Safety of Biogas Plants

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General Manager
German Biogas Association

9th of June 2014, Bangkok
Outline

- Accidents on biogas plants / Statistic evaluation of biogas dangers
- Hazards on biogas plants
- Legal framework & safety regulations in Germany
- Risk assessment / Explosion safety / Safe operation
- Ex-Zones on Biogas plants
- Responsibilities for manufacturer and plant operator
- Safety information’s for components of biogas plants
- Samples for safety instructions etc.
- Lessons learnt
- Standardization measures
- Activities of the German Biogas Association
- Best practice and how to prevent accidents
Hazards on biogas plants

Fundamental distinction of hazards:

- Health hazards

- Environmental hazards
Accidents with injured people on biogas plants

Number of biogas plants

Number of accidents

Years

Source: SVLFG = German Agricultural Occupational Health and Safety Agency
Deadly accidents on biogas plants in Germany

<table>
<thead>
<tr>
<th>Year</th>
<th>Deadly accidents</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1</td>
<td>- Plant operator fell with his head on the rim of the tractor</td>
</tr>
<tr>
<td>2012</td>
<td>2</td>
<td>- Plant operator was hit by the loader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Plant operator was run over by a tractor</td>
</tr>
<tr>
<td>2013</td>
<td>1</td>
<td>- Plant operator was killed when he cleaned a macerator</td>
</tr>
</tbody>
</table>

Source: SVLFG = German Agricultural Occupational Health and Safety Agency
Biogas = Flying an airplane!

**Meaning**: The start and the end of the operation are the dangerous phases of a biogas plant! And the operator of the plant must be well trained!
Analysis of personal injuries

Accidents on biogas plants

Source: SVLFG = German Agricultural Occupational Health and Safety Agency
Accidents on biogas plants

Proportion of accidents according to the hazards

- Chemical hazards: 7%
- Heat: 4%
- Radiation: 1%
- Noise: 1%
- No information: 1%
- Mechanical hazards: 86%

Source: SVLFG = German Agricultural Occupational Health and Safety Agency
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Health hazards on biogas plants

1. **Hazardous substances**: e.g. infections, sensitizing or toxic effects, viruses, bacteria, acids, chemicals ...

2. **Electrical hazards**: e.g. improper use of electric components, damaged electric cable

3. **Mechanical hazards**: e.g. moving parts of machinery, dangerous surfaces...

4. **Crash or falling down**: e.g. into pits, tanks or from buildings and ladders ...

5. **Fire hazards**: e.g. hot surfaces, fire

6. **Heat, noise**: e.g. CHP, ...

7. **Gas hazards**: e.g. explosion, suffocation, intoxication…
Health hazards on biogas plants

Hazardous Substances

- **Chemicals**: processing aids (essential nutrients), compounds for desulfurization = hazard of carcinogenic substances, toxic hazard

- When using a chemical substance distributed by a supplier, the operator can use the material data safety sheet (MSDS) to assist the development of a hazard assessment.

- If mixing of different materials is required for operational reasons, no materials should be combined from which the generation of hazardous gas concentrations due to reactions (e.g., acid-base reactions, large differences in temperature) could result. In particular, hydrogen sulphide can be released due to the addition of acidic components; ammonia can be released due to the addition of alkaline components.
Accident on a biogas plant with 4 dead people in 2005

- One day before the accident dairy and animal waste products were delivered to the biogas plant.
- This mixture was stored in a 100m³ mixing tank and has a very low pH-value (hydrolysis).
- At the day of the accident a dutch lorry driver delivered chopped hog (60°C, sulfide, pH-value 8,5).
- In the mixing tank both components were merged => chemical reaction with the release of a extremely high concentrated H₂S-gas cloud.
- Due to the opened mixing tank and the integrated mixer the deadly gas could spread throughout the closed hall.
- Estimated amount of H₂S: 10.000 ppm
- immediate death…
Health hazards on biogas plants

Hazardous Substances:

- In the Ordinance on Bio-substances, “biological agents” are defined as microorganisms that can cause infections or have sensitizing or toxic effects in humans.

Typical hazards:

- inhaling dusts or aerosols containing molds, bacteria, or endotoxins, e.g., from moist silage or dry chicken manure.
- pathogens: (e.g. Salmonellae, Enterobacter, Clostridiae, Listeria)
Sanitary measures -1

- **Livestock health control.** No animal manure and slurries should be supplied from any livestock with health problems.

- **Feedstock control.** Biomass types with high risk of pathogen contamination must be excluded from AD.

- **Separate pre-sanitation of specific feedstock categories is mandatory,** as stipulated by European Regulation EC 1774/2002. Depending on the category of feedstock, the regulation requires either pasteurization (at 70° C for one hour), or pressure sterilization (at minimum 133° C for at least 20 minutes and absolute steam pressure of minimum 3 bar).
Controlled sanitation: In the case of feedstock categories which, according to EC Regulation 1774/2002, do not require separate pre-sanitation, the combination of AD process temperature and a minimum guaranteed retention time (MGRT) will provide effective pathogen reduction/inactivation in the digestate.

Control of pathogen reduction efficiency in digestate by using indicator organisms. The efficiency of pathogen reduction must not be assumed, but verified by using one of the accredited indicator organism methods.
Health hazards on biogas plants

Electrical hazards:

- **Causes:** defective electrical equipment or electrical lines; defective lightning protection, defective electrical installation

- Prevention of ignition sources for explosion protection

- Defective electrical installation can cause fire

- Prevention of electrical shock

- Prevention: use of safe electrical equipment, turn off electricity, to ask advice from a electrician
Health hazards on biogas plants

Mechanical hazards:

- Moving parts of machinery
- Dangerous surfaces
Mechanical hazards
Mechanical hazards

Fire protection?

