Start-up of a Biogas Plant

Torsten Fischer and Dr Katharina Backes

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

London, Ontario
February 28, 2011
Engineering Office, specialized in Design and Engineering of Biogas Plants

Foundation: 1999

Team: 23

Experience: > 25 years

References: ca. 150 biogas plants in: Germany, Japan, Netherlands, Austria, Switzerland, Lithuania, Italy, Slovakia, Canada, USA, Spain, France, Ireland

Partner: Japan, Korea, USA, Canada, Bulgaria, France, Hungary, Turkey, Poland, Italy, Spain, Ireland, Serbia and Greece
Service offerings of Krieg & Fischer in the field of Biogas

- Studies
- Concept Development
- Calculations
- Permits & Approvals
- Engineering
- Tendering and Commissioning
- Construction
- Start-up
- Optimization/Retrofits
- Supervision and Consulting
References worldwide

- Prince Edward Island
- Cudworth Pork
- Inland Empire
- Tottori
- Prato
- Montargull
- Noyon
Kensington, Prince Edward Island, Canada

- Built: 2008
- Substrate: potato residues, oil, potato, starch
- Digester: 4 x 5,500 m³, steel tank
- Size: 12 MW\textsubscript{th}
- 2 stage digestion with hydrolysis, 2 secondary digesters with gas holder roof
- Biogas is used for heating purposes – hot water production
Start-up

All investment is done, but no income from selling energy has yet been generated

**Aim:** Full load in a preferably short period of time

Start-up too fast $\rightarrow$ digester acidification and collapse of biogas production

Start-up too slow $\rightarrow$ reduced income
German ordinance on Industrial Safety and Health (BetrSichV)

Aim of BetrSichV:
More individual responsibility and more flexibility in operation

Base: Ordinance for industrial safety, safety of equipment and products, supply of working materials

Safe handling of equipment and plants

Supply of working materials
Use of working materials
Plant requiring special safety monitoring system

Source: http://www.umweltschutz-bw.de/images/Recht/BetrSichV_3_Saeulen.gif
Start-up

• formal aspects
• insurance aspects
• organizational aspects
• functional aspects
Start-up: formal aspects

- Documentation of the biogas plant must be on site.
- The operator has to be instructed before.
- Who is the owner of the biogas plant during the period of start-up? And who performs the start-up? (EPC-contractor /general contractor or legal owner/engineering company)
- Who bears the risk? (Risk transfer planner EPC-contractor /general contractor or legal owner/engineering company to operator)
- Full commissioning by local authorities not yet possible.
- Obedience to the safety rules.
Start-up: formal aspects; safety rules

Safety Rules for Biogas Systems

Image of a biogas plant

German Agricultural Occupational Health and Safety Agency

This is a translation from the original German version entitled “Technische Information 4 Sicherheitsregeln für Biogasanlagen”. Every effort has been made to make it as accurate as possible, but the original German version should be the authoritative source.

Appendix 1

Operating Instructions for Initial Startup/Restart of a Biogas System

Sample

The initial startup of a biogas system is a special operating state, which requires special actions. The E1 zones, specified in the Explosion Protection Document, consider the operating state based on various conditions. Therefore, these particular hazards are considered separately in the operating instructions.

1. During the initial startup, a hazardous, potentially explosive atmosphere can occur in the gas space of the digester container, ignition sources (see, for example, Section 1.4.4) must be avoided (e.g., operate the agitator submerged).

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 no explosion hazard if the methane content of the gas is greater than 30% and the oxygen content is < 3%.

9. The CH4 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.
Start-up: formal aspects; safety rules

Appendix 1

Operating Instructions for initial Startup/Restart of a Biogas System

Sample

The initial start-up of a biogas system is a special operating state, which requires special actions. The EX-zones, specified in the Explosion Protection Act, must be considered when defining the operating state based on various parameters. Therefore, these particular hazards are considered separately when operating instructions.

1. During the initial startup, a hazardous, potentially explosive atmosphere can occur in the gas space of the digester container. Ignition sources (see, for example, Section 1.4.4) must be avoided (e.g., operate the agitator submerged).
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 substrates that are as active as possible, until all inlets and outlets (liquid valve closure disks) are sealed with substrates.
5. The fermentation substrates are 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) 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 no 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.

During the initial start-up, a hazardous, potentially explosive atmosphere can occur in the gas space of the digester...

