APPENDIX 5

GENERAL NOTES ON GAS GENERATION

A5.1 GENERAL

A5.1.1 Soft organic clays, peat, Made Ground and landfills are potentially subject to significant microbial degradation resulting in the formation of a mixture of gases and vapours.

A5.1.2 The chemical composition of landfill gas varies over time, a typical landfill gas can comprise up to 65% methane and 35% carbon dioxide. The properties of landfill gases are determined principally by the proportions of these two gases together with their mixture with air. Trace amounts of other gases such as hydrogen and hydrogen sulphide plus a range of organic vapours can also be present.

A5.1.3 Methane is colourless, odourless, non-toxic asphyxiant gas, which is flammable in air. However, the gas will only burn when mixed with air in certain proportions defined by the lower and upper limits of flammability (or explosibility). Any mixture of methane in air within these limits will burn if ignited. However, a mixture with a concentration of methane above the upper explosive limit (UEL) should not be considered safe since dilution with clean air will result in a composition within the flammable range. Thus mixtures above the UEL are a potential hazard and only mixtures below the lower explosive limit (LEL) can be considered safe. The LEL and UEL for methane are 5%v/v and 15%v/v respectively.

A5.1.4 Carbon dioxide is a non-flammable toxic gas with a long-term exposure limit of 0.5% by volume and a short-term limit of 1.5% by volume.

A5.1.5 On sites such as former docklands or reclaimed estuaries, gas is generated slowly and is characterised by low volumes of gas and low surface emissions. Development has taken place on such sites over many years without problems.

A5.1.6 In the case of recent landfills or mine workings, methane can be generated rapidly. This gives rise to large volumes of gas being produced with high surface emission rates. These conditions pose a risk to development.

A5.1.7 The Building Regulations Approved Document C (1992), ref. 5.4, gives guidance on the problems associated with the presence of landfill gas. This guidance suggests that where the level of methane is unlikely to exceed 1% by volume no further protection needs to be provided if the ground floor is suspended concrete and ventilated.

A5.1.8 Carbon dioxide should be considered independently of methane. Concentrations exceeding 1.5% by volume in the ground indicate a need to consider gas exclusion measures, while a level of 5% implies that specific design measures are required.

A5.1.9 Guidelines produced in Table 28 of CIRIA Report 149, ref. 5.5 are frequently used as a design tool with little regard to the nature of the gassing source or surface emission rates. However, this table was never intended as a definitive design tool.

A5.1.10 The most important aspect relating to the risk posed to a development by the gas regime below the site is how quickly is the gas coming out of the ground. The lower the surface emission rate the lower the risk.

A5.1.11 For design purposes the gas flow rate and gas concentration provide a more reliable method for classifying a site and specifying the scope of gas protection.

A5.1.12 A rational method for classifying gassing sites in terms of the risks posed by the presence of gas should consider the following, ref. 5.6.

- the source of the gas
- *the generation potential of the source*
- the location of the source and the presence of any natural geological barriers to migration
- the borehole flow rate and surface emission rate
- measured gas concentrations
- the nature of proposed development
- the confidence in the knowledge of the gas regime and any likely variations in concentration and borehole flow rate

A5.1.13 A risk ranking, ref. 5.5 deemed natural soils with low organic content posed the lowest risk in terms of gas generation while recent landfills, post 1960's, the greatest risk.

Source	Gas generation potential
Natural soils, low peat/lowest organic content	Low generation potential from small amounts of degradable material
Carbonate deposits e.g. Chalk	
Dock silt, Made Ground, low organic content	
Natural soil, Made Ground, high peat/organic content	Moderate generation due to increased levels of degradable material
Landfill – pre 1960	
Mineworking – susceptible to flooding	Potential for high generation if working (and pumping and ventilation) ceases and groundwater levels rise
Mineworking unflooded inactive	Potential for high generation if groundwater levels rise
Mineworking flooded	Potential for high generation if water levels vary
Landfill site, post 1960	High potential for gas generation due to high organic content

A5.1.14 The importance of surface emission rates together with gas concentrations lead to the following ranking system, ref. 5.7.

Scenario	Gas concentration	Borehole flow rate	Risk ranking
1	High	High	1
2	High	Low	3
3	Low	High	2
4	Low	Low	4

A5.1.15 A new method for characterising gassing sites is proposed, taking into account flow rates as well as gas concentrations, ref. 5.6.

