Forane® 1233zd
A High Performing, Low Global Warming Potential Blowing Agent For Spray PU Foam

Joseph Lynch
Arkema Inc
January 28, 2014

The comments and opinions in this presentation do not necessarily represent or reflect those of SPFA.
Arkema investigated many low GWP Blowing Agents to replace HCFCs and HFCs
Forane® 1233zd Blowing Agent

- trans-1-chloro-3,3,3-trifluoropropene
- GWP = 7
- Bp = 19°C
- MW = 130.5
- Non-flammable
- US 8,314,159
- EP 2,129,709
# Blowing Agent Comparison

<table>
<thead>
<tr>
<th></th>
<th>MW</th>
<th>BP</th>
<th>Flash point</th>
<th>LFL/UFL</th>
<th>GWP</th>
<th>Lambda (mW/m(^0)K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(°C)</td>
<td></td>
<td></td>
<td>10°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25°C</td>
<td></td>
<td></td>
<td>25°C</td>
</tr>
<tr>
<td>Forane® 1233zd</td>
<td>130.5</td>
<td>19</td>
<td>None</td>
<td>None</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>iC5</td>
<td>72</td>
<td>28</td>
<td>-51</td>
<td>1.4</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>nC5</td>
<td>72</td>
<td>36</td>
<td>-49</td>
<td>1.5</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>cC5</td>
<td>70</td>
<td>49</td>
<td>-7</td>
<td>1.5</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>HFC-134a</td>
<td>102</td>
<td>-27</td>
<td>NA</td>
<td>None</td>
<td>1320</td>
<td>12</td>
</tr>
<tr>
<td>HFC-365mfc</td>
<td>148</td>
<td>40</td>
<td>-24</td>
<td>3.4/13.0</td>
<td>782</td>
<td>11</td>
</tr>
<tr>
<td>HFC-245fa</td>
<td>134</td>
<td>15</td>
<td>None</td>
<td>None</td>
<td>1020</td>
<td>13</td>
</tr>
</tbody>
</table>
Forane® 1233zd
Safe To Use

- SNAP approved in US by EPA
- Listed on TSCA inventory in US
- Occupational Exposure Limit of 800 set by WEEL
  - OEL of HFC 245fa is 300.
- Non flammable liquid blowing agent
  - No Flash Point. No LFL / UFL
Forane® 1233zd
Environmental Performance

- Very short lived substance due to molecular structure
- Non Ozone Depleting Substance
- Non VOC classification
- Low Global Warming Potential of 7
Forane® 1233zd
Demonstrated Ease of Use

- All formulas developed & tested with currently used polyurethane raw materials
  - Excellent miscibility in PU raw materials
  - Compatible with conventional metals & elastomers
- No changes in packaging or drum storage
- Processed on existing PU spray equipment
- No changes in processing parameters or reactivity
Lower Vapor Pressure in B-Side Blends

Forane® 1233zd less susceptible to drum bulging or rupture

Permanent drum distention

Vapor Pressure psig

Temperature C

20 30 40 50 60

245fa Forane 1233zd
Forane® 1233zd
Improved Thermal Performance

Forane 1233zd delivers higher R Values per inch vs HFC 245fa

R Value

Initial
Aged

\[\begin{array}{c}
5 \\
5.2 \\
5.4 \\
5.6 \\
5.8 \\
6 \\
6.2
\end{array}\]

\[\begin{array}{c}
5 \\
5.2 \\
5.4 \\
5.6 \\
5.8 \\
6 \\
6.2
\end{array}\]

* Unoptimized formulas. Improvements likely with further system optimization
Forane® 1233zd
Improved Fire Performance

Forane 1233zd may allow for reduced fire retardant loadings

* Unoptimized formulas. Improvements likely with further system optimization
Forane® 1233zd Blowing Agent

Conclusions

- Safe and approved for use in US spray foam by EPA
- Non Flammable liquid blowing agent
- Low Environmental Impact
- Improved Thermal & Fire Performance
- Ease of Use with existing PU materials & equipment
FORANE is a registered trademark of Arkema
Next Generation Blowing Agents for Closed-Cell SPF-
Industry Update:

DUPONT™ FORMACEL® 1100:
SPRAY FOAM APPLICATION

Ernest B. Wysong
DuPont Chemicals & fluoroproducts
Wilmington, DE

The comments and opinions in this presentation do not necessarily represent or reflect those of SPFA.
**Issue:** HFC based blowing or foam expansion agents (FEA) have high global warming potential (GWP > 700)

**Implications:**
- Life Cycle Analysis and Sustainability
  - Higher GWP and lower R-value $\rightarrow$ higher greenhouse gas impact
  - Architectural design considerations (LEED, etc.)
- Some countries are regulating HFC’s (Japan, EU, Canada - Quebec)

**Solution:** Hydrofluoroolefin (HFO) technology
- Rapid removal from atmosphere
FORMACEL® 1100
REDUCTION OF THE ENVIRONMENTAL FOOTPRINT

- Ozone Depletion Potential (ODP) = 0 (no chlorine)
- Global Warming Potential (GWP) 100 yr ITH = 8.9\(^a\) (NOAA)
- Atmospheric lifetime = 22 days (NOAA)
- Nonflammable (ASTM E 681 at 60 \(^\circ\)C & 100 \(^\circ\)C)
- Boiling Point = 33 \(^\circ\)C (92 \(^\circ\)F)
- Vapor Thermal Conductivity \(k\) = 10.7 mW/mK @ 25 \(^\circ\)C
- AEL\(^b\) = 500 ppm 8hr / 12hr
- Maximum Incremental Reactivity (MIR) = 0.04 g O\(_3\)/g

\(^a\) Wallington et al CTM method = 2
\(^b\) DuPont Acceptable Exposure Limits (8-12 hr TWA)
FORMULATION ASPECTS

Formacel® 1100

- Excellent compatibility with polyols, polyisocyanates, catalysts, surfactants in use today
  → Easy formulation with current materials.

- Higher boiling point
  → Improves yield and easily handled (less pressurized drums even in warm weather)

- Optimization is required for catalyst levels, surfactant levels/types
  → Equivalent to improved foam properties versus current products.
Formacel® 1100 formulations show excellent stability versus current systems due to the outstanding compatibility with B-side components.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>HFC-245fa</th>
<th>FEA - 1100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyols / Flame Ret.</td>
<td>89.4</td>
<td>89.3</td>
</tr>
<tr>
<td>Dabco® DC 193¹</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Polycat® 30²</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>Dabco® T120³</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Foam Expansion Agent</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Water</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Formacel® 1100 gives similar application performance to current HFC formulations when properly formulated, even at low temperatures (e.g. -5 °C).

Example properties include:
- Yield – Comparable to improved
- Spray Behavior – Comparable
- Gel Times – Comparable
- Compressive Strength – Comparable to improved
- Dimensional Stability – Comparable
- Adhesion (Substrate and Foam) – Comparable
- Moisture Permeability – Comparable
- Thermal Conductivity – Comparable to improved
- Exposure Hazards – No new issues
Example of Low Temperature Application (-5 °C)

2 PCF Formulation
9-10 pbw Blowing agent

Operating Conditions

Spray Machine                        Gusmer-type (FF-1600)
Spray Booth Temperature                -5 °C
Machinery Room Temperature             15 °C

Sample 1  Applied to slate board with a 5mm primer layer, 30 sec interval, then a 30 mm layer.
Sample 2  Applied to plywood board with a 5mm primer layer and then two 25mm layers at 15 sec. intervals.

Observations:
- Spray pattern    OK
- Reactivity       OK
- Initial rise     OK
- Adhesion         OK
- Density          OK
Similar performance has been obtained at other temperatures and conditions.

**Summary:**
Formacel® 1100 provides comparable application behavior and physical property performance across a wide range of temperatures.