Hazard of squashing?
Mechanical hazards

Moving parts – watch your clothes!
Health hazards on biogas plants

Crash or falling down:
Falling:
- into tanks,
- from construction area, slap silo, ladder.....
What's wrong?
Components of biogas / biomethane

<table>
<thead>
<tr>
<th>Component</th>
<th>Biogas</th>
<th>Biomethane (natural gas quality)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane (CH$_4$)</td>
<td>50-75 %</td>
<td>&gt; 97 %</td>
</tr>
<tr>
<td>Carbon dioxide (CO$_2$)</td>
<td>25-45 %</td>
<td>&lt; 3 %</td>
</tr>
<tr>
<td>Oxygen (O$_2$)</td>
<td>2-4 %</td>
<td>&lt; 0.5 %</td>
</tr>
<tr>
<td>Hydrogen sulfide(H$_2$S)</td>
<td>&lt; 0-6,000 ppm</td>
<td>&lt; 5 ppm</td>
</tr>
</tbody>
</table>

ppm = parts per million = $10^{-6} = 0,000 \, 001$ %
Gas hazards – dangerous components of biogas

**Carbon Dioxid (CO₂)**
- CO₂: colourless, odorless, heavier than air
- MAC¹ 5000 ppm = 0.5 %; dangerous area above 8 Vol. %
- danger of suffocation

**Methane (CH₄)**
- methan ist colourless, odorless and lighter than air
- danger of suffocation
- explosive range 4.4 % - 16.5 %

**Oxygen (O₂)**
- O₂-concentration below 18 Vol.-% is dangerous

¹ maximum allowable concentration
Gas hazards – dangerous components of biogas

**Ammonia (NH₃)**
- ammonia is colourless, pungent smelling and lighter than air
- danger of fire 15% - 30%
- MAC¹ 20 ppm = 0.002%
- 30 - 40 ppm = irritation of mucous membranes, respiratory tract and eyes
- 1000 ppm = 0.1% = difficulty in breathing, unconsciousness

**Hydrogen Sulfide (H₂S):**
- H₂S is colourless, smelling like rotten eggs
- heavier than air, strong blood and nerve poison
- MAC¹ 10 ppm = 0.001%
- 50 ppm 0.005% = irritation of the respiratory tract
- 200 ppm 0.02% = paralyzed sense of smell
- 700 ppm 0.07% = respiratory arrest (death)

¹ maximum allowable concentration
Explosion hazards – „Explosion Triangle“

**Biogas**
- explosive range: 4.4 – 16.5 Vol-%

**Air (oxygen)**

**Relatively inactive mixture**

**Ignition**
- Ignition temperature: ≥ 750 °C
Difference between explosion / deflagration

**Deflagration:**
- Is an independent flame propagation (rate of combustion: up to 1 m / sec) in explosive atmospheres.
- Strong flame development

**Explosion:**
- Is the generic term for rapidly occurring chemical reactions (rate of combustion: 1-1000 m / sec).
- An explosion has no pressure wave.
- You may optionally detect a flash
Example for a biogas-explosion
Explosion/deflagration
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„Law-pyramid“ in Germany

- EU laws (e.g. ATEX 94/9/EG, ATEX 1999/92/EG, Seveso II)
- Occupational Safety and Health Act
- Ordinance on Industrial Safety
- Technical standards (e.g. DVGW G-1030; ....)

- Attention to detail
- Easy to modify
Main areas of biogas safety

- Immission control
- Product safety
- Working safety
- Energy law
- Water protection
# Ministeries involved in the biogas plant safety in Germany

<table>
<thead>
<tr>
<th>1.</th>
<th>Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>plant safety</td>
</tr>
<tr>
<td></td>
<td>environmentalism</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>2.</th>
<th>Federal Ministry of Labour and Social Affairs</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Ordinance on Industrial Health and Safety (explosion safety)</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>3.</th>
<th>Federal Ministry for Economic Affairs and Energy</th>
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<tbody>
<tr>
<td></td>
<td>energy supply</td>
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<thead>
<tr>
<th>4.</th>
<th>Federal Ministry of Food and Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Energy crops/ sustainability, Regional value, agricultural laws, greenhouse-gas reduction</td>
</tr>
</tbody>
</table>

## 1. Ministeries
- **Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety**
- **Federal Ministry of Labour and Social Affairs**
- **Federal Ministry for Economic Affairs and Energy**
- **Federal Ministry of Food and Agriculture**

## 2. Topics
- Plant safety
- Environmentalism

## 3. Agencies
- UBA (Bundesamt für Umwelt)
- KAS (Kernenergiegesetz)
- LAI (Landesamt für Arbeit und Soziales)
- AISV (Arbeitskreis für Industrielle Sicherheit und Gesundheitsschutz)

## 4. Regulations
- Ordinance on Industrial Safety and Health; German Occupational Safety and Health Act; Ordinance on Hazardous Substances, Ordinance on Biological Agents; Explosion Protection (94/9/EG, 99/92/EG, BGR 104, 11.PSGV)
- Machinery Directive 06/42/EG; Biogas Safety Rules
- Energy Economy Law (EnWG); Gas Network Access Ordinance (GasNZV); Technical Standards of the DVGW (German Technical and Scientific Association for Gas and Water): G 260, G262, VP265, G462, G415, G1030, G469
- Energieaufsicht z.B. DVGW

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*Source: Fachverband Biogas e.V.*
Federal Control of Pollution Act (BImSchG)

Every biogas plant needs a building permission prior to the start of construction:

- approval procedures according to the **Building Law**:
  - applicant is responsible to get every permission
  - important failings = Retrofitting to the state of the art

- approval procedures according to the **Federal Immission Control Act**
  - concentration effect: all permissions are included
  - designed according to state of the art
  - emission measurements (before the start; every 3 years) and a periodically expert report

- approval procedures depending from the seize of the plant and the input material categories (1.200.000 m³ biogas production capacity = simplified process; input of waste: 100 tonnes per day = formal process)

- changes on a existing biogas plant: the authority has to be informed about the proposed changes

- significant changes in the location, composition or operation of the biogas plant require a new permission (change authorisation)
Water protection – a new regulation (AwSV) is coming

Scheme of the new regulation:

1a. Input: substrates coming from the agriculture (silage, ....)

