GPC is the largest glass manufacturing event in North America, attracting global manufacturers and suppliers to exchange innovations and solutions.
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©2015 Tri-Mer Corp.
Welcome to the 76th Conference on Glass Problems (GPC), a content-rich, technically oriented conference, designed as a high-value resource for the glass manufacturing industry professional. The Glass Manufacturing Industry Council, in partnership with Alfred University, co-organize the conference, with programming direction provided by an industry advisory board. As a result, GPC offers a wealth of resources. Technical sessions are designed to cite real world data from manufacturers and solutions providers. Additional resources are available, such as our popular short courses, this year in operations, combustion, and fracturing. A symposium on Forming in Glass Manufacturing makes use of an entire day to examine the critical processes and latest technologies in depth.

You will find the most extensive platform for glass manufacturing industry networking and exhibiting in North America, with extensive vendor booths, hospitality salons, hospitality booths, and social events.

The Conference on Glass Problems is organized by the glass manufacturing industry for the glass manufacturing professional seeking a wealth of high-value resources in one event. Welcome to the 76th Conference on Glass Problems.
WHO IS GMIC
The Glass Manufacturing Industry Council (GMIC) is a trade association of the glass industry that includes among its members, representatives of all four sectors: container, fiber, flat and specialty glass companies as well as leading suppliers to the industry, research institutes, and industry experts. Our goal is to promote the interest, growth, and sustainability of the glass industry. GMIC does for individual companies what they can’t easily do on their own—provide technical education, coordinate technical initiatives, advocate with lawmakers, and promote the usage and image of glass products as a vital part of society around the globe.

If you are a glass industry manufacturer, supplier, or research organization, and you are not presently a member, we encourage you to join GMIC now to ensure the vitality of the industry through your support of the industry’s trade association. Membership dues are based on company size and category. Contact GMIC’s Executive Director, Robert Weisenburger Lipetz, for full information.

GMIC EXECUTIVE COMMITTEE
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GMIC STAFF
Robert Weisenburger Lipetz, Executive Director
Donna M. Banks, Executive Assistant

CONTACT GMIC
600 N. Cleveland Avenue, Suite 210 Westerville, OH 43082
+1-614-523-3033 | info@gmic.org | www.gmic.org

GMIC MISSION
Facilitate, organize and promote the interests, economic growth, and sustainability of the glass industry through education and cooperation in the areas of technology, and the environment.

ALFRED UNIVERSITY
The Kazuo Inamori School of Engineering at Alfred University (AU) is a leader in glass and ceramic education. Established in 1900 as the New York State School of Clayworking, the school has a long-standing history of providing industry a workforce well-educated in the manufacturing of glass and ceramic materials. Today, the school offers BS and MS degrees in five disciplines: Biomaterials Engineering, Ceramic Engineering, Glass Engineering Science, General Materials Science and Engineering and Mechanical Engineering as well as doctoral degrees in the materials disciplines.

The school also serves industry by advancing the forefront of ceramics and glass research. In addition to maintaining an active portfolio of federally funded research, the faculty routinely collaborate with industry or projects ranging from fundamental research through product/process development. Interactions with industry are conducted through the Center for Advanced Ceramic Technology (CACT) and the Center for High Temperature Characterization (CHTC). The CACT facilitates collaboration between industry and academia with the goal of creating economic impact for the CACT’s industrial partners. The CHCT is a user facility that provides research, and unparalleled access to equipment designed for characterizing materials in the situ at high temperatures.

For more information about the Kazuo Inamori School of Engineering: http://engineering.alfred.edu

Doreen Edwards, Dean, Inamori School of Engineering
Alfred University, dedwards@alfred.edu

K. Sundaram, Inamori Professor of Materials Science and Engineering
Alfred University, sundaram@alfred.edu

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Warren Curtis, PPG

PUBLICATION OF THE 76TH GPC PROCEEDINGS
Registered attendees of the 76th Conference on Glass Problems will receive a bound copy of the proceedings, published by The American Ceramic Society and Wiley, and shipped to you by mid-2016.
MEASURING TEMPERATURE TO IMPROVE PRODUCT QUALITY AND PROCESS CONTROL THROUGHOUT THE GLASS MAKING PROCESS

Building on more than twenty years of thermal imaging experience, AMETEK Land has continued to widen its range of temperature measurement solutions with the NIR Borescope.

With the NIR Borescope it is possible to use the proven technology of the NIR Thermal Imager to accurately image the temperature of the entire area with only a small opening in the wall of glass melt tanks. The NIR-b offers continuous, thermal imaging with full temperature measurements within the scene. In addition, AMETEK Land in collaboration with Glass Industry leaders, has developed a protective coating to ensure long term product reliability in one of the harshest instrumentation environments on a Glass Plant.

PROVEN APPLICATIONS OVER A 65 YEAR HISTORY IN THE GLASS INDUSTRY

FEATURES & BENEFITS

High temperature measurement accuracy - enables optimum process control using high definition temperature imaging

Simple installation and ease of use - minimizes cost and complexity

Short wavelength sensor - low sensitivity to emissivity changes; can be used through glass or quartz view ports

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SCHEDULE AT A GLANCE

**Monday, November 2, 2015**
- 11:00 a.m. – 5:00 p.m. Registration
- 12:00 – 4:30 p.m. Student Plant Tour
- 12:00 – 5:00 p.m. Fundamentals of Batch and Furnace Operations
- 12:00 – 5:00 p.m. Combustion
- 12:00 – 5:00 p.m. Breakage Analysis of Glass Containers
- 5:00 – 5:30 p.m. Student Meeting
- 5:00 – 11:00 p.m. Hospitality Suites at Hilton

**Tuesday, November 3, 2015**
- 7:30 a.m. – 5:30 p.m. Registration
- 8:00 – 8:45 a.m. Exhibiting
- 9:00 – 10:30 a.m. Energy and Glass Melting Session
- 10:30 – 11:00 a.m. Exhibiting
- 11:00 a.m. – 12:30 p.m. Batching Session
- 12:30 – 2:00 p.m. Lunch & Exhibiting
- 2:00 – 4:30 p.m. Combustion, Refractories, and Sensors Session
- 4:30 – 5:30 p.m. Exhibiting
- 7:30 – 11:00 p.m. Hospitality Suites at Hilton

**Wednesday, November 4, 2015**
- 7:30 a.m. – 4:00 p.m. Registration
- 8:00 – 9:00 a.m. Exhibiting
- 9:00 – 10:00 a.m. Environmental Session
- 10:00 – 10:30 a.m. Exhibiting
- 10:30 a.m. – 12:00 p.m. Modeling Session
- 12:00 – 1:30 p.m. Lunch & Exhibiting
- 1:30 – 3:30 p.m. Forming Session
- 4:00 – 5:00 p.m. GMIC Member Meeting

**Thursday, November 5, 2015**
- 7:30 a.m. – 12:00 p.m. Registration
- 8:00 a.m. – 4:30 p.m. Forming Technology in Glass Manufacturing
- 11:50 a.m. – 12:30 p.m. Lunch

PROGRAM SCHEDULE

**SUNDAY, NOVEMBER 1, 2015**
- 6:30 – 9:30 p.m. GPC ADVISORY BOARD DINNER

**MONDAY, NOVEMBER 2, 2015**
- 12 – 4:30 p.m. STUDENT PLANT TOUR – ANCHOR HOCKING

Short Courses
- 12 – 5:00 p.m.
  - FUNDAMENTALS OF BATCH AND FURNACE OPERATIONS – Room C-121
    Instructor: C. Philip Ross, President, Glass Industry Consulting International (GICI)
  - COMBUSTION – Room C-122
    Instructor: Kevin Lievre, Glass Industry Consultant – The content of this class is jointly developed by John Connors, Chief Technology Engineer, Batch & Furnace, PPG Fiber Glass and Kevin Lievre
  - BREAKAGE ANALYSIS OF GLASS CONTAINERS – Room C-123
    Instructor: Peter W. de Haan, Senior Scientist, American Glass Research (AGR)
- 5 – 5:30 p.m. STUDENT MEETING – Room C-121
- 5 – 11:00 p.m. HOSPITALITY SUITES AT HILTON

**TUESDAY, NOVEMBER 3, 2015**
- 8 – 8:45 a.m. EXHIBITING
- 8:45 – 9 a.m. OPENING REMARKS
  - Robert Weisenburger Lipetz, GPC Conference Director, Executive Director, Glass Manufacturing Industry Council
  - S. K. Sundaram, GPC Program Director, Inamori Professor of Materials Science and Engineering, Kazuo Inamori School of Engineering, The New York State College of Ceramics, Alfred University
- 9 – 10:30 a.m.
  - TECHNICAL SESSION: ENERGY AND GLASS MELTING
    Session Chairs: Jan Schep, Owens-Illinois, Inc. and Elmer Sperry, Libbey
    - 9 – 9:30 a.m. Dr. Hong Li, Senior Staff Scientist, PPG Industries, Inc. – Strength of Glass
    - 9:30 – 10:00 a.m. Stefan Laux, Director R&D, Praxair, Inc. – Operating Experience with OPTIMELT™ Regenerative Thermo–Chemical Heat Recovery for Oxy-Fuel Furnaces
    - 10 – 10:30 a.m. Mikael Le Guern, Business Development Manager, Schneider-Electric – Energy Savings through Automatic Load Tap Changer SCR Firing Techniques with Closely Coupled Transformers
- 10:30 – 11 a.m. EXHIBITING
## 11 – 12:30 p.m.  
**TECHNICAL SESSION: BATCHING**  
Session Chairs: **Phil Tucker**, Johns Manville, **Andrew Zamurs**, Rio Tinto Minerals, and **Martin Goller**, Corning Inc.

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<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>11 – 11:30 a.m.</td>
<td>Thomas Hughes, Senior Industry Technical Consultant, Naico an Ecolab Company</td>
<td><strong>Optimization Program for Batch Wetting Offers Benefits in Furnace Life, Energy Efficiency Operation</strong></td>
</tr>
<tr>
<td>11:30 – 12 p.m.</td>
<td>Mathieu Hubert, PhD, Scientist, CelSian Glass &amp; Solar BV</td>
<td><strong>Effect of Borate Raw Materials on the Melting Behavior of Alkali-lean Borosilicate Glasses</strong></td>
</tr>
<tr>
<td>12 – 12:30 p.m.</td>
<td>Stefano Ceola, Chemist, Sr. Project Manager, Stazione Sperimentale Del Vetro</td>
<td><strong>Glass Cullet: Impact of Color Sorting on Glass Redox State</strong></td>
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### 12:30 – 2 p.m.
**LUNCH**

### 12:30 – 2 p.m.
**EXHIBITING**

## 2 – 4:30 p.m.  
**TECHNICAL SESSION: COMBUSTION, REFRACTORIES, AND SENSORS**  
Session Chairs: **Laura Lowe**, HarbisonWalker International and **Larry McCloskey**, Anchor Hocking

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<th>Time</th>
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<tr>
<td>2 – 2:30 p.m.</td>
<td>Mark D’Agostini, PhD, Senior Research Associate, Air Products</td>
<td><strong>Oxygen-Enhanced Solid Fuel Combustion in Glass Melting Furnaces</strong></td>
</tr>
<tr>
<td>2 – 3:00 p.m.</td>
<td>Amul Gupta, PhD, R&amp;D Manager, RHI Glass</td>
<td><strong>Fused-cast AZS Corrosion, Exudation and Start-up Defects</strong></td>
</tr>
<tr>
<td>3 – 3:30 p.m.</td>
<td>Peter Simurka, PhD, Associate Professor/Researcher, Institute of Inorganic Chemistry SAS</td>
<td><strong>Corrosion of AZS Refractories – Source of Defects in Tableware Glass</strong></td>
</tr>
<tr>
<td>3:30 – 4 p.m.</td>
<td>Michel Gaubil, PhD, Senior Scientist/Glass Refractory Expert Manager, Saint-Gobain CREE</td>
<td><strong>What Makes Good Fused Cast AZS</strong></td>
</tr>
<tr>
<td>4 – 4:30 p.m.</td>
<td>Yakup Bayram, PhD, Chief Technology Officer, PaneraTech., Inc.</td>
<td><strong>Advanced Furnace Inspection and In-situ Furnace Monitoring via Radar Based Sensors</strong></td>
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### 4:30 – 5:30 p.m.
**EXHIBITING**

### 7:30 – 11 p.m.
**HOSPITALITY SUITES AT HILTON**

## WEDNESDAY, NOVEMBER 4, 2015

### 8 – 9 a.m.
**EXHIBITING**

### 9 – 10 a.m.  
**TECHNICAL SESSION: ENVIRONMENTAL**  
Session Chairs: **Glenn Neff**, Glass Service USA, Inc. and **James Uhlik**, Toledo Engineering Co., Inc.

