LABORATORY FERMENTER
AWILAB DIGESTER
SERIES 01
PART C: OPERATING INSTRUCTIONS

Original Instruction Manual

(Version 00.00)

Contact and Imprint

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1 Preface

PLEASE READ THE INSTRUCTION MANUAL AND SAFETY INSTRUCTIONS CAREFULLY BEFORE INSTALLATION AND OPERATION!

This Instruction Manual provides you with information to assist you in using the AwiLAB Digester. The Instruction Manual is part of the product and has to be kept throughout the service life of the product. When subsequently passing on the system or components of it to a third party, the customer has to provide the Instruction Manual along with it. The new owner of the system has to be trained with regard to the respective regulations. If you receive an amendment to the Instruction Manual at a later stage, such amendment will also be part of the Instruction Manual.

The system may only be used in a technically perfect condition and for its intended use, with awareness of safety aspects and possible hazards and in full adherence with the Instruction Manual. Please operate and maintain the AwiLAB Digester based on the information in this Instruction Manual.

The instruction manual for the AwiLAB Digester consists of three parts:
Part A: Product Description, Installation and Operation
Part B: Operation
Part C: Operating instructions

2 Identification

This Instruction Manual is intended for the Series 01 AwiLAB Digester of Awite Bioenergie GmbH.

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3 Safety Instructions

The system is only designed for situations of intended use. A non-intended use can lead to personal injury and property damage. Only use the system as intended.

The system generates and measures flammable or explosive gas. There is a potential risk of spread or ignition of a hazardous atmosphere. Make sure to observe the rules regarding explosion protection as well as the respective safety instructions.

When disassembling the fermenter, the stirrer is exposed. A start-up can cause injury. Disassemble the fermenter only in the power-off state (main switch).

Contact with substrates and microorganisms may be harmful to your health. Please take appropriate precautionary measures for hazardous substrates and microorganisms.

Microorganisms can produce methane and hydrogen in the fermenter. A dangerous atmosphere may therefore form when starting up and emptying (Ex zone 1 IIA T1 for methane, Ex zone 1 IIC T1 for hydrogen).

The tamper is made of plastic. Fast moving plastic parts can lead to discharges with spark formation. Use tamper only when the minimum level is reached or there is no hazardous atmosphere in the fermenter.

When emptying, atmospheric oxygen can get into the fermenter and can thus form an explosive mixture in the presence of fuel gas. Without further measures, this condition can last for a longer time (resulting in Ex-Zone 1). Create a work instruction for emptying, with the following approximate procedure proposed for the emptying.

- De-energizing the system
- Removing the tamper
- Emptying the fermenter by opening the ball valve
- Closing the ball valve
- Filling with water
- Lifting out the stirrer

Parts in the interior of the subsystems are under electrical voltage. Danger to life by electric shock! ALL installation/repair/maintenance operations on the system must only be carried out in a de-energized state and when the system is completely turned off. Observe electrical safety regulations.

The integrated gas analysis system conveys combustible gas. A continuous stay in the immediate vicinity of the system may lead to a statistically increased risk of explosion. Therefore, no persons are allowed to stay permanently in the vicinity of the system.

To ensure the safe and correct operation of the system, regular maintenance work is an absolute necessity, as during this process wearing parts (such as seals) are replaced and the whole system is checked thoroughly. Failure to comply increases the risk of gas leakage (danger of explosion inside the analysis device cabinet). The maintenance interval must therefore be observed.

The discharge tap of the condensate traps can lead to a risk of gas-leakage. Therefore please make absolutely sure to close the discharge tap after emptying the condensate traps.

The system contains icons with the following meaning:

 Attention, General Hazard Point. Refer to the documentation. Disregarding this can lead to death or serious damages to persons or property.

 Warning of dangerous electrical voltage.

Please also refer to the safety instructions in Part A & Part B!

3.1 Explosion Protection and Zone Division

 DANGER
During operation of the fermenter, flammable gas may be generated which, in combination with atmospheric oxygen, may cause an explosion. Safe operation requires compliance with work procedures. Follow all instructions in this description.

Microorganisms can produce methane and hydrogen in the fermenter. When starting up and emptying, a dangerous atmosphere may form for a certain time (Ex zone 1 IIA T1 for methane, Ex zone 1 IIC T1 for hydrogen). When substrate is added, flammable gas may locally mix with atmospheric oxygen.

A zone classification with regard to explosion protection depends on the local conditions.

