these hazards, including some others like "explosive dusts."

Likewise, health hazards have been more finely defined, but the change is not as dramatic as with physical hazards. The increased number of physical hazards is more in line with worldwide definitions already existing for the transport of dangerous goods. The changes to health hazards had to accommodate the various international systems with the guiding principle that no country would reduce the level of protection that previously existed. This will impact both Safety Data Sheets and labels.

The older definitions of health hazards include:

- Irritants • Corrosives
- Toxins • Sensitizers
- Effects on target organs (i.e. liver, kidney, nervous system, blood, lungs, mucous membranes, reproductive system, skin, eyes, etc.)

The newer definitions include:

- Acute toxicity, oral
- Acute toxicity, dermal

- Acute toxicity, inhalation
- Aspiration hazard
- Skin corrosion / irritation
- Eye corrosion / irritation
- Respiratory sensitization
- Skin sensitization
- Germ cell mutagenicity
- Carcinogenicity
- Reproductive toxicity, fertility
- Reproductive toxicity, development
- Specific target organ toxicity (STOT)
    - Single Dose
    - Repeat Dose

Most of these categories had been regulated previously, but now all categories of these hazards are being regulated. It is important to clarify that OSHA will not regulate materials of lower toxicity that would be in the home where children are present; this is because The Consumer Product Safety Commission regulates consumer labels, and that organization has yet to propose adoption of the GHS system.

So Where Do You Start? And What Do You Do?

First, manufacturers need to begin by classifying their products. If dealing with pure substances, this will be an easier task than if classifying mixtures. But either way, the criteria from the GHS is the rule. Classification will take longer than the old methods, and organizations need to begin this process now. The challenge is to work with accurate data. GHS does not require "testing," but it does require obtaining whatever information is available to accurately assess products.

Some things may calculate out to be more toxic as OSHA has expanded the definition of "toxic" from a toxicity of 500 mg/ kg out to 2,000 mg/kg in order to be consistent with the GHS. On the other hand, removal of the old 1% bright line means that you have 1% or more of a material with a certain health hazard, and mixtures will not automatically inherit that hazard. For example, some things formerly labeled as irritants may no longer be classified as irritants. So the classification and sub-classification, known as "categories," must be dealt with first.

Next, the GHS criteria will lead to the selection of symbols, signal words such as Danger or Warning, statements of hazard, and statements of precautions. These all have to go into Section 2 of the 16-section format of the Safety Data Sheet.

And following these considerations, here comes an important issue...as label content will appear on the SDS, both the SDS and the label need to be deployed together. SDSs are documents and can be sent out both in paper or as electronic files, but labels need to be applied to the actual package, which is not as easily accomplished. Key challenges of label production that must be accounted for include accommodating for color printing, dealing with different size products, accommodating multiple languages and transactional data.

As the industry is well aware by now, regarding color, OSHA requires a red border on all symbols used to communicate hazard categories. **Black** will just not do.

For many, using pre-printed label stock with red diamonds has become less practical, as the number of possible variations of pictograms needed varies and also requires manual oversight to make sure the correct label stock is being used.

Package size is also an important consideration in labeling as chemicals can be transported through supply in containers that vary in size from drums to small vials. The label needs to address both OSHA regulations and the size restrictions of the container, so for small packages it is a challenge to effectively utilize the limited real estate on a label.

Then there is the issue of dealing with languages on a label. In the United States, English is mandatory while other languages can be added optionally. For most other countries, e.g. European countries, the label must be produced in that country's language but may also require other languages if you sell and transport in other countries.

Extending the challenge of GHS labeling is a common requirement to apply transactional data such as batch numbers, lot numbers, or packing dates. This data, in conjunction with the variables of color, size and language, introduce complexity on the label that make pre-printing labels impractical.

Real-time, data-driven labeling is one of the primary pathways of dealing with these issues to ensure that the correct symbols, languages, and transactional data appear on labels of any size or shape. This approach also enables manufacturers to leverage the same regulatory content to ensure that the SDS and label agree with each other. The last thing they want is for the SDS to say one thing, and the label to say something else.

Ongoing regulatory changes in the chemical industry, successful GHS compliance, and regional regulatory adherence all require rapid labeling changes to be deployed quickly throughout the organization. The ultimate goal is meeting the requirements presented by the GHS at the same time you deal with the complexity of labeling hazardous materials to protect all participants in the global supply chain. To achieve this goal, companies must first understand the impact and changes that the GHS necessitates while pursuing an approach that accounts for the unprecedented level of complexity and change required for labeling in the chemical industry.

About the Author

Daniel Levine, CHMM is President of Product Safety Solutions, a consulting firm providing services in product hazard communication, TSCA compliance, and other regulatory areas affecting both manufacturing activities and finished products. Daniel's past positions include Director of Product Safety and Integrity for AlliedSignal Inc. and President of the Society for Chemical Hazardous Communication (SCHC). Due to his extensive experience in chemical industry safety, he received SCHC's 'Lifetime Achievement Award' in 2003 and was elected a 'Fellow' for the Institute of Hazardous Materials Management in 2010.

Benefits & Burdens of the Domestic Production Activities Deduction

By Michael J. Devereux II, CPA, CMP

As a response to the multiple definitions of hazard and multiple Enacted in 2004, the Domestic Production Activities Deduction (DPAD)[1] is generally 9% of a taxpayer's qualified production activities income (QPAI or qualifying income) for the tax year[2]. While this law is over a decade old, the IRS has issued recent guidance that may be favorable to thermoformers. The DPAD is designed to be the economic equivalent of a 3% reduction in tax rate on qualifying activities. This article will focus on how the DPAD applies to the various revenue streams of thermoformers, addressing qualification requirements of sales related to parts and molds, as well as determining which party is eligible for the deduction in instances of multiple parties' involvement in the same economic activities.

Basics of the Deduction

Qualifying income is equal to the taxpayer's domestic production gross receipts (DPGR or qualifying sales), net of allocable expenditures. Qualifying sales are those sales from the manufacture, production, growth, or extraction of qualifying production property in whole or in significant part by the taxpayer in the United States. In addition, the DPAD cannot be greater than that taxpayer's taxable income (or adjusted gross income) or 50% of the W-2 wages paid related to the activities giving rise to such deduction.

Most U.S. manufacturers engage in qualifying activities. That said, taxpayers should not assume that all net income is qualifying income. For taxpayers with qualifying activities, the following steps should be taken to compute its DPAD:

1. Determine the amount of qualifying sales (domestic production gross receipts).
2. Net allocable expenses against qualifying sales to determine qualifying income (qualified production activities income).
3. Multiply qualifying income by 9%.
4. Determine the taxable income (or adjusted gross income) and 50% of W-2 limitations.
5. The DPAD equals the smallest of 9% of qualifying income, taxable income, or 50% of the W-2 wages paid related to the activities giving rise to the DPAD.

Considering the Various Revenue Streams of a Thermoformer

Taxpayers must determine whether sales are qualifying on an item-by-item basis. The term "item" means the property held for sale by the taxpayer in the normal course of business. Therefore, thermoformers must first determine the "item" being sold. Taxpayers must consider the facts and circumstances in order to determine its item(s). Some considerations include:

1. Does the taxpayer sell plastics parts only?
2. If the taxpayer is selling the production mold to the customer, is the mold sold as part of its sale of plastic parts or is the mold held for sale as a separate item?
3. Does the taxpayer provide services for additional consideration that would be determined apart from the sales of goods?
4. If the mold is a separate item (product), was the mold manufactured "by the taxpayer"?

The answers to these questions may determine which sales are qualifying domestic production gross receipts and which are not. Taxpayers must keep books and records capable of determining which items are qualifying sales.

Multiple Parties Involved in the Same Economic Activity

IRS treasury regulations provide that only one party may claim the DPAD with respect to any qualifying activity performed in connection with the same qualifying production property[3]. That is, the item must be manufactured (1) *by the taxpayer* (2) *in whole or in significant part* within the U.S. This does not mean that multiple parties cannot have qualifying income for different stages in the economic activity. Rather, meeting these two requirements allows taxpayers to claim the DPAD for their stage within the overall economic activity.

If one taxpayer performs a qualifying activity pursuant to a contract with another party, then only the taxpayer that has the benefits and burdens of ownership of the qualifying production property is treated as engaging in qualifying activity[4]. Determining which party has the benefits and burdens of ownership is based upon the facts and circumstances, and taxpayers should consider which party has: the risk of loss, title of the work in process (WIP), control over the production process, liability with respect to "make good" contractual provisions, and an opportunity to benefit financially from increased efficiencies in the production process.

An item is treated as manufactured in whole or in significant part by the taxpayer if the manufacturing activity performed by the taxpayer is substantial in nature, taking into account all of the facts and circumstances, including the relative value i.e., cost added by the taxpayer[5]. Taxpayers looking to determine whether the manufacturing activities are substantial in nature with respect to an item in a more objective manner may rely upon the safe harbor provided in the Treasury Regulations. If the direct labor and overhead added by the taxpayer account for 20% or more of the taxpayer's cost of goods sold related to the item, the taxpayer is deemed to have manufactured the item in significant part .

Thermoformers must look to the relationship with both customers and vendors to determine whether another party has the benefits and burdens of ownership. For instance, an original equipment manufacturer (OEM) may contract with a thermoformer for the production of a plastic part. The thermoformer may contract with a third-party tool maker for the production of the mold used to produce the part. In this common set of facts, which parties are entitled to the DPAD and for which items? Again, taxpayers must look to the facts and circumstances in order to determine whether each item is manufactured by the taxpayer in whole or in significant part[6]. Some considerations include:

1. Is the mold a product held for sale to the OEM once the processor meets functional specifications e.g., making the mold an item or component thereof or does the processor retain ownership of the mold that is used in the production of the plastic parts, thereby making the mold a cost allocable to the plastic parts?
2. If the mold is sold to the OEM, does the contract between the OEM and the processor bundle the mold and parts into one item or may the OEM purchase the mold in a separate transaction and, subsequently, is free to use a different thermoformer to produce the parts?
3. If the mold is a separate "item," and a third-party toolmaker manufacturers the production mold to the thermoformer's specifications, does the third-party tool maker or the thermoformer have the benefits and burdens of ownership during the manufacturing process of the mold?
4. If the third-party tool maker is determined to have the benefits and burdens of ownership during the manufacturing of the production mold, does the thermoformer's direct labor and overhead account for at least 20% of all the costs allocable to the mold?

In most instances, the thermoformer will have the benefits and burdens of ownership related to the manufacturing of the plastic parts. Generally, thermoformers can benefit significantly from reducing cycle time, scrap, or press down-time.

Clearly, if the thermoformer manufacturers its own molds, it has the benefits and burdens of ownership during its manufacturing process. However, processors using third-party toolmakers will need to examine their contracts to determine which party has the benefits and burdens of ownership or if their direct labor and overhead account for at least 20% of the cost of the molds to determine whether the mold may be treated as qualified production property.

IRS Issues Directives Helping Taxpayers Determine Benefits & Burdens of Ownership

In order to reduce ambiguity in contract manufacturing arrangements, the IRS has issued three directives to help taxpayers determine which party has the benefits and burden of ownership during the manufacturing of an item.

The first directive identified three steps to determine which party has the benefits of burdens of ownership.

Step 1: Contract Terms
• Does the taxpayer have title to the work-in-progress (WIP)?
• Does the taxpayer have risk of loss over the WIP?
• Is the taxpayer primarily responsible for insuring the WIP?

