Ground Gas Developments

Emerging Guidance

SILC Annual Forum, April 30, 2013

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Contents

- Context of Existing Key Guidance Documents
- CIRIA Research Report – Testing and Verification of Protection Systems for Buildings Against Hazardous Ground Gases
- Revision of BS8485: Characterisation and Remediation of Ground Gas in Affected Developments
- New BS 8576:2013 – Guidance on Ground Gas Investigations

Overview of Key Guidance (Buildings)

Year	By	Title	Investigation	Assessment	Protective Measures
1996	CIRIA	R 149 Protecting development from methane			x
1997	DETR PiT	Passive venting of soil gases beneath buildings			x
2001	BRE	BRE 414 Protective measures for housing on gas contaminated land			x
2007	NHBC CIRIA BRE	Guidance for development proposals where CH_4 and CO_2 present C665 Assessing risk posed by haz. ground gases to buildings BR211 Radon: Guidance on protective measures for new buildings	x x	x x x	x x x
	BSI	BS 8485 Characterisation and remediation from ground gases	x	(x)	x
2008	CIEH	Local Authority Guide to Ground Gas	x	x	x
2009	CIRIA Wilson/Card/ Haines	C682 The VOC Handbook The Ground Gas Handbook	x x	x x	 x
2011	BSI	BS10175:2011 Investigation of contaminated sites – code of practice	x		
2013	BSI CIRIA	BS8576 Guidance on investigations for ground gas – permanent and VOCs Good practice on testing and verification of gas protection systems	x		 x

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Good Practice on the testing and verification of protection systems for buildings against hazardous ground gases

Buro Happold Limited

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Reason for Research:

- Recognition that significant number of installed systems are inadequate.
- Verification of remediation is a fundamental requirement.
- Very little detailed guidance for gas protective systems.
- Resilience of membranes to the construction process and appropriate detailing of flow paths to underfloor venting systems are fundamental to their performance.
- Verification often not planned for in the design/construction.

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Programme to publication

- Research began Spring 2012.
- Final report about to be submitted to CIRIA.
- Publication expected later this year.

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Objectives

- Define and promote good practice for the design and implementation of verification strategies for hazardous ground gas protection systems, for the designer, installer, verifier and regulator.
- Define need for and scope of verification activities during construction.
- Describe principles, advantages and disadvantages of various integrity test methods, and how to select the appropriate method.
- Identify practical issues that could impact on the verification process.
- Set out inspection and reporting details essential for the verification report.

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What it does not cover

- Selection of particular type of gas membrane
- Design (or checking) of adequacy of design measures
- Verification Plan examples/table of contents

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Scope of Research and Guidance

- Task 1: Scoping study.
- Task 2: Review of current practice.
- Task 3: Identification of good practice.
- Task 4: Provision of practical guidance for recording and reporting verification and integrity testing activities and results.

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Overview Content of Report

- Regulatory regime and complementary guidance.
- Needs and issues for testing and verification.
- Recommended verification procedures (Verification Plan).
- Integrity testing – methods, applicability, standards.
- Reporting requirements and Recommendations.
- Annex 1 – Tables of Suggested Levels of Verification
- Annexes 2 to 4 – Standard Specifications for integrity tests.
- Appendix A – The position of the membrane in construction.
- Appendix B – Considerations in the specification of membranes.
- Appendix D – Examples of good and bad practice.

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Membrane verification

- Need for appropriately qualified workforce
- Verification by appropriately competent, experienced and suitably trained personnel
- Preferably third party verifier, if appropriate/ possible
- Risk-based approach for determining need for and scope of verification activities (incl. integrity testing)
- Essential that integrity of gas protection measures is maintained post-verification

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Figure 3.1 Verifier scenarios

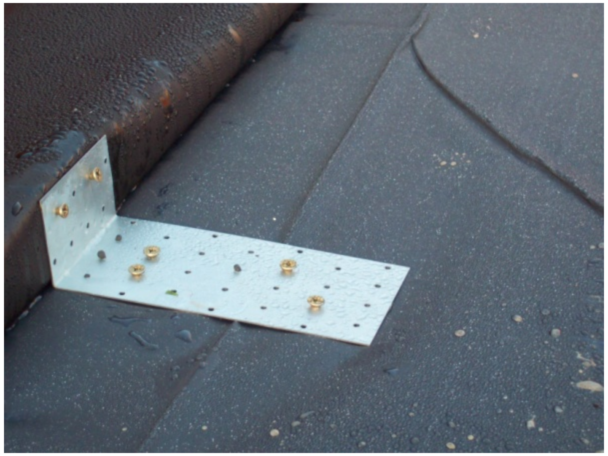
Notes: An extension to this scheme which includes integrity testing is discussed in Chapter 4 and presented in Annex 1

Scenario A: The verifier is an independent third party. Verification of every single plot is carried out by the third party.