1b. Input: substrates coming from the agriculture based in water protection areas

2. Concern principle

Best possible protection

Input: substrates which are not coming from the agriculture (waste/biowaste)

Structural and technical requirements
Water protection – a new regulation (AwSV) is coming

Biogas plant with agricultural input materials (type 1a/1b):

- New biogas plants in water protection areas can only build with a maximum of 3,000 m³ tank volume
- Existing biogas plants can’t increase their tank-volumina, only the digestate storage capacity
- Every biogas plant needs more than 9 month duration of storage for the digestate
- Every new biogas plant needs a rampart
- Existing plants have to build up a rampart not later than 5 years
- Audit requirement, leak detection (digester and pipes); rain water retention, specialized company for the construction, verification of applicability for the filling and storage facilities
- …
The rampart makes the difference…
Biogas plant with no agricultural materials (type 2):

- Underground facilities: jacketed tank (double wall) with leak detection
- Aboveground: liquid-tight restraint systems for single-wall plant parts (tank and pipes)
- Rain water with organic components (silage, manure...): dispose as waster water or waste
- Retrofit requirements (scope and measure) determined by the competent authority in specific case, no "grace period" for implementation
- Entry into force early 2015 !!!
Overview

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As a matter of principle, in determining protective measures, technical protective measures are to be preferred, for example, the filling of closed systems compared to organizational protective measures, such as, the time separation between human presence and filling procedures. Personal safety measures, such as wearing respiratory equipment, come into use only when other protective measures have been exhausted.
The Labour Protection Act is the legal foundation for performing a hazard assessment /risk assessment.

Supplementary requirements are found in the corresponding ordinances, such:
- as the Ordinance on Industrial Safety,
- Ordinance on Bio-substances,
- or the Ordinance on Hazardous Substances.

An obligation to document exists if there are more than ten employees. For activities with hazardous materials and bio-substances and in potentially explosive areas, the obligation to document applies regardless of the number of employees (Register of Hazardous Substances, Explosion-Protection-Document, etc.).
Consequently, all biogas systems are subject to inspection obligations according to §§ 14 and 15 of the BetrSichV, regardless of the employment activity or occupation of the workers. => Inspection before the first production of biogas (§ 14) and at latest after 3 years (§15).

This implies, in principle, that all biogas plants in Germany need an Explosion Protection Document!

The operator bears the responsibility to ensure that changes to the system are also updated in the documentation, such as, the circuit diagrams, the operating instructions, the Explosion Protection Document, etc.
Risk assessment

- The basis for the development of a hazard assessment is to protect and to reduce the exposure to risk and hazards of employees.

- The employer must determine, evaluate, and minimize the hazards and must consider the acquired knowledge during:
  - design and selection of work tools,
  - as well as the design of workplaces, work and production processes, work procedures,
  - and interactions of all of the above.
Risk assessment

When is a risk assessment necessary?

- as a first analysis before start up
- at regular intervals, in particular:
  - changes to regulations
  - changes in the state of the art
- if facilities are substantially expanded or rebuilt,
- in significant changes in the organization of work,
- after accidents, near-accident and diseases.
The higher the risk the more urgent the measure!!!
1 requirements for the operational organization
2 general requirements for jobs
3 general hazards - Technology
4 general Hazards - Electrical
5 slap silo
6 feeder
7 fermenter / secondary digester / gas-tight residue storage tanks
8 residue storage tanks, odor-tight or open
9 heating
10 pump technology / substrate lines
11 gas technology / gas pipes
12 CHP / gas processing
13 control / process control
14 hazardous substances on biogas plants
15 occupational hazards
16 environment-related hazards
17 hazards in different phases of the life cycle of the plant
18 other plant components
<table>
<thead>
<tr>
<th>area of activity</th>
<th>hazard</th>
<th>protection measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>responsibility</td>
<td>Aufgaben, Varantwotl</td>
<td>Alle Aufgaben, Kompetenzen und Verantwortlichkeiten liegen beim Unternehmer. Abweichungen von dieser Regel sind schriftlich fixiert.</td>
</tr>
<tr>
<td>selection of employees</td>
<td>Ungeeignete Personen einsetzen (Gesundheits- und Sachschäden)</td>
<td>Arbeitsmedizinische Eignung ist vor Einstellung abgeklärt.</td>
</tr>
<tr>
<td></td>
<td>Sich selbst, andere Be</td>
<td>Aufträge werden nur Beschäftigten mit entsprechender Aus- und Weiterbildung erteilt.</td>
</tr>
<tr>
<td></td>
<td>schäftigte und weitere Personen gefährden.</td>
<td>Beschäftigte werden gezielt weitergebildet.</td>
</tr>
<tr>
<td></td>
<td>Gefahren nicht erkennend und</td>
<td>Beschäftigte werden vor Aufnahme ihrer Tätigkeit über mögliche Gefahren sowie über Maßnahmen zu deren Abwendung unterwiesen.</td>
</tr>
<tr>
<td></td>
<td>oder Sicherheitsmaßnahmen nicht</td>
<td>Regelarbeitszeiten werden eingehalten.</td>
</tr>
<tr>
<td></td>
<td>beachten</td>
<td>Ruhepausen werden eingehalten.</td>
</tr>
<tr>
<td>work without appropriate</td>
<td>Arbeitszeiten, Erholzeiten und</td>
<td>Erste Hilfe Material ist vorhanden (Verbandkasten nach DIN 13157)</td>
</tr>
<tr>
<td>education and training</td>
<td>Pausen nicht einhalten</td>
<td>Notrufnummern sind bekannt.</td>
</tr>
<tr>
<td>safety instruction</td>
<td>Gefahren nicht erkennend und</td>
<td>Ausgebildeter Ersthelfer ist erreichbar.</td>
</tr>
<tr>
<td>working time</td>
<td>oder Sicherheitsmaßnahmen nicht</td>
<td>Regelarbeitszeiten werden eingehalten.</td>
</tr>
<tr>
<td>airst aid</td>
<td>beachten</td>
<td>Ruhepausen werden eingehalten.</td>
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Explosion hazards

- Explosion hazards must be determined and assessed. In particular, it must be determined where potentially explosive atmospheres can occur. Potentially explosive areas are to be classified into Ex-zones = Ex-Zone-Document is necessary for all biogas plants!

- Potentially explosive areas must be identified at their entrances by appropriate signage with black lettering on a yellow background.
Ex-Zones

Zoning = method aiming to analyse and classify the environment, in which an explosible gas atmosphere may occur, in order to facilitate the selection of devices (electrical and non-electrical devices) which may be operated safely in this type of environment, taking into account explosion groups and temperature classes.

In most practical situations in which flammable substances are used, it is difficult to ensure that an explosible gas atmosphere will never develop. It is just as difficult to fully exclude the possibility of ignition sources when working with electrical tools. - > Probabilities!!