Step 2: Production Activities
• Does the taxpayer develop the qualifying activity process?
• Does the taxpayer exercise oversight and direction over the employees engaged in the qualifying activity?
• Does the taxpayer conduct more than 50% of the quality control tests over the WIP while the qualifying activity was occurring?

If the taxpayer answers "yes" to two questions in each step, the taxpayer has the benefits and burdens of ownership during the manufacturing activity. If not, taxpayers must proceed to step 3.

Step 3: Economic Risks
• Is the taxpayer primarily liable under the "make good" provisions of the contract, for example, the warranty, quality of work, spoilage, overconsumption, or indemnification provisions?
• Does the taxpayer provide more than 50%, based on cost, of the raw materials and components used to produce the property?
• Does the taxpayer have the greater opportunity for profit increase or decrease from production efficiencies and fluctuations in the cost of labor and factory overhead?

If the taxpayer answers "yes" to two of the questions in Step 3, the taxpayer has the benefits and burdens of ownership during the manufacturing activity.

In superseding the first directive, the second directive provides that both the taxpayer and the counterparty agree at the outset of the manufacturing activity which party has the benefits and burdens of ownership.

The third directive clarifies the second directive related to taxpayers already under IRS examination and the removal of an attestation provision of the agreement with the counterparty suggested in the second directive.

The final directive makes clear that if the parties have not agreed, it should not be presumed the taxpayer does not have the benefits and burdens of ownership. Rather, the IRS must examine the facts and circumstances to determine which entity has the benefits and burdens of ownership for purposes of the DPAD.

Author's Observation: While the first directive was superseded, the questions identified in each step are helpful to taxpayers in determining whether they have the benefits and burdens of ownership during the manufacturing process, based upon the relevant facts and circumstances.

Conclusion

The DPAD is an extremely beneficial provision of the internal revenue code for taxpayers in the plastics manufacturing industry. Careful consideration of the requirements and questions posed in this article will help taxpayers ensure they are calculating the proper amount of DPAD, as well as help establish procedures that substantiate such positions in the event of an IRS examination.

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1. This provision of the code goes by many names, including, but not limited to, the Code Section 199 deduction, the manufacturers' deduction, and the U.S. production deduction.

2. The deduction was phased in over time with the deduction equal to 3% of QPAI in tax years beginning in 2005 or 2006; 6% of QPAI in tax years beginning in 2007, 2008, or 2009; and 9% of QPAI in tax years beginning in 2010 and thereafter.

3. Treasury Regulation §1.199-3(f)(1)

4. Treasury Regulation §1.199-3(f)(1)

5. Treasury Regulation §1.199-3(g)(2)

6. Treasury Regulation §1.199-3(g)(3)

Crude Oil and Natural Gas Price Dynamics: How They Affect Plastic Resin Prices

By Phillip Karig, Managing Director, Mathelin Bay Associates LLC, Saint Louis, MO

Crude oil and natural gas prices represent one leg of the "three legged stool" that is a key part of how the absolute price level and the price volatility of plastic resins are determined.

Though the three legs are interrelated, each of them can have a disproportionate impact on resin markets at certain times. The three legs are as follows: oil and natural gas prices; supply and demand; and resin inventory levels. Sometimes supply & demand, including planned and unplanned outages and longer term changes in resin production capacity, as well as plastics processors' seasonal and cyclical buying patterns, will be the most important of the three legs. Other times, resin inventory levels, including the ability of resin producers to export excess pounds, will be most important. Then there will be times oil and natural gas prices, especially crude oil prices in general and Brent crude prices in particular, will be the most important. We saw this when resin prices moved sharply lower alongside the steep slide in oil prices that began in the second half of 2014.

Every thermoformer, whether buying extruded sheet or buying resin and extruding it in-house, is extremely aware that crude oil and natural gas prices are important to understanding resin prices, but the exact role that oil and gas prices play often raises a number of questions.

<u>I know my resin producer is backward-integrated into low cost natural gas feedstocks, so why are my resin prices still so high in relation to their costs?</u>

Leaving aside the impact of supply & demand and inventory levels and using polyethylene as an example, there are U.S. producers making ethylene for less than twenty cents per pound, well below PE selling prices even after recent reductions. So why aren't PE prices even lower? The simple answer is that most of the world (and some U.S.-based producers) still makes PE from crude oil-based naphtha instead of natural gas liquids. Even if foreign PE producers wanted to make PE from natural gas it wouldn't do them much good since natural gas prices in many parts of the world are three to four times higher, or more, than in the U.S.

The bottom line is that the most cost competitive PE producers in the U.S. have a pretty good idea of what it costs their naphtha-dependent competition to make PE. They will only reduce prices to the point where they think their feedstock-disadvantaged competitors will start to lose money if they price their own PE any lower.

It is actually the recent drop in oil prices which has mitigated the disadvantage of producing PE from naphtha and not any sudden generosity from PE producers wanting to share more of the benefits of their low-cost gas-based feedstocks with their customers. This development has forced U.S. resin makers to lower their prices in order to continue competing for export business to higher cost parts of the world.

<u>Why are natural gas prices so much lower in the U.S. than the rest of the world? Will the cost advantage of producing resin from natural gas based-feedstocks in the U.S. continue for the long-term?</u>

Low U.S. natural gas prices are the result of record production of natural gas associated with rich natural gas deposits and advances in fracking technology, but that is not the whole story.

Unlike many commodities, natural gas is expensive and difficult to transport. The U.S. has almost zero natural gas liquefaction and export infrastructure. As a result, the normal process of commodity goods finding their way from lower cost markets to higher cost ones just hasn't worked for natural gas as it typically does for apples, oranges or plastic resins. In fact, ten years ago it looked as if the U.S. would have to import increasing amounts of natural gas, not export it. The fracking revolution changed all that, but there is still a lot of natural gas trapped in the U.S. today with no access to export markets.

The chart at right, Figure 1 (from British Petroleum), shows major natural gas trade flows in 2011 and highlights the almost complete lack of North American natural gas exports beyond NAFTA region at that time. Since 2011 dozens of companies have applied for permission to export liquefied natural gas, but only one has received approval so far and their plant is not scheduled to start exporting until late 2015.

U.S. manufacturers, most notably Dow Chemical in the chemicals and plastics industry, are very concerned about what increased natural gas exports might do to the current advantage of using low cost natural gas to manufacture here. They have been watching the export debate closely.

U.S. manufacturers don't fear how much natural gas exports might lower their competitors' costs because it is still expensive to liquefy and transport gas around the world. What they do fear, however, is that large-scale exports of natural gas will raise the costs of natural gas much closer to world levels when it can be exported at higher prices - much as resin can often be exported at higher prices now. And while resin buyers might see some small justice in resin producers facing much the same situation as they themselves do when buying resins, large-scale exports of natural gas have the potential to undermine some of the long-term

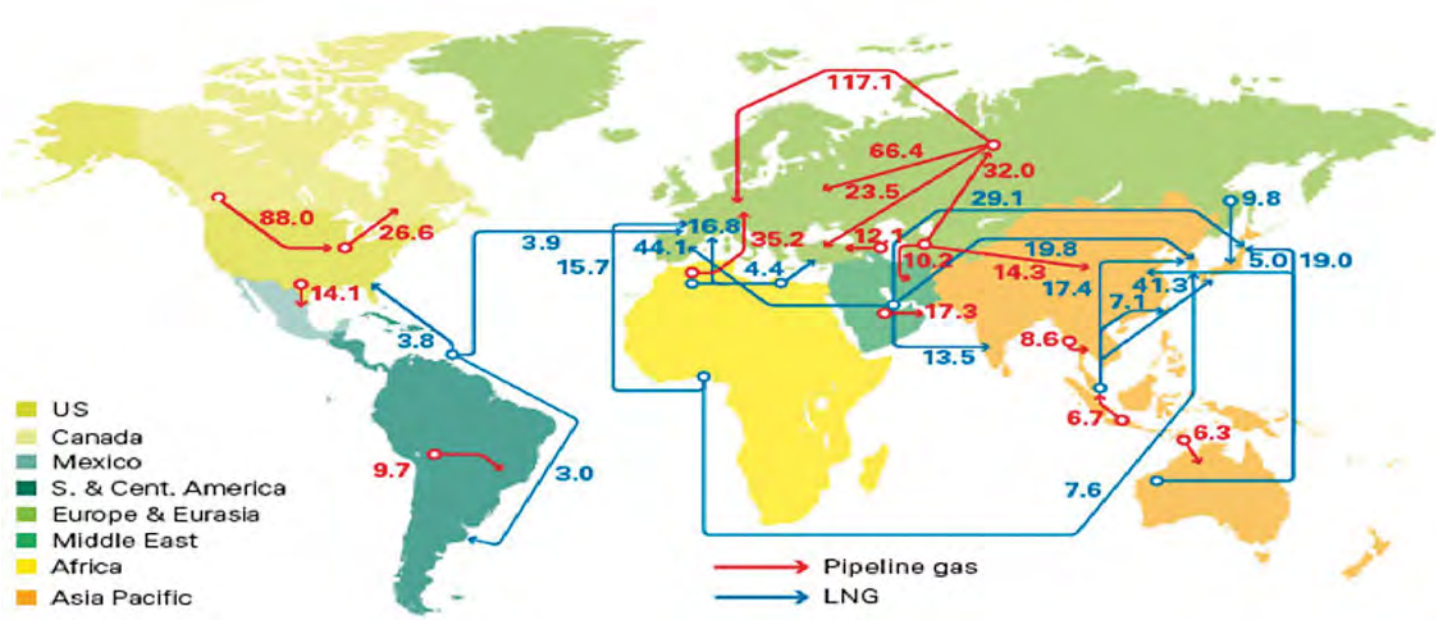

FIGURE 1: *Map showing flows of natural gas via pipeline & LNG tankers. Numbers in billion cubic meters of gas.*

rationale for building more resin plants in the U.S.

Unfortunately for both resin producers and processors the eventual scale of natural gas exports may hinge as much on international politics as economic arguments. At the time of writing, the U.S. Senate is debating a bi-partisan bill intended, in part, to take market share from Russian companies exporting natural gas to Europe. The bill would allow the Department of Energy to more quickly approve natural gas export facilities and would also change current export regulations to encourage exports to countries that do not currently have a Free Trade Agreement with the U.S. including Japan, China and several European countries. Figure 2 shows relative natural gas prices in various countries mid-2014 and highlights just how attractive exports might be to U.S. gas producers - and why resin producers are so concerned about the potential impact of exports on gas prices here.

Okay, crude oil and not natural gas has the biggest impact on resin prices because the U.S. gas market is isolated, but which crude oil market is most important for resin prices?

