

A New Way to Think About Industrial Insulation

Cryogel™ and **Pyrogel®** are revolutionary insulation materials made from nanoporous aerogel – the world's best thermal insulator. They are available in an advantageous flexible form for service temperatures from -460°F (-273°C) to 725°F (385°C). This wide range enables the products to perform in low, high, and dual temperature applications.

Aerogels have been in existence for more than 70 years. They consist of lightweight silica solids derived from a gel in which the liquid component has been replaced with gas. The silica solids, which are poor conductors, consist of very small, three-dimensional, intertwined clusters that comprise only 3% of the solids. Volume conduction through the solid is therefore very low. The remaining 97% of the volume is composed of air in extremely small nanopores. The air has little room to move, inhibiting both convection and gas phase conduction.



Aerogel monolith in its natural state.

These characteristics make aerogel the world's lowest density solid and most effective thermal insulator. The outstanding thermal properties of aerogels have been studied for decades, but Aspen Aerogels has developed a technically and economically viable form of aerogel for industrial insulation uses. Our unique process integrates aerogel into a carrier to create flexible, resilient, durable aerogel blankets with superior insulating properties.

Environmentally Friendly, Safe, and Durable Products

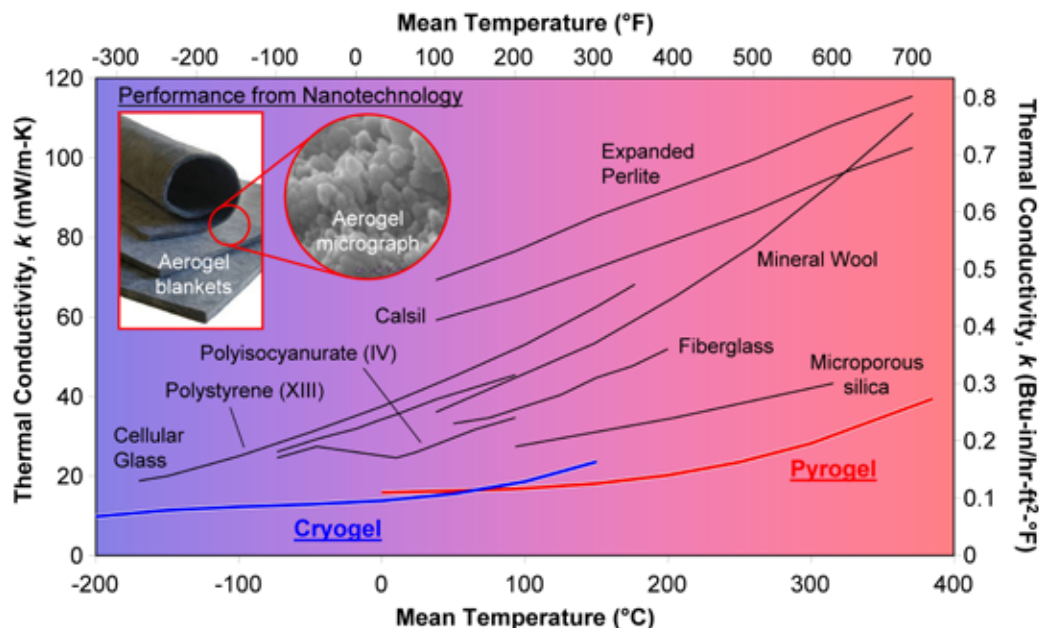
Environmentally friendly: Strict environmental regulations and increased awareness have led to the requirement for environmentally friendly insulation materials for use in industry. Aerogels pose no chemical threat to the environment. They are silica based, which is essentially sand, the principle raw material for glass. Cryogel and Pyrogel contain no respirable fibers and do not require blowing agents, so they are free of CFC and HCFC. These products can be safely disposed and, since the installed volume is considerably less than competing materials, there is less waste going to landfills.

Fire resistant: Cryogel and Pyrogel offer excellent resistance to flame spread and smoke emission. In actual hydrocarbon fires, they protect piping and equipment longer, which is critical to increasing the reaction time needed to respond to a catastrophic event.

Light weight: Cryogel and Pyrogel are lighter than other insulation materials on an installed basis. This enables them to be easily and safely handled on the job site. They can be installed in longer lengths than traditional insulations, which improves installation rates. Their light weight also reduces overall loading of the pipe and equipment support structure.

Durable: Cryogel and Pyrogel are flexible materials that deform under compression. They have excellent bounce-back properties, even when exposed to compression forces up to 1000 psi, and they can resist high impact loads with no damage and no compromise in performance. This is unlike rigid insulation, which handles load with little to no deformation but is friable and susceptible to cracking. This creates thermal short circuits and paths for moisture intrusion. Rigid insulations also are at risk of breakage during shipping and installation, and while in service.

Hydrophobic: Cryogel and Pyrogel are extremely hydrophobic and therefore have outstanding resistance to moisture.