<table>
<thead>
<tr>
<th>Foam Expansion Agent</th>
<th>HFC Blend</th>
<th>Formacel® 1100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Foam Density</td>
<td>28.0 kg/m³</td>
<td>28.1 kg/m³</td>
</tr>
<tr>
<td>Core Foam Density</td>
<td>33.5 kg/m³</td>
<td>34.9 kg/m³</td>
</tr>
<tr>
<td>Compressive Strength (Horz./Vert.)</td>
<td>0.240 Mpa/0.085 MPa</td>
<td>0.249 Mpa/0.080Mpa</td>
</tr>
<tr>
<td>Dimensional Stability (5 days @ 70 °C. 95% RH)</td>
<td>14.7 vol%, 1.6 thickness %</td>
<td>15.6 vol%, 1.0 thickness %</td>
</tr>
<tr>
<td>Thermal Conductivity (23 °C)</td>
<td>21.0 mW/m°K</td>
<td>20.1 mW/m°K</td>
</tr>
<tr>
<td>Moisture Permeability</td>
<td>1.25 ng/m.s.Pa</td>
<td>1.34 ng/m.s.Pa</td>
</tr>
</tbody>
</table>
Small scale testing of multiple formulations illustrates no negative impact on foam flammability versus HFC blends.

Large scale E84 testing indicates Class 1 performance can be achieved.

<table>
<thead>
<tr>
<th>Foam Expansion Agent</th>
<th>HFC-365mfc /HFC-227ea</th>
<th>Formacel® 1100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion Test (EN ISO 11925-2) Avg. of 6</td>
<td>130 mm</td>
<td>130 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Specimen</th>
<th>Flame Spread Index</th>
<th>Smoke Developed Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formacel® 1100 SPF Formulation</td>
<td>25</td>
<td>350</td>
</tr>
</tbody>
</table>
Non-optimized Formacel® 1100 formulations deliver equivalent to improved aged R-values versus HFC formulated foams.

- Improved R-value saves energy which reduces greenhouse gas impact

Formacel® 1100 has a low inherent GWP value

Life Cycle Analysis

- Lower GWP and higher R-value (lower energy consumption)
  → Lower greenhouse gas impact
Customer evaluations demonstrate that Formacel® 1100 is a viable foam expansion agent or blowing agent for spray foam applications as a replacement for HFCs.

Formacel® 1100 provides zero ODP and low GWP while maintaining desired characteristics: non-VOC, suitable boiling point, low vapor thermal conductivity and non-flammability.

Key parameters including stability, solubility, reactivity, physical properties, aging and flammability can be met with Formacel® 1100 in spray foam applications.

Commercialization (intermediate plant) by mid-2014, Large plant in 2016.
HONEYWELL
SOLSTICE® LIQUID
BLOWING AGENT (LBA)
IN SPRAY FOAM

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What is GWP and why do I care?

What is Solstice® LBA and how does it compare to Enovate 245fa?

Is Solstice® LBA commercial, can we buy it now and where will it be made?

What about the drum vapor pressure of spray foam systems formulated with Solstice® LBA system?

What about the shelf life of spray foam systems formulated with Solstice® LBA?

What is the quality of foam made with Solstice LBA?
COMMONLY ASKED QUESTIONS

- Where has spray foam formulated with Solstice® LBA been applied?

- How about equipment? What do I have to change to process spray foam systems formulated with Solstice® LBA?

- Proof is in the field, what about roofing yields and surface profile with Solstice® LBA systems?

- Is personnel exposure different with spray systems formulated with Solstice® LBA systems? Do I have to change my respiratory protection?

- Summary
WHAT IS GWP AND WHY DO I CARE?
WHAT IS GWP?

