NEW DEVELOPMENTS IN CLASS A SPRAY POLYURETHANE FOAM APPLICATIONS WITH GREAT LAKES PHT4-DIOL™ LV FLAME RETARDANT
Ensuring that spray polyurethane foam used in commercial and residential construction is adequately resistant to ignition and flame spread is essential to fire safety. To achieve reduced flammability, spray polyurethane foam used in roofing, attic and wall insulation must comply with Underwriters Laboratories 723 Class A test standard.

Traditionally, Great Lakes PHT4-Diol™ flame retardant has been used to meet this application requirement. This poster will present performance evaluation of Great Lakes Solutions’ next generation flame retardant, PHT4-Diol™ LV, which offers improved handling, efficiency, energy consumption and process safety while maintaining all the performance features of its predecessor, but with a significantly reduced viscosity.

The poster will demonstrate the versatility and flame retardant efficacy of PHT4-Diol™ LV in all-water blown spray polyurethane foam systems, 3rd generation blowing agents, and novel aromatic polyester polyols.
EXPERIMENTAL

- All additives, flame retardants, isocyanates, polyols and solvents were used as received without additional purification.

- **PHT4-Diol™** and **PHT4-Diol™ LV** flame retardants obtained from Great Lakes Solutions.

- Forane® 365mfc/227ea blend obtained from Arkema.

- An experimental, high functionality, aromatic polyester polyol obtained from Huntsman International.

- Foams for Steiner Tunnel Testing were manufactured with production spray foam machinery at Raven Lining Systems, NCFI Polyurethanes and Carpenter Company.

- Flammability performance for Steiner Tunnel Testing was performed by accredited labs at QAI Laboratories in Tulsa, Oklahoma and Underwriters Laboratories in Northbrook, Illinois using certified and calibrated Steiner Tunnels.
PHT4-DIOL™ LV

REACTIVE HALOGENATED FLAME RETARDANT

PHT4-Diol™ LV, tetrabromophthalate diol

- Reactive flame retardant intermediate
- Viscous, brown colored liquid which exhibits excellent compatibility with a broad range of commercial polyols and blowing agents
- Recommended as a reactive flame retardant for Class 1 / Class 2 rigid polyurethane foam
- Foams can be formulated for excellent physical properties or favorable economics
- Other applications include polyurethane RIM, elastomers, coatings, adhesives and fibers

**TYPICAL PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Lt. Brown Viscous Liquid</td>
</tr>
<tr>
<td>Bromine Content, %</td>
<td>43</td>
</tr>
<tr>
<td>Specific Gravity @ 25 °C, g/ml</td>
<td>1.7</td>
</tr>
<tr>
<td>Hydroxyl Number, mg KOH/g</td>
<td>210 - 275</td>
</tr>
<tr>
<td>Viscosity @ 25 °C, cPs</td>
<td>15,000 – 45,000</td>
</tr>
<tr>
<td>Acid Number, mg KOH/g</td>
<td>0.15 max</td>
</tr>
<tr>
<td>Water content, %</td>
<td>0.15 max</td>
</tr>
</tbody>
</table>
PHT4-Diol™ LV: Key Benefits to Customers

- Allows foam manufacturers to meet stringent fire safety standards such as ASTM E84 and UL 723

- Reduced viscosity of PHT4-Diol™ LV provides the following benefits:
  - Lowers or eliminates need for viscosity reducing materials
  - Greater latitude in formulating systems, broadens options for polyols to be used
  - Reduced energy requirements to keep PHT4-Diol™ LV at a targeted pump viscosity vs. PHT4-Diol™
  - Reduced material retained in drums and vessels

- Ease of conversion from PHT4-Diol™ to PHT4-Diol™ LV
  - Maintains equivalent foam properties
  - Same CAS and EINECS number as PHT4-Diol™ so no need for requalification of listed formulas
SPF FOR WALL INSULATION

