SAFETY PROCEDURES

BIOGAS HAZARD SAFETY POLICY

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Hazards

Biogas plants are complex process engineering systems in which a range of different hazards can occur. Essentially, the hazards can be divided into health hazards and environmental hazards. Possible hazards at biogas plants include fires and explosions, for example, but also dangerous substances (e.g. processing aids), electric current and not least biogas itself also presents risks. Attention also needs to be paid to mechanical hazards in certain parts of the plants.

ENVIRONMENTAL HAZARDS

Essentially the environment is only exposed to danger if biogas escapes into the atmosphere or working materials in the plant (e.g. digestion substrate, silage effluent, oils or fuels) enter nearby bodies of water. An accident of this type may be caused by structural faults or operating errors. Environmental hazards from biogas plants can be divided into emissions into air and emissions into soil and water.

Gaseous emissions

One of the main environmental advantages of biogas technology is the avoidance of uncontrolled greenhouse gas emissions from the storage of organic materials. Furthermore, biogas substitutes fossil fuels and synthetic mineral fertilisers, thus reducing carbon dioxide and methane emissions. However, methane – a particularly potent greenhouse gas – is also produced through the anaerobic digestion process at biogas plants. In order to preserve the climate change benefits of biogas, unwanted methane emissions must be kept to a minimum.

Analyses of biogas plants show that the digestate storage tank is one of the main sources of methane emissions, especially if it does not have a gas-tight

cover. The CHP unit also presents some hazard, however in a lower degree. Other plant components are normally relatively gas-tight, but gas leakages at connection parts between the gas storage and the digester and pre-digester pits could happen. Recommendations for minimising methane emissions include:

- All construction work must be as gas-tight as possible.
- An automatic flare system should be installed.
- This is particularly relevant regarding the CHP unit, as it is typically shut down for 5 to 10% of the time for essential maintenance and repair work; in this time biogas is produced continuously, and must not be allowed to escape unburned.
- It should be ensured that the plant's overpressure relief device is not released too often, the flare system should kick in before the overpressure relief device does.
- Digestate storage tanks should have a gas-tight cover.
- Methane emissions should be checked with appropriate measuring instruments, e.g. a gas camera or foam-forming agents.
- The CHP unit should be optimised for the combustion of biogas. The methane emissions of CHP units can range from below 1% to over 2% of methane production.

Emissions of ammonia from biogas plants should also be minimised. Ammonia causes acidification in soils, promotes eutrophication, can damage vegetation and can have detrimental impacts on health (in higher concentrations it is toxic; in groundwater, converted to nitrite, it adversely affects metabolism). Measures to reduce ammonia are similar tothose for methane. This means that gas emissions to the atmosphere should be avoided (especially fromthe digestate storage tank). The techniques used for field spreading of digestion products have a crucial influence on ammonia emissions. Where possible, digestion products should be worked into the soil quickly, and if at all feasible application should not take place when ambient temperatures are high (i.e. preferably on cool days and not around the middle of the day).

Various combustion products such as nitrogen oxides, sulphur dioxide, carbon monoxide and particulates, among others, are produced during the combustion of biogas. Emissions of these products should be regulated in the respective

national regulations. Emissions to soil and water The quantities of liquids processed and stored in biogas plants range from around a hundred to several thousand cubic metres, individual tanks often hold several thousand cubic metres. The contents of the tanks should not escape into the environment, whether in normal operation or in the event of an accident. Environmental impacts are most likely to arise from the organic load and nutrients. If a tank leaks, for example, large quantities of organically polluted liquids enter the environment. The high organic load (high chemical oxygen load) is broken down by microorganisms, thereby consuming oxygen. The greatly reduced oxygen content can lead to death of fish populations. If large quantities of substrate enter the environment there is a considerable risk of eutrophication of water bodies. The use of processing aids (refer to section on hazardous substances) also brings with it the risk of environmental hazards. Mixtures of trace elements, for example, if spilled into bodies of water, can be highly toxic for water organisms and have a longterm impact.

Health hazards

In light of the potential sources of danger outlined above it is impossible to completely rule out health hazards for operators, employees and third parties. These health hazards can be divided into four categories: hazardous substances, electrical hazards, mechanical hazards, and explosion and fire hazards.

Hazardous substances

Hazardous substances are substances, materials or mixtures that exhibit certain hazardous properties. Such hazardous properties include ‘harmful to health’, ‘toxic’, ‘very toxic’, ‘corrosive’, ‘sensitising’ and ‘carcinogenic’. Hazardous substances can take the form of solids, liquids, aerosols or gases. Hazardous substances that are particularly likely to be present at biogas plants are biogas, processing aids, oils, activated carbon, silage effluent, slurry, wastes and biological agents.