Scenario B: Verification of the first plot is carried out by an independent third party. Should the first installation be satisfactory, subsequent visits by the third party will occur at regular intervals thereafter, ensuring continued adherence to required standards. Should the installation of gas protection measures not meet required standards, verification procedures should revert to Scenario A.

Scenario C: The verifier consists of an independent third party aided by on-site presence (main contractor, membrane installer, resident engineer etc). Verification of the first plot is carried out by the third party. Should the first installation be satisfactory, subsequent verification can be carried out by an on-site presence. Should the required ground gas protection measures and filled in proformas not meet required standards, verification procedures should revert to Scenario B.

Follow-on works purposefully penetrating membrane. (GB Card and Partners)



Membrane cut by scaffolders and bricklayers after installation. (MEC Environmental Ltd)

Clean single sized stones with no fines acting as venting media, however no ventilation gaps in internal sleeper walls. (Smith Grant)

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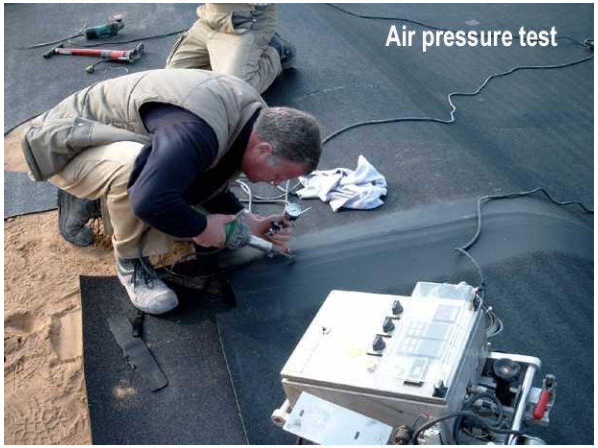
Integrity testing – some key issues

- Should be combined with visual inspection.
- Need for, extent and method of testing should be risk-based.
- Integrity testing not a substitute for well designed and thought out gas protection measures.
- Should not be carried out solely to obtain additional points under BS8485.
- Different methods have different limitations/ advantages:
  - Testing of seams.
  - Testing of (large) areas of flat membrane in final position.

CO_2 injection integrity testing. (Landline Ltd)

Dielectric porosity test, using electron beams and electronic instrumentation to detect holes or other anomalies such as blisters and bubbles. (NHBC)



Air pressure testing. (GSE Environmental)

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Verification Reporting

- Should be in accordance with CLR 11 model procedures and EA guidance on verification (2010)
- Include :
  - Conceptual site model for remediation.
  - Description of ground gas protection measures.
  - Description of verification plan.
  - Site- specific proforma for each inspection visit.
  - Photographs as supporting evidence.
  - Other lines of evidence such as air vent location plan, test results and monitoring data, specifications, etc …

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Recommendations

- Regulators, clients, consultants and contractors should discourage (not accept) insufficient/inadequate verification activities.
- Need for up-skilling across workforce to better disseminate best practice.
- Degree and intensity of independent verification should reflect:
  - Assessed level of risk.
  - Nature of gas protection system.
  - Quality of product(s).
  - Competence of installer.
- A 1200g membrane will typically not survive construction process intact.

Revision of BS 8485:2007

Code of practice for the characterisation and remediation from ground in affected developments

BSI Soil Quality Committee EH4

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BS8485 Revision

- 5 Year Review (2012) : Maintain, Revise, Withdraw ?

  Questionnaire Survey:

1. Do you use or reference this document regularly in your work?
2. Do you feel that the document as a whole is fit for purpose?
3. What other documents are available if this CoP is withdrawn?
4. Should the scope of the document be expanded, and if so into what areas?
5. Do you consider that this CoP should be replaced with a set of more specific documents?

BS8485 Revision

Programme

- Industry consultation Spring 2012
- EH4 committee recommend revision June 2012
- Initial scoping discussion workshop – October 2012
- Business case approved by BSI – April 2013
- Target publication 2014/2015

BS8485: 2007

Existing Content

- Intended for new build and for methane and carbon dioxide only.
- Overview of site characterisation (desk study, site investigation).
- Assessment of site characteristic hazardous gas flow rate and consequent characteristic situation (CS)/gas regime.
- Recommended approach (method) for selecting appropriate protective measures for differing gas regimes and different types of development.