3.2 Release of potentially toxic and harmful gases

In biogas, hydrogen sulphide is the most dangerous toxic component.
The occupational exposure limit is 5 ppm. With a high gas production rate / leakage rate of 0.2 m^3 biogas per hour, a hydrogen sulphide concentration of 1,000 ppm and 1 space air change per hour, the limit volume of the room is 40 m^3.

With very high concentrations of hydrogen sulphide or a very small room volumes, there is, however, a risk of poisoning from leakage. This risk can be reduced by operating instructions (conduct in case of odour of hydrogen sulphide), high reliability of the leak-tightness, dilution after discharge (ventilation or large room volume) or by detection.

4 Notes

On the following pages you will find instructions for the start-up, operation and emptying of the fermenter as well as the most important subcomponents of the system. Some guidelines are given, such as TS content (TS = dry matter) in the fermenter, or stirrer settings, or attention during sampling.

Further important information and instructions for carrying out continuous fermentation experiments and calculations for operation are described in [Lit. 1].

4.1 Initial Setup of the Laboratory Fermenter at the Beginning of the Experiment

This chapter contains notes and information on the initial setup of the AwiLAB Digester at the start of the experiment as well as information on possible installations.

4.1.1 Laboratory Fermenter

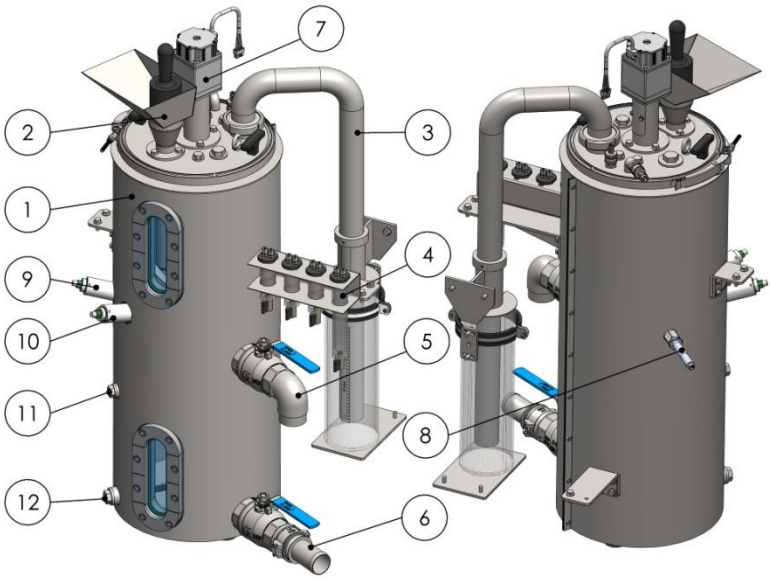

Illustration 1: Laboratory Fermenter AwiLAB Digester

In addition to the temperature sensorIllustration 1, item 8) there are several connections in the laboratory fermenter that can be used for optional installations (Illustration 1, items 9–12).

These have the following **connection sizes and maximum installation depths**:

- Item 8: G1/2“, 165 mm from sealing surface
- Item 9 & 10: G3/4“, 165 mm from sealing surface
- Item 11: G3/4“, 165 mm from sealing surface
- Item 12: G1“, 45 mm from sealing surface