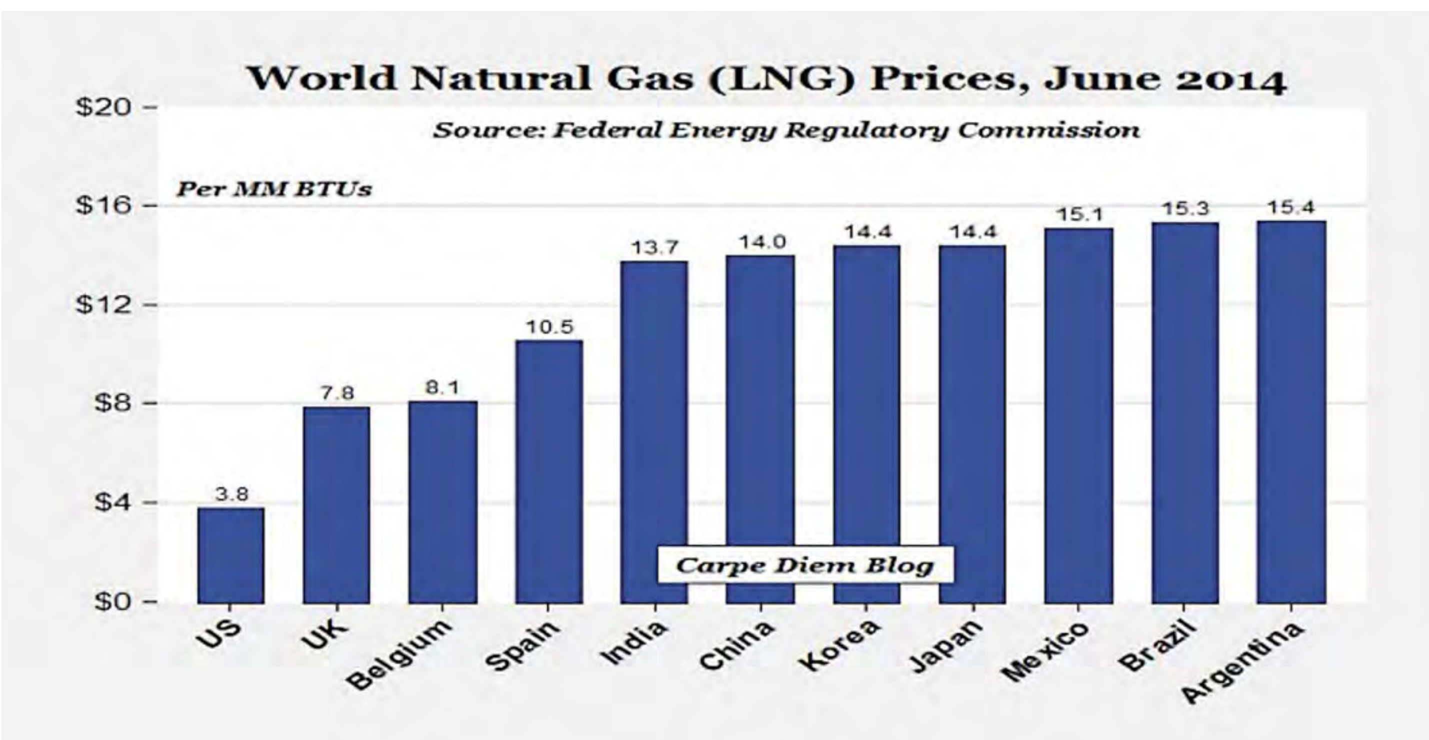

FIGURE 2: *June 2014 natural gas prices for selected countries ($/MMBTU basis)*

Even though the major U.S.-based crude oil commodities index is West Texas Intermediate (or WTI), the primary influence on resin markets is the Brent Crude Commodities Index which references the type of oil produced in the North Sea between Norway and the United Kingdom. The price of Brent crude is normally a few dollars per barrel higher than WTI crude, though sometimes it can be much as $10 or more per barrel higher.

U.S. resin producers incorporate the typically higher Brent price into their pricing determinations because they know that foreign resin producers do not have direct access to WTI crude. Much as is the case with natural gas, the market for crude oil exports from the U.S. is isolated and prices in the U.S. are normally lower but for different reasons.

Unlike natural gas, crude oil is much easier and less expensive to transport globally, but since the oil embargos of the 1970s, it has been illegal to export U.S. crude anywhere except to Canada. As production of U.S. crude has expanded greatly in the past few years, domestic oil inventories have often been higher (with lower prices) than they would be if exports of crude were legal. Inventories are also higher because the U.S. pipeline network is not optimized for transporting crude oil domestically from areas such as the oilfields in the Dakotas to refineries along the Gulf Coast. And many U.S. refineries were built or modified to process the grades of oil that are produced overseas rather than those produced in the U.S.

While the export ban is still in place, the U.S. has recently approved exports of minimally processed/distilled oil which technically doesn't count as crude oil. Over time this will tend to narrow the average price gap between WTI and Brent if minimally processed crude oil exports increase as expected.

So if Brent crude partially drives the market, why can't I just hedge my resin prices through crude oil futures and options?

While hedging resin prices is certainly possible, in most cases oil prices are just not the right reference point. Leaving aside questions of whether it is difficult to hedge resin prices or the mechanics of hedging, the correlation between resin prices and oil prices while high is not perfect and this imperfect correlation is the major challenge to using oil prices to manage resin prices.

Some resins such as polypropylene can be as much as 90% correlated with oil prices. That sounds high, but in practice a 10% difference can be enormous. Think, for example, about the similarities between various types of automobiles: they all have wheels, brakes and hundreds of other things in common, but a relatively small number of differences in materials, marketing and technology result in everything from a Kia to a Lamborghini.

In addition, the relationship between a particular resin and the price of oil can and does change over time. We should never forget that the other two legs of the stool - supply & demand and resin inventory levels---are often more important than oil prices at any particular point in time.

How to think about oil and gas when thinking about buying resin. If given a choice between specifying various resins at the outset of a project, ask whether the production of a resin in the U.S. is natural gas "advantaged" or "disadvantaged." Prices for advantaged resins may not be lower than other resins, but supply will tend to be more secure in the long-run.

Advantaged resins include PE made exclusively from ethylene and PVC largely made from it. In the disadvantaged group are those resins that are more heavily dependent on crude oil based naphtha, including PP, PS and ABS. Owing to the shift of U.S. feedstock production to lighter natural gas liquids there have been ongoing shortages of propylene monomer, for example, which have contributed to volatility in PP prices. Readers should also understand that when oil prices drop sharply there will be an incremental increase in refining of heavier feedstocks which can contribute to sharp drops in prices of formerly disadvantaged resins compared to advantaged resins - but remember that any such relative relief is bound to last only as long as oil prices remain low.

Finally, even if you've specified an advantaged resin such as PE it is important to understand your resin supplier's feedstock position. Not every PE supplier is vertically integrated back to natural gas. If your supplier is making PE without being integrated back to natural gas they will almost always be disadvantaged when it comes to being able to offer you the best price. And when the market has long-term resin overcapacity - as it will again - they will likely be among the companies that will have to rationalize their capacity first.

Postconsumer PET Thermoformed Containers: Recyclable vs. Recycled

By Chandler Slavin, Marketing Manager & Sustainability Coordinator, Dordan Manufacturing

Five years ago I was working Dordan's booth at the Walmart Sustainable Packaging Expo in Bentonville, Arkansas, when a packaging engineer from Burt's Bees walked by. "Thermoformed packaging!?" I exclaimed enthusiastically, only to be met with an ambivalent expression and the following remark, "We are getting out of thermoformed trays because thermoformed packaging isn't recyclable."

A lot has changed since then. The National Association for PET Container Resources (NAPCOR) is the trade association for the PET plastic packaging industry. NAPCOR reports that in 2013, PET thermoforms collected for recycling in the U.S. and Canada increased 25% over 2012, from 47.8 million pounds to 60 million.[1] In five years, PET thermoformed containers went from being largely landfilled to now being collected for recycling in the majority of American communities.[2] This tremendous development in post-consumer thermoform recycling served as the foundation for my 2013 "Recycling Report" published in *Plastics in Packaging* magazine.[3] In that article I described the industry-initiated timeline of events that facilitated the inclusion of thermoformed packaging in the recycling infrastructure. I stated the following in my conclusion:

With the majority of American communities now accepting all non-bottle rigid containers for recycling and the technical barriers to PC PET thermoform recycling being resolved, the floodgates to PET thermoform are nearly ready to be opened.[4]

So, have the floodgates opened? Are communities finding a market for post-consumer PET thermoformed packaging? It is one thing to accept material for recycling; it is quite another to actually recycle it. What follows is a discussion of how three different communities in America actually recycled post-consumer PET thermoform packaging into second-generation products and packaging. Through a discussion of the different education, collection, sortation, and reprocessing methods used, insight will be provided into which model proves best in class, allowing other communities to follow suit.

Background

In July 2011, The Society of the Plastics Industry (SPI) and NAPCOR released a request for proposals seeking submissions from recycling program operators that were interested in establishing a model program for collection and intermediate processing of PET thermoformed flake. SPI and NAPCOR expected grant recipients to address all necessary areas to implement a comprehensive and efficient program to recycle PET thermoforms including consumer education, outreach to non-residential sources of thermoforms, collection, intermediate processing, segregation and bailing, and marketing of material.[5] The grant was available to any recycling program operators that could implement a program for private, county, municipal, or joint-venture facilities. Regional cooperative programs as well as state managed or directed programs were also included.[6] The primary grant in the amount of $63,000 was awarded to Montgomery County (Maryland) Department of Environmental Protection's Division of Solid Waste Services. Secondary grants were awarded to the Pennsylvanian Recycling Markets Center of Middletown, PA ($25,000) and the Firstar Fiber, Inc. of Omaha, NE ($10,000). Each recipient was selected for its unique demographics and market realities.

Grant Recipient Demographics

Montgomery County Division of Solid Waste Services provides waste management facilities, programs and services to a diverse customer base of 1.5 million people living and working in the county. This includes single-family homes, multi-family apartments and condominiums, commercial businesses and organizations, and governmental facilities. The County also facilitates away-from-home recycling opportunities such as local/regional events and festivals.[7] Montgomery County's goal upon receiving the grant was to develop an efficient urban/suburban model for PET thermoform recycling.

Based in Middletown (near Harrisburg), the Pennsylvania Recycling Markets Center (RMC) is a non-profit corporation providing waste management services for 165,000 residents of Elk and Lebanon Counties. Elk County has a population of 31,946 and offers public, private, and non-profit recycling collection operations including two curbside and six drop off programs sponsored by local government. The Lebanon County Recycling Program serves a population of 133,568 and, like Elk County, offers public, private, and non-profit recycling programs including seventeen curbside collection programs and eight drop off programs, all sponsored by local government.[8] RMC's goal upon receiving the grant was to develop a successful rural collection model for PET thermoform recycling.

Firstar Fiber, Inc. is a privately-owned recycler providing waste management services to Omaha and Lincoln metropolitan regions, central and northeastern communities of Nebraska and the Sioux City, Woodbury County, and western regions of Iowa. With its diverse customer base and collection methods, Firstar built a strong collaborative PET thermoform recycling program team that includes Omaha's recycling office, local college sport venues, and regional grocery representatives.[9] Firstar's goal upon receiving the grant was to implement a sustainable residential and away-from-home PET thermoform recycling model.

Education and Consumer Outreach

Because of the different demographics among the grant recipients, different education and consumer outreach programs were initiated. Montgomery Country employed the most extensive forms of education, investing in everything from advertisements in cable television, radio, movie theater previews, print publications, residential mailers and transit advertising. RMC invested in more moderate educational messaging, including residential mailers and radio advertisements. Firstar focused on targeted messaging, like video advertisements at sporting events (to facilitate away-from-home recycling) and "I'm Recyclable" stickers on grocery products.[10]

Intermediate Processing

In my 2010 and 2013 Recycling Reports[11] I argued that issues of look-a-like contamination i.e., how you sort PET thermoformed containers from other rigid plastics destined for landfill, is one of the largest technical hurdles to the inclusion of PET thermoformed containers in the PET bottle recycling stream. After all, it is thought that the inclusion of PET thermoforms in PET bottles bales merits the highest post-consumer value for recyclers due to the excessive domestic and international demand for quality RPET. Each grant recipient, therefore, had to develop a method for sorting PET thermoforms from other look-a-likes such as PVC clamshells so as not to compromise the value of the PET bottle bales. While current market preferences indicate that the best way to sort PET thermoforms from other contaminating thermoforms is via automated sorting systems e.g., use of infrared technologies, each recipient developed the best process for sortation considering access to capital and existing sorting methods.