The first step consists in the evaluation of these probabilities via the definition of zones. - > Explosion protection document in accordance with the EU 99/92 Directive (ATEX)!!

This requires a closer examination of each component of the process plant which contains flammable materials and could therefore represent a source of release.
Ex-Zones

Zone 0
A place in which an explosive atmosphere, consisting of a mixture of air with flammable substances (gas, vapour or mist), is present continuously, for long periods or frequently. E.g.: overflow aid, Zone 0 in the pipe and in the area near the overflow.

Zone 1 (radius 1 m)
A place in which an explosive atmosphere, consisting of a mixture of air and flammable substances (gas, vapour or mist), is likely to occur occasionally, in normal operation conditions. E.g. immediate vicinity of manholes accessing the gas storage tank or on the gas-retaining side of the fermentation tank, and in the vicinity of blow-off systems, pressure relief valves.

Zone 2 (radius 1-3 m)
A place in which an explosive atmosphere, consisting of a mixture of air and flammable substances (gas, vapour or mist), is not likely to occur in normal operation conditions, but if it does occur, it will be for a short period only. E.g. manholes, for example, and the interior of the digester, and in the case of gas storage tanks the immediate vicinity of aeration and ventilation openings.
The ATEX directive consists of two EU directives describing what equipment and work environment is allowed in an environment with an explosive atmosphere. ATEX derives its name from the French title of the 94/9/EC directive: *Appareils destinés à être utilisés en ATMosphères EXplosibles.*
Requirements for Ex-Zones

Zone 0
In Zone 0, only resources must be used that are approved for Zone 0 and that are appropriately labelled. Basically, only devices and protection systems of the Equipment Group II, Category 1 G, according to Appendix 1 of the Directive 94/9/EU, can be used.

Zone 1
In Zone 1, only resources must be used that are approved for Zone 0 or 1 and that are appropriately labeled. Basically, only devices and protection systems of the Equipment Group II, Category 1 G or 2 G, according to Appendix 1 of the Directive 94/9/EU, can be used.

Zone 2
In Zone 2, only resources must be used that are approved for Zone 0, 1, or 2 and that are appropriately labelled. Basically, only devices and protection systems of the Equipment Group II, Category 1 G, 2 G, or 3 G, according to Appendix 1 of the Directive 94/9/EU, can be used.
ATEX directive

- In Ex-Zone 0: devices of category 1
- In Ex-Zone 1: devices of category 1 or 2
- In Ex-Zone 2: devices of category 1, 2 or 3

here: 2 G
### ATEX directive

**Atex:**
- **G** = explosive area of gas-, steam-, fog- and airmixture
- **D** = explosive area of dust - airmixture

**Symbol for prevention of explosions**
- **T** = temperature class: T1-T6
- **Ex** = complies to the National Standards (e.g. DIN)
- **EEx** = complies to European Standards (EN)

**Device class:**
- **I** = use for mines
- **II** = other ex-areas

**ATEX category**
- **I** = use for mines
- **IIA, IIB, IIC** = other ex-areas

**Explosion group:**
- **I** = use for mines

**Safety-concepts (type of protection):**
Explosion protection zones

- Pressure protection
- Gas storage
- Gas pipe
- Mixing tank
- Condensate tank
- Digestor / gas storage / rupture disk
- CHP / gas flare

Diagram labels:
1. Digestor / gas storage / rupture disk
2. Mixing tank
3. Gas storage
4. Gas storage
5. Condensate tank
6. CHP / gas flare
7. Pressure protection
Explosion protection zones - plan
Explosion protection zones - plan
Collection of examples (Ex-Zones on biogas plants) from the employers liability insurance association (BGR 104 – published May 2014)
### Surroundings of simple plastic film systems

<table>
<thead>
<tr>
<th></th>
<th>Surroundings of simple plastic film systems</th>
<th>2.4.3.3</th>
<th>2.4.3.5</th>
<th>No zone</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>The technical leakproofness is monitored for the first time and repeatedly, e.g., detection by gas camera, followed by check with foaming agents or suitable gas detector.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>same as a), but without recurrent check</td>
<td>2.4.3.3</td>
<td></td>
<td>Zone 2: 3m around the plastic film and 2m down at 45° see figure, ...</td>
<td>None</td>
</tr>
</tbody>
</table>

### Surroundings of manual sampling points for gas

<table>
<thead>
<tr>
<th></th>
<th>Surroundings of manual sampling points for gas</th>
<th>2.4.3.3</th>
<th>2.4.4.2</th>
<th>Zone 2: 1m around the exit point</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Inside spaces</td>
<td>Manual sampling point technically leakproof by shutoff valve and additional closure.</td>
<td>2.4.3.3</td>
<td>2.4.4.2</td>
<td>Zone 2: 1m around the exit point</td>
</tr>
<tr>
<td>5.2</td>
<td>Outdoors</td>
<td>same as 4.8.15.1</td>
<td>2.4.3.3</td>
<td>2.4.4.2</td>
<td>Zone 2: spherically in the close vicinity around the exit point</td>
</tr>
</tbody>
</table>
Prevention of ignition sources - 1

- Hot surfaces (turbocharger of the CHP)
- Flames and hot gases
- Mechanically produced sparks: rubbing, striking, abrading
- Electrical plants: sparks (switching operations, loose connections, compensating currents),
- Electrical currents, cathodic corrosion protection: stray, return currents (welding facilities); body contact or earth fault, magnetic induction, lightning stroke
- Static electricity: discharge of charged conductive parts which are arranged in an isolated fashion; charged parts made of non-conductive materials (plastic) – bunch discharges; separating processes
Prevention of ignition sources - 2

- Lightning stroke: direct and indirect (induction)
- Electromagnetic waves: radio transmitters, welding machines, strong laser radiation
- Ionising radiation: X-ray, radioactive radiation
- Ultrasonic
- Adiabatic compression and impulses
- Exothermic reaction, including self-ignition of dusts
Integrated explosion protection

primary Ex-protection

- prevent formation of explosible atmospheres
- substitution, inert atmosphere, concentration-limitation, intensive ventilation…

secondary Ex-protection

- preventing the ignition
- Ex-Zoning, preventing sources of ignition, organizational measures…

tertiary Ex-protection

- reduction of explosion consequences
- Personal Safety Equipment (PSA), explosion suppression, explosion pressure resistance.
- => evacuation or enough distance
The worker tried to close the digestate pipe from the first digester to the secondary digester due to maintenance.