  [The methodology is a ‘required number of points’ for the given regime and development type, and ‘solution scores’ for different types of protective measures.]
- Annexes on underfloor ventilation performance and ‘variables’ to be considered in remedial solution selection.

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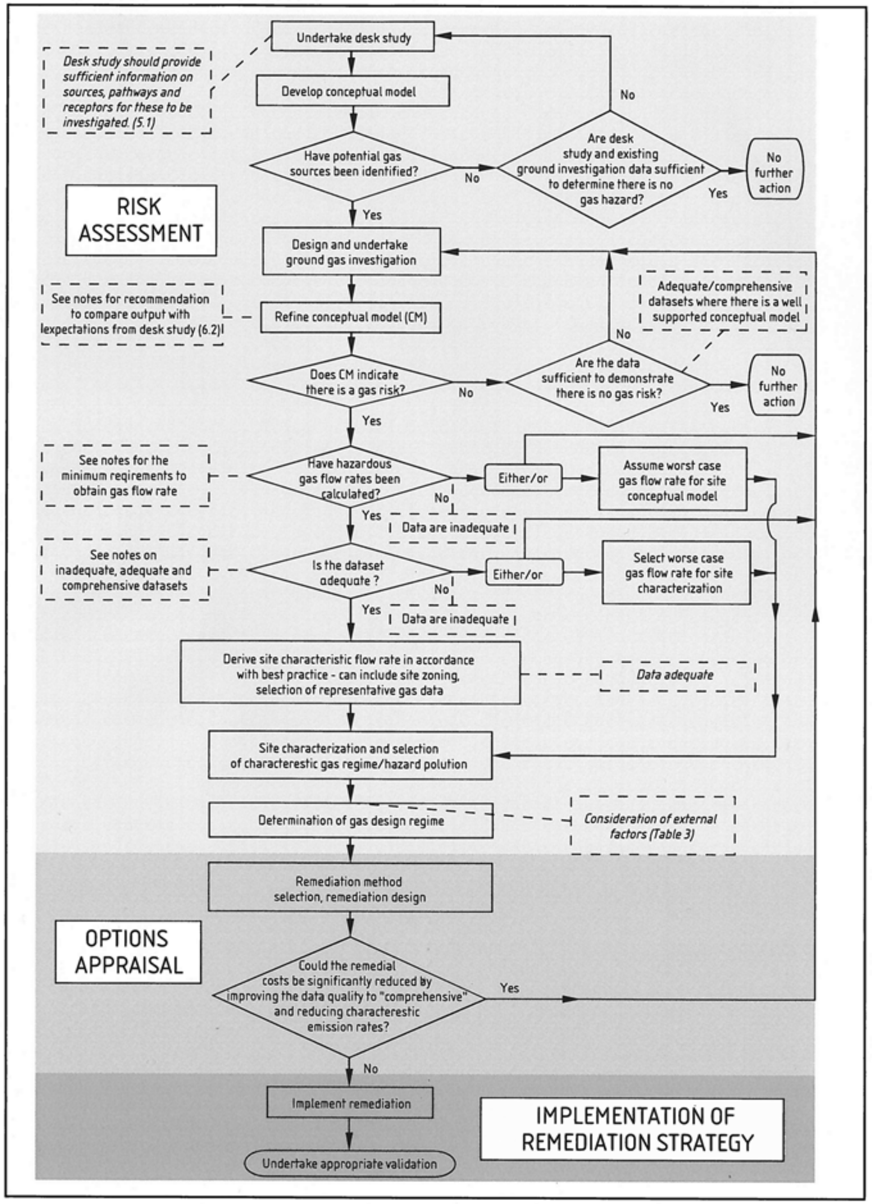
BS8485 Revision

- Desk study (BS10175).
- Conceptual model.
- Site investigation (CIRIA C665 & NHBC).
- Conceptual model.
- Haz. gas flow rate (GSV).
- Zoning?
- Remediation design.

