

Other Safety

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REVIEW OF LANDFILL GAS: INCIDENTS AND GUIDANCE

by E M Gregson

Introduction

This note reviews landfill gas incidents in the UK over the period 1987 - 1995 and also provides details of the main sources of guidance on the safe control and use of landfill gas.

Background

Landfill gas is produced by the microbial decomposition of landfilled waste in an oxygen free (anaerobic) atmosphere. The gas is approximately 65% methane and 35% carbon dioxide plus traces of other organic vapours. Its composition varies with age and the type of waste. The odour of landfill gas is associated with trace compounds such as hydrogen sulphide, mercaptans and ethylene.

The rate and duration of gas production depends on the nature of the waste and oxygen availability. Some sites may continue gassing for over 50 years. The gas can move or 'migrate' in any direction within the site, depending on the permeability of the waste layers. It can also migrate off-site, if measures are not taken to prevent it. One indication that gas is escaping from the site and venting through the ground outside is the presence of yellow and dying vegetation.

Landfill gas, being predominantly methane, is flammable. (Methane has a flammable range of between 4.4% and 15% by volume in air.) As the gas migrates, it can accumulate in voids, underground services, buildings etc. resulting in a risk of fire and explosion.

Gas monitoring and control measures are the responsibility of the site operator and are described in the conditions of the site licence issued by the Environment Agency (EA) or the Scottish Environmental Protection Agency (SEPA). The aim of gas control is to prevent migration off-site. This can be achieved by a gas barrier (lining of the excavation) combined with stone filled vent trenches which can vent gas to atmosphere. Venting can also be carried out using borehole pipes spread throughout the site or at selected points where gas can be pumped to them through a gas drainage system inside the tip. If the quantity or quality (odour) of the gas is such that it requires destroying a 'flare-off' system may be adopted.

Landfill gas can also be exploited for industrial use. This may be as fuel to a nearby factory or to produce electricity either for local consumption or for the national grid.

The end result of landfill is generally the restoration of the land to agriculture or similar purposes. This can be achieved by capping the area with an impermeable layer of clay followed by layers of subsoil and soil. Aftercare of the site may be necessary and will involve monitoring the land for gas.

If the site is in a prime location such as within a town or city it may be used for building, even though the site is still gassing.

Incidents involving landfill gas

Incident data for the period 1970 to 1995 is given in **table 1**. It was taken from four sources:

- a. FIREX (the TD E5 fire and explosion incident database). All the incidents on FIREX have been reported to HSE under RIDDOR;
- b. TDFCGVR, the Technology Division, Field Consultant Group Visit Report database;
- c. The results of a previously unpublished survey carried out by the Technology Division of HSE in December 1989;
- d. A Department of the Environment publication 'The Technical Aspects of Controlled Waste Management. Appraisal of Hazards Related to Gas Producing Landfills Volume 1'.

The majority of the incidents are associated with the accumulation of landfill gas in confined spaces, such as within buildings. In most cases the gas did not ignite or reach a flammable concentration but the levels were sufficient to cause concern and in some cases the site was evacuated as a precaution. There are about ten incidents where the gas ignited resulting in injury.

Guidance on landfill gas

Table 2 lists all documents consulted during the review. Those which are considered to provide particularly useful background information and guidance are given below: Department of Environment, Transport and the Regions (DETR) (previously Department of Environment) :

Waste Management Paper No. 27: Landfill Gas, A Technical Memorandum providing guidance on the monitoring and control of landfill gas 2nd Edition, 1991

Waste Management Paper No. 26A: Landfill Completion, 1994

Waste Management Paper No. 26B: Landfill Design, Construction and Operational Practice, 1995

Waste Management Paper No. 4: The Licensing of Waste Facilities, 2nd Edition 1988

Circular 21/87, Development of Contaminated Land

Other Guidance:

Methane: Its Occurrence and Hazards in Construction, CIRIA Report 130 1993.

Monitoring of Landfill Gas. Institute of Waste Management. June 1990.

