SAFETY IMPLICATIONS IN THE WASTE INDUSTRY FOLLOWING IMPLEMENTATIONS OF ATEX DIRECTIVES

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SUMMARY: Introduction of ATEX Directives 95 and 137 in July 2003 increased pressure on all industries dealing with potentially explosive atmospheres, including the waste industry. Both the equipment and the operating procedures had to be reviewed in order to comply with the directives. ATEX is the acronym of French words **AT**mosphere **EX**plosives. In the UK, although the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) were published well before implementation of the directives, the level of its understanding in the waste industry appeared to be low. Biogas Technology Limited being responsible manufacturer of equipment and provider of services has significantly contributed to implementation of ATEX directives and DSEAR into the landfill gas industry by being first to introduce and present the issue to relevant regulatory and professional bodies, reviewing its own designs and procedures and informing its customers of possible implications of the directives.

1. DIRECTIVES, REGULATIONS AND GUIDANCE

1.1 ATEX 95 (100a) Directive 94/9/EC

ATEX 95 Directive puts a duty onto the manufacturer or supplier of products used in potentially explosive atmospheres to classify the equipment by relevant categories in respect of its health and safety requirements for design and construction to ensure free movement of goods within the EU. It requires compliance with the conformity procedures and marking the equipment with a CE mark. The manufacturer or supplier must work out and keep an evidence of compliance in accordance with the relevant groups and categories of equipment. Equipment other than for mining applications would belong to group II (marked in Roman numbers). Then, depending on the hazardous area characteristics (Zone 0, 1 or 2 for gas or Zone 20, 21 or 22 for dust) for which the equipment is intended to use, relevant category 1, 2 or 3 is assigned. Ways of obtaining the evidence of compliance are described in corresponding Annexes to directive. The level of evidence, depending on the equipment group and category, may vary from an EC Type-Examination Certificate derived by an independent notified body as the most stringent one to Manufacturer's Statement and Certificate of Conformity at the lower end, with intermediate

levels of documentation as explained in relevant Annexes of the Directive. Classification criteria of the equipment, described in Annex I of the Directive, stipulate three levels of protection of the equipment – very high, high and normal. The design of the equipment should take into account operating conditions, grade of release of explosive substance involved, level of ventilation, types and locations of electrical and non-electrical components, potential sources of ignition, protection levels and frequency of testing. The equipment must be affixed with a plate showing name and address of the manufacturer, "CE" marking (and number of notified body if relevant), series or type of designation, specific marking of explosive protection (Greek capital epsilon and small chi in regular hexagon), equipment group and category and indication of the type of explosive atmosphere – gas or dust.

1.2 ATEX 137 (118a) Directive 1999/92/EC

ATEX 137 Directive regards health and safety protection of workers and puts a duty onto the employer to ensure minimum level of protection of workers across the EU. The duties incorporate prevention of formation of explosive atmosphere in the work place, avoiding ignition of explosive atmosphere, control the effects of explosion, use of compliant equipment, carrying out a Risk Assessment, zone classification and their marking and creating an Explosion Protection Document. The interface between both directives is depicted in Table 1.

1.3 Regulations and Guide for the ATEX Directives

The EU Council issued in 2003 a "Non-Binding Guide of Good Practice for Implementing of the European Parliament and Council Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres" (ATEX 137 Directive) that concerns in broad terms identification of hazards, risk evaluation, safety measures for workers and ensuring safe working environment during operations.

Table 1 Interface between ATEX Directives 95 and 137.

ATEX 95	ATEX 137
MANUFACTURER	EMPLOYER
EQUIPMENT GROUP / CATEGORY	ZONES
CATEGORY 1 CATEGORY 2 CATEGORY 3	ZONE 0 / 20 ZONE 1 / 21 ZONE 2 / 22
H&S / STANDARD REQUIREMENTS	INSTALLATION & MAINTENANCE
RISK / IGNITION HAZARD OF EQUIPMENT	RISK ASSESSMENT OF THE WORKPLACE
CONFORMITY DOCUMENTS	EXPLOSION PROTECTION DOCUMENT
QUALITY CONTROL	REGULAR UPDATES

It also gives useful information helping to create an Explosion Protection Document and to implement co-ordination measures if several operators are present at the same workplace.