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<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>2 – 2:30 p.m.</td>
<td>Alan Stephens, Director, Fives Stein Limited</td>
<td><strong>Forehearth Heating</strong></td>
</tr>
<tr>
<td>2 – 3:00 p.m.</td>
<td>Pierre Lankeu Ngankeu, Senior Mechanical Engineer, Bucher Emhart Glass</td>
<td><strong>Improvements to Bucher Emhart Glass Vertiflow Mold Cooling Applications in Glass Container Production</strong></td>
</tr>
<tr>
<td>3 – 3:30 p.m.</td>
<td>Steven Brown, Principal Mechanical Engineer, Bucher Emhart Glass &amp; Dubravko Stuhne, Production Technique, Vetroconsult, Ltd.</td>
<td><strong>The Qualification of a New Glass Strengthening Process</strong></td>
</tr>
<tr>
<td>4 – 5:00 p.m.</td>
<td>GMIC MEMBER MEETING – Room C-110</td>
<td><strong>GMIC MEMBER MEETING – Room C-110</strong></td>
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### 10:30 a.m. – 12 p.m.
**TECHNICAL SESSION: MODELING**  

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<tr>
<th>Time</th>
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<th>Topic</th>
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<tr>
<td>10:30 – 11 a.m.</td>
<td>Erik Muijsenberg, PhD, Vice President, Glass Service Inc.</td>
<td><strong>Optimizing the Energy Input to a Glass Melting by Intelligent Furnace Design and Operating Practices</strong></td>
</tr>
<tr>
<td>11 – 11:30 a.m.</td>
<td>Andries Habraken, Senior Consultant, CelSian Glass &amp; Solar BV</td>
<td><strong>CFD Base Control Glass Furnace Control System Based on Time Transient Computer Model</strong></td>
</tr>
<tr>
<td>11:30 a.m. – 12 p.m.</td>
<td>Andries Habraken, Senior Consultant, CelSian Glass &amp; Solar BV</td>
<td><strong>Glass Melt Quality Optimization by CFD Simulations and Laboratory Experiments</strong></td>
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### 12 – 1:30 p.m.
**EXHIBITING**

### 1:30 – 3:30 p.m.
**TECHNICAL SESSION: FORMING**  

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<tr>
<td>1:30 – 2 p.m.</td>
<td>Steve Heveron-Smith, VP Business Developement, Lumetrics</td>
<td><strong>Non-Contact Optical Measurement of Multilayered and Coated Glass at the Hot or Cold End</strong></td>
</tr>
<tr>
<td>2 – 2:30 p.m.</td>
<td>Dubravko Stuhne, Production Technique, Vetroconsult, Ltd.</td>
<td><strong>The Qualification of a New Glass Strengthening Process</strong></td>
</tr>
<tr>
<td>3 – 3:30 p.m.</td>
<td>Steven Brown, Principal Mechanical Engineer, Bucher Emhart Glass &amp; Dubravko Stuhne</td>
<td><strong>Advanced Furnace Inspection and In-situ Furnace Monitoring via Radar Based Sensors</strong></td>
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</table>
GMIC FORMING TECHNOLOGY SYMPOSIUM
A Symposium of the Glass Manufacturing Industry Council

THURSDAY, NOVEMBER 5, 2015

Description: The Symposium on Forming Technology in Glass Manufacturing focuses on the latest technologies in the market to support critical processes and address current challenges in glass manufacturing. It provides a forum for the audience to gain technical knowledge and exchange experiences with each other in support of the advancement and application of forming technologies.

Audience: Glass manufacturing engineers and technical managers in container, tableware, fiberglass, and float glass segments, as well as forming products and services providers.

Objectives: The participants should come away from the symposium with knowledge of problem solutions and new developments in forming technology in glass manufacturing.

Program Committee:
Chairman: Alessandro Borsa – Senior Research Associate Process Technology, Johns Manville
Kenneth Bratton – Manager of Forming Process Engineering, Emhart Glass Research
Matthew Hyre – Senior Scientist/Physicist/Professor of Mathematics, Emhart Glass Research and Northwestern College, St. Paul
Gregory Nafziger – Senior Forming Research Engineer, Owens-Illinois
Steven Olesen – Senior Advanced Technology Engineer, World Kitchen
Richard Pudliner – Production Manager, World Kitchen
David Purvis – Senior Engineer, Owens Corning
Andrew Thomsen – Project Engineer, Guardian Industries
Robert Weisenburger Lipetz, MBA - Executive Director, Glass Manufacturing Industry Council

8:00 – 8:30 a.m.  PROGRAM I - INTRODUCTION
8:00 – 8:05 a.m. Welcome – Robert Weisenburger Lipetz, Glass Manufacturing Industry Council
8:05 – 8:30 a.m. Overview of Forming in all Segments of Glass Manufacturing, Including Differences and Commonalities – Container Glass - Gregory Nafziger, Owens-Illinois; Tableware - Steven Olesen, World Kitchen; Float Glass – Rajiv Tiwary, PPG Industries

8:30 – 10:20 a.m.  PROGRAM II – FIBERGLASS
8:30 – 8:55 a.m. An Overview Glass Fiber Manufacturing Technologies – Bruno A. Purnode, Owens Corning
8:55 – 9:00 a.m. Q&A
9:00 – 9:25 a.m. Issues in Forming Very Fine Fibers – Doug Boessneck, AGY
9:25 – 9:30 a.m. Q&A
9:30 – 9:50 a.m. BREAK
9:50 – 10:15 a.m. New Platinum DPH-Materials for the Glass Industry - Dr. Stefan Vorberg, Heraeus Deutschland GmbH & Co. KG
10:15 – 10:20 a.m. Q&A

10:20 a.m. – 1:30 p.m.  PROGRAM III – TABLEWARE AND CONTAINER GLASS
10:20 – 10:45 a.m. Modeling of Gob Delivery, Shape and Temperature through Scoop, Trough and Deflector – Xu Ding, Emhart Glass Manufacturing
10:45 – 10:50 a.m. Q&A
10:50 – 11:15 a.m. Blank Mold Loading on IS Machines – Dr. Walter Anderson, Owens-Illinois; co-author Robin Flynn, Owens-Illinois
11:15 – 11:20 a.m. Q&A
11:20 – 11:45 a.m. Coating to Reduce Swabbing – Robert Morin, Material Science Group
11:45 – 11:50 a.m. Q&A
11:50 a.m.– 1:30 p.m. LUNCH
12:30 – 12:55 p.m. Benefits of Plunger Monitoring with PPC – Chris van Reijmersdal, Processing Forming Tech, Emhart Glass Manufacturing
12:55 – 1:00 p.m. Q&A
1:00 – 1:25 p.m. Tribological Investigations of the Glass-Metal Contact in Glass-container Production – Dominik Orzol, Friedrich-Schiller-Universität Jena

1:30 – 2:30 p.m.  PROGRAM IV – FLOAT GLASS
1:30 – 1:55 p.m. A New Era in Float Glass Forming – Bertrand Strock, Fives Stein
1:55 – 2:00 p.m. Q&A
2:00 – 2:25 p.m. Modeling Glass Forming in Float Baths – Rajiv Tiwary, PPG Industries
2:25 – 2:30 p.m. Q&A
2:30 – 3:50 p.m. PROGRAM V – MODELING
2:30 – 2:55 p.m. Forehearth Modeling – Erik Muijsenberg, Glass Service
2:55 – 3:00 p.m. Q&A
3:00 – 3:20 p.m. Break
3:20 – 3:45 p.m. Fiber Forming Physics – Alessandro Borsa, Johns Manville
3:45 – 3:50 p.m. Q&A
3:50 – 4:30 p.m. PROGRAM VI - WRAP UP
3:50 – 4:20 p.m. Panel Discussion – Moderated by Alessandro Borsa, all speakers participate
4:20 – 4:30 p.m. Concluding Remarks – Alessandro Borsa
4:30 p.m. SYMPOSIUM ENDS
**Hospitality Booth & Salon Hosts**

Takes place at the Hilton Columbus Downtown

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www.acsitoledo.com

As an integrator of information and control system solutions, ACSI engineers in both the United States and Europe are able to provide customers with quality technical engineering, system design, factory acceptance, installation supervision, commissioning services, and training. Our knowledge can be applied to float glass, fiberglass, container glass, tableware, lighting, tubing, and specialty systems. Types of solutions we provide are temperature control, DCS replacement, batching control, glass level control, model predictive control, packaging & sortation control, and production tracking.

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www.airproducts.com/glass

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www.areaimpianti.it

Area Impianti designs and installs flue gas treatment and co-generation turnkey plants worldwide. Our company has successfully accomplished flue gas filtration systems for more than 80 glass furnaces. Thanks to an advanced know-how, we can treat all the pollutants generated from the glass fusion process, namely: dust, SOx, HCl, HF, metals and others. We have also conceived a special solution for the catalytic treatment of the NOx (DeNOx SCR). Our technology includes heat recovery system and cogeneration with production of electric power. The company is certified ISO 9001, 14001, OHSAS 18001 UL.

**BASF Corp**
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- Container Mould
- Fiber Glass Stream
- Fiberizing Disk
- Forehearth
- Furnace Crown and Bottom
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www.jmcanty.com

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www.flammatec.com

FlammaTec, spol. s r.o. (Czech Republic) and its daughter company FlammaTec GmbH (Germany) are leading suppliers of advanced burner technology for glass furnaces. Founded in 2008 by two partner companies (STG Combustion Control GmbH & Co KG, and Glass Service, Inc.), FlammaTec has already supplied over 2,000 burners to 100+ projects on float, container, tableware and special glass furnaces. FlammaTec burners offers:
• Underport Gas Injector, Flex or Freejet
• Underport Gas/Oil Dual Injector, Flex or Freejet
• Underport Heavy Oil Injector (also for backup solutions)
• Sideport Gas Injector
• New Oxy/Gas Burner
• Safety skids and control panels

Fosbel, Inc.
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Phone: +1-216-362-3900
www.fosbel.com

Fosbel provides Innovative Glass Furnace Maintenance Solutions. Fosbel offers a wide range of repair and inspection services and has conducted more than 2,500 repairs to virtually every type of glass furnace around the world. In addition to ceramic welding technology to repair refractory at operating temperature, Fosbel has also developed many innovative hot repair solutions including port floor restoration, checker cleaning, dual crown overcoating and hot bottom repairs. Fosbel’s experienced engineers and technicians are familiar with almost any furnace condition, and repairs are conducted in an effective and efficient manner, providing improved energy efficiency while minimizing production downtime.

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HB 101
P.O. Box 493, 436 East Beau Street, Washington, PA 15301
Phone: +1-724-225-1100
www.frazier-simplex.com

Frazier-Simplex, Inc. has provided state-of-the-art batch chargers and innovative furnace design and glass production equipment since its founding in 1918 in Washington, Pa., USA. The company strives to continuously provide glass industry with expertise of batch charging equipment, design and engineering for glass furnace and furnace rebuild, turnkey solutions to a number of glass production for glass tubing, fibers, and other specialty glass products, as well as design and engineering expertise to a growing business of solid waste processing and hazardous waste disposal and vitrification.

