

Independent & Cost-Effective Gas Safety Solutions

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DATE: 05.05.07.

Rev No: 03

Dear All,

Welcome to the Spring 2007 edition of our Client Update.

Firstly, I should apologise for the 'gap' between the previous Update & this one; this hasn't arisen through a lack of worthwhile information, rather than a lack of time...

So, now we have a few minutes to spare, let's get cracking.

1. AREA GAS SAFETY ASSESSMENTS

We were commissioned to undertake a training/consultancy exercise for Cardiff University in order to assist staff in the undertaking of area gas safety assessments. This involved establishing the risk assessment procedure (for review or new-build) of compressed and/or cryogenic gas containers located in and around the site(s) and then, in accordance with the relevant legal drivers (e.g. DSEAR, PSSR, etc.) & the Guidance (CoP's, etc.), to establish a common sense approach for the recording of the assessment, the assessment of leakage, spillage, failure modes, the calculation(s) of impact through to the possible control measures that may be required including fixed-point gas detection, shut-off systems, etc.

This was presented to the University Estates, OSHA, School Safety Advisors and other concerned/interested parties.

In order to record the assessment, we designed a 3 page pro-forma for recording the assessment and copies of this are available to our clients on request.

Whilst the calculations that are associated with oxygen depletion (or enrichment) are fairly well established, especially in relation to cryogenic gas safety, we also ran through some example scenarios involving cylinder gas discharge/losses and the associated calculations and, given some recent enquiries from various clients on this subject, the following may be of interest:

EXAMPLE: A laboratory with an approximate volume of 150 m³ contains a single cylinder of hydrogen gas. The cylinder has a capacity of 50 litres and cylinder filling pressure is 175 barg.

Using the established notation then: $V_r = 150 \text{ m}^3$ and $V_g = (50 \times 175)/1000 = 8.75 \text{ m}^3$

If the cylinder were to discharge completely and suddenly to equilibrium (i.e. 1 atm) then $V_g = 8.7 \text{ m}^3$

Hydrogen has a density of 0.09 kg/m³ so a total of 0.783 kg of hydrogen or 783,000 mg of gas would be discharged into a volume of 150 m³ giving a concentration of 5220 mg/m³ and this may be converted to a concentration in vpm by multiplying 5220 by (23.644/MWt of hydrogen)

This results in a conc'n of: 61,710.9 vpm or 6.17% H₂ v/v i.e. above the l.e.l. and, given a suitable source of heat (> or = the AIT) or ignition (> or = to the minimum ignition energy), then detonation could ensue.

This example is a starting point and, not surprisingly, begs a number of questions:

Q. Is this figure for the concentration of gas a sensible estimate?

A. The model is crude. Given the relative density of hydrogen (0.07 cf. air = 1) then gas would accumulate at ceiling level and rapidly reach concentrations within the explosive range before the cylinder was fully discharged.

Q. Is this a likely scenario?

A. Whilst this has happened in the past [with devastating consequences] we could suggest that actual likelihood is very low. Our risk rating might then be: 5 if

Likelihood = 1 x Impact/Severity = 5 **ADDITIONAL CONTROL MEASURES REQUIRED**

And, consequently, fixed point gas detection would be considered to be both reasonable and practicable.

Leakage of this gas through badly made tubing connections or porous hoses is a more likely scenario. If this were the case, what would be the impact?

Let's assume that the gas is regulated to 4 barg for the process and is supplied to process via 1/4" o.d. plastic tubing. By timed pressure drop testing in relation to system size, we have estimated that the gradual loss of gas from the system = ~1 litre/min.

As a flow-rate this = ~60 litres/hr or 0.06 m³/hr

In the same laboratory (150 m³) which has 2 air changes/hr, Vr = 300 m³

hence, 0.06 x DENSITY = 5,400 mg H₂/hr into 300 m³ = a concentration of 18 mg/m³ or 213 ppm or ~0.02% hydrogen gas v/v at equilibrium.

On this basis, we have become reliant upon the ventilation as a control measure - if the ventilation system was to fail the gas concentration [at high level] would gradually rise and, eventually, we could enter the explosive range (at ~4% hydrogen v/v).

