WASTE MANAGEMENT INDUSTRY

LANDFILL OPERATIONS INVOLVING

POTENTIALLY EXPLOSIVE ATMOSPHERES

INDUSTRY CODE OF PRACTICE

ESA ICoP 5, edition 1, August 2007

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FOREWORD

James Barrett, Head of the Manufacturing Sector of the Health and Safety Executive.

This code has been prepared by the Environmental Services Association in consultation with the Health and Safety Executive and has been endorsed by the Waste Industry Safety and Health (WISH) Forum which represents the interests of the industry.

This Code should not be regarded as an authoritative interpretation of the law, but if you follow the advice set out in it you will normally be doing enough to comply with health and safety law in respect of those specific issues on which the Code gives advice. Similarly, Health and Safety Inspectors seeking to secure compliance with the law may refer to this Guidance as illustrating good practice.

The HSE believes that the contents of this Code demonstrate good practice in the waste management industry and commends its use.

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In this document, footnotes are indicated with letter ([a]) and endnotes (references to documents used) with a number ([1]).

1 INTRODUCTION AND SCOPE

1.1 Executive summary

This document (ESA ICoP 5) is one of a number called up by the primary document (ESA ICoP 1) that, together, advise on how to fulfil the requirements of the Dangerous Substances Explosive Atmospheres Regulations:2002 ('DSEAR')[1] for the waste management industry. Within this ICoP, a 'hazardous area' is one in which a flammable gas/air mixture is, or could be, present. Other risks not relating to the risk of fire or explosion (e.g. toxic risks) are not covered.

ICoP 5 attempts to apply existing codes of practice to the specific situations found in waste management industry operations associated with landfill gas extraction. ICoP 6 will deal with operations associated with landfill gas treatment and other waste management activities.

ICoP 5 comprises a set of recommendations only and is not mandatory, but is intended to represent good practice. Alternative practices may be employed provided the level of safety is maintained. Site-specific factors should always be considered when applying this ICoP. Throughout ICoP 5, there are situations covered that may require additional verification of the validity of the assumptions. On a particular site, it is the Site/Facility Manager[a] who holds the final responsibility to ensure DSEAR compliance.

The intention is that as many as possible of the standard situations will be included in this ICoP to allow the operation of waste management facilities to be performed in a consistent manner across the industry by suitably-qualified persons, while complying with DSEAR.

It is envisaged that this Edition will be reviewed and re-issued during 2007. In the interim, further information in the form of method statements may be made available as addendums. Comments from the industry are welcomed and should be sent to ESA (m-kelly@esauk.org) before 31 December 2006.

1.2 Scope

This ICoP should be applied in the design of new works, the maintenance and extension of existing works and other operations performed by the waste management industry.

Part 1 operations associated with landfill gas extraction
This will be further sub-divided into the following:

Engineering, covering
1 Development
2 Construction (capping and completion)
3 Maintenance and aftercare
4 Temporary works
5 Day-to-day operations

Part 2 operations associated with landfill gas treatment and other waste management activities; this will be included in a subsequent edition of this ICoP.

This document does **not** consider
- drilling operations, for which a safe system of work is currently being developed in association with the relevant bodies;
- safety issues associated with toxic, asphyxiant or other hazards associated with landfill materials;

[a] Wherever this term is used, it should be understood that the Site/Facility Manager can appoint another person for certain duties, but the Site/Facility Manager holds overall responsibility for ensuring that the duties are carried out.

Many aspects of waste industry activities that relate to DSEAR compliance are covered by other ICoPs in the series:

- Top-level document (ESA ICoP 1) – Edition 1 published November 2005
- Area classification for landfill gas (ESA ICoP 2) – Edition 2 published April 2006
- Leachate storage, treatment and disposal (ESA ICoP 3) – Edition 1 published April 2006
- Drilling (ESA ICoP 4) – under discussion
- Operations (treatment) (ESA ICoP 6) including liquid treatments/solidification, advanced conversion technologies, aerosol destruction facilities – under discussion
- Solid waste non-destructive facilities (ESA ICoP 7), including civic amenity (CA) sites, transfer stations and materials recycling facility (MRF) – under discussion

1.3 Quick-start guide

The following steps give a typical route for a site to be DSEAR compliant. ICoP 1 gives more details. This is only a summary of the requirements and is not intended to be an exhaustive coverage. The most useful document that covers DSEAR requirements in general terms is the HSE publication, Approved Code of Practice L138[2].

1. Perform an area classification of the site and produce an area classification drawing (guidance in ICoP 2 Edition 2)
2. Mark hazardous areas and pipes (see section 5.6.7 of this ICoP)
3. Identify activities associated with an explosion risk that require risk assessments and write the relevant method statements (use the templates in the relevant Appendices in this ICoP).
4. Compile a database of all fixed electrical and non-electrical equipment that is located in zoned areas plus all portable/transportable equipment that may be used in hazardous areas. Each item should be uniquely identified.
5. Set in motion an inspection programme such that all the equipment in hazardous areas is inspected at least once every three years against EN 60079-17 (every 12 months for portable equipment). Many companies employ outside contractors to do this, but the database will need to be up-to-date before they can start.
6. Ensure the site procedure for accidents, incidents and emergencies is available and up-to-date – more information is given in section 5.6.5 of this ICoP.
7. Ensure that the Site/Facility Manager (or another suitable person) is adequately trained to verify that new installations comply with DSEAR, since this is the person who must sign off new installations before they are put into service. Identify any other training needs, particularly ensuring that the explosive risks of landfill gas are included in site inductions. Ensure that the duty of co-ordination between the Site/Facility Manager and the contractors is carried out. More information is given in section 5.6 of this ICoP.

2 GLOSSARY OF TERMS

Table 1: glossary of terms

Term	Explanation
Apparatus group	The part of the certification code (IIA, IIB, IIC or II) that indicates the range of gases and vapours for which the equipment is suitable. Equipment marked IIC or II is suitable for all gases and vapours (provided the temperature class is appropriate). IIB equipment is suitable for IIA and IIB gases. IIA equipment is suitable only for IIA gases.
Area classification	The process of zoning the site to delineate between hazardous areas and non-hazardous areas
Basal seal	Mineral liner, plastic membrane, combination liner or other impermeable material underneath the waste, primarily engineered to prevent leachate from seeping into the ground below the landfill.

Table 1: glossary of terms	
Term	**Explanation**
Butt welding (of pipes)	This is usually a fully-automatic process, but overseen by an operator. The pipe is placed into a mechanical alignment machine. A planer is placed between the pipe ends and the pipe ends are planed square. The planer is powered by an electric motor. A hot plate is then placed between the two pipes ends to melt the pipe; once melted, the two ends are forced together for a set period of time. The hot-plate is a hollow-steel plate which is oil filled, with heating coils immersed in the oil. These machines are usually powered by an external portable generator.
Category 1G equipment	Equipment with a very high level of protection, suitable for installation in zone 0[b]; it may equally be used in zones 1 and 2. Most category 1g electrical equipment is protected by intrinsic safety.
Category 2G equipment	Equipment with a high level of protection, suitable for installation in zone 1; it may equally be used in a zone 2.
Category 3G equipment	Equipment with a standard level of protection, suitable for installation in zone 2.
Electrofusion welding (of pipes)	A method for welding together two pieces of HDPE pipe. A collar with integral heating coils is placed over the pipe and connected to a control box, which supplies the current to heat the coils; when the joint is made, the collar and integral coils remain on the pipe
Extrusion weld	Extrusion welding uses a commutator-type electric drill with a heater box attached. The heater box is designed on the same principal as a hot air drier with the same exposed heating elements, Both the motor and the heater box receive air from the surrounding environment.
FID	Flame ionisation detector – generally used for surface emissions monitoring, typically up to 1000 or 10,000 ppm of hydrocarbons depending on the model
Flameproof (Ex d)	A method of protection whereby the equipment is protected for use in a potentially explosive atmosphere by being enclosed in an explosion-proof enclosure. This method is suitable for a wide range of applications, such as motors, luminaires, junction boxes, switch units, instruments, etc. Such equipment is permitted in zones 1 and 2. See also Appendix 3.
Flux box	A chamber that, when sealed against a landfill surface, allows surface emissions to enter by diffusion as a result of the concentration gradient between the landfill surface and atmosphere.
FML	Flexible membrane liner (synonymous with 'geomembrane') – used for capping cells. There are various grades of flexibility (e.g. VFML = very flexible membrane liner)
Fusion weld	Fusion welding involves the use of commutator-type electric motor to power a heated wedge (also known as a wedge welder) along the joins between two geo-membrane panels. The electric motor receives cooling air from the surrounding environment, notably at the seam where the edges of the panels meet.
Geomembrane	A plastic sheet used to cap wells – also known as a 'flexible membrane liner'.
Hazardous area	An area where there is a reasonable probability of finding a potentially explosive atmosphere
Increased safety (Ex e)	A method of electrical protection that eliminates sources of ignition inside the enclosure, which is also weatherproof. Increased safety is used as an alternative to flameproof for some items, such as luminaires, junction boxes and larger-frame motors. Like flameproof, Ex e equipment can be used in zones 1 and 2. See also Appendix 3.
Intrinsic safety (Ex ia, Ex ib)	A method of protection, only applicable to low-power electrical equipment, which prevents the equipment igniting a potentially explosive atmosphere by limiting the energy of sparks to a safe level; similarly, there are no excessively hot surfaces. Intrinsic safety is the most common method of protection for instruments and allows them to be used in zones 0, 1 and 2 (Ex ia) or zones 1 and 2 (Ex ib). Such equipment is describe ed as being 'intrinsically safe' – this term is frequently over-used and cannot, for example, be used to describe motors, luminaires, pumps, etc. Some torches are partly or fully intrinsically safe. See also Appendix 3.

[b] Note that equipment should ideally be installed in the non-hazardous area or, if in a hazardous area, in the zone of least risk

Table 1: glossary of terms	
Term	**Explanation**
Leachate	A water-based liquid that collects in a landfill site, containing numerous contaminants depending on the constituents leached from the landfill mass
Lower explosive limit (LEL)	The minimum amount of flammable gas that, mixed with air, will produce a potentially explosive atmosphere; it is usually expressed as a percentage by volume
Maintenance	See section 4.
Negligible extent	Where the estimated volume of a potentially explosive atmosphere is small (less than 0.1 m^3, equivalent to a sphere of radius 0.3 m)[c], it is defined as having 'negligible extent' and no zoning applies.
Non-hazardous area	An area where there is a negligible or extremely low probability of a potentially explosive atmosphere being present; such an atmosphere may be present under catastrophic failure conditions or during maintenance activities
Permit-to-work	See section 5.5.13
Potentially explosive atmosphere	A mixture of gas and air that is within the flammable range, i.e. Between the LEL and UEL
Potentially flammable atmosphere	Synonymous with 'potentially explosive atmosphere' – this term is preferred by the Institute of Petroleum Code Part 15 for area classification ('IP15')
Purging	A process for replacing one gas with another, usually landfill gas with air (or sometimes nitrogen). Purging may be required prior to pipe repairs and achieved by inserting an air supply pipe into the section of isolated pipe or using the air leaking in from a break to flush the landfill gas down the pipe to the next isolation valve.
Saddle patch	A plastic patch, shaped so that it fits snugly over a pipe, which is then electrofusion welded to the pipe to give a permanent repair
Second-hand equipment	From the point of view of the ATEX Directive, this is all equipment except that purchased directly from the manufacturer. It could be previously used/installed equipment, hired in equipment, new equipment that has been held in stores, or new equipment that has been purchased from a distributor.
Site/Facility Manager	The person holding overall responsibility for ensuring that all duties relating to compliance with the various regulations are carried out. Wherever this term is used, it should be understood that the Site/Facility Manager can appoint another person for certain duties.
Temperature class	Equipment is designated with a temperature class, T1 to T6; T6 equipment is the coolest (below 85°C), whereas T1 equipment is the hottest (below 450°C). Gases and vapours are also assigned temperature classes T1 to T6 to allow suitable equipment to be chosen.
Type 'n' (or 'N') protection	This is a level of protection that is only applicable to electrical equipment for use in zone 2 and uses a variety of protection methods to provide a basic level of security against igniting a potentially explosive atmosphere. See also Appendix 3.
Upper explosive limit (UEL)	The maximum amount of flammable gas that, mixed with air, will produce a potentially explosive atmosphere; it is usually expressed as a percentage by volume
Vacuum tester	A box-like piece of equipment that is used to test the integrity of a extrusion-type plastic weld on geo-membrane.
Wedge welder	See 'Fusion weld'
Zone 0	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
Zone 1	A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

c Strictly speaking, a 'hypothetical volume' (V_Z) of less than 0.1 m^3 rather than a zone volume is the criterion for being "of negligible extent". EN 60079-10:2003 calculation 4 (conclusion) states that a V_z <0.1 m^3 allows the ventilation to be assessed as degree 'high'. From the definition of degree 'high' in clause B.3.1, a zone of negligible extent results.

Table 1: glossary of terms	
Term	**Explanation**
Zone 2	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

3 PROPERTIES OF LANDFILL GAS

Table 2: properties of landfill gas		
Property	**Value**	**Comments**
Constituents	Methane (CH_4)– 60% v/v Carbon dioxide (CO_2)– 40% v/v 35.3% CH_4 by mass	Proportions may vary but these values will be used for calculation purposes (see table below). CO_2 is not flammable.
Molecular mass (M)	27.2 kg/kmol (60% CH_4)	Methane has a molecular mass of 16; carbon dioxide has a molecular mass of 44. Therefore, landfill gas containing 60% methane will have a molecular mass as follows: M = [(60 x 16) + (40 x 44)]/100
Explosive limits[3]	4.4 – 16.5% v/v[d]	Assumed as for pure methane[e] in air
Relative density (air = 1)	0.94	Air has an average molecular mass of 29 kg/kmol
Minimum temperature of landfill gas (for calculation purposes)	10°C	From LFTGN 03[4]
Apparatus group	IIA	As for methane
Auto-ignition temperature	537°C	As for methane
Temperature class	T1	As for methane

Since landfill gas has the least onerous apparatus group and temperature class, all hazardous area equipment is suitable for use with landfill gas provided it has been correctly selected against other criteria, notably the zone.

In preparing this ICoP, the presence of hydrogen as a gas produced in the microbial decomposition of waste has not been considered. In general, as hydrogen is associated with the early stages of the degradation process, it is unlikely that gas extraction for power generation or utilisation (combustion) within a landfill gas flare would be initiated. However, it may be the case where some form of odour control involving gas collection from waste is required.

Monitoring may take place, indicating the presence of a significant concentration of hydrogen approaching or exceeding the LEL. If this is the case, then a specific risk assessment based on actual measurements and conditions present should be undertaken to identify any risk of a potential explosive atmosphere being present with, where required, suitable and sufficient mitigating measures put in place. Hydrogen is a IIC/T1 gas with an LEL of 4% v/v.

There are many other components associated with the decomposition of waste – refer to LFTGN 04[5] which addresses the health and environmental aspects, but not primarily the flammable risk.

d BS EN 61779-1:2000 quotes 4.4% – 17%

e It is likely that the LEL for landfill gas is higher than that of pure methane, on account of the CO_2 content

4 GENERAL PRINCIPLES OF OPERATIONS ON LANDFILL SITES

The approach should be to ensure that, **wherever possible, flammable materials should be absent from the workplace** when maintenance activities are being performed. This is not possible in all situations in the waste management industry, but current practices should always be assessed to attempt to find a safer way of working. Hot work (e.g. oxy-acetylene welding) should always be done in a non-hazardous area wherever possible, otherwise under a relevant permit to work.

The sites will already have been zoned in accordance with ICoP 2. The zoning is relevant when temporary working is done in a zone 1 or zone 2, usually without affecting the gas containment. Safety is usually achieved by working under a relevant permit, involving continuous methane monitoring where necessary. Certain equipment should be located outside the hazardous area as a matter of course: Photo 1 shows a generator that could easily be moved outside the zone. (The temporary method of sealing the well is also suspect).

Photo 1: Generator located within a zone 2

Generally, the zoning does not apply to engineering activities involving opening of the containment system, as area classification does not cover such activities, although the zoning is useful background information[f]. In effect, the concept of zones (which relate to everyday running) should be replaced by a consideration of how a potentially explosive atmosphere can be avoided to a very high level of confidence while work is progressing. This may be achieved in a number of ways, singly or in combination, for example:

- isolation valves
- bagging (blocking the pipe being worked on to prevent landfill gas entering the working area)
- squeezing the pipe to cut off the gas
- vacuum testing to determine if a well is under vacuum prior to removing the cap
- purging with air or nitrogen[g]
- continuous methane monitoring
- installation of blanking plates between flanges

Isolation methods may not be completely reliable at preventing gas from seeping through. Insufficient time may be left between isolation and the start of work, such that landfill gas may remain in the pipe in an explosive concentration. Also, gas from another source may be present. For these and other reasons, a gas test is essential, using an appropriate, suitably-certified gas analyser.

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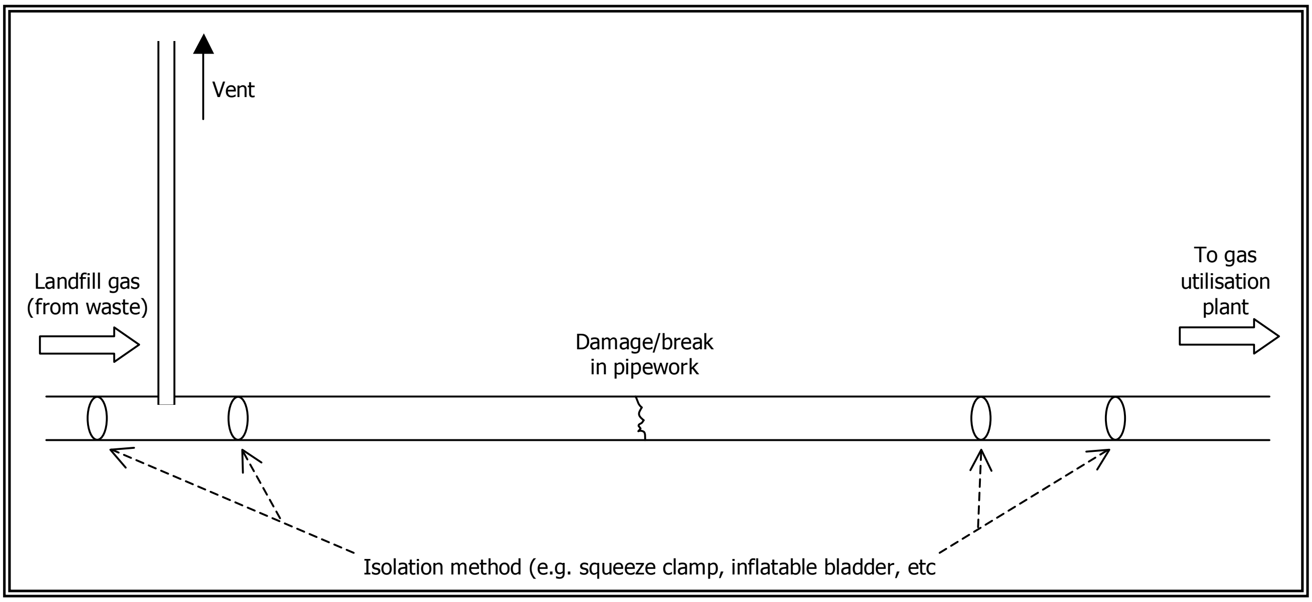
f Some maintenance activities, such as sampling, that do *not* generate an excessively large potentially explosive atmosphere may be included within the area classification process.

g Beware of asphyxiation

Figure 1 shows one method for ensuring effective isolation is that used by the gas industry, using a 'double-block-and-vent' system.