Fuse Tech/Hot Tech Group
Salon # Emerson Burkhart B
3400 Silica Rd., Sylvania, OH 43560
Phone: +1-419-841-9323
www.fusetech.com

Fuse Tech’s core business is ceramic welding and refractory repair on both cold and hot furnaces. We also have equipment to photograph inside the furnace for use in damage and operation evaluation. Through the use of high pressure water lasers, Fuse Tech is able to remove debris from port sills as well as the tops of checker packs, flues and tunnels. Hot Tech will help you with your refractory and operational problems. Specializing in drilling, rebuilds, hot repairs, cold repairs, diamond chainsawing, burner block replacements and overcoats. Fuse Tech/Hot Tech also is a source for consulting on furnace problems.

Glass Service, Inc.
HB 200
3340 SE Federal Highway, #200, Stuart, FL 34997
Phone: +1-772-287-6061
www.gsl.cz

Glass Service, Inc. (GS) is a leading global consultant specializing in glass melting/conditioning, furnace control, operation, troubleshooting, and furnace design optimization. GS has developed the successful expert system, ES III, which has become the leading platform for fully automatic furnace and forehearth control, providing significant cost savings to glass production. Another development of GS, furnace modeling software GFM 4 optimizes furnace design and doubles as a successful troubleshooting tool. The GS laboratory performs defect analyses, and utilizes basic and applied research in its melt testing facilities. Headquarters located in Czech Republic, with offices in Netherlands, Slovakia, United States, and China.
HarbisonWalker International
Salon # Bellows A
1305 Cherrington Parkway, Suite 100, Moon Township, PA 15108
Phone: +1-412-375-6000
www.thinkHWI.com
HarbisonWalker International (formerly known as North American Refractories Company) engineers, manufactures and supplies a full line of refractories to support the most demanding glass making applications. HWI’s experienced Installation Group provides the glass industry with high quality hot and cold repair service as well as hot sealing of new furnaces. Our Glass Support Team is located in Pittsburgh, Pa. and Cincinnati, Ohio with sales representatives that cover the United States, Latin America, South America, Europe and Asia. Our glass support team works closely with each customer to ensure the best possible refractory solutions are met. We have 17 plant locations in the United States, one each in the United Kingdom, Mexico, China, and Indonesia.

Henry F. Teichmann, Inc.
HB 16
3009 Washington Road, McMurray, PA 15317
Phone: +1-724-941-9550
www.hft.com
Henry F. Teichmann, Inc. started servicing the glass industry in 1947. Our engineering, technical service, purchasing, construction and project management team is committed to providing turnkey services for batch plants, complete glass plants, electric furnaces, container glass furnaces, float glass furnaces, fiber glass furnaces, foam glass furnaces, sodium silicate furnaces, pressed glass melting services, TV glass furnaces, hand glass processes, tableware and lighting products. In our 68 years we have serviced over 1,000 projects worldwide. Our engineering staff has provided furnace designs utilizing regenerative package furnace, cross-fire furnace, end-fire furnace, electric furnace and oxyfuel melter technologies.

Lilja Corp.
HB 205, HB 207
229 Rickenbacker Cr., Livermore CA 94551
Phone: +1-925-455-2300
www.liljacorp.com
Lilja Corp. is an assertive leader in industrial and glass furnace construction. Our managers, supervisors and craftsmen are known industry wide for their high standards, performing quality work, meeting project schedules and a commitment to a safe working environment. We are a full service general engineering contractor, specializing in the construction of processing, manufacturing and warehousing facilities, glass melting furnaces and all related systems and industries. Lilja Corp. has been serving the needs of the glass industry for over 35 years. With offices located in the US and Canada.

Optimation
HB 307
50 High Tech Drive, Rush, NY 14543
Phone: +1-585-321-2300
www.optimation.us
Optimation offers a multi-disciplined design team for any aspect of your batch processing needs, with best practices for equipment arrangements, dust collection, storage, weighing, mixing and transport of batch. The team has tackled a full-range of batch problems, providing leading-edge solutions for end clients. During the feasibility phases of your projects, Optimization can provide services for cost assessment, risk assessment and high-level design. Once capital approval is secured, the design team is available for engineering drawing packages, equipment schedules, site plans and test plans. We offer continuity throughout specification, design, integration, development, implementation, calibration, troubleshooting, startup, debug and production.

Praxair, Inc.
HB 204, HB 206
39 Old Ridgebury Road, Danbury, CT 06810
Phone: +1-360-320-4131
www.praxair.com/glass
Praxair is a leader in innovative oxyfuel technologies for the glass industry. With over 70 years of oxyfuel combustion experience in the glass industry and over 200 oxyfuel projects completed worldwide, our technologies can deliver substantial fuel savings, increased productivity and product quality, reduced NOx emissions and alkali volatilization, and prolonged furnace campaign. Praxair is a Fortune 250 company. We also supply atmospheric, process and specialty gases, high performance coatings, and related services and technologies. Among the gases we supply are oxygen, nitrogen, argon, carbon dioxide, helium, and hydrogen.
RHI US Ltd.
Salon # Emerson Burkhart A
Attn: Glass Group, 3956 Virginia Avenue, Cincinnati, OH 45227
Phone: +1-513-753-1254
www.rhi-ag.com
RHI AG is the world market and technology leader in high-grade ceramic refractory materials. A global player with Austrian roots, RHI employs roughly 8,000 people worldwide at 33 production sites in Europe, North America, Latin America, South Africa and China and is represented by over 70 sales offices in four continents. RHI is the only global refractories supplier to offer products for all aggregates of the basic industry. The RHI umbrella brand combines a series of traditional brands that have been established in the market for many years, including Didier, Veitscher, Radex, Dolomiti Franchi, Interstop, and Monofrax.

RoviSys
HB 301, HB 303, HB 305
1455 Danner Drive, Aurora, OH 44202
Phone: +1-330-995-8103
www.rovisys.com
As an engineering services company, RoviSys specializes in process control and information automation. We have incorporated state of the art systems around the world for major glass manufacturers. As an independent company, we work with you to design and develop the best solution to meet your needs, not ours. With 400 employees and four locations worldwide we are well suited to provide you with state of the art control and information systems. We have experience in all major sectors of the glass manufacturing industry. From your batch house to your warehouse RoviSys delivers on time, every time.

Saint-Gobain SEFPRO
HB 201, HB 203, HB 300, HB 302
9200 Shelbyville Road, Suite 531, Louisville, KY 40222
Phone: +1-502-329-7605
www.sefpro.com
SEFPRO is glad to support glassmakers’ success by delivering top quality refractory products and services that give you the advantage. Thanks to our worldwide network and outstanding innovation power, you can trust us for meeting your ever evolving needs. Tell us about your projects – working together, we can and will make the difference!

SSOE Group
HB 15
1001 Madison Avenue, Toledo, OH 43604
Phone: +1-567-218-2234
www.ssoe.com
SSOE Group is a full service engineering company and your resource for glass plant engineering from start to finish. Experience spans decades and includes projects with every major glass manufacturer. Our capabilities span a complete range of services, from the batch house through furnace, production line packaging utilities and environmental.

Toledo Engineering Co., Inc.
Salon # Bellows B
3400 Executive Parkway, P.O. Box 2927, Toledo, OH 43606
Phone: +1-419-537-9711
www.teco.com
The TECO Group, consisting of Toledo Engineering Co., Inc., TECOGLAS Ltd., KTG Systems, Inc., KTG Engineering Ltd., ZEDTEC Ltd., EAE Tech and Dreicor Inc. specialize in the design and construction of glass melters of all types, including fuel-fired regenerative and recuperative furnaces, oxy-fuel furnaces, electric melters, electric boost systems and forehearth and distributors/working end. The TECO Group also provides batch plants, emission control systems and process control systems on a turnkey basis. KTG Engineering Ltd. manufactures furnace equipment such as batch chargers, electrode holders, spy hole covers, etc. Glass plant engineers, designers, constructors, and technical service providers.

ONLINE GPC CONFERENCE EVALUATION
We continually strive to improve the quality of the conference. Your feedback from the online evaluation will be considered carefully by the GPC advisory board in designing future conferences. Please go to the website address below for this brief evaluation.
https://www.surveymonkey.com/r/76_GPC_Attendees

Online Conference Evaluation (for exhibitors only)
If you presented an exhibit booth at the 76th GPC, we would appreciate your feedback to help us improve the exhibiting opportunity. (This survey is for exhibitors only.)
Please go to the website address below for this brief evaluation.
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Online Conference Evaluation (for hospitality suite hosts only)
If you presented a hospitality booth or salon at the 76th GPC, we would appreciate your feedback to help us improve the opportunity. (This survey is for hospitality suite hosts only.)
Please go to the website address below for this brief evaluation.
https://www.surveymonkey.com/r/76_GPC_Hospitality

THANK YOU FOR TAKING THE TIME TO PROVIDE YOUR FEEDBACK ON CONFERENCE HOSPITALITY SUITES.
**EXHIBITORS**

Tuesday, November 3 | 8 – 9 a.m.  
10:30 – 11 a.m.  
12:30 – 2 p.m.  
4:30 – 5:30 p.m.  

Wednesday, November 4 | 8 – 9 a.m.  
10 – 10:30 a.m.  
12 – 1:30 p.m.  

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**Advanced Control Solutions, Inc.**  
**Booth # 105**  
8750 Resource Park Drive, Sylvania, OH 43560  
Phone: +1-419-843-4820  
www.acsitoledo.com  
As an integrator of information and control system solutions, ACSI engineers in both the United States and Europe are able to provide customers with quality technical engineering, system design, factory acceptance, installation supervision, commissioning services, and training. Our knowledge can be applied to float glass, fiberglass, container glass, tableware, lighting, tubing, and specialty systems. Types of solutions we provide are temperature control, DCS replacement, batching control, glass level control, model predictive control, packaging & sortation control, and production tracking.

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**Advanced Energy**  
**Booth # 219**  
1625 Sharp Point Drive, Fort Collins, CO 80525  
Phone: +1-970-221-0108  
www.advanced-energy.com/pcm  
Advanced Energy has devoted more than three decades to perfecting power—enabling design breakthroughs and driving growth for leading semiconductor, industrial, and solar customers. AE thermal management systems offer energy-efficient, electric heat solutions used for glass manufacturing and costing. Solutions include specialty pyrometers with active-reflectance measurement, SCR power controllers, and power supplies.
Allstates Refractory Contractors, LLC
Booth # 403
P.O. Box 256, 218-B Mechanic Street, Waterville, OH 43566
Phone: +1-419-878-4691
www.allstatesrefractory.com
We are a full-service industrial process general contractor providing all-encompassing solutions for the glass, metals' and petrochemical industries.

American Ceramic Society, The
Booth # 415
600 N. Cleveland Ave., Ste. 210, Westerville, OH 43082
Phone: +1-866-721-3322
www.ceramics.org
The American Ceramic Society is the leading professional membership organization for ceramic and glass materials scientists, engineers, researchers, manufacturers, plant personnel, educators, and students. The Society serves more than 9,000 members from more than 70 countries.

American Glass Research
Booth # 418
603 Evans City Road Butler, PA 16001
Phone: +1-724-482-2163
www.americanglassresearch.com
American Glass Research, an independent, research, consulting and analytical laboratory, offers expertise in testing, design analysis, training, glass composition, heavy metal analysis, product liability and auditing for glass container industry.

AMETEK Land
Booth # 212
150 Freeport Rd., Pittsburgh, PA 15238
Phone: +1-412-828-9040
www.landinst.com
Monitors and analyzers for industrial infrared temperature measurement, combustion efficiency and environmental pollutant emissions. Infrared temperature measurement product range includes on-line thermometers and systems, portable infrared thermometers, thermal imagers, and infrared linescanners. Combustion and environmental monitoring products, including combustion efficiency monitors, stack gas emissions analyzers, portable gas analyzers and coal-fire detection systems. Markets include glass, iron and steel, metals and metal processing, and the mineral processing industry.

