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11 Vincent Avenue, Llandudno, Conwy LL30 1NZ • Tel: 01492 876261 • Fax: 0870 1310013

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STFC Rutherford Appleton Laboratory
Harwell Oxford
Didcot
OX11 0QX

For the attention of Mr Stephen Watson R66 1.15

12th May 2012

Our ref: STF1201LTR01

Dear Stephen,

Re: Risk Assessment of MICE H_2 Delivery System

Further to our meeting of 10th May 2012 and previous email correspondence, I identify below a number of considerations relating to the risk assessment for the hydrogen delivery system, in particular questions raised about zoning, electrostatic ignition and overpressure in the event of an explosion.

System Zoning

The question was raised about whether it was appropriate to identify an explsoive atmosphere zone outside the ventilation system envelope. However, since the system operates under suction, and is only pressurised at fan discharge, any leak on the suction side would allow air to enter the system rather than allow an uncontrolled hydrogen release. On this basis I see no requirement to identify a zone external to the system. Since the basis of the design is to provide sufficient dilution to maintain concentrations below LEL and the system contains only secondary sources of release, it may be argued that the system internals and discharge vents are themselves non-hazardous.

Electrostatic Ignition

The question has been raised about the possibility of an electrostatic discharge within the system ductwork forming a source of ignition. Since the ductwork uses elements of polyproylene and other high resitivity materials there is the possibility of a charge development through particulate impingment. It is not possible to definitively state that a discharge could not occur, but there are a number of considerations that point to reduced risk:

- The ambient air does not have high particulate levels and intakes are filtered.

- Charge dissipation is influenced by relative humidity and suface moisture levels; internet searches typically identify a relative humidity of less than 30% as potentially problematic. Relative humidity as measured in the MICE hall on the morning of 10th may 2012 was 40% with a temperature of 23C.

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- Polypropylene is routinely employed on ductwork for fume cupboards.
- The basis of safety for the system is that dilution will be below LEL for all anticipated leaks.
- Polypropylene is known to be used elsewhere on site where hydrogen is used and has not been identified as a hazard.

Overpressure:

In an email (16.02.12) from Halliday, Stack and Dewhirst Ltd it was proposed that a screening calculation could be used to evaluate the risk associated with overpressure:

'The screening calculation would use the maximum pressure generated by a contained explosion of hydrogen ie. 8.4 Bara (ref: Explosion Hazards in the process industries, R K Eckhoff ISBN 978-0976511342 Pub: Gulf Publishing Company, 2005 Table 2-5 page 21). The free internal volume of the ventilation system can be calculated. The approximate internal volume of R5.2 can also be calculated from its dimensions. The over pressure can then be estimated as:

Building Overpressure = (Starting pressure + generated pressure) / Building volume.'

I believe the formula should include the 'starting volume' since this would clearly have a bearing, but in this instance the volume of the system is so small in relation to the building volume that this is not a critical concern:

If we use;

Building Overpressure = [(Starting pressure + generated pressure) x Starting Volume]/ Building volume

We have;

Building Overpressure = 8.4 barA x 2.5m3/5160m3 = 0.004bar

At such low values there does not appear to be any structural concerns for the building.

The above 'steady state' calculation does not consider the transient effects of a blast wave. As a further screening calculation we can consider the 'TNT equivalence'. This is known to offer poor representation of gas explosions particularly at low pressures where it is known to overestimate the pressure. Nevertheless it is used to provide estimates, and the overestimate is no embarrassment in terms of a screening calculation.

The Gas Explosion Handbook (http://www.gexcon.com/handbook/GEXHBcontents.htm) (last accessed 10th May 2012), identifies a TNT mass equivalence of 10 x 20% of the hydrocarbon fuel mass.

The handbook also identifies a stochiometric hydrogen-air mixture as having a hydrogen content of 26.9g/m3

If we assume a nominal volume of 2.5m3 we have a hydrogen mass of 2.5 x 26.9 = 67g

And a TNT equivalent mass of 67 x 10 x 20% = 135g

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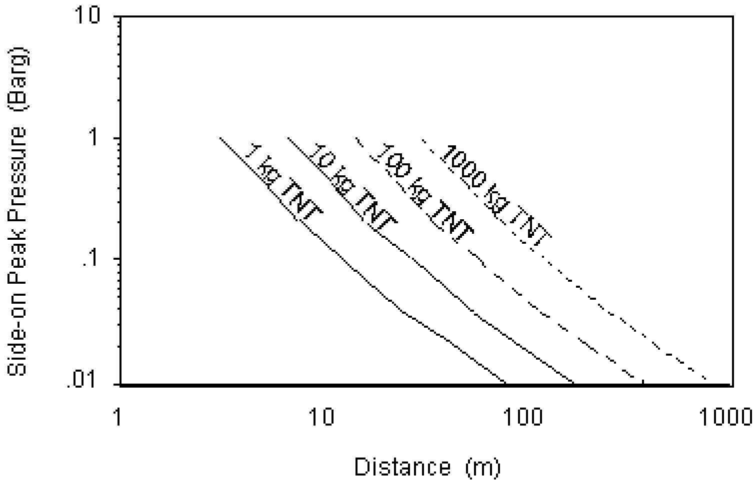
The handbook offers the following plot of pressure against distance:



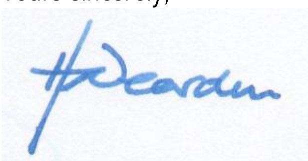
Extrapolating to 0.135 kg, we can estimate a peak pressure of approximately 0.2barg at 5m distance in free space. Since a good deal of the system is external to the building and the notionally exposed personnel are the other side of a 1.5m thick concrete shield wall there appears to be no prospect of injury. (Although there are cable duct penetrations through the wall these would be expected to further attenuate the blast pressure).

General Observations

To reitereate the findings given in the report of the *Safety review on the pre-operation of the MICE Hydrogen System* (V2.11 31-Oct-2011), it appears that compounded conservatism may have inflated the SIL targets for protections systems. A particular point is that the tolerable risk nominations are increased by a factor10 when the number of exposed people changes from one to only two, and that the nominations were identified on the basis of 3rd party risk even though 3rd party exposure is typically for very limited periods.

You will understand that I am not in a position to definitively pronounce on the risks discussed above, or on the validity of the references employed, but I trust the considerations identified will be useful in allowing you to make an informed judgement.

Yours sincerely,



Harvey T.Dearden