Figure 1: Double block and vent system for isolating pipes



Only when all other options have been exhausted should work in the presence of a potentially explosive atmosphere be contemplated. The risk assessment for such situations is outside the scope of this ICoP.

All work must be carried out by competent persons, using equipment in accordance with the manufacturer's instructions. The various ICoPs assume that the pipework and fabrications are selected, installed and maintained in accordance with best industry practice.

In addition to the correct selection of equipment, it should be noted that wiring faults are a potential ignition source unless the circuit is intrinsically safe and cabling should be installed to minimise the risk of mechanical damage.

5 LANDFILL SITE OPERATIONS

5.1 Development operations

5.1.1 Design

A consideration when designing new facilities is to take account of flammable gases and explosive atmospheres in and around features which are within the waste. It is important that workers can work safely during the life of the installation, without being exposed to potentially explosive atmospheres.

Examples of design considerations are:

1 Segmented concrete rings in a leachate tower are prone to being a source of gas emissions during construction.

2 Some engineering activities take place adjacent to areas where landfill gas is present. Therefore, the impact on these operations needs to be considered, for example extending perimeter walls from an existing (gassing) cell to a new (non-gassing) cell.

3 Designing a feature such as a side-wall riser that has a zone that extends over the site boundary;

4 Inclusion of means of isolation[h] at suitable intervals on the gas collection system to facilitate repair, maintenance and in case of emergencies.

5 Conduits can create a gas path that allows landfill gas to be present in an unexpected place

The designer is required to consider hazards associated with the design and, where possible, reduce the risk by modifying the design. Refer to the designer's role in the CDM[6] Regulations. The CQA[i] plan should pay

h For example, valves, access areas for pinching, port for pigging, etc.

i Construction Quality Assurance procedures due regard to DSEAR requirements. Non-CDM activities should also be assessed with regard to DSEAR requirements.

The following should be considered
- Mount any control cabinets outside the zone from the gas or leachate well
- Install wells after tipping has ceased, so that it is not necessary to control the risk of vehicles close to the well
- Avoid jubilee-clip type connections where better alternatives are available
- Design wells that can be securely capped, so that foam and other unreliable temporary measures need not be used
- Include a vent-trench a few metres from the edge of any geo-membrane liner to extract landfill gas so that welding to the next cell is not done in the presence of a potentially explosive atmosphere
- Avoid perforated pipes above the cap, as these allow landfill gas to escape and also allow air in, producing a potentially explosive atmosphere inside the pipe
- Mild steel rusts quickly and makes modification difficult, encouraging unreliable temporary measures
- Consider locating in-waste monitoring boreholes at the edge of the site rather than in the middle, to avoid having to divert vehicles around these obstructions
- Drainage layers should be capped to avoid the potential of gaseous emissions and the potential for an explosive atmosphere to form
- Side slope risers should be selected to allow for a properly-fitting end-cap, which will facilitate the subsequent installation of pumps and control mechanisms
- Large metal covers that are too heavy to lift easily are a potential spark hazard if dropped down a metal- or concrete-lined well
- Pipework and pipework connections should be to an approved industrial standard: 'home-made' flanges and other connections should be avoided

5.1.2 Environment Agency and other regulatory bodies

The Environment Agency (or equivalent regulatory body[j]) often has a focus on license or permit conditions which control environmental hazards. Within this, there may be no consideration of DSEAR issues, in which case there is an urgent need to discuss this via the appropriate forum. Health and safety issues must take precedence over environmental considerations.

5.1.3 Construction

Constructional activities are to be undertaken with due regard to DSEAR; this will include specific details in such areas as:
- site set-up
- training
- permit to work – see section 5.5.13
- contractor's health & safety plan including method statements, risk assessments, etc.

5.1.4 Designing to minimise equipment in hazardous areas

Wherever possible, installing equipment in hazardous areas should be avoided. If unavoidable, the equipment should be installed in the zone of lowest risk. There are safety benefits with his policy, but there are also a number of additional costs associated with equipment installed in hazardous areas:
- the initial cost is usually considerably higher than equivalent standard industrial equipment;
- installation may involve additional costs if a suitably-qualified person needs to be hired to install it;
- maintenance or calibration may take longer because the equipment may require isolating, due to the flammable risk;
- the equipment requires a periodic inspection[k] to cover its explosion-protection properties, not just its functionality.

Examples of equipment that can usually be located outside the hazardous area are instrument control panels for environmental management systems, pumps, etc. However, where panels are supplied as suitable for use in hazardous areas, these can, of course, be used within a zoned area. Further information on the marking of hazardous area equipment is given in Appendix 3.

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[j] In Scotland, the appropriate body is SEPA.

[k] Reference ESA ICoP 1 section 7 for further information; a typical inspection frequency for fixed equipment is every 3 years.

5.2 Capping and completion

Capping normally takes place when a cell is at the early stages of landfill gas production. Before capping, landfill gas comes out of the waste mass at a relatively even rate and disperses rapidly, such that surface emissions testing usually detects only low concentrations of gas, well below the LEL, a few centimetres above ground level. Placing a geo-membrane[I] on top of the waste mass collects the gas and prevents dispersion, increasing the risk of a potentially explosive atmosphere forming. This is particularly likely to occur, for example, around the points where wedge welding cannot be used and patches are required. However, if scavenger pipes are laid before the geomembrane is deployed then this risk ia eliminated or at least greatly reduced.

This being the case, primary consideration should be given to capping systems that do not involve welding. The welding process itself introduces the following potential ignition sources:

- ♦ heat guns
- ♦ sander
- ♦ fusion (wedge) welder

These are not normally certified items.

The risk of ignition from sanders and wedge welders is low. The risk from hot air guns can be greatly reduced by decreasing the wattage of the heating element. Additional procedures to control the risk from local concentrations of landfill gas are given later in this section.

Alternatives to welding include:

1. 'lap-and-lay' of the geo-membrane (although a limited amount of welding may be required to weld the boot)
2. geo-synthetic clay liners
3. engineered clay
4. adhesives (under consideration by the industry but demonstrated not to provide durable jointing)

Where practicable, non-welding methods should be used. However, there are a number of other factors (apart from DSEAR considerations) that need to be considered, e.g.:

- ♦ the ingress of air under conditions of over-extraction;
- ♦ the ingress of surface water, particularly in the short term;
- ♦ in some areas of the country, there is a shortage of inert material for covering the geo-membrane and welding reduces emissions in these circumstances.

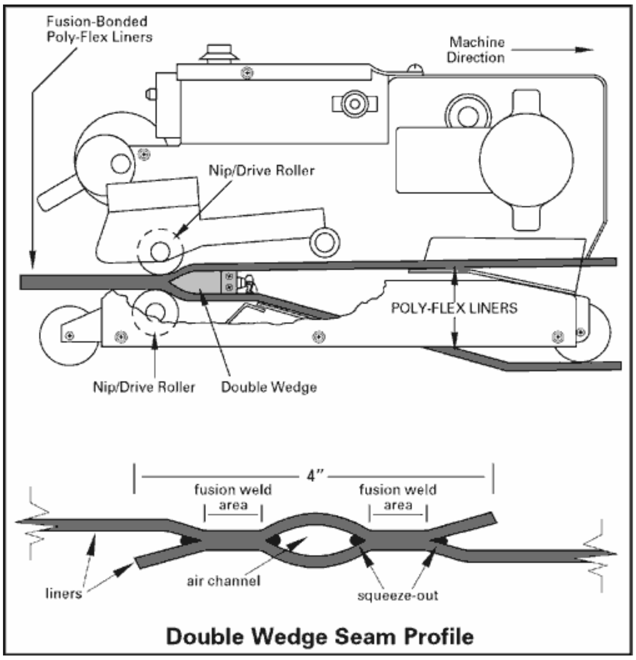
Therefore, welding techniques need to identify the risks and control them.

5.2.1 Welding and patching geo-membranes

Sheets of geo-membrane (known as 'panels') are laid across the landfill mass and welded to each other using a 'wedge-welder' (see Figure 2 below).

[I] The geo-membrane is commonly a high density or medium density polyethylene sheet

Figure 2: Wedge welder



Wedge-welding. A wedge welder is used to fuse the edges of panels together. It comprises a copper block with heated metal elements and the maximum temperature employed is normally limited to 420°C[m]. It is a low volume device, frequently hand-built and is uncertified. However, there may be sufficient time for a significant quantity of flammable atmosphere to accumulate underneath the panels. In this case, a system of gas extraction or another effective measure should be employed to purge the area.

As an example of a gas control measure, scavenger pipes may be laid before capping starts, e.g. where the landfill gas is collecting in significant quantities underneath the panels – see Photo 2

Photo 2: 'Ballooning' due to landfill gas collecting under geo-membrane

Patching. Where four panels join, there is a need for a patch to be added, since the wedge welder requires access to both sides of the geo-membrane. Once the panels of the geo-membrane are in place and welded together, they tend to concentrate landfill gas and a likely escape route is through the area where the four panels join. The usual procedure is as follows:

1 A hot air blower (manufactured by Leister and others) is used to melt the geo-membrane at certain points and form a tack weld around the patch over the hole.
2 A 240 V[n] standard industrial sander is used to buff the surface to break the slightly oily surface on the membrane to be able to create a good weld.
3 An extrusion-type welder is then utilized, which incorporates a heavy-duty hot air blower to pre-heat the geo-membrane. This device also has a heated barrel that warms a plastic welding rod or plastic

m This is the maximum quoted by manufacturers of wedge welders.
n There is too much voltage reduction and too high a current with a 110 V sander.

granular to approximately 220°C, the extruded material then being directed to a shoe that shapes the extrusion weld or ribbon.

4 The weld is tested using one of two methods:

  a Spark testing: this requires a thin metal wire to be included in the joint, which is then covered with the extruded weld ribbon. A spark gun is run over the weld ribbon, just above the buried wire, and produces a spark between the gun and the rod. If there is a fault in the weld, the spark concentrates in the hole and the weld can be repaired by extrusion welding over this point.

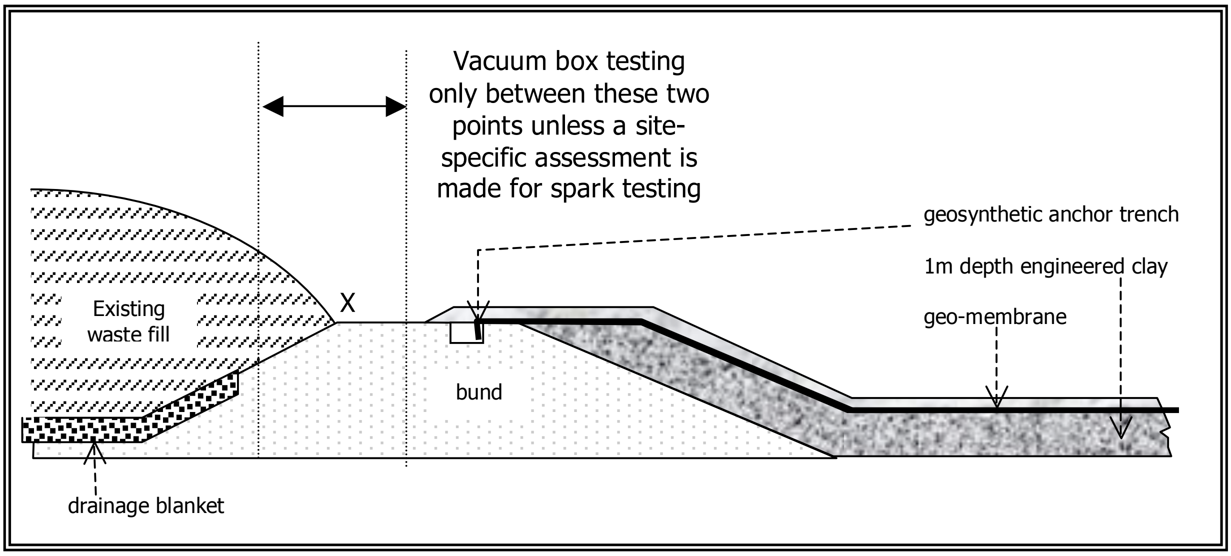
  b Vacuum test: the weld is sprayed with a soap-like solution and a box with a transparent lid placed on top. A vacuum is produced in the box and bubbles can be seen emerging from any faults in the weld.

In some patching operations, the various stages may be carried out in the presence of a potentially explosive atmosphere but none of the items are certified. A high-power hot air source is needed for steps 1 and 3 and the temperature is sufficient to cause the ignition of the geo-membrane if played on one spot for too long. Hot-air blowers (step 1 above) have red-hot elements to heat the air. The air temperature could be sufficient to cause the ignition of the geo-membrane if played on one spot for too long. However this has never been observed and is considered most unlikely. This risk is eliminated by proper use of the hot air blower and by controlling the outlet air temperature by limiting the heating element size and by regular cleaning of the air intake filter to avoid accumulation of dust particles. Similarly, the hot air blowers incorporated in the extrusion welders (step 3 above) are equipped with lockable temperature controllers that prevent overheating, or if necessary can be fitted with air heaters of reduced power rating.

Where sealing of the panels of the geo-membrane is required, there are currently no practical alternatives to the seam-welding and patching method.

Because of these precautions, welding is not a high-risk activity, although ignitions and fires have been recorded. Incidents involving ignitions are usually associated with spark testing. Therefore, spark testing should be restricted to areas where there is a low probability of landfill gas being present, e.g. most basal linings. However, when connecting to an existing cell, the probability of an ignition is increased and spark testing should not be used unless a site-specific risk assessment has been carried out. It should be noted that there is a significant probability of a potentially explosive atmosphere forming where existing waste meets a bund (point X on Figure 3 below), as this is at the extreme limit of the extraction system.

Figure 3: areas where spark testing may not be permitted



It is difficult to estimate the extent of the potentially explosive atmosphere at the interface, X. The amount of landfill gas escaping depends on factors such as the extraction rate, age of the deposited waste, etc. Since the landfill gas is likely to be escaping along the line of the membrane rather than at a single point, it is not unreasonable to assign the same extent as used in ICoP 2 for a gas well, typically 2.2 m.

A common situation is where new waste has been tipped across the entire bund and on top of the existing waste fill. It is necessary to remove this waste to expose at least 2m width of geomembrane on the bund. The issue of vehicles relocating old waste is addressed in section 5.3.2.

The completed capping area may look like Photo 3. Note the bund is to the left of the capped cell – where the two meet is where an explosive atmosphere could be present.

Photo 3: Completed capped cell

5.2.2 Sample requirements for seam welding on temporary liner installations

The purpose of this guidance is to allow the safe operation of the welding equipment while in use.

1. Risk assessments and method statements must be submitted by the contractor undertaking the work. These will include:
   - use of the seam welder
   - use of the extrusion welder
   - working on a steep gradient
   - working on changing surfaces
   - working in adverse weather conditions

2. All documentation supplied by the contractor must consider the DSEAR implications of the work.

3. A contractor safety plan must be completed and all contractors inducted; a relevant permit should be issued for all aspects of the work[o].

4. An FID and gas analyser must be available for use throughout the period of work. These instruments must carry a service record and an in-date calibration certificate.

   The gas detection limits from the FID at the seam are as follows:
   - 1000 ppm – cease operation;
   - 5000 ppm – cease work.

   At the vent or extraction equipment used to extract gas from the joint area:
   - 0-3% CH_4 is the operating range when work may continue;
   - 3-4% CH_4 – increase the rate of extraction;
   - above 4% - cease work and contact the site manager; readings should be taken at intervals of no greater than 2 hours.

5. Installation of the liner should be undertaken using the contractor's standard risk assessment and method statements. The CQA will be agreed on a site-specific basis in conjunction with the contract.

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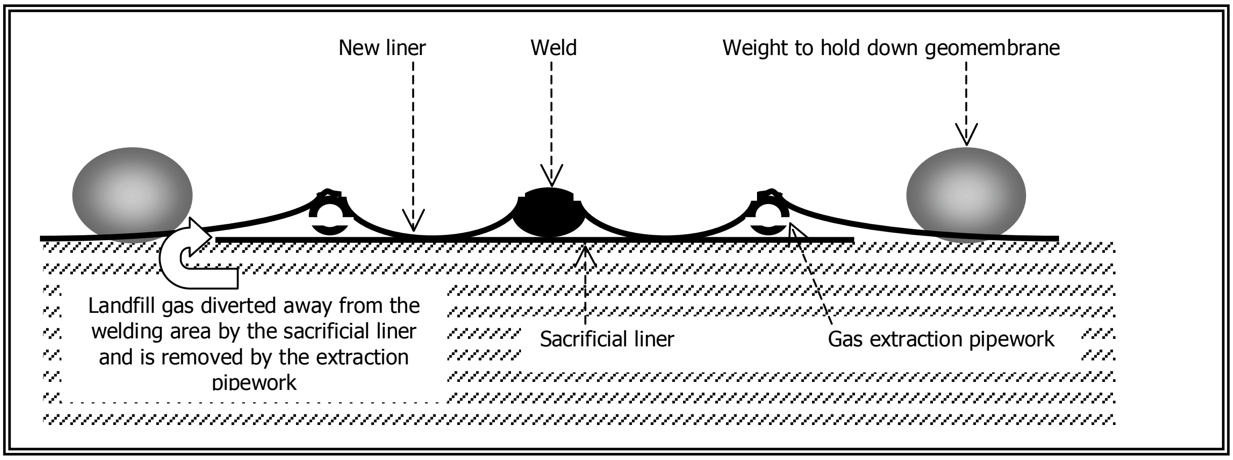
o For a CDM project, this will generally be the principal contractor; for a non-CDM project, this will generally be the Site/Facility Manager

Figure 4 below show an example of one possible method of controlling the levels of landfill gas when seam welding.

Figure 4: Location of extraction pipes when seam welding – side view

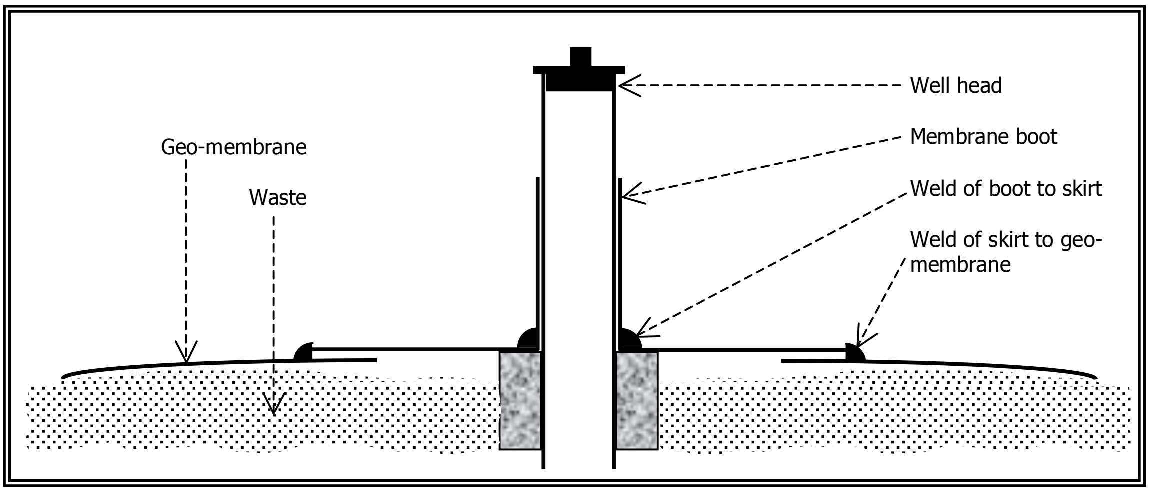


A similar system incorporating a sacrificial membrane but without the extraction pipes has been employed on German landfill cappings. Ballasting by flat hoses would appear to be unnecessary in consideration of contractor's normal ballasting against wind uplift

5.2.3 Connecting the geo-membrane to the well head

There are special considerations around the gas/leachate well itself when the geo-membrane is connected to the well head using a 'boot'. The boot is a pre-fabricated sleeve that is placed over the well. The boot and skirt are usually welded to each other elsewhere, which is advisable, as this therefore makes it unnecessary to weld close to the well (a zone 2[p]). The extraction pipe is removed from the well head, the 'boot' is placed over the well and the extraction pipe replaced. The boot is then welded to the geo-membrane – see Figure 5 and Photo 4.