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Cryogel Flexible Insulation



Material:

Cryogel is a low temperature insulation consisting of nanoporous aerogel, which is the world's lowest density solid and best thermal insulator. Cryogel incorporates these properties in a flexible form that can be installed quickly and easily.

Uses:

- Cryogenic processes: gas, petrochemical
- Cryogenic storage: gas, petrochemical
- Below ambient processes: gas, petrochemical, refining
- In-service insulation application
- Dual temperature
- Acoustic
- Chilled water
- Pipe in pipe
- Composite systems

Applications:

Piping, vessels, equipment, tanks

Properties:

Service Temperature Range: -460°F (-273°C) to 392°F (200°C)

Thermal Performance: Cryogel has the lowest thermal conductivity value of any material used for cryogenic service. Therefore, its required thickness is extremely small compared to other cold insulation materials. In most cases, condensation control thickness is sufficient to meet the desired heat gain limitation. Cryogel's minimal thickness results in a smaller surface area and reduced heat gain compared to other insulation materials. This heat gain "safety factor" maximizes system performance by improving process control, which results in optimized production and energy savings. Cryogel also does not age, so its thermal performance remains constant over time.

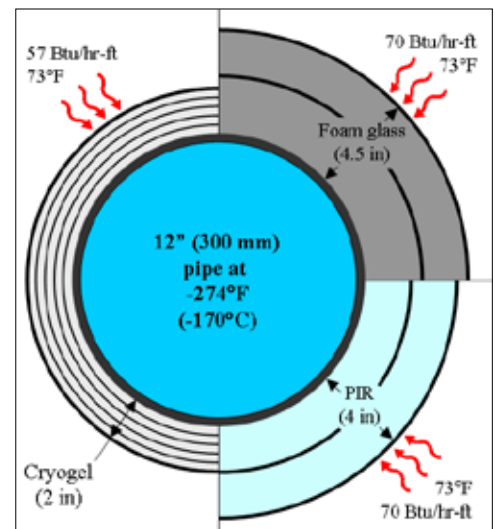
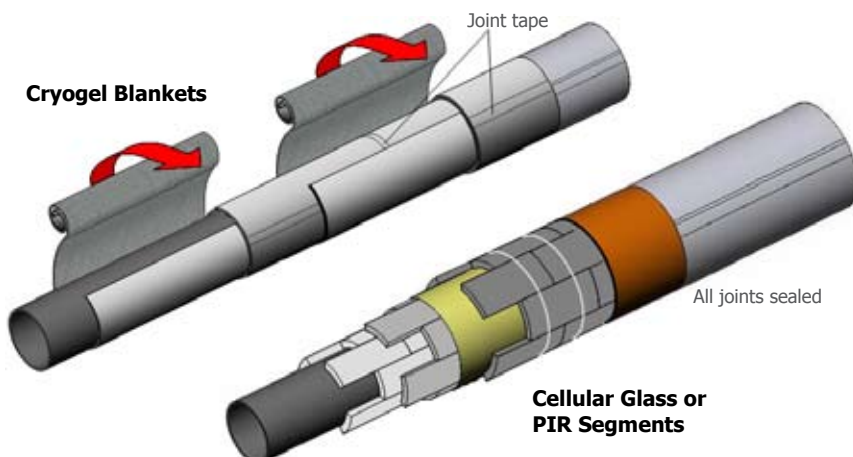
Moisture and Vapor Resistance: Permeability to water and water vapor are critical to any insulation system operating at cryogenic temperatures. Cryogel is hydrophobic with excellent resistance to moisture. Its nanopores form a tortuous network of "dead end" clusters that resist vapor penetration, condensation, and ice.

Structural Integrity: Cryogel is well-suited for below ambient and cryogenic applications. Under these severe conditions, its structure experiences no damage, its performance is unaffected, and it remains totally flexible. This is unlike rigid, cellular insulation materials, which experience contraction, thermal shock, extreme stresses, damaged structure, and degraded insulation performance in the same conditions.

Dimensional Stability: Cryogel insulation has a coefficient of thermal expansion similar to that of steel, so there is minimal movement of the insulation system. Its low contraction rate and flexible wrap application eliminate the need for costly and labor intensive expansion/contraction joints required by traditional rigid insulation systems.

Cryogel Insulation System Advantages:

- Thinness creates more space in and around pipe racks and equipment.
- Thinness can decrease the overall size of a production facility, resulting in major material reductions and cost savings.
- Thinness results in volume and freight savings, decreased accessory requirements, minimal site storage, and simplified logistics.
- Unique flexible form and wrap application makes installation faster, easier, and less costly. Rigid insulation systems require numerous segments that must be effectively sealed.
- Competitive with other insulation systems on an installed basis due to decreased material requirements, logistics improvements, reduced installation time, and shorter construction schedules.



All three designs meet the same condensation control criteria

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Pyrogel Flexible Insulation



Material:

Pyrogel is a high temperature insulation consisting of nanoporous aerogel, which is the world's lowest density solid and best thermal insulator. Pyrogel incorporates these properties in a flexible form that can be installed quickly and easily.