Montgomery County proved to be extremely effective via manual sorting: it processed clear PET thermoforms in *secondary sort* once all the fiber, metal, PET bottle and HDPE containers had been removed. The County trained sorters to visually identify PET thermoform packaging from other look-a-likes, relying on NAPCOR's technical training and a video it developed internally. Grant funding was used to purchase two hoppers and to hire two individuals devoted to sorting PET thermoforms.[12]

RMC, with its focus on rural recycling programs, relied on source separation at drop off locations as the primary processing method for PET thermoform recycling. Those thermoforms not readily distinguishable as PET were put aside for further analysis via portable plastic resin analyzing equipment procured by RMC through grant funding. RMC also acquired durable storage containers that could be easily broken down when not used. Grand funds were also used for bulk mailing of education material and radio advertisements.[13]

Firstar processed curbside collected thermoforms via manual sorting into mixed plastic loads. The process to recover PET bottles and thermoforms was neither manual nor strictly mechanical insofar as requiring optical sorters. Instead, both items were left on a conveyor that fed the container sort line. The items would then fall off the end along with aluminum cans which were removed with eddy current. Firstar sorters removed only plastics #2-7, letting PET stay on the line. Sorters then visually identified PET thermoforms on the line via NAPCOR technical training. Grant funding was used to situate participating colleges with recycling containers and the aforementioned targeted educational media.[14]

The Results

In Montgomery County, the total PET thermoforms shipped during the grant period was 258.67 tons vs. the 40.14 tons shipped six months before the grant. For RMC, the PET thermoforms collected were mixed with bottles, with 10% of each bale by weight estimated to be PET thermoforms. Mixed PET bottle/thermoform bales totaled 27.4 Tons, 2.74 Tons being PET thermoforms. And at Firstar, a study performed on the PET sorted identified that PET thermoforms represented 9% of the total PET processed. The company estimates that thermoforms were approaching 1% of PET bales, though no definitive figures exist for total PET bottle and/or thermoform tons shipped/sold. Firstar suggested that allowable levels of thermoforms could be 5-10% by weight of PET bottle/thermoform bales and that only a manual sort could maintain low capital costs. Relying on sort crews further provides responsiveness to match the developing supply chain i.e., scale up or down thermoforms collected to match intermediate PET processors' tolerance. It was determined that end market value related to combining thermoforms with bottles would inform material handling procedures at the MRF level. Similarly, the market would determine levels of tolerance.

Conclusion

There is no one-size-fits all when it comes to recycling post-consumer PET thermoforms. These model programs demonstrate the unique character of each community's waste management systems and how this variability informs the type of sorting methods required to find a home for post-consumer PET thermoform containers. NAPCOR urges recyclers/MRFs looking to collect PET thermoforms to talk to buyers about the available markets because each will have its own specifications for procurement. It is also recommended to sort PET using best practice guidelines to reduce look-alikes. Several PET reclaimers in the US and Canada now include specified percentages of PET thermoforms allowable in their PET bottle bales as part of their bale specifications, demonstrating the continuing development of this new market.[20]

Looking Ahead

We have come a long way in the last five years. From landfilling PET thermoforms to collecting to actually recycling, post-consumer PET thermoforms are now a sustainable medium for protecting and selling product at retail. Due to the efforts of PET and recycling stakeholders up and down the supply chain, I can now exclaim with pride, "Recyclable and recycled thermoformed packaging!" at the next Walmart Sustainable Packaging Expo.

Special thanks to Eileen Kao, Chief, Waste Reduction and Recycling Section of the Montgomery County Department of Environmental Protection and Kate Eagles, Program Director at NAPCOR.

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Thermoforming Technical Problems I Wish I Could Solve

Modeling Heating a Multilayer Sheet

By Jim Throne, Dunedin, FL

Preamble

Several years ago, I regaled readers of TFQ with micro-mini-profundities on various technical aspects of the concept we know as thermoforming. Recently, your erstwhile editor invited me to pontificate on these matters. I have accepted the proffered gauntlet. But instead of expounding professorially, I'd like to write in a more conversational tone about problems I haven't solved and may never get around to solving. A caveat: I haven't scoured the literature for specific solutions to many or all of these problems. Please feel free to set me straight if I am preaching to the choir. Another caveat: I will always employ the editorial "we."

Prologue

After hacking away at the technical aspects of heating sheet for a generation or so, I think we all have a pretty good understanding of how a sheet heats. There are three basic energy sources – conduction, convection, and radiation. Heating plastic sheet usually involves all three, the ratio depending on the thickness of the sheet. Conduction is essentially unimportant with thin sheet, for example. Most or essentially all of our technical approaches to energy transport from heaters to sheet and sheet to mold and formed part to the environment consider the sheet to be monolithic, meaning that the sheet has the same thermal characteristics throughout its cross-section.

What's the problem?

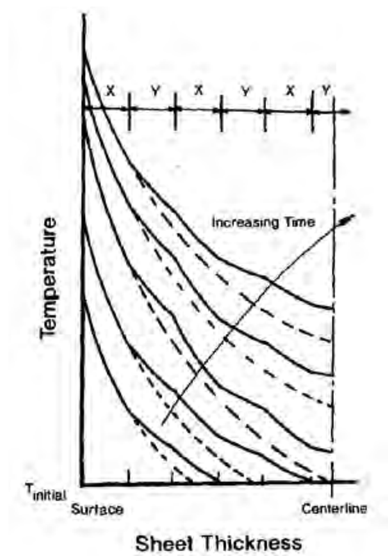
Simply put, not all of our sheets are monolithic. Thick-gauge sheet can be multilayer, whether the sheet contains a protective cap layer (acrylic-capped ABS) or contains a core of regrind (ABA-type structure). Thin-gauge sheet may have a moisture-resistant layer, a gas-barrier layer, and tie layers (PP-tie-EVOH-tie-PS). The question that has nagged me for some time deals with energy uptake at the interfaces between these layers.

Why is this an issue?

First let's eliminate the effect of convection. Convection only occurs at the surface of the plastic sheet. So we can eliminate its effect. This leaves radiation and conduction. We always solve the conduction problem by assuming equal heat flux at any interfacial surface. This means that all the energy coming from one side of the surface is conducted through the interface to the other side of the surface. Arithmetically, it looks like this:

$$q_i = k_i \frac{\partial T}{\partial x}\bigg|_{interface} \equiv k_{i+1} \frac{\partial T}{\partial x}\bigg|_{interface} = q_{i+1}$$

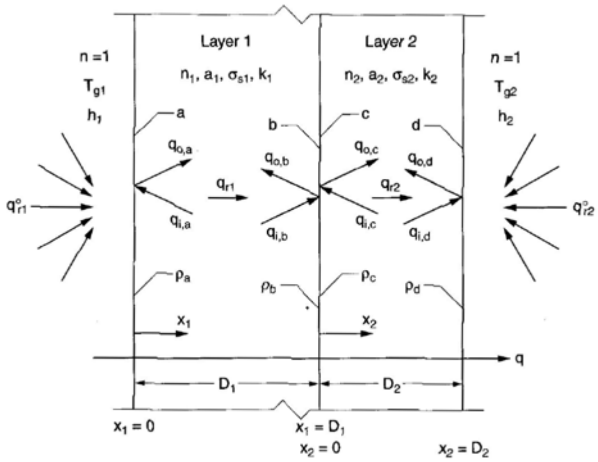
The time-dependent temperature profile through a multilayer sheet would look something like this:



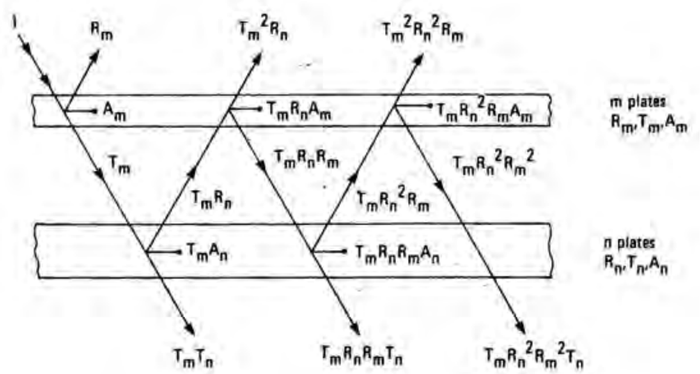
What about radiation? Radiant energy is reflected, absorbed, and/or transmitted. For plastics, reflectivity is negligible. This means that inbound radiation is either volumetrically absorbed by or transmitted through the plastic sheet. The amount of radiant energy transmitted through a plastic decreases exponentially with increasing sheet thickness. Here's a simple way of looking at this. Consider swimming in water. Sunlight decreases with water depth. Sunlight is visible electromagnetic radiation. We heat plastic with infrared electromagnetic radiation. We will address this in a later issue when we consider volumetric energy absorption in general.

So what's the problem?

Transmission characteristics and therefore absorption characteristics are affected at each interface in multilayer sheet. The thinner the sheet (or the thinnest layers of the sheet), the greater the overall effect. The more layers there are, the greater the complexities become to understand the energy interchange. Here is the scenario for just two layers.



Here it is for m+n layers:



Keep in mind, though, that each layer may have unique transmission/absorption characteristics. That's the nature of plastic!

Oh, and one more issue to contend with. Keep in mind that there is a difference between a dyed colorant and a pigmented one. Typically, dyes are organic. While they may have slight effects on the transmission/absorption characteristics of the plastic, the effects can be relatively easily accommodated. Pigments, on the other hand, are solids. These chunks absorb inbound radiant energy as well as effectively blocking transmission beyond their positions. Think solar eclipse. It is fortunate that we do not add substantial levels of pigment to color our plastics. Keep in mind that pigments tend to have higher densities than the plastic. As a result, X% by weight of a pigment is usually a percentage of X by volume. "We" may consider this in another problem session.

So why do we care?

Because we need to make certain that the inner layers are in the forming temperature range and the outer layers are not overheated. This is a specific problem when a thick inner layer forming temperature range is several dozens of degrees greater than that of the thinner outer layer.

So how do we solve the problem?

In 1931, two researchers – Kubelka and Munk – worked out the way pigments opacified paints against sunlight, aka electromagnetic radiation. Their concern was the reflectivity or albedo of the multiple layers. In short, how thick did the top layer need to be to adequately cover the color of the substrate?

They determined that not only do pigments block incoming radiation, they absorb and re-radiate it. Pigments are dispersed throughout the paint layer. One approach is to consider multiple layers of the pigments. Those layers near the surface obviously influence radiant absorption/transmission more than layers that are deeper into the paint layer.

Has it been done? Yes, but not using the Kubelka-Munk approach. Years ago, my colleagues and I considered a two-layer thick-gauge sheet being formed into a shower stall. PVC was the thin layer that provided rear surface fire protection. ABS was the thick layer that provided the sanitary surface. The math was horrendous.

So there are two problems to be solved here. First, effective modeling of the heating of semi-transparent, volumetrically absorbing multilayer sheet is needed. And second, determining the overall effect of pigment level on radiant energy absorption and reflection of multilayer sheet. Are these problems tractable? Of course. But the arithmetic is pretty steep. If you want the challenge, check out R. Siegel and J. Howell, *Thermal Radiation Heat Transfer*, 4th Ed., Taylor & Francis, NY, 2002. Warning: Begin at the beginning! Otherwise you won't learn the terminology needed in the later chapters.