In the United Kingdom the requirements of the ATEX 137 Directive (and Chemical Agents Directive 98/24/EC) have been implemented through the DSEAR (Dangerous Substances and Explosive Atmospheres Regulations 2002). The purpose of DSEAR is to protect the workers and other persons from fire or explosion or other energy-releasing event caused by dangerous substances. DSEAR puts onto an employer duty to carry out risk assessment to his employees. The risk should be eliminated or reduced and where it is not possible, it should be controlled and mitigated by technical and organisational measures.

Five Approved Codes of Practice (ACOP) have been issued in the UK in 2003 following the ATEX Directives – "Design of plant, equipment and workplaces", "Storage of Dangerous Substances", "Control and Mitigation Measures", "Safe Maintenance, Repair and Cleaning", "Unloading Petrol from Road Tankers". There is no specific ACOP for waste industry or biogas applications as yet, although the need for it was flagged to the Health and Safety Executive (HSE). First four ACOPS contain general guidance some of which is applicable to situations in the waste industry.

It is worth noting that the waste water treatment industry in the UK is much more advanced with implementation of the ATEX Directives than solid waste industry. Working visits in last two years to over forty plants across England and Wales demonstrated designated zone areas, marked at the entrance to the works and Explosion Protection Documents in place. One of the reasons could be that processes, operations and materials in the treatment works could be more predictable than on landfills for example.

2. APPLICATION AREAS

2.1 General waste processing

Waste industry in general has had already quite well established system of safe system of works. Implementation of the ATEX Directives and following regulations in the UK is resulting in review of the current risk assessment procedures and approach to classification of the areas under the DSEAR. All the activities that may involve exposure of the personnel and other persons to potentially explosive atmospheres have to be identified and re-assessed. Sufficient control measures, emergency procedures and equipment must be provided. The staff must be provided with relevant safety information and adequate training. Areas that may involve generation of potentially explosive atmospheres must be marked in accordance with the regulations. The final date for implementation of the Directives for existing facilities is 30 June 2006. All new equipment and operations must comply with them from day one.

An important aspect of application of the Directives in waste management is an understanding of the variety of plants, processes, operations and materials handled.

Although it is unlikely that the DSEAR would be practically imposed onto householders putting some materials that may give off flammable vapours into the waste bin, in reality the risk can potentially start from the point of collecting and transporting the waste. Transfer stations and recycling plants where the waste is handled would be the next point to re-assess. Waste treatment and processing works (e.g. mechanical-biological treatment, anaerobic digesters, composting and thermal treatment plants) and ultimately landfills – all will have areas where potentially explosive atmospheres may arise due to the nature of the raw waste itself, its decomposition or final products of their treatment.

During the course of risk assessment it is necessary to take account of materials handled by the waste management industry. These can be solids giving off dust, liquids generating

flammable vapours, and flammable gases like methane, carbon monoxide, hydrogen and hydrogen sulphide arising in the decomposition and treatment processes.
Potential ignition sources (just few examples is given below) that are extensively listed in the relevant ACOP and standards harmonised with Directives can be divided by:

- heat energy (e.g. open fire, hot surfaces, internal combustion engines, intense radiation)
- electrical energy (e.g. electromagnetic radiation, electrical arch, lights, static discharges, excessive temperatures due to overload or use of inverters in electrical motors, lightning)
- mechanical (e.g. friction, ultrasonic, mechanically generated sparks, shock waves) and
- chemical (e.g. self heating, pyrophoric and exothermic reactions).

