

INCREASING REACTOR COOLING RELIABILITY AND CONTROL WITH NITROGEN SYSTEMS

With the ability to achieve temperatures as low as -140°C , liquid nitrogen cooling systems offer the most efficient and effective means to cool down chemical reactions to temperatures below -40°C . Praxair's cryogenic nitrogen systems can achieve faster sustained cooling rates and more precise temperature control than mechanical or other cooling media. Here we provide some key features that you should expect from cryogenic cooling systems.

Reach very low temperatures reliably

Cryogenic reactor and fluid cooling helps achieve the stringent operating parameters and increasingly tight process controls demanded for pharmaceutical and biotechnical processes. Praxair's proprietary direct and indirect cooling technologies provide the benefits of liquid nitrogen's refrigeration capabilities without the risk of freezing. The net benefit is improved process reliability and system availability, compared with alternative cooling systems.

- **Lower temperatures** on demand.
- **Increased flexibility:** Praxair's cryogenic cooling systems expand the operating window, handling a broader range of cooling profiles and temperatures. This supports a greater number of challenging chemical synthesis reactions.
- **Reduced cooling batch time.**
- **Improved product selectivity.**

Increase efficiency and reduce operating costs

The Praxair DCOOL™ and NCOOL™ systems feature Praxair's proprietary cryogenic heat exchanger, which extracts the cooling value from both liquid and gaseous nitrogen. This results in up to 98% nitrogen utilization efficiency, which significantly reduces nitrogen consumption (up to 50%) versus other, less sophisticated cryogenic cooling techniques.

- **Reduced energy costs:** Eliminate the high cost of power and electrical infrastructure associated with mechanical systems.
- **More control options:** Gain the ability to enhance yield and improve stereo-selectivity for some organic synthesis processes.
- **More efficient resource use:** In some cases, nitrogen may be reused for other areas of the plant, further minimizing operating costs.

Reduce maintenance and space requirements

Praxair's cryogenic cooling systems have minimal moving parts and eliminate dependence on mechanical blowers or compressors. Nitrogen systems therefore provide greater unit availability, increased reliability and reduced maintenance and operating costs.

- **Less capital cost:** With no downtime for unfreezing or de-icing, eliminate the costs associated with redundant systems.
- **Less space:** Cryogenic systems require less floor space than mechanical units.

Environmentally and energy friendly cooling

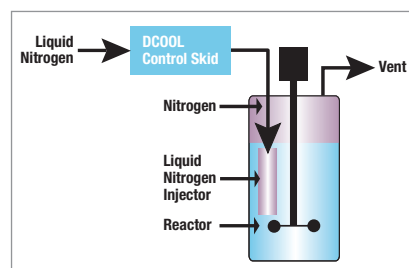
Praxair's cryogenic cooling systems do not require mechanical refrigeration or the use of halogenated coolants (CFCs or other compounds). This reduces release of ozone depleting substances and provides a less energy dependent source of cooling to your operations. The net result is more reliable cooling on demand, less risk of runaway reactions and a cleaner environment.

CONTACT PRAXAIR AT 1-800-PRAXAIR (1-800-772-9247), OR LOG ON TO WWW.PRAXAIR.COM.

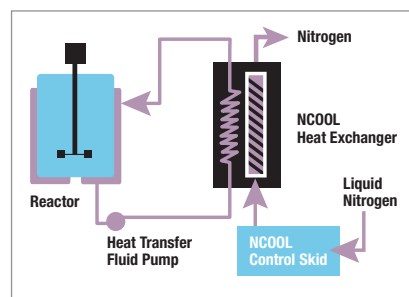
SYSTEM OPTIONS

Praxair systems are available in capacities ranging from approximately 70,000 to 500,000 Btu/hour. They are well suited for both the intermittent batch operations often associated with small scale chemical synthesis or for the continuous operation associated with commercial scale production. Moreover, nitrogen flow automatically adjusts to meet refrigeration demand, maximizing nitrogen utilization efficiency, reducing overall operating costs.

Direct Cooling Praxair's DCOOL System employs a direct injection cooling technique utilizing Praxair's



non-freezing injector to achieve maximum cooling efficiency. Injecting the liquid nitrogen directly into the process fluid or reactants achieves fast response and precise temperature control required for fine chemical applications. The proprietary injector is a critical component as it eliminates the freezing risk associated with other direct injection approaches.



Indirect Cooling Praxair's NCOOL System utilizes the cooling power of nitrogen and the highly efficient NCOOL heat exchanger to tightly control the temperature of the recirculating heat transfer fluid. This provides more rapid response and closer approach temperatures without the risk of freezing associated with other cryogenic systems.