Analytical Testing: A User's Guide

With introduction by Paul Uphaus, Commercial Development Manager, Primex Plastics

In our continued effort to provide technical resources to members of the thermoforming division and the broader industry, the Materials Committee of the SPE Thermoforming Board of Directors offers this list of typical testing procedures. Perhaps you have had to send out samples for evaluation to a Mechanical Testing Lab. Or it was necessary to send samples to an A2LA-accredited (American Association for Laboratory Accreditation) third party lab for testing. The following is a list of the various test used to create both the physical and analytical properties seen on a typical resin technical data sheet. It is our hope that this list will provide you with useful information about how tests are conducted and the significance of the results.

Fourier Transform Infrared Spectroscopy (FT-IR) – Measures the absorption of an infrared light source by a given sample. Each chemical component of a material will absorb the infrared light at different wavelengths creating a fingerprint of the material. Based on where this absorption takes place, the polymer family can be identified and in a lot of cases, special variations or additives as well. The FT-IR can be run in two different modes. Since our samples are usually heavy sheet stock, we typically run our scan in the reflective mode. Samples can also be measured in transmittance mode if the samples are translucent. Once scans have been taken, they can be compared, using the software, to existing libraries of known standards. This helps in identifying those unknown materials. Sample Size Needed: .0625" diameter minimum. Test Time: 45 seconds per scan. Test Result: Unique Absorption Spectra. Test Significance: Generic Polymer Family Identification of Unknown Samples. Test Limitations: Surface test only.

Differential Scanning Calorimetry (DSC) – Measures the heat energy (calories) required to maintain a consistent temperature between a baseline sample and a given sample. As the temperature slowly ramps up and cools down, transitions are seen on the thermal curve. For amorphous materials, the transition is seen as Step Transition and it is identified as the Glass Transition Temperature. In the case of crystalline or semi-crystalline materials, peaks are created that identify the Melting Point and Recrystallization temperature of the sample. As with FT-IR where these transitions take place, and ultimately their shape, are unique to specific materials. Since DSC heats and melts an entire sample, any mixed material composition, whether from blending or multi-layer structures, can be seen as well. Sample Size Needed: A 10 mg sample is usually sufficient. Test Time: Approx. 45 minutes. Test Result: Glass Transition Temperature, Melting Point, Recrystallization Temperature. Test Significance: Identification of multi-material blends and constructions. Test Limitations: Many rubbers and modifiers achieve their Glass Transition Temperature at temperatures less than ambient.

Thermogravimetric Analysis (TGA) – Measures the changing weight of a sample exposed to high temperature in an oxidative environment. Since the sample is allowed to combust in a somewhat open environment, different portions of the composition are consumed at different temperatures. The resulting residue (ash) can also be measured to indicate the level of fillers present. TGA is a very useful tool in identifying the carbon black and filler content of samples in a much shorter time than is possible with a traditional muffle furnace type ash test. Sample Size Needed: 0.25" minimum thickness and a minimum weight of 10 mg. Test Time: Approx. 45 minutes. Test Result: Weight Change over temperature and time, Residue. Test Significance: Accurate indication of filler levels. Test Limitations: Slower ramp speeds provide more detailed results.

Physical Property Testing

Specific Gravity – (Ref ASTM D792) - Determines the weight per volume of a given material or material structure. Typically expressed in grams/cubic centimeter, this value is used to calculate the theoretical sheet weight. Basic material identification techniques often include the distinction of whether a sample floats or sinks. In that regard, material with a Specific Gravity greater than 1.00 will sink while those less than 1.00 will float. Specific Gravity values are also used along with Melt Flow to distinguish the different Polyethylene material families (LDPE, MDPE, and HDPE). Specific Gravity is one of the few physical properties with a linear relationship to the inputs. ***Sample Size Needed:*** 1.5"x3". ***Test Time:*** Approx. 15 minutes. ***Test Result:*** Average Density in g/cc. ***Test Significance:*** Grade distinction within polymer families. ***Test Limitations:*** Styrenic materials take longer to run and require a smaller sample size.

Melt Flow – (Ref ASTM D1238) - Measures the flow rate of the material under a specific set of time, temperature and pressure conditions. In terms of extrusion, this is one of the most important properties as it provides a strong indication of our ability to extrude and control the material in our process. Since the temperature and pressure have a major impact on the result and vary from material to material, it is especially important to ensure when making comparisons that results are apples-to-apples. Melt Flow can also be used to distinguish the HMWPE materials from HDPE grades. ***Sample Size Needed:*** 10 grams minimum. ***Test Time:*** 20-30 minutes start to finish. ***Test Result:*** Melt Flow in grams per 10 minutes. ***Test Significance:*** Identifies process ability of materials and distinguishes certain grades. ***Test Limitations:*** Gives an indication of the flow rate, but does not provide an indication of Melt Strength.

Tensile Strength – (Ref ASTM D638) - Provides a measure of the ability of the material to hold itself together and resist an external pulling force. Typically the strength at Yield and/or the strength at Break are identified. Tensile testing also provides a measure of Elongation. The full combination of tensile properties provides insight into the elasticity of the material. Materials with high elongation results are typically more durable and able to withstand more physical abuse. Materials with low elongation results are typically more rigid with better stiffness. It is important when comparing tensile properties reported by various sources to ensure that the test speed and specimen size are consistent. Results will vary wildly when run at slow head speeds versus fast. ***Sample Size Needed:*** Typically injection molded dog bones are used. If cutting from flat sheet, a minimum of 5 samples .75" x 6" are needed. ***Test Time:*** Dependent on the head speed and elongation of the samples. **Test Result:** Tensile Strength, Tensile Strength @ Break, Tensile Modulus, Elongation @ Yield, Elongation @ Break. ***Test Significance:*** Insight into the durability of a material. ***Test Limitations:*** Difficult to replicate the forces seen in actual applications.

Flexural Modulus – (Ref ASTM D790) - A three-point bending test that quantifies the stiffness of a material. Test specimens are placed on pedestals separated by a distance equal to 16 times the thickness of the test sample. A force is applied to the center of the span and the amount of strain imparted on the outer most fibers of the sample is measured. Results provide a true indication of the stiffness of the material and its ability to withstand a load. ***Sample Size Needed:*** Typically .125 x .5 x 5". ***Test Time:*** 5 minutes per test bar. ***Test Result:*** Flexural Modulus. ***Test Significance:*** Stiffness/Rigidity. ***Test Limitations:*** Span is tied to sample thickness.

Notched Izod Impact Strength – (Ref ASTM D256) – Pendulum style impact test of a notched sample subjected to a shock force. Typically used on more notch sensitive materials such as HIPS and ABS. The force absorbed by the notched sample is measured and the type of failure is described (No Break, Partial Break, Hinged Break, Complete Break). ***Sample Size Needed:*** .125 x .5 x 2.5". ***Test Time:*** 5 minutes. ***Test Result:*** Impact Strength in ft-lbs/in. ***Test Significance:*** Defines the notch sensitivity of a material. ***Test Limitations:*** Crystalline materials typically result in a No Break result.

Heat Deflection Temperature – (Ref ASTM D648) - Measures the influence of heat and pressure on the stability of a material. Sample bars are placed on edge in a three-point bending fixture and immersed in a circulating oil bath. The temperature of the oil is gradually increased. Testing is stopped when the bar deflects 0.010" and the temperature is recorded. Typical pressures used are 66 and 264 psi. **Sample Size Needed:** multiple bars .5" wide and 6" long. ***Test Time:*** Dependent on ramp rate and heat resistance of the material. ***Test Result:*** Temperature. ***Test Significance:*** Helps to define the maximum temperature environment the sample could likely withstand as well as the maximum temperature at which a formed part could be removed from a mold without warping. ***Test Limitations:*** Difficult to test samples less than .125" thick because they won't stand in the fixture long enough for test completion. Results are affected by annealing.

Vicat Softening Point – (Ref ASTM D1525) – Provides a measurement of when the surface of a material is soft enough under temperature to be penetrated by a blunt nosed probe. A sample is placed in the circulating oil bath with a blunt nosed probe of 1 sq. mm area with a load resting on the surface. The temperature of the oil is gradually increased to the point that the probe penetrates the sample 0.040" and the temperature is recorded. ***Sample Size Needed:*** .125 x 0.5 x 1". ***Test Time:*** Dependent on the ramp rate and heat resistance of the material. ***Test Result:*** Temperature. ***Test Significance:*** Identifies the minimum temperature at which the surface of the material could be molded. Test Limitations: Thinner samples may have to be stacked/layered to prevent influence from the backing plate.

Gardner Impact – (Ref ASTM D5420) – Provides a measurement of the impact resistance of flat sheet samples to a blunt force blow. The specimen is positioned on a platform above an opening of a specified diameter. The striker (tup) sets on top of the specimen. A weight is then lifted to a predetermined height and dropped onto the striker transferring energy into the sheet. The impact site is then examined to see if any fracturing has occurred. A failure is identified as any surface crack or opening that can be caught or felt by fingernail. The platform opening diameter, the striker diameter, and the weight used must all be specified. The literal Gardner Impact Strength is identified as the drop height at which 50% of the impact sites pass and 50% fail. ***Sample Size Needed:*** 4 x 4". ***Test Time:*** 5 seconds per specimen. ***Test Result:*** Gardner Impact in ftlbs. ***Test Significance:*** Simulates impacts caused by flying objects such as stones. ***Test Limitations:*** Pass/Fail judgments are somewhat subjective.

Shore Hardness – (Ref ASTM D2240) – Provides a measurement of the hardness of the surface of a plastic sample. The sample material to be tested must be at least .250" in thickness (layering of pieces is acceptable to obtain the necessary thickness). Durometer values are generated by measuring the spring force resistance as an indentor is pressed into the surface of the sample. The diameter of the indentor head is different depending on the Durometer scale being used. Typically, readings are taken 2 seconds after the indentor has been introduced to the sample. ***Sample Size Needed:*** .250 x 2 x 3" (layering can be used to obtain the needed thickness). ***Test Time:*** 5 seconds per specimen. ***Test Result:*** Shore Hardness per scale (Shore D). ***Test Significance:*** Identifies the hardness of the surface of a given sample. ***Test Limitations:*** Various hardness scales do not correlate with one another. Hardness judgment is somewhat subjective.

Multi-Axial Impact – (Ref ASTM D3763) – Provides a measurement of the Total Energy required to puncture a test specimen. The sample plaque is clamped to a table that has an opening suitable to receive a dart with a .5" radius tip. The dart contains a load cell as well as a trigger flag for collecting data. The dart is released from a sufficient height to puncture the sample. Additional weights can be added to facilitate enough force and speed to accomplish a puncture. As the dart punctures the sample, the energy consumed is calculated based on the load placed on the load cell and the change in speed of the dart as it travels. The resulting curve also gives an indication of whether the induced failure is ductile or brittle in nature. ***Sample Size Needed:*** 4" x 4". ***Test Time:*** 45-60 seconds per sample. ***Test Result:*** Total Energy measured in ft-lbs (Plotted curve can also qualify failure mode as either ductile or brittle.).

Test Significance: Izod attempts to identify the 'strength' of the material while Instrument Impact seeks to define the 'weak point.' ***Test Limitations:*** Difficult to generate enough energy to puncture thicker and more resilient material samples.