The plant operator gave the worker a gymnastic ball to close the pipe with the outflowing biogas.

Meanwhile, biogas escaped and an explosive atmosphere has formed.
Deflagration on a biogas plant with 1 injured worker

- The worker just finished his work and wanted to go out from the intermediate building.
- The explosible atmosphere inside the intermediate building was ignited.
- The worker wore a disposable suit made of lightweight plastic fabric.
- 50% of the body surface was burned.
- A heavy flammable cotton suit, would have significantly reduced the effects of the deflagration.
Deflagration on a biogas plant with 1 injured worker
Good idea, but poor execution

Blister for gaspipes with pressure gauge and shut-off valve
Accidents on biogas plants / Statistic evaluation of biogas dangers
Hazards on biogas plants
Legal framework & safety regulations in Germany
Risk assessment / Explosion safety / Safe operation
Ex-Zones on Biogas plants
Responsibilities for manufacturer and plant operator
Safety informations for components of biogas plants
Samples for safety instructions etc.
Lessons learnt
Standardization measures
Activities of the German Biogas Association
Best practice and how to prevent accidents
Responsibilities for manufacturers:

- European Machinery directive (2006/42/EG) = German Product Safety Act
- Operating instructions and risk analysis for the product (biogas plant or components)
- Declaration of incorporation (e.g. ATEX / Ex-Zone) / installation instructions
- Declaration of conformity (CE-mark)
- Maintenance instructions

Responsibilities for plant operators:

- Responsible for the safety on the biogas plant (documentation of the supplier...)
- Create a risk assessment
- Prepare a explosion protection document as part of the risk assessment
- Safety instruction
- Testing of the equipment
- Maintenance
- Create a safety manual for:
  - hazardous materials,
  - machinery etc.
- Create a work instruction for:
  - Cleaning the digester
  - entering pits etc.
Operating instructions and instruction manuals

- The manufacturers introduce products into the market with operating instructions.
- The operating instructions from the component manufacturers must be collected and safely stored.
- During the transfer of manufacturer documentation for individual components, devices, and machines, the plant operator has to ensure that the required operating instructions, including each of the required manufacturer’s declarations and, if applicable, the certificates of conformity, are present.
- For the operation of different resources, equipment, etc., the operator has to create an instruction manual which includes content such as the operating instructions, as well as information about hazards that result from the installation conditions.
Operating instructions and instruction manuals

- In addition, special operating states such as startup and shutdown of the system need a specific instruction.

- The employees must be instructed regularly about safe operation, e.g., using the instruction manual.

- Additionally, with the use of external companies, for example, during corrective maintenance, servicing, and modifications, the instruction manual can be the basis to give the external company or employee what needs to be done (basis for a work order) and how.
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Connection points in gas lines
Connection points in gas lines for non-stationary equipment, such as, mobile gas flares, must be equipped with shutoff valves. The shutoff valve must be built in before the connection of the non-stationary equipment, as viewed in the gas flow diagram. Operation must occur without hazard.

Fire Protection
For information regarding equipping with fire extinguishers, refer to BGR 133 “Equipping Workplaces with Fire Extinguishers.” More extensive fire prevention measures must be coordinated with the responsible regional and specialist fire department offices.

Thermal insulation
The thermal insulation of the digester container must be at least normal combustibility, e.g., B2 DIN 4102. In the area of 1 m around openings, at which gas escapes during normal operation, the thermal insulation must be made from hard material that is difficult to ignite, e.g., B1 DIN 4102.
Safety installations
Digester containers must be provided at all times with effective safety installations that prevent an inadmissible change of the internal pressure. The liquid seals must be designed and installed as safety seals, so that the sealing liquid does not spill out during overpressure or under-pressure and flows back again on its own during the alleviation of the overpressure or under-pressure.

In the digester and post digester containers, it must be guaranteed that the fill levels are not exceeded, e.g., in that the fermented substrate is fed via a frost-free riser pipe (spillover) into the liquid manure storage.
Fill openings/plug screw feeder

Fill openings, e.g., solids dosing feeders, should be secured so other objects do not fall. Measures to prevent other objects from falling in are, e.g.:

- covered fill hoppers with a height > 1.30 m combined with a covering
- fill funnels without a covering with a height of \( \geq 1.80 \) m
- fixed installation of grids with a bar grid of \( \leq 20 \) cm
- self-closing flaps with perpendicular openings
- flushing gutters with which perpendicular openings are covered

If the digester is filled by means of a plug screw feeder, a sufficient submersion must be present considering all operating states in order to prevent a possible gas escape. The submersion must correspond at least five-fold of the triggering pressure of the overpressure protection.
Gas storage (pressure < 0.1 bar)
Gas storage must meet the requirements for being gas tight and resistant to pressure, media, UV, temperature, and weather. For the selection of materials, especially for plastic membranes, the following requirements must be met:

- tensile strength minimum 500 N/5 cm or
- tensile strength 250 N/5 cm
- gas permeability with respect to methane < 1000 cm³/m² x d x bar
- temperature resistance for the use case (mesophilic, thermophilic digestion process)
- gas storage must be checked for tightness before being in operation
Ventilation and exhausting of gas storage rooms

Installation rooms for the gas storage must have effective ventilation (cross ventilation). Diagonal ventilation should be attempted. The supply air opening should be placed in the area of the floor, and the exhaust air opening should be placed below the ceiling.

The supply air and exhaust air opening must each have the following minimum cross sections:

<table>
<thead>
<tr>
<th>Gas Storage Volume</th>
<th>Cross Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 100 m³</td>
<td>700 cm²</td>
</tr>
<tr>
<td>up to 200 m³</td>
<td>1,000 cm²</td>
</tr>
<tr>
<td>above 200 m³</td>
<td>2,000 cm²</td>
</tr>
</tbody>
</table>
Safety information for components of biogas plants - 6

Safety distances

To avoid mutual impact in the case of damage, preventing flashover to adjacent systems in the case of fire, and for the protection of the gas storage from damage, such as heating as a consequence of fire, safety distances of at least 6 m must be provided in the horizontal direction between the gas storage and adjacent systems, equipment, or buildings (with a height lower than 7.5 m) not belonging to the biogas system, or to pathways or transport paths. For a building height > 7.5 m (gas storage or building not belonging to the system), the following applies:

0.4 \times H1 + 3m

The safety distance can be reduced through sufficient earth covering or sufficiently dimensioned safety wall or fire protection insulation (e.g., firewall).
System control and process control engineering
In principle, the safe operation of a system must be guaranteed. In particular, an overfilling of the digester, an unintended flow of substrate into the pipe and container lines of the system, an impermissible pressure increase in the digester, as well as an uncontrolled escape of gas, must be prevented.