4.1.2 Installations in the Cover

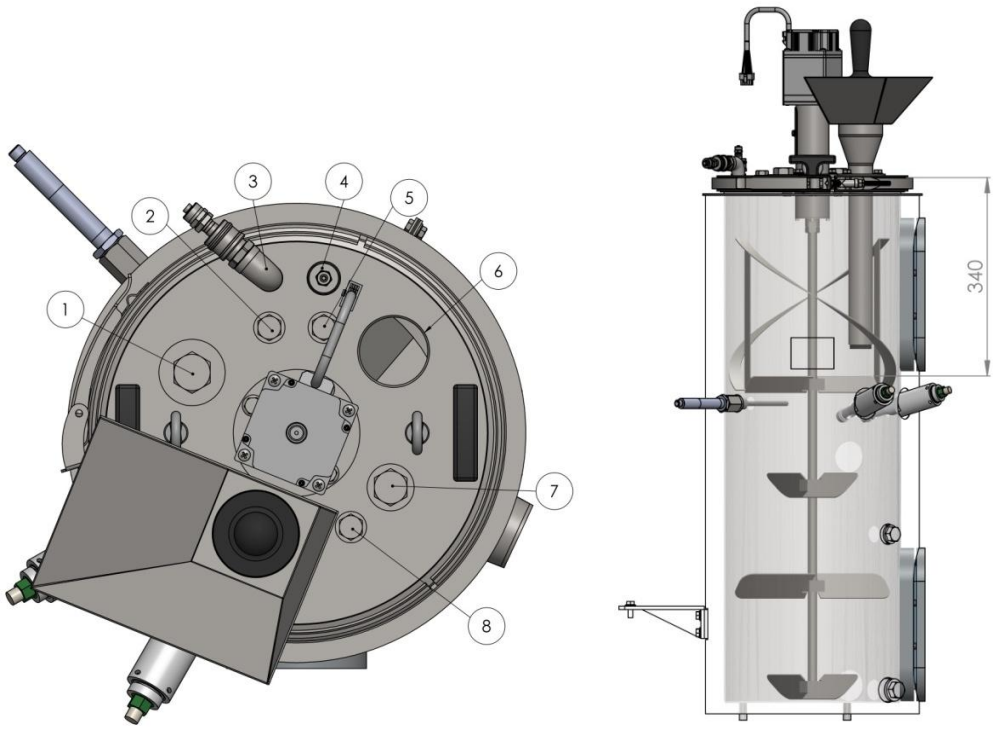

Illustration 2: Plan View Cover

There are several connections in the cover of the laboratory fermenter. In addition to the stirrer, the feeding input and the overpressure protection, there are also connections for optional installations. These have the following connection sizes:

- Item 1: G1 1/2“
- Item 2, 5 & 8: G 1/2"
- Item 7: G 1“

The **maximum installation depth of 330 mm** must be observed each time here.

4.1.3 Stirrer

The stirrer is equipped with a helix-like installation at the top, while paddles are mounted as a standard in the middle and lower sections. The paddles can be individually adjusted by the customer in their horizontal orientation. Other types or sizes of installation can optionally be realized upon request after technical inspection.

Illustration 3: Stirrer with standard installations

4.1.4 Filling of the Laboratory Fermenter

 WARNING
The filling of the fermenter must be carried out in the de-energized state!

WARNING
Microorganisms can produce methane and hydrogen in the fermenter. A dangerous atmosphere can therefore form when starting up and emptying (Ex zone 1 IIA T1 for methane, Ex zone 1 IIC T1 for hydrogen).

When filling the laboratory fermenter, make sure that all optional fittings in the laboratory fermenter are connected or closed, and that the sampling neck and the discharge neck are closed, so that no fermenter contents can escape.

It is recommended to fill approx. 2/3 of the desired filling volume without the cover directly into the fermenter. Then have two persons carefully insert the stirrer into the fermenter. Particular attention should be paid to the temperature probe, which protrudes into the fermenter, and possibly other lateral installations. Place the lid onto the fermenter with 2 persons and attach the chain with the spring safety hooks to the eyelets on the lid and hang it on the eyelet on the frame (cf. Illustration 4).

Illustration 4: Suspension of cover on the frame

Illustration 5: Suspension of cover incl. stirrer

Attach the stirrer shaft with the stirrer motor to the underside of the cover (s. Illustration 5). Using the handles on the cover, slowly lower the setup with 2 persons. Pay attention to the temperature probe and any other lateral installations!

Close the lid with the V-band clamp. The adjustment screw of the quick release is factory-set and must be readjusted as needed. Insert the securing pin of the V-band.

Allow the remaining inoculum to flow in slowly over the filling device until the desired target fill level (cf. Illustration 6; No. 1 on the upper sight glass) has been reached. After completing the filling process, insert the substrate tamper into the filling unit.

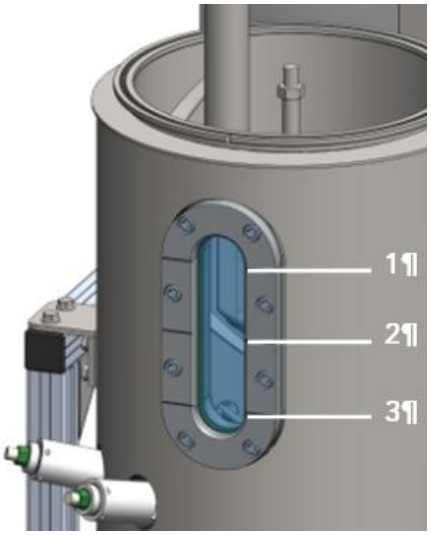

Illustration 6: Sight glass: Minimum filling quantity marking no. 3, target quantity marking no. 2, max. filling quantity marking no. 1

WARNING
The head space initially contains atmospheric oxygen. Fermentation processes can produce methane and hydrogen, which can form an explosive mixture. Inert the gas space before a dangerous atmosphere can arise. Create work instructions for the startup

 WARNING
Contact with substrates and microorganisms may be harmful to your health. Please take appropriate precautionary measures for hazardous substrates and microorganisms.