Scratch & Mar – (Ref Taber Method) – Provides a measurement of the scratch or mar resistance of plastic sheet. For scratch testing, tips with diameters of 0.1, 0.4, and 1mm can be used with the 1mm tips being the default setting. For mar testing, tips with 7mm tips are used. In addition to the tips, force is applied in the form of weights representing between 2 and 20 Newton's. The sheet sample is clamped onto a traveling carriage. The tips with weights are gently lowered onto the surface of the sheet. The carriage is then actuated causing the tips to be dragged across the sheet surface. The sheet is then examined to quantify the degree of the scratching or marring. Generally a visual examination is conducted though the depth and/or width of the scratch toughs could be measured as well. ***Sample Size Needed:*** 5" x 12". ***Test Time:*** 1 minute per sample. ***Test Result:*** Subjective categorization of scratch and mar resistance. ***Test Significance:*** Measures the relative resistance to scratching and marring. ***Test Limitations:*** Test doesn't necessarily translate well to in use wear concerns and interpretation of results is somewhat subjective.

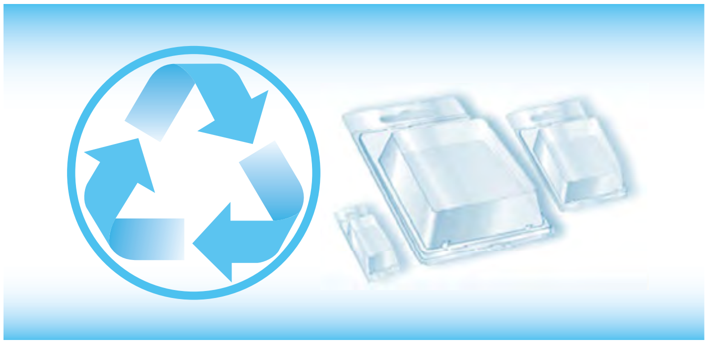
Accelerated Weathering – (Ref Q-Lab) – Provides a simulated exposure sequence to ultra violet radiation that allows weatherability to be categorized. Several variations of test exposures exist, but for our purposes we typically follow two settings. First, our QUV panel use fluorescent fixtures which emit UVA-340 radiation. The 340nm light wavelength sits near the middle of the harmful UV spectrum emitted by the sun. For exposures on the QUV panel, we use 728 hours as the equivalent to 1 year worth of literal south Florida exposure. The QUV panel is run with 100% light all the time. Second, our Xenon chamber uses a xenon arc light fixture which emits light that covers the 300-400nm wavelength. The xenon arc light more fully mimics the harmful light band emitted by the sun but relative exposure times are longer. For exposures in the Xenon chamber, we use 1200 hours as the equivalent to 1 year worth of south Florida exposure. Also in the Xenon chamber we run a cycle consisting of 102 minutes of light followed by 18 minutes of light and water. The water portion of the cycle attempts to mimic the influence of dew and/or rain on the way the radiation is applied to the sample. In both cases, appropriately sized samples are needed to allow the requested testing to be completed during or at the conclusion of the exposure cycle. In most cases, color and general surface appearance are tracked though other properties could be measured as well. ***Sample Size Needed:*** Dependent on testing needs though 3" x 5" is typical. ***Test Time:*** Dependent on application. ***Test Result:*** Property quantified measurement of the influence of the exposure. ***Test Significance:*** Useful for apples to apples comparison of the effects of UV exposure under specific conditions. ***Test Limitations:*** It is impossible to fully and accurately recreate the harmful radiation aspect of the sun or replicate all of the exposure conditions seen in various applications.

Color Spectrophotometer – (Ref ASTM D6290) – Provides for the relative comparison of color consistency between an identified master or standard and a trial. For best results, the surface, thickness, and opacity of the master and trial should be as close as possible. Any differences in these areas can create big variations in readings. Equipment functions that must be agreed upon include the light source/illuminant, color space, observation angle, and aperture view. Primex default conditions use illuminant D65, CIE L*a*b* color space, a 10° observation angle and the small aperture view (SAV). Measurements involve bouncing a light off of the sample and measuring the reflectance and refraction of the light pattern that returns. By doing this, a lightness/darkness value (L), a Green/Red value (a), and a Blue/Yellow value (b) are determined. The comparison of these values between the standard and trial samples creates the Delta values (DL, Da, Db) that describe how the samples are different and the total difference (DE) which describes their overall variation. Generic Primex tolerances specify a DE < 1.50 for all materials except ABS which must maintain a DE< 2.50 due to the susceptibility for yellowness. Even with those tolerances in place, a visual override exists for all colors. In essence, no matter how bad the numbers are if the sample looks good it is, and no matter how good the numbers are if the sample looks bad it is. ***Sample Size Needed:*** 2" x 2". ***Test Time:*** 1 minute. Test Result: Color reading showing DE, DL, Da, and Db results. ***Test Significance:*** Numerical characterization of color appearance. ***Test Limitations:*** Many factors influence the accuracy and repeatability of the readings. Correlation between units is difficult. Equipment cannot mimic the color perception that is possible with the human eye.

Opacity – (Ref ASTM D1746) - Opacity measurements provide a means of describing the amount of light that transmits through a sample. Primex uses two methods to measure opacity, a Densitometer and a Light Meter. The Densitometer is most typically used in plastics to measure translucent samples. The instrument is calibrated using a film of known density and generates an Optical Density result. A light source is emitted from a platform below the sample and a measurement head picks up the transmittance from above. Measurements are literal spot results but can be taken at intervals across a web to quickly determine consistency. Using the Densitometer, low readings are more translucent while high readings are more opaque. The Light Meter is our most common method of measuring opacity. The view head of the Light Meter is mounted in the bottom of an enclosed box that has a sliding door. At the top of the box is a light source with a rheostat control (dimmer switch). Deeper inside the box is a piece of frosted glass used to evenly disperse the light. With the box closed and nothing over the Light Meter view head, the light source is adjusted so that a reading of 100 foot candles is seen on the meter. The sample to be measured is then placed over the view head and the box closed again. The reading on the Light Meter is recorded. This value states the literal percentage of light transmission through the sample. Using this technique, lower readings are more opaque while higher readings are more translucent. ***Sample Size Needed:*** 3" x 3". ***Test Time:*** 15 seconds per sample. ***Test Result:*** Optical Density (Densitometer), Percent Transmission (Light Meter). ***Test Significance:*** Provides means of quantifying sample light transmission characteristics. ***Test Limitations:*** No good correlation between methods. Customer may not have similar setup.

Gloss Meter – (Ref ASTM D2457) - Provides an indication of the gloss level of a plastic sheet sample based on reflectance. The Gloss Meter is placed on the surface of the sheet and measurements are taken. The meter bounces a light off of the surface at a 60° angle and the measures the intensity of the reflected light. Typically 5 readings are taken at various locations across the surface of the sheet and the average is reports. Higher values indicate higher gloss levels. ***Sample Size Needed:*** As small as 2” x 2”. ***Test Time:*** 5 seconds per reading. ***Test Result:*** Gloss as measured in Gloss Units. ***Test Significance:*** Provides a repeatable numeric description of the gloss level of the sample. ***Test Limitations:*** It is very important to ensure a good seal between the view head of the Gloss Meter and the sample being read. As a result, reading formed parts can be difficult.

Orientation – (Ref ASTM D2732) – Provides an indication of how much the polymer chains have been stretched as well as how well they are aligned. During the extrusion process, a surplus of material is supplied to the nip of the rolls to ensure good roll contact is maintained throughout. This helps to ensure the thickness and surface pattern is consistent. As a result, as the material enters the nip it is thinned and stretched before it begins to cool. Once the skins are cooled or set, the rubber rolls maintain the tension as the sheet is pulled down the line. The Orientation test heats the material back up enough to release the stresses that have been induced during the process. Samples are cut from sheet in sizes typically 2” x 10” although the actual ASTM specification recommends 10” X 10”. The samples are then placed on trays covered with talc, sand, or some other medium that will allow them to move. The trays are placed in an oven and baked for 20-30 minutes. Oven temperature is based upon the material being tested. Once the samples cool again, the size is measured and compared to the original size. The percentage Orientation is the measurement of how much the sample changed in size. ***Sample Size Needed:*** 2” x 10” pieces are normally used but any size can work. These samples are normally cut from a full web sample. ***Test Time:*** Up to 30 minutes to run the test plus cooling time. ***Test Result:*** Percent Orientation (shrinkage). ***Test Significance:*** Orientation equals stress, so property performance can be affected. Secondary processing performance such as thermoforming is greatly affected by the orientation level. The combination of Melt Flow and Orientation help to indicate how well the material will support itself during forming. ***Test Limitations:*** Various methods are used throughout the industry. Interpretation of the appearance/look of the samples after testing is equally important. **NOTE:** *An alternate method used with Styrenics is to immerse 4” x 4” samples in a heated oil bath. Measurements before and after are still compared.*



Machinery Builders from Turkey Competing with World's Best

*[**Editor's Note:** we are grateful to Steven Pacitti, editor of the excellent "Plastics in Packaging" magazine published by Sayers Publishing Group (UK) for allowing TQ to reprint this article in its entirety. This article first appeared in the December 2014 edition.]*

European and North American thermoforming machinery manufacturers are keeping a close eye on the development of Turkish competitors. With the technology moving forward rapidly, Steven Pacitti finds out if Turkish manufacturers are having it all as they like it.

When European thermoforming machinery manufacturers met in the Czech Republic earlier this year, the threat posed by Turkish machinery makers was a major topic of conversation.

The general manager of Turkish thermoformer Sem Plastik, Yavuz Eroglu, explained that domestic machinery now offered a viable middle ground between the lower prices of Asian suppliers and the more expensive Europeans (Plastics in Packaging, June 2014 and Thermoforming Quarterly, Vol. 33, No. 2).

Two of the country's manufacturers of thermoforming machinery exhibited their latest technology at the Eurasia Packaging Istanbul show in September, giving visitors the opportunity to get up close and personal with what Istanbul-based firms Inpak Makina and Yeniyurt Makina have to offer.

It is instantly apparent when watching these Turkish machines in action that any preconceptions one might have about the technology should be left at the door. Not only do they match the speed and machine-build quality of their European and North American counterparts, but the machines feature mostly European parts. Yet, based on the labour costs in Turkey, the machines can be purchased at an extremely competitive price.

Talking to *Plastics in Packaging*, Robert Purves, sales engineer for Inpak Makina, explained: "Our target with the TS-800 thermoforming machine is to increase our European and UK market among others to the west. To be successful in Europe you need the good points of the well-known machine brands but not their bad points.

At Eurasia Packaging Istanbul, Inpak unveiled a new version of the TS-800 with a four-column forming station. Aptly named TS-800/4+R, it comprises forming, hole-punching, cutting and robot stacking for PET, PP, PVC, PS, HIPS or OPS sheet.

Purves, a former sales and service engineer at Illig UK with a long history in the thermoforming machinery sector, is proud of Inpak's new forming station with servo plug assist, which he says is stronger than competitive systems and therefore provides greater stability to moulds to produce flat flanges to products that will be sealed in a later process.

Rethinking technology

Inpak Makina started operating in the thermoforming machinery business in 2006 after a client asked company owner Ridvan Inan, a mechanical design engineer, to build a servo-controlled thermoformer, which had not been designed locally until then. Inan took up the challenge and built a reliable, durable system that gives sustainable high speed and high capacity.

With customers happy to reduce their investment costs for a high capacity machine, Inpak Makina expanded its packaging machinery business into thermoforming.

With fast and reliable service support, Inpak managed to convert a number of local companies that had been clients of European thermoformers. But the story did not end up with just the local market.

After presenting at international exhibitions, the machine has been approved by customers from a number of countries and Purves comments that customers buying Inpak machines have gone on to make further investments in the company's equipment.

With a team of 50 staff, Inpak now exports to five continents and more than 20 countries, with 85 per cent of the company's production exported to locations including Canada, Germany, South Africa, Russia, Australia, The Netherlands, Bulgaria, UAE and Egypt. The company can produce 50 machines a year.

