Hazardous Area Classification of Low Pressure Natural Gas Systems using CFD Predictions

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BACKGROUND: DSEAR

BACKGROUND: DSEAR

- Responsibility of employers to control or eliminate risks from explosive atmospheres in the workplace.
- Puts into effect EU Directive 99/92/EC (ATEX)
- [http://www.hse.gov.uk/fireandexplosion/dsear.htm](http://www.hse.gov.uk/fireandexplosion/dsear.htm)
DSEAR ZONING

• Classification of hazardous areas according to **zones**.

• Control & mitigation measures: appropriate equipment and/or ventilation for zoned areas.
APPLICATION OF DSEAR

• To whom does it apply?
  - *All* workplaces where dangerous substances are present, used, or produced.
  - Excluding domestic premises (provided people are not working there).
 TIMESCALES OF DSEAR

• When do the regulations come into force?
  - July 2003 for new premises
  - July 2006 for all premises (both old and new)
DSEAR: NATURAL GAS SYSTEMS

- Estimated ~600,000 businesses potentially affected.
- Required to carry out risk assessment, classify areas into zones and adopt appropriate control/mitigation measures.
ZONING: BS EN 60079-10:2003

• To provide guidance on zoning, DSEAR suggests that BS EN 60079 is used.

• BS EN introduces concept of a ‘Vz’ gas cloud volume to quantify the hazardous zones.
Vz DEFINITION

• Volume of gas in which mean gas concentration is 25 or 50% of the Lower Explosive Limit (LEL).

• If $V_z < 0.1 \, \text{m}^3$, ventilation can be described as ‘high’, and the gas cloud is of ‘Negligible Extent’
• Calculation method:

\[
\frac{dV}{dt} \bigg|_{\text{min}} = \frac{(dG/\text{dt})_{\text{max}} \cdot T}{k \cdot \text{LEL}_m \cdot 293}
\]

\[
V_z = \frac{f(dV/\text{dt})_{\text{min}}}{0.03}
\]

• Origin of method unknown

• Overly conservative?
AIMS

- To compare predictions of Vz using:
  - BS EN 60079-10:2003
  - Computational Fluid Dynamics (CFD)
CASES CONSIDERED

• Outdoor unobstructed release
• Pressures: 0.5 – 5.0 barg
• Hole Sizes: 0.25 – 5.0 mm²
• Methane, propane, butane and natural gas
• Numerical solution of conservation equations governing transport of mass, momentum and energy.

• Values of velocity, pressure, temperature and gas concentration found at mesh points.
COMPUTATIONAL FLUID DYNAMICS (CFD)

Open end

Open sides

Coflow (0.5 m/s)

Jet
2.2% Methane 50% LEL
COMPUTATIONAL FLUID DYNAMICS (CFD)

2.2% Methane 50% LEL

Vz volume (Mean concentration 50% LEL)
## RESULTS: METHANE

<table>
<thead>
<tr>
<th>Leak Conditions</th>
<th>50% LEL Vz Volumes (m$^3$)</th>
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<tbody>
<tr>
<td></td>
<td>CFD</td>
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<tr>
<td>Pressure (barg)</td>
<td>Area (mm$^2$)</td>
</tr>
<tr>
<td>5.0</td>
<td>2.5</td>
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<td>2.5</td>
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<td>0.5</td>
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BS EN is 2 – 3 orders of magnitude larger
RESULTS: METHANE
RESULTS SUMMARY

• Over the range of cases considered, BS EN estimates $V_z$ to be 2 – 3 orders of magnitude larger than the CFD.

• Predictions for propane, butane and natural gas show similar trends to methane.
CONCLUSIONS

- There is a high level of conservatism in BS EN 60079 for low-pressure releases.
- Present CFD results may help to prepare risk assessments and area classification.
- Need to study obstructed spaces.
JOINT-INDUSTRY PROJECT ON AREA CLASSIFICATION

- To experimentally validate the concept of Vz and ‘negligible extent’.
- To examine gas dispersion and ventilation in indoor plant areas
- To define area classification rules for low-pressure secondary leaks of natural gas for indoor plant areas based on provision of ventilation.

http://www.hsl.gov.uk/news/index.htm#gas
THANK YOU

Any questions?