Antonini & Figli s.r.l.
Booth # 118
Represented in the USA by Argent Enterprises Inc.
Phone: +1-724-499-5800
www.antoninisrl.com
Antonini s.r.l. is an Italian company specialized, from over 60 years, in annealing and decorating lehrs, tempering lines, mould preheating ovens and other accessories for hollow glass industry. Designers, manufacturers, suppliers and installers of annealing and decorating lehr’s, also special lehrs for glass blocks, toughening and car head lamps.
US agent: Argent Enterprises Inc. | aeinc@windstream.net

AREA IMPIANTI Corp
Booth # 114
24-15 Queens Plaza North, Long Island City, NY 11101
Phone: +1-718-937-7770
www.areaimpianti.it
Area Impianti designs and installs flue gas treatment and co-generation turnkey plants worldwide. Our company has successfully accomplished flue gas filtration systems for more than 80 glass furnaces. Thanks to an advanced know-how, we can treat all the pollutants generated from the glass fusion process, namely: dust, SOx, HCl, HF, metals and others. We have also conceived a special solution for the catalytic treatment of the NOx (DeNOx SCR). Our technology includes heat recovery system and cogeneration with production of electric power. The company is certified ISO 9001, 14001, OHSAS 18001 UL.
US agent: Argent Enterprises Inc. | aeinc@windstream.net

Argent Enterprises, Inc.
Booth # 116
PO Box 163, Graysville, PA 15337-0163
Phone: +1-724-499-5800
www.aeincglass.com
Argent Enterprises Inc., together with its industry partners, provides services and equipment to the entire glass industry. Antonini – Italy, Area Impianti – Italy, Batisti – Italy, Falorni – Italy, General Glass Equipment – USA, JSJ Jodeit – Germany, Lahti Precision – Finland, Longwall Services – USA, Lubisol – Bulgaria, Motim Fused Cast Refractories – Hungary, Parkinson-Spencer Refractories – England, Pneumofore – Italy, TECNO 5 – Italy.
We have eight table top exhibits at the 76th GPC meeting, please visit us. Argent Enterprises Inc., is the exclusive agent in the USA for the following companies:
• Motim Fused Cast Refractories Ltd – Hungary E25 Suppliers of AZS materials.
• Antonini srl – Italy E30 Suppliers of Lehrs.
**EXHIBITORS**

**Borton-Lawson**  
*Booth # 319*  
613 Baltimore Drive, Suite 300, Wilkes-Barre, PA 18702  
Phone: +1-570-821-1999  
www.borton-lawson.com  

Borton-Lawson, a full-service, multidisciplinary engineering firm has been providing solutions in the glass industry since 1994. Our projects have ranged in size from full furnace rebuilds to upgrades or replacements of ancillary systems. Our design and construction support services encompass all facets of engineering including civil, structural, refractory, electrical, mechanical, automation, environmental, surveying, and procurement and construction administration services. Our high-value process approach and use of the latest 3D laser scanning and design technologies makes Borton-Lawson the right choice to add full-service engineering support to your project team.

**Bucher Emhart Glass**  
*Booth # 214*  
Emhart Glass SA, Hinterbergstr. 22, 6330 Cham, Switzerland  
+1-573-437-2132  
www.bucheremhartglass.com  

Bucher Emhart Glass is the world’s leading supplier of advanced technologies for manufacturing and inspecting glass containers. Its portfolio consists of glass-forming and inspection machinery, systems, components, spare parts, refractory, advice and services for the glass container industry. Bucher Emhart Glass uses its innovative strength to ensure that glass remains the ideal packaging material for food, beverages, cosmetics and pharmaceutical products. Bucher Emhart Glass refractory products are supplied to a wide variety of glass industries, including the glass container fiberglass, pressed ware, stemware, hand glass, and specialty glass industries. With its long history of quality and craftsmanship, Bucher Emhart Glass refractories are preferred by glass manufacturers throughout the world.

**BWF Envirotec, USA**  
*Booth # 207*  
1800 Worldwide Blvd., Hebron, KY 41048  
Phone: +1-859-282-4550  
www.bwf-envirotec.us  

BWF Envirotec is the world’s leading supplier of filter media and bags for industrial filtration. As both a needle felt producer and bag fabricator, BWF Envirotec has the unique ability to match industry characteristics with the properties of the needle felt ensuring maximum bag performance. In addition, the standard services offered by our Environmental Services Division are bag change-outs, leak detection, mechanical inspections, and process reviews.

**Carmeuse Lime & Stone**  
*Booth # 206*  
3600 Neville Rd., Pittsburgh, PA 15225  
Phone: +1-412-777-0747  
www.carmeusena.com  

Carmeuse Lime & Stone is a leading manufacturer of lime and limestone/dolomite to the glass industry. Carmeuse has 28 plants that supply and serve most of the USA and Eastern Canada. We also have a technical service laboratory in Pittsburgh Pa., staffed by glass industry experts.

**DIAS Infrared Corp.**  
*Booth # 215*  
6 Barbara Dr., Warwick, NY 10990  
Phone: +1-845-544-7055  
www.dias-infrared.com  

Solutions for noncontact temperature measurement, infrared cameras, line cameras, pyrometers, calibration sources, pyroelectric detectors and system solutions.

**DSF Refractories & Minerals, Ltd.**  
*Booth # 107*  
Friden, Newhaven, Nr Buxton, Derbyshire, SK17 0DX UK  
Phone: +44 1629 636 271  
www.dsf.co.uk  

DSF Refractories & Minerals Limited, established in 1892 in the Derbyshire Peak District, is the largest shaped refractory manufacturer in the UK. Recognised as one of the world’s leading suppliers of bonded refractories to the glass industry, products include a wide range of high alumina refractory bricks & shapes based on mullite, andalusite, chamotte, bauxite, spinel and pure alumina. Shapes are manufactured by pressing or casting techniques which are then high fired to give optimum properties in service. The company has a highly knowledgeable Sales & Technical team with a determination to provide the best solution for our customers.

**Edward Orton Jr. Ceramic Foundation, The**  
*Booth # 200*  
6991 Old 3C Highway, Westerville, OH 43082  
Phone: +1-614-895-2663  
www.ortonceramic.com  

The Edward Orton Jr. Ceramic Foundation manufactures pyrometric products and thermoanalytical instruments. In addition, the Foundation operates an independent material testing laboratory specializing in refractory, glass, whiteware, and advanced ceramic materials.
Eurotherm by Schneider Electric
Booth # 315
44621 Guilford Dr Ste. 100, Ashburn, VA 20147
Phone: +1-703-724-7300
www.eurotherm.com

Eurotherm by Schneider Electric offers enterprise control systems for the glass industry, in addition to highly advanced process control solutions. Process control systems operate in a timescale appropriate to the production process, whereas management information systems typically provide time delayed information. This delay seriously impacts the decision making process for both management and operators. Eurotherm by Schneider Electric enables the glass industry to transfer productivity data into information in a timely manner, thereby providing both management and operators information indicating real time profitability in a dashboard format. Eurotherm by Schneider Electric will discuss several offerings including Wonderware System Platform, Eurotherm process control, Foxboro field devices and Avantis Asset Management.

F.I.C. (UK) Limited
Booth # 317
Longrock Industrial Estate, Penzance, Cornwall, TR20 8HX UK
Phone: +44 (0) 1736 366 962
www.fic-uk.com

F.I.C. is the leading technology supplier in melting and conditioning of ultra, high quality glass. With proven designs of all sizes of electric furnaces and electro-boost systems. We have extensive experience in the TFT and cover glass markets as well as float glass, ‘E’ glass fibre and all specialist glasses such as borosilicate, high alumina and zero alkali glasses. We can supply all types of electrodes including tin oxide and molybdenum and associated holders and electrical connection systems. Our High ‘Q’ holder has a removable waterway and our Maxi ‘Q’ holder is designed to operate continuously in molten glass above 1,600°C and are ideal for top electrode systems as well as on-the-run replacement for competitors failed holders.

Fives Stein Limited
Booth # 106
4A Churchward, Southmead Park, Didcot, Oxon, OX11 7HB, UK
Phone: +44 1235 811 111
www.Glass.fivesgroup.com

Fives Stein Limited is a leading supplier in high-quality melting and conditioning for all types of glass. We design, manufacture, install, commission and service glass plant and equipment tailored to your specific needs. With over 90 years of experience in a wide range of glass processes and applications all over the world, we can provide a complete range of services. We provide full support and training for your teams, on our equipment, to assist with your full-scale glass production needs.

We are part of the Fives, an industrial engineering group, who design and supply machines, process equipment and production lines for the world’s largest industrial groups. The group has over 8,000 employees worldwide and an annual turnover in excess of $2 billion.

Frazier-Simplex, Inc.
Booth # 100
P.O. Box 493, 436 East Beau Street, Washington, PA 15301
Phone: +1-724-225-1100
www.frazier-simplex.com

Frazier-Simplex, Inc. has provided state-of-the-art batch chargers and innovative furnace design and glass production equipment since its founding in 1918 in Washington, Pa., USA. The company strives to continuously provide glass industry with expertise of batch charging equipment, design and engineering for glass furnace and furnace rebuild, turnkey solutions to a number of glass production for glass tubing, fibers, and other specialty glass products, as well as design and engineering expertise to a growing business of solid waste processing and hazardous waste disposal and vitrification.

GEA Group
Booth # 216
9165 Rumsey Road, Columbia, MD 21045
Phone: +1-410-997-8700
www.niroinc.com

GEA offers a variety of integrated designs and technologies for glass furnace emissions. We take a plant-specific approach to custom design the optimal solution for each particular site. With decades of experience across several industries, we utilize various filtration techniques for particulate removal and dust transport. For SO₂ and other acid gases, GEA provides several scrubbing techniques using a variety of configurations and reagents. NOx removal can be provide in conjunction with particulate removal, with the flexibility to increase removal rates for future considerations if desired.
General Glass Equipment
Booth # 115
645 South Mill Road, Suite 1, Absecon, NJ 08201
Phone: +1-609-345-7500
www.generalglassequipment.com
General Glass Equipment Company is an engineering and manufacturing organization that has dedicated its corporate activities exclusively to the domestic and worldwide glass manufacturing industry for more than 80 years. The activities of the firm encompass virtually every aspect of glass manufacturing from plant design and construction, personnel training, project engineering, and general consultation to innovative product development for manufacturing economies. Our extensive background in the industry offers general glass clients the benefit of a comprehensive perspective of glass manufacturing on a domestic and an international scale. Authorized Representative: Argent Enterprises Inc. | aeinc@windstream.net

Glass Manufacturing Industry Council (GMIC) Booth # 419
600 N. Cleveland Avenue, Suite 210, Westerville, OH 43082
Phone: +1-614-523-3033
www.gmic.org
GMIC is a trade association of the glass industry that includes among its members, representatives of all four sectors: flat, container, fiber and specialty glass companies as well as leading suppliers to the industry, research institutes and industry experts. Our goal is to promote the interests and growth of the glass industry.

Glassworks Hounsell
Booth # 305
Park Lane, Halesowen, West Midlands B63 2QS, UK
+44 (0) 1384 560 666
www.glassworkshounsell.co.uk
Global suppliers of batch charging and wetting systems for all types of furnaces and glasses. With more than 40 years in this field and 1,200 machines worldwide we are both experienced and innovative. Additionally we also provide electrodes and ancillary equipment used in electric melting of high quality glasses. Combine all this with our skill set as specialist precision engineers and any customization requirements are easily achievable.

