Understanding Gas Protection Measure Selection within Waterproofing Systems

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The Main Hazardous Gases

- \( \text{H}_2\text{S} \)
- CO
- \( \text{CH}_4 \)
- \( \text{H}_2 \)
- Rn
- \( \text{N}_2 \)
- \( \text{CO}_2 \)
- VOCs
Sources of UK ground-gas

Natural
- Bedrock and sediments containing Uranium
- Calcareous rock (limestone)
- Coal bearing strata
- Organic sediments (peat, alluvium)

Anthropogenic
- Landfill
- Made ground
- Mining
- Past contaminative activity
British Coalfields

Risks from:

- Methane
- Carbon Dioxide
- Carbon Monoxide
- Hydrogen Sulphide
- Oxygen deficiency
Abbeystead Valve House Disaster, 1984

16 people killed
28 people injured
Carbon dioxide discovered in Gorebridge homes

June 2014
2017 Update

64 homes demolished
23,000 former landfills in England & Wales
Loscoe Explosion, 1986
3 people injured
"Radon is the second highest cause of lung cancer in the UK, after smoking"
BS 8485:2015

Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

Published June 2015

- Increased scope (site investigation and risk assessment)
- Updated to latest good practice
- Includes changes to building types
- Expanded and modified scoring tables
- Verification
Ground-Gas Risk Assessments

Tier 1 - Is there a pollutant linkage?
- Initial Conceptual Site Model

Tier 2 - Generic risk assessment
- What is the empirical level of risk?
- Need sufficient monitoring data to determine a GSV and a Characteristic Situation

Tier 3 - Site specific risk assessment
- What is the quantitative risk?
- Use numerical models to calculate gas accumulation beneath & within buildings
- Detailed qualitative risk assessment

Tier 4 - Receptor monitoring
- Monitoring directly at or near to the receptor

Which ever tier – use multiple-lines of evidence
Conceptual Site Model Development

Using site investigation data and monitoring data to identify plausible pollution linkages that require further management
Weekly monitoring on these dates shows almost no methane

Weekly monitoring on these dates shows falling methane

Weekly monitoring on these dates shows rising methane
**BS8485:2015**

### Characteristic Situations

<table>
<thead>
<tr>
<th>CS1</th>
<th>Very Low Risk</th>
<th>No Special precautions required</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS2</td>
<td>Low Risk</td>
<td>Passive Gas Protection (&lt;30m span)</td>
</tr>
<tr>
<td>CS3</td>
<td>Moderate Risk</td>
<td>Highest level of passive protection and limit for private unmanaged residential dwellings</td>
</tr>
<tr>
<td>CS4</td>
<td>Moderate to High Risk</td>
<td>Lower active systems for commercial and industrial. Managed residential possible with care.</td>
</tr>
<tr>
<td>CS5</td>
<td>High Risk</td>
<td>Large industrial sheds with large open areas. Really think about it.</td>
</tr>
<tr>
<td>CS6</td>
<td>Very High Risk</td>
<td>Yes even here you can develop, but should you be building on it?</td>
</tr>
</tbody>
</table>

Experts in Continuous Monitoring
### BS8485:2015 - Building Types & Sensitivity

**Table 3  Building types**

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
<th>Type D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Private</td>
<td>Private or commercial/public, possible multiple</td>
<td>Commercial/public</td>
<td>Commercial/industrial</td>
</tr>
<tr>
<td>Control (change of use, structural alterations, ventilation)</td>
<td>None</td>
<td>Some but not all</td>
<td>Full</td>
<td>Full</td>
</tr>
<tr>
<td>Room sizes</td>
<td>Small</td>
<td>Small/medium</td>
<td>Small to large</td>
<td>Large industrial/retail park style</td>
</tr>
</tbody>
</table>

- Requires **Professional Judgement**
- Can have different types in the same building
BS8485:2015 - Scoring

Determine your minimum score requirements using a “combination of two or more” of the following elements:

- Ventilation measures
- Structural barrier or basement
- Gas-resistant membrane

You can’t use the same element twice!
BS8485:2015 - Gas Protection Score, Table 4

Table 4  Gas protection score by CS and type of building

<table>
<thead>
<tr>
<th>CS</th>
<th>High risk</th>
<th>Minimum gas protection score (points)</th>
<th>Medium risk</th>
<th>Low risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Type A building</td>
<td>Type B building</td>
<td>Type C building</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3.5</td>
<td>3.5</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>6.5(^a)</td>
<td>5.5(^a)</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td>5</td>
<td>— (^b)</td>
<td>6.5(^a)</td>
<td>5.5</td>
<td>4.5</td>
</tr>
<tr>
<td>6</td>
<td>— (^b)</td>
<td>— (^b)</td>
<td>7.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

\(^a\) Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.

\(^b\) The gas hazard is too high for this empirical method to be used to define the gas protection measures.