This growing amount of export business has led to Inpak Makina forming distribution agreements in North and South America for its servo-driven thermoforming machines.

Inan's mechanical engineering background also led to considerable amounts of re-thinking when it came to traditional thermoforming technology. For example, Inan used special needle bearings on the toggle systems and these provide gapless joints that ensure accuracy during the cutting process, whereas some manufacturers use standard pins and bushes.

But it does not end there, as Purves explains: "We moved the air and vacuum valves to the back, closer to the forming tables, meaning shorter pipe-work and a shorter distance and time to fill with air or vacuum. This reduces air consumption and improves energy efficiency. It is also a quieter machine with this modification with a faster forming time.

"Another study on energy efficiency is implementing a Regenerative drive system for servo controls. With a conventional stacker the machine can achieve up to 65 cycles effectively in production. The robot stacking system can achieve a maximum 45 cycles compared with 35 cycles for a large European competitor. Our AB stacking at 45 cycles is very fast. The number of trays in a stack is a very important concern at high-speed production rates.

“We can offer a dry vacuum pump without oil if required, which is more energy efficient and saves time and cost on servicing."

The machine is made using mainly European parts — for example, energy saving heating elements are by Germany's Elstein, servo motors by SEW, chains by IWIS and the control technology from Austrian firm B&R.

"If it is wanted we can offer moulds together with the machine as well." Purves, who is based in Peterborough, UK, has had positive feedback so far from UK and Irish thermoformers on the build quality and service.

The importance of exports

Yeniyurt Makina, another Istanbul-based thermoforming machinery manufacturer, counts Europe, India, Oceania and CIS countries as its strongest markets, with 90 per cent of company sales coming from exports.

Joint managing director Ercan Tuylu told Plastics in Packaging that target markets for 2015 include Central Europe, USA and the Far East, and the company has already signed partnership agreements in these markets.

Like Inpak, European parts contribute the majority of the inner workings of Yeniyurt’s thermoformers, with suppliers including Germany-based firms Nord (gear motors), Beckhoff (PLCs and servo motors), SEW-Eurodrive (also servo motors), Elstein (heating elements), and IWIS (chains), Italy’s Dvp (vacuum pump), US-based Mac (valves) and Japan's Smc (pneumatic elements). The company makes it own moulds.

Yeniyurt has a number of machines in its portfolio, with production speeds ranging from 40 cycles per minute for the YM-7205, YM-9005 and YM-125 machines, to 45 cycles per minute for the YM-6545/3 FCS (form/cut/stack), YM-6545/4 FPCS (form/punch/cut/stack, YM-125/3 FCS and YM-125/4 FPCS, and 55 cycles per minute for the YM-8565/3 FCS and YM-8565/4 FPCS. Draw depths range from 60mm to 160mm.

“Our newest project is for a complete in-line system consisting of forming, punching, padding, top and bottom labelling, punching, cutting, and lowering to the hands of the packer,” says Tuylu. “We also offer various options such as five different models of robot stacker, with the latest SpYder type a world’s first in thermoforming. We can also offer a conveyor and elevator system at the rear of the machine and a number of other flexible modifications on the machines.”

With robot stacking, Tuylu says that 45 cycles is standard for the company, while 58 cycles is possible without robot stacking using 140-micron gauge PET material.

At the Eurasia Packaging Istanbul show, Chris Fulbrook, who handles sales on behalf of Yeniyurt from his base in the UK, explained that the company sold two machines to a customer in Peru (at the K’2013 show in Germany) and has recently sold four machines into the UK and one to New Zealand.

For the Peruvian customer, Yeniyurt has a relationship with a local producer of spare parts.

Asked why a European converter should purchase a Yeniyurt machine, Tuylu responds: “We offer at least the same quality machine as a well-known Illig or Kiefel. But we offer a better price on the machine and moulds and can provide flexibility, reliability and high production output. We also have excellent service time. We guarantee a service team will arrive in 72 hours in any European country.”

Tuylu continues to explain that Yeniyurt has two partners and five engineers living in the UK in order to service the market, as well as four engineers in Istanbul looking after the UK market.

“That’s the reason we have been working with market-leading companies in the UK for almost five years, but we plan to increase our market share with more options on the machines and some new strategies.”

One area that Yeniyurt has targeted recently with innovation is energy efficiency. Here the company has developed an isolation system in its ovens that uses special heating elements. The continuous power consumption to produce 275 to 300kg does not rise above 60kW, which Tuylu calls an “excellent figure”.

Yeniyurt currently has 592 machines in operation around the world.

The tipping point

Inpak Makina and Yeniyurt Makina are not the only two thermoforming machinery manufacturers in Turkey. Others include Guven Teknik, Kuzey Global, Detay Makine Plastik, and HT Thermoform.

While these companies are forging themselves a solid business outside of Turkey, what is the view of major domestic thermoformers?

SEM Plastik’s Yavuz Eroglu, who spoke at the European Thermoforming Conference about the strengths of Turkish machinery makers, is also president of the Turkish Plastics Industry Foundation (PAGEV).

His company’s thermoforming operation is comprised of 85 per cent WM (TFT) machines, with 15 per cent of production coming from Guven Teknik machinery.

“We are the only client of WM (TFT) in Turkey that still invests in the existing supplier. All other thermoformers have shifted to Inpak," he admits.

SEM Plastik started investing in local machinery after 2009 and explains that investment in Turkish equipment is accelerating.

Benefits to Turkish equipment, he says, include fast service and spare parts delivery: "We have service in a maximum of three hours at our door and spare parts are delivered fast and at cheap prices compared to overseas competitors. Also, Turkish thermoforming machinery producers also make the moulds themselves or have close relationships with local mould makers, which is a preference for a converter."

He explains that first investment cost is some 30 per cent less than for European machinery.

Responding to claims by European thermoforming machinery makers earlier this year that Turkish manufacturers could not offer the same machine speeds or functions, Eroglu says: "That is not true. Speeds are at the same level. But most important to consider is sustainability of speed over a number of years." What Eroglu means here is that local machines in Turkey have only been on the market for six or seven years and for SEM Plastik, he wants to be sure about the long-term performance of these machines.

"So we are giving a chance to local machines gradually, as they age and give us more confidence in the years ahead."

Having arguably delivered the most talked about presentation at the thermoforming conference earlier this year, Eroglu said that feedback from delegates to his speech was mixed: "Some of our European machinery suppliers were mainly focused on the figures related to the booming Turkish converting market, and thus new machine sale opportunities. Some of them were focused on the growing Turkish thermoforming machinery production as they find a possible thread for their business. Meanwhile, my suggestion is strategic joint ventures between Turkish machine companies and European ones, which will enable a better service to the local Turkish market and easily reach the Middle East and neighbouring countries."
The latter is an opinion not shared by Inpak's Robert Purves, who comments that his company sold four machines at the Eurasia Packaging Istanbul show (two of the new type and two of the old).

"I was in the factory in Istanbul recently and it was full of machines under build," he said.

In response to Eroglu's view that Turkish machinery manufacturers need to show sustainable performance over a number of years to gain confidence, Purves simply says: "Most people who have seen the machine are very impressed with the build quality. Besides, among the others, German and South African customers converted from European suppliers and bought respectively four and 10 machines from Inpak, which can be shown as evidence of that confidence already."

It is no doubt a view shared by Yeniyurt Makina's Ercan Tuylu who finishes by saying that his company has "an almost perfect system with no compromise on quality."

Judging by the machinery on display at the Turkish packaging fair in September, they certainly have reason to be confident. ❙

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Review of AMI Thin Wall Packaging Conference (Europe) 2014

By Conor Carlin, Editor, Society of Plastics Engineers' *Thermoforming Quarterly*

The City of Cologne in Germany is renowned for its famed "Dom", the imposing cathedral with twin spires that managed to survive Allied bombing during World War II. During the month of December, the city is also known across Europe for its "Weihnachtsmarkt" or Night Christmas Markets. With locals and tourists milling around temporary outdoor structures containing everything from wintry clothes to local cuisine to hot mulled wine ("Gluhwein"), the spirit of the season arrives at the beginning of December. It is also the time of year when around 200 packaging professionals gather at the Maritim Hotel for the annual Thin Wall Packaging Conference.

Sponsored by Applied Market Information (AMI), a UK-based market research firm, the Thin Wall Packaging (TWP) Conference is now in its 9th iteration in Europe (next year will be the 4th annual event in the US). Brand owners including Nestle, General Mills, Heinz and Yoplait are prominent speakers and attendees at this conference with packaging technologists and material scientists at the fore. From resins to in-mold labeling, from thermoforming to injection molding technologies, TWP can claim to be a pre-eminent forum where leading-edge technologies and innovative packaging designs come together.

180 delegates attended the 9th Annual AMI Thin Wall Packaging Conference in Cologne (courtesy of AMI LLC)

Food Waste and the Role of Packaging

One central theme emerged at this year's event: the challenge of food waste and the salutary role that packaging (plastic and other) plays in this global phenomenon. It could be argued that this theme can be classified under the megatrend of sustainability since recyclability, bio-based materials and light-weighting all played a significant role in the conference proceedings.

According to Marcel Keuenhof, a packaging technologist "and enthusiast" from Heinz in The Netherlands, fully one-third of all food produced gets lost or wasted. The majority of this waste occurs in the supply chain and at the consumer level. Innovative and effective packaging, especially as related to the increased shelf-life of foods, is critical to reducing such volumes of waste.

With new developments in materials science and technological innovations in injection and thermoforming machinery, the majority of papers reinforced this central theme introduced by major food companies such as Heinz and General Mills. Many of the converters positioned themselves as solutions providers, in both the sustainable and technological sense. Weight reduction is a key element in managing CO_2 emissions since transportation of packaged goods to market plays a large role in carbon accounting. In one statistical insight, metal cans have been downgauged by 45% since 1974. Other insights showed that plastic is chosen in 44% of new product launches for food and vegetable packaging[1]. Several discussions about foamed materials such as "Envalight" from Spanish company EDV Packaging highlighted novel solutions that answered the need both for extended shelf life and optimized performance of the package.

The Pull of Market Makers

The conference opened with presentations from two powerhouses in consumer goods: Yoplait and General Mills. According to the speakers, the role of packaging continues to evolve. In the past, functionality was the primary driver of innovation as packages met the foundational needs of "Preserve, Promote, Protect." As the retail landscape changed and economic challenges had to be met through consolidation, packaging solutions came from retail providers while package designers helped turn containers into vehicles for cost-center optimization. Today, a combination of new messaging (full disclosure of ingredients, sourcing, brand), divergent demographics and environmental standards mean that packaging is a competitive differentiator in evolving channels.

Yoplait discussed a recent packaging innovation that led to increased sales in the highly fragmented yogurt market. A new pot thermoformed from foamed PS was at the heart of a new product launch. The container was slightly larger than its predecessor but because of the foamed material selection, it had a lower part weight.

Belgian company DeSter provided unique insights into the airline catering business. Part design plays a critical role in airline food service due to extreme space limitations (cabin galleys, trolleys, passenger trays). With more and more airlines maximizing seat layouts, the space for food preparation is getting smaller. New APET/CPET thermoformed trays with fold-over hinges are just one example of how companies are dealing with these constraints. From a material perspective, many airlines are moving away from styrenics and choosing olefins, primarily PP, due to better chemical resistance and lower weights. Generally speaking, injection molded parts are more expensive than thermoformed parts in this context.

