Flexible Aerogel Insulation for Coker- and Sulfur-Unit Applications

John Williams  
Aspen Aerogels, Inc.  
Northborough, MA  
508-691-1137  
jwilliams@aerogel.com

Trevor Seipp  
Becht Engineering  
Calgary, AB  
403-256-3575  
tseipp@becht.com

Presentation Outline

- Product Overview
- Hot Work
- Reference Projects and Designs
- Becht Engineering Designs
- Questions

What Is An Aerogel?

- Aerogels are nanoporous solids invented in the 1930’s
- Aerogels are created when silica is gelled in a solvent
  - When the solvent is removed, what remains is “puffed-up sand”, with up to 99% porosity
- Nanopores cage the air molecules, retarding heat flow
- Long molecular chains increase the solid path-length through the silica, reducing thermal conductivity

The Aerogel Advantage: Superinsulation performance in a flexible blanket form
Aerogel Thermal Performance – With the Flexibility of a Blanket

- Start with a non-woven blanket
  - Typically polyester, glass, carbon, or ceramic fiber
- Fill that blanket with a wet gel
- Remove the solvents via supercritical CO2 extraction
- Roll the blanket onto a spool

---

Aspen’s Aerogel Manufacturing Process

- Step 1: Fill fibrous batting with a liquid-solid solution
- Step 2: Extract solvents with supercritical carbon dioxide
- Step 3: Resulting dry, fiber-reinforced aerogel blanket

---

Health and Safety Aspects of Aerogels

- Aerogels are an amorphous (non-crystalline) silica with 97% of particles larger than 45μm
  - Only the pores are nano-scale (~0.01 μm)
  - Aerogel particles are much larger
- Amorphous silicas have been studied by OSHA, EPA, and the OECD, concluding:
  - “Demonstrated lack of toxicity, mutagenicity.”
  - “Is not expected to pose a carcinogenic risk.”
  - “Silicas are inert when ingested, and unlikely to be absorbed through the skin.”
  - “No concerns for human health.”
- Typical dust loading in fab-shop is <5 mg/m³
  - OSHA limit for amorphous silica is 80 mg/m³

Recommended PPE is paper dust mask, work gloves, and safety glasses
Aspen’s Industrial Products Span the Temperature Range

- Pyrogel XT (5 and 10 mm)
  -4°F to 1200°F (-40°C to 650°C)
  - 3 to 5 times lower k-value than perlite, calcium silicate, cellular glass, or mineral/glass fiber
  - Excellent productivity, especially on towers, vessels, and large pipe
  - Water repellent
  - Resists mechanical abuse and thermal degradation

- Cryogel Z (5 and 10 mm)
  -460°F to 200°F (-273°C to 90°C)
  - 2 to 3 times lower k-value than cellular glass or PUR/PIR foams
  - Fast, simple installation is insensitive to workmanship or site conditions
  - Excellent durability and fire resistance
  - Available with integral vapor barrier:
    - Single-step installation
    - Multiple plies provide system redundancy

Aerogels Have the Lowest k-Value of Any Industrial Insulation

- Aerogels enable thinner designs at the same level of thermal protection

Thickness for Equivalent Thermal Performance
Pyrogeles Resists the Enemies of Insulation: Water, Heat, and Abuse

**Damage Tolerant**
Cryogel and Pyrogeles easily withstand most impact or compressive loading events (e.g., footfalls, tool strike), and will spring back to the original performance even at loads > 100 psi. Further, because there is no brittle failure mechanism (its a flexible blanket), damage remains local and will not propagate.

**Thermally Stable**
Aspen Aerogel’s products do not use organic binders, so will not crumble or sag in hot service.

**Water Repellant**
During Katrina, an aerogel-insulated pipe was flooded with sea water. Afterward, the pipeline was drained, dried, and retested with no degradation. That pipe was then sealed, and is now in service off the coast of Africa.