Figure 5: well with boot and skirt fitted



Refer also to section 5.2.1 for a discussion of welding geomembranes.

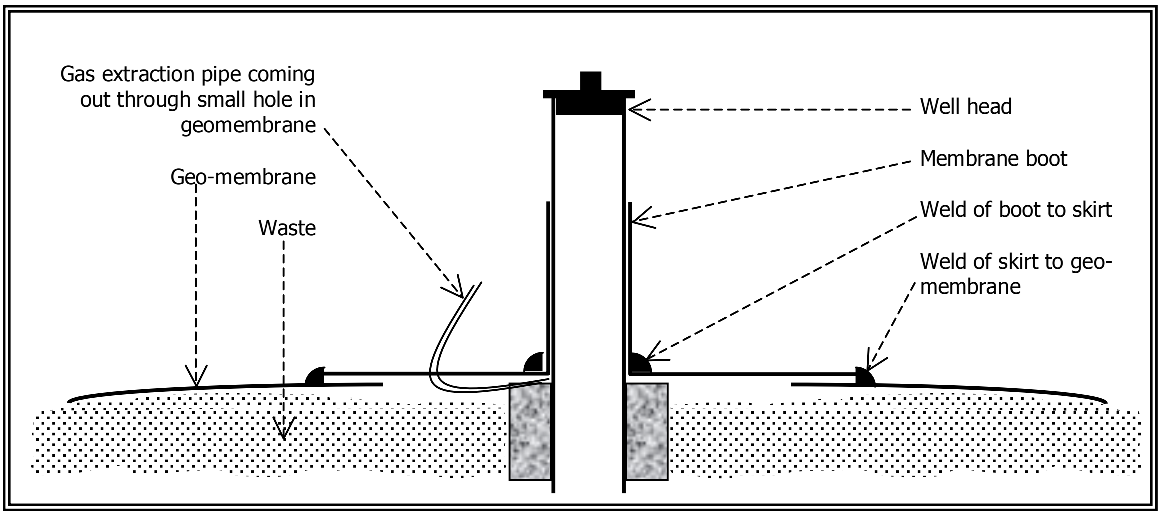
p ICoP 2 assigns a zone 2, typically of radius 2.2 m around wells

Photo 4: Boot and skirt around a leachate well

Note that Photo 4 shows a pipe that is open and venting to atmosphere, which is not good practice.

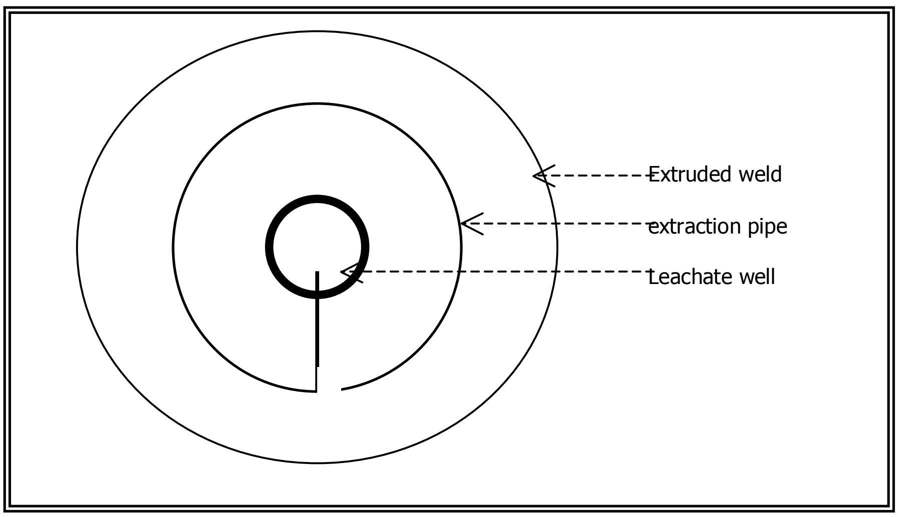
One problem is that it is likely that landfill gas will be collecting underneath the geomembrane to which the boot is being welded. Where this is the case, one method that has been employed uses a gas extraction pipe, connected to a suitable extraction system, which may be used to minimise the danger. This is shown diagrammatically in Figure 6.

Figure 6: Gas scavenging when welding a boot to the geomembrane



The gas extraction pipe (a 32mm water pipe is suitable) will be typically be drilled with 8 mm holes, 250 mm apart. The pipe is arranged around the well as shown in Figure 7.

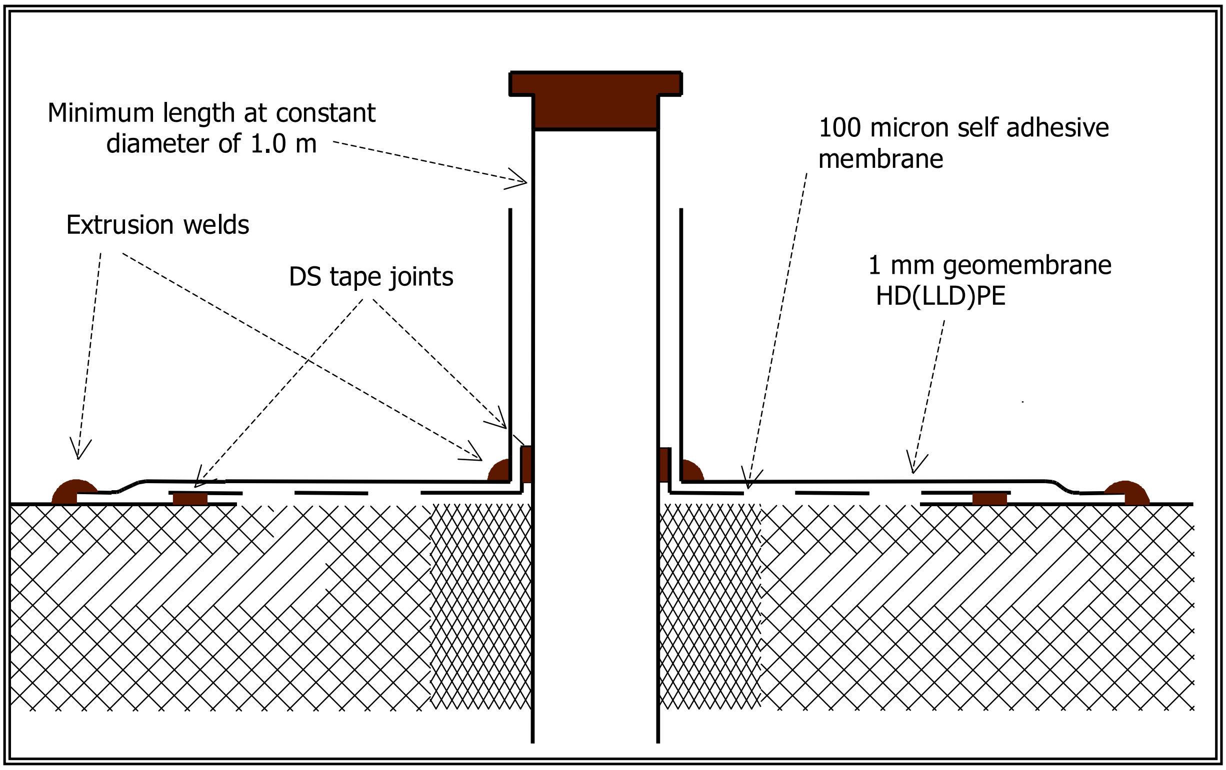
Figure 7: Plan view of gas extraction hose around a well during welding



A simpler approach to the problem of welding around gas welds is currently employed in Germany and is shown in Fig 6A below. The thin sacrificial geomembrane is installed first with attachment to the permanent geomembrane left outside the limiting radius. Gas is thereby prevented from rising into the area where the permanent geomembrane pipe boot can then be fabricated and installed in situ or prefabricated if preferred.

This procedure can also be applied to welding of capping around leachate risers –see Photo 4 above.

Figure 8: Gas well with temporary membrane pipe boot



5.2.5 Lap-and-lay capping

Panels of geo-membrane are placed so that they overlap. The addition of subsequent restoration layers on top of the geo-membrane holds the two panels together without the need for welding. There are no specific issues with this method relating to DSEAR, since welding is not employed, but note that a potentially explosive atmosphere may be present at the joint until such time as it is covered with restoration material. However, even when lap-and-lay is used for the general capping, it is possible that the geo-membrane will be welded around the well – see section 5.2..

Lap-and-lay and other mechanical alternatives to the welded boot have not been found to work as successfully as welding to the geo-membrane at the well head.

5.2.6 Welding pipework by electrofusion

In-situ pipework welding often requires electrofusion welding techniques, which are different to welding during capping operations. Electrofusion welding poses a controllable ignition risk if the process is carried out in accordance with the electrofusion fitting manufacturer's recommendations. In particular, the pipe ends must be cut 'square' and fully inserted in to the fitting to cover all of the electrofusion heater coils and the pipes must be correctly aligned using appropriate clamps to ensure that there is no deflection of the pipe ends within the fitting. The clamps must remain in place for the duration of the manufacturer's recommended cooling cycle. (Note: it is not always feasible to utilise clamps and so every effort must be made to ensure correct alignment of the pipes).

If the electrofusion fitting is assembled and fused correctly, the temperature rises at the fusion-interface, causing considerable 'melt-pressure' to develop which is contained by 'cold-zones' at each end and the centre of the fitting. The temperature at the fusion-interface is typically in the range 200-280°C (depending on the size of fitting and manufacturer), which is sufficiently far below the auto-ignition temperature of landfill gas (537°C). However, if the fitting is faulty or the joint has been assembled incorrectly, overheating can develop or the heater coils can short-circuit causing excessively high temperatures to develop, which can exceed the auto-ignition temperature of polyethylene which is in the range 340-400°C depending on the resin type used in manufacture. If sufficient air is present, flames can develop that could ignite gas if present. Vertical leachate wells are often extended using electrofusion couplers; heat generated by fusing the couplers can create a 'chimney' effect. (Note: once assembled prior to fusing, the joint it is not leak-tight).

If monitoring shows the pipe contains a potentially explosive atmosphere, as may be the case when the final connection to a system is made, the pipes should be isolated from gas by utilising one of the following techniques: 'squeeze-off', inflatable bung or balloon[q], purged or vented and continuously monitored for gas. The means of isolation should not be removed until the cooling cycle of the electrofusion fitting has been completed.

In general, electrofusion and butt fusion equipment is not explosion-protected and should not be used unless the area has been shown to be free from a potentially explosive atmosphere.

Repairing pipes already connected to the system also requires consideration. Repairs are necessary when, for example, an excavator fractures or cuts through the pipe. The pipe is likely to be at an under-pressure in normal operation, but when isolated, gas pressure can build-up rapidly and start to escape from the breach in the pipeline. The damaged section should be isolated on each side of the breach to prevent gas escape and air ingress into the landfill gas extraction system.

The usual sequence of events is as follows:

1 dig out around the pipe[r]
2 block off the flow of landfill gas using isolation procedures as given in section 4
3 wait enough time until a gas test using a certified gas analyser[s] shows that the landfill gas is below its LEL inside and around the pipe – however, if this proves to be an unacceptably long time, purging or ventilating by an appropriate method may be necessary
4 cut out the damaged section of pipe using a suitable tool[t]
5 clean the pipe
6 weld a new section of pipe
7 reconnect to the gas extraction system and remove the bladders (if fitted)

This procedure is covered by a method statement – see Appendix 10.

Ideally, damaged sections should be cut out and replaced. However, it is also possible that minor damage could be repaired using an electrofusion-welded saddle. A possible problem with this method is that the extent of the crack in the pipe may not be visible and the repair is therefore ineffective. Saddles also protrude and are therefore more vulnerable to damage.

With respect to #1, digging out around the pipe may introduce ignition sources by impact between the digging implement and buried stones or metal. Landfill gas is sometimes denser than air, depending on its composition and temperature, and may linger in the pit. This produces risks of explosion and asphyxiation. The worst-case scenario is where there is sufficient air in the pipe for there to be a potentially explosive atmosphere inside, which, if ignited by an external source, could cause an explosion within the pipe. It should be remembered that the *inside* of landfill gas collection pipes are usually classified as zone 1 or zone 2, depending on their location in the system (see ICoP 2), recognising the fact that a potentially explosive atmosphere is a reasonably foreseeable event. A damaged pipe is much more likely to have air inside. An explosion in the pipe is likely to cause injury to someone working in the pit and it is unacceptable to introduce a 'medium' ignition source, such as a shovel. Therefore, work with a shovel can only take place when the flammable gas has been proven to be below the LEL[u].

Little test data currently exists as to whether a worst-case landfill gas/air mixture inside a pipeline produces a dangerous explosion if ignited. The pressure rating of the pipework is commonly specified as 6 barg, which should contain the maximum anticipated explosion pressure. Nevertheless, experience within the

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q A method statement for drilling holes in pipes is included in Appendix 5

r Consider the implication that digging a hole may create a confined space.

s The personal gas monitor worn by the worker is not generally sufficient for this purpose because it typically does not measure up to LEL concentration. Suitable monitors are available, however.

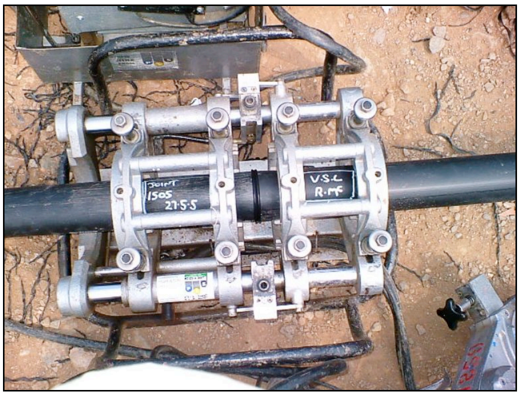
t Power tools are permitted provided it can be guaranteed that the area remains gas-free

u Note: COSHH considerations would also prevent someone working in an area with high gas concentrations industry suggests that an explosion within the pipe is a significant hazard. Therefore, every attempt should be made to ensure that the digging out process does not introduce an ignition source. A mechanical excavator is often used, but if used carefully, the bucket is likely to be moving too slowly to be a credible ignition source. The remnants of soil are removed with a shovel; the person should be aware that this is a potential ignition source, though it is unlikely that, in these circumstances, a spark could be generated. The pipe is invariably non-metallic.

5.2.7 Butt fusion (automated method)

Butt welding is generally used for new pipework, where there is no flammable gas risk. If there is a possibility of a flammable gas, then the same precautions as for electrofusion welding should be applied.

Photo 5: Butt fusion operation showing clamps holding pipe in position



5.2.8 Vent trenches

A vent trench is a means of prevention of gas migration from a landfill site into the surrounding area. It is a low resistance route for gas flow to atmosphere. Generally, the trench is filled with stone to make it permeable. Although a vent trench is specifically designed to release gas, it is generally at such low concentrations that the potentially explosive atmosphere will be of negligible extent and no zone is required. However, work in the vicinity of a vent trench should only be carried out after atmospheric testing has been undertaken.

5.3 Vehicles within already-zoned areas

5.3.1 Landfilling in already-zoned areas

The landfill mass is usually built up over days or weeks, whereby fresh waste is deposited on top of existing compacted waste, which may have been in place long enough for anaerobic decomposition to have started, with the consequential production of significant amounts of landfill gas.

A vertical leachate riser, for example, is built up section-by-section, with fresh waste being added on top of old waste. This requires vehicles to operate very close to the riser itself, both to deposit the waste and to move it into position around the riser. Photo 6 shows this.

Photo 6:Depositing waste close to a leachate well

Industry experience is that ignitions from this source are rare. However, the risk, though small, must be minimised, typically by ensuring that features such as leachate risers are well sealed.

ICoP 2 classifies uncapped landfill as a zone 0 of negligible extent, implying that gas in small amounts is leaching out of the ground on an almost continuous basis. FID measurements confirm this. Ignition of this amount of gas by a vehicle would be unlikely as the ignition sources associated with the vehicle are not usually close to the ground. Ignition would not cause a dangerous situation and would not usually be noticed. ICoP 2 also recognises that there are exceptions to this and that landfill gas will collect below ground and travel up fissures or natural barriers.

The potential ignition sources from vehicles at or close to ground level are as follows:

- hot exhaust of mobile plant
- hot brake drums or discs
- impact sparks from blade/wheel of mobile plant
- static discharges between the mobile plant and the ground
- tipping of 'hot loads'

The physical size of the mobile plant is such that most of it will be outside the zoned area. Also, landfill gas has a relatively high auto-ignition temperature (537°C) and it is unlikely that it will be ignited by a hot surface on the vehicle. Of the two spark sources, electrostatic discharges to earth are unlikely. Impact sparks are a possible ignition source under the right circumstances.

Hot loads[v] should not be tipped close to a zoned area.

To these ignition sources, the driver may introduce others, particularly when out of the cab:

1. static charge on the driver when leaving the vehicle;
2. smoking;
3. carrying unauthorised electrical equipment.

2 and 3 can and should be eliminated by safe working practices for those working in hazardous areas. All sites are non-smoking and this must be enforced. There is a theoretical risk of a static discharge causing an ignition but the driver should not leave the vehicle while it is in a hazardous area – this is typically within 2.2 m of a well – beyond this is a non-hazardous area.

The overall risk of ignition of a significant quantity of landfill gas is very low and the result of an ignition is likely to be a flash-fire rather than an explosion *provided there is no explosive atmosphere within an adjacent gas/leachate collection well*. Therefore, the use of mobile plant in uncapped areas is acceptable provided measures are taken to ensure that the well is not potentially explosive.

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v Hot loads are not normally accepted, although they may be tipped without the knowledge of the Site/Facility Manager.

Examples of such measures are:

- gas-tight sealing of the well (note – temporary capping or other temporary sealing measures may not be effective, especially if the well is under significant pressure)
- knowledge that the age and/or condition of the well are not conducive to significant landfill gas production
- knowledge that gas extraction is effective
- gas testing before work starts

5.3.2 Relocating old waste

A specific risk is associated with disturbing waste that has been in place for some time and therefore generating landfill gas in significant quantities. Pockets of landfill gas may be opened and the gas released, possibly underneath the vehicle. However, experience within the industry suggests that the risk of an ignition is, nevertheless, low and the consequences of an ignition unlikely to cause injury to the driver. No specific precautions are therefore required, but consideration should be given to the nature of the waste being moved, e.g. the possible presence of aerosols or LPG containers.

5.3.3 Agricultural vehicles in zoned areas

During and after completion of restoration of the landfill site, it may be used for agricultural purposes. This could involve ripping, ploughing, seeding, mowing, etc. requiring vehicles to be close to wells, i.e. within a zoned area. This is a zone 2 close to the well, so the probability of a potentially explosive atmosphere is very low, but the same justification applies as in the previous section, i.e. no specific precautions are required.

A specific risk is with damaging surface-laid pipes that are not visible to the vehicle driver due to the length of the grass. Under normal circumstances, pipework should not be surface-laid for this reason and, if it exists, measures must be implemented to reduce the risk of damage.