 WARNING
When assembling the fermenter, the stirrer is exposed. A start-up can cause injury. Assemble the fermenter only in a de-energized state (main switch).

 CAUTION
Cover and stirrer are heavy and unwieldy. Non-ergonomic lifting of loads is a health risk. Get help from a second person.

4.1.5 Connections

After filling the fermenter and closing the cover, tighten the milk pipe connection of the overpressure protection with the hook wrench (cf. Illustration 2, item 6). Connect the electrical connection of the motor stirrer to the control cabinet (see Illustration 7, item 1).

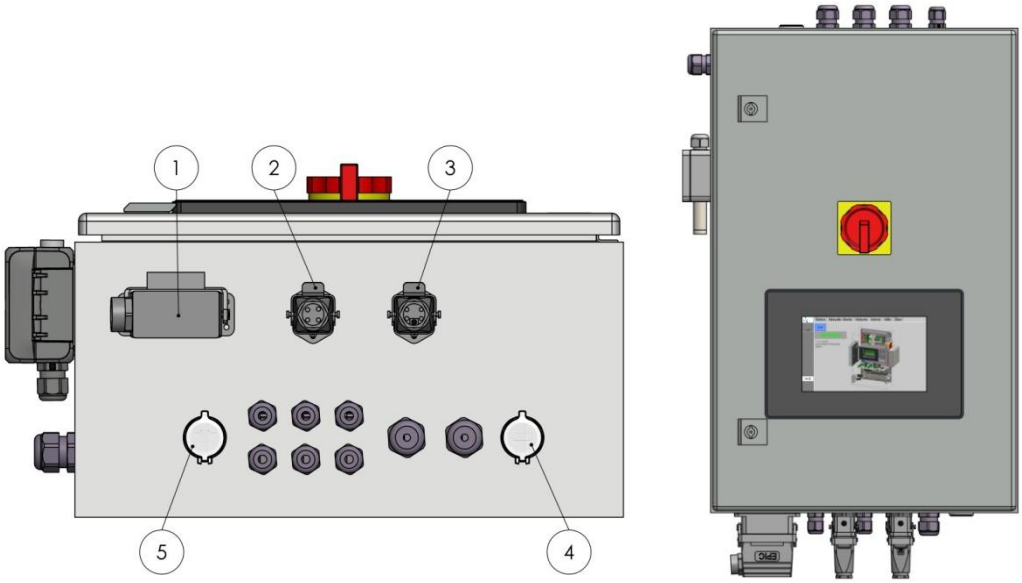

Illustration 7: Control Cabinet

Connect the gas analysis gas line of the gas volume measurement to item 3 and the condensate hose to item 4 (Illustration 8). Pay attention to the gas flow plan!

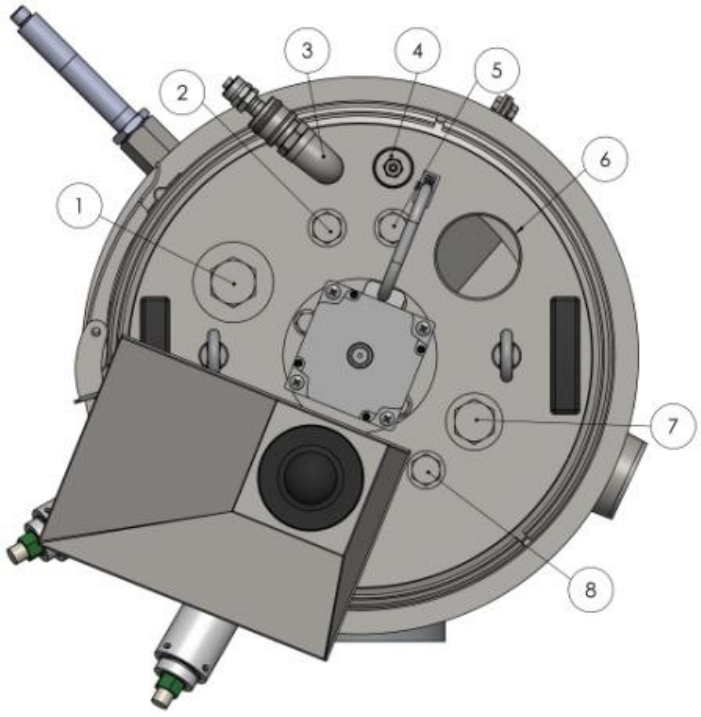

Illustration 8: Plan View Cover

4.1.6 Overpressure protection

It is recommended to set a pressure of approx. 20 mbar (scale up to a maximum of 30 mbar) in the water storage tank.