Typical hazards include:

- Risk of asphyxiation and/or poisoning by fermentation gases /biogas in feedstock receiving areas. Release of highly toxic gases such as hydrogen sulphide in the receiving area, especially during mixing, as a result of reactions between feedstock materials.
- Hazards associated with the use of additives and auxiliary materials with hazardous properties (e.g. carcinogenic and reprotoxic mixtures of trace elements).

Biological agents

According to the International Labour Organisation (Hurst & Kirby, 2004), biological agents are any microorganism, cell culture or human endoparasite which may cause an infection, allergy, toxicity or otherwise create a hazard to human health. In biogas plants, these biological agents can occur in feedstock, digestates and biogas condensates.

The intake of biological agents through the respiratory tract, hand-to-mouth contact, skin/mucous membrane contact, cuts and stab injuries is relevant to the assessment of potential hazards.

The following are examples of hazards that may arise from biological agents during the production of biogas:

- Inhalation of dusts or aerosols containing moulds, bacteria or endotoxins, for instance from silage or dry poultry excrement that has become damp (SVLFG, 2016).
- If activities are conducted with visibly mouldy wastes, it is impossible to rule out acute toxic effects from the inhalation of mycotoxins or other microbiological metabolic products (TRBA 214, 2013).

Additional hazards that may arise in plants where other substrates are used beside energy crops, liquid manure and solid manure: biological agents in cosubstrates (e.g. pathogens); manual contact during sorting.

Various risky agents and materials are also liable to arise in the course of waste treatment. These may include impurities (interfering substances), animal carcasses, or wastes from hospitals, doctor's practices or households with people who are sick or in need of care (e.g. used syringes and cannulas).

Biological agents can also be introduced by rodents, birds or other animals and their excrement.

Hazards from electrical equipment

A variety of electrical equipment is used in biogas plants (control equipment, CHP unit, pumps, agitators, measuring instrumentation, etc.). Under certain circumstances this equipment may have adverse effects on health as a result of electrical hazards from the presence of electrical energy.

- Danger of electric shock or arc caused by an electric shock through an individual's body or by an arc flash. Example: damaged power cables on agitators
- Danger from electric or magnetic fields from irritant effects in the human body created by the circulation of induction currents caused by electric fields, induced currents or magnetic fields. These effects occur in a frequency range up to 30 kHz (low-frequency range). Example: electromagnetic, electrical and magnetic radiation from the generator of the CHP unit (danger for people with pacemakers).
- Danger from static electricity caused by an electric shock from the discharge of static electricity.

Mechanical hazards

Mechanical hazards are usually not specific to biogas technology. However, the most common types of accident at biogas plants are attributable to mechanical hazards: falling, impact, crushing, cutting. Accident blackspots in this connection include work on the silo or other workplaces at a height, work in the vicinity of rotating parts (e.g. feeding systems) or work in the vicinity of moving vehicles (risk of being run over). Accidents are particularly likely to occur during maintenance and repair work if inadequate protective measures have been taken.

4.7. Gas hazards

Biogas is a mixture of different gases, the concentration of which may vary depending on the plant in question. Key constituents of biogas are listed below,

along with their properties regarding risks to health (see Table 2). The workplace exposure limit (TRGS 900, 2016) or occupational exposure limit (OEL) is the timeweighted average concentration of a substance in air at the workplace over a specified reference period at which no acute or chronic harm to the health of employees is expected to be caused. As a rule, the limit is set on the assumption that the exposure is for eight hours a day, five days a week over a working lifetime. The workplace exposure limit is specified in units of mg /m³ and ml/m³ (ppm).

	Properties	Hazardous atmosphere	Workplace exposure limit
CO_2	Colourless and odourless gas. Heavier than air.	8 % v/v, danger of asphyxiation.	5500 ppm
NH_3	Colourless and pungent-smelling gas. Lighter than air.	Above 30–40 ppm mucous membranes, respiratory tract and eyes become irritated. Above 1000 ppm breathing difficulties, potentially inducing loss of consciousness.	20 ppm
CH_4	Colourless, odourless gas. Lighter than air.	4.4–16.5 %	-
H_2S	Highly toxic, colourless gas. Heavier than air. Smells of rotten eggs	Above a concentration of 200 ppm the sense of smell becomes deadened and the gas is no longer perceived. Above 700 ppm, inhaling hydrogen sulphide can lead to respiratory arrest.	5 ppm