Uses:

- Hot processes: gas, petrochemical, refining
- Steam lines
- Overwrap (maintenance)
- Storage: gas, petrochemical, refining
- Dual temperature
- Refractory
- Acoustic
- Heat tracing
- Pipe in pipe

Applications:

Piping, vessels, equipment, tanks

Properties:

Service Temperature Range: -460°F (-273°C) to 725°F (385°C)

Thermal Performance: Pyrogel has the lowest thermal conductivity value of any material used for hot service. Therefore, its required thickness is 50% - 80% less than other hot insulation materials.

Moisture Resistance: Moisture is a problem in insulation at temperatures up to 200°C. It can form within the insulation and cause corrosion under the insulation (CUI). Pyrogel is hydrophobic (resistant to liquid water) through the entire matrix of the material (not just on the surface) and provides excellent resistance to moisture. Other insulations tend to absorb moisture over time, potentially corroding the substrate. Pyrogel also meets all specifications for stress crack corrosion of stainless steel.



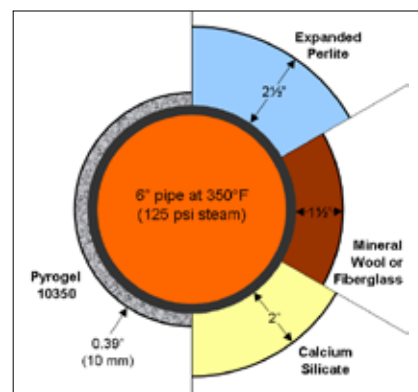
Pyrogel is super-hydrophobic

Logistics: From procurement through installation, Pyrogel simplifies logistics because of its decreased volume requirements. These advantages include freight savings, storage space, and simplified inventory.

Installation: Pyrogel is quickly and easily installed by wrapping it onto piping and equipment. In contrast, rigid insulation materials are installed piece by piece in sections, which is very labor intensive. Pyrogel also is applied in longer lengths and at a faster rate than other insulation materials, which shortens the project schedule.

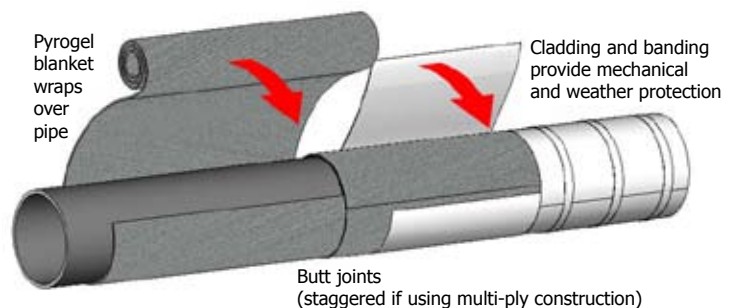
Special Applications:

- **Overwrap System** – Most hot insulation materials used today will eventually become wet, resulting in heat and energy loss, poor process control, and corrosion. This problem can be fixed by wrapping a single layer of 6 mm Pyrogel with metal jacket over the existing insulation and jacketing. The Pyrogel overwrap drives moisture out of the wet inner layers, resulting in improved thermal performance and reduced operating costs. It also decreases the outer surface temperature to correct personnel protection levels.
- **High Temperature Composite System** – High temperature applications require higher insulating values. Most high temperature insulation materials (ceramic fiber, mineral wool, etc.) have to be applied in extremely large thicknesses to achieve such values. But for reasons such as space constraints and economics, thick insulation might not work. In these cases, Pyrogel can be used in combination with the other material to substantially reduce the total thickness.
- **Economical Combination System** – In high temperature applications, rigid insulation materials such as perlite and calcium silicate can crack or break when banded around pipe and over weld seams, or when a pipe expands in service. A single 6 mm layer of Pyrogel can be applied to the inner surface of rigid materials to provide a "cushioning" effect, which reduces damage and waste. Adding Pyrogel also lessens the amount of rigid insulation needed, reducing the overall thickness by 50% - 80%.



All four designs provide the same level of thermal protection (130 Btu/hr-ft)

Pyrogel Blankets



Installation of flexible aerogel blankets is fast and intuitive

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Field-Proven Applications for Cryogel and Pyrogel



16' x 20' Vessel: Aerogel blankets increase labor productivity on tanks, towers, and vessels.



Steam Pipe Retrofits: Simple, fast installation of single-ply aerogel blanket overwrap can drive moisture out of old, wet insulation and recover system performance.



Pre-Insulated Pipe: Pyrogel enables pre-insulation and subsequent transport of pipe.



Removable Covers: Aerogel removable blankets are thinner, lighter, and last longer than conventional materials.



Tank Roofs: Aerogel demonstrates improved productivity on tank roofs.



Tight Access Areas: Flexible aerogel blankets are ideal for tight access areas and can withstand periodic flooding.

Heat Exchange Modules: Aerogel blankets easily survive the rigors of over-the-road travel.



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