Characteristic Situation	Limiting volume flow of CH_4 or CO_2 (l/hr)[1] from borehole	Additional limiting factors	Typical source of generation
1	<0.07	Methane not to exceed 1% volume and carbon dioxide not to exceed 5% by volume	Natural soils with low organic content
2	<0.7	Borehole air flow rate not to exceed 70l/hr otherwise increase to content Characteristic Situation 4	Natural soil, high peat/organic
3	<3.5	Borehole air flow rate not to exceed 701/hr otherwise increase to Characteristic Situation 4	Old landfill, inert waste, mineworking flooded
4	<15	Quantitative risk assessment required to evaluation scope of protection measures	Mineworking – susceptible to flooding, completed landfill, inert waste
5	<70		Mineworking unflooded inactive
6	>70		Recent landfill site

1. Limiting volume flow rate of gas = gas concentration x measured borehole flow rate

2. Site characterisation should be based on gas monitoring of concentrations and borehole flow rates for a minimum of one year and covering a range of atmospheric conditions. For readings covering less than one year but over six months, increase Characteristic Situation by 1. For reading covering less than 6 months but over three months, increase Characteristic Situation by 2.

3. Source of gas and generation potential/performance must be identified

A5.1.16 On the basis of the Characteristic Situation the scope of protection measures may be determined as below.

Characteristic Situation	Typical scope of protection measures	
	Residential Building	Office/commercial/industrial development
1	No special precautions	No special precautions
2	Well constructed ground or suspended floor slab. Waterproofing membrane sealed around penetrations, passively ventilated underfloor sub-space and wall cavities	Reinforced concrete cast in-situ ground slab. All joints and penetrations sealed. Possibly waterproofing membrane. Granular layer below slab passively vented to atmosphere with interleaved geocomposite strips or pipes

3	Wall constructed suspended or ground slab. Gas resistant membrane and passively ventilated underfloor sub-space	Reinforced concrete cast in-situ ground slab. All joints and penetrations sealed. Waterproof/gas resistant membrane and passively ventilated underfloor sub-space
4	Well constructed suspended or ground slab. Gas resistant membrane and passively ventilated underfloor subspace, oversite capping and in ground venting layer	Reinforced concrete cast in-situ ground slab. All joints and penetrations sealed. Gas resistant membrane and passively ventilated underfloor sub-space
5	Specific gas resistant membrane and ventilated underfloor void, oversite capping and in ground venting layer and in ground venting wells	Reinforced concrete cast in-situ slab. All joints and penetrations sealed. Gas resistant membrane and passively ventilated underfloor sub-space. In ground venting wells
6	Not suitable unless gas regime is reduced first and quantitative risk assessment carried out to assess design of protection measures in conjunction with foundation design	Reinforced concrete cast in-situ ground slab. All joints and penetrations sealed. Gas resistant membrane and actively ventilated underfloor sub-space, with monitoring. In ground venting wells

1. Typical scope of protection measures may be rationalised for specific developments on the basis of quantitative risk assessments based on CIRIA Report 152.

2. Note the type of protection is given for illustration purposes only. Individual site specific designs should provide the same number of separate protection methods for any given Characteristic Situation.

3. In all cases there should be minimum penetration of ground slabs by services and minimum number of confined spaces such as cupboards above the ground slab. Any confined spaces should be ventilated.

4. Foundation design must minimise differential settlement particularly between structural elements and ground bearing slabs.

5. Buildings with basement car parks, provided with ventilation in accordance with the Building Regulations, may not require gas resistant membranes for Characteristic Situations 3 and 4.

IAN FARMER ASSOCIATES

Gas and Groundwater Monitoring Results

Contract No:	3914
Contract Name:	Bolton upon Dearne
Date:	14.3.06

Background Readings:

O_2% v/v		CO_2%v/v		CH_4% v/v	
H_2S ppm		CO ppm		N_2 % v/v	

Weather Conditions	
Ground Conditions (dry/wet etc.)	
Atmospheric Pressure (Start):	
Atmospheric Pressure (Finish):	

Hole No:	Time (hh:mm)	O_2% v/v Lowest	CO_2% v/v Steady	CH_4% v/v Steady	H_2S ppm Steady	CO ppm Steady	N_2 % v/v Steady	Gas Flow Rate (l/hr) Steady	SWL mBGL	Base of Pipe mBGL
BH3									0.4	
BH4									DRY	
BH5									DRY	
BH6									DRY	
BH7									GL	

Remarks: BH7 flooded by surface water

ND = Below detection limit of instrument. NR = Not Read.

Readings are taken over a 30 second period.

