

PolarFit™ reaction cooling systems

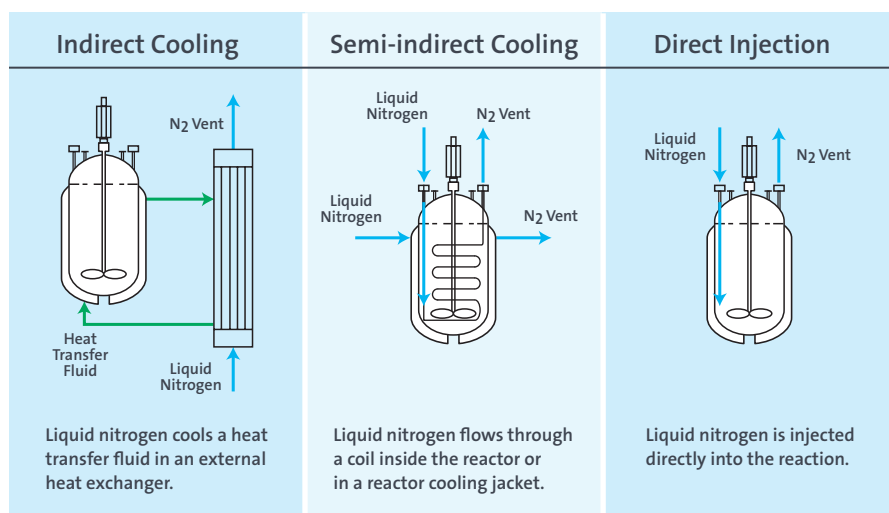


As pharmaceutical, biotech, and specialty chemical companies develop new and increasingly complex molecules with challenging reaction requirements, there is growing interest in low-temperature technologies. Cooling as low as $-100\text{ }^{\circ}\text{C}$ can improve reaction selectivity, enable safe processing of highly reactive compounds such as organolithium reagents, and prevent decomposition of unstable intermediates, thereby increasing yields.

Air Products' PolarFit reaction cooling systems use the cooling power of liquid nitrogen to provide a fast, precise, flexible, and low-cost way to provide the temperatures needed for your advanced synthesis reactions.

System designs to meet your reaction requirements

Air Products offers three different PolarFit reaction cooling systems, depending on your low-temperature requirements: indirect, semi-indirect, and direct. All systems can be supplied in different cooling capacities and can be used for both batch-scale and continuous operations. Control systems for all three types of cooling are designed to prevent freezing or other process disruptions.



Careful selection of the cooling system is critical in establishing a robust and safe manufacturing process:

- **Indirect cooling** provides the most system flexibility and control, as well as the ability to reuse the nitrogen for other applications. Also, this type of system can easily be combined with existing heating and chilling circuits. Initial costs could be higher due to the additional equipment required and the use of heat transfer fluid.
- The **semi-indirect** method provides accurate temperature control, the ability to reuse the nitrogen for other applications, and simplicity of operation. Drawbacks include reduced efficiency, the demand on reactor volume, and the risk of non-homogeneous cooling within the reactor.
- **Direct injection** of liquid nitrogen provides fast, precise cooling down to $-196\text{ }^{\circ}\text{C}$. But solvent entrainment, foaming, and localized freezing can occur. Also, the potential exists for environmental impact due to the atmospheric release of volatile organic compounds.

Our technical specialists can assist in determining the best system to meet your needs.

Multiple benefits compared to mechanical cooling

Because PolarFit systems use liquid nitrogen as a refrigerant, they are extremely efficient at cooling chemical reactions to temperatures below $-60\text{ }^{\circ}\text{C}$. They offer a number of advantages over mechanical refrigeration systems.

Flexible refrigeration capacities

- No matter what chemical reaction you need to cool, the reaction temperature can be precisely controlled by maintaining, increasing, or decreasing the flow of liquid nitrogen.

Reduced costs

- Low operating costs—the liquid nitrogen usage automatically adjusts to meet refrigeration requirements. In many cases, liquid nitrogen can be reused elsewhere in your operation, e.g., for inerting or blanketing.
- Low investment costs—often, capital requirements and installation costs are a fraction of the cost for mechanical systems when temperatures below $-60\text{ }^{\circ}\text{C}$ are needed.

Improved reliability

- With few moving parts and simple temperature controllers, the systems are reliable and easy to maintain, and achieve precise temperature control without the risk of freezing.

Energy efficient

- PolarFit reaction cooling systems are less energy dependent, reducing operating costs and increasing reliability in the event of power outages.

Benefit from our expertise

Air Products has over 40 years' engineering and R&D experience in applying cryogenic solutions to reaction cooling and other applications. Our engineers can assist you in evaluating your process and identifying the most efficient solution to fit your requirements. Whether you need feasibility consulting or a complete liquid nitrogen cooling system, we can provide you solutions that include the following:

- Design, fabrication, and supply of liquid nitrogen reaction cooling equipment.
- Specially developed control system software for precise temperature control.

To speak with a specialist regarding your reaction cooling needs, please contact us at:

Americas, Corporate Headquarters

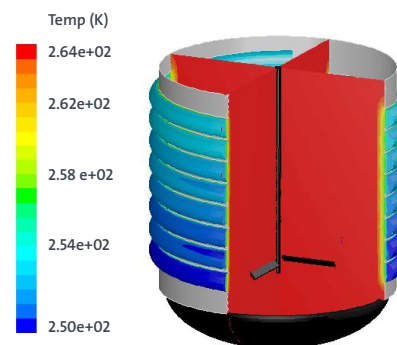
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- Proprietary in-house modeling systems to optimize the cooling process.
- Highly efficient heat exchanger systems.
- Liquid nitrogen supply.
- Evaluation of nitrogen vent reuse.

Air Products' extensive know-how in computer modeling can help predict the cooling profile of your reaction.



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