<table>
<thead>
<tr>
<th>GWP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SF₆</td>
<td>22,800</td>
</tr>
<tr>
<td>23</td>
<td>14,800</td>
</tr>
<tr>
<td>143a</td>
<td>4,470</td>
</tr>
<tr>
<td>227ea</td>
<td>3,220</td>
</tr>
<tr>
<td>134a 365mfc/227ea</td>
<td>1300</td>
</tr>
<tr>
<td>87/13</td>
<td>1110</td>
</tr>
<tr>
<td>245fa</td>
<td>1030</td>
</tr>
</tbody>
</table>

**Current**

- Solstice® LBA GWP Same As CO₂

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**Sources:**

- Okunaga university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1996. The solstices of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.
Environmental & GWP Awareness Growing

Consumer Products and Air Pollution

Should a label indicating a product's carbon footprint be mandatory?

- Yes 8
- No, it should be done on a voluntary basis 15
- The carbon footprint is of no interest to me 72
- DK/NA

In 2006, the Legislature passed and Governor Schwarzenegger signed AB 32, the Global Warming Solutions Act of 2006, which set the 2020 greenhouse gas emissions reduction goal into law. It directed the California Air Resources Board (ARB or Board) to begin developing discrete early actions to reduce greenhouse gases while also preparing a scoping plan to identify how best to reach the 2020 limit. The reduction measures to meet the 2020 target are to be adopted by the start of 2011.

Assembly Bill 32: Global Warming Solutions Act

Assembly Bill 32 includes a Number of Specific Requirements:

- ARB shall prepare and approve a scoping plan for achieving the maximum technologically feasible and cost-effective reductions in greenhouse gas emissions from sources or categories of sources of greenhouse gases by 2020 (Health and Safety Code (HSC) §38561). The scoping plan, approved by the ARB Board December 12, 2008, provides the outline for actions to reduce greenhouse gas emissions in California. The proposed scoping plan identifies, among others,

Can insulation materials, which we use to save energy and help prevent climate change, cause greenhouse gas emissions? Yes, in two ways. First, it takes energy to produce and ship these materials—which we refer to as "embodied energy"—and using forest fuels for these energy needs releases carbon dioxide (our most significant greenhouse gas). So in a sense, all insulation materials have embodied global warming potential (GWP). Second, two of our common insulation materials are made with hydrofluorocarbons.

Staying Ahead of Regulatory Curve
WHAT IS SOLSTICE® LBA AND HOW DOES IT COMPARE TO ENOVATE® 245fa?
## Comparative Physical Properties

**Solstice® LBA**

<table>
<thead>
<tr>
<th>Property</th>
<th>Solstice® LBA</th>
<th>Enovate® 245fa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mol. Weight</td>
<td>130</td>
<td>134</td>
</tr>
<tr>
<td>Flashpoint</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>°C</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>°F</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>LFL / UFL (Vol % in air)</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>ODP</td>
<td>~0&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>~0</td>
</tr>
<tr>
<td>GWP, 100 yr</td>
<td>1&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>1030&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>OEL (PEL)</td>
<td>800&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>300</td>
</tr>
</tbody>
</table>

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### Notes:
- (E) 1-chloro-3,3,3-trifluoro-propene
- Trans isomer
- Physical properties are one of a mosaic of attributes that must be assessed to determine the suitability of any material as a blowing agent.

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1. No impact on ozone layer depletion and is commonly referred to as zero. Reference: Preliminary report: Analyses of tCFP’s potential impact on atmospheric ozone; Dong Wang, Seth Olsen, and Donald Wuebbles Department of Atmospheric Sciences University of Illinois, Urbana, IL
2. Reference (Private Correspondence with Donald Wuebbles)
4. Honeywell Internal OEL
IS SOLSTICE® LBA COMMERCIAL?

CAN WE BUY IT NOW?

