Safety of biogas plants: General introduction, experiences from practice and lessons learned

Dipl. Wirt. Ing. (FH) Marion Wiesheu, Head of Training and Safety, Fachverband Biogas e.V., German Biogas Association

Frank Hofmann, International Affairs, Fachverband Biogas e.V., German Biogas Association
Content

• Why is safety on biogas plants that important?
• Hazards on biogas plants
• Risk evaluation and precautions
• Pictures from practice
Why is safety on biogas plants that important?

- Unsafe biogas plants can be a danger to humans and the environment
- Every accident damages the image of the technology and therefore of the sector
- Every accident costs a lot of money
- Every accident can lead to new safety requirements
Accident
Fire in the CHP and electrical room with leakage

How did the accident happen:

• Leaky oil pressure line (approx. 70 liters of engine oil leaked)
• Ignited on the turbocharger exhaust system
• Fire in 3 CHP units, entire electrical and gas installation
  • Power supply failure
  • Failure of agitators
  • „Yeast dough accident“
• Gas generation could be protected from flying sparks
• Total damage of approx. € 1.2 million (insurance only covered part of it)

Causes for the high extent of damage:
Fire protection concept, smoke detector, fire barrier, automatic gas gate valve, sufficient extinguishing water, ... not available.

Marion Wiesheu
03.03.2021

Source: Toni Baumann
Hazards on biogas plants

General hazards:

• Health hazards

• Environmental hazards:
  – gaseous emissions (CH4, CO2, NH3, NOx, Sox, CH2O …)
  – emissions to soil and water (digestate, silage, processing aids…)

Source: Biogas Safety first! Guidelines for the safe use of biogas technology; Fachverband Biogas e.V.; Photos: Josef Barth and Uwe Mühling
Types of accidents with injured persons at biogas plants

- Mechanical: 86%
- Chemical: 7%
- Thermal: 4%
- Radiation: 1%
- Noise: 1%
- Not specified: 1%

Source: SVLFG = German Agricultural Occupational Health and Safety Agency
Working areas of the accidents

Accidents in biogas plants between 2009 – 2011 in Germany

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

- Hot surfaces
- Mechanical hazards
- Electric shocks caused by electric components
- Danger from fire
- Biological agents
- Noise
- Falling, crashing, etc.
- Danger of explosions

Source: ISO 7010
Mechanical hazards

• Mechanical hazards are present through moving parts of machinery and dangerous surfaces.
• They are usually not specific to biogas technology.
## Gas hazards

Gas hazards are present on biogas plants through dangerous components of biogas itself:

<table>
<thead>
<tr>
<th></th>
<th>Properties</th>
<th>Hazardous atmosphere</th>
<th>Workplace exposure limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>Colourless and odourless gas. Heavier than air.</td>
<td>8% v/v, danger of asphyxiation.</td>
<td>5500 ppm</td>
</tr>
<tr>
<td>NH₃</td>
<td>Colourless and pungent-smelling gas. Lighter than air.</td>
<td>Above 30 – 40 ppm mucous membranes, respiratory tract and eyes become irritated.</td>
<td>20 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 1000 ppm breathing difficulties, potentially inducing loss of consciousness.</td>
<td></td>
</tr>
<tr>
<td>CH₄</td>
<td>Colourless, odourless gas. Lighter than air.</td>
<td>4.4 – 16.5% biogas = 6-22 Vol. %</td>
<td>-</td>
</tr>
<tr>
<td>H₂S</td>
<td>Highly toxic, colourless gas. Heavier than air. Smells of rotten eggs</td>
<td>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.</td>
<td>5 ppm</td>
</tr>
</tbody>
</table>

Source: Biogas Safety first! Guidelines for the safe use of biogas technology; Fachverband Biogas e.V.
Fire/heat hazards

- Fire hazardous materials:
  - Biogas
  - wooden constructions,
  - trace elements for the biological process
  - sulphuric acid for gas- and air washer
  - ………

- Hazard of fire due to hot surfaces
  - engines/motors
  - gas flare
  - drying systems for digestate
  - …

- Hazard of scalding: hot water, steam….

Source: Biogas Safety first! Guidelines for the safe use of biogas technology; Fachverband Biogas e.V.; Photo: Uwe Mühling
Hazardous substances

• Hazardous substances can take the form of solids, liquids, aerosols and gases.

• Chemicals
  • Processing aids
  • compounds for desulfurization
  • ……..