The digesters are connected to the atmosphere via the operationally ready overpressure protector...

The gas generated during the starting of the digestion process discharges via the exhaust line (gas overpressure protection)...

All safety equipment must be checked for the proper function...
Start-up: insurance aspects

- Documentation of the biogas plant has to be on site
- The operator have to be instructed
- Lightning protection
  - there are no explicit directives
- Commissioning tests have to be passed
- Full commissioning by local authorities not yet possible
Start-up: organizational aspects

- Organization of inoculum as seeding material
- Heating of the digester
- Test of leak tightness of the tanks
- Safety device
  - Depending on building material (steel/concrete)
  - Depending on gas holder
- Desulphurization
Start-up: functional aspects

- The construction of the plant is finished.
- All tanks are leak tested, equipped with all instrumentation and are insulated.
- All piping and valves connected with the digesters are leak tested and tested for free flow.
- Motors for pumps and other driven equipment items are tested and functional.
Start-up: functional aspects

To be tested and positive in function:

- heating system
- substrate system (mixers, grinders, pumps, valves, pipe work…)
- gas system
- instrumentation system (pressure relief…)
- electrical system
- condensate trap
- emergency flare
Start-up: functional aspects

• A heating source is needed to heat the digester. (as CHP is not working yet)

• The inoculum should be adapted to the input substrate:
  1. Inoculum from a biogas plant using the same substrate
  2. Inoculum from another biogas plant
  3. Cattle manure (old manure is most suitable)
  4. Other manure
  5. Sewage sludge from a sewage plant
Start-up: functional aspects

The inoculum has to fulfil some criteria:

- **pH value** 7.5 – 8.0
- **IA/PA value** < 0.3
  (IA: intermediate alkalinity,
   PA: partial alkalinity)
- Low acetic acids < 1,000 mg/l
- Low heavy metals content
- No trash, no impurities
Stages of Start-up

1. Heating Primary digester
   - Water
   - Open

   Secondary digester
   - Water
   - Open

2. Heating Primary digester
   - Water
   - Open

   Secondary digester
   - Water
   - Open

   Gas quality measurement
   - Close
   - Open
Stages of Start-up

3. Filling to about 20 cm below operation fill
   - Water
   - Manure
   - Inoculum
   - Heating

   Primary digester

4.
   - Biogas
   - Inoculum
   - Manure
   - Water
   - Heating

   Secondary digester

   Gas quality measurement

   Open

   Close

   Activated

   Open
Stages of Start-up

5.

Heating

Primary digester

- Water
- Manure
- Inoculum
- Biogas

Secondary digester

- Water
- Biogas

6.

Heating

Primary digester

- Water
- Manure
- Inoculum
- Biogas

Secondary digester

- Water
- Biogas

Gas quality measurement

Blow off in case of bad quality (flare)
Stages of Start-up

7.

- Desulphurization with iron salt, no addition of oxygen
- Keep the volume of gas as small as possible to accelerate the production of biogas with good quality
- Temperature increase with 3-4 K per day
Stages of Start-up (flat digester)

1. **Primary Digester**
   - Water
   - Open

2. **Primary Digester**
   - Process-Temp.
   - Water
   - Open
   - Close

3. **Primary Digester**
   - Process-Temp.
   - Substrate
   - Inoculum
   - Water
   - Open
   - Close

4. **Primary Digester**
   - Process-Temp.
   - Digestate
   - Water
   - Open
   - Activated

---

**Krieg & Fischer Ingenieure GmbH**

**Speaker: Torsten Fischer**

**February 28, 2011**
Stages of Start-up (flat digester)

5. Process-Temp. activated
   CH4 O.K.
   Digestate
   Primary Digester

6a. Process-Temp. activated
   Digestate
   Primary Digester

6b. Process-Temp. activated
   CH4 O.K.
   Digestate
   Primary Digester

7. Process-Temp. activated
   CH4 O.K.
   Digestate
   Secondary Digester

feed

CH4 < 40%

Off-Gas

open

secondary

transfer

Water

Secondary Digester

Water
Damage during Start-up

The Start-up of a digester is a critical stage

- for an period of time an explosive methane / oxygen mixture exists.
- the operator is not yet experienced with his biogas plant
Start-up of a Biogas Plant

Torsten Fischer and Dr Katharina Backes

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

London, Ontario
February 28, 2011