Aerogels Will Not Promote Corrosion Under Insulation (CUI)

- Pyrogele and Cryogel are durably water repellent, even at high temperatures
- The open-cell nature of Aspen’s Aerogel blankets allows any water that gets around or beneath the insulation to evaporate out
- Aerogel pH is engineered to be > 7

Pyrogeles is super-hydrophobic, yet also...
Hot Applications

Pyrogel XT Has Many Benefits On Hot Process Equipment

- Industry’s best $k$-value saves energy with 2-5X less material
  - Greater space efficiency
- Installation productivity
  - Shop- or field fabrication
  - Very fast in 1 & 2 ply designs
  - Single-man installs
  - Good in difficult-access areas
- Greater in-service durability
  - Durable hydrophobic
  - Will not crack, crumble, or sag
- Reduces jacketing, banding, and vapor barrier costs
- Packed volume reduced 5-10X
  - Less scrap, trucking, storage
- Single part number simplifies logistics, planning
- Excellent fire protection

Installation of Flexible Aerogel Blankets Is Fast and Intuitive

- Pyrogel blanket wraps over the pipe
- Cladding & banding provide mechanical and weather protection
- Butt joints (staggered if using multi-ply construction)
Flat-Pack Elbows Ship Easy and Install fast

Pre-kitted 'lobster tail' elbows ship flat for better packing efficiency

Multi-layer lobster tails are quickly laid up on the elbow and taped in place

Subsequent layers are installed with a staggered joint pattern

The finished elbow is covered with a vapor barrier and jacketed with metal

Pyrogel Enables Increased Pipe Density

<table>
<thead>
<tr>
<th>Insulation Material</th>
<th>Pyrogel</th>
<th>Rigid Pipe Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; Pipe: 56% more on a rack</td>
<td>![Pyrogel 2&quot;&quot;]</td>
<td>![Rigid Pipe Cover 2&quot;]</td>
</tr>
<tr>
<td>6&quot; Pipe: 44% more on a rack</td>
<td>![Pyrogel 6&quot;&quot;]</td>
<td>![Rigid Pipe Cover 6&quot;]</td>
</tr>
<tr>
<td>12&quot; Pipe: 28% more on a rack</td>
<td>![Pyrogel 12&quot;&quot;]</td>
<td>![Rigid Pipe Cover 12&quot;]</td>
</tr>
</tbody>
</table>

* Assumes 2 inch clearance space

Aerogel Offers Simplified Inventory Management and Logistics

- Results of a trade study of a typical new-build plant insulation project...

<table>
<thead>
<tr>
<th>Rigid Pipe Cover</th>
<th>Pyrogel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distinct Part No.'s</td>
<td>28</td>
</tr>
<tr>
<td>Insulation only</td>
<td></td>
</tr>
<tr>
<td>Distinct Parts</td>
<td>36,000 pieces</td>
</tr>
<tr>
<td>4:1 ratio</td>
<td></td>
</tr>
<tr>
<td>Packed Volume</td>
<td>5700 m³</td>
</tr>
<tr>
<td>6:1 ratio</td>
<td></td>
</tr>
<tr>
<td>Packed Footprint</td>
<td>53 m x 53 m</td>
</tr>
<tr>
<td>2 m stack height</td>
<td></td>
</tr>
</tbody>
</table>

Pyrogel can reduce the material handling and inventory management required on big jobs
Cryogel Z and Pyrogel XTF Provide Excellent Fire Protection

UL 1709 test results based on a 10W49 I-beam:
Time-to-failure for different insulation types and thicknesses

Economics On 1000 m of 30” Pipe (North America)

Reference Projects
Aspen Aerogels’ Products Have Been Specified Around the World

Sulfur Tanks at Refinery in Veracruz, Mexico
- **Scope**: Five 24ft x 105ft liquid sulfur tanks (roof and walls)
- **Date**: 4Q09
- **Process Temp**: 275°F (135°C)
- **Design Goal**: Heat conservation, process control
- **Insulation**: 2 layers (20 mm) of Pyrogel XT, hung like curtains
- **Results**:
  - Before jacketing was installed, while the insulation was still bare and held on with only spray adhesive, a storm with heavy rain and 60 mph gusts blew in. Not a single piece of insulation was lost.
  - Performance is in exceeding expectations.