Readings Taken By:	
Checked By:	

IAN FARMER ASSOCIATES

Gas and Groundwater Monitoring Results

Contract No:	3914
Contract Name:	Bolton upon Dearne
Date:	21.03.06

Background Readings:

O_2% v/v	17.5	CO_2%v/v	ND	CH_4% v/v	ND
H_2S ppm	ND	CO ppm	ND	N_2 % v/v	82.4

Weather Conditions	RAINING
Ground Conditions (dry/wet etc.)	WET
Atmospheric Pressure (Start):	1009
Atmospheric Pressure (Finish):	1008

Hole No:	Time (hh:mm)	O_2% v/v Lowest	CO_2% v/v Steady	CH_4% v/v Steady	H_2S ppm Steady	CO ppm Steady	N_2 % v/v Steady	Gas Flow Rate (l/hr) Steady	SWL mBGL	Base of Pipe mBGL
BH3		17.5	ND	ND	ND	ND	82.4	0	0.34	3.3
BH4		17.5	ND	ND	ND	ND	82.4	0	DRY	4.22
BH5		17.6	ND	ND	ND	ND	82.4	0	DRY	6.3
BH6		17.7	ND	ND	ND	ND	82.4	0	DRY	5.4
BH7									0.1	6.74

Remarks: BH7 flooded by surface water

ND = Below detection limit of instrument. NR = Not Read.

Readings are taken over a 30 second period.

Readings Taken By:	
Checked By:	

IAN FARMER ASSOCIATES

Gas and Groundwater Monitoring Results

Contract No:	3914
Contract Name:	Bolton upon Dearne
Date:	27.3.06

Background Readings:

O_2% v/v		CO_2%v/v		CH_4% v/v	
H_2S ppm		CO ppm		N_2 % v/v	

Weather Conditions	RAIN
Ground Conditions (dry/wet etc.)	WET
Atmospheric Pressure (Start):	
Atmospheric Pressure (Finish):	

Hole No:	Time (hh:mm)	O_2% v/v Lowest	CO_2% v/v Steady	CH_4% v/v Steady	H_2S ppm Steady	CO ppm Steady	N_2 % v/v Steady	Gas Flow Rate (l/hr) Steady	SWL mBGL	Base of Pipe mBGL
BH3									GL	1.35
BH4									DRY	1.2
BH5									DRY	4.2
BH6									DRY	3.4
BH7									GL	4.65

Remarks: BH7 flooded by surface water

ND = Below detection limit of instrument. NR = Not Read.

Readings are taken over a 30 second period.

Readings Taken By:	
Checked By:	

IAN FARMER ASSOCIATES

Gas and Groundwater Monitoring Results

Contract No:	3914
Contract Name:	Bolton upon Dearne
Date:	5.4.06

Background Readings:

O_2% v/v	21	CO_2%v/v	ND	CH_4% v/v	ND
H_2S ppm	ND	CO ppm	ND	N_2 % v/v	79

Weather Conditions	SUNNY
Ground Conditions (dry/wet etc.)	BH6, BH7 WET
Atmospheric Pressure (Start):	1011
Atmospheric Pressure (Finish):	1012

Hole No:	Time (hh:mm)	O_2% v/v Lowest	CO_2% v/v Steady	CH_4% v/v Steady	H_2S ppm Steady	CO ppm Steady	N_2 % v/v Steady	Gas Flow Rate (l/hr) Steady	SWL mBGL	Base of Pipe mBGL
BH3		20.9	ND	ND	ND	ND	79.1	0	0.36	3.3
BH4		18.7	2.5	ND	ND	ND		0	DRY	4.22
BH5		20.9	0.2	ND	ND	ND	79.1	0	DRY	6.3
BH6		21	ND	ND	ND	ND	79	0	DRY	5.44
BH7										6.77

Remarks: BH7 flooded by surface water

ND = Below detection limit of instrument. NR = Not Read.

Readings are taken over a 30 second period.

Readings Taken By:	
Checked By:	

IAN FARMER ASSOCIATES

Gas and Groundwater Monitoring Results

Contract No:	3914
Contract Name:	Bolton upon Dearne
Date:	4.5.06

Background Readings:

O_2% v/v	20.7	CO_2%v/v	ND	CH_4% v/v	ND
H_2S ppm	ND	CO ppm	ND	N_2 % v/v	79.2

Weather Conditions	DRY SUNNY
Ground Conditions (dry/wet etc.)	DRY SUNNY
Atmospheric Pressure (Start):	1008
Atmospheric Pressure (Finish):	1009

Hole No:	Time (hh:mm)	O_2% v/v Lowest	CO_2% v/v Steady	CH_4% v/v Steady	H_2S ppm Steady	CO ppm Steady	N_2 % v/v Steady	Gas Flow Rate (l/hr) Steady	SWL mBGL	Base of Pipe mBGL
BH3	12:35	20.4	ND	ND	ND	ND	79.5	0.1	0.6	1.25
BH4	13:20	17.7	0.1	ND	ND	ND	82.1	0.1		2.15
BH5	13:10	20.5	ND	ND	ND	ND	79.4	0		4.25
BH6	12:50	20.7	ND	ND	ND	ND	79.2	0.1	DRY	3.36
BH7	13:00	20.1	ND	ND	ND	ND	79.8	0	GL	4.65

Remarks: BH7 flooded by surface water

ND = Below detection limit of instrument. NR = Not Read.

Readings are taken over a 30 second period.

Readings Taken By:	
Checked By:	