Global Combustion
Booth # 316
Unit 43, Evans Business Centre, Easter Inch, Bathgate, EH48 2EH, Scotland, UK
Phone: +44 (0)1506 657 310
www.globalcombustion.com
Global Combustion Systems specialize in the design, manufacture service and commissioning of gas, oxygen and fuel oil combustion control systems which are used in the glass melting process worldwide. Systems include: Underport, throughport and side-of-port burner systems used on regenerative furnaces. Hot air and oxygen burners for unit fired furnaces. Each system is engineered for the specific requirements of the customer, meeting environmental, production quality and efficiency requirements. Global Combustion Systems have two technical support bases, UK and China.

H.C. Stark, Inc.
Booth # 314
45 Industrial Place, Newton, MA 02461
Phone: +1-617-630-5800
www.hcstarck.com
H.C. Starck, a leading global supplier of technology metals from refractory materials molybdenum, tungsten, tantalum and niobium, has a diverse portfolio for the glass melting and photovoltaic industries showcasing its innovative, engineering excellence. H.C. Starck’s products achieve outstanding resistance to chemical corrosion, degradation, and minimal glass discoloration for large area coatings, pharmaceutical, lighting, wind and solar applications.

Heraeus Materials Technology
Booth # 304
Heraeusstr. 12-14, 63450 Hanau, Germany
Phone: 201-647-8672
www.heraeus.com
Heraeus specializes in the manufacture of platinum, gold, iridium, and specialty metal parts for the glass industry. With over 150 years of experience in precious metals and worldwide operations, Heraeus has the capability to provide the highest quality products in the most sophisticated designs. Items include stirring, liners, electrodes, crucibles, cladding, and other custom designed parts, in high strength alloys and grain stabilized materials, specifically designed for glass manufacturing. All of our products are backed by our expertise and world-class technical support.

Hotwork USA
Booth # 101
223 Gold Rush Rd., Lexington, KY, 40503
Phone: +1-859-276-1570
www.hotwork.com
Worldwide supplier of glass furnace heating, expansion control supervision, regenerator sulfate burnout, glass draining with hot water recycling, wet cullet filling, furnace cooldowns and hold hots, and electronic crown rise monitoring. The only continuous operating hotwork heatup company since 1965 and proud sponsor of The Phoneix Award Committee.
EXHIBITORS

ilis gmbh
Booth # 204
Konrad-Zuse-Str. 22, 91052 Erlangen, Germany
Phone: +49 9131 974 7790
www.ilis.de
ilis develops, produces and distributes software solutions, measuring systems as well as automated test equipment for quality assurance in the glass and optical industry. With the measuring and testing equipment of the StrainMatic™ and StrainScope™ series, the company develops imaging polarimeter systems for the automatic and objective measurement of residual stress in glass and plastics. BatchMaker™ and Chroma™ provide the glass industry standardized software solutions for simple and reliable calculation of batch recipes and glass properties, as well as for transmission and color measurement.

Johnson Matthey plc
Booth # 303
Orchard Road, Royston, Hertfordshire, UK, SG8 5HE
Phone: +44 (0) 1763 253 000
www.noble.matthey.com
Johnson Matthey Noble Metals is a fabricator and refiner of platinum group metals. With almost 200 years of experience and expertise Johnson Matthey can offer complete PGM solutions to the glass industry. This includes complex platinum, rhodium and iridium fabrications. Also the ability to apply a fully recoverable platinum coating to refractory materials for ultimate wear resistance in molten glass.

Lahti Precision Oy
Booth # 112
Ahjokatu 4 A, PL 22, 15801 Lahti, Finland
Phone: +358 3 82921
www.lahtiprecision.com
Lahti Precision – Expertise That Weighs. Lahti Precision Oy is one of the leading suppliers of glass raw material handling systems. Lahti Precision serves the producers of:
• Float glass, flat and figured glass
• Container and tableware glass
• Insulation and reinforcement fiberglass
• Solar glass / low iron glass
• Flat screen, TV and other technical glass
• Borosilicate and water glass, and other special glass
By supplying:
• Complete batch plants and cullet systems
• Weighing, dosing and mixing systems and components
• Control systems and components
• Cullet return systems
• Plant modernizations and control system upgrades
US agent: Argent Enterprises Inc. | aeinc@windstream.net

L.G.P. International, LLC
Booth # 103
5041 Payne Avenue, Dearborn, MI 48126
Phone: +1-248-444-2289
http://glass-properties-lab.com
Laboratory of Glass Properties specialized on precise measurements of glass and melt properties for more than 50 years. Since 2002 we provide various glass testing services under business name L.G.P. International. In addition to measurements of high-temperature IR absorption, viscosity, density, CTE, surface tension, and other physical properties we perform development of high-performance glasses for different applications (glass-to-metal seals, high-strength fibers and sheets, low-DK fibers, IR-transparent glasses, thin-wall containers).
Mathematical modeling of glass forming processes is an important area of our interest.

Longwall Services, Inc.
Booth # 113
63 South Country Club Rd., PO Box 737, Meadow Lands, PA 15347
Phone: +1-724-228-9898
www.longwallservices.com
Longwall Services Inc. manufactures and supplies cullet conveyors, glass breakers, bottle sinkers and conveyor belt cleaners for the glass industry. Products for the glass industry include:
• Water Bath Scraper Conveyors
• Glass/Bottle Breakers
• Bottle Sinkers
• SMART Brush Belt Cleaners
US agent: Argent Enterprises Inc. | aeinc@windstream.net

LumaSense Technologies, Inc.
Booth # 401
3301 Leonard Court, Santa Clara, CA 95054
Phone: +1-906-370-0232
www.lumasenseinc.com
Temperature is a key factor in optimizing any energy-intensive glass production process. In fact, it is so important that the only way to truly ensure product quality meets the stringent marketplace requirements is by carefully monitoring the temperatures of the production equipment and the glass being produced.
LumaSense Technologies, Inc. offers over 50 years of experience in providing non-contact temperature measurement technologies. Our infrared thermal imagers and pyrometers deliver fast and accurate temperature readings and are the perfect solution for customers working with flat glass, solar glass, container glassware, utility glassware, or technical glass production.
EXHIBITORS

**Lumetrics**  
**Booth # 312**  
1565 Jefferson Rd, #420, Rochester, NY 14623  
Phone: +1-585-214-2455  
www.lumetrics.com  
Lumetrics® is the leader in flat glass and tubing measurement systems. Since 2003 Lumetrics® has worked with all of the leading glass manufacturers in the world in the measurement of their specialty glass products. Lumetrics® OptiGauge™ provides non-contact measurement of single and multilayer glass products including tubing, safety and water glass, float glass, and coatings, even in a tin bath. The OptiGauge™ is used in R&D labs, quality control, and online process measurement. Our technology is even used for in-process glass slimming measurements to increase customer throughput by over 30%.

**Luoyang Dayang High-Performance Material Co. Ltd.**  
**Booth # 102**  
Songzhuang Development Zone, Mengjin, Luoyang, Henan, P.R.China 471121  
Phone: +0086-379-6707-1191  
www.refractory-dy.com  
Leading Chinese fused cast materials manufacturer, 10,000 tons/year salable products of AZS 33, AZS 36, AZS 41, α-β Alumina, and Fused high Zirconia in 88% and 95%.

**Magnec/Metrel, Inc.**  
**Booth # 313**  
223 W. Interstate Rd., Addison, IL 60101  
Phone: +1-630-543-6660  
www.magneco-metrel.com  
MMI has developed a family of refractory monolithic products referred to as “Metpump” for glass furnace applications. MMI’s unique cement free colloidal silica bonded monolithic refractory products offer an alternative to the electrofused cast blocks for the glass furnace. Metpump Products can be used in five different applications: 1) major repairs of the melter and regenerator 2) full or partial crown construction or repair 3) partial construction of the furnace 4) minor repairs of the melter and regenerator 5) full construction of the furnace.

**McGill AirClean**  
**Booth # 416**  
1777 Refugee Road, Columbus, OH 43207  
Phone: +1-614-829-1200  
www.mcgillairclean.com  
McGill AirClean has over 40 years of experience in engineering, manufacturing, and installing air pollution control equipment. In the glass industry alone, we have over 250 installations worldwide controlling many different pollutants such as particulates, heavy metals, acid gases (SOx, HCl, HF, and Boron), VOCs, and NOx. Our products and services include dry and wet electrostatic precipitators, fabric filter systems (including ceramic filters), spray dry and dry injection acid gas scrubbers, regenerative thermal oxidizers, DeNOx reactors (SCR), mobile testing services, and parts and service.

**Mixer System, Inc.**  
**Booth # 412**  
190 Simmons Avenue, PO Box 10, Pewaukee, WI 53072  
Phone: +1-262-893-5315  
www.mixersystems.com  
Mixer Systems is an American manufacturer of four types of mechanical batch mixers for the glass & refractory and ceramic industries. Located near Milwaukee, Wisc. USA, we have supplied over 3,500 projects in 42 different countries worldwide since 1945. The planetary mixer works like an egg beater and provides excellent mixing action for colored batches or hard to mix applications where top to bottom mixing action is critical to the end product. The horizontal shaft mixer is a paddle or spiral blade mixer that is lower cost, lower maintenance than the pan mixers. The turbin mixer is a low profile, pan mixer that features angled mixing paddles and it moves in a circle for constant, intensive mixing action. The twin shaft mixer has twin, horizontal shafts with six mixing paddles per shaft. This is a very intensive mixer with mixing times as little as 60 seconds and discharge times of 5-10 seconds.

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Phone: +36 96 574 100  
www.motim.hu  
Motim Fused Cast Refractories Ltd.is recognized as a world leader producing fused cast AZS and alumina refractories, refractory castables. Our products are used in the glass manufacturing furnaces. More than 95% of our turnover is from export sales. Our traditional markets are Western and Central Europe, but we are present with our products on all continents of the world. Represented in the USA by Argent Enterprises Inc. | aeinc@windstream.net
Nalco, an Ecolab Company
Booth # 205
1601 W. Diehl Road, Naperville, IL 60563
Phone: +1-630-305-1000
www.ecolab.com
Nalco, the global leader in water, hygiene and energy technologies and services; providing and protecting what is vital: clean water, safe food, abundant energy and healthy environments. We utilize our expertise and innovation in helping our customers to save water, reduce energy consumption, and improve process operations. Our highly trained site engineers will work with you to develop an effective engineering solution that meets your corporate cost, production, and sustainability goals.

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PCI Gases manufacturers’ on-site oxygen generators ideally suited to the glass industry. The melting of raw materials to produce glass primarily relies on the combustion of natural gas or fuel oil with air. Since the 1980’s, the glass industry has increasingly adopted oxy-fuel technology, or the use of oxygen instead of air for combustion to improve economics through higher throughput, better quality, fuel savings and reduction of air pollutant emissions such as NOx and SOx. It is estimated that over 20% of glass produced globally is melted using oxy-fuel technology. Oxygen is also used to reduce NOx emissions by 30-40% in air-fuel melters via technologies such as Oxygen Enriched Air Staging (OEAS). To further expand the use of oxy-fuel and OEAS to potential new users, PCI’s VSAs provide oxygen on-site using an innovative approach using less moving parts to improve overall cost and reliability. Stop by today to get more information.

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PaneraTech, Inc., is one of the most innovative sensor technology companies in the world, developing unique solutions that far surpass expectations. We are pioneers in developing smart melter solution that is comprised of two sensors: (1) refractory thickness sensor to measure residual wall thickness and (2) furnace tomography sensor that images early stage glass penetration behind the insulation for preventive maintenance and furnace life optimization.