5.4 Maintenance and aftercare

The sub-sections below do not constitute an exhaustive list; any activity must be assessed with respect to the risk of ignition of an explosive atmosphere, if present.

5.4.1 Cap maintenance

Leaks are usually detected as a result of a surface emissions survey. Cap maintenance involves exposing the cap and repairing it. Refer to section 5.2.1.

5.4.2 Pumps: removal, replacement and general use

The term 'pump' will be taken to include the integral electrical motor where relevant.

Submersible pumps in gas and leachate wells are removed for maintenance and replaced with reconditioned pumps on a rolling programme. These pumps have a permanently-attached lifting line.

The use of pumps that are not marked as suitable for hazardous area duty is addressed in sections 5.7.4 and 5.7.5 for non-electrical and electrical equipment respectively. In summary, these sections indicate how such non-approved equipment may continue to be used in zone 2. Non-approved equipment without any electrical part may be used in zone 1[w]. It is permitted to recondition an existing non-approved pump and re-install it, or fit a spare non-approved pump from stores, but if a *new* pump is purchased as a replacement, it should be ATEX-marked. Typical marking is given in Appendix 3.

As with all equipment, approved or not, pumps should be operated outside the zoned areas where possible. However, where use in a hazardous area cannot be avoided, the operational problems listed in Table 3 should be borne in mind:

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[w] In both cases, the end user needs to have a written justification for the use of the pump.

Table 3: operational problems with pumps				
	Applicable?			Problem
	air-driven	pneu-matic	electric-ally driven	
1	applies	N/A	applies	When a pump is first started, there is torque induced movement that may lead to chafing of: ♦ the power cable insulation (if electrical) – this is a potential ignition source; or ♦ the air line (if air-driven) resulting in air ingress into the system - may produce a potentially explosive atmosphere where none existed before For electrical pumps, it is possible to use a pump that has the cable covered between the motor and the top of the pump; the cable is tied to the pipework to ensure it does not rub the side of the borehole.
2	N/A	N/A	applies	Various types of electrically-driven pumps may be installed with different over/under-current protection requirements, for example: 1 progressing cavity (Archimedes screw) type – if it runs dry, the current demand increases; 2 multi-stage centrifugal – if it runs dry, the resulting cavitation causes the current demand to decrease and may cause damage to the impeller (possibly fragmentation) The types of pump are readily interchangeable, so a technician with no knowledge of the safety system already installed may not set the required over/under-current protection. The protection system must match the type of pump motor. Undercurrent protection on both 'auto' and 'manual' settings is necessary for all standard borehole pumps.
3	applies	applies	applies	Most control systems for leachate pumps include a 'hand' setting allowing manual control of the operation of the pump. This can lead[x] to the pump running dry and overheating. However, even on a "hand" setting, there should be suitable protection to prevent the pump running dry - normally this is undercurrent or overcurrent protection. The "auto" control is usually for devices such as transducers, timers, thermostats etc.
4	√	N/A	N/A	Leaking of the air lines to and from an air-driven pump down a well could create a potentially explosive atmosphere in the well where none may have existed before, by introducing air and bringing the landfill gas into its flammable range. 'Air fuses' in pneumatic lines to shut off air supplies in the event of a failure of the line are becoming available and should be considered. Exhausting inside the headworks is bad practice and exhausting to atmosphere should be encouraged. If exhausting into the headworks is done deliberately to avoid spurious operation of the differential pressure switch on the pump, other pump designs are available.
5	√	√	√	Many leachate wells are constructed from steel - these are known to rust, leading to flaking of the metal into the leachate. This then gets ground up in the pump, causing premature failure and a potential ignition source. However, pumps selected for leachate extraction are designed to deal with such abrasive and sticky materials so no specific action is required apart from routine maintenance of the pumps.
6	√	√	√	There is a risk of an impact spark between a pump and a metal or concrete pipe. Aluminium-bodied pumps are a particular spark risk with steel pipes, especially if the steel is rusty[y]. The risk can be reduced by careful consideration of the lifting technique and lowering the pump slowly into position.

[x] There are numerous examples of this

[y] Aluminium reacts with rust, liberating energy (the so-called 'Thermite Reaction'), so impacts between the two materials are particularly spark-prone

Table 3: operational problems with pumps				
	Applicable?			Problem
	air-driven	pneu-matic	electric-ally driven	
7	√	√	√	Pumps with a plastic body can become electrostatically charged and transfer the charge to a metal part of the enclosure – since this may not be earthed in the case of a portable device, an electrostatic spark to earthed metal is possible.

When pumps are replaced, the balance of risk is in favour of non-electrical pumps and these types, rather than electrically-driven pumps, should be specified[z] where possible. However, there are situations where an electrically-driven pump is the only practical option (e.g. high volume throughput) and such pumps may be used provided measures are taken to minimise the risks associated with such pumps.

Existing non-approved electrically-driven pumps may still be used in a zone 2 (see Appendix 1) provided care is taken to protect the electrical cable. Note that electric pumps lowered down a well for submerging in the leachate will be passing through a zone 1, so should be electrically isolated until submerged.

5.4.3 Inspection of wells using a camera

Camera inspections may be required to find a failure in the containment system. A CCTV-type camera is lowered into the well along with a suitable light source. Wells are usually designated as a zone 1 throughout under the guidance in ESA ICoP 2, and uncertified electrical equipment is *not permitted* in a zone 1 unless it is first shown to be free from a potentially explosive atmosphere.

Therefore, if uncertified cameras and lights are used, the atmosphere must be shown to be or rendered outside the explosive range by suitable means, e.g. by gas monitoring, purging.

5.4.4 De-silting procedures for wells

There are a number of ways to achieve de-silting, for example:

- ♦ suction from above: a pipe from a tanker is lowered into the well and a pump on board the tanker sucks out the water/silt – this method is limited to a maximum hydrostatic head of approximately 10 m, although the operating maximum is less than this;
- ♦ venturi suction method: a pipe is lowered down the well with slots in the pipe just above the liquid level - a large volume of gas that enters the pipe via the slots allows liquid to be sucked up to much greater heights than the limit of hydrostatic head;
- ♦ temporary insertion of a specialised pump to loosen the sediment, the power being supplied from outside the well – the silt/water is pumped out from below and there is no limit to the pumping head;
- ♦ jetting – a unit on the surface powers a water lance that is lowered into the well to clear more compacted blockages; the silt/water is pumped out from below or above

There are a number of issues with the use of the venturi method:

1. landfill gas is sucked out at a substantial rate – this is vented via the vacuum pump of the tanker and may create a large potentially explosive atmosphere; however, it is likely that the gas will be already diluted to below its LEL by the flow of air.
2. landfill gas is sucked out at such a rate that air may enter the well, creating a potentially explosive atmosphere where none may have existed before.

These factors should be considered if this method is used and should be addressed in risk assessments and method statements.

The potential ignition sources of pumps are dealt with in section 5.4.2. One additional ignition source introduced by de-silting operations is static discharge, which is possible with high pressure water jets from the water lance. Guidance from the Institute of Petroleum[7] indicates that liquids like water that have a high conductivity (>1000 pS/m) do not normally give rise to electrostatic charge build-up *unless spraying occurs*, as is the case in this operation. However, it is highly probable that the charged droplets will be able to dissipate their charge harmlessly when they first make contact with the structure of the well and no charge

z At the time of writing, no small (less than 6") electrically-powered ATEX-marked borehole types pumps are available.

accumulation will occur, since all parts of which are well earthed. Thus, it is only necessary to consider the possibility of the spray falling onto non-earthed conductive parts.

5.4.4 Surface, borehole and target[aa] monitoring

Surface monitoring may be by means of a FID, a flux box, or other similar device. Generally, these devices are not certified, but the monitoring is for environmental compliance and the levels detected are almost invariably far below the LEL; such monitoring devices are unable to measure concentrations in the explosive range[bb]. Uncertified monitoring devices are unsuitable and must not be used where there is a potential explosion risk unless an ignition hazard assessment has been undertaken, the results of which have shown it to be safe to operate. Such a risk might occur where there is containment of a potentially explosive atmosphere, such as inside a well or around sampling points. Where surface monitoring is performed around a well, the device itself gives an early warning of high methane concentrations, at which point it should be withdrawn from the area and a certified analyser used instead. (A safer system of work may be to monitor firstly with a portable IR analyser to determine that there is no explosive atmosphere present prior to using the surface monitoring equipment).

Borehole (including perimeter borehole) monitoring requires a different instrument to surface monitoring because the measured level of methane (from landfill gas) are high and possibly mixed with air and within the explosive range. IR analysers are typically used and intrinsically safe versions are available - only this type should be used unless a risk assessment has been completed and the results of which have shown that the analyser is safe to use.

Likewise, for target (specific location) monitoring, an intrinsically safe analyser should be used unless the results of a risk assessment have shown the analyser to be safe to operate in these circumstances.

A method statement for the use of surface monitoring equipment is included in an Appendix when this ICoP is re-issued.

5.4.5 Cutting down wells

Settlement of the waste mass means that the upper part of the pipework of a well becomes increasing exposed. This requires the headworks to be removed, the well to be sawn off and the headworks re-attached.

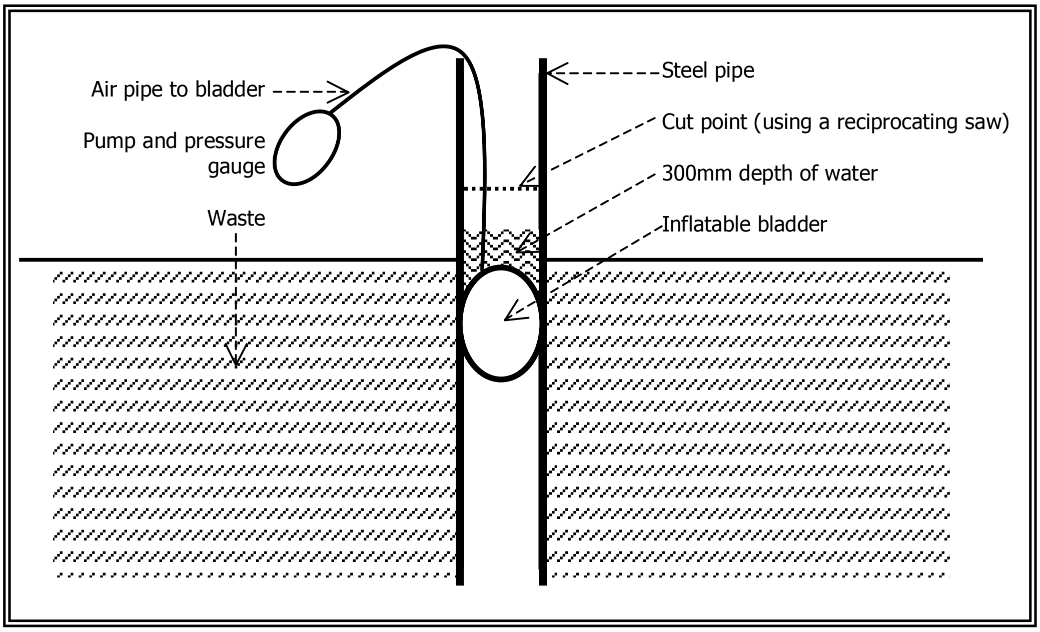
If the pipework is made of steel or other metallic material, there is an unacceptable ignition risk if this is sawn off in the presence of a potentially explosive atmosphere. One possible procedure is as follows:

1 remove headworks
2 insert an inflatable stopper into the pipe to block the flow of gas (see Figure 9 below)
3 pour water onto the top of the stopper to a depth of approximately 300 mm
4 cut off the excess section of well, preferably with a reciprocating saw
5 re-attach the headworks

aa Target monitoring is when a specific area is monitored for the purpose of working in the area

bb For comparison purposes, the scale on a FID might go up to 1000 ppm or 10,000 ppm, whereas the LEL of landfill gas is 44,000 ppm.

Figure 9: Typical isolation method for cutting down a steel-cased gas well



If the work is carried out in a chamber below ground level, the work should be preceded by a gas test.

A method statement for this activity is included in Appendix 8. Permits-to-work are discussed in section 5.5.13.

5.5 Temporary works and other day-to-day operations

5.5.1 Pin wells

The installation of a pin well usually involves pushing a metal spike into the waste mass, which is then removed and a perforated tube inserted, during which operation landfill gas is likely to be released. Fires and explosions during installations are rare, particularly those causing injury. Nevertheless, a risk remains and must be minimised. The safety case is based on:

1 minimising the probability of an ignition source being introduced;
2 minimising the number of workers within range of a possible fire or explosion;
3 maximising the distance between essential personnel and the installation operation;
4 providing suitable PPE or other protection for essential personnel.

The installation of pin wells is commonly performed by the site operator, whereas outside contractors are usually used for the installation of other wells. Both types of drilling are covered in ICoP 6.

A further risk occurs when the pin well is connected to the existing infrastructure; refer to section 5.2.6.

5.5.2 Scavenger pipes

Scavenger pipes are horizontal gas collection pipes laid in the waste. The only aspect that poses a flammable atmosphere risk is the connection to extraction system. Refer to section 5.2.6.

5.5.3 Temporary gas collection

This is usually used prior to the installation of the permanent gas collection system. The temporary gas collection system takes the form of a pipe system that is laid on the ground, for example for odour control. These are then connected to either the extraction system, a temporary flare or other gas management facility as appropriate.

In principle, this activity is no different to the installation of scavenger pipes and the only flammable risk is when the pipe is connected to the extraction system – refer to section 5.2.6.

5.5.4 Pipe repairs

This is covered in section 5.2.6.

5.5.5 Excavations

It is sometimes necessary to dig an excavation, for example to repair a section of damaged well. Landfill gas tends to collect in excavations and trenches such as shown in Photo 7, especially where there is damage to or removal of the Bentonite seal or the well is leaking. The possibility of landfill gas accumulations in excavations to explosive concentrations should always be considered, even where there is no obvious release point, if gas migration is a possibility. In addition to the explosion potential, the toxic risk should also be assessed.

Photo 7: Excavation with the potential for landfill gas to accumulate

5.5.6 Daily cover

This is a routine operation to cover waste. Soil (or another material) is deposited on top of the freshly-tipped waste at the end of each day and spread with mobile plant. This is done to deter vermin, reduce the fire risk, litter control and reduce the odour.

The waste below the surface is likely to be capable of generating landfill gas, so this operation raises the same issues of the use of vehicles in such situations – see section 5.3.

Additional techniques include:

1 application of foam, sprayed onto the surface at the end of each day – there is a potential static ignition hazard from this activity, but the quantity of gas ignited is likely to be small and the risk to personnel low;

2 HDPE (or similar) sheets spread over the waste – this method does tend to collect gas, but does not involve welding, so ignition sources are unlikely to be introduced.

5.5.7 Portable and mobile generators

Portable generators are distinguished from mobile generators in that they are generally mounted within a frame and are small enough to be manually handled by one or two persons. Mobile generators are generally accepted as those that require lifting into place with a crane (or similar) and/or are fitted with wheels to allow them to be towed from location to location using mobile plant. As a general rule, portable generators are fuelled by petrol, whereas mobile generators are operated on diesel fuel.

Portable generators are introduced on a temporary basis, for example:

- ♦ electrofusion welders
- ♦ hand tools
- ♦ hot air guns
- ♦ odour control units (although not necessarily using a portable generator)
- ♦ pumps

A generator is a potential ignition source in the following respects:

- the electrical control equipment close to ground level is usually uncertified and is a potential ignition source, particularly if landfill gas emitted from the ground collects inside an electrical enclosure;
- incandescent particles emitted from the exhaust may travel some distance into an adjacent hazardous area, where there is a probability of a potentially explosive atmosphere being present and ignited

Clearly, generators should not be sited within a zoned area (e.g. typically within 2.2 m of a well) unless the area is known to be free of a potentially explosive atmosphere. Also, the generator should be installed in an area where emissions of landfill gas from the ground either do not occur or are unlikely to be significant. If emissions of landfill gas are reasonably likely, installing the generator on a concrete or other impermeable apron will prevent flammable gas building up inside the enclosure.

Where there is a possibility of emissions of landfill gas underneath the generator, care should be taken to prevent build-up in the generator as far as is reasonably practical, e.g. by siting it where fissures are unlikely. A FID sweep will confirm the absence of landfill gas at the time of installation, but the ground conditions may change. Mounting the generator slightly off the ground, with free ventilation underneath the generator, will greatly reduce the probability of flammable quantities building up inside the enclosure. Leaving the generator on the back of the truck or within a fuel oil bund achieves this.

Leaks of fuel also need to be considered. If the fuel is diesel, if it is spilled on the ground, it can only form a potentially explosive atmosphere if it falls onto an absorbent material to act as a wick. Pools of diesel can normally be regarded as non-hazardous.

If the fuel is petrol, this is highly volatile and a potentially explosive atmosphere will form during fluid transfer; a larger potentially explosive atmosphere will form if a spillage occurs. Re-fuelling should not take place close to potential ignition sources. The generator must be switched off for refuelling.

5.5.8 Mobile pumps

As with all equipment, pumps should be operated outside the zoned areas where possible. Further guidance on pumps is in section 5.4.2.

5.5.9 Mobile flares

A mobile flare is useful in remote locations and may be used for odour or gas control to burn off gas from a well or series of wells that cannot be used for power generation (low methane or high oxygen).

Usually such a system is used where the methane quantity within the landfill gas is low or the oxygen content is raised and therefore is unsuitable for utilisation within a landfill gas engine. It has a connection to the gas collection system and is usually sited on top of or close to the waste mass.

Clearly, the flare should be located outside a zoned area[cc]. The flare is an ignition source in three respects:

- the flame from the flared gas, which will not pose a significant risk if in a safe location;
- the electrical control equipment close to ground level is usually uncertified and is a potential ignition source, particularly if landfill gas emitted from the ground collects inside an electrical enclosure – consideration should be given to providing an air gap between the electrical enclosure and the ground;
- incandescent particles emitted from the chimney may travel some distance into an adjacent hazardous area, where there is a probability of a potentially explosive atmosphere being present and ignited.

---

cc The general landfill surface may be classified by ICoP 2 as zoned, possibly a zone 0, but the zone is of "negligible extent". This is effectively a non-hazardous area for the purpose of placing plant on the surface, taking due account of landfill gas collecting in enclosures.

Photo 8: Flare located too close to a vent

The area classification of flares is covered in ESA ICoP 2.

5.5.10 Odour control systems

There are two types of odour control system:

1 odour suppression type: contains a generator supplying a motor and fan and emits a perfumed mist – these items are covered in section 5.5.7;

2 scavenger system using pipework – see section 5.5.2 - to take the gas to a flare or other treatment

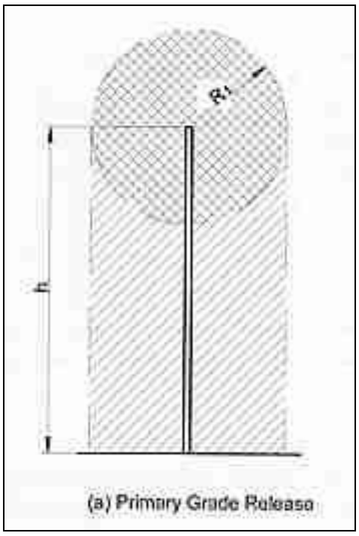
5.5.11 Temporary buildings

Temporary buildings, such as site cabins, have their own electrical supply; many are not fitted with gas detection. Such buildings should not, ideally, be located in areas where landfill gas may be emitted from the surface. Where this is not possible, the same considerations apply as for mobile plant equipment discussed in the previous sections.

