Lower Energy Cost with Game-Changing Surfactants!

Dr. Rossella Riccio
July 16, 2020
OVERVIEW

- Background
- Product features & benefits
- VORASURF™ additives performance
- Conclusions
- Questions & Answers
**THIS IS DOW**

- **2019 NET SALES**: $43B
- **EMPLOYEES**: ~36,500
- **MANUFACTURING SITES**: 109 sites
- **GLOBAL REACH**: 31 countries in which Dow manufactures products

**DOW CONSUMER SOLUTIONS**

- **2019 NET SALES**: $5.4B
- **EMPLOYEES**: ~7,000
- **MANUFACTURING SITES**: 21 sites
- **GLOBAL REACH**: 12 countries in which Dow manufactures products

- Innovation & manufacturing footprint across North America, Latin America, Europe and Asia
- Largest global silicones player\(^1\) with 75+ years of industry leadership

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Note: All data as of December 31, 2019

\(^1\)Largest global silicones player, based on annual sales
DOW DESIGNS SERVICES TO ADDRESS THE EVOLVING NEEDS OF CUSTOMERS, so interactions are simple, intuitive and effective.

- Customer-focused Dow.com features an expanded e-commerce platform supporting easy product selection, sampling and purchase of select products
- The annual Customer Experience (CX) survey captures feedback from direct customers and distributors to help identify areas for improvement

DOW SHARES OUR CUSTOMERS’ PASSION FOR INNOVATION with an openness and agility that makes working with our people a pleasure.

- Customers collaboratively innovate with us at our new Inspiration Studio in Seneffe, Belgium, where Dow’s materials science technologies are on display all in one place

DOW EARNs OUR CUSTOMERS’ TRUST with consistent quality and supply while collaborating to improve their business and the planet.

- Regional Customer Care Centers get to the root of customer problems and provide real-time analytics to improve CX
- Partnering with customers on new recycling technologies and resource conservation as part of advancing a circular economy

Delivering a Winning Customer Experience

Easy

Enjoyable

Effective
SUCCESSFUL, RELIABLE, SAFE AND EFFECTIVE SOLUTIONS FOR INDUSTRIAL AND CHEMICAL PROCESSING

- Foam control agents
- Coating resins & binders
- Coating & ink additives
- Surface & material modifiers
- Processing aids
- Mold release agents
- Surfactants
- Formulation intermediates
- Silanes

- Pulp Processing
- PU Additives
- Coatings
- Food & Beverages
- Plastic Additives
- Textile Treatment
- Agrochemicals
- Automotive Care
- Leather Finishing

Optimized manufacturing process
Enhanced product properties
Improved sustainability performance
What are Polyurethane Additives?

Polyurethane Additives (PUA) – Value creating – in PU Foams manufacturing

- Foam’s performance, structure, insulation, flammability, breathability, moisture and more.

PU = Polyol + Isocyanate + Catalyst + Blowing Agent + **Surfactant** + *other additives*

We believe the **Silicone Surfactant** is a highly critical additive, as it is used in almost all PU foam applications.

- **Support of mixing**
- **Stabilization of bubbles**
- Compatibility and dispersion
- Minimalize coalescence and stabilization

Flexible Molded

Flexible Slab

Microcellular

Rigid
FOAM CELL STRUCTURE

- High Resilient/Flexible molded
- Flexible
- Microcellular
- Rigid
Polyol and isocyanate molecules formed with cross-linked urethane groups.

**Cross-linked polyurethane**—hard and rigid.
60 Years of History in Silicone Surfactants for Polyurethanes

Industry standards
- VORASURF™ DC 193 Additive
- VORASURF™ DC 5604 Additive
- VORASURF™ DC 5357 Additive
Committed to reliable, cost-effective solutions and application support

60 years of manufacturing expertise

Over 200 distinct silicone surfactant products
>50 sold into PU segment
~150 sold into other industries

Global PU foam generation and testing capabilities

Leverage Dow’s back integration in silicones and polyethers
**KEY APPLICATIONS & INDUSTRY DRIVERS IN RIGID PU FOAM**

**Applications**

- Domestic appliances
- Commercial appliances
- Construction
- OCF/Spray
- Insulation pipes