The DETR takes the lead on landfill sites and so is responsible for the majority of publications advising on the safe control and monitoring of landfill gas. HSE has not published any guidance on landfill gas but there are a number of internal papers including :

OC846/8, Licensing of Waste Disposal Sites (*HSE role in License reviews*)

OC9/1(Rev), Environmental Protection Act. (*as above, but for general Integrated Pollution Control reviews*)

Guidance on gas monitoring and evacuation procedures

One of the main concerns with landfill gas is the possibility of gas accumulation inside buildings constructed on or close to a landfill site. Protection of new buildings is usually achieved using a dual barrier approach: low permeability gas membrane to resist the passage of gas, and some form of ventilation/extraction system to disperse the gas safely to atmosphere. The requirements for particular developments will be specified by the relevant planning authorities in line with Building Regulations.

Gas monitoring may also be a requirement. However, evidence from HSE's specialist groups indicates that gas detectors are not always installed at the most effective location and the reason for their installation is not always understood by the occupier.

The main source of advice on gas monitoring is Waste Management Paper 27 Appendix C 'Monitoring for landfill gas in buildings'. WMP27 gives information on portable monitoring equipment, including how and where to take samples. There is no equivalent advice for the installation of fixed gas detectors used for continuous monitoring inside buildings. In general, there is little guidance on the installation of gas detectors. A draft European standard prEN 50073 'Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of combustible gases' is in preparation. Publication is expected in 1999. With regard to evacuation of sites affected by landfill gas WMP27 Appendix C is again the main source of guidance. It recommends that continuous monitoring devices should be set to alarm at a methane concentration of 1%v/v (20%LEL) or carbon dioxide in excess of 1.5%. Buildings should be evacuated if these concentrations are detected.

WMP27 also recommends an action level at a methane concentration of 0.25%v/v (5%LEL) or carbon dioxide in excess of 0.5%v/v. The recommended actions are shown in **table 3** below.

Update since this DIN was written

BS EN 50073, as referred to above, has now been published providing non application specific guidance for point detectors.

In addition, there are a number of other recent standards on various aspects of gas detection e.g. BS EN 50054, IEC 61779 (various parts), BS EN 50241 and BS EN 50270.

According to evidence from the RSG's, a gas alarm level of 20%LEL, as recommended by WMP27, has been widely implemented. However, the recommendation for a lower action level (5%LEL) is not necessarily adopted. A lower action level has obvious advantages. It gives more time to assess the risk, identify the source and point of ingress and introduce remedial measures. It also gives more time to evacuate personnel, if necessary. This would seem particularly relevant where large numbers of the public may be present - increasingly business parks and retail complexes are being built on former landfill sites.

Table 1 Incidents involving landfill gas from 1970 to 1995

Key

FIREX = HSE, TD fire and explosion database

TDFCGVR = TD & FCG visit report database

TD = Incidents, from list compiled by Technology Division, HSE, December 1989 (unpublished)

DoE = from 'The Technical Aspects of Controlled Waste Management. Appraisal of Hazards

Related to Gas Producing Landfills Volume 1'. Department of the Environment, Waste

Technical Division

Date	Location	Incident	Source
1995	Bramfield Herts	Installing electro-fusion welded plastic joint. Landfill gas ignited and lifted borehole head. 1 injured.	FIREX TDF CGVR
1995	Crowborough, E. Sussex	Gas sampling at industrial estate adjacent to landfill site. Gas detected. Ventilation and monitoring recommended	TDFC GVR
1994	Loughborough	Possibility of gas build-up in treatment plant adjacent to landfill site.	TDFC GVR
1993	Midhurst, W Sussex	Construction work on former landfill site. Risk from gas assessed.	TDFC GVR

