

Guidance for the safe operation of Liquid (CO₂ or N₂) Injection Systems

Liquid nitrogen (LIN) and liquid carbon dioxide (LCO₂) have been widely used to chill products for more than twenty years. Air Products has developed the LIN/LCO₂-IS technology, a unique injection kit to enable food equipment to utilise cryogenic chilling capabilities. Achieving these benefits also means that certain risks must be managed. This Safetygram provides awareness about potential hazards as well as guidelines for the safe operation of chilling equipment (examples: mixers, blenders, cutters) equipped with the LIN/LCO₂ Injection Systems. This document assumes that the chilling system is being supplied by an Air Products tank system.

General precautions

- **Guard against dangerous atmospheres:** Within the industry, there have been incidents where operators have been exposed to potential harm when nitrogen (N₂) or carbon dioxide (CO₂) has escaped from cryogenic application equipment and reduced the surrounding oxygen to an unacceptably low level or increased the carbon dioxide level to an unacceptably high level. Persons operating or maintaining LIN/LCO₂-IS equipment need to be aware of the hazards presented when using either nitrogen or CO₂ injection systems, due to the extremely high flow rates involved.
- **Use of liquid nitrogen and asphyxiation:** Liquid nitrogen is colourless, odourless and non-toxic however in conditions where gas is not diluted effectively or removed to a safe area then this can cause low oxygen concentrations. Air Products' Safetygram 17 gives more details on the specific dangers related to oxygen deficient atmospheres.
- **Use of liquid CO₂ and intoxication:** In addition to the asphyxiation risk, there is a more immediate risk when using CO₂ instead of nitrogen because of CO₂'s health hazards. Air Products' Safetygram 18 gives more details on the specific dangers related to CO₂.
- **Fresh air should be supplied to the production area** to ensure that the extraction fan performance is not affected and that any residual gas is diluted to reduce its concentration ensuring that the atmosphere within the facility is indistinguishable from that of the outside air.
- **Fixed atmosphere monitoring should be installed within the production area** in the vicinity of the LIN/LCO₂-IS chilling equipment. The monitors shall be installed, operated, calibrated, and maintained as prescribed by their manufacturer.
- **The inside of chilling equipment may be full of pure gaseous nitrogen or CO₂ after cooling cycle, with no oxygen.** Therefore, the inside of a food equipment equipped with LIN/LCO₂-IS should be considered as a confined space. Therefore, safeguards and robust procedures must be in place ensuring that operators can't be exposed to dangerous atmospheres (low oxygen levels or high CO₂ levels) whilst operating or maintaining equipment.

Specific operational advice

- A documented operational readiness inspection should be carried out on all equipment/installation whether new or modified before any system is commissioned, and gas introduced into the system for the first time.
 - Since people cannot detect the presence of nitrogen or CO₂, it is highly recommended by Air Products that atmosphere Monitoring is installed in the production room. Monitors should be equipped with a visual and audible alarm to alert workers if oxygen levels fall below 19.5% oxygen or CO₂ levels rise above 0.5%, allowing prompt evacuation to a safe area if the level continues to drop. The number and location of monitors is critical to ensuring safe operations. Monitors shall be installed to manufactures instructions. If supplementary splashproof protection is used during clean-down it must be removed when the machine is in service, and if permanent splashproof protection is used this must not affect the performance or response time of the monitor.
 - Operation and maintenance of Atmosphere monitors is a user responsibility and is critical that they are calibrated/maintained in good working order as per manufacturer's instructions. Air Products can assist with site-specific recommendations on monitoring systems. Personal monitors should be used to provide additional protection by monitoring in the vicinity of the worker's breathing zone.
- Air Products mandates the liquid flow control system be equipped with at least a manual valve and an automatic safety isolation valve. It is highly recommended that the automatic shutoff valve shuts off the supply at minimum of 18% oxygen or a maximum of 1.5% CO₂ however these levels could be more stringent depending on local specifications. Manual valves allow operators to shut off the liquid supply when necessary. These valves must be easily accessible in safe areas to facilitate emergency response to alarm levels. In addition to local manual isolation valves a manual valve should be located outside the building, typically at the liquid supply tank. Thermal relief valves must be installed between valves to prevent trapped liquid from over-pressurizing piping. These relief valves must be set higher than that of the pressure relief system at the supply tank.