**Polyurethane Foam**

**Main drivers**

- Environment preservation (ozone & climate)
- Energy-saving

**Sustainability:**
Cost efficiency, durability, low emissions, voluntary green technology certification
**Transitioning to Low GWP*, Low ODP** BLOWING AGENTS

<table>
<thead>
<tr>
<th>Generation</th>
<th>Blowing agent</th>
<th>ODP, CFC-11=1</th>
<th>GWP, 100 year, CO₂=1</th>
<th>Flash point °C</th>
<th>Thermal conductivity, mW/(m.K) at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gen 1</td>
<td>CFC</td>
<td>1</td>
<td>10,900</td>
<td>N/A</td>
<td>8.4</td>
</tr>
<tr>
<td>Gen 2</td>
<td>HCFC</td>
<td>0.12</td>
<td>725</td>
<td>N/A</td>
<td>9.7 – 13</td>
</tr>
<tr>
<td>Gen 3</td>
<td>HFC</td>
<td>0</td>
<td>1,300</td>
<td>N/A</td>
<td>10.5 – 13.7</td>
</tr>
<tr>
<td>Alternative</td>
<td>Pentane</td>
<td>0</td>
<td>11</td>
<td>-49</td>
<td>13.3 - 15</td>
</tr>
<tr>
<td>Alternative</td>
<td>Methylal</td>
<td>0</td>
<td>&lt;1</td>
<td>-18</td>
<td>14.5</td>
</tr>
<tr>
<td>Alternative</td>
<td>Methyl formate</td>
<td>0</td>
<td>&lt;5</td>
<td>-19</td>
<td>10.7</td>
</tr>
<tr>
<td>Gen 4</td>
<td>HFO</td>
<td>0</td>
<td>7</td>
<td>N/A</td>
<td>10 - 13</td>
</tr>
</tbody>
</table>

Silicone Surfactants for PU foams need to evolve

*GWP: Global Warming Potential --- **ODP: Ozone Depletion Potential

The graphic representations are presented here for illustrative purposes only and should not be construed as product specifications.
YOUR ALLY TO ADDRESS SUSTAINABILITY AND ENERGY EFFICIENCY REQUIREMENTS

Environment, Sustainability & Regulations

- EU- Regulation laying down Eco-design requirements (1 October 2019)
- EU- New energy efficiency labels (March 2021)
- US- Energy Star
- Blowing Agents transition, phase out of ozone-depleting and polluting substitutes
  - EU F- Gas Regulation (17 May 2014)
  - US- Significant New Alternatives Policy (SNAP) Program
- European Green Deal
ENERGY LABELLING: A GLOBAL TREND
Rigid PU Foam: Megatrends & Main Customer Requirements

### Sustainability & Regulation
- Blowing agent transition
- Insulation performances
- New Energy labelling for appliances
- Voluntary label certification
- Cyclic
- Fire performance/additive

### Profitability
- Density - Lower is better
- Demolding - Faster is better
- Scrap rate - Lower is better

### Manufacturing Reliability
- Aesthetics - Nice PU surfaces are better
- Chemical stability - Shelf life of the fully-formulated polyol
- Physical stability - No phase separation of the formulated blends (...and clear blend)
- Storage temperature
**WHY IS RIGID PU USED FOR INSULATION?**

Thicknss (mm) required to achieve EQUIVALENT insulation

- **50 mm** RIGID PU FOAM
- **80 mm** EXPANDED POLYSTYRENE 1.6 X
- **90 mm** MINERAL WOOL 1.8 X
- **100 mm** CORK 2 X
- **130 mm** WOOD COMPOSITE 2.6 X
- **200 mm** SOFTWOOD 4 X
- **760 mm** CONCRETE 15.2 X
- **1720 mm** BRICK 34.2 X

**THERMAL CONDUCTIVITY:**

The capacity of a material to conduct heat

<table>
<thead>
<tr>
<th>System</th>
<th>Units</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial/North America</td>
<td>BTU /in (h · ft · F)</td>
<td>K</td>
</tr>
<tr>
<td>Système International - SI</td>
<td>W / (m · K)</td>
<td>λ</td>
</tr>
</tbody>
</table>