Date	Location	Incident	Source
1992	Inverness	Landfill gas detected in industrial estate adjacent to active landfill site. Methane generation affected by tidal levels. Gas monitoring required.	TDFC GVR
1992	Airdrie	Landfill gas migrating into adjacent property, causing concern. Continuous monitoring and ventilation of buildings.	TDFC GVR
1992	Alton, Staffordshire	Methane detected on site of 'haunted house' at amusement park. Source not discovered. Ventilation and gas detectors installed	TDFC GVR
1992	Farnborough	Buildings constructed on old landfill site. Recommendation to repair any cracks in building rafts caused by subsidence.	TDFC GVR
1992	Newport, Gwent	Concern about levels of gas during road construction across former landfill site.	TDFC GVR
1992	Bracknell	Concerns about gas from council-owned landfill site	TDFC GVR
1991	Area 10	Nature reserve formed on old landfill site. Teenagers gained unauthorised access to underground culvert. Lit match and ignited gas. 3 injured.	FIREX
1991	Area 15	Landfill gas built up inside house adjacent to waste disposal site detected by routine monitoring. Extension built over deep water well.	FIREX
1991	Reading	Gas smelled in warehouse, site evacuated for 24 hours. Analysis showed it to be landfill gas.	FIREX
1991	Barry, S. Glam	Concern about proposed development of landfill site for residential, leisure, commercial and office use.	TDFC GVR
1991	Halesowen, Birmingham	Design and construction of buildings on a former landfill site.	TDFC GVR
1991	Preston	Concerns about gas in factory next to completed landfill site.	TDFC GVR
1990	Barnsley	Landfill gas detected in factory adjacent to landfill site.	TDFC GVR
1990	Catwick, North Humberside	Concern about landfill gas migrating from completed site into complex of former farm buildings.	TDFC GVR
1990	Thurmaston, Leicester	Premises built on former landfill site. Gas entering through cracks in the floor. Ventilation and gas monitoring recommended.	TDFC GVR
1990	Bradwell	Concern about landfill gas entering cave system from proposed disposal of waste in disused quarry.	TDFC GVR
1990	Pontyclun, Mid Glam	Concern about lighting for public footpath next to landfill site,	TDFC GVR
1990	Ebbw Vale, Gwent	Drilling in shaft used for venting on a landfill site. Spark from unprotected drill ignited gas. 3 injured	FIREX TDFC GVR
1989	Croydon	Minor ingress into school	TD
1989	Rochdale	Emission at school playing field	TD
1989	Area 5	Ingress from floor of warehouse, built on landfill site.	FIREX
1989	Tonbridge	Factory units built on former landfill site. Gas detected by monitors and levels triggered the alarm at 5%LEL. The fire brigade evacuated the whole site.	TD
1989	Warrington	20 year old workshops and offices built on former landfill site. Low levels of gas detected. Monitoring recommended.	TDFC GVR
1989	Rainham, Essex	Ingress of gas into industrial units built on landfill site.	TDFC GVR
1988	Huncote, Leics	Methane detected around the lower explosive limit (LEL) within a recreation centre. The centre was built in 1978 on the site of a landfill closed in 1974. Design of the centre did incorporate ventilation to alleviate problems although subsequent settlement of waste left void spaces for gases to collect. The centre closed whilst remediation was investigated.	DoE
1988	Appley Bridge, Lancs	Partial blockage of passive venting trench was thought to have allowed excessive off site migration of LFG. An accumulation of methane in the site offices some 50m off site was ignited and exploded causing structural damage. No staff occupied the building at the time.	DoE
1988	Leigh, Wigan	Building developer forced to stop work when LFG was seen bubbling through puddles at distances up to a quarter of a mile from a redundant landfill site.	DoE

