Issue 109
Feb. 2021
Division of Technical Resources
Office of Research Facilities
National Institutes of Health
Technical News BULLETIN

Engineering Requirements for N_2 and LN_2 Use and Storage

Introduction

Nitrogen (N_2) has many uses in laboratory operations. As an inert gas, N_2 is primarily used to control the atmosphere for sensitive equipment and experiments. At a temperature of -196° C (-320° F), nitrogen in its liquid form (LN_2) can be used in tanks or freezers for maintaining samples in a cryogenic condition. However, if not properly stored and handled, nitrogen can pose a health risk to workers; as a result, spaces where N_2 and LN_2 are present must be conscientiously designed and constructed to mitigate such risks.

Nitrogen Risks

N_2 comprises approximately 78% of standard breathing air, while oxygen (O_2) comprises only about 21%. Because of its large concentration in breathing air, most people consider N_2 to be a harmless gas. When released in a confined space such as a closed room, however, the percentage of N_2 can quickly increase to over 80%, thus reducing the percentage of O_2 to less than 19%; this is known as oxygen displacement. At O_2 levels below 19%, humans can start to experience adverse effects. At 16% O_2 levels, breathing and pulse rates can be affected, which can impact cognitive functions. As O_2 percentage levels continue to decrease, people will fall into unconsciousness, and eventually the conditions could become fatal. Because of these potentially serious risks associated with the use, storage, and generation of nitrogen, whether in a gaseous or liquid state, spaces where N_2 or LN_2 are present must be carefully evaluated during the design and construction phases of a project to ensure the appropriate safety measures are in place.

Design Guidelines and Considerations

Gaseous N_2 is usually stored in cylinders and piped to various points of use, so the storage area may be within the lab itself or a local storage room. LN_2 is usually stored in bulk containers outside the facility and piped into the lab for use in tank freezers or low temperature freezers; however, it can also be stored locally in cryogenic storage dewars within the lab or an associated storage room.

N_2 has a specific gravity just less than breathing air (0.97 compared to 1.0) so its natural tendency at standard temperature and pressure is to rise to the top of the room or space. For this reason, NFPA 55-6.17.4.3 calls for exhaust ventilation grilles no more than 12” from the ceiling in a space where N_2 or LN_2 is located. It is critical to note, though, that when N_2 is released from a high pressure cylinder through a small orifice, such as a shut off or regulator valve, the temperature of the gas will drop from expansion; similarly, when LN_2 tanks are vented to remove the fog in the tank for access to samples, the temperature of the released N_2 gas will be extremely cold. Both these scenarios cause the N_2 to fall to the lower levels of the room. As the N_2 gas quickly warms, it will rise due to its lower specific gravity, and as it rises through the breathing zone of the users, the percentage of O_2 can be reduced to an impactful level for the occupants in the space. For this reason, N_2 should also be treated as a gas that is heavier than air and should therefore also be exhausted at a point no more than 12” above the floor of the space, per NFPA 55-6.17.4.2. Simultaneously treating N_2 gas as both heavier than air and lighter than air to fully address health risks means that exhaust ventilation points should be located at both high and low levels in the space. These exhaust ventilation points should be located behind the points of potential release to draw the gas away from the breathing zone of users within the space.

Oxygen monitoring is required to protect personnel in the event of a situation where oxygen displacement reaches hazardous levels. The intent of the monitor is to warn occupants of low oxygen levels so they can immediately vacate the area and contact authorities to address the emergency condition. NFPA 55-6.9 requires an Employee Alarm System is required to warn users and occupants in the event of an emergency, and DRM Chapter 12.3: Compressed Gas and Cryogenic Systems provides control and alarm requirements specific to NIH facilities in concert with NFPA 55. In particular, DRM Section 12.3.1.J calls for the use of oxygen monitoring specific to the gas to be detected. The OSHA Respiratory Protection Standard (29 CFR 1910.134) also requires oxygen monitoring for any place oxygen percentages could potentially fall to less than 19.5%. As noted above, the use or storage of N_2 and LN_2 can reduce oxygen percentages below the OSHA threshold, so oxygen monitors should be included in the design and construction of spaces containing N_2 or LN_2.

Monitors should be equipped with at least two sensors located in the breathing zone, approximately 4’ above the floor, and should also provide both audible and visual notification of an alarm. A remote audible and visual alarm should be provided directly outside the space to provide notification to anyone outside the space to not enter the area. Additional guidance and requirements for the use of oxygen monitoring in NIH aseptic production facilities can be found in DRM Section 13.10.7. Information on oxygen monitoring for the use of LN_2 in BSL-3 laboratories can be found in DRM Section 8.6.10.B.

Additional Information

1. NFPA 55, Compressed Gases and Cryogenic Fluids Code, 2020
2. The OSHA Respiratory Protection Standard (29 CFR 1910.134)
3. NIH Design Requirements Manual Sections: 6.17.4, 8.6.10, 12.3, 13.10.7