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Booth # 119
Holmfield, Halifax, West Yorkshire UK HX3 6SX, UK
Phone: +44 (0) 1422-254 472
www.parkinson-spencer.co.uk
Parkinson-Spencer Refractories Ltd. manufacture and supply refractories, engine products and systems for the glass industry.
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• Dense bonded alumina glass contact blocks for the distributor and forehearth
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Plansee is the largest fully integrated partner worldwide for the glass industry, providing its customers with technically advanced designs manufactured from our high performance materials (molybdenum, tungsten, tantalum, niobium) which result in excellent corrosion resistances, coarse grain structure, and the highest purity.
Plansee’s leading edge technologies and high performance materials provide for an efficient glass melting process. Stop by Plansee’s booth to discuss the features of their molybdenum glass melting electrodes, tank reinforcements, stirring and gobbing equipment. Plansee continues to contribute to making glass production more effective and environmentally friendly.
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www.refrmachserv.com
Sawing, grinding and assembling of refractory materials to service the glass and steel industries.

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www.rovisys.com
As an engineering services company, RoviSys specializes in process control and information automation. We have incorporated state of the art systems around the world for major glass manufacturers. As an independent company, we work with you to design and develop the best solution to meet your needs, not ours. With 400 employees and four locations worldwide we are well suited to provide you with state of the art control and information systems. We have experience in all major sectors of the glass manufacturing industry. From your batch house to your warehouse RoviSys delivers on time, every time.

S.I.G.MA. S.r.l.
Booth # 301
Via delle Grigne, 12/A, 22070, Locate Varesino (CO) Italy
Phone: +39 0331 82 31 95
www.sigmaref.it
S.I.G.MA. Group, specialized in the production of refractory materials for the glass industry since 1990, supplies a complete high quality range of materials including sillimanite, mullite, zircon-mullite, zircon, high-alumina, fireclay, fused cast, insulating, magnesite, silica, special cements and concretes. Thanks to two manufacturing facilities, one in Locate Varesino (Italy) and the other in Plovdiv (Bulgaria) now operating at full speed, S.I.G.MA. Group is a leader in Europe in terms of capacity, prices and lead times of shaped pieces. In detail SIGMA Italy produces 3,200 tons/year of special pieces and 6,500 tons/year of pressed material, while SIGMAREF Bulgaria produces 2,500 tons/year of special pieces. Completing the range, about 5,000 tons/year are produced by our partners and controlled by our technicians both with regards to production and auditing.

Safety Controls Technology (SCT)
Booth # 414
6993 Pearl Road, Middleburg Heights, OH 44130
Phone: +1-216-502-1507
www.sct.us.com
Safety Controls Technology, Inc. (SCT) provides safety and health services for glass demolition and rebuild sectors including clients that have requirements to comply with local, state or federal regulations. SCT is a woman-owned business enterprise (FBE, DBE, SBA, EDGE) delivering comprehensive occupational and environmental engineering consulting services to both the public and private sectors.

SAFINA Materials, Inc.
Booth # 202
100 Hilbig Rd, Ste B, Conroe, TX 77301
Phone: +1-936-828-3469
www.safinamaterials.com
SAFINA is a precious metal products manufacturer with a history dating back to the 1860s. SAFINA has long been a trusted supplier to the world renowned Czech glassmaking industry. SAFINA’s products include platinum and Pt alloy crucibles, funnels, stirrers, plungers, and more. The company also makes a full line of thermocouple wires for temperature sensing applications as well as platinum coated ceramic parts.

SORG Services USA
Booth # 213
SORG Services USA, Inc., 2970 Valley View Drive, Toledo, OH, 43615 USA
Phone: +1-724-366-6513
www.sorg.de
The SORG Group through their member companies can supply turnkey installations and equipment from raw material delivery through the glass gob worldwide. This includes all aspects of the furnace lifetime cycle. From sustainable designs, construction, services, repairs, through demolition at the end of the campaign. SORG through EME, Nikolaus Sorg GmbH & Co. KG, and SKS delivers Made In Germany solutions to all sectors of the glass industry. Our latest products include the LoM burners and the BATCH3 system. LoM burners are low momentum, low maintenance oxyfuel burners. BATCH3 consists of the IRD® Doghouse, EME-NEND® chargers and the proven Sorg® batch and cullet preheating systems.
Special Shapes Refractory Company, Inc.
Booth # 307
1100 Industrial Blvd., Bessemer, AL 35022
Phone: +1-205-424-5653
www.ssrco.com
Special Shapes Refractory Company (SSRCo) is a family owned business that manufactures specialized, engineered pre-cast refractory shapes utilizing SSRCo developed refractory mixes for use in the glass industry. We offer grinding and finishing services, quick turn-around times for emergency repairs, and with our co-op partners, we can provide refractory solutions that assist our customers for either “hot or cold” repairs. As we move into our 30th year, SSRCo is still continuing to work on refractory developments, both in refractory material and shape designs, that will continue to help our customers compete in the global market.

Specialty Rondot, Inc.
Booth # 302
30 Montgomery Street, Suite 240, Jersey City, NJ 07302
Phone: +1-201-434-3600
www.specialtyrondot.com
Specialty Rondot is the industry leader in providing the most up to date and advanced forming equipment to the container glass industry. Our high quality equipment and precision instruments implement the most advanced technology available today.

Specialty Rondot, a Groupe Rondot company, specializes in servicing the container glass industry through the supply of unique products and customized engineering solutions. The product range is comprised of products manufactured by Groupe Rondot companies such as Graphoidal, Rondot and Sonicam as well as complimentary products from external Principals such as Sheppee International, Pennine Industrial Equipment and Heat-Up. Experienced sales engineers are available to visit customers and discuss regular requirements as well as potential efficiency and quality improvements within the container glass manufacturing process. CAD design services are offered for bespoke customer solutions or modifications to standard equipment.

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Booth # 417
P.O. Box 350427 – Toledo, OH 43635
Phone: +1 314-374-3100
www.tiama.com
TIAMA AMERICAS based in Toledo (USA), is the American subsidiary of the French leader of inspection solutions: the Tiama Group. Tiama is a global provider of on-line process and quality control for glass packaging industry.

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The TECO Group, consisting of Toledo Engineering Co., Inc., TECOGLAS Ltd., KTG Systems, Inc., KTG Engineering Ltd., ZEDTEC Ltd., EAE Tech and Dreicor Inc. specialize in the design and construction of glass melters of all types, including fuel-fired regenerative and recuperative furnaces, oxy-fuel furnaces, electric melters, electric boost systems and forehearth and distributors/working end. The TECO Group also provides batch plants, emission control systems and process control systems on a turnkey basis. KTG Engineering Ltd. manufactures furnace equipment such as batch chargers, electrode holders spy hole covers, etc.

Tri-Mer Corp.
Booth # 201, 203
1400 Monroe St., Owosso, MI 48867
Phone: +1-989-321-2991
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Tri-Mer Corporation offers completely integrated ceramic catalyst filter systems for glass furnace emissions. The Tri-Mer technology offers a high-performance approach to removing Particulate (PM), SO2, HCl, and NOx in a single all-in-one system. Acid gases such as SO2, HCl, and HF are removed with integrated dry sorbent injection. NOx is destroyed by nanobits of SCR catalyst embedded in the filter walls and used in conjunction with integrated ammonia injection. Other pollutants such as metals are also effectively captured. If only PM or PM+ SO2 and/or HCl need to be controlled, standard filters without catalyst are utilized. Tri-Mer is the largest supplier of ceramic filter systems in the world, with many installations in float and container glass. Tri-Mer offer turnkey services ranging from design engineering and in-house manufacturing to installation and aftermarket service.
EXHIBITORS

Umicore AG & Co. KG  
Booth # 218  
Platinum Engineered Materials, Rodenbacher Chaussee 4, PO Box 1351 63457 Hanau, Germany  
+49 6181 59-8197  
www.pem.umicore.com  
Umicore’s business unit Platinum Engineered Materials is a global technology leader for either cast or FKS® Platinum materials based single-source, tailor-made, engineered system solutions to the special glass industries. We support key players to reach the best possible performance with their special glass production processes at the interface of our Platinum group metal components and its immediate periphery by means of our process excellence model. Process excellence translates into total cost reduction (savings), increase of competitiveness (solutions), and reduction of risk (security).

Usable Glass Strength Coalition, LLC  
Booth # 419  
600 N. Cleveland Avenue, Suite 210, Westerville, OH 43082  
Phone: +1-614-523-3033  
www.gmic.org/ugsc.htm  
Most glass companies cannot independently support a fundamental research agenda to understand and improve the usable strength of glass. However by working together with pooled funding and shared risk, the opportunity to improve the usable strength of glass is achievable. The UGSC supports fundamental, precompetitive research on increasing the useable strength of glass across all sectors; provides an opportunity for researchers to develop expertise in industrial applications; develops tools and measurement techniques for the advancement of glass science; and publishes valuable precompetitive glass research in the public domain.

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Vesuvius is a community of experts. Present around the world, we deliver solutions to our customers to improve their efficiency. The services we offer encompass design and engineering, products and operations management. Our global network of plants brings us within reach of our customers, serving them in real time, with the capacity and flexibility they need to respond to their markets’ demands.

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Warner Power’s comprehensive power conversion and magnetics capabilities provide our customers with “turn-key” solutions to a wide variety of demanding glass industry applications. Our custom-designed GreenStar switch mode and Furnastar SCR based power supplies combine active control with custom transformers and other selected components to reduce total cost of ownership and improve product quality.  
GreenStar Switch Mode Power Supply  
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• Ripple output is less than 1% RMS

SAVE THE DATE!

77th Conference on Glass Problems (77th GPC)  
November 7 - 10, 2016 | Columbus, Ohio  
The exhibit and technical sessions will take place in the Greater Columbus Convention Center. The Hospitality Suites will be located across the street at the Hilton Columbus Downtown.
**ABSTRACTS** in Alphabetical Order by Speaker Last Name


**Advanced Furnace Inspection and Monitoring Based on Radar Sensors**

Furnaces are currently inspected on a regular basis with thermal imaging sensors and other techniques that heavily rely on experience of the plant personnel. However, despite these inspections, the industry still experiences major glass leaks and premature shut-downs of furnaces. This results in inefficient asset utilization and major production disruption. Therefore, advanced inspection of furnaces that provides deterministic erosion profile of the refractories and also detects an early stage glass penetration within the insulation layer will result in safer and longer furnace operation through preventive and proactive maintenance.

To address this major industry need, we have been developing ground-penetrating radar based Refractory Thickness Sensor and Furnace Tomography Sensors for the last several years. The former measures residual AZS thickness on operational furnace. The latter identifies and 3-D images early stage glass penetration into insulation for preventive and proactive maintenance.

At the conference, we will discuss the underlying fundamentals behind the sensor technology, and case studies on operational furnaces highlighting the major difference between the proposed sensor technology and thermal imaging and other technologies that are currently being used by the industry.

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**Steve Brown**, Principal Mechanical Engineer, Bucher Emhart Glass; **Ken Bratton**, Manager of Forming Process Engineering, Bucher Emhart Glass; **Dubravko Stuhne**, Production Technique, Vetroconsult Ltd.

**The Qualification of a New Glass Strengthening Process**

Thermal strengthening of flat glass has been used for over 70 years in the architectural and automotive industries but it is a new concept for the beverage and container markets. This strengthening process changes the structure and the nature of the glass, adding a stored energy component, which requires that the process be both qualified and validated prior to industry acceptance to show that the thermally-strengthened end product meets the design specifications in terms of function, strength, durability and safety.

In this instance, the “Qualification” ensures that the necessary equipment has been chosen and installed correctly and the “Validation” shows that the process, including personnel and equipment, has the capability to produce containers that meet customer’s specifications.

This paper will focus on the efforts required to qualify and validate a new process in the glass industry, together with some results from our experiences including: equipment qualification, validation runs, sampling techniques employed, test results and other related activities.

Included in the test results will be a special series of tests used to evaluate risk and line simulation and loop techniques designed to simulate the effects of multiple trips through a filling line and consumer handling in the returnable marketplace.