- There are several additional notes to this table
- You may consider different parts of the building requiring different scores
### BS8485:2015 - Table 5 Structural Barrier

**Table 5**  
**Gas protection scores for the structural barrier**

<table>
<thead>
<tr>
<th>Floor and substructure design (see Annex A)</th>
<th>Score A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast suspended segmental subfloor (i.e. beam and block)</td>
<td>0</td>
</tr>
<tr>
<td>Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)</td>
<td>0.5</td>
</tr>
<tr>
<td>Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations</td>
<td>1 or 1.5 B)</td>
</tr>
</tbody>
</table>

- **Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing** 0
- **Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing** 2.5

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**Notes:**

A) The scores are conditional on breaches of floor slabs, etc., being effectively sealed.

B) To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in (see A.2.2.2).

C) The score is conditional on the waterproofing not being based on the use of a geosynthetic clay liner waterproofing product (see C.3, Note 4).

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- Not all concrete is the same!
- Any breaches in slabs need sealing
- Annex A provides further detail
Code of practice for protection of below ground structures against water from the ground

6.5 Ground gases

The insertion of a ground barrier for the prevention of radon, methane and other ground gases and contaminants from entering a structure should be considered in the design, choice of the materials and installation of any waterproofing system.
Type or Grade?

**Grade** is the end use
1 – Car parking
2 – Plant rooms and workshops
3 – Ventilated residential and commercial areas

**Type** is the protection system
A - Barrier
B – Structurally integral
C – Drained
## BS8485:2015 - Ventilation

<table>
<thead>
<tr>
<th>Element</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure relief</td>
<td>0.5</td>
</tr>
<tr>
<td>Passive sub floor ventilation</td>
<td>Very Good 2.5, Good 1.5</td>
</tr>
<tr>
<td>Active dispersal layer</td>
<td>1.5 to 2.5</td>
</tr>
<tr>
<td>Active positive pressurisation</td>
<td>1.5 to 2.5</td>
</tr>
<tr>
<td>Ventilated car park (to approved Doc F)</td>
<td>4</td>
</tr>
</tbody>
</table>

- Much more detail in this version
- Need to design it
- **Prove** your ventilation works
- **No active** for Type A Building
<table>
<thead>
<tr>
<th>Protection element/system</th>
<th>Score</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas resistant membrane meeting all of the following criteria:</td>
<td></td>
<td>The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints.</td>
</tr>
<tr>
<td>• sufficiently impervious to the gases with a methane gas transmission rate &lt; 40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method);</td>
<td></td>
<td>For example, a minimum 0.4 mm thickness (equivalent to 370 g/m² for polyethylene) reinforced membrane (virgin polymer) meets the performance criteria in Table 7 (see C.3).</td>
</tr>
<tr>
<td>• sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;</td>
<td>2</td>
<td>If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.</td>
</tr>
<tr>
<td>• sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• capable, after installation, of providing a complete barrier to the entry of the relevant gas; and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• verified in accordance with CIRIA C735 [N1]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Detail in Design, Detailing in Installation
CIRIA C735 - Verification

“The process of demonstrating that the risk has been reduced to meet remediation criteria and objectives based on a quantitative assessment of remediation performance”

• All installations should have some form of verification

• Verification should be proportionate to:
  • A) the risks from the site,
  • B) the experience of the installation operatives

• Verification should be conducted by suitably qualified and Independent practitioners.
C735 Decision Structure

Example of elements to be considered

Gas regime
- Low risk: CS2
- Intermediate risk: CS3/4
- High risk: CS4 and above

Design complexity
- Simple: Few service entries/penetrations, gas membrane and sub floor void
- Complex: Variety of gas protection measures, numerous columns/penetrations/service entries, corners and small spaces

Number of plots/buildings
- Small: <5
- Medium: 3–15
- Large: >10

Installation workforce
- Non specialist
- Skilled: General builder/groundworker qualified and experienced installer (NVQ Level 2 qualification in gas protection installation).

CIRIA C735 Figure 3.1
Verification Plan

Verification Plan’s should include:

• Site summary
• Design / specification compliance
• Acceptable installation methods
• Installer / verifier competencies
• Inspection / testing regime
• Non-conformance resolution
• Define Contents of Final Verification Report
Integrity Testing

a) In line with methodologies in Annex 2, 3 and 4 of CIRIA 735 (Leak Detection)
   • Smoke Testing
   • Tracer Gas Testing
   • **Dielectric Testing**

b) In line with methodologies in ASTM D4437 (Seam Testing)
   • Pick/Probe Test
   • **Air Lancing**
   • Pressure Testing

There are also others
Verification Monitoring

Pre and Post Remediation Monitoring Evidence
Summary

Site Investigation
• desk study
• trail pits
• monitoring
• laboratory analysis
Weeks to Months

Risk Assessment
• Conceptual Site Model
• Consideration of gases and vapours
• Generic GSV
• Detailed assessment
• Assigning Characteristic Situation

Design & Specification
• Proportionate to the risks posed
• BS8485 Points Scoring System
• Ventilation
• Structure
• Membrane
• BS8102 Considerations

Installation
• NVQ Level 2 Qualification
• Protection from Follow on Trades

Verification
• C735
• Verification Plan
• Independent
• Integrity testing
Thank you!

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