CAUTION

If the water level in the overpressure safety device is too high, a corresponding overpressure builds up in the fermenter and in the connected gas system. This may lead to a leak in the gas bags. If the water level is too low, gas escapes through the overpressure protection. As a result, occupational exposure limits may be exceeded and the functionality is disturbed. Pay attention to maintaining a water level corresponding to approx. 20 mbar according to the scale.


WARNING

The overpressure protection is designed in such a way that the rated pressure of 100 mbar of the gas system is not exceeded, even at maximum water level. A modification or closing of the pipe can lead to impermissible pressures of more than 100 mbar, which can lead to gas leakage and explosion in the connected systems. Do not modify the system.


WARNING

The permissible overpressure for the gas meter is 50 mbar. Exceeding this can lead to leakage and therefore a dangerous atmosphere. Fill the overpressure protection according to the marking so that this pressure is not reached.

4.1.7 Gas bags

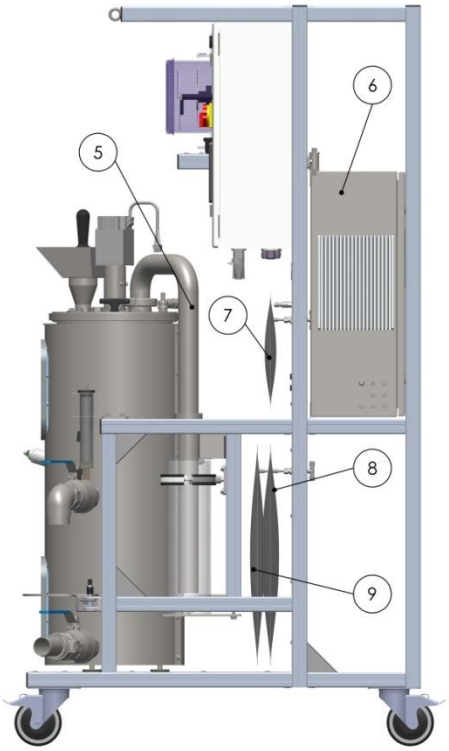

Illustration 9: Position gas bag

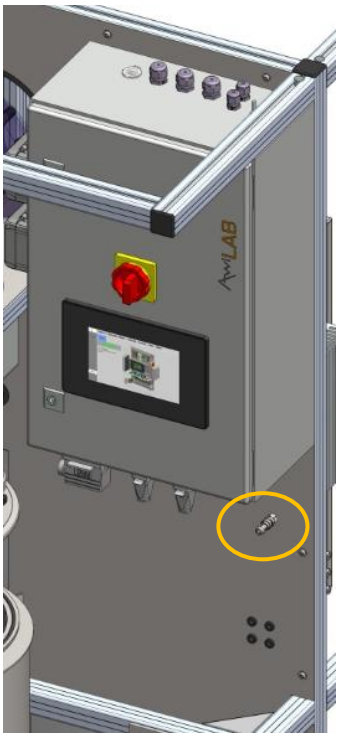

Illustration 10: Connection filling inert gas bag

Gas bag No. 7 serves as a pressure equalizing bag for e.g. sampling. This bag is empty at the start of the experiment. Gas bag No. 9 is a collection bag for the biogas to be produced. This bag too is empty at the beginning of the experiment. The gas bag No. 8 serves as an optional storage tank for an inert gas (recommended N_2) for inerting the container e.g. during the emptying process or during pressure equalization after the gas measurement. It should always be well filled. To fill the inert gas bag, connect it with the supplied coupling at the marked connection in Illustration 10. Connect the end of the hose to the inert gas cylinder (not included) and slowly open the gas cylinder until the bag is well-filled. After completing the filling process, close the gas bottle and remove the coupling. Optionally, the gas bag can also be filled with air by connecting the coupling piece with the loose end of the hose at the marked point. (Atmospheric) oxygen may interfere with the biological process, therefore an inert gas is advisable.

4.1.8 Gas Volume Measurement

For gas volume measurement, a drum gas meter is included in the standard delivery. With very small amounts of gas (1 ml/h to 1 l/h), a gas quantity detection via milligas counter is advisable. Please note that the respectively correct cable supplied by Awite is attached to the gas volume measurement. Cables not delivered by Awite can cause component failure.

Instructions for installing the drum gas meter (TGZ) can be found in the attachment

4.1.9 Pressure test

Before starting the experiment, it is advisable to carry out an automatic pressure test of the entire system (see instruction_b-awilab-digester-DE-01, chapter 3.1.2.4 "Miscellaneous").