Coker Drums at Refinery in Lake Charles, LA
- **Scope**: Temporary insulation of coker drums after problems arose with the current birdcage system
- **Date**: 1Q09
- **Process Temp**: 950°F (510°C)
- **Design Goal**: Heat conservation, process control
- **Insulation**: 3 layers (30 mm) of Pyrogel XT
- **Results**:
  - Installation labor was reduced by 60-75%
  - Material continues to meet or beat expected thermal performance, despite exposure to the elements (the temporary nature of the install means that the weather barrier is incomplete, with many gaps)
  - These “thermal band-aids” have proven so durable that Pyrogel XT is now the baseline insulation material for the next coker revamp
Coker Feed Line at Refinery in Kuwait

- Scope: 200 ft of 12" pipe
- Date: 2Q10
- Process Temp: 930°F (500°C)
- Design Goal: Heat conservation
- Insulation: 6 layers (60 mm) of Pyrogel XT
- Results:
  - Owner experienced problems with binder burnout in the previously specified mineral wool pipe cover
  - Burnout lead to a loss of concentricity, which led to thermal losses, openings in the jacket, and subsequent water ingress
  - Pyrogel XT uses no organic binders, and so will not sag over time

Sulfur Recovery Unit at Refinery in Torrance, CA

- Scope: 120 x 5 ft carbon bed vessel
- Date: 2Q10
- Process Temp: 60-300°F (15-150°C) cyclic
- Design Goal: Heat conservation
- Insulation: 2 layers (20 mm) of Pyrogel XT
- Results:
  - This vessel was particularly susceptible to corrosion under insulation because of it’s cyclic service within the CUI zone (32-300°F)
  - The previous insulation was water-absorbent and corroded out the bottom head within one year
  - Pyrogel XT installed quickly with a novice insulation contractor

Sulfur Recovery Unit Project / Maintenance in Dartmouth, NS

- Scope: Various piping and equipment
- Date: 2008-present
- Insulation: Pyrogel XT + VentureClad
- Results:
  - Various projects in 2008-09 were used to benchmark aerogel productivity & cost against the baseline MW / SS spec
    - A new sulfur recovery unit
    - A 60' asphalt tank (at right)
    - 1200' of 4" ET brine line
  - Pyrogel XT + VentureClad was found to be cheaper on the basis of total installed cost, and provided energy, logistical, anti-CUI benefits
  - Facility has since converted to 90% Pyrogel XT for maintenance and capital projects
Towers, Vessels and Other Large Format Equipment

- The productivity advantages of blanket material vs. block is generally most pronounced on large-format piping and equipment, with labor savings approaching 80%.
- Equipment and piping can also be pre-insulated, since aerogel can easily handle the rigors of shipping and erection.

SAGD Operation in Ft. McMurray, AB

- **Scope**: 3 km of 24" pipe
- **Date**: Summer 2009
- **Process Temp.**: 300°C (570°F)
- **Design Goal**: Heat conservation
- **Other Factors**: All piping was pre-insulated in Edmonton and trucked 6 hours to remote work site
- **Results**:
  - Eliminated need for an on-site man camp
  - Reduced effective labor rate from $200/hr to $45/hr

Insulation Work Was Carried Out In Controlled Environment
24” x 40ft Sections Fully Jacketed with 0.020” SE Aluminum

Pre-Insulated Pipe Handled with Standard Equipment...

…and Is Stacked, Ready for Shipment
Summary and Conclusions

• Efficiency
  – Most efficient insulation materials in the world
  – Saves energy
  – Reduces touch temperatures

• Productivity
  – Flexible blanket form for increased productivity
  – Streamlined planning, supply chain, and logistics
  – Better space efficiency
  – Enables pre-insulation of piping and equipment

• Durability
  – Resistance to damage by water, heat, and mechanical abuse
  – Will not promote corrosion under insulation
  – Exceptional fire protection

Pyrogel-Enabled Coker Insulation Design from Becht Engineering

Thank You