HFC-245fa BLOWN FOAM MEETING UL 723 CLASS A

<table>
<thead>
<tr>
<th>Flame Retardant</th>
<th>Density</th>
<th>Test Panel Thickness</th>
<th>FSI</th>
<th>SDI</th>
<th>Class Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT4-Diol™ LV</td>
<td>2 lbs/ft³</td>
<td>6”</td>
<td>20</td>
<td>450</td>
<td>Class A</td>
</tr>
<tr>
<td>PHT4-Diol™</td>
<td>2 lbs/ft³</td>
<td>6”</td>
<td>20</td>
<td>450</td>
<td>Class A</td>
</tr>
</tbody>
</table>

Steiner Tunnel Class Designations

<table>
<thead>
<tr>
<th>Class Designations</th>
<th>Flame Spread Index</th>
<th>Smoke Developed Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A or Class I</td>
<td>0 – 25</td>
<td>0 - 450</td>
</tr>
<tr>
<td>Class B or Class II</td>
<td>26 - 75</td>
<td>0 - 450</td>
</tr>
<tr>
<td>Class C or Class III</td>
<td>76 - 200</td>
<td>0 - 450</td>
</tr>
</tbody>
</table>

Tests performed according to ASTM D3574 and Underwriters Laboratories 723 (Steiner Tunnel test).

Both foams were designated Class A / Class I / Type I.

PHT4-Diol™ LV provides equivalent flammability performance at equal loadings to PHT4-Diol™ in spray polyurethane foam applications.
## SPF for Roofing Applications

**FORANE® 365MFC/227EA Blown Foam Meeting ASTM E84 Class I**

<table>
<thead>
<tr>
<th>Flame Retardant</th>
<th>Density</th>
<th>Test Panel Thickness</th>
<th>FSI</th>
<th>SDI</th>
<th>Class Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT4-Diol™ LV</td>
<td>3 lbs/ft³</td>
<td>2”</td>
<td>30</td>
<td>350</td>
<td>Class I</td>
</tr>
<tr>
<td>PHT4-Diol™</td>
<td>3 lbs/ft³</td>
<td>2”</td>
<td>30</td>
<td>350</td>
<td>Class I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXP1</th>
<th>EXP2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental polyester polyol</strong></td>
<td>76.9</td>
</tr>
<tr>
<td>PHT4-Diol™ LV</td>
<td>4.0</td>
</tr>
<tr>
<td>PHT4-Diol™</td>
<td>4.0</td>
</tr>
<tr>
<td>TCPP</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>FORANE® 365MFC/227EA</strong></td>
<td>8.7</td>
</tr>
<tr>
<td>HFC-245fa</td>
<td>0.7</td>
</tr>
<tr>
<td>Water</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Catalysts/Surfactant blend</strong></td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
<tr>
<td>pMDI Index</td>
<td>105</td>
</tr>
</tbody>
</table>

- Tests performed according to ASTM D3574 and ASTM E84 (Steiner Tunnel test).
- Both foams were designated Class A / Class I / Type I.
- Panels tested at Exova (Canada).

**PHT4-Diol™ LV provides equivalent flammability performance and compatibility with Forane® 365mfc/227ea at equal loadings to PHT4-Diol™.**
# SPF for Wall Insulation

## All-Water Blown Foam Meeting UL 723 Class A

<table>
<thead>
<tr>
<th>Density</th>
<th>Flame Retardant</th>
<th>Test Panel Thickness</th>
<th>FSI</th>
<th>SDI</th>
<th>Class Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raven 551</td>
<td>0.5 lbs/ft³</td>
<td>PHT4-Diol™ LV</td>
<td>4”</td>
<td>20</td>
<td>400</td>
</tr>
<tr>
<td>Raven 550</td>
<td>2 lbs/ft³</td>
<td>PHT4-Diol™ LV</td>
<td>4”</td>
<td>20</td>
<td>400</td>
</tr>
</tbody>
</table>

Raven Linings Systems offer an innovative alternative to traditional spray polyurethane foam attic and wall insulation.