Processes that take place in the waste processing and disposal can be categorised by physical (crushing, compacting, evaporation), biological (bacterial treatment and natural biodegradation) and chemical (mixing of waste, treatment with specific agents to stabilise waste). Depending of the nature of the process, all of them may lead to creating flammable gases and vapours as well as ignition sources.

In logical sequence, from the source of origin to the end of treatment and final stabilisation, operations that should be considered while producing the Explosion Protection Document required by DSEAR would comprise of those connected with collecting, loading and unloading of waste, transport, cleaning and painting of containers, compaction, crushing, shredding and baling, installation, maintenance and cleaning of the equipment, maintaining various treatment processes, taking and handling samples, etc.

Domestic waste would not have a safety data sheet, like one could expect for various substances classified under Chemicals Hazard Information and Packaging for Supply Regulations, therefore this may make risk assessment complicated and in certain circumstances additional tests may be required.

2.2 Landfills and landfill gas

Locations that could be identified on landfills where Explosion Protection Document would most likely apply comprise of waste tipping face, uncapped, covered and restored areas, landfill gas collection and treatment systems, environmental compounds (gas pumping stations and flares), landfill gas power stations, leachate collection, recirculation and treatment systems, buildings (if located on or close to waste deposits), gas and water monitoring points, any confined spaces.

Main substance that would need to be accounted for due to decomposition of waste is landfill gas – mixture of methane and carbon dioxide in various proportions (including explosive range 5-15% of methane in the air) with addition of hydrogen at early stages of decomposition and hydrogen sulphide. Although presence of carbon dioxide and nitrogen in the mixture would have quenching effect, it is advisable to consider "the worst case scenario" with pure methane. This approach is extending the safety margin. Also the guidance and standards in most cases refer to natural gas. Considerable percentage of other flammable gases (e.g. H_2 and H_2S) that have much wider range of flammability in comparison to methane would need to be recognised during risk assessment. As an example, 10 litres of CH_4 in the air will result in having 200 litres of explosive mixture at lower explosive limit (LEL) at Standard Temperature and Pressure.

Major operations necessary to review during creation of EPD are unloading waste on the tipping face, taking samples, covering of waste, drilling into waste, excavations, installation and joining of gas and leachate pipes, installation and maintenance of leachate and condensate pumps, routine maintenance of equipment (e.g. fans, flares, KO Pots, valves), responding to emergencies, pumping trials, installation and maintenance of temporary gas and leachate collection systems on uncompleted landfill areas, installation and maintenance of leachate recirculation systems, installation and maintenance of electrical equipment, taking gas readings,

sampling gas and leachate. The list is not exhaustive and would need to be reviewed in each individual case.

The old HSE statistics, published in 1999, shows that majority of incidents involving landfill gas was due to accumulation of gas in confined spaces and that in most cases the gas did not ignite, but levels were sufficient to raise concern, resulting in evacuation. This statistics is in need for update in order to understand the level of risk and efficiency of safety measures adopted in the industry within recent years. Over a period of 25 years 60 incidents involving landfill gas were recorded in the UK by the HSE, 11 of them resulting in injuries. There were 17 injured persons and 2 fatalities.

Examples of incidents with landfill gas:

- accumulation of gas from adjacent landfill in houses, resulting in explosion and destruction of buildings
- unexplained landfill gas collection pipe fire, suspected static electricity discharge or act of vandalism
- explosion of landfill gas in confined space due to use of spark generating tools
- fire of electro-fusion welded plastic gas pipes due to inadequate purging and poor source gas isolation
- explosion and flash fire during extraction of a leachate pump from the well due to use of inappropriate tools and procedures
- accumulation of gas in building containing leachate recirculation system due to unsealed tanks and operation of ejector pumps in dry gas wells
- gas explosion in the changing room located on old part of landfill
- flash fire on the surface of landfill caused by dropping lit cigarette butt
- landfill gas flash fire during drilling in waste.