Date	Location	Incident	Source
1988	Stangate, Kent	Extensive LFG migration was detected around a landfill quarry. Vegetation near the site died and explosive levels of methane detected in soils around neighbouring houses.	DoE
1988	Shropshire	LFG was escaping from a site and had been detected in neighbouring homes. A passive venting system proved ineffective in preventing off site migration.	DoE
1988	Eastwood Quarry Notts	Despite a passive venting system installed to prevent off site migration, LFG continued to be detected around residential properties as close as 10m to the boundary of a redundant landfill.	DoE
1988	Atherstone Warks	Residential estate had been developed adjacent to a redundant landfill. Monitoring within homes detected low levels of methane in some down stairs rooms.	DoE
1988	Nuneaton, Warks	Methane concentrations up to 3.3% were detected in a sewer running close to the boundary of an infilled clay quarry and into the grounds of a hospital some 200m away.	DoE
1987	Stone, Dartford	Temporary throttling back of gas abstraction during Christmas vacation was thought to have allowed excessive off site migration of LFG. An accumulation of methane, forming an explosive mixture within a house less than 50m from the site boundary was ignited. An occupant suffered mild burns and temporary deafness. The building was structurally damaged.	DoE
1987	Maidstone Kent	Rapid build up of methane in manholes close to collages near to a landfill site occurred as melting snow stimulated gas production. Immediate remediation was required.	DoE
1987	Drighlington Leeds	Occupants of a house were evacuated when methane was found to have migrated from an adjacent landfill site, accumulating in a cellar to explosive levels.	DoE
1987	Blackburn	Concern about new factory being built on landfill site. Ventilation within the building and below the base slab.	TDFC GVR
1986 to 1988	West Midlands	7 incidents were reported in which methane at levels of 30-50% by volume were detected within residential areas. In one instance in Walsall in 1986, a porch was destroyed as a result of methane accumulating and exploding in a property some 100m from a landfill completed in 1975. Another incident required a property to be evacuated	DoE
1986	Loscoe, Derbys	Coinciding with a rapid drop in barometric pressure, methane migrating from an adjacent landfill site was drawn into a bungalow less than 20m from the site boundary. An explosive mixture was ignited, totally destroying the building and injuring 3 occupants.	DoE
1986	N Ireland	Explosion in factory, 1 fatal	TD
1985	Mellers Tip Preston	LFG was detected within a residential area adjacent to a landfill site, putting an estimated 30 houses at risk.	DoE
1984	Abbeystead	Explosion in valve house, 16 fatal, 17 injured. (Naturally occurring methane)	TD
1984	St Helens, Lancs	Investigation revealed LFG to be migrating from an infilled quarry through shallow coal workings. Methane was detected at significant concentrations in and around residential properties. Remediation required grouting the workings to prevent lateral migration of methane.	DoE
1983	Doncaster, Yorks	Migration control scheme proved ineffective in preventing the detection of methane within new residential properties adjacent to completed landfill.	DoE
1983	Nuttall	Explosion in manhole. Landfill gas.	TD
1982	Middleton Broom	Methane detected in houses bordering landfill sites gave rise to serious anxieties amongst residents. Despite remediation further accumulations were found in surface water drains and service ducts in 1983.	DoE
1982	Morley, Leeds	Explosive concentration of methane was ignited in a sewer beneath a landfill, injuring two young boys.	DoE
1982	London	Explosion in cable manhole, 2 injured	TD
1982	Sheffield	Explosion in water borehole. (Naturally occurring methane)	TD
1980	Ormskirk	Explosion in manhole, 2 injured.	TD
1980?	North West	Person killed when entering a culvert containing an asphyxiating atmosphere of LFG.	DoE
Pre 1981	GLC-3 Case Studies	1971 - Gas migration from a complete landfill in a worked out chalk quarry on the North Downs, was of concern to neighbouring residential properties. On completion of another site, methane was found to be migrating towards adjacent farm land adversely affecting the growth of crops.	DoE
	Various Cases	- 2 instances of gas accumulating to alarming concentrations in buildings built on completed landfill. In one an explosion caused injury to a woman.	DoE
		- 1 instance of serious subsidence, necessitating demolition of several buildings built on a completed landfill significant concentrations of methane detected in manholes and cracks.	DoE

Date	Location	Incident	Source
		- 3 instances of lateral gas migration causing problems to residential properties, a school play area and a telephone service duct beneath a motorway.	DoE
		- several migration problems around the perimeters of landfill sites in the chalk formations of Kent and Surrey.	DoE
1979	Christchurch	Explosion in toilet. 1 injured	TD
1978	Aveley, Essex	Serious odour nuisance reported from residents surrounding the site including some complaints of site including some complaints of sore throats and headaches.	DoE
1977	Huddersfield	Ignition at water borehole. (Naturally occurring methane)	TD
1977	Pudsey	Ignition at water borehole. (Naturally occurring methane)	TD
1972	Airdrie	Ignition in manhole, one injured.	TD
1971	Steventon	Explosion at well cover injured one. (Naturally occurring methane)	TD
1970	Stone, Kent	Accumulation of CO ₂ in the basement of an off site house provided an asphyxiating atmosphere. 2 men entering collapsed and 1 died.	DoE