Of particular concern is the possibility of landfill gas migrating along buried cable ducts directly into the building and collecting in a panel or other source of ignition. It is essential that this route is avoided and it is recommended that all buildings have a well-ventilated air gap underneath, such that any cable ducting ventilates into this air gap. This greatly reduces the possibility of flammable gas migration into the building. If the design includes consideration of the problem of gas accumulation, gas detection will not be necessary. The initial design considerations should consider the elimination of the need for 'bottom' entry of cables into the building.

Septic tanks are installed close to most temporary buildings. If conditions within the tank are anaerobic, which is highly likely, methane will form and mix with the air above the liquid level. Therefore the interior of the tank should be classified as a zone 0. If a vent pipe is fitted, a zone 1 of nominal radius 1 m is appropriate, with a zone 2 extending to ground level. The zoning of the vent shown in below is based on IP15 Figure 5.3(a). R_1 is 1 m.

Figure 10: Zoning for a vent



If work is carried out in these hazardous areas, appropriate precautions are required as detailed else where in this ICoP.

5.5.12 Banding

Banding involves multiple injections of a 'sock' up to 15 m into the waste. The process causes release over a large area. Mobile plant will be working on top of this area during installation and subjected to the released gas.

Photo 9: Banding

This is a specialist activity and outside the scope of this ICoP – a site-specific risk assessment will be required.

5.5.13 Permit-to-work system

The following three pages show a sample permit-to-work pro-forma that can be adapted as required. Ideally, a single permit should cover all risks, rather than having a separate permit, for example, when there are DSEAR issues relating to explosive atmospheres.

Enterprise Limited
PERMIT TO WORK

1) To: ………(Recipient).

2a) Sections of Site ………………………………………………………………………………………………………

2b) Location ……

3) Work to be carried out: ……………………………………………………………………………………………...

4) The following services have been isolated / locked off-

	Method of Isolation Employed	By whom
Electricity		
Gas		
Process Fluids		
Air/Water		
Drains/Vents etc		
Instrument Connections		
Others		

5) Special precaustions which need to be taken:

(a) Personnel to be notified: ____
(b) Fire fighting equipment/personnel:____
(c) Rescue equipment/personnel:____
(d) Sparkproof tools:____
(e) Suitably-certified (e.g. Ex d, Ex ia/ib) equipment: _______________________________
(f) Burning and welding:____
(g) Ventilation:____
(h) Atmosphere testing:____
(I) Presence of sludge____
(j) Other factors:____

6) Results of atmosphere tests:

Location of Test	Date	Time	Test For	Result	Repeat Time 8 hrs ?	Competent Person

7) Subject to the conditions stated in section 5, the work which is detailed at 3 above can then be undertaken.

This permit is valid until (Time) ……………a.m./p.m. after which time a new permit will be required for work to proceed:

Signed:………………………………………………………………… (Initiator)
Date/Time:………………………………………………………………a.m/p.m.
Position:…………………………………………………………………………

8) I understand the work, and the precautions which are necessary which are necessary to carry out the work safely.

Signed:………………………………………………………………… (Initiator)
Date/Time:………………………………………………………………a.m/p.m.
Position:…………………………………………………………………………

9) The work detailed at 3 above is / is not* complete

Signed:………………………………………………………………… (Initiator)
Date/Time:………………………………………………………………a.m/p.m.

10) The plant has been inspected and tested and is / is not* available for return to service.

PERMIT TO WORK

Notes and Instructions for use.

1) If the recipient is an external contractor, the name of the firm and the site-representative should be shown.

2a) To show an area of the Works and not a specific part of equipment.

2b) To indicate the most hazardous zone in the area in which the work is to be carried out.

3) This permit is to be issued for work carried out under the site manager's own or his delegated authority.

4) At this stage isolation/locking off will have been carried out on all the services. The method of carrying out the task shall have been agreed between the initiator and the recipient.

If necessary, the work shall have been carried out under a separate authority (the Supervisor's Authority) and be governed by the same conditions as are applied to the Supervisor's Authority.

The detail given should show the services involved, the method of isolation employed and by whom the work has been carried out.

5a) To show personnel to be informed other than those actually carrying out the work.

5b))
5c)) To show the equipment and personnel to be on standby at the location of the work.

5d))
5e)) To show details of any requirements for special tools, bearing in mind the zone area which has been shown at (2b)

5f) To show whether burning or welding may be carried out in the working area.

5g) To show if natural ventilation is sufficient or if mechanical means are necessary, and if so, to what extent.

5h) To show if the frequency of testing and the type of test is required.

5i) To show if sludge is present and if so any extra precautions which should be taken.

5j) Note any special precautions which may be necessary including the use of protective clothing.

6) To be completed by a chemist/designated competent person.
If the continuous monitoring is required, and there is sufficient room on the Manager's Authority for the results obtained, a separate sheet shall be issued for the results which shall be apended to the Manager's Authority.

7) The permit shall only be valid for the duration of the recipients current shift. The permit shall be returned to the initiator by the time stated or earlier if the work has been completed earlier than envisaged.

8) To be signed by the recipient on the understanding that he has received the necessary verbal or written instructions sufficient to be able to carry out the work safely. Further - if unforseen difficulties occur - especially where an external contractor is involved, he must have been instructed to seek further guidance from the initiator before continuing the work.

9) If the work is not complete, a further certificate will be required before the work can proceed.

10) This section should be completed by the initiator after handing back by the recipient. It serves as a reminder of the current state of the equipment. If the initiator is not the Manager, arrangements must be made to keep the Manager informed of the current situation.

11) Copies to be distributed as follows:-

Top copy to be issued to the recipient, encapsulated in a clear plastic sleeve and posted immediately adjacent to the working location.

Bottom copy - to remain in the book of certificates which itself should be kept under the immediate jurisdiction of the Site Manager.

Clients Drawing of Section of Site Operating Under Permit To Work

Appended Here

5.5.14 Photographs of unacceptable practices

Photo 10: Badly repaired cable joint using electrical tape

This would be a potential source of ignition on failure.

Photo 11: No headworks installed on leachate chamber

Photo 12: Poorly installed control panel – too close to potential release point of landfill gas

Photo 13: Lack of maintenance – excessive corrosion of borehole pump.

This pump was used for leachate extraction.

Photo 14: Poor standards of installation

There are bolts missing in the blanking plate and valve flanges, which would potentially give rise to larger releases of landfill gas than assumed in the ICoP for calculating the zone radius. The wooden bungs are not a standard sealing arrangement.

Photo 15: Poor standards of installation – control panel Located within zoned area

Photo 16: Control panel installed too close to leachate chamber

The control panel is installed such that it is within the zone 2 around the leachate chamber.

Photo 17: Unprotected leachate extraction point

The leachate extraction point is unprotected from vehicle movements & there is no indication of the zone extent around the potential release point.

Photo 18: Open side riser producing a large potentially explosive atmosphere

Photo 19: Control panel showing signs of corrosion

It is likely that the panel is not manufactured to the correct specification.

Photo 20: Open side riser

This open side riser will produce a large potentially explosive atmosphere. There is evidence of other poor installation design: the pump is supported down the side riser by rope secured around a local tree and then attached to the discharge pipework from the installation.

Photo 21: Poor installation - control panels left on the ground within zoned areas

Photo 22: Blanking plate on the leachate chamber not secured

This gives a potential for a substantial release of landfill gas.

Photo 23: Poor Design - bucket used as a head works and sealed with tape

This is a leachate extraction point – there is significant potential for landfill gas release

5.6 Personnel on site

5.6.1 Employees and contractors

Where there are two or more employers sharing a workplace, DSEAR regulation 11 requires the Site/Facility Manager to ensure that all workers are aware of the site safety procedures and that contractors who are not familiar with the site are made fully aware of the risks. Contractors must be alerted to the possible presence of dangerous quantities of landfill gas in certain operations, such as

- ♦ wedge-welding and patching during capping operations,
- ♦ digging down alongside existing gas and leachate wells when repairing damage, etc.

This information should be communicated at the contract stage as well as when the contractors appear on site

Compliance with Regulation 11 should be by means of an appropriate site induction in addition to an explanation of, plus adherence to, the permit-to-work system, where the work requires this. Training is covered more fully in ESA ICoP 1 section 9.

No unescorted access to the site should be permitted without the permission of the Site/Facility Manager.

It is commonly the case that two employers share a site (e.g. a gas management compound) on a semi-permanent or permanent basis. The same principles still apply regarding the duty of co-ordination placed on the Site/Facility Manager but the permit system may not need to be as frequently renewed.

5.6.2 Customers

'Customers' in this context refers to companies using the landfill site to dispose of waste, carried in by trucks. There are a number of explosion hazards associated with these activities, due to the necessary use of vehicles, sometimes close to potential releases of landfill gas (or other flammable hazards such as aerosols).

Customers should be made aware of the safety procedures relevant to their activity by an appropriate method, e.g. the issue of site safety rules, signage, etc. The routes of the access roads are intended to avoid the vehicles driving close to or through a zoned area.

It is recommended that key information be presented to customers on their first visit to the site. This may be included along with key information relating to other risks and site procedures. A suggested format is as follows:

Key information regarding explosion risks

Tipped waste generates methane!

Where you see this sign:

it indicates areas where landfill gas may be present.

There is an explosion risk if ignited.

Follow the instructions on the sign.

No smoking anywhere on the site

5.6.3 Visitors

Visitors are those who are not engaged in 'work' but who may be shown round the site. The danger of explosion is not the main risk facing visitors, since being hit by vehicles or machinery is a far higher risk. The following minimum requirements should be in place to protect their safety:

1 a basic site induction, outlining the risks: the visitor may sign to indicate he/she has received the induction
2 provision of appropriate PPE;
3 escorted at all times.

A written record of those receiving the induction should be held.

No access to the site should be permitted without the approval of the Site/Facility Manager.

5.6.4 Regulatory authorities

Members of regulatory authorities (e.g. Environment Agency, Health and Safety Executive, Customs and Excise) are visitors, but they have statutory powers of entry and may arrive on sites unannounced. Every assistance should be given to enable such persons to carry out their duties, however their safety during their visit remains the responsibility of the Site/Facility Manager and a suitable induction must be carried out before going onto the landfill site.

The Site/Facility Manager cannot deny these regulatory authorities access to the site, unless there are exceptional circumstances where there is an unacceptable risk to safety. The Site/Facility Manager cannot obstruct the regulatory authorities in their duties. However, he/she should ensure that any access to the site, in particular any hazardous area, is in accordance with the local site rules and permit to work system.

The regulatory authorities themselves must comply with the local site rules and permit to work system and provide adequate risk assessments or other information. In addition, they should implement suitable control measures to demonstrate to the Site/Facility Manager that they can safely access the hazardous areas. The regulatory authorities should have due regard to this Code of Practice in planning site visits.

The regulatory authorities may bring monitoring or other equipment onto site. This equipment must be suitable for the zone in which it might be used and be maintained and calibrated in accordance with the manufacturer's instructions.

5.6.5 Accident, incident and emergency protocols

DSEAR Approved Code of Practice L138 paragraphs 300 to 303 are particularly relevant. The recommendations in these paragraphs can be summarised as follows: as a minimum, the Site/Facility Manager is responsible for contacting the emergency services (during a non-emergency period) to outline the risks and be available, if required, to meet the emergency services to discuss emergency procedures.

Such discussions help the emergency services to prepare their own response procedures and precautionary measures. The information that may be required includes:

a the identity, location and possible quantities of flammable materials – mainly this will be landfill gas, but other flammables on site (e.g. gas cylinders) should be identified;
b the foreseeable types of accident/incident/emergency and the hazards that may result;
c where on site such incidents could occur, the effects, other affected areas, possible escalation;
d internal emergency arrangements.

Equally, some fires do not constitute an emergency and the industry has proven methods of dealing with them. This applies particularly to fires underground.

With an ever-changing site topography, it is important to plan for the emergency services, particularly the fire brigade, to have access to all areas where they might be needed. If an incident occurs, the Site/Facility Manager, or a designated person, should be available to assist the emergency services when they arrive on site.

5.6.6 Public access and security

Some sites have been restored and are available for public recreation, e.g. converted to golf courses, country parks, etc. Sensitive equipment such as manifolds may have been buried but certain features such as wells) may still protrude from the ground. A risk assessment is required and consideration should be given to a range of options, such as restricting access with physical barriers, re-directing footpaths or disguising the equipment with foliage.

On sites which are about to be transferred to public access, all equipment should be fenced off or in a suitable locked chamber. ICoP 2 Edition 2, Figure 5 indicates that chambers such as those used to house pipework manifolds will be zone 2 internally, but there is n o external zone.

Some operational sites have a public footpath running across the site but otherwise only restricted access. Such footpaths should be fenced off, indicating that access to the rest of the site is restricted. See also section 5.6.7.

5.6.7 Marking hazardous areas and pipes

DSEAR Regulation 7 requires that, *where applicable*, zones should be marked with the sign shown below. The purpose of signs is to warn of areas where an explosive atmosphere may occur in such a quantity that employees need to be warned of its presence, so that they can take the necessary precautions in relation to the risk.

On a landfill site, there are a large number of relatively small zoned areas (e.g. in and around gas wells, pin wells, leachate risers, etc.) but the majority of the site surface is not zoned. The key question to consider is how best sign the site to inform workers and other persons most appropriately.

It is recommended that a sign at the main entrance is installed to alert anyone entering that the site contains zoned areas, but this sign should not give the impression that the entire site is one large hazardous area.

The following sign is therefore suggested:

Some sites have other entrances and some even have public footpaths across the site. Consideration has been given to the fact that signs that are too explicit may increase the risk of malicious damage by unauthorised persons if they are made aware of the explosion potential within a gas well, etc.

At such secondary entrances, a sign such as the following is recommended:

Consideration should be given to fencing the footpath.

Each individual well or other zoned area should be marked. It is helpful to also mark the zone extent, so a small sign as follows would be ideal:

A small, self-adhesive label is sufficient. The zone information may be omitted if workers are made aware by other methods regarding the zone extent. The above sign is suitably informative to legitimate personnel but does not unnecessarily alert others to the explosion potential.

Landfill gas pipes should also be marked where necessary to avoid confusion.

5.7 Equipment used in zoned areas

5.7.1 General

Zones 0, 1 and 2 all indicate the *probability* of a potentially explosive atmosphere being present:

zone 0: high probability (more than 1000 hours/year)
zone 1: medium probability (between 10 and 1000 hours per year)
zone 2: low probability (less than 10 hours/year, typically much less than this)

However, the zones do not indicate whether a potentially explosive atmosphere is *actually* present. There are two basic approaches to doing work in hazardous areas that does not involve breaking into the containment system (which is usually covered under maintenance):

1) work with suitably-approved equipment, tools and clothing that are designed to avoid introducing an ignition source (sparks and hot surfaces), *or*

2) work under a permit system that ensures that the area is gas free while the work is being carried out – this allows the use of non-approved equipment, such as grinders, welders (strong ignition sources), petrol generators (medium ignition source) and uncertified instruments (weak ignition source).

An example of 1) would be going into a zone 1 with an intrinsically safe sampling instrument to open the sample point and make a measurement.

An example of 2) would be the cutting down of a well that has been isolated and purged to remove explosive concentrations of landfill gas – the worker would be following a method statement and be working under the permit system.

The permit system, therefore, allows operations in zoned areas that are likely to introduce an ignition source, but the risk is controlled.

5.7.2 PPE

Suitable PPE need not exceed that usually employed in general engineering situations, i.e. (anti-static) safety boots or shoes with an *internal* toe protector[dd], eye protection, hard hat, high-visibility jacket/waistcoat, ear protection, personal gas monitors, etc. as appropriate, in line with site rules. However, note that COSHH issues are outside the scope of this ICoP, which deals only with the flammable risks.

5.7.3 Anti-static clothing

PD CLC/TR 50404[8] clause 9.4 states that "In spite of the fact that modern clothing, made from synthetic textiles, can readily become electrostatically charged it is not, in general, an ignition risk providing that the wearer is earthed by means of suitable footwear and flooring".

The DSEAR ACoP L138 requires that anti-static footwear and clothing should be provided when the risk assessment identifies that it is required. Paragraphs 263 and 264 are particularly relevant and the requirements may be interpreted as follows: anti-static footwear and flooring that is not highly insulating (e.g. concrete, earth) are generally sufficient for areas where there is a flammable gas or vapour risk

A minimum requirement, therefore, is that anti-static footwear is used whenever work is done in a hazardous area, unless done under a relevant permit or where the risk of a person becoming electrostatically charged is low.

Anti-static footwear is potentially ineffective when walking on an HDPE geomembrane or other insulating surfaces. There is currently no evidence to quantify the hazard that this poses but personnel should be aware of the potential risk.

5.7.4 Existing non-approved non-electrical work equipment in zoned areas

Appendix 1 deals with non-electrical equipment. The situation may be summarised as follows:

dd External steel toe protectors may be a spark ignition risk

- Before 1 July 2003[ee], there was no need to give non-electrical equipment in a hazardous area more than a basic assessment for its ignition capability but for DSEAR, a formal (if simple) ignition hazard assessment is required;
- Non-electrical equipment installed after 1 July 2003 should be ATEX-marked (usually by the manufacturer) to indicate that it is suitable for hazardous area use.

Currently, most non-electrical equipment clearly fits into the first category, i.e. it is not new and was already installed on 1 July 2003. A basic ignition hazard assessment using the guidance in Appendix 1 should be undertaken. For equipment in zone 2, this is generally straightforward; a little more thought is required for zones 1. There is very little such equipment, if any, in zones 0.

5.7.5 Existing non-approved electrical work equipment in zoned areas

Appendix 2 deals with non-approved electrical equipment. The situation may be summarised as follows:
- Apart from 'simple apparatus' in intrinsically safe circuits, uncertified electrical equipment is not (and never was) permitted in zones 0 and 1[ff]
- In zone 2, electrical equipment installed before 1 July 2003 was probably certified, although uncertified equipment was (and still is) permitted. Equipment installed after 1 July 2003 should be at least ATEX-marked by the manufacturer and will usually also be certified by a third party.

A typical example of an uncertified item of fixed electrical equipment is a pump motor submerged in a well. This could be a zone 2 or even a non-hazardous area – see ICoP 2. In a zone 2 location, provided the motor was assessed by the end user as being 'safe in normal operation', certification was not required. DSEAR requires such equipment to be re-assessed and the results recorded. This need not be particularly onerous for some equipment (particularly motors, junction boxes and other simple to assess items), but the guidance in Appendix 2 should be referenced.

Uncertified portable equipment (such as mobile phones, PAT testers, hand-held sampling instruments, surveying equipment, etc.) pose a bigger problem. In zone 1 (and 0) they must not be carried into the hazardous area, even if switched off. Although there is provision for equipment to be assessed for zone 2 use, the end user is not generally equipped to assess such complex items.

There are zones 2 around most sampling points on the gas collection system (see ICoP 2). However, the operator may locate the instrument outside the zone and sample the gas via a tube of a suitable length.

Also, it is permissible to use uncertified equipment in hazardous areas provided the hazardous area is demonstrated to be free of a potentially explosive atmosphere while work is being carried out. Therefore, uncertified equipment may continue to be used provided there is continuous gas monitoring or another suitable method to ensure that the worker and the associated electrical equipment do not come in contact with a potentially explosive atmosphere.

A risk assessment approach can be used in specific cases, but there needs to be a good reason why the normal practices of using certified equipment or operating under a relevant permit cannot be used. Mobile phones are one such case and are discussed in section 5.7.7.

5.7.6 Hand torches

Only certified torches should be used in hazardous areas unless the area is known to be free from a potentially explosive atmosphere.

5.7.7 Mobile phones used by lone workers

Lone working is used extensively in the waste management industry. A central part of the safety case for such workers is that they report periodically by mobile phone to a controller. At the present time, the vast majority of mobile phones are uncertified.