Fires and explosions on landfills can be caused not only by landfill gas. One of the known incidents involved crushing with compactor on a tipping face large amount of gas filled cigarette lighters confiscated by Customs & Excise. Underground fires with not clearly explained mechanism of origin also contribute to this sad statistics.

3. COMPLIANCE MEASURES

3.1 Manufacturers and users

In order to comply with the ATEX Directives, Biogas Technology adopted systematic approach.

Firstly, design of the standard equipment has been reviewed. In general flares manufactured so far were not far away from the required level of compliance, being in accordance with relevant standards. Main differences were caused by the fact that the previously adopted design risk assessment was not strictly formalised. Safety measures were based on previously adopted standards and good industry practice, based on over 10 years manufacturing and experience. Checks on electrical and non electrical components revealed scope for increasing safety and further reducing the risk, and these changes (e.g. re-positioning of a component outside of the hazardous zone, changing the source of gas release from primary to secondary or changing a component to different category) were immediately incorporated into manufacturing of the new equipment. A special table for qualifying the equipment under the ATEX Directive has been adopted, qualifying own potential source of ignition and use in potentially and intended explosive atmospheres.

For the previously manufactured plants a programme of review and upgrading was developed in order to achieve compliance by the deadline of 30 June 2006. This was not easy task, as some

of the plants although based on standard template were custom made, so they needed individual approach. A recognised independent body was involved in the assessment review process. Main difficulties at this initial stage of implementation of the ATEX Directives that started in late 2002 were that not all the manufacturers of components were in the position to definitively assess their own products. Hence the whole process was delayed in time. The design risk assessment is an ongoing process and it is being constantly reviewed. Simple measures like preventing of formation of explosive atmospheres, avoiding ignition sources, changing maintenance regime and operating procedures have been implemented. A good practical test that proved the company's approach was design and supply to a customer of eight gas flares for coal mines industry that successfully passed scrutiny of the HSE and Mining Inspectorate.

Secondly, the final users of equipment and the regulators had been made aware of the ATEX requirements and their responsibilities. According to the Directive, even if the employer (end user) selects a plant on the basis of advice from supplier, the end user has still responsibility for the safety of that equipment. As the waste industry was not fully aware of the implications of the ATEX Directives, a campaign was launched together with recognised organisations (SIRA, Chartered Institution of Wastes Management) in order to raise awareness within the end users of the equipment. A questionnaire for the end user had been developed, however the difficulty in its application was in the fact that the end users could not clearly qualify the hazardous zones on their sites. Hence implementation of this approach is ongoing.

Biogas Technology personnel are also a "user" in regard to operations carried out on landfills during provision of its services. These have been reviewed during brain storm sessions and results and conclusions were adopted along with the progress of the analysis. The good side of the brainstorm was also to identify and re-assess internal operations and procedures that fell under ATEX Directives, i.e. workshop and maintenance operations, storage, receiving visitors on sites, experimental and development work. At the moment the existing written procedures are being reviewed and updated.

3.2 Working examples

One of the examples regarding manufactured plant is a resulting zoning diagram of standard skid mounted enclosed ground flare (Figure 1). This zoning diagram has been derived from calculations based on the Institute of Gas Engineers Safety Recommendations IGE/SR/25. Review of the design took into account number of potential primary and secondary gas releases, inspection frequency and distances between the components. During the process of assessment measures were undertaken to change the primary sources of release into secondary ones, to move certain components outside of the identified zoned area and to change category of specific apparatus that could not be relocated due to the dimension constraints. Obviously, prior to the installation and commissioning the risk assessment in respect of DSEAR will have to be assessed by the end user and any issues identified would need to be addressed.

The second example (Figure 2) represents operations approach during excavating of the leachate riser. Again, in accordance with the IGE/SR/25 Guidance the extent of hazardous zones were calculated and recommendations made in regard to control and mitigation measures of the operations. These included number of staff involved, safe distances, monitoring equipment and procedures required, as well as controlling the dilution of potentially explosive atmosphere.