4.2 Operation

4.2.1 Feeding

The daily feeding of the substrate takes place via the filling device or optionally via an additionally attached pump in the introduction port provided for this. The substrate is to be added slowly and continuously so that the amount of gas produced by the introduction can be correctly detected by the gas volume meters.
It is advisable to switch the stirrer to continuous operation during feeding, so that the substrate is evenly distributed during introduction and does not settle on top as a floating layer. In addition, stirring results in a better transfer of the temperature of the fermenter heater into the fermenter interior, thus preventing overheating of the microorganisms on the edge of the fermenter.
The feed amount depends on different parameters. Information on the calculation of the feed quantity can be found in **VDI 4630 Organic Matter Fermentation – Substrate Characterization, Sampling, Substance Data Collection, Fermentation Experiments** [Lit. 1].
Depending on the volumetric load, feeding is to be divided into 2 batches per day. It is advisable to always carry out the feeding at approximately the same time of the day.


WARNING

Contact with substrates and microorganisms may be harmful to your health. Please take appropriate precautionary measures for hazardous substrates and microorganisms.


WARNING

The tamper is made of plastic. Fast moving plastic parts can lead to discharges with spark formation. Use tamper only when the minimum level is reached or there is no hazardous atmosphere in the fermenter.

4.2.2 Stirrer

In order not to disturb the biological process due to high flow velocity, it is advisable to set a low stirrer speed. This is also dependent on the paddle installations and positions.

Shortly after feeding, a slightly higher stirrer speed may make sense for a short time in order to distribute the substrate evenly in the fermenter and not to cause any floating or sinking layers. You can also increase the speed of the stirrer for a short time or change its rotation direction in order to loosen clumps around the stirrer.

The motor power of the stirrer is limited; it is therefore advisable not to use higher dry matter contents (DM content) than approx. 12% in the fermenter. A continuous operation of the stirrer of 100% is not advisable, since the motor would thus run at its load limit over a longer period of time. Also, a pause interval is advisable (e.g., stirring for 15 minutes, pause for 5 minutes) so as not to overload the motor of the stirrer, thus ensuring a longer service life. In the stirrer settings, the DM content and the viscosity of the fermenter content must be observed.


WARNING

When disassembling the fermenter, the stirrer is exposed. A start-up can cause injury. Disassemble the fermenter only in the power-off state (main switch).

4.2.3 Gas bags

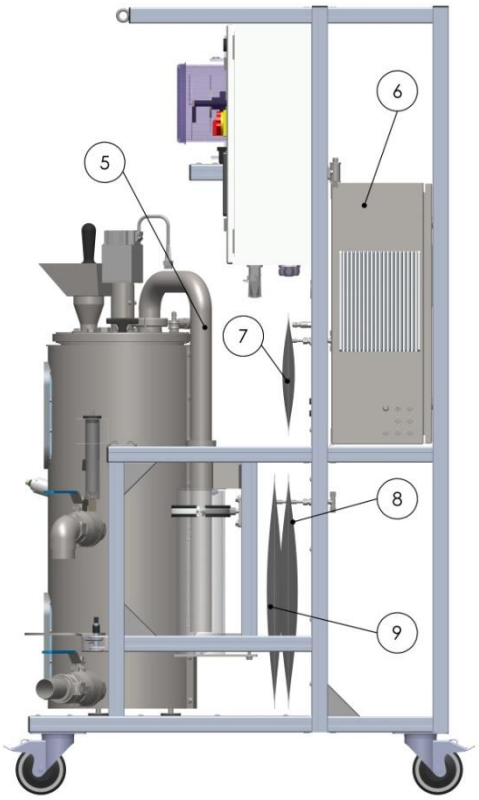

Illustration 11: Gas Bag Numbering

Gas bag No. 7 should be filled during operation. Should this not be the case, this is an indication of a leak in the system. The gas collection bag (No. 9) is cyclically filled and emptied repeatedly during operation (measurement of gas composition via the gas analysis system). The filling capacity of gas bag No. 8 is continuously reduced during operation and must be refilled when necessary (cf. Chapter 4.1.7).

4.2.4 Gas Volume Measurement

During the individual experiment phases, the gas volume of the produced gas is continuously measured. While feeding, the gas volume measurement will run much faster than during normal operation. In order to detect the amount of gas generated by the feeding, a slow and constant supply of the substrate is advisable.


WARNING

The mixing of biogas with atmospheric oxygen can lead to an explosive mixture. The effect depends on the volume. For this reason, a flame arrester is installed immediately before and after the gas meter to limit the dangerous volume. The arresters must not be removed because they limit the effect of an ignition. Nor should the gas meter be replaced by a larger one without reassessing the risk.