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**Stefano Ceola**, Chemist, Senior Project Manager, Stazione Sperimentale De Vetro; **Nicola Favaro**, Chemist, Lab Director, Stazione Sperimentale De Vetro; **Antonio Daneo**, Chemist, Analyst-Optical Analysis Expert, Stazione Sperimentale Del Vetro

**Glass Cullet: Impact of Color Sorting on Glass Redox State**

Nowadays cullet is one of the main raw materials for the glass industry in Europe. More than 60 % of glass cullet is recycled to produce new glass packaging, with furnaces producing green color glasses with more than 90 % recycling rate.

Post-consumer dry recyclables are collected in two main different ways in Europe: mono-material collection (optionally with color differentiation), or mixed with other dry recyclables (multi-material collection; plastic, mixed color glass, cans).

To increase the amount of cullet recycled in the flint glass production, the recyclers have installed new color sorting machines able to produce high quality colored and no-colored flow from the mixed color cullet.

The introduction of such machine has having a positive impact on the amount of cullet recycled, however some unexpected contraindications have been registered. The redox of the cullet feed is strongly impacted by the relative amount of the different colors. Small variation can modify the redox of the batch, introducing instability on the glass color, especially in case of reduced glasses (amber and uvag).

The speech will provide an overview of the cullet collection system in Europe. The impact of the color sorting machines on the glass redox will be analyzed.

A new method developed by SSV to determine the inorganic redox will be described and its application on some real cases illustrated.

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**Oxygen-Enhanced Solid Fuel Combustion in Glass Melting Furnaces**

In response to intense product price competition and higher fuel costs, many glass makers in Asia have embarked upon fuel-switching from natural gas and fuel oil to lower-cost solid fuels; namely petroleum coke and coal. Air Products has in turn developed a burner, the Cleanfire® SF, which efficiently combusts these solid fuels, while also enabling simple, on-the-fly fuel-switching back to liquid and gaseous fuel firing modes as dictated by changes in economic conditions. This burner is a timely and convenient offering for glass manufacturers who are considering alternative fuel utilization during times of market and/or fuel price volatility. Recent experiences summarized in this paper illustrate the benefit of proper oxygen usage, the importance of solid fuel feed system design on combustion performance and potential effects of solid fuel firing on glass quality.
**ABSTRACTS in Alphabetical Order by Speaker Last Name**

**Michel Gaubil**, Ph.D. Senior Scientist, Glass Refractory Expert Manager, Saint Gobain CREE; **Thierry Colozzi**, Technical Support Manager, Saint Gobain SEFPRO; **Isabelle Cabodi**, Ing, Fused Cats Refractory R&D Group Leader, Saint Gobain CREE

**What Makes Good Fused Cast AZS?**
SEFPRO is the worldwide leader in providing refractory solution for the glass industry. Based on our 85 years of refractory experience, we will present the key points for fused cast AZS properties to secure long furnace life and guarantee high glass quality. Specifically, we will discuss the impact of chemistry and chemistry distribution linked to the solidification process. We will also describe microstructure evolution and internal structure analysis of AZS soldier blocks. All these elements have a direct impact on corrosion resistance and glass defect formation. The approach of microstructural analysis combined with new methodology to study block filling will help us to define new criteria for block performance. From this technical knowledge we will advise a refractory specification to take the best of your fused cast refractory block.

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**Amul Gupta**, Ph.D. R&D Manager, RHI Glass; **Kevin Selkregg**, Analytical Lab Manager, RHI Glass; **Roland Heidrich**, Ph.D. R&D Scientist, RHI Glass

**Fused-cast AZS Corrosion, Exudation and Start-up Defects**
Glass defects containing Al₂O₃ and ZrO₂ are often thought to originate from AZS refractories. However, correct identification of the root cause of such defects isn’t always easy. Exudation is often blamed for furnace start-up defects, when in fact corrosion could be the key source. This paper will present results from analysis of start-up defects, and laboratory exudation and corrosion tests performed to understand the root cause of defects.

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**Andries Habraken**, BSc, Senior Consultant Computer Modeling, CelSian Glass & Solar; **Johan van der Dennen**, Consultant, CelSian Glass & Solar; **Piet van Santen**, MSc. Senior Consultant APC, CelSian Glass & Solar

**CFD Based Control: Glass Furnace Control System Based on Time Transient Computer Model**
Conventional Model based Predictive controllers (MPC) use a process model that is derived from experiments on a furnace. Such control system is limited to the tested operational area. Instead of using field data the empirically derived process model can be exchanged by validated CFD simulations. Dynamic computer models do not only describe the furnace time-transient dynamics and important correlations in a very accurate way, but they also present the furnace behaviour in a much broader operational window. Therefore rMPC (control based on dynamic computer models) enables control functionalities over the complete operational area and enhances the controllability of the furnace. CFD models of furnaces and forehearth systems used for process improvement projects are now used in the engineering phase of rMPC control systems and therefore are re-capitalised upon during.

In this presentation, detailed dynamic modelling results of a furnace are discussed, and examples are given on the application of a CFD model in a control system.

**Glass Melt Quality Optimization by CFD Simulations and Laboratory Experiments**
The quality of a glass melting process is determined by the melting-in performance, the sand grain dissolution and the removal of gas bubbles by fining. For good quality it is essential that each trajectory/path starting from batch charging to the throat or waist of the tank shows complete melting and fining. Each part of the glass melt should be exposed to temperatures such that fining can occur. The fining onset temperature and melting performance for an industrial glass tank depends on the batch composition, sand grain size, type and amount of fining agent, furnace atmosphere and the redox number of the batch. Laboratory experiments are carried out to determine the most important parameters for industrial batches. At CelSian, the results of these laboratory experiments are used as input to the CFD (Computational Fluid Dynamics) model GTM-X, which then provides the temperature and flow fields in the industrial melting tank, along with the calculation of the individual glass melt trajectories. This combination of experiments and CFD simulation proves to be a very powerful tool for determining the fining and melting performance of industrial furnaces. Special attention will be paid for the location of the fining zone, with respect to the convection flows in the melt.

In this presentation, batch melting-in and fining experiments as well as CFD modeling of industrial furnaces will be presented and the critical trajectories for these furnaces will be identified. The performance of these tanks for batches with different compositions (normal flint, and low iron) will be investigated and demonstrated. The dependence on furnace design and furnace operation, especially process settings such as pull rate, bubbling rate, waist cooler position, and cullet percentage will be discussed.
Non-contact Optical Measurement of Multi-layered and Coated Glass at the Hot or Cold End

There have been no easy ways to measure multilayer glass structures in float glass plants and other glass manufacturing facilities. Touch gauges are used in total thickness applications but are cumbersome and limited in their use. Laser triangulation is non-contact and used for total thickness but is difficult to align and limited in functionality. Coated glass, water glass, auto and security glass all pose challenges to traditional measurement devices. Additionally, other measurement challenges exist when measuring thin glass used in cell phones, tablets, computers, televisions and other consumer goods. Optical interferometry provides an accurate and easy to use solution to all these challenges. Optical interferometry is a technology that has been around for years, but advances in components and technical expertise has enabled a much more robust system with enhanced capabilities to be manufactured. Telecom grade components with their long life and durability form the backbone of this system. This presentation will highlight multiple examples of challenges customers encountered and solutions provided using the optical technology. We will discuss the following examples of challenges encountered and their solutions:

• Measurement of float glass inside the tin bath
• Measurement of coated glass and water glass at the hot end of a float glass line
• Measurement of thick architectural glass of up to 35mm
• Measurement of safety and auto glass including measurement of the polymer interlayer. This includes measuring wedge in the polymer for heads up auto displays
• Measurement of ultra-thin glass for consumer devices
• In-process measurement of glass being etched to a specific thickness with extremely dangerous hydrofluoric acid
• Measurement of glass stacks for consumer products to ensure parallelism of the layers
• The presentation will highlight both the technical solutions and the business reasons to move forward with optical measurement for different glass thickness challenges.

Effect of Borate Raw Materials on the Melting Behavior of Alkali-lean Borosilicate Glasses

Borosilicate glasses are of utmost importance in a large number of commercial applications, and are among the most largely produced types of glass. The boron, integrated within the structure of these materials, confers to the glass outstanding properties and is irreplaceable for numerous glass compositions (such as low thermal expansion lab-ware or display glasses).

For industrially produced borosilicate glasses, different types of borate raw materials can be chosen by the manufacturers (e.g. borax, boric acid, colemanite). The selection of the type of borate employed for the glass batch depends notably on the type of borosilicate and the exact composition of the raw material itself (e.g. the sodium-containing borax would not be used for alkali-free glasses) as well as on economic considerations. The choice of the borate raw materials may also have an impact on the melting process itself, e.g. on the melting kinetics and the evaporation processes. In this study, the influence of the choice of the borate raw materials upon the melting behavior of alkali-lean borosilicate glasses is presented.

Industrial alkali-lean borosilicate glass batches were melted using CelSian’s High Temperature Melting Observation System and Evolved Gas Analysis setup (HTMOS/EGA). It is shown that the type of borate raw material employed has an effect on the melting and finishing behaviour of the glass. Notably, the influence of hydrated vs. anhydrous borate raw material (boric acid vs. boron oxide) is highlighted.

Optimization Program for Batch Wetting Offers Benefits in Furnace Life, Energy Efficiency, Operation

This presentation serves as an update to Nalco’s presentation at GMIC/2013, which highlighted results of applications of Dry Batch Optimizer technology in the container glass industry. Since that time, we have additional experience, case histories, and insight into the impact of such a program in both container and float glass plants. The authors will discuss proper use of this technology to aid in the effectiveness of batch wetting, allowing glass manufacturers to take full advantage of the benefits of batch wetting while minimizing or eliminating its drawbacks. Pre-wetting of batch material prior to its addition to the furnace is a common practice, and most glass manufacturers agree on its benefits: reduced dusting inside /outside the furnace, extension of furnace life, reduced fouling of regenerators, and better control of particulate emissions from the furnace. Nalco has now documented information showing that we can achieve additional benefits such as: improved homogeneity of the batch mixture, reduction of excess moisture and associated energy benefits, improved batch pile shape and resulting melting efficiency leading to additional energy savings, improved cleanliness of mixers with reduced torque/wear and tear, and, finally, improved safety resulting from reduced dusting as well as reduced need for operator intervention to clean the batch feed system.
Uyi Iyoha, Ph.D. Business Development Manager, Praxair; Sho Kobayashi, Ph.D. Corporate Fellow, Praxair, Inc.; Euan Evenson, Program Development Manager, Praxair, Inc.

**Optimizing Low Momentum Oxy-fuel Burner Performance in Glass Furnaces to Minimize Furnace Emissions and Alkali Volatilization**

Glass manufacturers in U.S. and EU are facing increasing pressure to reduce NO\textsubscript{x} emissions from glass furnaces and to comply with new, lower NO\textsubscript{x} emissions limits. To achieve these ever tightening NO\textsubscript{x} limits, glass manufacturers sometimes install oxy-fuel combustion which is widely known to produce very low NO\textsubscript{x} emissions. However, depending on the type of oxy-fuel burners installed in the furnace, the particulate emissions from the furnace and the refractory crown corrosions resulting from alkali concentration in the furnace may be excessive. The desire to reduce particulate emissions and rapid crown deterioration have led to the development of low momentum oxy-fuel burners for glass furnaces.

Typically, these low momentum oxy-fuel burners are installed in the breastwall of the glass furnaces, placing the burner blocks directly on the tuckstone which are typically in the range of 8 to 16 inches high. Praxair’s CFD modeling and field experience show that for low momentum burners installed directly on the tuckstone close to the glass melt, the flame is pulled downward toward the melt surface as a result of the Coanda effect. This phenomenon increases the impinging velocity of the flame on the glass surface, limiting the efficacy of the low momentum burners to reduce furnace emissions.