In both cases the risk was assessed on the basis of the amount and properties of released gases, conditions of operations, explosive atmosphere persistence time, ventilation available, normal or adverse conditions, potential ignition sources, and process monitoring results. In order to minimise the risk, recommendations were made in regard to control measures, e.g. keeping the working area clean, limiting number of personnel, restricting of working zone, reduction of sources of release, restricting of ignition sources and monitoring of the process.

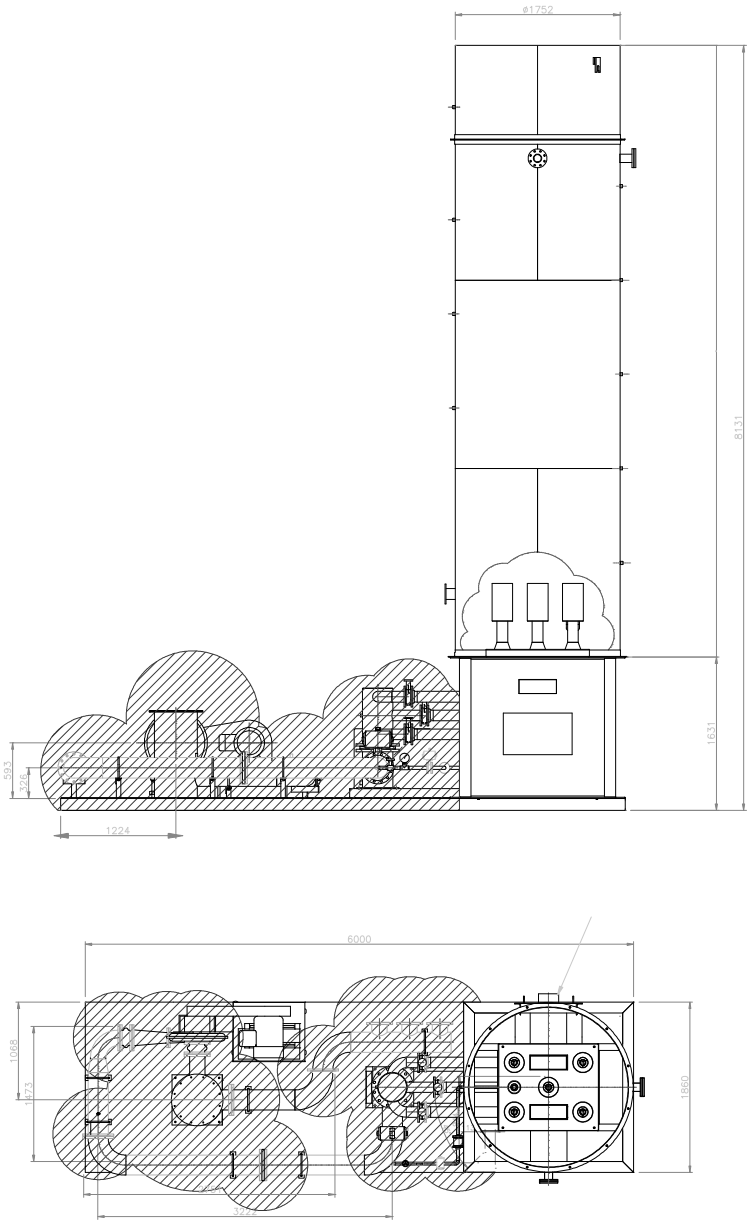

Figure 1 Zoning diagram of standard enclosed ground flare on the skid

The shadowed area represents Zone 2 only as the Zone 1 from drains or sampling points was eliminated by simple engineering measures, changing primary sources of release into secondary ones. All the electrical and mechanical equipment inside the zones had to be checked for its compliance (certificates and Ex plates) on the basis of information from the suppliers. As zones from various points of potential release of gas are overlapping, the simplest approach in this particular case would be adopting “blanket” Zone 2 on the whole plant and marking it respectively at the plant location. Specific DSEAR risk assessment would apply to operation of the flare, especially to start up, shut down, taking gas samples, emergencies and maintenance.