Control systems with safety functions must be fail-safe if they are not secured by a redundant system, e.g., a mechanical overpressure protection against over-pressure, or e.g., an overflow spillway.

Examples:
- Closing the automatic gas rapid shutoff device at the CHP unit.
- Switching off the corresponding gas compressor.
- Switching off all parts that are not EX-protected in gas-pressurized machine rooms (CHP unit, gas cleaning, etc.).
Gas processing - desulphurization by air injection in the gas room over the digester

The air-dosing pump must be adjusted so that it delivers at most a volume flow of 6 per cent of the biogas generated in the same time period. The air dosing must be dimensioned so that even in the case of a failure of the air flow, no significantly higher quantity of air can be supplied. In the supply to the gas room, a non-return protection (non-return valve) is required, as close to the gas room as possible. Between the non-return protection and the gas room, no additional devices can be inserted except for a blocking device.
biogas pipe - design and material
Gas-carrying lines must be designed according to the generally recognized rules of the technology. The correct production and impermeability must be proven, e.g., by manufacturer’s certification.

Pipelines must be resistant to its contents and to corrosion. Pipes that are resistant to biogas are composed of, for example, steel, stainless steel, polyethylene (PE-HD) and PVC-U.

Tip – PVC-U pipes: PVC is not UV-resistant and has a low resistance to impact. For PVC use, correct storage and processing must be observed. For this, particular attention must be paid to the information regarding installation and usage, e.g., the manufacturer’s information, as well as the bonding information and the installation information from the Plastic Pipe Association. The expertise of the pipe installer must be verified.
Tip for biogas pipes:

If gas lines are installed outside of the biogas system or on surfaces that are not in spatial functional connection to the biogas system, plastic gas lines must be laid according to the technical specifications of DVGW [German Technical and Scientific Association for Gas and Water] G 472 Rules.

Mechanical damage due to settling (e.g., at passages through walls) must be avoided by appropriate passages and corresponding connections.

In the case of moist gas, the pipelines must be laid so that they are frost-proof. Condensate collectors must be constructed frost-proof and continuously capable of function.
Tip for biogas pipes:

Pipelines must be labelled according to DIN 2403 according to the flow substance and the direction of flow. Color for the labelling: yellow.

The location of underground gas pipelines must be marked with gas pipeline warning tape.

Flashback arrestors must be installed in front of gas-consuming equipment, such as boilers and CHP units, as close to the equipment as possible, corresponding to the instructions of the manufacturer.
Safety equipment, overpressure/under-pressure protection

Every gas storage must be equipped with at least one safety device against exceeding or falling below acceptable pressure.

Through a separate under-pressure monitor in the gas system or an equivalent protective measure, the under-pressure protector must activate a forced shutdown of the gas-consuming equipment and an error message must occur.

It must be possible to shut off the gas containers individually and to shut them off from each other.

The exhaust lines of the overpressure and under-pressure protection must discharge at least 3 m above the ground, and

- discharge 1 m above the roof or the upper edge of the container, or
- must be displaced at least 5 m away from buildings and passageways.
Ventilation of CHP-rooms

Installation rooms must have supply air and exhaust air openings that cannot be closed. These allow a cross ventilation of the installation room. With technical ventilation, it must be guaranteed that the exhaust is led away from the ceiling area. In the case of natural ventilation, the supply air opening must be located in the area of the floor, and the exhaust air opening must be located on the opposite wall in the area of the ceiling. The exhaust of the CHP installation room must be discharged directly into the open air.
Cutoff CHP
It must be possible to shut off the combined heat and power unit at any time by using an illuminated switch located outside of the installation room. The switch must be labeled permanently and be easily visible with “Emergency Shut-off Switch for Combined Heat and Power Unit ” and must be accessible.

Cutoff for the gas supply
It must be possible to shut off the gas supply to the combined heating and power unit, in the open, outside of the installation room, as close to the CHP unit room as possible. The on and off position must be labeled. The same requirements apply also to electrically-operated shutoff valves.

Shutoff valves
Two shutoff valves must be installed in the gas line in front of each motor aggregate. The valves must automatically close when the motor stops.
Installation of gas-warning devices

Sensing devices should be placed above, depending on the gas properties, in the proximity of possible release sources. The influences of the ventilation and its possibly different operating states must be considered in the placement.

Operating instructions must be written for the case of the alarm being triggered by the gas-warning device or interruptions of the gas-warning device.
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Best practice and how to prevent accidents
Safety information for the plant operation

- Operating instructions must be available for taking the system into service.
- The operation and maintenance of the biogas system must be performed only by reliable persons familiar with the work.
- At least two persons at the biogas system must have received certified operator training.
- The operating instructions with safety information must be observed.
- Operating instructions must always be placed permanently in the operating room.
- An operational log must be kept in which all daily measurements, control, and maintenance work, as well as malfunctions, is recorded.
Safety instructions for entering tanks and pits

- Clearance measurements of dangerous areas
- Ventilation of the tank and pit
- Rescue elevator with safety rope and fall adsorber
- Personal safety equipment: portable Ex-Zone and multi-gas detector
- Portable breathing apparatus
- Second person outside of the tank/pit for safety measures
Requirement to label

P 02: fire, smoking etc. are prohibited

P 06: No Admittance Without Authorization

W 21: explosive atmosphere

W 03: poisonous substances warning sign

M 03: earprotection

M 09: use safety harness

M 04: use respiratory protection

W 16: biohazard warning sign

W 01: warning flammable substances
2. The empty digesters are initially blocked from the gas collection system.

3. The digesters are connected to the atmosphere via the operationally ready overpressure protector and the exhaust lines.

4. The digesters are filled within a short time period with substrate that is as active as possible, until all inlets and outlets (liquid valve closure disks) are sealed with substrate.