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Newly engineered surfactants with improved compatibility with blowing agents, offering enhanced surface aesthetics for cold chain and water heater applications.
VORASURF™ RF 5382 ADDITIVE

Properties | Test | Unit | W/ Benchmark 1 | W/ Benchmark 2 | VORASURF™ RF 5382 Additive
---|---|---|---|---|---
Formulation | Fully formulated polyol (1) / B-side without silicone | pbw | 97.2 | 97.2 | 97.2
| Silicone surfactant | pbw | 2.8 | 2.8 | 2.8
| Blowing agent: c-P/i-P (70/30 v/v) | pbw | 13.5 | 13.5 | 13.5
| PAPI 27-Polymeric MDI | pbw | 150 | 150 | 150

B-side blend quality
- Appearance without c-P/i-P (70/30 v:v) @ 3 days | Visual observation | Clear | Clear | Clear
- Appearance with c-P/i-P (70/30 v:v) @ 10 days | Visual observation | Clear | Clear | Clear

Properties | Test | Unit | W/ Benchmark 1 | W/ Benchmark 2 | VORASURF™ RF 5382 Additive
---|---|---|---|---|---
Mechanical | Average skin compression strength @ 10% over packing | kPa (psi) | 158.8 (23.0) | 150.5 (21.8) | 153.3 (22.2)
| Average skin compression strength @ 15% over packing | kPa (psi) | 185.8 (27.0) | 181.6 (26.3) | 181.6 (26.3)
Post mold expansion | Post-demold expansion @ 10% over packing @ 5 min | % | 3.1 | 2.8 | 3.0
| Splits | Yes/no | No | No | No
Insulation | Thermal conductivity @ 10°C (50°F), ASTM C518 | mW/m.K (BTU.in/ft².°F.h) | 20.6 (0.143) | 20.2 (0.140) | 20.4 (0.141)

VORASURF™ RF 5382 Additive performances aligned to industry requirements.

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# VORASURF™ RF 5374 ADDITIVE

## Properties

<table>
<thead>
<tr>
<th>Test</th>
<th>Unit</th>
<th>W/ Benchmark 1</th>
<th>W/ Benchmark 2</th>
<th>VORASURF™ RF 5374 Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully formulated polyol (2) / B-side without silicone</td>
<td>pbw</td>
<td>97.5</td>
<td>97.5</td>
<td>97.5</td>
</tr>
<tr>
<td>Silicone surfactant</td>
<td>pbw</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Blowing agent: c-P/i-P (70/30 v/v)</td>
<td>pbw</td>
<td>14.5</td>
<td>14.5</td>
<td>14.5</td>
</tr>
<tr>
<td>PAPI 27-Polymeric MDI</td>
<td>pbw</td>
<td>146</td>
<td>146</td>
<td>146</td>
</tr>
<tr>
<td>Appearance without c-P/i-P (70/30 v:v) @ 3 days</td>
<td>Visual observation</td>
<td>ref</td>
<td>ref</td>
<td>=</td>
</tr>
<tr>
<td>Appearance with c-P/i-P (70/30 v:v) @ 10 days</td>
<td>Visual observation</td>
<td>ref</td>
<td>ref</td>
<td>=</td>
</tr>
</tbody>
</table>

## Formulation

- **Fully formulated polyol (2) / B-side without silicone**
- **Silicone surfactant**
- **Blowing agent: c-P/i-P (70/30 v/v)**
- **PAPI 27-Polymeric MDI**

## B-side blend quality

- **Appearance without c-P/i-P (70/30 v:v) @ 3 days**
- **Appearance with c-P/i-P (70/30 v:v) @ 10 days**

## Mechanical

- **Average skin compression strength @ 10% over packing**
- **Average skin compression strength @ 15% over packing**

## Post mold expansion

- **Post-demold expansion @ 10% over packing @ 6 min**
- **Splits**

## Insulation

- **Thermal conductivity @ 10°C (50°F), ASTM C518**

## Aesthetics

- **Observation of Brett panels with inserts**

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**VORASURF™ RF 5374 Additive performances aligned to future industry availabilities**
## VORASURF™ RF 5388 ADDITIVE