Table 2 Landfill references

HSE	
1	HSE OC 9/1(Rev), Environmental Protection Act. (Internal only)
2	HSE OC 846/8, Licensing of Waste Disposal Sites (Internal only)
3	Hazards in Buildings on Landfill Sites: a First Analysis A R Baker HSE, Research & Laboratory Services Division, July 1981.
4	Examination of the premises of Trent Engineering Co Ltd, Lenton, Nottingham in relation to the presence of methane and other gases. A R Baker, C H H Willis. HSE, Research & Laboratory Services Division, June 1981.
5	The Validation of Methodology in the Determination of Methane in Water. Phase 1 - Literature Review and laboratory Trials. October 1988. Report No. CO 1911 -M/1/EV 8710. By: N C Blakey & D A Cooke, Water Research Centre. (Internal for HSE)
6	The Validation of Methodology in the Determination of Methane in Water. Phase 2 - Field Monitoring Exercise. May 1989. Report No. CO 2179-M. By: K Lewin, Water Research Centre
7	The Validation of Methodology in the Determination of Methane in Water - Final Report. March 1990. Report No. CO 2401-M. By: K Lewin, N C Blakey & D A Cooke, Water Research Centre
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9	Waste Disposal Training Notes (Draft) 1997. HSE Metals & Minerals Sector (Quarries) (Internal only)
Department of Environment, Transport and the Regions (DETR)	
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13	Waste Management Paper No. 26B: Landfill Design, Construction and Operational Practice, DoE, 1995. HMSO.
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15	Waste Management Paper 26E, Landfill Restoration and Post Closure Management (Consultation draft August 1996)
16	Waste Management Paper No. 27, Landfill Gas, DoE, 2nd Edition, 1991. HMSO.
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19	Guidelines for the Safe Control and Utilisation of Landfill Gas. Part 2 - Control and Instrumentation. ETSU B 1296-P2. DoE Report CWM067B/92. DoE Wastes Technical Division
20	Guidelines for the Safe Control and Utilisation of Landfill Gas. Part 3 - Environmental Impacts and Law. ETSU B 1296-P3. DoE Report CWM067C/92. DoE Wastes Technical Division
21	Guidelines for the Safe Control and Utilisation of Landfill Gas. Part 4A - A Brief Guide to Utilising Landfill Gas. ETSU B 1296-P4A. DoE Report CWM067D1/92. DoE Wastes Technical Division

22	Guidelines for the Safe Control and Utilisation of Landfill Gas. Part 4B - Utilising Landfill Gas. ETSU B 1296-P4B. DoE Report CWM067D2/92. DoE Wastes Technical Division
23	Guidelines for the Safe Control and Utilisation of Landfill Gas. Part 5 - Gas Wells. ETSU B 1296-P5. DoE Report CWM067E/92. DoE Wastes Technical Division
24	Guidelines for the Safe Control and Utilisation of Landfill Gas. Part 6 - Gas Handling and Associated Pipework. ETSU B 1296-P6. DoE Report CWM067F/92. DoE Wastes Technical Division
25	Construction of new buildings on gas contaminated land. Building Research Establishment 1991
26	Development of Contaminated Land Circular 21/87, DoE
27	The Building Regulations 1991, Approved Document C, Site preparation and resistance to moisture Department of the Environment 1991
28	Note on the development of and after-use of landfill sites, 8th edition, 1990 Interdepartmental committee on the development of contaminated land
	Department of Energy
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39	BRE's Work on Contaminated Land. V. Paul, R. Hartless & S. Gavin. Building Research Establishment, Watford. Environmental Protection Bulletin 029, March 1994, p12-16.
40	Protection of Buildings from Hazardous Gases. Phillipa A Towler & P J Young. Journal of the Institute of Water and Environmental Management 7 June 1993, p283-294.
41	"New Guidelines on Landfill Gas", Chemistry in Britain, January 1997, p9.
42	Working under pressure ?, The Waste Manager. May 1994, p14-15.
43	BS EN 50073 'Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of combustible gases' British Standards Institute

Table 3 Trigger concentrations for gas in buildings

Gas concentration	Location	Action
<p>More than:-</p> <p>1% v/v methane/flammable gas</p> <p>or 1.5%v/v carbon dioxide</p>	<p>Voids in occupied areas; unoccupied voids near occupied areas;</p> <p>points of ingress into occupied areas eg service ducts, cracks at skirtings</p>	<p>Evacuate building;</p> <p>ventilate building;</p> <p>control sources of ignition;</p> <p>identify source of gas;</p> <p>identify points of ingress;</p> <p>institute control measures;</p> <p>monitor continuously.</p>
<p>Equal to or less than:-</p> <p>1% v/v methane/flammable gas</p> <p>or 1.5%v/v carbon dioxide</p>	<p>Anywhere in the building eg occupied or unoccupied voids, points of ingress, service ducts, underfloor cavities etc.</p>	<p>Ventilate areas affected;</p> <p>control sources of ignition;</p> <p>identify source of gas;</p> <p>identify points of ingress;</p> <p>institute control measures;</p> <p>institute monitoring scheme.</p>