5. The fermentation substrate is heated.

6. During the startup/heating of the system, the system must not be fed further.

7. The gas generated during the starting of the digestion process discharges via the exhaust line (gas overpressure protection) into the open air, and displaces the air that is present in the digester.

8. After testing the gas quality, biogas fills into the gas system and the gas storage. The gas quality is sufficient and there is not explosion hazard if the methane content of the gas is greater than 30% and the oxygen content is < 3%.

9. The CHP units are turned on. They automatically suction the gas from the gas storage. Sufficient biogas quality can be determined by gas measurement.

10. All safety equipment must be checked for the proper function.
# Inspection documents

## Membran gas storage

### Sample

<table>
<thead>
<tr>
<th>Address of the site:</th>
<th>Biogas system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator of the system:</td>
<td>Biogas system:</td>
</tr>
<tr>
<td>System installer:</td>
<td>Inspecter of the membrane storage:</td>
</tr>
</tbody>
</table>

### Membrane Storage

<table>
<thead>
<tr>
<th>Manufacturer:</th>
<th>Company:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material:</td>
<td></td>
</tr>
<tr>
<td>Dimensions:</td>
<td></td>
</tr>
<tr>
<td>Gas impermeability:</td>
<td>For methane: cm³/m² d. bar</td>
</tr>
<tr>
<td>Strength:</td>
<td>Tear strength: N/5 cm Tensile strength: N/5 cm</td>
</tr>
<tr>
<td>Temperature Resistance</td>
<td></td>
</tr>
<tr>
<td>Seals:</td>
<td></td>
</tr>
<tr>
<td>Installation procedure:</td>
<td></td>
</tr>
</tbody>
</table>

### Leak Test

| Test area: | |
| Test method: | |
| Test medium: | |
| Test result: | |

## Biogas pipe

### Inspection Document for Gas-Carrying Pipes

<table>
<thead>
<tr>
<th>Address of the site:</th>
<th>Biogas system:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator of the system:</td>
<td>Biogas system:</td>
</tr>
<tr>
<td>System Installer:</td>
<td>Inspector of the piping:</td>
</tr>
</tbody>
</table>

### Piping

<table>
<thead>
<tr>
<th>In the CHP unit room</th>
<th>In the ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer:</td>
<td></td>
</tr>
<tr>
<td>Material:</td>
<td></td>
</tr>
<tr>
<td>Dimensions:</td>
<td></td>
</tr>
<tr>
<td>Strength:</td>
<td></td>
</tr>
<tr>
<td>Pipe connections:</td>
<td></td>
</tr>
<tr>
<td>Seals:</td>
<td></td>
</tr>
</tbody>
</table>

### Leak Test

| Test section from - to | |
| Test pressure: | Initial test with 1 bar, main test with 110 mbar |
| Test duration: | Initial test 10 min, main test 10 min. |
| Test medium: | Air |
| Test result: | |

Note:
Location/Date:
Stamp/Signature:
Operating instruction for a biogas system in normal operation - 1

In general:
- During filling and emptying, pay attention to pressure fluctuations and ensure good accessibility to the operating equipment.
- Avoid ignition sources, according to 1.4.4, in the zones according to the Explosion Protection Document.

Daily:
- Record the gas meter reading and operating hours of the motor.
- Check the motor oil level.
- In the control room, at the control box, check whether the malfunction lights are illuminated.
- Check the water pressure in the heating system.
- Check the air-dosing pump of the desulphurization system for operability.
- Monitor the digester temperature.
- Select the agitation intervals so that no layer of scum/sediment layer develops.
- For all inlets and outlets, assure that the liquid manure/substrate flow is maintained according to the process regulations.
- The airflow injected for desulphurization must be matched to the current gas production rate (max. 6% vol.).
- Check the fill levels in the digester and end storage.
- Check the membrane connectors (e.g., attachment hose at the membrane gas storage).
Operating instruction for a biogas system in normal operation - 2

**Weekly:**
- Check the fill level of the sealing liquids in the overpressure and under-pressure protectors and condensate separator; if necessary, in the case of a danger of frost, check the antifreeze agent (if the weather warrants, daily checks are also required).
- Check the submerged propeller function; observe whether vibrations are present.
- Visually inspect the motor and the lines.
- Check the gas magnet valve for function and contamination.
- Check the intermediate space of the self-closing gas shutoff valve for tightness.

**Monthly:**
- Actuate all scrapers a few times so that they are not stuck.
- Possibly remove the oil deposits in the CHP unit and clean the oil catch basin.

**Twice a year:**
- Check the ventilation and exhaust in the machine room of the CHP unit.
- Inspect the electrical systems for damage.
- Check the under-pressure monitor of the gas system for function.
- Check the function of the gas sensors, fire detector (if present).
Operating instruction for a biogas system in normal operation - 3

**Annually:**
- Check the gas-carrying system parts for damage, tightness, and corrosion.
- Calibrate the gas sensor with suitable test gas.

**Every 2 years:**
- Check the fire extinguishers.

**Pits and shafts:**
Before entry and during presence in the pits and ducts, it must be guaranteed that there is no hazard of poisoning, as well that there is sufficient breathable air present. Operating equipment must be reliably secured so they don’t switch on (lock out procedures). Ensure that there is sufficient ventilation. In the case of insufficient ventilation, there is a danger of asphyxiation, fire, and explosion.
PERMISSION for welding, soldering, cutting, grinding and similar operations in explosible areas (gas pipes and fittings)

<table>
<thead>
<tr>
<th>Working place</th>
<th>Date and time of the work</th>
<th>Description of the work</th>
<th>Category of the work (welding…)</th>
<th>Who is doing the work (own worker or specialized company)</th>
<th>Specific qualification of the worker</th>
<th>Specific hazards (explosible dust…)</th>
<th>Safety measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
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- Working place
- Date and time of the work
- Description of the work
- Category of the work (welding…)
- Who is doing the work (own worker or specialized company)
- Specific qualification of the worker
- Specific hazards (explosible dust…)
- Safety measures
PERMISSION for welding, soldering, cutting, grinding and similar operations in explosible areas (gas pipes and fittings)

Safety measures:
- Fire and rescue guard
- Next fire warning device
- Next telephon
- Fire extinguisher
- Work equipment

Permission - the security measures listed must be carried out.