The Promise of In-Mould Labeling

Another major thread running through many presentations was the increasing adoption of plastic solutions, despite ongoing regulatory challenges in the form of outright bans and difficulties presented by potential contamination of recycling streams. Glass and metal cans are being replaced by new, innovative plastic containers that are both injection molded and thermoformed. Ancillary technologies such as decorative printing and in-mold labelling (IML) are helping to create value-added solutions for leading global brands.

On the topic of IML, several presenters made the distinction between IML and IML-T, with "T" standing for "thermoforming." For many years now, this has been a developmental (and expensive) technology but it appears that some standardization is starting to develop. According to representatives from RPC, a multinational converter using both thermoforming and injection technologies, IML-T suffered from too many individual approaches that required substantial investments in unproven technology. Today, IML-T is more modular and flexible with competitive unit cost levels with 'traditional' IML. Those who were patient and willing to work through next-gen systems are starting to see big benefits. Verstraete, a Belgian company focusing on IML and IML-T solutions that prints 45 million labels per day, is planning a multi-year, multi-million Euro investment to sustain future growth in this area.

In what was possibly the most contentious discussion of the event, a cost comparison between IML and IML-T provoked debate among thermoforming OEMs and injection OEMs on the subject of machine prices. What can be stated based on facts is that IML-T offers certain advantages in cycle times and tool cavitation which, all else equal, can lead to higher production volumes. As innovations in materials, labels and equipment continue, we can be certain of seeing increased adoption of IML-T parts in local supermarkets.

New Material Developments

The food packaging sector has benefited mightily from advances in barrier film technology, including the well-known PE/EVOH/PE or PP/EVOH/PP sandwich materials and oxygen-scavenging films which dramatically improve shelf life. But there are other drivers for new material development including legislation, recycling, tax reduction and public opinion. In the Nordic countries, for example, a tax is levied on plastic waste based on the percentage polymer content. Scanfill, a Sweden-based company, is promoting mineral fillers to help reduce the polymer content in thermoformed sheet. In addition to helping companies reduce their potential tax liabilities, the Scanfill material is said to offer improved barrier properties over PP because the mineral content increases the oxygen and water barrier. Data provided by the company suggests a reduction in cycle time due to the lower volume of polymer in the sheet. This also translates to lower energy costs and lower CO_2 emissions.

In what was arguably the most interesting paper for those at the nexus of biomaterials and packaging, Dutch company Avantium presented details on their PEF polymer. According to the company, Polyethylene Furanoate is a new polyester derived from 100% renewable feedstocks. Through their proprietary YXY catalysis process (pronounced "ixy"), the company is working on developing "drop-in" processes whereby existing assets in the PE value chain can be used without significant modification. Though they are still at the pilot stages of development, early results suggest that PEF could have impressive performance-based characteristics including improved oxygen and water barriers. Working in conjunction with Wifag-Polytype for thermoforming trials, the company performed microwave and freezer tests. Because PEF has higher thermal stability than PET, this could have important benefits for items such as packaging for microwaveable ready meals.

Like other 2nd generation biomaterials, PEF's success will depend on whether or it can be cost-effective at scale. With large, sustained investments required to reach industrial production levels, bio-based materials have yet to reach their full potential. It remains to be seen if Avantium's approach will result in a product that can outperform traditional petrochemical-based materials in both mechanical properties and economics.

Turnkey cup camera inspection (CCI) system with automatic packing behind Gabler M98 thermoformer (courtesy Mould & Matic GmbH)

Closing the Loop?

Innovation comes in many forms and it was clear from several papers that the thin wall packaging segment continues to provide high-tech solutions to global challenges. Attendees learned about novel chemistry that results in improved material performance as well as machine technology that makes these breakthroughs possible. On the machinery side, a joint presentation from Mould & Matic of Austria and Visy Plastics of Australia illustrated some new technology in online inspection of thermoformed parts. While the application of IT to the thermoforming process is now happening with systems like Tool Vu, only a few in the industry have proposed the possibility of a closed-loop process whereby adjustments to the forming parameters are initiated based on inspection of final parts. In this particular case, Visy and Mould & Matic collaborated on a project to ensure 100% inspection of a thermoformed PP container. The challenges were significant: very high speed lines (up to 1400 cups/min) with separation ("unstacking") of containers prior to inspection before restacking and then final packing. The system was designed to inspect for flange and body imperfections as well as sidewall accuracy. The results are impressive: the end-user went from a manual inspection process with a reject rate of 7.243% to an automatic inspection process with 0.002% reject rate. While this cannot claim to be a true closed-loop system at the moment, the implementation of the high-speed visual inspection system is an important technological development for the thermoforming process.

AMI continues to deliver a high-quality program for those serving the thin wall packaging market sector. Next year will be the 10th annual event in Europe and the 5th in the US.

References

1 Source: Datamonitor consumer insights (from EDV Packaging presentation at 2014 TWP Cologne, Germany)

Roger Kipp
Councilor

Communication Input and Output for Sustainability

The perception of value follows value creation and robust communications. SPE continues to be the vital resource for education, technical data verification and cutting-edge plastic industry innovation. Essentially, you can't stay effective in the rapidly changing plastics industry unless you are in SPE. For the next generation of plastics professionals, SPE programs that generate jobs and increase promotion opportunities are equally important. That technology resource however, is only as effective as the communication tools provided by SPE leadership. ***"You won't use it if you're not aware it's there."***

Networking at SPE conferences is a primary resource to generate new business leads, make contacts and learn about innovative technology. In fact, conferences, TopCons, and workshop formats have been identified through SPE surveys as a primary source of member value.

Those reading this article do not need to be convinced of this. You are members and have therefore experienced the value of a Thermoforming Conference, an Extrusion Division Technical Conference, ANTEC and other events. You value the *Thermoforming Quarterly*, SPE websites and other technical journals such as *Plastics Engineering*. The challenge is thus: as a society, we all need to be engaged in the communication process if we want to sustain this valuable resource of knowledge and sharing among those of common professional interests.

It is critical to remember that communications works on different levels. We need systems that support the communication input as well as the output. We must also encourage diversity of thought. SPE now has those systems in place to provide knowledge (output) and encourage technical data (input).

The upgrade, expansion and modernization of these communication platforms have been a primary focus of SPE leadership. Over $300,000 has been invested in communications enhancement projects:

• *Upgrading the account management system* for improved services to members and member groups with greater flexibility.
• *A new and modern website* with a searchable database including a technical library, SPE Journals, online plastics research, industry resources search, "Find a Consultant", career solutions and e-networking platform "The Chain" to engage member technical sharing.
• *Conference apps* supporting conference navigation
• *Plastics Engineering Magazine* upgraded to today's needs
• *Re-branding* to introduce the next generation SPE

These are all new systems that will continually improve through the ability of members to interact, innovate and communicate. Let's all jump on board and be part of that process as we continue to build web content.

ACTION LIST

Project	Target date	Investment cost	Status
Upgrade AMS	June 2013	120,000 $	done
NEW WEBSITE	March 2014	150,000 $	done
Conferencing APP's	August 2013	20,000 $	done
E-networking platform	September	30,000 $	In progress
PE magazine overhaul	July 2013	0 $	done
Re-Branding	October 2013	12,000 $	done

A review of these platforms reveals that SPE is providing these communication input and output opportunities. It is important that we see these systems as strategies toward sustainability for the society as a whole. Use them and share them with non-SPE members. SPE leadership has developed these resources to foster communication among the membership and to encourage new membership by:

• Expanding the use of technology
• Addressing generational gaps
• Expanding and sharing resources
• Expanding the global brand
• Engaging members

I would be pleased to provide further detail and discuss your thoughts on these member value communications enhancements. Please always feel free to connect with me at srkipp@msn.com.

In closing, I want to share that the ANTEC meeting in March (during NPE in Orlando) will be my last meeting as the Thermoforming Division Councilor. Term limits have finally caught up to me! It has been a privilege to serve the Division and I look forward to working with the incoming Councilor to ensure a smooth transition.


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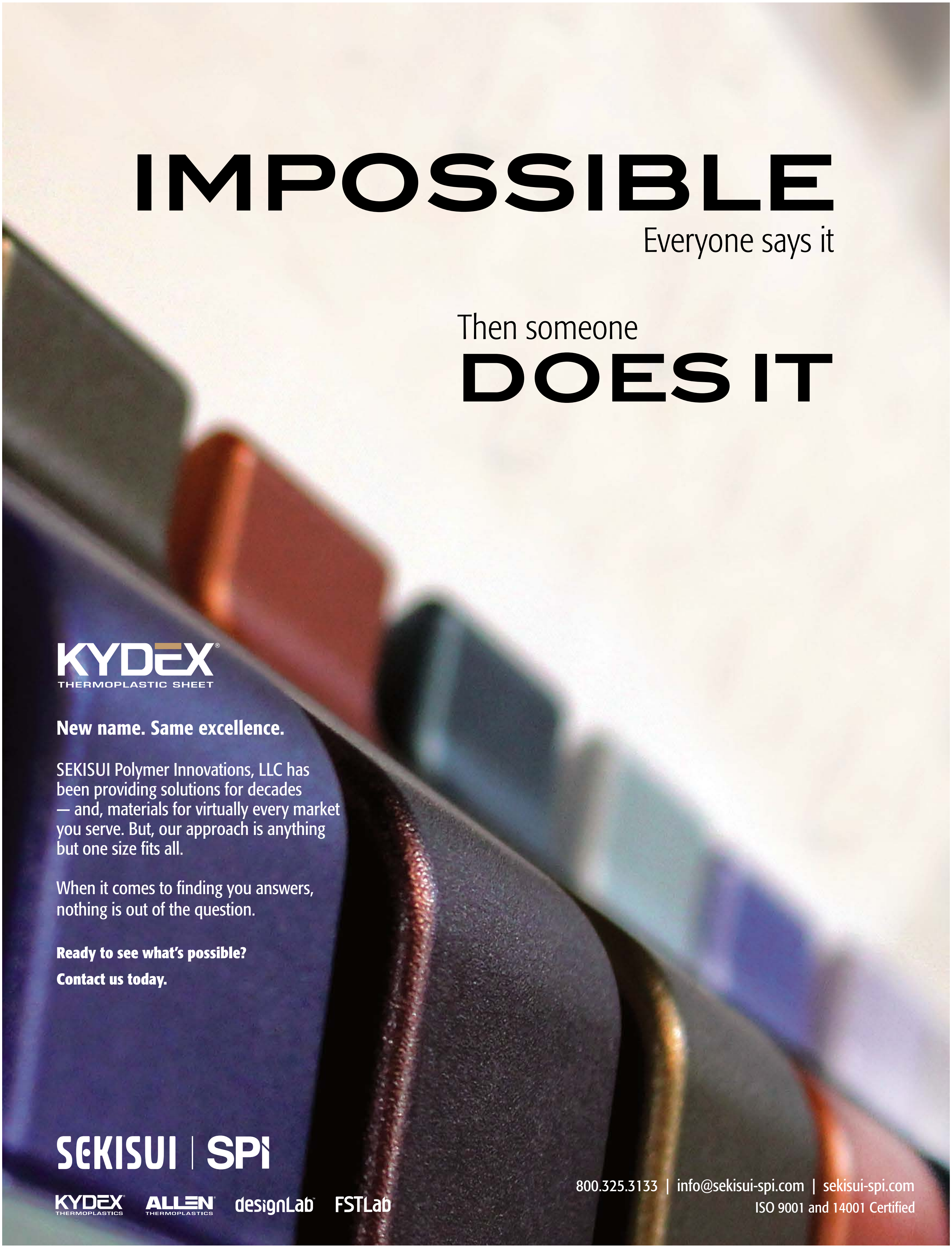
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