WHERE WILL IT BE MADE?
COMMERCIALIZATION STATUS - REGULATORY STATUS

- Current registrations:
  - US (SNAP and PMN)
  - Canada
  - EU REACH (<10MT)
  - China (<10MT)
  - Japan
  - S. Korea, others
- Registrations in Process: EU REACH (1,000MT), China (1,000MT), Australia, Philippines, New Zealand
- No limitations on sales in: India, Indonesia, Mexico, Brazil, S. America, Central America, M. East, Africa

- US VOC Exemption Granted

Globally Registered for Sale
Global trials and sales on-going across multiple applications

- Appliance: US, China, Korea, Japan, Europe
- Spray foam: US, Canada, Japan, Europe
- Panel (continuous and discontinuous): US, Europe, Japan
- Chillers: US
- Solvents: US, Europe
Large Plant Being Built, Operational Q2, 2014

Supply availability
Today: Large “semi-commercial” plant
Q2 2014: World class, large scale plant in Louisiana
Planning / Engineering on 2nd large-scale plant

Product Available Today
WHAT ABOUT THE DRUM VAPOR PRESSURE OF SPRAY FOAM SYSTEMS FORMULATED WITH SOLSTICE® LBA?
EXAMPLE: COMPARISON OF ROOF SYSTEM POLYOL PREMIX VAPOR PRESSURE

Lower Vapor Pressure of Solstice® LBA Polyol Blend Improves Processing
WHAT ABOUT THE SHELF LIFE OF SPRAY FOAM SYSTEMS FORMULATED WITH SOLSTICE® LBA?
### EXAMPLE: SHELF LIFE EVALUATION OF SPF ROOFING POLYOL BLEND

<table>
<thead>
<tr>
<th>Storage Time @ Room Temperature</th>
<th>Reactivity, sec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cream</td>
<td>Tack Free</td>
</tr>
<tr>
<td>Initial</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>199 days</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Change in Reactivity, sec</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

*Polyol @ 80 °F (27 °C) / Iso@ 70°F (21°C)*

Data provided by West Development Group

*Solstice® LBA Polyol Blends Have Acceptable Shelf Life*
WHAT IS THE QUALITY OF FOAM MADE WITH SOLSTICE LBA?
# COMPARISON OF ROOF FOAM TEST DATA

<table>
<thead>
<tr>
<th>Test</th>
<th>Solstice® LBA</th>
<th>Enovate 245fa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, pcf</td>
<td>2.5</td>
<td>-</td>
</tr>
<tr>
<td><em>R</em>-value (Initial, 1 “ thickness)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature, °F/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 / 4</td>
<td>7.2</td>
<td>-</td>
</tr>
<tr>
<td>70 / 21</td>
<td>6.4</td>
<td>6.2</td>
</tr>
<tr>
<td>110 / 43</td>
<td>5.9</td>
<td>-</td>
</tr>
<tr>
<td>Closed Cell Content, %</td>
<td>93</td>
<td>&gt; 90</td>
</tr>
<tr>
<td>Compressive Strength (parallel), psi</td>
<td>&gt; 50</td>
<td>&gt; 40</td>
</tr>
<tr>
<td>Burn Performance, UL 790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With silicone coating</td>
<td>3”/ 12 “ slope</td>
<td>2” / 12” slope</td>
</tr>
</tbody>
</table>

Data provided by West Development Group

*SPF Formulated With Solstice LBA Has Improved Properties*
WHERE HAS SPRAY FOAM FORMULATED WITH SOLSTICE® LBA BEEN APPLIED?
COMMERCIAL ROOFING APPLICATIONS WITH SOLSTICE® LBA

Growing Pipeline of Commercial Roofing Projects
COMMERCIAL WALL FOAM APPLICATIONS

Growing Pipeline of Commercial Wall Projects
HOW ABOUT EQUIPMENT?