4.2.5 Sampling

Sampling usually takes place via the sampling neck. Place the appropriate sample container on the plate underneath the sampling neck and slowly open the manual tap of the sampling neck, as higher pressures can form due to the further outgasing substrate. Typically, the first batch of sampling is returned to the fermenter, and the second batch of the sample is used for analysis, for retention samples or the like.

4.3 Emptying of the Fermenter


WARNING

Always drain the fermenter in de-energized mode!

In order to empty the fermenter, an emptying neck is provided, to which a 2" outlet hose (not included in delivery) can be attached to dispose of the contents of the fermenter accordingly.


WARNING

Microorganisms can produce methane and hydrogen in the fermenter. A dangerous atmosphere can therefore form when starting up and emptying (Ex zone 1 IIA T1 for methane, Ex zone 1 IIC T1 for hydrogen).

WARNING

When emptying, atmospheric oxygen can get into the fermenter and can thus form an explosive mixture in the presence of fuel gas. Without further measures, this condition can last for a longer time (resulting in Ex-Zone 1). Create a work instruction for emptying, with the following procedure proposed for the emptying.

Procedure proposed for the emptying:

- De-energizing the system
- Removing the tamper
- Opening the overpressure protection
- Emptying the fermenter by opening the ball valve
- Closing the ball valve
- Fill with water to displace gas and avoid sparking
- As needed, let it soak overnight
- Before emptying the water, first remove the stirrer (see chapter 5.2)

5 Cleaning

The following description of the cleaning requires that the fermenter was first drained according to instructions (see chap. 4.3).

5.1 Fermenter

 WARNING
Always clean the fermenter in de-energized mode.

The fermenter may only be cleaned with acid-free cleaning agents. Rinsing the fermenter with water is not a problem. Gas-carrying lines must be free of dirt. After completion of the experiment, the fermenter including all built-in components must be thoroughly cleaned.

In case of heavy soiling, it is recommended to increase the temperature (about 45°C – 50°C) after emptying the fermenter and filling it with water, and to let the stirrer and other built-in components soak overnight in the water. After that, remove the cover and clean all components thoroughly.

5.2 Stirrer

The fermenter was previously emptied according to instructions in chapter 4.3 and refilled with water.

The stirrer and the cover are locked together. To loosen the stirrer, loosen it from the cover by turning.

Proposed procedure for removing the stirrer:

- Attach the chain to the eyelets on the cover as well as the eyelet in the frame (cf. Illustration 5)
- Lift the cover slowly (2 persons!)
- Separate the stirrer shaft from the engine (cf. Illustration 4)
- Lift and lower the cover (2 persons!)
- Lifting out the stirrer (2 persons!)
- Emptying the fermenter by opening the ball valve

Thoroughly clean the stirrer with water and a brush.


CAUTION

Cover and stirrer are heavy and unwieldy. Non-ergonomic lifting of loads is a health risk. Get help from a second person.

5.3 Gas Volume Measurement

Instructions for cleaning the drum gas meter can be found in the system.

5.4 Overpressure protection

To clean the overpressure protection, unscrew it on the milk pipe thread and turn the pipe to the side. Remove the pipe from the bracket and remove it from the water tank, rinse with water and, if necessary, clean with a brush. Then remove the water storage tank and thoroughly clean it as well.

5.5 Gas Analysis System, Switch Cabinet, Control Cabinet

The casing of the control cabinet and the gas analysis system may only be cleaned with acid-free cleaning agents. The display screen may only be cleaned with suitable cleaning agents and cleaning cloths. Only expert personnel is allowed to clean the inside of the gas analysis casing and the gas-bearing lines and components so that the operational safety is not jeopardized.

6 Inspections and maintenance

 WARNING
Wear of parts can lead to leakage and malfunction. This may even cause an explosion. Wear parts must be replaced regularly. Check the device regularly and have the recommended maintenance performed regularly.