This paper will discuss CFD modeling of low and high momentum oxy-fuel burners in an oxy-fuel container glass furnace and show the effect of burner design and placement in the furnace on NO\textsubscript{x} emissions and alkali volatilization. Our results show the momentum of the burner and the elevation of the burner in the furnace, relative to the glass melt, plays very important roles in reducing NO\textsubscript{x} emissions and alkali volatilization. Results show that the alkali volatilization and NO\textsubscript{x} emissions can be reduced by almost 40% when the burner design and location are optimized.

Hwano Kim, Ph.D. Research Associate, Air Liquide

**Air Liquide Heat Oxy-combustion: An Innovative Energy Saving Solution for Glass Industry**

Oxy-combustion today is a mature technology and well known for higher efficiency and lower NO\textsubscript{x} compared to air combustion even without recovering wasted energy from flue gas. Rising energy cost and more stringent environmental regulation make the technology more attractive.

In order to take it one step further, HeatOx uses wasted energy from flue gas to preheat oxygen and natural gas to 650°C and 450°C, respectively. The technology employs air as an intermediate heat transfer fluid instead of direct heat exchange between flue gas and O2/NG to guarantee safe and maintenance free operation. HeatOx is a proven technology with two float glass references, where 10% fuel reduction compared to the traditional oxy-combustion and by up to 25% compared to the usual regenerative air-fired furnaces.

Air Liquide and SISECAM, supported by LIFE European program, are closely collaborating for the implementation of a new HeatOx system at an industrial scale. The main objective is to reduce CO\textsubscript{2} and NO\textsubscript{x} by 23% and 90% compared to traditional air combustion liked to tableware glass production.

The HeatOx technology described here is specifically adapted to container, fiber and technical glass furnaces. A special attention is given to a staged and compact HeatOx burner and multi-channel oxygen and natural gas heat exchangers. The HeatOx burner is operable with both hot and cold reactants maintaining constant flame coverage. The multi-channel heat exchangers feed oxygen and natural gas to multiple burners with independent control of flow rate and temperature for each burner.

Stefan Laux, Dr.-Ing., Director R&D, Praxair, Inc.; Alonso Gonzalez, VP Operations, Grupo Pavisa; Solorzano, Enrique, Grupo Pavisa; Uyi Iyoha, Associate Director Business Development, Praxair, Inc.; Wu, K, Praxair, Inc.; Sho Kobayashi, PhD, Corporate Fellow, Praxair, Inc.

**Operating Experience with OPTIMELT™ Regenerative Thermo-Chemical Heat Recovery for Oxy-fuel Furnaces**

The operation of glass furnaces with oxy-fuel combustion in combination with advanced heat recovery is a compelling low cost solution. Praxair has developed and demonstrated a regenerative heat recovery system for oxy-fuel fired furnaces that uses regenerators in a similar way to which conventional regenerators are used for air preheating. The OPTIMELT™ Thermo-Chemical Regenerator (TCR) technology stores waste heat from the hot flue gas and uses this energy to reform a mixture of natural gas and recirculated flue gas to hot syngas. The natural gas reacts endothermically in the hot checker pack with the water vapor and CO\textsubscript{2} in the recycled flue gas, forming H\textsubscript{2} and CO as a hot syngas fuel and resulting in efficient thermo-chemical heat recovery.

This novel technology for heat recovery was successfully installed on a 50 t/d commercial container glass furnace in 2014 and has been operated in daily production since then. In addition to a positive impact on production and quality, the TCR system successfully reduced natural gas consumption by 16 to 20% depending on glass type and cullet rate. The presentation will summarize the extensive operating experience with the installation and include operational data and results.
Mikael Le Guern, Master Electrical Engineering, Business Development Manager, Schneider-Electric; Rene Meuleman, Business Leader Global Glass, Schneider Electric

Energy Savings through Automatic Load Tap Changer SCR Firing Techniques with Closely Coupled Transformers

Typical applications for automatic load tap changer in the glass industry include platinum bushing loads for fiberglass manufacturing, and boosting electrodes for electrical glass melters. This technique can also be applied to most transformer coupled loads. Historically, transformer coupled loads have used an SCR (Silicon Controlled Rectifier) firing technique called ‘phase angle’ to tightly control the energy supplied to a process. Unfortunately, when applied to inductive loads, phase angle firing creates harmonic distortion that disrupts the incoming power source, resulting in potential interference to sensitive electrical equipment, low power factor in the system and inefficient use of energy.

This technique has come under increased scrutiny as glass manufacturers face ongoing pressures to reduce energy consumption and the associated costs in order to achieve financial viability, whilst meeting social and environmental responsibilities.

Alternative firing methods such as ‘zero cross’ avoid the disruption to the power source, but this method can create an unfavorable situation with the transformer and potentially result in costly equipment failures. At the same time, zero cross method is not suitable for some of the very sensitive loads used in glass applications.

Utilizing automatic load tap changer on multi-tap transformers avoids the issues relating to the individual firing modes. It makes it possible to create a solution using the best case firing mode, while avoiding the downsides by significantly reducing harmonic distortion and improving the power factor. Further efficiency benefits can be achieved by using closely coupled load transformers that lower the inductance in the system, helping to eliminate energy waste, while maintaining and even improving the quality of the process.

A wide range of advantages become possible, such as reducing energy bills where penalties are applied based on poor power factor or exceeding tariff limits, and improving compliance with international EMC (Electromagnetic Compatibility) standards. It also leads to cost savings through optimization of equipment due to the smaller size requirements of transformers, cables and switchgears, further negating the need for extra power factor correction methods and the maintenance of those systems.

By utilizing the knowledge built on 40 years of designing, installing and commissioning practical glass solutions, this paper will show how system complexity and overall investment costs can be reduced, plus how running costs can be lowered through saving energy and improving the quality of end products.

Hong Li, Senior Staff Scientist, Fiber Glass Science and Technology, PPG Industries, Inc.

Strength of Glass

The article provides a selective review of glass and glass fiber strength, focusing on effect of glass surface hydrolysis. Application of Griffith-Inglis-Orowan theory on fracture of glass and glass fiber is demonstrated, elucidating importance of the moisture water on changing glass surface energy. Fundamental understanding of fracture mechanisms of glass and glass fiber supports the development of new glasses and glass fibers with higher pristine strengths and durable/compatible hydrophobic coatings to improve usable strengths of glass and fiber glass products.

Erik Muijsenberg, H.P.H., Glass Service; Brada, J., Glass Service, Inc.

Optimizing the Energy Input to a Glass Melting by Intelligent Furnace Design and Operating Practices

This paper will demonstrate how Intelligent Furnace Design & Operating Practices can increase the overall glass furnace efficiency by utilizing advanced furnace modeling to help select the most-optimal furnace design for a certain type of glass and pull. This can be achieved by installing electric heating in unique ways to improve the so called Space Utilization. The average residence time of a common glass furnace can be for example, 30 hours, while the minimum residence time is sometimes only 3 hours, so the whole available space volume is poorly used. One of the concepts is to change lateral glass convection into transversal convection. This results in an increase in the minimal residence time, with the glass being better fined due to it passing through the hot spot, and also better homogenized.

Furthermore, flexible top firing energy input is optimized in conjunction with the electric boost in the most optimal combination. Altogether this can save significant energy, increased furnace pull rate and reduced emissions can also be achieved.

A flexible furnace using natural gas and electric heating can be operated at higher pulls per square meter and cubic meter when needed and at same time reduce energy costs at a given pull rate. Such an optimal designed furnace can be controlled in the economical optimum using advanced Model Based Predictive Control (MBPC). MBPC can decide better than Human Operators to use which energy input in the most optimal way, keeping the balance between temperature stability, glass quality, furnace lifetime and actual, to-the-minute costs of the used energy source. Due to the fast implementation of renewable energy sources the costs of energy in the near future may vary each hour. In Germany over 30% of electric energy is coming from renewable energy, which make electricity pricing very dynamic due to the varying of its availability and sources.

Due to the fast implementation of renewable energy sources the costs of energy in the near future may vary each hour. In Germany over 30% of electric energy is coming from renewable energy, which make electricity pricing very dynamic due to the varying of its availability and sources.

Operating the optimal furnace design (with gas firing and electric heating/boosting) with fully automatic Model Based Predictive Control allows the glass producer to operate the furnace in the optimal cost-effective way with minimum use of operators. The technology can theoretically offer a pull increase of 10-20%, while energy costs reduction can be 2-10%.
Pierre Lankeu Ngankeu, Senior Mechanical Engineer, Bucher Emhart Glass; Paul Stargardter, Mechanical Engineer, Bucher Emhart Glass

*Improvements to Bucher Emhart Glass Verti-Flow Mold Cooling Applications in Glass Container Production*

During the forming process molds are used to cool the glass while it is blown into its final shape. The heat removed from the glass is dependent on mold temperature. This makes mold cooling one of the most critical aspects of the glass container production. Air is often used as a cooling medium. For over 30 years Emhart glass has been using the Verti-flow cooling system on the Blow (or mold) side. This system provides cooling air to the molds from the bottom plate mechanism. This system has always been limited to cooling only being available while the molds are closed. Some processes, namely those with smaller contact times on the blow side would benefit from additional cooling time. In addition, because the Verti-flow cooling air travels from the bottom to the top, it is difficult to achieve a good vertical temperature distribution for containers that require more cooling in the upper parts of the mold. In order to increase the flexibility of the Verti-flow cooling system on the blow side, Emhart Glass has developed Verti-flow Assist. This system complements the Verti-flow system by enabling cooling when the molds are closed. Verti-flow can be used to cool the molds while they are closed and Verti-flow assist is used while the mold is open. In this paper we will present the existing Verti-flow system along with the Verti-flow assist concept as it has been implemented into the AIS and NIS machines.

Peter Šimurka, Associate Professor, Institute of Inorganic Chemistry SAS; Ing. Jozef Kraxner, PhD Institute of Inorganic Chemistry SAS; Peter Vrábel, Associate Professor, Rona a.s.; Ing. Tomáš Paučo, Rona a.s.

*Corrosion of AZS Refractories – Source of Defects in Tableware Glass*

The relationship between the composition of defects presented at tableware glass products and a glass phase of the AZS refractory material is studied. Mineralogy composition was determined on refractory samples taken from the working and melting parts of furnace after campaign termination as well as on the samples where laboratory static corrosion tests have been realized. The concentration profiles of oxides presented in AZS refractory glass phase were determined by SEM and EDX analysis. Samples of the final products containing different types of inhomogeneities were collected during regular production in a period of 48 months and analyzed.

The corrosion mechanism consists of diffusion of alkalis from the glass melt into the refractory, dissolution of the Al₂O₃ and ZrO₂ in the glass phase, diffusion of Zr and Al from the refractory into the glass melt, creation of the boundary layer area and erosion of the boundary layer area. The content of Al₂O₃ is about 30 wt. % in the refractory glass phase placed above the metal line; it varies from 10 to 24 wt. % in the part located below the metal line. Defects in final products originate mainly from the refractory located in the melting part of furnace below the metal line.

Alan Stephens, Director, Fives Stein Limited,

*Forehearth Heating*

For many years now incremental improvements have been made to forehearth heating systems that have made them more efficient, more controllable and safer but, fundamentally, they are still mostly K-type firings systems, which were introduced in the 1920s. The system feeds a mixture of gas and air to rows of small pencil burners arranged down either side of the forehearth channels. The efficiency and distribution of the heat inside the forehearth is dictated and limited by this arrangement and further improvements are limited.

This paper will discuss the development and trials of an alternative combustion system that uses fewer burners but distributes the heat better and more efficiently AND provides the opportunity for direct heat recovery, which cannot be achieved using premix systems. The combustion controls offer the same accuracy of control as the best existing systems but with the potential for an even higher turn-down ratio, improved safety, and direct heat recovery. The burners provide better heat distribution and more efficient combustion, resulting in improved side heating. Real fuel savings should result from the wider turn-down ratio and improved combustion efficiency, whilst the improved heat distribution will allow improvements in the thermal homogeneity of the glass leaving the forehearth.
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