GAS SAFETY UK
CLIENT UPDATE FOR FEBRUARY 2002

Estimating the effects of liquid nitrogen leakage, spillage and evaporation - towards the Risk Assessment

For those of us who have met in a training context, it is possible to recall that 'worst scenario' calculations are recommended as a part of the [liquid nitrogen storage area] assessment process. [All] this calculation attempts to achieve is an estimate of oxygen depletion by liquid: gas evaporation and subsequent oxygen displacement. If the calculated oxygen concentration turns out to be < or = to 19% by volume then control measures are required: this is a very useful first-order assessment technique and a driver for action to be taken.

However, in more life-like scenarios, liquid evaporates from dewars at 'known' rates, air changes occur and dewars have to be topped-up. In such cases, estimating the rate of release may be more meaningful - this may impact as a change in oxygen concentration that is significant but doesn't need to invoke the idea of total loss or spillage of the vessel contents; catastrophe is a possibility although Risk Assessment requires that we take likelihood into account.

For example, let's assume that we have 'n' dewars of 'w' litres capacity. Static losses can be taken as 'x' litres of liquid/hr and this factor, due to the deterioration of insulation quality over time, may be doubled (i.e. 2 'x'). The expansion ratio of liquid nitrogen into nitrogen gas is ~683. Hence:

('n' times 2 'x') times 683 = litres of gas loss/hr

Convert to m_ (i.e. litres x 10_), to give m_/hr

Estimate the room size (m_) and then, 'guesstimate' the number of air changes/hr.
(use 0.3 - 0.5 if there's no forced ventilation):

(Rate of Release) / (0.3 to 0.5 of Room Volume) = %age rate of change.

In the case of 'topping-up', we can safely assume ~10% additional losses for each volume of liquid that's decanted. The amount required to top-up = 'y', so

(y litres times 0.1) times 683, and then convert to m_

We may then add this value to the background rate of release. If this total rate of change is ~5% or more, then forced-ventilation, fixed-point oxygen depletion monitoring, etc. may be required. N.B. A 5% change in the 20.9% of the air that is oxygen, equates to a drop of around 1% oxygen by volume.

This estimation process is eased by assuming that time tends toward infinity ('equilibrium') and, as we can then dispense with the clutter of the inverse natural logarithm progressions per unit time, it all gets a lot more 'user friendly'.

Lets have a bash at an example:

_% = depletion of oxygen

(Remember that ~21% of air is oxygen (or 0.21) times _ as a decrease, is the same as increasing the 'inert' fraction ~79% of the air by delta).

If we had 2 x 200 litre capacity non-pressurised tanks (400 litres) in a storeroom (4m x 5m x 3m = 60m_). And, if mean static losses of 0.25 litres of liquid/hr, have quoted by the vessel manufacturer (this rate is a valid mean value for two manufacturer's and 7 different vessel capacities). These two vessels will lose 0.5 litres of liquid/hr, and then we'll double this, to allow for less than brand-new insulation = ~1.0 litre/hr, as an estimated liquid loss rate.

This is equivalent to ~683 litres of gas/hr when it's expanded or 0.683 m_ of nitrogen gas/hr. So:

0.683 / (60 x 0.4) = 0.028

_ = ~3%

But! If both dewars are topped-up every day, in order to make these static losses good, then:

24 litres must be decanted and ~10% of this will go into the atmosphere. Assuming all decanting is done within the same 1 hour period:

2.4 litres x 683 = 1,639.2 litres of nitrogen gas = 1.639 m_ of gas

(1.639 + 0.683) / (60 x 0.4) = 2.322 / 24 = 0.968

_ = ~10%!!

Hence, during the topping-up exercise the rate of air change becomes wholly inadequate and we would recommend:

1. Forced ventilation &

2. Fixed point oxygen monitoring in order to: (a) prove that the engineered control is effective/operational and (b) to re-assure the employee that this job is safe.

So, in case you missed it...

At background rates of evaporation in our examples above, the equilibrium oxygen concentration works out at around 20.4% and we need to think about controls, in relation to catastrophe, quite seriously. During top-up, however, we can predict an oxygen concentration of

N.B.
Please see our product information leaflets on our '3 Series' fixed-point gas detection (oxygen, flammable gases and toxic gases), for additional information.

Good luck!

David Bayliss

BJ Industries Ltd (Gas Safety UK Division),
Claylands Avenue, Dukeries Industrial Estate, Worksop,
Nottinghamshire S81 7DJ U.K.
Tel: 01909 501771. Fax: 01909 501022.
E-mail: sales@bj-industries.co.uk
Web site: www.gas-safety.uk.com