Start-Up of a Biogas Plant
Organization, Technology, Responsibility

Torsten Fischer, Christine Ahlborn and Dr Katharina Backes

Krieg & Fischer Ingenieure GmbH
Bertha-von-Suttner-Straße 9, D-37085 Göttingen, Germany
Tel.: ++49 551 900 363-0, Fax: ++49 551 900 363-29
Fischer@KriegFischer.de
www.KriegFischer.de

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Engineering Office, specialized in Design and Engineering of Biogas Plants

Foundation: 1999
Team: 20
Experience: > 25 Years
References: ca. 150 Biogas Plants in: Germany, Japan, Netherlands, Austria, Switzerland, Lithuania, Italy, Slovakia, Canada, USA, Spain, France, Ireland, Russia, India, China and Argentina

Partner in: Japan, Canada, Bulgaria, France, Poland, Italy, Spain, Serbia, Greece and China
Explosion in Biogasanlage

Broken pipe: digestate spilled. What a job!
Failure at biogas plants

- Fire / deflagration, explosion
- Damage by releases substances
- Personal injury

Source:
http://www.initiativen-mit-weitblick.de/16.html
Sugar industry
Dinteloord, The Netherlands

- Built: 2011
- Substrate: sugar beet ends, sugar beet leafs, sugar beet, vegetable waste 114,000 t/a
- Digester: 4 x 4,480 m³ steel tank
- Upgrading of 1,750 m³/h biogas to 990 m³/h methane
- Gas holder above secondary digester
- Treatment of digestate with decanter
Inland Empire, California, USA

- Built: 2006/2007
- Substrate: cattle manure (270 tons/year, DM 12%), liquid waste from food industry (83 tons/year) food waste
- Sediment removal from the digester
- Gas distribution in a biogas grid, expected gas production 18,813 m³ per day
- Expected power generation capacity: 1,500 kWₑ
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organizational aspects
legal aspects
biological aspects
documentation
Ordinance on Industrial Safety and Health – BetrSichV

Ordinance concerning the protection of safety and health in the provision of work equipment and its use at work, concerning safety when operating installations subject to monitoring and concerning the organization of industrial safety and health at work.

Betriebssicherheitsverordnung
- Ordinance on Industrial Safety and Health
- Hazard Assessment
Safety
Lower and Upper Explosive Limit

Explosion area:
Exceeding of 11.6 Vol% oxygen
and
between 4.4 Vol% methane (100% LEL) and
16.5 Vol% methane (100% UEL)

source: after Tabarasan / Rettenberger – UBA
Forschungsbericht 12/1982, Nr. 1030227 Teil 1
Agenda

• Basics start-up
• Definition of the phases of start-up
• Process of start-up
• Documentation – Who and When?
• Responsibilities during start-up procedure
Basics start-up

Status quo:

- There are no standards for start-up
  - no legal, technical or contractual requirements

- BetrSichV or technical directives contain no definition or standards of start-up operations

- Variety in terms requires definitions: Commissioning, putting into operation, initial operation, trial operation, start-up
Basics start-up

Definition of the terms:

➢ Normal operation
State in which the equipment or plants and other devices are used or operated within their design parameter (compare BetrSichV and TRBS 2152).

➢ Stationary operation
The biology of the biogas plant is established. There are no significant changes in the state of biological process parameters any more.

➢ Continuous operation
Substrates are supplied almost continuously. Biogas and digestate are continuously discharged.

➢ Start-up
Transfer of a biogas plant from production of the first molecule of methane in the fermenter, up to biogas production of 50% of the predicted gas amount with a methane content of 50%.
Basics start-up

Classification of Start-up:

<table>
<thead>
<tr>
<th>Preparing technical operational readiness incl. “cold start-up”</th>
<th>Start-up (Phases I-III)</th>
<th>Continuous operation</th>
<th>Shut-down</th>
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<tbody>
<tr>
<td>Unsteady operation</td>
<td>Stationary operation</td>
<td>Normal operation</td>
<td></td>
</tr>
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</table>
Basics start-up

To whom does the plant belong during start-up operation? (→ work safety)

- Construction by EPC-contractor
  → EPC is (probably) owner of the plant during start-up

- Planning by engineering office
  → future operator is owner of the plant
Basics start-up

Who has to prepare the hazard assessment regarding start-up and normal operation?

- The basis of the start-up of the biogas plant has to be the hazard assessment of the employer and the EPC-contractor.

### Start-up
- Employer of the employees of the plant
- EPC contractor as operator

### Continuous operation
- Employer of the employees of the plant
Basics start-up

Plant system:

Gas occupied space: A room filled with biogas in each individual tank (above the substrate surface)

Gas occupied space system: Totality of all gas spaces incl. all the connected between them gas lines.
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## Basics start-up

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- Normal operation
Definition of the phases of start-up

Dividing phases of start-up - Why?

- Long period of time
- Structuring of the process:
  - Clear definition of beginning, end, and transition from one phase to the other
- Concrete assignment of necessary documents and responsibilities during the single phases
- Probably limitations of safety relevant standards to single phases.
Definition of the phases of start-up

Phases of start-up:

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<th>Phase II</th>
<th>Phase III</th>
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| **Start-up begins with the first introduction of substrate** in the fermenter, which can produce methane. Phase I lasts until biogas with a methane content is produced, which allows the connection of a flare (from approximately 25%). | **In the gas-occupied space of the last tank of the considered gas occupied system, a gas production is done with a methane content of about 25% - 50%. The gas is burned using the flare.** | **In the gas-occupied space of the last tank of the gas-occupied space system, a gas production is done with a methane content of more than 50%.**  
**The gas is utilized in the CHP or the gas processing.** |

**End of Start-up:**
- 50% of expected gas amount
- CH₄ content above 50%
- Acceptance CHP/gas consumer took place
- Documentation received
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Process of start-up

Phase I
Section 1 of the start-up process:
Process of start-up

Phase I
Section 4 of the start-up process:

Start feeding

Heating

Biogas
Fermentation substrate
Fermenter

activated

open

Gas processing or flare

CHP

Fermentation residue
Secondary fermenter / digestate storage

open

activated
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Documentation needed for start-up

General requirements documentation

• At the beginning of start-up the documentation can not be complete
  ➢ Reasonable (Pre-) documentation

• Responsibility lies with:
  ➢ Client
  ➢ Employer
  ➢ Plant manufacturer / Planner
  ➢ Operator
Documentation needed for start-up

Documentation on **training and instruction of the operating staff**

*Plant manufacturer / Planner*

*Employer within the meaning of BetrSichV*
Documentation needed for start-up

Test report for cold start-up of each unit (incl. measuring and control technology), which is used within the scope of Phase I

Plant manufacturer/Planer
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Responsibility during start-up procedure

- Structured approach by clear allocation of responsibilities

- Determination of responsibilities i.a. in contracts and start-up concept
Responsibility during start-up procedure

Plant manufacturer / Planner

Has to determine the **amount of produced biogas** that is required to safely displace the oxygen in the fermenter.
Summary

- Start-up is complex
- No publications about start-up so far
- No definition of start-up (beginning, procedures, etc.) so far
- No properly documented start-up concepts
- No proper hazard assessments

Aim: number of accidents must be reduced in future.
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