WHAT DO I HAVE TO CHANGE TO PROCESS SPRAY FOAM SYSTEMS FORMULATED WITH SOLSTICE® LBA?
## COMPARISON OF SPF ROOFING PROCESSING PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>245fa</th>
<th>Solstice® LBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportioner</td>
<td>Graco H-40</td>
<td>Graco H-40</td>
</tr>
<tr>
<td>Pressure, psi</td>
<td></td>
<td>psi</td>
</tr>
<tr>
<td>A ( ISO)</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>B ( POLYOL)</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Hydraulic psi</td>
<td></td>
<td>psi</td>
</tr>
<tr>
<td></td>
<td>125-300</td>
<td>125-300</td>
</tr>
<tr>
<td><strong>Processing Temperatures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature, °F</td>
<td></td>
<td>°F</td>
</tr>
<tr>
<td>A ( ISO)</td>
<td>120</td>
<td>130</td>
</tr>
<tr>
<td>B ( POLYOL)</td>
<td>120</td>
<td>130</td>
</tr>
<tr>
<td><strong>Spray Guns</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusion</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Probluer</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Gap</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Gun Clean Out Frequency, # Sets</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Data provided by West Development Group
PROOF IS IN THE FIELD, WHAT ABOUT ROOFING YIELDS AND SURFACE PROFILE WITH SOLSTICE® LBA SYSTEMS?
## YIELD ANALYSIS ON GRAVEL BUR SURFACE

<table>
<thead>
<tr>
<th>Date</th>
<th>5/17/2013</th>
<th>6/20/2013</th>
<th>7/1/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job Details</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed</td>
<td>ft²</td>
<td>m²</td>
<td>ft²</td>
</tr>
<tr>
<td>13000</td>
<td>1208</td>
<td>10300</td>
<td>957</td>
</tr>
<tr>
<td>Amount system applied</td>
<td>lb</td>
<td>kg</td>
<td>lb</td>
</tr>
<tr>
<td>5700</td>
<td>2585</td>
<td>4600</td>
<td>2087</td>
</tr>
<tr>
<td><strong>Foam Application</strong></td>
<td></td>
<td></td>
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<tr>
<td># Passes</td>
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<tr>
<td>Thickness/ pass,</td>
<td>in</td>
<td>cm</td>
<td>in</td>
</tr>
<tr>
<td>0.75</td>
<td>1.9</td>
<td>0.75</td>
<td>1.9</td>
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<tr>
<td><strong>Field Conditions</strong></td>
<td></td>
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<tr>
<td>Temperature</td>
<td>°F</td>
<td>°C</td>
<td>°F</td>
</tr>
<tr>
<td>Max Temp</td>
<td>69</td>
<td>15</td>
<td>73</td>
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<tr>
<td><strong>Yield</strong></td>
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<tr>
<td>% Improvement vs. 245fa</td>
<td>12</td>
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<td>10</td>
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</tbody>
</table>

Data provided by West Development Group

### As High as 12% Yield Improvements
ROOF FOAM SURFACE QUALITY

Smooth Orange Peel Surface

Data provided by West Development Group

Reports of Lower Coating Requirement From Field
IS PERSONNEL EXPOSURE DIFFERENT WITH SPRAY SYSTEMS FORMULATED WITH SOLSTICE® LBA?

DO I HAVE TO CHANGE MY RESPIRATORY PROTECTION?
SOLSTICE® LBA
PERSONAL EXPOSURE DURING SPRAY

Applicator exposure using Assay Technology Dosimeter
Applicators wearing PPE during application

Exposure To Solstice® LBA During Spray Well Below PEL
SUMMARY
SUMMARY
SOLSTICE® LBA IN SPF

- System
  - Lower system vapor pressure
  - Acceptable system shelf life
- Foam
  - Improved R-Value
  - Higher compressive strengths
- Application
  - Applied using existing equipment with minimal processing changes
  - Personal exposure well below PEL
  - Applied in a variety of field conditions in multiple countries

Solstice® LBA Ideal Replacement for 245fa in SPF
SUMMARY
SOLSTICE® LBA

We found:

- Superior Performance to 245fa
- Environmentally sustainable (GWP = 1)
- Non flammable
- Honeywell is increasing Solstice® capacity
  - Honeywell has semi commercial plant operational today
  - Commercial scale Solstice® LBA plant is coming on line in Q2 2014
  - Engineering starting for second Solstice® LBA plant

Solstice® LBA: Low Climate Impact, Energy Efficient
VISIT OUR BOOTH # 206/208 AND LEARN MORE ABOUT SOLSTICE ® LBA SPRAY FOAM

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