Ground gas and VOCs - best practice techniques for risk assessment and verification of mitigation measures

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Introduction

- Where are we now?
- Most common issues with ground gas and vapour assessment
- Advances in continuous monitoring
- BS8485: 2015 and relationship with other guidance
- Considerations when using BS8485: 2015
- Verification of systems (CIRIA C735 and BS8485)

- This is a whistle-stop tour of the key issues
Where are we now?

Complete continuous monitoring (includes flow rates) is now possible and allows us to refine risk assessments.
Issues in gas risk assessment

- Poor (or non existent) conceptual site models
- Monitoring in poorly designed wells, deep wells or wells for groundwater sampling
- The belief that methane (or any other gas) above background concentration in the ground will pose a risk
- Reliance on advice from gas protection installers and suppliers
- Belief that gas risk assessment is limited to use of Wilson and Card (GSV) screening method
Issues in gas risk assessment

• Historic use of 1% methane and 5% carbon dioxide as trigger levels for gas in the ground
• When considering above ground development there is no unsafe concentration of gas in the ground
• How fast can it migrate out of the ground (if at all) – pressure and flow rates or diffusion
• Screening values are seen as absolutes and used for “DQRA” – GSVs are extremely conservative
• 90% methane in ground may pose no risk to development at ground level
• Overly conservative assessments when only carbon dioxide is present (and it is not from a high risk source)
BS8485: 2015

- Code of practice for the design of protective measures for methane and carbon dioxide ground gases for **new buildings**
- Does not apply to retrofit (even if the building is brand new and has just been built)

### Table 2: CS by site characteristic GSV

<table>
<thead>
<tr>
<th>CS</th>
<th>Hazard potential</th>
<th>Site characteristic GSV $^A$</th>
<th>Additional factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td>Very low</td>
<td>&lt;0.07</td>
<td>Typically &lt;1% methane concentration and &lt;5% carbon dioxide concentration (otherwise consider an increase to CS2)</td>
</tr>
<tr>
<td>CS2</td>
<td>Low</td>
<td>0.07 to &lt;0.7</td>
<td>Typical measured flow rate &lt;70 L/h (otherwise consider an increase to CS3)</td>
</tr>
<tr>
<td>CS3</td>
<td>Moderate</td>
<td>0.7 to &lt;3.5</td>
<td>–</td>
</tr>
<tr>
<td>CS4</td>
<td>Moderate to high</td>
<td>3.5 to &lt;15</td>
<td>–</td>
</tr>
<tr>
<td>CS5</td>
<td>High</td>
<td>15 to &lt;70</td>
<td>–</td>
</tr>
<tr>
<td>CS6</td>
<td>Very high</td>
<td>&gt;70</td>
<td>–</td>
</tr>
</tbody>
</table>

$^A$ The figures used in this column are empirical.

**NOTE** The CS is equivalent to the characteristic GSV in CIRIA C665 [6].
BS8485:2015

• Key changes from 2007 version:
  ▫ Amendments to scoring system – to remove inconsistencies
  ▫ Requirements for a gas membrane – this is causing some issues
  ▫ Inclusion of the TOC approach from CLAIRE RB 17
  ▫ More detail on gas protection design in the Appendices
  ▫ Requirement for verification of gas protection measures
  ▫ Reporting requirements
The intention of the updated standard is to ensure that quality, robust products are used as gas membranes.

Clause 7.2.4 - the membrane choice should be made according to the resistance of the material to the passage of the challenge gas and the resistance to site damage during and after installation.

The prescriptive nature of the methane resistance figure in Table 7 is at odds with the preceding text.

Some 1mm HDPE membranes and water proofing membranes are more suitable as gas membranes around basements or below slabs than aluminium foil membranes but have a methane gas transmission rate > 40ml/m²/day/atm.
BS8485: 2015 – gas membranes

- Alternatively, membranes that meet the requirements of the Geosynthetic Research Institute Standards GM13 (Rev 14, 1/6/16) and GM17 (Rev 12 11/4/15) for geomembranes used as landfill liners or capping materials will be suitable.
- 40ml/m²/day/atm requirement can be overridden by specific assessment – it is for guidance only (refer to statement at beginning that the British Standard should not be used as a specification).
- Use guidance in CIRIA C748, *Guidance on the use of plastic membranes as VOC vapour barriers* to specify appropriate properties (e.g. tear strength, puncture resistance).
BS8485: 2015