Signature of the responsible plant operator and of the worker

<table>
<thead>
<tr>
<th>Brand- und Rettungswache</th>
<th>Während der Arbeit (Name):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nach Arbeitseende (Name):</td>
</tr>
<tr>
<td></td>
<td>Dauer (Std.): ______h.</td>
</tr>
<tr>
<td></td>
<td>Kontrolle auf verdeckte Nachbrände, Glutrester usw.</td>
</tr>
</tbody>
</table>

ACHTUNG:
- Besonders achten auf kleine Neben-Brände durch Schweissperlen und Flexfunken!

Alarmierung: Standorte
- Nächstgelegener Brandmelder: _________________________
- Nächstgelegenes Telefon: ______________________________

ACHTUNG:
- Achtung: Im Inneren von Stahl- und Stahl und Stahlbeton-Behälter ist oft keine Verbindung zum Mobilfunknetz vorhanden!

Feuerlöschergerät und -mittel
- □ Feuerlöscher mit
- □ Wasser
- □ Schaum
- □ CO₂
- □ ABC-Pulver  □ BCF-Pulver
- □ Wasserschlauch (angeschlossen) mit Sprühdüse?

Sonstige anwendungspflichtige Arbeitsmittel und Arbeitsschutz-Ausrüstung
- □ Leiter, Steighilfen
- □ Absatzsicherung
- □ Helmlicht
- □ Gehörschutzpflcht
- □ Augenschutzpflcht
- □ besondere Leuchtmittel
- □ besondere Kommunikationsmittel
- □ spez. Hebezeuge für Werkzeuge und Schweissgasflaschen

Erlaubnis
- Die aufgeführten Sicherheitsmaßnahmen sind durchzuführen.

Die Unfallverhütungsvorschriften (BGV A1 sowie BGV D1) sind zu beachten.

Datum
- Unterschrift des verantwortlichen Betreibers der Biogasanlage
- Unterschrift des Ausführenden
Outline

- Accidents on biogas plants / Statistic evaluation of biogas dangers
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- Ex-Zones on Biogas plants
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- Lessons learnt
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- Best practice and how to prevent accidents
Exemplary defects on biogas plants - 1

- Inadequate planning documents / RI-flow diagrams
- Lightning Protection deficient
- Flare defective / incorrect installation
- Gas storage without static
- Gas pipe aboveground in PVC without UV-protection
- Lack of test plans / test reports: gas tightness; Electrical safety; Commissioning test (BetriebsicherheitsV) ...
- Lack of documentation: manuals, operating instructions, declaration of conformity, safety data sheets, manufacturer's declarations, etc.
- Lack of emergency power concept

Source: KAS – Dr. Ziegenfuß
Exemplary defects on biogas plants - 2

- Instrumentation, control and automation facilities are not connected or functionally
- Faulty overfill protection in the digester
- Faulty wiring: emergency stop, smoke detector, gas detector ...
- Lack of risk assessment, safety concept, fire protection concept
- Inadequate amount of fire water, missing fire extinguishers
- Missing placarding of EX-zones on the system
- Explosion protection document is missing ...
- Missing alarm and emergency plan

Source: KAS – Dr. Ziegenfuß
Lessons learnt - 1

- Biogas plants are complex process plants with several hazards.

- The operating personnel and the plant owner need professional skills and knowledge. Important is periodic retraining!!!

- Also well-qualified plant designers and manufacturers are required.

- In the last years the safety on biogas plants in Germany was not in the focus of the authorities.

- At the moment, some new regulations for the safety of biogas plants will be prepared.
Lessons learnt - 2

- The German biogas plant manufacturers collected over the past 14 years a lot of experience.

- Experienced designers and manufacturers of biogas installations are available. Ideally, they have diverse references, maybe in Thailand.

- Enhanced measures for the standardization of components and materials for biogas plants are in progress

- Currently in preparation: development of safety management systems
Lessons learnt - 3

- Problem in Germany: we have a lot of responsible authorities and too many confusing rules.

- For the plant operator and the manufacturers, it is hard to be informed on the different regulations.

- Critical is the lack of enforcement of regulations.

- Due to some minor defects, the authorities want to make more new regulations.

- Great danger of over-regulation and the disproportionate burden to the operators and manufacturers => economy in danger!
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Standardization measures to prevent safety problems

- **Some new specific regulations for biogas are in preparation**
  - Avoidance of emissions from biogas: CHP - formaldehyde, digestion process, manure storage, gas flare, gas-storage, safety distances around biogas plants
  - Optimize the safety culture on biogas plants (biogas-trainings, selfmonitoring, the use of hazardous materials desulfurization …)
  - Some new requirements on occupational safety
  - Fertilizer-regulation: problems with nitrate in water and soil

- The relevant biogas and rule-making association are working on some new regulation in addition to the regulatory ministries authorities: DVGW, DWA, GBA, VDI, DIN, VDE etc.
- International activities: ISO TC 255 „Standardization of Biogas“
Activities of the German Biogas Association (GBA)

- **Ex-Protection**
  - Collection of examples for Ex-Zones

- **Biogas trainings**
  - Biogas Training Network of the GBA
  - Technical knowledge and expertise for biogas plants in the EnWG / DVGW G1030

- **Gas storage**
  - Position paper for requirements: quality of the membrane, tightness, static monitoring

- **Gas flare**
  - Position paper: technical and safety requirements
  - Technical standard in preparation with DVGW, DWA

- **Checklist for plant inspector**
  - New checklist from the GBA

- **Hazardous Incident Ordinance**
  - Guidance from the GBA

- **Several...**
  - Insurance: special conditions for GBA members
  - Workshop for plant inspectors (§ 29a BImSchG)
  - Newsletter for authorities/ministries
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- Legal framework & safety regulations in Germany
- Risk assessment / Explosion safety / Safe operation
- Ex-Zones on Biogas plants
- Responsibilities for manufacturer and plant operator
- Safety informations for components of biogas plants
- Samples for safety instructions etc.
- Lessons learnt
- Standardization measures
- Activities of the German Biogas Association
- Best practice and how to prevent accidents
Thank you for your attention!

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... and take part in our

24. International BIOGAS
– Convention and Trade Fair
27.-29.01.2015, Bremen, Germany

... international excursion: 30.01.2015