Figure 1 **Ground gas characterization and assessment flowchart**



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BS8485 Revision

Table 2 **Required gas protection by characteristic gas situation and type of building**

Characteristic gas situation, CS	*NHBC traffic light*	Required gas protection			
		Non-managed property, e.g. private housing	Public building A)	Commercial buildings	Industrial buildings B)
1	*Green*	0	0	0	0
2	*Amber 1*	3	3	2	1 C)
3	*Amber 2*	4	3	2	2
4	*Red*	6 D)	5 D)	4	3
5			6 E)	5	4
6				7	6

NOTE Traffic light indications are taken from NHBC Report no.: 10627-R01 (04) [3] and are mainly applicable to low-rise residential housing. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.

A) Public buildings include, for example, managed apartments, schools and hospitals.
B) Industrial buildings are generally open and well ventilated. However, areas such as office pods might require a separate assessment and may be classified as commercial buildings and require a different scope of gas protection to the main building.
C) Maximum methane concentration 20% otherwise consider an increase to CS3.
D) Residential building on higher traffic light/CS sites is not recommended 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.
E) Consideration of issues such as ease of evacuation and how false alarms will be handled are needed when completing the design specification of any protection scheme.

Table 3 **Solutions scores**

PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
a) Venting/dilution (see Annex A)			
Passive sub floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) A)	Very good performance	2.5	*Ventilation performance in accordance with Annex A.*
	Good performance	1	*If passive ventilation is poor this is generally unacceptable and some form of active system will be required.*
Subfloor ventilation with active abstraction/pressurization (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) A)		2.5	*There have to be robust management systems in place to ensure the continued maintenance of any ventilation system. Active ventilation can always be designed to meet good performance. Mechanically assisted systems come in two main forms: extraction and positive pressurization.*
Ventilated car park (basement or undercroft)		4	*Assumes car park is vented to deal with car exhaust fumes, designed to Building Regulations Document F [5] and IStructE guidance [6].*
b) Barriers			
Floor slabs			
Block and beam floor slab		0	*It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum. Breaches in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances.*
Reinforced concrete ground bearing floor slab		0.5	
Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab		1.5	
Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints		1.5	
Fully tanked basement		2	
c) Membranes			
Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation B), C)		0.5	*The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation, and the integrity of joints.*
Proprietary gas resistant membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA) B), C)		1	
Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation		2	
d) Monitoring and detection (not applicable to non-managed property, or in isolation)			
Intermittent monitoring using hand held equipment		0.5	
Permanent monitoring and alarm system A)	Installed in the underfloor venting/ dilution system	2	*Where fitted, permanent monitoring systems ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe.*
	Installed in the building	1	
e) Pathway intervention			
Pathway intervention		—	*This can consist of site protection measures for off-site or on-site sources (see Annex A).*

NOTE In practice the choice of materials might well rely on factors such as construction method and the risk of damage after installation. It is important to ensure that the chosen combination gives an appropriate level of protection

A) It is possible to test ventilation systems by installing monitoring probes for post installation validation.
B) If a 1 200 g DPM material is to function as a gas barrier it should be installed according to BRE 212 [8]/BRE 414 [9], being taped and sealed to all penetrations.
C) Polymeric Materials >1 200 g can be used to improve confidence in the barrier. Remember that their gas resistance is little more than the standard 1 200 g (proportional to thickness) but their physical properties mean that they are more robust and resistant to site damage.

BS8485 Revision

Expected changes

- Better definition of terminology used.
- Substantial re-structuring and expansion of text.
- More clarity on membranes and on CQA.
- Inclusion of verification planning and implementation.
- Cross reference to key documents issued since 2007.
- Change title?
- Not radon but possibly low level VOCs.

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BS 8576:2013

Guidance on investigations for ground gas

Permanent gases and Volatile Organic Compounds (VOCs)

New BS8576:2013

- Draft for public comment (DPC) issued 1 October 2013 – Period for comment ended 30 November 2012
- About 300 technical and editorial comments
- Interim draft seen by BSI committee EH4 Soil Quality on 24 January
- Pre-publication draft due at the end of February
- Publication – April 2013

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New BS8576:2013

- Provides guidance on monitoring and sampling VOCs and permanent gases (e.g. methane).
- Should be read in conjunction with BS 10175.
- Some detailed technical changes to existing advice.

[What is "typically done" is not necessarily good practice.]

- Does not cover:
  - risk evaluation and characterisation.
  - selection, design and verification of protective measures.
  - radon.

New BS8576:2013

Annex B   RADON

- Provides background information on radon including about how it is regulated and about methods of in-situ measurement for radon in ground gas.

[BS ISO 11665-1 Measurement of Radon in the Environment – Air: Radon-222 - Part 1: Origins of radon and its short-lived decay products and associated measurement methods, will provide background information on radon, the need for appropriate desk studies, and measurement of atmospheric concentrations above the ground surface.]