• Relationship with other guidance:
  ▫ CIRIA C665 Assessing Risks Posed by Hazardous Ground Gases to Buildings – the scoring system in BS8485 is based on C665 but covers a wider range of scenarios and supersedes it
  ▫ NHBC Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present - traffic lights can still be used if the building type is appropriate or if NHBC approval is required
  ▫ CIRIA C735 Good practice on the testing and verification of protection systems for buildings against hazardous ground gases – The British Standard requires gas protection to be verified in accordance with this
BS8485: 2015

- Relationship with other guidance:
  - CLAIRE RB17 RB 17 - A Pragmatic Approach to Ground Gas Risk Assessment – The TOC approach is included in the Standard, although it has been amended
  - The Local Authority Guide to Ground Gas: Chartered Institute of Environmental Health – more detail on DQRA methods
BS8485: 2015 and waterproofing

- Table 5 – Gas protection score for the **structural barrier**
- Scores for basement floor and walls that conform to Grade 2 or 3 waterproofing to BS8102
- Grade 3 cannot be achieved with waterproof concrete alone?
- Is the BS8485 score for structural concrete barrier only or the complete waterproof system? – it is not clear
- Is there double counting if the waterproof membrane is also considered to be a gas membrane?
- There is confusion at the moment
BS8485: 2015 and waterproofing

- Type A, CS 2 – score required is 3.5
- Block and beam, gas membrane and void – score = 0+2+2.5 = 4.5
- Reinforced concrete slab and gas membrane – score = 3 or 3.5 – how is this different to waterproof construction?
- Waterproof basement only = 2 or 2.5 even though it may have thick concrete walls and a robust membrane that is also resistant to gas. Difficult to provide vent layers around deep basements
- Specific modelling has shown that one manufacturers system can provide adequate gas resistance up to CS3 using a waterproof membrane and suitable concrete construction
Gas protection design

- Once the scope of the protection has been determined the gas protection will require detailed design:
  - Design of ventilation layer (if required)
  - Design of gas membrane (if required)
  - Detailing of concrete slab
  - Integration with waterproofing design of basements
  - Preparation of verification plan
Example

- Industrial development – 66% methane and 14l/h flow rate
- CS4 according to simplistic Gas Screening Value approach
- Source is an organic layer in an old backfilled area – limited potential to generate gas – consider the CSM!
- DQRA - removed need for gas membranes and venting layer – heavy reinforced concrete construction is a good gas barrier
- Sealing of service entries required
- Consider if venting layer could be flooded by groundwater
- Limited pressure relief vents in ground to stop gas pressure building up
- On most sites assessments are verified by surface emissions mapping and flux chamber testing
1m MADE GROUND - predominantly granular materials of chalk, flint, quartzite, brick, clinker and concrete. Limited degradable material - wood

TOC average 1.5%, range 0.2% to 4.3% with higher values associated with clinker

4m MADE GROUND - infilled settling pond for sugar beet processing. Predominantly granular materials of chalk, flint, quartzite, brick, clinker and concrete. Some organic content

TOC average 4.3%, range 0.3% to 7.5%

LIMESTONE - Oolitic Limestone. Background source of carbon dioxide

400mm thick reinforced concrete suspended floor slab - excellent resistance to gas

4m ALLUVIUM - Soft or very soft organic clay and silt with some layers of PEAT.
Example

- GSV indicates CS3
- (12.4% CO2 and 24.1 l/h flow)
- DQRA indicates CS1
Complete continuous monitoring

- Continuous monitoring with flow rates now possible
- Opens up new and exciting possibilities for ground gas risk assessment where appropriate
- It can provide value for clients by reducing need to install gas protection, reducing cost of site investigation, reduce scope of gas protection or reduce ongoing monitoring requirements/costs
- Statistical analysis of distributions and comparison of trends from different gas sources
- Assessment of well radius of influence
- Assessment of gas permeability of the ground
- AmbiSense/EPG will be publishing papers and running seminars showing how you can get value from the data
Example of benefits
Time series methane – in landfill

Concentration time series (methane)

Flare turned 'on'