Raven 550 and Raven 551 are all-water blown spray polyurethane foams based upon soy polyol and Great Lakes PHT4-Diol™ LV.

PHT4-Diol™ LV provides flammability performance and outstanding compatibility with all-water blown spray polyurethane foams.

Tests performed according to ASTM D3574 and ASTM E84(Steiner Tunnel Test). Both foams were designated Class A / Class I / Type I.
CONCLUSIONS

- **PHT4-DIOL™ LV** is an innovative, reactive, low viscosity brominated flame retardant for UL 723 Class A (Steiner Tunnel Test) compliant rigid spray polyurethane foam applications, including attic and wall insulation, millwork, pour-in-place, and roofing.

- **PHT4-DIOL™ LV** provides equivalent flammability performance at equal loadings in rigid spray polyurethane foam applications as **PHT4-DIOL™** while providing the benefit of reduced viscosity.

- **PHT4-DIOL™ LV** is an effective and compatible flame retardant for rigid spray polyurethane formulations that utilize only water as a blowing agent, Forane®365mfc/227 ea blends or high functionality, aromatic polyester polyols.

- **PHT4-DIOL™ LV** is the product of Great Lakes Solutions’ “**Greener Innovation**” strategy to achieve the goal of providing sustainable, effective fire safety solutions.
ACKNOWLEDGEMENTS AND THANK YOU!

For formulation assistance:
- Tripp Ishmael - Raven Linings Systems
- Matt Nguyen - Huntsman International
- Rick Stoehr - NCFI Polyurethanes

For use of their spray foam equipment and testing:
- Raven Linings Systems
- NCFI Polyurethanes
- Carpenter Company

For guidance concerning fluorinated blowing agents:
- Robert Smith - Arkema
BIOGRAPHY

 Carl Powell is the Technical Team Leader for Polyurethane Foams at Great Lakes Solutions, a Chemtura business, in West Lafayette, IN.

 He received his B.S. in Biology from the Virginia Polytechnic Institute & State University (VA TECH) in 1995 and his MBA from Strayer University in 2009.

 Carl joined the company in 2008 with primary responsibilities for development and applications testing of new products for polyurethane foams, as well as, technical support and customer service.

 He is an integral team member in the commercialization of PHT4-Diol™ LV and Emerald Innovation™ NH-1.
• Global specialty chemical company listed on the New York Stock Exchange / EURONEXT ("CHMT")
• $3.0 billion in revenues
• More than 4,500 employees worldwide
• Global headquarters in Philadelphia, Pennsylvania, USA
• Regional headquarters and shared service centers in Sao Paulo, Brazil; Shanghai, China; Middlebury, Connecticut, USA; and Manchester, United Kingdom
Great Lakes Solutions, an Industry Leader

**KEY BUSINESSES**

- Flame Retardants
- Brominated Performance Products

**INDUSTRIES SERVED**

- Electrical & Electronics
- Insulation & Furniture
- Automotive
- Fine Chemical/Pharmaceutical
- Energy: Oilfield & Mercury Control
- Fumigation
- Biocides
- Automotive Tires

**KEY GROWTH DRIVERS**

- Greener innovation
- Rapid growth in electronics
- Flame retarded energy efficient thermal insulation
- Increased global fire safety standards

**Pie Chart**

- Energy
- Fumigation
- Fine Chem/Pharma
- Other
- Insulation & Furniture
- Auto
- Electrical & Electronics
We have invested in three world-class, global research & development technology centers in West Lafayette, Trafford Park and Nanjing. Our Technology Centers provide a host of value-added services including:

- Chemical Synthesis
- Application Research
- Formulation Guidance
- Polymer Processing
- Analytical Testing
- Pilot Process Development
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