Wherever work in zoned areas takes place, it is almost always in a zone 2, so the risk is low. Ideally, no uncertified electrical equipment should be taken into any hazardous areas, but it is a greater risk for the operator to leave the uncertified phone outside the zone than to have it on his/her person, as he/she may

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[ee] 1 July 2003 was the date that the ATEX Directives and much of DSEAR came into force.

[ff] Apart from 'simple apparatus', there are a few exceptional circumstances where uncertified equipment is legitimately used in zones 0 and 1, but this is outside the3 scope of the ICoP.

be unable to reach the phone if injured. It is not feasible for every area to be checked for flammable gas before the worker enters, although this should be done where reasonably practicable.

It is extremely costly to replace all mobile phones in use with certified equivalents. The HSE have stated that they believe that the risk associated with the use of a mobile phone on a landfill site is lower than, say, that associated with the electrostatic discharge that could occur from clothing being worn[gg]. However, they have reported that there are concerns where phones have a metal case - these have been reported as being capable of producing an electrostatic discharge of sufficient energy to ignite methane gas[hh].

The HSE have indicated that a risk assessment should be undertaken but have indicated that, where working in a zone 1 or higher risk, mobile phones should not be used and two people should be in attendance for such work; this should be covered under a permit-to-work system. Method statements etc. should detail what actions are required.

To summarise, uncertified mobile phones without a metal case may be used in zones 2 but not zones 1 or 0. Mobile phones with a metal case cannot be used in any zones. They should not be used for work that involves the deliberate generation of a potentially explosive atmosphere, e.g. breaking into the containment system.

5.7.8 Non-approved personal electrical equipment in hazardous areas

There are a number of items of personal electrical equipment that may be inadvertently or deliberately carried by a worker into a hazardous area:

1. digital watch
2. infra-red key fob
3. pacemaker (with battery beneath the skin)
4. hearing aid
5. personal stereo
6. electronic organiser
7. site radio
8. camera
9. mobile phone, possibly with camera/flash facility, MP3/headphone facility

The general rule is that non-approved equipment should not be brought into a hazardous area. However, digital watches and infra-red key fobs are usually not specifically prohibited and are, in fact, extremely unlikely to be capable of igniting methane.

Pacemakers with a battery under the skin are acceptable because the flammable gas cannot come in contact with the device.

Hearing aids are clearly essential items, but a certified device should be used unless a risk assessment shows otherwise. However, it is unlikely that a modern in-the-ear hearing aid would be capable of igniting landfill gas.

Personal stereos, personal organisers, personal mobile phones and other items that are not essential should not be carried into hazardous areas.

5.7.9 Tools for use in potentially explosive atmospheres

EN 1127-1:1998 Annex A gives guidance and the part referring to gases is quoted below.

> "Instructions on the use of hand-held tools shall take the following into account. Two different types of tools have to be distinguished:
>
> a) tools which can only cause single sparks when they are used (e.g. screwdrivers, spanners, impact screwdrivers);
>
> b) tools which generate a shower of sparks when used during sawing or grinding.

gg This hazard can be mitigated by the use of anti-static footwear – see section 5.7.3.

hh Although plastic is capable of generating and storing electrostatic charge, being a good insulator, the charge does not readily move to an earthed object. An unearthed conductor, however (such as a metal mobile phone case) could become charged and will readily conduct charge into a spark if earthed.

> "In zone 0, no tools which can cause sparks are permissible. In zones 1 and 2, only steel tools according to a) are permissible. Tools according to b) are only permissible if it is ensured that no hazardous explosive atmosphere is present at the workplace. However, the use of any kind of steel tools is completely prohibited in zone 1 if the risk of explosion exists because of the presence of substances belonging to explosion group IIC (according to EN 50014) (acetylene, carbon disulphide, hydrogen), and hydrogen sulphide, ethylene oxide and carbon monoxide, unless it is ensured that no hazardous explosive atmosphere is present at the workplace during the work with these tools.
>
> "The use of tools in zones 1 and 2…. should be subject to a 'permit to work' system. This shall be included in the information for use."

In summary, therefore, EN 1127-1 does not require the use of non-sparking (e.g. phosphor bronze) tools in zones 1 and 2 for landfill gas and normal (e.g. steel) tools that are 'single sparking' can be used without the requirement to ensure that a potentially explosive atmosphere is absent.

Note that maintenance activities that deliberately create a potentially explosive atmosphere are not covered under zoning and a separate risk assessment is required. However, provided the spark risk is only that the tool may be dropped onto the ground, steel tools are permissible, since the spark risk is very low. Great care should be taken to prevent steel tools (or other large metal objects such as well covers) from being dropped into open steel- or concrete-lined wells that contain landfill gas.

5.7.10 Bird scarers

These should not be operated in a hazardous area and, for those involving a projectile, consideration should be given to where the projectile might land.

5.8 Off-site issues

5.8.1 Infrastructure/support activities

Such activities may include:

- temporary road crossings
- pipe corridors and service ducts (with gas, leachate, electrical cables) under public roads
- lighting/CCTV towers
- radio masts

Although the temporary generation of a potentially explosive atmosphere during installation is permitted in an off-site location (with measures being implemented to prevent public access), it is not permissible for areas to which the public have access to be permanently zoned. In other words, the edge of zones must be inside the site boundary. For existing installations where this cannot be achieved, existing zones 2 may remain where the installation cannot be readily moved further inside the site boundary, subject to a risk assessment, since the risk to the general public is very low. Where zones 1 exist on public land, this is usually due to an operational activity such as sampling and the public can be excluded from the area while the operation is carried out.

The consequence of this is that, where installations close to a public road or other space require a zoned area, this should be located sufficiently inside the site boundary. Examples that may be close to public areas include:

- perimeter boreholes
- the point where service ducts under public roads come above ground – these will only require a zone if they contain a potential release such as a flanged joint
- pipe manifolds

5.8.2 Methane monitors in off-site buildings

Methane monitors may be provided to dwellings close to landfill sites where migration of landfill gas is a possibility. Where these are required to monitor gas levels up to and exceeding the LEL, they will be intrinsically safe. There should be a procedure in place for re-calibrating them at the required interval. Where such monitors are required only to measure levels of methane well below the LEL, they need not be intrinsically safe.

5.8.3 LPG heaters in cabins, etc.

Liquefied petroleum gas (LPG) is a mixture consisting mainly of propane and butane in varying proportions. It is a gas that liquefies under a modest pressure and is stored in fixed tanks or portable cylinders.

The zoning associated with the delivery, storage and distribution of propane (LPG) in fixed installations is dealt with in ICoP 3.

APPENDIX 1: ASSESSMENT OF ALREADY-INSTALLED NON-ELECTRICAL EQUIPMENT

The following appendix is supplied for information only
and is not intended in itself to impart a level of training necessary for a competent person

A1.1 Legal requirements

DSEAR Regulation 17(2)(a) reflects the ATEX 1999/92/EC[9] Worker Protection Directive and states: -

"…. a workplace which contains places where explosive atmospheres may occur …. which is or has been in use on or before 30th June 2003 shall comply with the requirements of regulations 7 and 11 no later than 30th June 2006 …."

DSEAR Schedule 3(1) states: -

"Equipment and protective systems for all places in which explosive atmospheres may occur must be selected on the basis of the requirements set out in the EPS Regulations[10] unless the risk assessment finds otherwise."

New equipment should be marked as ATEX-compliant. With specific regard to non-electrical equipment installed before 30th June 2003, it will not be marked in any way as being suitable for use in a potentially explosive atmosphere. DSEAR requires such equipment to be assessed for its ignition capability, although it is not required to meet the constructional requirements of new equipment found in the EPS Regulations. The assessment should be completed by 30th June 2006. *There is no requirement to retro-fit ATEX-marked equipment* unless a risk assessment indicates a replacement is required.

What follows is guidance of how non-electrical equipment that is already installed can be assessed as suitable for continued use. Typical examples that require an assessment are: -

- pumps
- couplings (e.g. between a motor and the associated pump)
- conveyor belts
- hoists
- solenoid valves
- gearboxes
- brakes

The ignition hazard assessment for equipment in the following zones will now be discussed. The level of protection required for the various zones is summarised in Table 4:

Table 4: Levels of protection required for different zones

Gas/vapour zone	Probability of explosive atmosphere	ATEX Category	Requirements
2	low	3G	Safe in normal operation
1	medium	2G	Safe even with 'expected malfunctions'
0	high	1G	Safe even with 'rare malfunctions'

Similarly, Category 1D equipment can go into a zone 20, Category 2D into zone 21 and Category 3D into zone 22.

A1.2 Already-installed non-electrical equipment in zone 2

Zone 2 is the low risk zones where an explosive atmosphere arises only very occasionally, usually as a result of the failure of plant equipment (e.g. leaking flange or seal) or human error (accidental spill). As such, the requirements for the installed equipment are not excessively onerous and often are easily met by normal well-designed industrial equipment.

The requirements for equipment in these zones can be broadly summarised as follows: -

in normal operation, the equipment should not spark
and should not have excessively hot surfaces;
its ingress protection should be suitable for the environment

EN 1127-1 lists thirteen type of ignition source:
1 hot surfaces
2 flames and hot gases
3 non-electrically-generated sparks
4 electrical apparatus
5 stray static currents, cathodic corrosion protection
6 static electricity
7 lightning
8 electromagnetic fields in the frequency range 9 kHz to 300 GHz
9 electromagnetic radiation in the frequency range from 300 GHz to 3000 GHz or wavelength from 100 μm to 0.1 μm (optical spectrum)
10 ionising radiation
11 ultrasonics
12 adiabatic compression, shock waves, gas flows
13 chemical reactions
However, most or all will not apply to non-electrical equipment in normal operation.

When considering non-electrical equipment, and whether it is acceptable for continued use in zone 2 hazardous area, it is usually self-evident whether it sparks or not. With regard to temperature rise, very few of those parts exposed to the flammable gas or dust will exceed even 100°C, which makes the item acceptable for the vast majority of flammable materials[ii]. It should be stressed that only normal operation needs be considered for these zones; fault conditions (such as a seized bearing) are not taken into account, due to the low probability of such a fault occurring at exactly the same time as the explosive atmosphere. It is important to stress that the above assumes that the equipment is properly maintained.

Table 5 below shows a typical ignition hazard assessment for a range of devices in zone 2. Only normal operation is included, but loss of lubrication, for example, caused by poor maintenance is also included. The last column (Reference) is not important to users, but is included for information only, as it cross-references the measure to the relevant constructional standard.

Table 5: Typical ignition hazard assessment for non-electrical devices in zone 2

Potential ignition source in normal operation (Cat 3)	**Examples of measures taken to prevent ignition source from becoming effective**	**Reference**
General		
Loss of coolant	There is no immediate source of ignition as a result of coolant loss. Is the cooling water monitored by a level detector linked to the control system?	EN 13463-1
External impact causing failure or reduced clearances	Are all parts robustly manufactured and would withstand a likely impact?	EN 13463-1
Sparking caused by static charging	CLC/TR 50404 does not impose restrictions on plastic parts for Category 3 equipment.	CLC/TR 50404
Poor earthing	Are suitable earth facilities provided? Are all electrical parts earthed?	EN 13463-1
Hydraulic pump		
Pump surface temperature	What is the design running temperature? Highly unlikely to be excessively hot in normal operation.	EN 13463-1
Pump oil temperature	Highly unlikely to be excessively hot if suitably topped up.	EN 13463-1

ii For those flammables with very low auto-ignition temperatures (e.g. carbon disulphide, CS_2), then a more careful approach will be required, possibly involving actual measurement of the surface temperature or contacting the manufacturer. Regarding flammable dusts, be aware that a 75 K safety factor must be applied to the AIT of the dust layer and a 2/3 safety factor to the AIT of a cloud.

Table 5: Typical ignition hazard assessment for non-electrical devices in zone 2		
Potential ignition source in normal operation (Cat 3)	**Examples of measures taken to prevent ignition source from becoming effective**	**Reference**
Loss of lubrication causing overheating	Regular oil level checks recommended in user instructions.	User instructions
Coupling (vibration absorption type, laminations)		
Vibration exceeds coupling manufacturer's specification, causing failure	Is the vibration within the manufacturer's limits and has it been checked by test?	EN 13463-1
Fixings work loose	Are all fixings tightened to manufacturer specified torque?	EN 13463-1
Coupling (vibration absorption, rubber tyre type)		
Surface temperature	Can usually be assessed as not exceeding temperature of other parts.	EN 13463-1
Vibration exceeds coupling manufacturer specification, causing failure	Is the vibration within the manufacturer's limits and has it been checked by test?	EN 13463-1
Pump (piston type)		
Surface temperature	Is a temperature switch fitted? Has the casing temperature been measured?	EN 13463-1
Loss of lubrication through leaks causing overheating	Are regular oil level checks carried out as recommended in user instructions?	EN 13463-5
Seal temperature	Seals are manufactured from a low coefficient of friction material (nitrile, PTFE, Viton, etc.) and are not expected to achieve a running temperature in excess of other parts of the equipment.	EN 13463-5
Rotating shafts		
Debris falling onto shaft creates sparks or hot surfaces	Are shafts guarded to prevent inadvertent contact?	EN 13463-1
Mixers		
Contact between rotating and stationary parts	Is the construction suitably robust to maintain clearances under load?	EN 13463-1
Blades become loose and separate, causing impact sparks	Are all fixings torque tightened to manufacturer's specification?	EN 13463-1
Bearing and seal temperature (if supported by separate bearing not on motor)	Is the speed within the limit prescribed by the manufacturer? Does the equipment have a temperature sensor?	EN 13463-1 EN 13463-5
Gearbox		
Oil loss	Are periodic checks on lubricant level and condition of oil seals performed?	EN 13463-8

The principles of the ignition hazard assessment in Table 5 will be applied to specific examples in the following sub-sections. For simplicity, each ignition hazard assessment is complete in itself, although this involves some duplication of the information in Table 5.

A1.2.1 Ignition hazard assessment of an already-installed electrically-driven pump in zone 2

Figure 11: Typical diaphragm pump

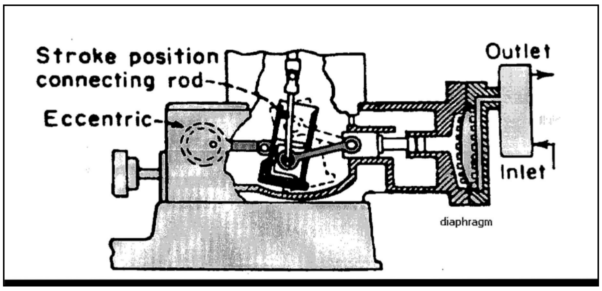


Table 6 shows a typical ignition hazard assessment for this type of pump

Table 6: Typical ignition hazard assessment for an electrically-driven pump in zone 2	
Normal operation	**Compliance**
External impact causing failure or reduced clearances	All parts are robustly manufactured and would withstand a likely impact
Poor earthing	Suitable earth facilities are provided. All electrical parts are earthed
Pump surface temperature	Highly unlikely to be excessively hot in normal operation.
Pump oil temperature	Highly unlikely to be excessively hot if suitably topped up.
Loss of lubrication causing overheating	Regular oil level checks recommended in user instructions.
Vibration exceeds coupling manufacturer's specification, causing failure	Vibration limits for coupling verified by checking the manufacturer's specification.
Fixings work loose	All fixings tightened to manufacturer specified torque
Debris falling onto shaft creates sparks or hot surfaces	Shafts are guarded to prevent inadvertent contact
Oil loss from gearbox	Periodic checks on lubricant level and condition of oil seals
Summary	Pump is acceptable if suitably-protected against impact and maintained/lubricated at the required intervals; avoid excessive vibration.

A1.2.2 Ignition hazard assessment of an already-installed air-driven pump in zone 2

Table 7: Typical ignition hazard assessment for an air-driven pump in zone 2	
Normal operation	**Compliance**
External impact causing failure or reduced clearances	All parts are robustly manufactured and would withstand a likely impact
Pump surface temperature	Highly unlikely to be excessively hot in normal operation.
Pump oil temperature	Highly unlikely to be excessively hot if suitably topped up.
Loss of lubrication causing overheating	Regular oil level checks recommended in user instructions.
Fixings work loose	All fixings tightened to manufacturer specified torque
Summary:	Pump is acceptable if suitably-protected against impact and maintained/lubricated at the required intervals; avoid excessive vibration.

A1.2.3 Ignition hazard assessment of an already-installed gas booster in zone 2

Figure 12: Gas booster

The gas booster has a zone 2 internally (this is the classification given to the landfill gas pipework from the manifold to the gas compound) and also externally (due to leaks from its own seal).

Table 8: Typical ignition hazard assessment for a gas booster in zone 2

Normal operation	Compliance
External impact causing failure or reduced clearances	All parts are robustly manufactured and would withstand a likely impact
Sparking caused by static charging	There are no plastic parts in contact with the process medium. Plastic parts are not subjected to a charging mechanism.
External surface temperature	Highly unlikely to be excessively hot in normal operation.
Vibration exceeds coupling manufacturer's specification, causing failure	Vibration limits for coupling verified by manufacturer checking on test.
Fixings work loose	All fixings tightened to manufacturer specified torque
Seal temperature	Seals are manufactured from a low coefficient of friction material (nitrile, PTFE, Viton, etc.) and are not expected to achieve a running temperature in excess of other parts of the equipment.
Debris falling onto shaft creates sparks or hot surfaces	Shafts are guarded to prevent inadvertent contact
Contact between rotating and stationary parts	All clearances generous. Construction is suitably robust to maintain clearances under load.
Blades become loose and separate, causing impact sparks	All fixings torque-tightened to manufacturer's specification
Bearing and seal temperature (if supported by separate bearing not on motor)	Check that the speed is within the limit prescribed by the manufacturer.
Oil loss from gearbox	Periodic checks on lubricant level and condition of oil seals
Summary:	Booster is acceptable if suitably-protected against impact and maintained/lubricated at the required intervals; avoid excessive vibration.

A1.3 Already-installed non-electrical equipment in zone 1

Unlike in zone 2, foreseeable malfunctions should be considered when assessing non-electrical equipment in zones 1. Thus, the situation is somewhat more complicated. However, relatively little equipment, if any, falls into this category in the waste management industry.

When first considering the issue, the difficulty usually arises as to what constitutes a 'foreseeable malfunction' and whether such should be tolerated in a zone 1. Useful guidance on how to do the ignition hazard assessment can be found in EN 13463-1:2001, which is one of a suite of standards giving the constructional requirements for hazardous area non-electrical equipment. It should be stressed that there is no suggestion in the ATEX Directive that existing equipment should either be made to comply with these standards or else replaced, but they can be used for guidance.

A note in EN 13463-5 section 5.1 is included here because it gives guidance that is of general use: -

"Slow-moving parts with a circumferential speed of less than 1 m/s do not normally require protection against heating by friction and non-electrical sparks".