New BS8576:2013

BSI Soil Quality Committee (EH4)

- Mike Smith (Chair)
- Bill Baker (CIEH)
- Geoff Card (GB Card & Partners)
- Trevor Howard (EA)
- Hugh Mallet (Buro Happold)
- Shaun Robinson (EA)
- Steve Wilson (EPG)
- Katy Baker (Arcadis)

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New BS8576:2013

Permanent Gases and VOCs

- Frequently occur together
  - e.g. petroleum hydrocarbons degrade to yield carbon dioxide (aerobic) or carbon dioxide + methane.
- VOCs often co-disposed deliberately or casually with other wastes.
- VOCs may be in, or underlain by, gas producing strata.
- As far as practical guidance provided in integrated text.
- Only where the approach to monitoring & sampling are different are they dealt with separately.

New BS8576:2013 - Contents 1

1. Scope
3. Definitions
6. Development of preliminary conceptual model
9. Field work – Permanent gases
10. Field work – VOCs
11. Monitoring & sampling reports
12. Quality assurance
13. Refining the conceptual model
14. Report on the investigation

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New BS8576:2013 - Contents 2

A. Regulation of land contamination

B. Radon

C. Anaerobic degradation and formation of methane and carbon dioxide

D. Background

E. Sampling protocols (permanent gases)

F. Assessment of sufficiency of data

G. Apparatus for measuring gas flows

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New BS8576:2013

Clause 8 Investigation Strategy

8.1 General considerations

8.2 Monitoring and sampling plan

8.3 Installation options

8.4 Location of monitoring installations

8.5 Response zones

8.6 Timing & frequency of monitoring

8.7 Deciding on the appropriate level of gas monitoring (permanent gases)

8.8 Deciding on the appropriate level of gas monitoring (VOCs)

New BS8576:2013

Figure 6 **Decision matrix for initial monitoring**

	Generation potential of source				
Gas monitoring requirements	Very low	Low	Moderate	High	Very high
Gas monitoring might not be necessary					
Gas monitoring over a period of 2 months with up to weekly measurements					
Gas monitoring over a period of 2 months up to 6 months with up to fortnightly readings					
Gas monitoring over a period of 6 months up to 12 months with up to fortnightly readings. Use high frequency monitoring where appropriate					

NOTE The darker the section on the matrix, the more likely it is that monitoring is needed.

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New BS8576:2013

Clause 9 Fieldwork – permanent ground gases

- 9.1 **General considerations**
- 9.2 **Construction of monitoring wells**
  - 9.2.1 General
  - 9.2.2 Borehole formation
  - 9.2.3 Installation of standpipe in well
  - 9.2.4 Driven monitoring probes
  - 9.2.5 Multi-level installations in a single well
  - 9.2.6 Flux chambers
  - 9.2.7 Surface surveys

9.3 **Instruments for use on-site**

- 9.3.1 Concentrations
- 9.3.2 Sample volumes and sampling rates
- 9.3.3 Flow rate measurement
- 9.3.4 Monitoring well pressure measurements.

9.4 **Recording information**

9.5 **Making on-site measurements**

9.6 **Sampling for laboratory measurements**

9.7 **Storage & transport of samples**

New BS8576:2013

Construction of monitoring wells for permanent gases

- An air tight screw top or bung should be fitted to the top of the standpipe …
- Two gas taps should preferably be fitted into the cap from which the gas samples can be taken.
- One tap has a 3mm tube (or similar) attached to it internally that extends to about 0.5 m above the standing groundwater level.
- Gas is extracted from one tap & recycled through the other after passing through the instrument to give an average reading and mixing the gas in the standpipe (only OK if gas composition not changed by instrument).

New BS8576:2013 - Clause 9.3.3

Flow rate measurements

- Different methods of measurement give different results – method used should always be stated.
- Main methods are:
  - (i)Thermal Dispersion Flow Transducer
  - (ii) Orifice style flow sensor.
- The latter restricts flow and can lead to under-recording of flow rates in some wells.
- The commonly used gas risk assessment method (CIRIA guidance) was developed using data recorded with flow meters without a restriction.

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New BS8576:2013

BS 10175 amendment consequent on publication of BS 8576

- Changes will be kept to a minimum
- BS 8576 will be made “Normative” and text amended as necessary
- Annex I – regulatory position etc. will probably be withdrawn and reference made to Annex A in BS 8576.

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