Safe Method of Use 21 – Safe Storage of Liquid Nitrogen

A. Background

When Liquid Nitrogen vapourises to the gaseous form (e.g. when it is spilled) it undergoes a large volume expansion. One litre of liquid nitrogen produces approximately 680 litres of nitrogen gas.

This rapid expansion of nitrogen will quickly displace the existing atmosphere within a confined space and can cause oxygen depletion if control measures are not in place.

The extent of oxygen depletion will depend on the volumes of liquid nitrogen vapourising and the volume of the room. It is important to note that asphyxia will occur without any warning as the human body will react to increased blood carbon dioxide and not lack of oxygen

Asphyxia – Effect of O2 Concentration

O2 (Vol %)	Effects and Symptoms
18-21	**No discernible symptoms** can be detected by the individual. A risk assessment must be undertaken to understand the causes and determine whether it is safe to continue working.
11-18	Reduction of physical and intellectual performance **without the sufferer being aware**.
8-11	Possibility of fainting within a few minutes without prior warning. **Risk of death below 11%.**
6-8	Fainting occurs after a short time. **Resuscitation possible** if carried out immediately
0-6	Fainting almost immediate. **Brain damage**, even if rescued.

***WARNING**: The situation is hazardous as soon as the oxygen concentration inhaled is less than 18 %.*

B. Minimum Room Volumes for Storage of Containers of Liquid Nitrogen

The following minimum room sizes have been calculated to assist you select the correct location in which to place liquid nitrogen containers. Note that the room volume calculations are based on oxygen concentration not falling below 18% in the vent of a ‘worst case scenario’ involving loss of all the liquid nitrogen in the container. If it is impracticable to move the liquid nitrogen container (i.e. the container is attached or is an integral part of an item of equipment) the room must have an oxygen alarm.

a. 10 Litre Liquid Nitrogen Container

Volume of the Room must be not less than 53m^3. Assuming a 3 meter room height this minimum room volume is approximated by a floor area of 18m^2.

b. 25 Litre Liquid Nitrogen Container

Volume of the Room must be not less than 133m^3. Assuming a 3 meter room height this minimum room volume is approximated by a floor area of 45m^2.

c. 30 Litre Liquid Nitrogen Container

Volume of the Room must be not less than 159m^3. Assuming a 3 meter room height this minimum room volume is approximated by a floor area of 54m^2.

d. 40 Litre Liquid Nitrogen Container

Volume of the Room must be not less than 212m^3. Assuming a 3 meter room height this minimum room volume is approximated by a floor area of 72m^2.

e. 50 Litre Liquid Nitrogen Container

Volume of the Room must be not less than 265m^3. Assuming a 3 meter room height this minimum room volume is approximated by a floor area of 90m^2.

Most laboratories are approximately 5 meters deep so the minimum size of a room in which a 25 litre dewar is stored must be 15 meters long (a large laboratory)
In a corridor 2.5 meters wide the corridor must be at least 18 meters long. Corridors are often continuous around the building so, all other considerations aside, they are the most likely places to have the required volumes in which to store larger volumes of liquid nitrogen.

C. Procedure for Replenishing Liquid Nitrogen Storage Dewar in an Alarmed Room:

Ensure the main door is open when filling a liquid nitrogen storage dewar. In the event of a spill, the nitrogen generated will equilibrate with larger volumes in corridors and is less likely to displace oxygen to dangerously low levels.

Never fill a cylinder behind closed door.

D. Oxygen Alarms

Note that oxygen alarms have a cartridge sensor which needs to be replaced every 24 months. The sensor should be calibrated every 12 months to compensate for measurement drift. In the event of cartridge failure the unit will alarm (i.e. the instrument will ‘fail safe’).

Annex 1. Basis of Calculations

Basis of Calculations is taken from formula derived from British Compressed Gas Association Code of Practice 30 and working on the basis that oxygen concentration must not fall below 18% in a 'worst case scenario'.

Filling and spillage together

The 'worst case' scenario, where the entire contents of a dewar are lost to the room immediately after filling, equivalent to 110% of vessel contents to allow for the 10% filling losses prior to spillage:

$$V_o = 0.21 \left[V_R - \left[\frac{1.1 * V_D * f_g}{1000} \right] \right]$$

where:

1.1	=	110% volume loss during filling and spillage
V_R	=	room volume, m^3
V_D	=	dewar capacity, litres
f_g	=	gas factor. This is 683 for nitrogen. (Nitrogen gas takes up 683 times the volume of nitrogen liquid, ie one litre of liquid nitrogen creates 683 litres of gaseous nitrogen.)
0.21	=	The normal concentration of oxygen in air, 21%
*	=	multiply

Note Risk assessment must assume the worst case scenario of spillage after filling.

Vo derived from this equation is then used to calculate the percentage of oxygen after the event.

$$Cox = \frac{100 * V_O}{V_R} = \text{resulting oxygen concentration \%}$$

where:

V_O	=	the volume of oxygen, m^3
V_R	=	the room volume, m^3
*	=	multiply