### Formulation

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Unit</th>
<th>W/ Market Benchmark</th>
<th>VORASURF™ RF 5388 Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully formulated polyol(3) / B-side without silicone</td>
<td>pbw</td>
<td>97.4</td>
<td>97.4</td>
<td></td>
</tr>
<tr>
<td>Silicone surfactant</td>
<td>pbw</td>
<td>2.6</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Blowing agent: c-P</td>
<td>pbw</td>
<td>14.5</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td>PAPI 27-VORATEC™ SD100</td>
<td>pbw</td>
<td>152</td>
<td>152</td>
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</table>

### B-side blend quality

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Unit</th>
<th>W/ Market Benchmark</th>
<th>VORASURF™ RF 5388 Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance without c-P @ 3 days</td>
<td>Visual observation</td>
<td>Clear</td>
<td>Clear</td>
<td></td>
</tr>
<tr>
<td>Appearance with c-P @ 10 days</td>
<td>Visual observation</td>
<td>Clear</td>
<td>Clear</td>
<td></td>
</tr>
</tbody>
</table>

### Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Unit</th>
<th>W/ Market Benchmark</th>
<th>VORASURF™ RF 5388 Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>Average skin compression strength @ 10% over packing</td>
<td>kPa (psi)</td>
<td>130 (18.8)</td>
<td>124 (18.0)</td>
</tr>
<tr>
<td></td>
<td>Average skin compression strength @ 15% over packing</td>
<td>kPa (psi)</td>
<td>148 (21.4)</td>
<td>147 (21.3)</td>
</tr>
<tr>
<td>Post mold expansion</td>
<td>Post-demold expansion @ 10% over packing @ 5 min</td>
<td>%</td>
<td>3.9</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Splits</td>
<td>Yes/no</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Insulation</td>
<td>Thermal conductivity @ 10°C (50°F), ASTM C518</td>
<td>mW/m.K (BTU.in/ft² °F.h)</td>
<td>19.5 (0.135)</td>
<td>19.6 (0.135)</td>
</tr>
<tr>
<td></td>
<td>Cell size – Pore! scan</td>
<td>Equivalent diameter</td>
<td>183</td>
<td>187</td>
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</tbody>
</table>

**VORASURF™ RF 5388 Additive performances aligned to industry requirements**
VORASURF™ POLYURETHANE ADDITIVES FOR HFO BLOWN SYSTEMS

HFO- 1336mzz Compatible

Proposed surfactants

VORASURF™ RF 5374 Additive
VORASURF™ RF 5382 Additive
VORASURF™ RF 5388 Additive

HFO- 1233zd(E) Compatible

Proposed surfactants

VORASURF™ RF 5374 Additive
VORASURF™ DC 5357 Additive
## PERFORMANCE, QUALITY, RELIABILITY AND PROFITABILITY

<table>
<thead>
<tr>
<th>Surfactant</th>
<th>Bunstock Spray foam</th>
<th>Lamination board</th>
<th>High density molded</th>
<th>Appliance</th>
<th>Pour-in-place</th>
<th>Salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>VORASURF™ RF 5382</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>General-purpose surfactant for rigid foam applications; with enhanced pentane compatibility.</td>
</tr>
<tr>
<td>VORASURF™ RF 5374</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Surfactant for pentanes and HFOs blown rigid foam systems.</td>
</tr>
<tr>
<td>VORASURF RF 5388</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Surfactant for pentanes blown rigid foam systems with improved system compatibility &amp; aesthetics.</td>
</tr>
<tr>
<td>VORASURF™ DC 193</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>General-propose surfactant for rigid foam applications; surfactant for footwear (shoe sole) and integral skin applications.</td>
</tr>
<tr>
<td>VORASURF™ DC 5604</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>General-purpose rigid foam surfactant for use in polyurethane foams; offers enhanced aesthetics to pentane-blown appliance application.</td>
</tr>
<tr>
<td>VORASURF™ DC 5357</td>
<td>–</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Surfactant for insulation panels, pour-in-place applications.</td>
</tr>
</tbody>
</table>

✓ = Attribute present in product. – = Attribute absent in product. Relative effects of surfactants are based on studies in standard formulations. Formulation to formulation differences may vary.

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Learn more and order samples at

www.dow.com/vorasurf

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