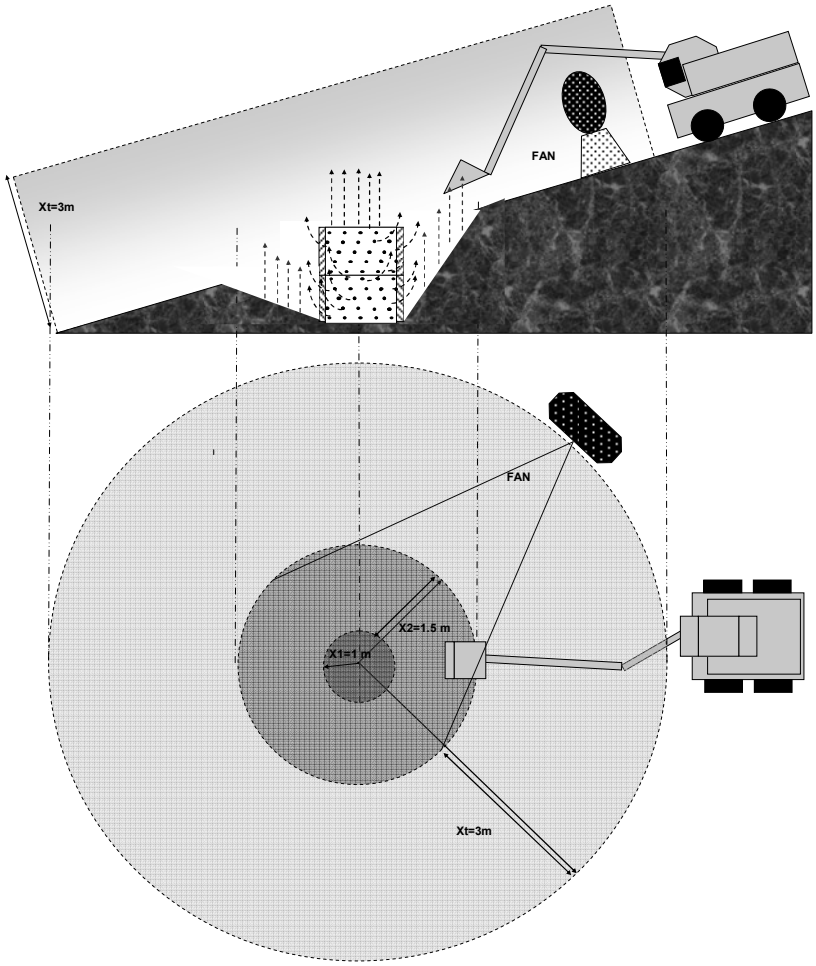

Figure 2. Schematic diagram of calculated zones during excavation of leachate riser

This diagram represents extent of Zone 1 in the middle and Zone 2 outside. It was recommended to have minimum number of personnel, special arrangements for excavator to limit potential of sparking (both mechanical and operational), constant monitoring of gas concentration in the air along affected area and a dilution fan below certain wind speed.

4. CONCLUSIONS

Assessing all the UK operational and closed landfills and other solid waste treatment and processing plants to achieve ATEX compliance is a challenging task requiring specialist knowledge and consideration of site specific requirements. Some complex situations may involve multidisciplinary teams. There are still some grey areas left for interpretation waste industry to be clarified along the process of assessment. E.g. should a landfill gas flare be considered as part of an assembly of a gas collection system or stand-alone equipment? There are still some ambiguities in calculations of the zones and interpretation of the input data. Simple cases of DSEAR risk assessments can possibly be done by the adequately trained personnel, familiar with site specific circumstances and operations. More complex cases would require specialist advice. Considering volume of work achieving the deadline of 30 June 2006 seems to be a challenging task, especially in the absence of Approved Code of Practice specific for the waste industry.

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