Logically, we should, of course, control the danger at source. In this example, it would be sensible to replace the tubing with a better material that was made with better/fewer joints. But the residual concerns that would surround this installation include the fact that the gas has no warning smell (& a fault could occur when the room was unoccupied), the leak wouldn't necessarily be audible, the operator may make or break joints, modify the system and, in turn, give rise to a loss of integrity, etc., etc.

These concerns, the [remote] possibility of regulator failure and ultimately the potential impact may lead us to the conclusion that:

- (i) Fixed point hydrogen detection is required
- (ii) A warning or indication of ventilation loss is required
- (iii) Automatic shut-off of the hydrogen supply (up-stream) of the regulator that is actuated at 20% of the l.e.l. is required.

By the same route, given the nature of risk assessment, a different assessor could conclude that on the basis of likelihood, the possibility is so remote that an explosion probably won't occur and we can carry on as before. I suppose that's the joy of risk assessment at the qualitative rather than the quantitative level.

As always, if you have any questions on this topic or if you need additional advice then please feel free to get in touch.

With regard to DSEAR (the Dangerous Substances & Explosive Atmospheres Regulations), mentioned above, it's worth bearing in mind that these Reg's require that:

- (a) Work involving the use or handling of dangerous substances is risk assessed.
- (b) Control measures that reduce (as far as reasonably practicable) or eliminate risks must be provided.
- (c) Any equipment required for accidents or emergencies must be provided.
- (d) Workers must be provided with information and training.
- (e) Where/If necessary, areas where explosive atmospheres could/will occur should be zoned*

(The zoning exercise will, in turn, drive the implementation of those control measures associated with ignition sources especially electrical apparatus that is of a suitably protected type [ATEX approved]).

*Zones are assigned in the following way:

ZONE 0 = an area or place in which an explosive [vapour:air] mixture is continuously present or present for long periods (traditionally this was >1,000 hours/yr.).

ZONE 1 = an area or place in which an explosive mixture is likely in normal operation (say, 10 - 1,000 hours/yr.).

ZONE 2 = an area or place in which an explosive mixture is unlikely in normal operation and if it does occur then it will only be for short periods of time (say, <10 hours/yr.).

This approach has been pretty standard for many years in industrial situations (oil, gas, chemicals, etc.) but this rigour has now to be applied to smaller scale work in research, manufacturing, etc. Whilst it may seem 'over the top' to some, there's no logical argument to say that we shouldn't assess similar risks just because we aren't working in a place like Flixborough.

On lighter (pardon the pun) note please bear in mind that we continue to offer the following range of services:

1. Gas cylinder and cryogenic liquid safety training. We have recently introduced a train-the-trainer course for those who are required to supervise others in the selection and fitting of gas regulators (e.g. technical staff who assist research students).

2. A comprehensive range of gas control and handling equipment (cylinder pressure regulators, hoses, tubing, connectors, cylinder trolleys, etc.) - you can download the short-form [.pdf] catalogue from our website: www.gas-safety.uk.com.

In this area of our work we remain committed to quality with economy and a safe solutions approach to the setting up of such equipment.

3. The installation & testing of gas cylinders manifolds and pipelines. With our colleagues in Gas Technical, this aspect of what we offer continues to go from strength to strength.

END NOTE

When we handle, store or use toxic gases, it has (for pretty obvious reasons) become commonplace to store these gases under forced ventilation (in fume cupboards or gas cabinets).

Occasionally, we do encounter examples of users who seem to think that it is safe to locate such gases in the open laboratory or work area.

Let's have a look at an assessment for such a scenario:

We have located a single, 10 litre capacity, cylinder of nitric oxide in the laboratory mentioned above ($V_r = 150 \text{ m}^3$).

The gas is stored at 34 barg and if we had a total loss of product (via the regulator bonnet vent e.g. in the event of diaphragm failure) then we could anticipate a discharge of 0.34 m^3 of nitric oxide. With a density of 1.27 kg/m^3 , this amounts to $\sim 0.43 \text{ kg}$ of gas being diluted to an air concentration of 5733 mg/m^3 . If, as above, we convert this to a vpm concentration then a resulting concentration of 4,518 vpm could be anticipated.

The lethal concentration for 50% of a population over 1 hour for nitric oxide = 115 ppm.

Suffice to say, if it did happen it wouldn't be a good place to be!

If you have any questions about the issues covered in this Update then please feel to get in touch with us at the address below.



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