• Biological agents
  • microorganism
  • cell culture
  • human endoparasite

• Hazardous properties: harmful to health, toxic, very toxic, corrosive, sensitizing ……..
Electrical hazards

• Electrical equipment:
  • Control equipment, CHP unit, pumps, agitators, measuring instruments, …

• Causes for accidents:
  • Defective electrical equipment, electrical lines, lightning protection, electrical installations, …

• Hazards:
  • Explosions, fires or even electrical shocks

• Preventive measures:
  • Use of safe electrical equipment,
  • Turn off electricity,
  • To ask advice from a qualified electrician

Source: ISO 7010
Other sources of hazards

- **Surrounding environment:**
  - Flooding
  - Earthquakes
  - Storms
  - Ice and/or snow
  - Power outage
  - Heavy rainfall
  - Frost

- **Inappropriate behavior:**
  - Action by unauthorized persons
  - Dangers caused from the staff (Operating errors, Sabotage, …)
Risk evaluation and precautions

Hazard Assessment

• The hazard assessment is obligatory for operators of biogas plants. Its goal is to protect and reduce the exposure to risks and hazards of employees.

• The results of this assessment should help the operator determine, evaluate and minimize the hazards by appropriate safety measures.

• Its results should be considered in the design and selection of equipment and material and in the design or workplaces, work processes and operating sequences.

• The findings of the hazard assessment and all recurring updates must be documented!
Risk evaluation and precautions

T-O-P Principle

**Technical protective measures**
- Gas warning devices
- Mechanical ventilation
- Protective covers for rotating parts
- Enclosed metering station for process additives

**Organisational protective measures**
- Work instructions
- Briefing on procedures
- Emergency plans
- On-call service
- Inspections and tests
- Requirements for lone working

**Personal protective measures**
- Gloves
- Work clothing
- Respiratory protection
- Safety shoes
- Safety glasses

Source: Biogas Safety first! Guidelines for the safe use of biogas technology; Fachverband Biogas e.V.
Fire prevention

Possible ignition sources on biogas plants

- Hot surfaces, flames and hot gases, mechanically caused sparks,
- Electricity
- ...

Ex-Zoning

Zone 0 or zone 20
An area in which a hazardous explosive atmosphere consisting of a mixture of air and combustible gases, vapours or mists is present continuously or for long periods or frequently.

Zone 1 or zone 21
An area in which a hazardous explosive atmosphere consisting of a mixture of air and combustible gases, vapours or mists is likely to occur occasionally in normal operation.

Zone 2 or zone 22
An area in which a hazardous explosive atmosphere consisting of a mixture of air and combustible gases, vapours or mists does not normally occur but, if it does, does so only rarely and for a short period.

Source: Biogas Safety first! Guidelines for the safe use of biogas technology; Fachverband Biogas e.V.
A biogas plant is a complex industrial building!

Experiences show:
- that the better the planning, the more successful a project can be.
- it is better to invest more in a reliable plant than buying a low cost technology with low performance parameters.

Most important is the reliable, stable and safe operation with low maintenance effort and low still stand time.

Every biogas plant should have a hazard assessment and an explosion protection document.

The operating staff and the plant owner need professional skills and knowledge for safety, they need to be trained regular.

⇒ Keep it safe and simple!
⇒ For more information see our safety guidelines

Available as a pdf in English, Spanish, French, Portuguese, Serbian, Indonesian and soon in Dutch! www.biogas-safety.com
Examples from Practise I

Unsafe Genset installation
Examples from Practise II

Danger of falling into the lagoon
Examples from Practise III

- Outflow regulated by hand. The worker stands in the outflow.
- Slippery standing position
- Several items to stumble
Examples from Practise IV

- Overgrown condaensate trap
Examples from Practise V

- Start up phase of a lagoon is very sensitive
- Membrane is partly swimming on water, partly filled with biogas
- During operation:
  - Questionable safety, especially during heavy weather conditions
  - Like storms rainy season etc
Examples from Practise VI

- Gas storage membrane is not technically fixed
Thank you for your attention!

For more information:
Fachverband Biogas e.V. (German Biogas Association)
Angerbrunnenstr. 12
85356 Freising - Germany

Tel: +49 8161 9846-60
Email: info@biogas.org
Web: www.biogas.org

Available as a pdf in English, Spanish, French, Portuguese, Serbian, Indonesian and in Dutch
www.biogas-safety.com