To ensure a smooth running of the experiment, it is advisable to carry out the following work **daily**:

- Examination of the analysis gas line → no fermenter contents or liquid present (exception: hoses to the condensate separator "AwiKon" or hose to the gas cooler within the gas analysis, and condensate outlet line from the gas cooler; see gas flow chart)
- Overpressure protection → no fermenter content present (otherwise there could be a blockage of the analysis gas line → check and correct the problem)
- Gas collection bag (Illustration 11, No. 9) → not filled too much
- Pressure compensation bag (Illustration 11, No. 7) → filled (exception: after sampling)
- Deviation of actual fermenter temperature to fermenter setpoint temperature: max +/- 2°C
- Stirrer motor rotates (if not in stirring break → check the stirring interval as necessary)
- After feeding: Substrate tamper in feeding opening
- No error messages on the panel
- Daily biogas production [l/d] similar to previous day (with the same amount of feed and substrate)
- Analysis of the produced biogas → concentrations approximately equal, time intervals between measurements approximately equal
- Gas composition without abnormalities

The following work must be carried out **weekly**:

- Level check and, if necessary, adjustment of the fermenter volume (same level each week)

The following work must be carried out **monthly**:

- Overpressure protection: Check the level of the water and, if necessary, adjust to the defined values
- Cleaning and calibration of various probes (if present)

The following work must be carried out **on a yearly basis**:

- Cleaning gas flow meter
- Service, maintenance of gas analyzer (**by third party**) and complete system

The following work must be carried out **as necessary**:

- Emptying of condensate trap
- Level of barrier fluid (water) check the drum gas meter and adjust if necessary

 CAUTION

An opened condensate trap leads to leakage of gas. As a result, occupational exposure limits can be exceeded. Close the discharge tap after emptying the condensate traps.

6.1 Maintenance

For the safety of the entire system, regular maintenance work is an absolute necessity, as during this process wearing parts (such as seals) are replaced and the whole system is checked thoroughly. In order to maintain the warranty, a first maintenance and calibration service is required within the first 6 months, thereafter every 12 months at the latest as a rule. Depending on requirements, it might also be necessary to service the system every 6 months or less. Maintenance work may only be carried out by qualified personnel and the maintenance intervals must be adhered to. The state of the system must be checked on a regular basis, error messages need to be addressed.


WARNING

Wear of parts can lead to leakage and malfunction. This may even cause an explosion. Wear parts must be replaced regularly. Check the device regularly and have the recommended maintenance performed regularly.

6.1.1 Replacing a Fuse Gas Analysis System


WARNING

Electrical voltage is present at the fuse slots. Danger due to electric shock! Prior to replacing fuses, you must turn off the main switch and thereby disconnect the gas analysis system from the main power supply.

The fuses are located in the fuse terminals F1 (230 V) and F2 (24 VDC).

6.1.1.1 Specification Fuse F1 (Input Voltage 230 VAC)

Standard: IEC/EN 60127 - 2/2
Type: 5x20 mm
Designation: F 10A L 250VAC

6.1.1.2 Specification Fuse F2 (Power Supply Unit Output Voltage 24 VDC)

Standard: IEC/EN 60127 - 2/2
Type: 5x20 mm
Designation: F 5A L 250VAC

6.1.2 Replacing a Fuse, Control Cabinet

The control cabinet contains circuit breakers and fuse terminals.


WARNING

Electrical voltage is present at the fuse slots. Danger due to electric shock! Prior to replacing fuses, you must turn off the main switch and thereby disconnect the gas analysis system from the main power supply.

6.1.2.1 Circuit breakers

The circuit breakers can be reinserted after triggering and troubleshooting. In the event of permanent malfunction, these must be replaced in accordance with electrical regulations.

6.1.2.2 Specification Fuse F10 (Power Supply Unit Output Voltage 24 VDC)

Standard: IEC/EN 60127 - 2/2
Type: 5x20 mm
Designation: T 10A L 250VAC

6.1.2.3 Specification Fuse F21 (PLC Backup Fuse 24 VDC)

Standard: IEC/EN 60127 - 2/2
Type: 5x20 mm
Designation: T 5A L 250VAC

6.1.2.4 Specification Fuse F22 (Motor Logic Backup Fuse 24 VDC)

Standard: IEC/EN 60127 - 2/2
Type: 5x20 mm
Designation: T 5A L 250VAC

6.1.2.5 Specification Fuse F23 (Motor Logic Backup Fuse 24 VDC)

Standard: IEC/EN 60127 - 2/2
Type: 5x20 mm
Designation: T 1A L 250VAC

6.1 Technical Data

For technical data, please refer to the provided data sheets.

6.2 Disposal

For a fee, Awite is prepared to take back any Awite devices that need to disposed of and salvage them.

7 Bibliography

Lit. 1: VDI-RICHTLINIEN, Vergärung organischer Stoffe – Substratcharakterisierung, Probenahme, Stoffdatenerhebung, Gärversuche, November 2016, ICS 13.030.30, 27.190

8 Document and Change History

Date	Change	New Dates and Versions	Editor
2018-05-08	Initial document created	00-00	Breier/Murnleitner