Unlike general freezing equipment due to the extremely high instantaneous flow rate that are common in chilling injection equipment there is a risk that the atmosphere surrounding the equipment could reach dangerous levels very quickly in the event of equipment failure.

In addition to this a vapour cloud could be present which would restrict visibility causing another major hazard and restrict any evacuation procedure.

Therefore:

- Lids, doors, covers, inspection ports where someone could break the plane with their head if open must be installed with a safety switch which automatically isolates the LIN or LCO₂ supply if not sealed. The safety switch must comply with ISO13849 or equivalent and be appropriately rated for the high level of safety integrity that is required.
- The maximum achievable flow rate should be matched to an appropriate exhaust such that in the event of uncontrolled flow all the gas can be removed by the extraction system.

- The exhaust system design should vent any gas to a safe location taking into account the high instantaneous flow rates. The exhaust duct should rise vertically from the blender and be straight, except for the essential 90° bend at a radial fan. The discharge of the exhaust fan should be pointing away from air intakes and directed such that nitrogen or CO₂ does not accumulate on the roof. It is recommended that the discharge is angled upward at 45 degrees to assist with dispersion. It is recommended that appropriate exclusion zones are placed around any exhaust outlet however a site-specific analysis may be required. (Any change to the exhaust system / location should be subject to a management of change procedure carried out in conjunction with the gas supplier).
 - To help prevent insect or bird ingress in the factory via the exhausting system, the LIN-IS and CO₂ system can keep the exhaust fan running at minimum speed all the time.
 - Any “Cleaning in Place” system must have an isolation valve which is closed in normal operation. Quick release hose connections are recommended.
 - Equipment with a vacuum cycle is not suitable to be used in conjunction with LIN-IS unless it has been fully risk assessed and confirms to local standards.
 - Any changes to the system including the room dynamics, exhaust system, injection system, ventilation, equipment safety systems should be subject to a formal management of change review.
 - Personnel should be trained on the symptoms and hazards of oxygen-deficient atmospheres and the hazards of nitrogen and CO₂.
 - For these related safetygrams, visit airproducts.com/safetygrams: Safetygram 2, “Gaseous Nitrogen;” Safetygram 7, “Liquid Nitrogen;” Safetygram 16, “Safe Handling of Cryogenic Liquids;” Safetygram 17, “Dangers of Oxygen-Deficient Atmospheres.” Safetygram 18, “Carbon Dioxide”.
- For Safety Data Sheets for nitrogen and CO₂, visit airproducts.com/msds
- Ventilate the production room with adequate supplies of fresh air. The required fresh air needed depends on the room size and the number, size, and type of liquid nitrogen or carbon dioxide equipment in the room. With the increasing need for hygienically designed food factories, also be aware that reducing airborne contamination by reducing fresh air intake can increase the chance a hazardous atmosphere.
 - Do not change nitrogen/carbon dioxide valves or add nozzles without consulting Air Products, as this may permit a higher cryogen flow than can be safely removed. For the same reason, do not increase storage tank pressure.
- It is recommended to close the manual nitrogen supply valves on the LIN or CO₂ Injection System at the end of the production day.
 - Follow all safety recommendations and procedures described in the equipment Operating Manual. Only approved, trained personnel should operate and clean the equipment.

Air Products has food freezing specialists around the globe to answer questions about the safe operation of cryogenic chilling/freezing equipment.

Visit our Food site at airproducts.com/food to find the contact for your region.

Emergency Response System

For 24-hour assistance involving products from Air Products, please refer to the contact details listed on your MSDS. Up to date MSDS documents can be downloaded at: airproducts.com/msds

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Product Safety Information

For MSDS, Safetygrams and products safety information: airproducts.com/msds
For other products safety information: airproducts.com/productsafety

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Technical Information Center

European Industrial Gases Association (EIGA) eiga.eu
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