The general approach, which takes care of most of the ignition hazards, is as follows: -

ensure that the equipment is maintained in accordance with the manufacturer's guidelines and that all parts with a potential to become ignition sources are replaced at or before the specified interval

A1.4 Already-installed non-electrical equipment in zone 0

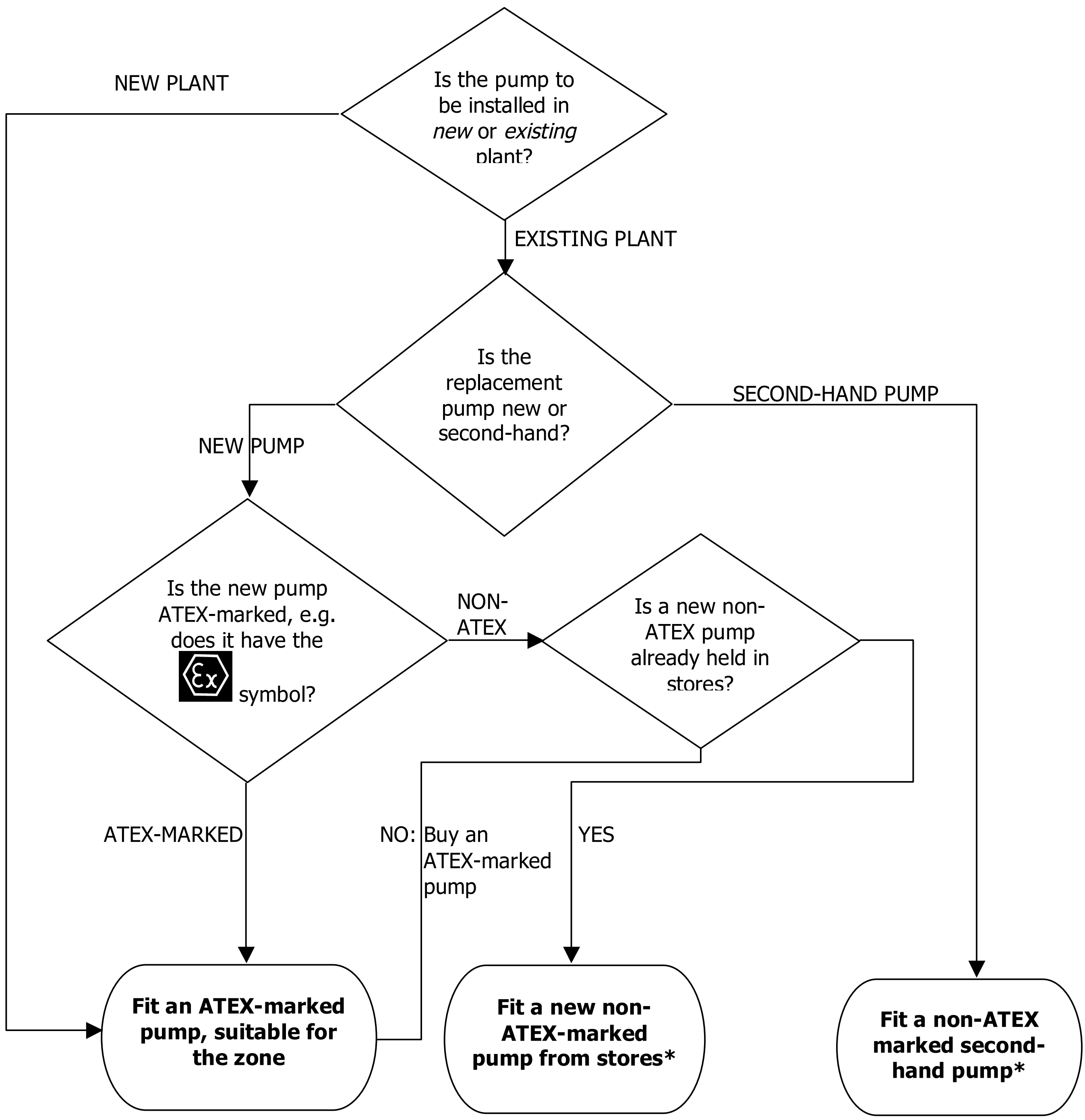
Such equipment is relatively rare, but certain examples may require consideration. The ignition hazard assessment should consider 'rare malfunctions' as well as 'expected malfunctions'. To take the example of sealed bearings, the mechanical seal protecting the bearings could be in contact with the zone 0. Possible approaches could be: -

- monitoring the barrier fluid level or pressure or flow
- an analysis of past failure rates
- periodic vibration or temperature monitoring
- as for equipment in lower risk zones, the routine maintenance and scheduled replacement of the bearings should be as recommended by the manufacturer.

A1.5 Selection flowchart

Figure 13 summarises when ATEX-marked pumps are required and when they are not. It can equally be applied to other items of non-electrical equipment, such as gas boosters, hoists, etc.

Figure 13: Flow chart for selecting a pump or other item of non-electrical equipment



* Note: before any non-ATEX item can be installed, an ignition hazard assessment is required, but this is the task of the Site/Facility Manager, not the installer. In many cases, the pump will be fitted into a zone 2, in which case the ignition hazard assessment for non-ATEX equipment is straightforward. Only properly-maintained, correctly-installed pumps should be used.

A1.6 Summary

An assessment of already-installed non-electrical equipment in zone 2 is relatively straightforward but a more careful analysis is required for the higher-risk zones. It is not possible to give a detailed approach for all situations, but the application of sound engineering judgement and implementation of reasonable precautions, proportionate to the zone classification, to prevent potential ignition sources becoming active is sufficient to comply with the requirements in the ATEX Worker Protection Directive. New equipment should be ATEX-marked.

APPENDIX 2: ASSESSMENT OF ALREADY-INSTALLED UNCERTIFIED ELECTRICAL EQUIPMENT

The following appendix is supplied for information only and is not intended in itself to impart a level of training necessary for a competent person.

A2.1 The legal situation

DSEAR Regulation 17(2)(a) reflects the ATEX 1999/92/EC Worker Protection Directive and states:

"…. a workplace which contains places where explosive atmospheres may occur …. which is or has been in use on or before 30th June 2003 shall comply with the requirements of regulations 7 and 11 no later than 30th June 2006 …."

DSEAR Schedule 3(1) states: -

"Equipment and protective systems for all places in which explosive atmospheres may occur must be selected on the basis of the requirements set out in the EPS Regulations unless the risk assessment finds otherwise."

With very few exceptions, newly-installed equipment must be marked as ATEX-compliant. With specific regard to electrical equipment installed before 30 June 2003, it will generally be certified if it is used in a gas/vapour zone but *may* not be certified in the following instances: -

- ♦ electrical equipment for gas/vapour zone 2 may be uncertified if the end user (typically) had assessed it as acceptable – for such equipment, see below;
- ♦ electrical equipment for dust zones may be certified for gases/vapours but no certification for dusts existed – for such equipment, see below;
- ♦ simple apparatus in an intrinsically safe circuit is, by definition, uncertified – this is outside the scope of this Appendix.

A2.2 Uncertified electrical equipment in zone 2

This section deals with equipment installed in zone 2 before the ATEX directives came into force on 1 July 2003. The requirements for zone 2 were and are considerably more relaxed than for zone 1 and EN 60079-14:2002[11] clause 5.2.3c permits the use of uncertified equipment in zone 2, provided it is assessed as meeting the requirements of the relevant standard. These requirements can be summarised as follows for the commonest form of Type n equipment ("Ex n non-sparking"):

a) the enclosure is normally required to be IP54 minimum, though protection by location (e.g. indoors) permits a lower level of ingress protection;
b) the equipment shall contain no sources of ignition in normal operation, i.e.
   - **hot surfaces:** no surfaces hotter than the ignition temperature of the hazard gas
   - **sparks:** no normally-sparking components are permitted, e.g. switches, relays unless encapsulated), contactors, circuit-breakers, potentiometers (unless the spark is current-limited) and easily-separated connectors (secure with adhesive if necessary). Such items are acceptable if certified to another concept, e.g. Ex d switches.

It should be stressed that the assessment takes account only of normal operation, and not fault conditions (e.g. a conductor coming loose from a terminal or a fuse blowing), since it is considered a sufficiently low risk that such a fault could occur at exactly the same time as a flammable gas is present in the enclosure. The enclosure is not required to be gas-tight for this method of protection.

There is no upper voltage limit and uncertified terminals are permitted. It is also possible to use test-disconnect terminals (non-sparking in normal operation), fuse terminals and other terminals incorporating components such as diodes. However, it is usual to use test-disconnect and fuse terminals that are *certified* as Ex n/N, since these are readily available.

Common examples of uncertified items of equipment that may be thus assessed are: -

- A.c. induction motors (paying particular attention to maximum temperature; sometimes a guide is that the limiting temperature for the wiring insulation is stated on the marking plate as a "Class"[jj], having no relationship to North American Classes I, II and III)
- Junction boxes
- Non-purged panels with no sources of ignition
- Panels containing potential ignition sources that are protected by the pressurisation principle

This relaxation in EN 60079-14 clause 5.2.3c does not apply to zone 1: all electrical equipment should be certified: an assessment and subsequent use of uncertified equipment is not recommended.

Note that the ATEX 1999/92/EC Worker Protection Directive requires *new* equipment (electrical and non-electrical) for zone 2 to be marked as ATEX-compliant.

jj Class A = 105°C, class E = 120°C, class B = 130°C, class F = 155°C, class H = 180°C, class N = 200°C (values from EASA Electrical Engineering Handbook)

APPENDIX 3: OVERVIEW OF HAZARDOUS AREA TERMINOLOGY

A3.1 In which zone can equipment be used?

Before the ATEX Directives, the method of protection defined the zone of use for electrical equipment as shown in Table 9:

Table 9: Relationship between protection method and zone for pre-ATEX equipment

Zone 0 equipment	Zone 1 equipment	Zone 2 equipment
intrinsically safe, type Ex ia	intrinsically safe, type Ex ib flameproof, Ex d increased safety, Ex e pressurised, Ex p encapsulated, Ex m quartz-filled, Ex q oil-filled, Ex o special, Ex s	Non-incendive, Ex N or Ex n

This method of deciding on the zone is no longer used. The ATEX 94/9/EC Directive additionally covers non-electrical and dust-protected equipment and introduces the concept of 'Categories', which may be summarised as shown in Table 4 below:

Table 10: Relationship between ATEX Category and zone

ATEX Category	Level of protection	Zones of use	
		G = gas and vapour zones	D = dust zones
1	Safe with two independent faults *or* safe even when rare malfunctions are considered	0	20
2	Safe with one fault *or* safe when foreseeable malfunctions are considered	1	21
3	Safe in worst-case normal operation	2	22

ATEX marking is given in more detail in the following Appendix. If an item of equipment is ATEX-marked, this marking shows the zone in which it may be installed or used. For example, if equipment is marked as follows:

II 2G

The 'II' indicates it is certified for surface use (non-mining) and the '2G' indicates it is Category 2G equipment. From the table above, it can be seen that this can be used in zones 1 and 2 only. Even then, it is important to check that the apparatus group and temperature class are appropriate for the gas hazard.

Equipment marked:

II 3GD

is again suitable for surface industries but this time it is Category 3GD. It can be used in zones 2 (gases) and 22 (dusts).

Thus, ***it is the category, not the protection concept, that should now be used to determine the applicable zones of use***. However, the apparatus group and temperature class must also be suitable. This is not an issue for landfill gas, since methane is among the least sensitive of gases, but the following information is given for general guidance.

A3.2 Apparatus groups

Both items of equipment and gases/vapours are assigned apparatus groups. The apparatus group may take one of the following four forms:

Table 11: Apparatus group		
Apparatus group	**Description**	**Suitable for use with gases and vapours with apparatus groups:**
IIA	Equipment suitable only for gases that are least likely to transmit a flame or are relatively insensitive to spark ignition	IIA only
IIB	Equipment suitable for gases that are moderately likely to transmit a flame or are fairly sensitive to spark ignition	IIA and IIB
IIC	Equipment suitable for gases that are highly likely to transmit a flame or are very sensitive to spark ignition	IIA, IIB and IIC
II	Equipment suitable for all gases (effectively the same as IIC equipment)	IIA, IIB and IIC

Landfill gas is a IIA gas, meaning even IIA equipment is suitable. Clearly, IIB and IIC (or 'II') equipment is also suitable. There are therefore no limitations with respect to apparatus group.

A3.3 Temperature class

Dust-protected equipment is marked with an actual maximum surface temperature. For other equipment, a "temperature class" is used. This is based on the hottest surface where igniting the flammable gas/vapour would destroy the protection and may refer to the inside or outside of the enclosure.

Table 12: Temperature class		
Temperature class	**Description**	**Suitable for use with gases and vapours with temperature classes:**
T1	The hottest temperature class – the maximum temperature does not exceed 450°C	T1 only
T2	The maximum temperature does not exceed 300°C	T1 and T2
T3	The maximum temperature does not exceed 200°C	T1, T2 and T3
T4	The maximum temperature does not exceed 135°C	T1, T2, T3 and T4
T5	The maximum temperature does not exceed 100°C	T1, T2, T3, T4 and T5
T6	The maximum temperature does not exceed 85°C	All temperature classes

Most equipment on the market is T3, T4, T5 and T6.

The temperature class is always quoted in relation to an ambient range. If the ambient temperature range is not marked on the equipment (e.g. T_a = -20°C to +60°C), then the default range of -20°C to +40°C can be assumed. Using the equipment outside its ambient range invalidates the certification, though such use is not necessarily unsafe; responsibility for such use lies with the installer, not the manufacturer or certification body.

Landfill gas is a T1 gas, meaning an item of equipment with any temperature class is suitable. There are therefore no limitations with respect to temperature class.

APPENDIX 4: HAZARDOUS AREA EQUIPMENT MARKING

A4.1 General

Prior to the issue of the ATEX Directives, only electrical equipment for gases and vapours was marked for hazardous area use. From 1 July 2003, the ATEX Directives came into force and required all equipment to be marked if it was to be used in hazardous areas. Not only electrical equipment, but also non-electrical, as well as dust-protected equipment now requires marking.

A4.2 Pre-ATEX marking for electrical equipment

An example of typical marking for an item of intrinsically safe equipment would be similar to the following

Armageddon Industries

Nemesis 666 Toxic Gas Monitor
EEx ia IIC T4 (Ta = -20^{o}C to +60^{o}C)
Ui = 28V, Ii = 120mA, Pi = 0.84W, Ci = 0, Li = 58μH
STATIC HAZARD: clean only with a damp cloth
Serial number: nnnnn
PTB Ex 99E2100X

	is the European mark that indicates the equipment is explosion protected
EEx ia IIC T4	is the certification code and tells the user the zones of use
Ui = 28V …. etc.	is the safety description, indicating what the equipment may be connected to
Sira Ex 99E2100X	is the certificate number
X	at the end of the certificate number indicated special conditions for safe use, that are written in the certificate and should always be referenced when installing or inspecting the equipment.

A4.3 How to work out the zone of use

On pre-ATEX equipment, only electrical equipment for flammable gases and vapours was marked as suitable for hazardous areas. The zone could be worked out from the type of protection, as shown in Table 13:

Table 13: Zones for pre-ATEX equipment

Equipment suitable for zone 0	Equipment suitable for zone 1	Equipment suitable for zone 2
Intrinsic safety, EEx ia	Equipment for zone 0 *plus* Intrinsic safety, EEx ib Flameproof, EEx d Increased Safety, EEx e Pressurised, EEx p Encapsulated, EEx m Oil-filled, EEx o Quartz-filled, EEx q Special, Ex s	Equipment for zones 0 and 1 *plus* Ex N or Ex n, EEx nA, EEx nC, EEx nL, EEx nR, EEx nP, EEx nZ

With the advent of the ATEX Directives, ***it is the <u>category</u> that determines which zone the equipment can go into.***

A4.4. ATEX categories

The more onerous the zone, the greater the requirements for equipment installed in it. The ATEX 'Product' Directive[kk] introduced the concept of 'Categories' of equipment. This is summarised in Table 4 for equipment protected against flammable gases[ll].

A4.5 ATEX marking for electrical equipment

Armageddon Industries, Salem, USA

CE nnnn Ex II 2G

Doomwatch 999 Flammable Gas Monitor

EEx ia d IIC T4 (Ta = -20°C to +60°C)

Ui = 28V, Ii = 120mA, Pi = 0.84W, Ci = 0, Li = 58μH

STATIC HAZARD: clean only with a damp cloth

Serial number: yy/nnnnn

Sira 06ATEX2999X

There is additional marking for equipment which has ATEX certification:

- the address of the manufacturer
- the CE mark followed by the reference number of the notified body responsible for issuing the quality notification (not necessarily the certificate)
- II = the ATEX Group, i.e. non-mining
- 2G = ATEX Category
- the year of manufacture

Examples of ATEX Group and Category marking:

II 2G — indicates that the equipment is Group II (non-mining use), category 2, for gases (allowing it to be used in zones 1 and 2), compatible with T4 equipment

II 1D (T90°C) — indicates that the equipment is Group II (non-mining use), category 1, for dusts (zones 20, 21 and 22). T90°C is the external surface temperature of the equipment. The latest dust standards introduce additional marking, but this is outside the scope of this ICoP.

[kk] ATEX Directive 94/9/EC

[ll] Mining equipment has different categories

A4.6 ATEX marking for non-electrical equipment

Atlantis plc, Wastewater, LA6 6UW, UK
Scirocco Mk II Pump
30/600 r.p.m. IP65
ATL 06ATEX0001
Serial number: yy/nnnnn
II 2GD c k T4

Non-electrical equipment for all but zone 0 need not be certified by a third party Notified Body such as Sira, Baseefa, PTB, etc. Instead, the manufacturer can declare compliance and mark the equipment according to the ATEX Directive. In the example above:

ATL 06ATEX0001	is *not* a certificate number, but the manufacturer's technical file reference number
	indicates the equipment meets all the relevant European Directives
	is the European mark that indicates the equipment is explosion protected
II	tells the user that the pump is for non-mining use ('I' is for mining)
2	is the Category
G	stands for Gas, so Category 2G equipment can go into zones 1 and 2
D	stands for Dust, so Category 2D equipment can go into zones 21 and 22
c	stands for 'constructional safety' (perhaps the commonest of a number of protection methods for non-electrical equipment
k	stands for 'liquid immersion', another common non-electrical protection method
T4	is the temperature class (135°C maximum)

APPENDIX 5: METHOD STATEMENT FOR DRILLING INTO GAS PIPELINES

Scope

This Method Statement covers drilling into PE landfill gas pipe work under negative and positive pressure.

PPE Required

Hardhat, high visibility jacket, leather type gloves, anti-static steel mid-soled shoes or boots, eye protection, hydrogen sulphide personal monitor (which should be worn at all times during the task).

Introduction

This method statement has been prepared to cover the activity of the drilling and formation of a hole within a landfill gas pipe manufactured from HDPE (or similar material). Two scenarios have been considered in this document: where the operating pressure relative to atmosphere at the commencement of the activity could be either positive or negative.

Depending upon the pressure within the pipe work at the time of the activity, there is a potential to form an explosive atmosphere either within the gas pipe (if under negative pressure) or external to the pipe, centred on the resultant hole if under a positive pressure.

DSEAR requires operators to have systems in place to reduce or mitigate the risk of an explosive atmosphere forming and where it does to eliminate or reduce the risk of personal injury or harm to an acceptable level. The activity described by this method statement is considered a maintenance activity as described by DSEAR.

Where possible, all drilling of pipe work required for the installation of sample points, etc. into the landfill gas infrastructure should be done before the system (or part of) is connected to the existing or made live.

Description

To aid in the management of landfill gas or the process of isolation of landfill gas from a particular part of the landfill gas infrastructure, there is a requirement to install either sample taps, plugs etc as monitoring locations or points at which an inflatable bladder can be inserted to provide a gas seal. In general the largest hole that would be drilled into the gas line would be 38mm (1 ½”) in diameter.

As a rule, the gas collection infrastructure installed within the body of the waste up to the inlet of the gas booster plant is operated under a negative pressure. Exceptions to this could arise if blockages (partial or full) occur in any part of the gas system resulting in a positive pressure developing.

Under normal operating conditions, all gas delivery pipe work from the outlet of the boosters will be under a positive pressure.