Date

06-Dec-16  13-Dec-16  20-Dec-16  27-Dec-16  03-Jan-17  10-Jan-17  17-Jan-17  24-Jan-17  31-Jan-17  07-Feb-17

Concentration %/V

0  10  20  30  40  50  60  70  80  90  100

Barometric pressure (mb)

850  870  890  910  930  950  970  990  1010  1030  1050

CH4  Barometric Pressure

epg
Time series of GSV in landfill

GSV Time Series (methane)

Flare turned 'on'

Date

06-Dec-16  13-Dec-16  20-Dec-16  27-Dec-16  03-Jan-17  10-Jan-17  17-Jan-17  24-Jan-17  31-Jan-17  07-Feb-17

Barometric pressure (mb)

0  0.5  1  1.5  2  2.5  3  3.5  4  4.5  5

GSV (l/h)

methane GSV (l/h)  Barometric Pressure
Times series of gas concentration and flow outside landfill
What are the implications?

- The time series of methane concentration shows a relationship with atmospheric pressure.
- Methane increases with reducing atmospheric pressure – could be interpreted that emissions also increase as atmospheric pressure increases.
- BUT
- The GSV shows no significant relationship – flows are not affected.
- It also shows the flare system is not having any effect on this particular well.
- Partial continuous monitoring without flow rates is misleading.
Statistical analysis
Issues with VOC risk assessment

- Lack of CSM
- Poorly designed monitoring wells
- Lack of vapour sampling
- Vapour sampling from wells with groundwater
- No consideration of building construction in risk assessment model
- Use of generic models (e.g., J&E and CLEA) when not appropriate
- DQRA is not just about changing parameters in CLEA – often have to use other models
VOC Membranes

- VOC or hydrocarbon membranes
- In order to specify the correct membrane you need to know the vapour permeation rates
- The rate of vapour permeation through the membrane should be assessed to see if the product is appropriate
- See CIRIA C748
- You need to see independent laboratory test reports
- Do not rely on the manufacturers data sheets or statements
Verification of gas or vapour protection

What is needed:

- Design to verify against – this should be completed by the consultant – not the supplier, installer or verifier
- Drawings showing the design
- Details for corners and penetrations
- Verification plan (including whether integrity testing is required or not)
Membrane integrity test methods

- Tracer gas testing is not the only method of integrity testing (despite what you might have been told by those selling it!)
- CIRIA Report C735 includes standard method statements for testing
  - Tracer gas
  - Dielectric porosity
  - Smoke testing
CL:AIRE Accreditation Scheme

- Accreditation scheme being developed for gas protection verifiers
- Independent and voluntary
- Set up and scrutineers are volunteers from industry
- Not for profit
- Do not need to attend courses run by any specific organisation
- Currently being developed
- CL:AIRE will be running training courses (but attendance at these is not mandatory)
When verification or installation goes wrong

- Continuous monitoring of void space below floors
- GSV for this site was <0.07l/h (no flow detected) with carbon dioxide at 17% (deemed to be Characteristic Situation 2)
- Source colliery spoil below site
- This case study also shows how the use of carbon dioxide concentrations alone to define gas risk can be misleading
- Yet again the real problem was the lack of any consideration of the CSM
Continuous monitoring in floor void
• No correlation with atmospheric pressure
• Closely correlated to temp – local degassing of surface soils
Post construction monitoring of voids

- Need to monitoring well into the void – not at air bricks
- Cannot feed pipes through airbricks – curl up inside cranked ventilator or end up curling in void
- Need specific installation – drill into the void
- Cannot treat as a flux box by sealing air vents – there is still a lot of air flow via cavities, etc
- Post construction monitoring gives most benefit when linked with meteorological data (especially wind speed and direction)
- Also need temperature and humidity in void
- Compare actual performance with design performance
- Ambisense/EPG
Comparison with predicted
Summary

- Always consider the CSM – it is not just about gas monitoring data
- Issues with BS8485: 2015 - gas membranes gas transmission rate and waterproofing
- Verification is important
- CLAIRE accreditation scheme for verifiers
- Complete continuous monitoring with flow rates is a game changer and can help you reduce costs for clients
- AmbiSense/EPG will be publishing papers and running seminars showing how you can get value from the data

- Thank you for listening