Pre-Start Checks

A Inform your supervisor or site management of where you are going and what you are doing.
B Obtain a ‘Permit to Work’ for the task
C Check for additional hazards that may be present.
D Make sure that the results of any Risk or CoSHH assessments applicable to this have been taken into account.
E Ensure that all the tools and equipment necessary to carry out the task is available and in good working order. No electrical equipment (including battery powered tools) should be used during this activity unless they are ATEX certified and designed for use in a hazardous area. Priority should be given to the use of mechanical hand operated tools such as a brace and bit to drill the hole into the gas pipe work.
F Using a suitable representative location of the gas passing through the pipe line at the point of drilling, using an appropriately-certified portable gas analyser, measure the concentration of the methane, carbon dioxide, oxygen and hydrogen sulphide present within the pipe line. Note and record the results of the measurements.
G If the measured value of hydrogen sulphide is above 10ppm seek further guidance before undertaking the task. Hydrogen sulphide is toxic and at elevated concentrations is extremely flammable.
H Check to ensure that all the correct personal protective equipment (PPE) is available and is worn at the appropriate time. The PPE must be in good order.

I Make sure that a mobile phone is readily available (refer to any Additional Guidance Note on Lone Working if applicable).

1) DRILLING A HOLE WHEN THE GAS LINE IS UNDER A POSITIVE PRESSURE

Carrying out the task

1 Isolate the section of gas line, if possible, where the hole is to be drilled using any gas valves that may be installed within the system. Acceptable means of isolation include closure of existing valves within the gas line, squeeze clamps (with vent arrangement) or other methodology as appropriate.

2 If it is not possible to isolate the section of gas line, turn off the gas booster(s). This may have a knock-on effect and should be discussed in full with the unit manager.

3 Using an appropriately-certified instrument, at a representative location, measure the pressure within the gas main and monitor the pressure until it reduces to either a balance position (neutral pressure) or negative pressure within the pipe line.

4 If a negative pressure is achievable, go to the section 'Drilling a hole when the gas line is under a negative pressure.'

5 If it is not possible for operational reasons to reduce the pressure within the gas line, ***no drilling should take place on a positive pressure system***.

2) DRILLING OF A HOLE WHEN THE GAS LINE IS UNDER A NEGATIVE PRESSURE

1 At a representative location, down stream of the drilling location, on the gas collection system, using an appropriately-certified analyser, measure the pressure within the gas line to confirm that it is under a negative pressure relative to atmosphere. Measure the concentration of methane, carbon dioxide and oxygen within the gas stream; note and record the readings.

2 Using the brace and bit, drill the hole into the pipe line

3 Restrict the air ingress into the gas pipe by temporarily placing a piece of polythene sheet or similar over the hole.

4 Offer up the 'tap', remove the polythene and cut the thread into the pipe as quickly as possible.

5 Remove the 'tap' and again temporarily restrict the air ingress into the pipeline using a piece of suitable material.

6 Offer up the plug, sample tap etc, remove the material and screw in the fitting until tight and no air leak into the pipe line can be detected.

7 Using the monitoring location as in item 1 of this section, confirm that the gas quality is in line with the measurements taken earlier. If there are any differences between the readings outside of expected tolerances, and there have been no changes on the gas field or gas management system has occurred since the initial reading, determine whether or not the change is due to the installation of the pipeline fitting; repair as required. Check the gas readings on completion and confirm that they are in line with the initial readings.

8 Remove all equipment and materials from the area ensuring all control panels, chambers etc. are closed or locked where applicable.

9 Check that the area has been left in a safe and acceptable condition.

10 Contact your supervisor or site management and inform them that the work has been completed.

11 Sign off the Permit to Work.

APPENDIX 6: METHOD STATEMENT FOR LOWERING A GAS WELL IN THE OPERATIONAL AREA

Scope

This method statement has been prepared as a generic approach to the task of reducing the height of gas extraction well located in a restored area of a landfill site. For this particular safe system of work it has been assumed that the gas well and connecting head works and collector pipe (discharge line) has been constructed from HDPE or similar materials.

PPE Required

Hard hat, high visibility jacket, leather type gloves, anti-static steel mid-soled shoes or boots, eye protection, hydrogen sulphide personal monitor (which should be worn at all times during the task).

Introduction

Landfill gas (of which methane is the primary flammable constituent) is explosive in certain concentrations with air (4.4 to 16.5% by volume). Trace gases present in landfill gas, such as hydrogen sulphide, are also potentially explosive, but only at much higher concentrations than found in landfill gas. However, if present at significant concentrations, then a far more important COSHH[mm] issue prevails for which additional safe systems of work should be initiated.

This particular task is carried out on a frequent basis on a landfill facility and tends to arise as either the land 'naturally' settles or works are undertaken whereby the ground around the gas well is lowered artificially as part of site engineering works.

This task is usually required to be carried out for reasons, which include:

A Enabling safe access to the control valve and monitoring points on the gas well as part of the environmental management of the landfill gas to be maintained.

B Planning conditions imposed on the facility may require the gas well to be at a pre-determined height above the natural level of the ground.

C The prevention or the reduction of the potential for air to ingress into the gas management system through the reduction of the depth of the bentonite seal in relation to the perforated sections of the gas well liner.

Pre-start checks

1 Communicate with the site/facility manager and check that no other extraordinary works or activities are taking place on the site that could impact on either the task of lowering the gas well or that could impact on the 'other' activity in an uncontrolled/adverse manner without additional precautions being put in place.

2 Ensure that all equipment/tools for carrying out the task are readily available, in sound condition and good working order.

3 Ensure that all Personal Protective Equipment (PPE) is available, in good condition and suitable for the task being carried out. Generally, the only PPE to meet the requirements of the Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) is anti-static footwear, but other PPE will usually be required for other reasons.

4 Raise a Permit to Work (PTW).

5 Carry out a gas test and pressure/vacuum measurement at the gas well to be lowered. Analyse the results to verify that the atmosphere within the gas well is both under a vacuum and an explosive atmosphere is not already present. If the gas well is under positive pressure, make the necessary change to the control valve position to produce a vacuum within the well – again attempting not to form an explosive atmosphere/mixture within the well. If a vacuum cannot be produced within the gas well, review the system, carry out any changes until a resultant vacuum can be achieved. If an explosive mixture is formed within the gas well, identify the source of any potential air ingress and remediate prior to commencement of the task. Record all results of measurements taken.

[mm] COSHH = Control of Substances Hazardous to Health

6 Carry out a gas test around the external vicinity of the gas well to check that there is no methane (landfill gas) as significant concentrations (should be less than 25% of the lower explosive limit of methane i.e. <1.1%). If methane levels are detected in excess of this value, identify the source of landfill gas and eliminate prior to commencement of the task. Record all results of atmospheric testing.

7 Identify suitable means of isolation of the landfill gas within the gas well originating from the waste mass. Acceptable means of isolation could be squeeze clamps, inflatable bladders etc. (For this safe system of work described here, the use of an inflatable bladder has been incorporated into the procedure).

8 As required, mark out a safe working area around the gas well and identify by suitable means (e.g. warning tape etc.) and restrict access to the working area to those persons involved with the undertaking of the task.

9 Where there is potential for vehicles to approach close to the working area, consideration should be given to the installation of a temporary barrier to prevent vehicle movements in the area.

Carrying out the Task

10 With the gas well proven to be under extraction, drill a hole of suitable size (nominally 25mm dia.) at a location in the gas well liner below the point at which the gas liner will be cut.

11 Keeping to a minimum the air ingress through the newly-drilled hole, produce a thread of an appropriate specification on the internal surface of the hole to enable a bung to be screwed in to form a seal on completion of the task.

12 Insert the inflatable bladder through the hole and inflate.

13 Using an appropriate test meter, measure the atmosphere within the well head/collector line (dependent upon the sample point location) and check that the gas well including head works is free from landfill gas ('gas free').

14 Close the control valve on the head works.

15 Check that the bladder has sealed by carrying out a gas test within the gas well. If sufficient space is available, this could be done either through the drilled hole or via the gas sample point provided it is located prior to the control valve on the collector line. Only when proven to be sealed should the task continue. In the event that a positive seal has not been achieved, consideration should be given to the installation of a second inflatable bladder, in effect producing a 'double block' arrangement. Good practice would be to include the use of a pressure gauge or other pressure-measuring device on the 'bladder' to ensure that it retains its pressure whilst the task is being carried out.

16 Isolate the collector line after the control valve. This could normally be achieved by the use of an appropriately-sized squeeze clamp.

17 Split the mechanical (bolted) seal at the control valve.

18 Remove the gas wellhead works. This is generally a manual operation; therefore the requirements of the Manual Handling Regulations should be taken into account. Depending upon the degree of settlement of the land, gaining access to the head works may require working at height and hence suitable and sufficient measures should be put in place to reduce the risk of an accident occurring. Remove the head works to a safe, secure location for re-use.

19 Identify the location of where the gas well liner is to be cut.

20 Using an appropriate hand saw, cut the gas well liner down to the appropriate length.

21 If required, cut the section of pipe on the inlet of the head works (this would normally be sized to slot inside the well liner and form an interference fit).

22 Renew the Fernco coupler (or similar securing device) as appropriate to form a gas tight seal between the gas well liner and the head works.

23 Re-fit the head works to the well liner and tighten securing device as appropriate to form a gas tight seal.

24 Re-connect the collector line, including control valve to the head works. Ensure that all the bolts securing the pipe work are re-fitted to the appropriate torque setting.

25 Ensure that the control valve is in the closed position.

26 Remove the squeeze clamp from the collector line.

27 Open the control valve on the head works so as to impart a suction on the gas well.

28 Carefully deflate the bladder within the gas well (beware of gas pressure that may have built up behind the bladder) and remove when sufficiently deflated.

29 Fit a screwed bung of the appropriate size into the hole within the well liner ensuring a gas tight seal with no air ingress into the system.

30 Carry out a gas test on the atmosphere within the gas well or on the collector line to prove that no excess air is being drawn into the gas extraction system.

31 Remove all waste, equipment and tools from the working area.

32 Return PTW to originator, sign off as appropriate.

APPENDIX 7: METHOD STATEMENT FOR THE REPLACEMENT OF AN ELECTRIC PUMP IN A CONDENSATE KO POT

Scope

This Method Statement covers the replacement of an electric pump within a condensate knock out pot.

PPE required

Hard hat, high visibility jacket, leather type gloves, anti-static steel mid-soled shoes or boots, eye protection, hydrogen sulphide personal monitor (which should be worn at all times during the task).

Introduction

This safe system of work has been prepared as a generic approach to the task of replacing an electric submersible pump within a condensate knock out (KOP), which in turn forms part of a landfill gas management system.

Condensate forms as the landfill gas extracted from the waste mass cools. If this liquid is left within the gas management system, it could eventually restrict the flow of gas from the waste mass, giving rise to potential environmental issues. Condensate can have a number of hazards associated with it: any person working on these types of systems is likely to come into contact with the liquid and should be aware of the steps and precautions required to be taken.

Landfill gas (of which methane is the primary flammable constituent) is explosive in certain concentrations with air (4.4 to 16.5% by volume). Trace gases present in landfill gas, such as hydrogen sulphide, are also potentially explosive, but only at much higher concentrations than found in landfill gas. However, if present at significant concentrations, then a far more important COSHH issue prevails for which additional safe systems of work should be initiated.

It has been assumed for this protocol that the design of the KOP is simple in that it has the following associated characteristics:

A The KOP is an 'in line' unit with landfill gas passing through the main collector chamber unabated. The KOP is installed directly into virgin ground (outside of the waste mass).

B The electric control panel for the pump is located in close proximity to the KOP.

C Access to the collection chamber of the KOP is gained via a bolted, flanged lid.

This particular task is carried out on a frequent basis on a landfill facility and is usually required as part of a planned maintenance programme where the pumps are inspected and serviced on a regular basis or have to be replaced/repaired following failure.

All personnel involved with undertaking this task should be trained and/or competent in the required disciplines.

1 Pre-start checks

1. Communicate with the site/facility manager and check that no other extraordinary works or activities are taking place on the site that could impact on either the task of lowering the gas well or that could impact on the 'other' activity in an uncontrolled/adverse manner without additional precautions being put in place.
2. Ensure that all equipment/tools for carrying out the task are readily available, in sound condition and good working order.
3. Ensure that all Personal Protective Equipment (PPE) is available, in good condition and suitable for the task being carried out.
4. Raise a Permit to Work (PTW).
5. Isolate the power supply to the pump at the local control panel. Apply safety lock to isolator switch. Prove the power supply 'dead'.

6 If required where the local control panel feeds other electric consumers, isolate electrically the local control panel back at the distribution board or other point of supply. Apply a safety lock to the isolator switch.

7 Carry out a gas test around the external vicinity of the KOP to check that there is no landfill gas (methane) at significant concentrations (should be less than 25% of the lower explosive limit of methane i.e. <1%). If methane levels are detected in excess of this value, identify the source of landfill gas and eliminate prior to commencement of the task. Record all results of atmospheric testing.

8 Using a suitable instrument, measure the quantity of the gas within the system immediately downstream of the KOP to be worked on. Record the results.

9 Identify suitable means of isolation of the landfill gas both on the inlet and discharge sides of the KOP. Acceptable means of isolation could be

- ♦ squeeze clamps (dependent upon the size of the pipe)
- ♦ inflatable bladders
- ♦ flooding of the inlet and outlet pipe work with water
- ♦ shutting any in-line gas valves
- ♦ shutting down the entire gas extraction system (this is considered last resort as it could lead to potential uncontrolled releases of landfill gas into the atmosphere).

10 As required, mark out a safe working area around the gas well and identify by suitable means i.e. warning tape etc. and restrict access to the working area to those persons involved with the undertaking of the task.

11 Where there is potential for vehicles to approach close to the working area, consideration should be given to the installation of a temporary barrier to prevent vehicle movements in the area.

2 Carrying out the task

12 Arrange for the disconnection of the pump cable from the local control panel. Dependent upon the method of installation i.e. if 'hard wired' into the control box, arrange for a competent/trained person to disconnect.

13 Isolate the gas lines into and out of the KOP using an acceptable methodology that will produce a gas tight seal.

14 Relieve any pressure within the KOP by venting out to atmosphere through a convenient point e.g. sample point. Whilst this event is taking place, ensure that no equipment/tools etc. (which could include mobile phones) that could become a source of ignition are present and/or energised as appropriate in the vicinity of the KOP. Whilst the residual pressure within the KOP is venting, ensure that all personnel remain at a safe distance from the KOP and ideally, conditions allowing, away from the source of landfill gas being emitted from the KOP. As part of the Pre-Start checks, the measurement of hydrogen sulphide within the landfill gas should have been carried out, the results of which will determine the degree of respiratory protection required (if necessary) to be worn by persons carrying out this task.

15 After a suitable time (typically 10 minutes), take gas measurements (in particular methane and hydrogen sulphide) of the atmosphere using an appropriate instrument to check that it is 'safe' and approach the KOP to check that the residual pressure within the KOP has dissipated.

16 Close the vent point on the KOP.

17 Having isolated the gas lines, prove that the isolation method has been successful. This can be achieved by measurement of the pressure within the KOP using an appropriate measuring device. Take a measurement of the pressure within the KOP. Leave the system for 10 minutes and re-take the pressure measurement. If the gas isolation method has been successful, there should be no difference in the results of the two pressure measurements. If the pressure has increased, investigate the cause and if required apply additional/alternative means of gas isolation to the inlet and outlet gas lines. If required and conditions allow, the installation of a 'double block and vent' system on the inlet and outlet gas lines should be applied. This has the advantage that in the case of failure or seepage of gas pass the first block (e.g. inflatable bladder, in line vale) the gas will take the path of least resistance which in this case would be the vent. The vent pipe should be fed far enough away from the working area and any potential source of ignition so as not to give rise to the formation of an explosive atmosphere in the vicinity of the discharge of the gas. Where possible, the vent should preferably be allowed to discharge at height and not ground level.

18 Where level probes or other sensing devices are installed within the KOP, disconnect any instrument leads feeding to them.

19 Depending upon the design of the system, isolate the condensate discharge line from the main condensate collector line. Disconnect the discharge line (before any non-return valve or other means of isolation that maybe installed) outside of the KOP; beware of any residual condensate that maybe present within the pipe.

20 Remove the sensing device(s) (providing this can be achieved without removal of the lid from the KOP).

21 Unbolt and remove the lid of the KOP. Because of the large size of some of the KOPs installed within some gas management systems, consideration should be given as to whether or not there is a significant risk of persons falling into the KOP. If this is the case, provisions must be put in place to eliminate this risk e.g. the wearing of a safety harness appropriately secured to a fixed point.

22 Lift out the pump from the KOP. This is generally a manual operation; therefore the requirements of the Manual Handling Regulations should be taken into account.

23 Remove the cables through the glands within the lid of the KOP, taking care not to damage the glands. If the glands become damaged or would no longer provide an air tight seal if reused, they should be replaced as the new or repaired pump is installed.

24 Install the new/repaired pump into the KOP, ensuring as far as is reasonable that the pump is in the correct orientation on the base of the KOP chamber.

25 Connect the condensate discharge line from the pump to the existing system; ensuring all connections are sufficiently tightened to prevent leaks occurring.

26 Replace the top of the KOP and secure using all bolt locating points with the correctly sized bolt and ensure that they are tightened to the correct torque specification.

27 De-isolate the condensate discharge system to the pump.

28 Remove any safety locks installed on electric supply and control panels and re-energise the power supply to the pump.

29 Check the phase rotation of the pump to ensure that it is pumping as required.

30 De-isolate the inlet and outlet gas lines from the KOP. Where 'flooding' of the KOP has been used to form a gas seal, allow the pump to remove all the excess liquid before checking for air ingress into the system.

31 Take measurements of the quantity of the landfill gas within the system at the closest point downstream of the KOP (as used in point 8 of the Pre-Start Checks) to check that air ingress into the system is not taking place.

32 Review the results of the gas measurements with those taken earlier; investigate and remediate any problems identified.

33 Remove all equipment/tools and waste associated with the task from the area.

34 Return the PTW to the originator, sign off as appropriate.

APPENDIX 8: METHOD STATEMENT FOR RAISING GAS WELLS IN THE OPERATIONAL AREA

To be issued at a later date.

APPENDIX 9: METHOD STATEMENT FOR INSTALLATION OF NEW SECTIONS TO THE GAS COLLECTION SYSTEM

To be issued at a later date.

APPENDIX 10: METHOD STATEMENT FOR MODIFICATIONS TO EXISTING GAS COLLECTION SYSTEMS

To be issued at a later date.

APPENDIX 11: METHOD STATEMENT FOR REPLACEMENTS OF SUBMERSIBLE PUMPS IN PRE-BOOSTER AREAS

To be issued at a later date.

APPENDIX 12: REFERENCES

The following publications were referenced in compiling this document:

[1] Dangerous Substances Explosive Atmospheres Regulations:2002 ('DSEAR') regulation 7 requires area classification to be undertaken

[2] L138: Dangerous substances and explosive atmospheres regulations 2002: approved code of practice and guidance. HSE books. ISBN 0 7176 2203 7

[3] Environment Agency publication LFTGN03: Guidance on the management of landfill gas, page 53, section 6.2.3, downloaded August 2005.

[4] Guidance on the Management of Landfill gas, document LFTGN 03, September 2004, Environment Agency

[5] Guidance for monitoring trace components in landfill gas, document LFTGN 04, September 2004, Environment Agency

[6] Construction, Design and Management (CDM) Regulations:1994

[7] Report on the risk of static ignition during refuelling: a study of the available relevant research, May 2001, Institute of Petroleum, section 5.5.8

[8] PD CLC/TR 50404. Electrostatics - Code of practice for the avoidance of hazards due to static electricity.

[9] ATEX Directive 1999/92/EC: Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

[10] Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 – these are the Regulations that implement the ATEX 94/9/EC Product Directive into UK law.

[11] EN 60079-14:2003 - Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines).