LABORATORY FERMENTER AWILAB DIGESTER SERIES 01 PART A: PRODUCT DESCRIPTION AND INSTALLATION

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. The type plate on the right hand side panel of the device indicates the device type, the required voltage supply and the rated output.

The manufacturer's address is:

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The Declaration of Conformity with the used product standards is included in the appendix (chapter 8.1).

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.

Depending on the size of the surrounding room, leakage of even small amounts of biogas can create an explosive or harmful atmosphere. Do not place in small, very airtight rooms.

During normal operation, gas is generated in the fermenter as well as exhaust gas from the analyzer. Channel gas out of the installation room.

Biogas contributes to the greenhouse effect and thus to climate change. If possible, do not discharge gas into the atmosphere.

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).

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 when 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 procedure proposed for emptying:

- De-energize the system
- Remove the tamper
- Empty the fermenter by opening the ball valve
- Close the ball valve
- Fill with water
- Lift out the stirrer

The rated overpressure of the gas analysis system is 100 mbar. The pressure of calibration gas is higher. The occasionally existing precision pressure regulator can fail (snagged membrane). A higher pressure may cause damage and leaks, whereby an explosive atmosphere could arise. Ensure that no more than 100 mbar of pressure is reached. Set a pressure regulator before the precision pressure regulator to max. 100 mbar.

The leakage of calibration gas may lead to hazards (poisoning, explosion, fire). Set up the entire calibration gas system (calibration gas cylinders, connection lines, fittings, and process analysis device) in a sufficiently large or ventilated room. A leakage test of the calibration gas system is necessary before initial operation.

Parts in the interior of the subsystems are at dangerous 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.

Biogas contains hydrogen sulphide. Gas leakage can lead to acute inhalation toxicity. At hydrogen sulphide concentrations of more than 22,000 ppm or space volumes of less than the standard container size (32 m^3) or lower air exchange rates than once per hour, the risk of a possibly even fatal hydrogen sulphide poisoning due to gas leakage has to be assessed on an individual basis and appropriate measures have to be taken. Avoid small volumes of space and low air exchange rates.

An improperly performed installation, electric installation, initial operation or maintenance of the overall system may cause hazards, especially due to gas and electrical current. These activities must therefore only be performed by trained specialist personnel. The specialist personnel must have read and understood the Instruction Manual and follow its instructions.

The main switch serves as a mains disconnection facility to shut down the function and avoid hazards caused by electric current. The system has to be installed in such a way that the main switch operation is not impeded.

In case of a defect, gas leakage can occur. In case of insufficient ventilation, even small amounts can lead to a hazard (poisoning, explosion) over a longer period of time. The natural air exchange may be too low in small, airtight rooms. Ensure adequate ventilation (taking into account the ratio of gas production and volume).

Different electrical voltages may be present at the terminals of the control cabinets. An incorrect connection will lead to malfunction and hazards arising from electrical current. For information on the allocation of the different terminals and the wiring in the cabinet, please refer to the electric diagrams provided as part of the system.

Combustible gas could enter back into the gas analysis system through the exhaust gas line and create an explosive atmosphere there. Therefore, only introduce the exhaust gas into gas-bearing areas with a maximum overpressure or underpressure of 20 mbar.

Gas which may be toxic, flammable or explosive flows through the exhaust pipe. Therefore, the exhaust gas must not be released inside the building unless an there is appropriately sufficient ventilation.

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 by gas leakage (danger of explosion inside the analyzer cabinet). The maintenance interval must therefore be observed.

The state of the integrated gas analysis system must be checked on a regular basis, error messages need to be addressed. In the event of gas leakage, the error messages "potentially dangerous atmosphere" or "risk of explosion" as well as in the case of loose hose ends, porous hoses or other leaks that lead to an explosion hazard, the device must be shut down. Contact Awite or an Awite contract partner.

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 fuses that are under electrical voltage. Danger to life by electric shock. Replace the fuses only in a non-energized state. Observe electrical safety regulations.

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 B & Part C!

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.

3.1.1 Overall System (Fermenter and Surroundings)

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.

In the risk assessment, the following residual hazards were identified which can be controlled by organizational measures. A zone classification with regard to explosion protection depends on the local conditions. The following proposal cannot therefore replace an individual risk assessment.

Potential Hazard	Notes and Measures
Creation of a Hazardous Atmosphere during start-up. Ignition by sensors.	If flammable gas (methane, hydrogen) forms before the residual oxygen is consumed, an explosive atmosphere arises that could be ignited by defective sensors not covered by liquids. Therefore, initially displace the oxygen by inertization (e.g., with nitrogen or carbon dioxide).
Spark formation in the area of the tamper	The tamping process could possibly cause sparking. Therefore, operate the tamper only when the funnel is immersed in the liquid, thereby preventing a hazardous volume.
Drawing in air during sampling	When removing liquid, air can flow back through the gas meter (counter runs backwards). From 13% (v/v) oxygen (Limiting Oxygen Concentration, LOC) for methane and 5% (v/v) for hydrogen, flammable atmospheres can arise. Do not take more sample than can be balanced by the gas compensation bag.
Creation of a Hazardous Atmosphere during emptying	When emptying, air is sucked into the fermenter. This can create a dangerous atmosphere. Prevent ignition by de-energizing and filling with water (see below)

No danger through a hazardous atmosphere outside of the fermenter was identified, with the following assumptions:

Zone, System Part	Assumption, Reason
No zone outside the fermenter	Air exchange rate of the installation room 25 times higher than the gas formation rate in the fermenter, which flows unhindered in case of leakage (for example 0.2 m³/h biogas, 1 air change per hour => room volume limit 2.5 m³). By opening / adding substrate with a filled fermenter, less than 10 liters of gas is released, as the filler neck is immersed in liquid.

3.1.2 Gas Analysis Subsystem

Applies only within the EU and in countries in which the ATEX Directive (2014/34/EU) also applies. The ATEX marking is located on the left outside of the casing.

Marking per ATEX with

 II 2/- G IIA

Gas-carrying pipes with inflammable or explosive gas of explosion group IIA (biogas) may be connected to the device at the appropriate point (zone 2 or 1 in the interior of the line). The device or the system itself has to be installed outside of a hazardous atmosphere.
Note: If the fermenter interior is classified as an ex-zone, if hydrogen contents of more than 4% (v/v) can occur in the biogas and if at the same time the hydrogen content in the fuel gas is more than 10%, then the potentially explosive gas mixture cannot be considered as gas of ignition group II A any more. In this case, appropriate flame arresters would have to be installed between the fermenter gas room and potential ignition sources (gas analyzer).

For the gas analysis part, a comprehensive risk assessment was conducted. In the present constellation, safety is even higher, since in the case of leaks, less gas can escape than it would with large systems.

3.1.3 Flame or explosion propagation over gas bearing lines

With gases belonging to explosion group IIA (methane, biogas), tube and pipe connections with an internal diameter of 4 mm have the same effect as a deflagration arrester (tested length of 11 cm). As the distance from the hose to the relevant ignition sources (sensors) is always less than 50 times the hose diameter, there is no need for separate deflagration arresters between the analysis device and gas-bearing lines with larger cross-section and hazardous atmosphere with the explosion group IIA and up to zone 1. There is an inspection report of an approved ATEX test centre verifying this.

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 room air change per hour, the limit volume of the room is 40 m^3.

With very high concentrations of hydrogen sulphide or very small room volumes, there is, however, a risk of poisoning from leakage. This risk can be reduced by operating instructions (how to behave 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 Product Description

The following chapter contains information on the intended usage, the ambient conditions during operation and storage as well as safety information.

4.1 Intended Usage

 WARNING
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 laboratory fermenter system basically consists of a fermenter, gas meter, control cabinet, valve box, and gas analysis system. These components are mounted on a module rack.

The system is designed for biogas fermentations in the typical temperature range of 5°C to 90°C and an ambient pressure with slight underpressure or overpressure (100 mbar). It is not intended to have the system sanitized by heat sterilization (>90°C).

The process analysis systems serve as analytical device for air, biogas, sewage gas, biomethane as well as optionally hydrogen up to 100 vol% and hydrogen sulphide up to 5 vol%. They are neither part of explosion protection nor a warning device. They are used without any additional pressure reducing measures for measuring biogas with a maximum of 20 mbar of overpressure or underpressure.

In the case of more than 20% hydrogen in the fuel gas proportion, ignition group IIA is left, therefore additional flame arresters must then be installed, since the 4 mm hose used only acts as a flame arrester for ignition group IIA.

The suitability for use in safety-critical applications must be assessed by the user for each case. Reliability data may be provided by Awite if required.

4.2 System Components

The system consists of the following components:

- Test fermenter (cf. 4.2.1)
- Gas analysis system (cf. 4.2.2)
- Control cabinet (cf. 4.2.3)
- Control cabinet gas collection (cf. 4.2.4)
- Gas meter (cf. 4.2.5)
- Overpressure protection (cf. 4.2.6)
- Condensate traps (cf. 4.2.7)
- Other components (cf. 4.2.8)

These components are mounted on a module rack. The dimensions of the system are shown in Table 1. There must be enough space in front of the system to operate the system.

Table 1: Dimensions Overall System

Overall system	Height [mm]	Width [mm]	Depth [mm]
with rollers / feet	1955	700	1172

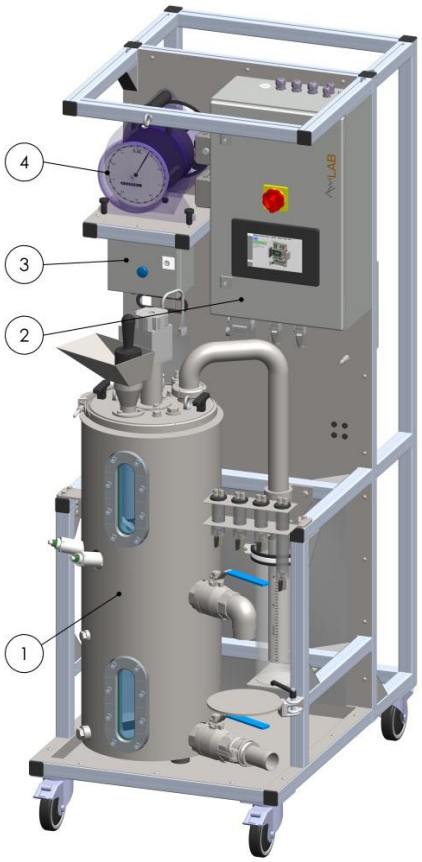


Illustration 1: Front view AwiLAB Digester

1. Fermenter
2. Control cabinet incl. display
3. Control cabinet gas collection
4. Gas meter

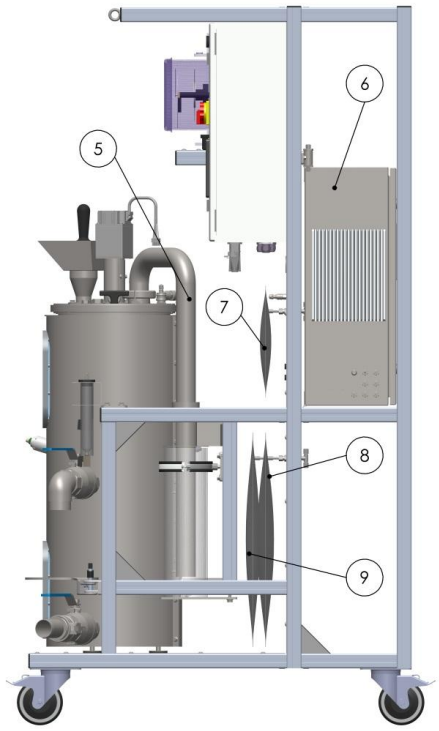


Illustration 2: Side view AwiLAB Digester

5. Overpressure protection
6. Gas Analysis System
7. Gas compensation bag
8. Inert gas bag
9. Gas storage bag analysis gas

4.2.1 Test fermenter

Note: *Further information on parameters, connection sizes or optional installations can be found in* ***Part C - Operating instructions*** *of the Instruction Manual.*

The AwiLAB Digester along with the most important installations is shown in Illustration 3. The basic configuration includes components 1–8, optional installations possible (e.g. items 9–12).

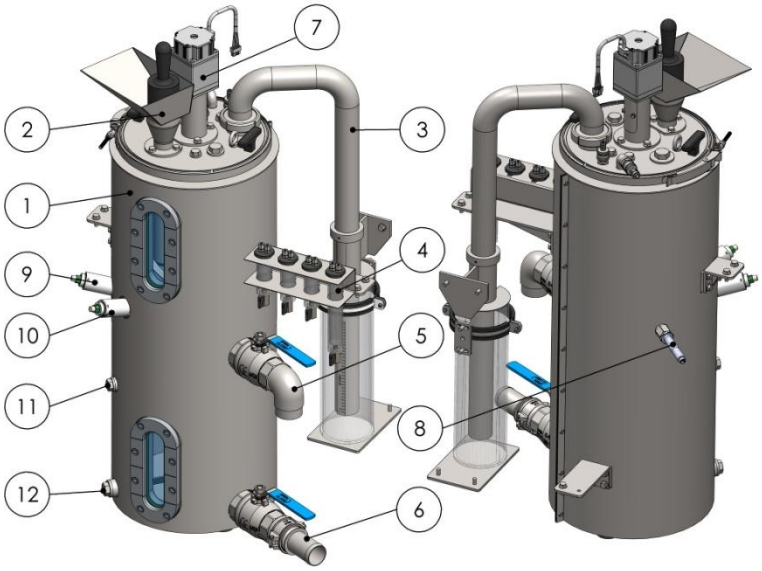


Illustration 3: Basic Configuration Fermenter with Optional Components

1. Fermenter
2. Filling unit
3. Overpressure protection
4. Condensate traps
5. Sampling neck
6. Discharge neck
7. Motor with stirrer
8. Temperature sensor
9. Optional probes
10. Optional probes
11. Optional connections
12. Optional connections

optional further installations possible

The fermenter has a capacity of approx. 60 l. The normal filling quantity is 50 l. The sight glasses are used to detect sinking and/or floating layers. The lid is connected to the fermenter via a quick release device. The fermenter is fully insulated and can be heated via a self-limiting electrically operated heating cable. To protect the insulation, a coating of stainless steel sheet is mounted.

4.2.1.1 Standard Installations Fermenter

The substrate is introduced directly into the fermentation liquid via the filling unit (Illustration 3, item 2). The introduction takes place below the fill level and thus prevents floating layers. An optimal mixing is ensured. The introduction is completed in a gastight manner by means of the filler neck.

The temperature sensor (Illustration 3, item 8) measures the temperature inside the fermenter and controls and regulates the fermenter temperature.

For sampling, a 2" sampling neck (Illustration 3, item 5) is available at medium fermenter height. Cleaning or emptying of the fermenter is carried out via a 2" emptying neckIllustration 3, item 6) at the bottom of the fermenter. At the discharge neck, an outlet hose (not included) can be attached via the dairy coupling. The size of the nozzles prevents clogging during sampling and emptying.

4.2.1.2 Standard Installations Cover

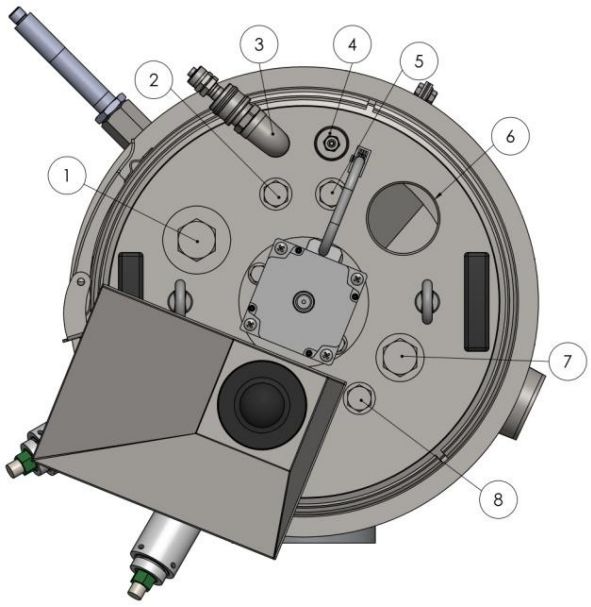


Illustration 4: Plan View Cover

1. Not allocated
2. Not allocated
3. Connection gas meter / gas storage bag
4. Connection condensate trap fermenter (pressure compensation bag)
5. Not allocated
6. Connection overpressure protection
7. Not allocated
8. Not allocated

By default, the motor is equipped with a stirrer (Illustration 3, item 7), as well as the filling unit (Illustration 3, item 2) for the substrate, an overpressure protection device (Illustration 3, item 3) and a connection for gas amount measurement (Illustration 4, item 3). There are several optional devices for further sensors etc. The connection sizes and maximum installation depths are described in **Part C - Operating instructions**.

The stirrer is speed-controlled and can be operated in clockwise or counter-clockwise rotation. Recording the power consumption is possible. To prevent floating and sinking layers, blades are attached on the stirrer. The stirrer can be separated from the fermenter cover via a special coupling.

4.2.1.3 Optional Installations

Optionally, various components in the cover and / or fermenter can be added by the customer or realized by Awite upon request.

4.2.2 Gas Analysis System

4.2.2.1 Dimension and Installation

The gas analysis system is located inside a stainless-steel wall cabinet and is attached to the back of the frame.

Table 2: Dimensions Gas Analysis System

Device type	Height [mm]	Width [mm]	Depth [mm]
AwiFLEX	700	564	268

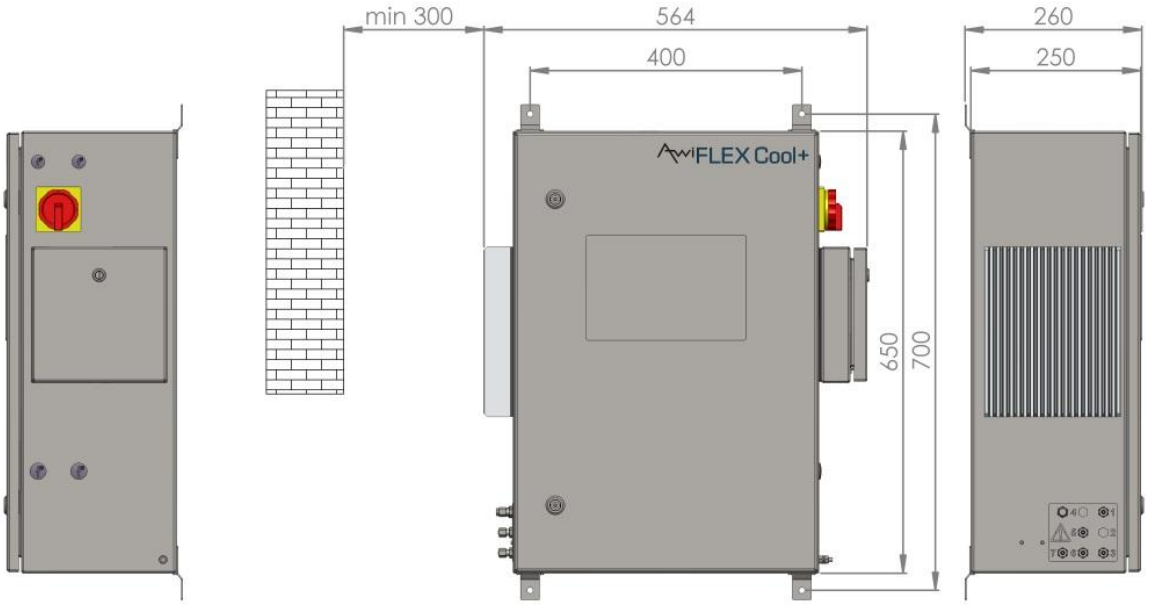


Illustration 5: Awite GAS Analysis System for AwiLAB Digester

4.2.2.2 Parts/components

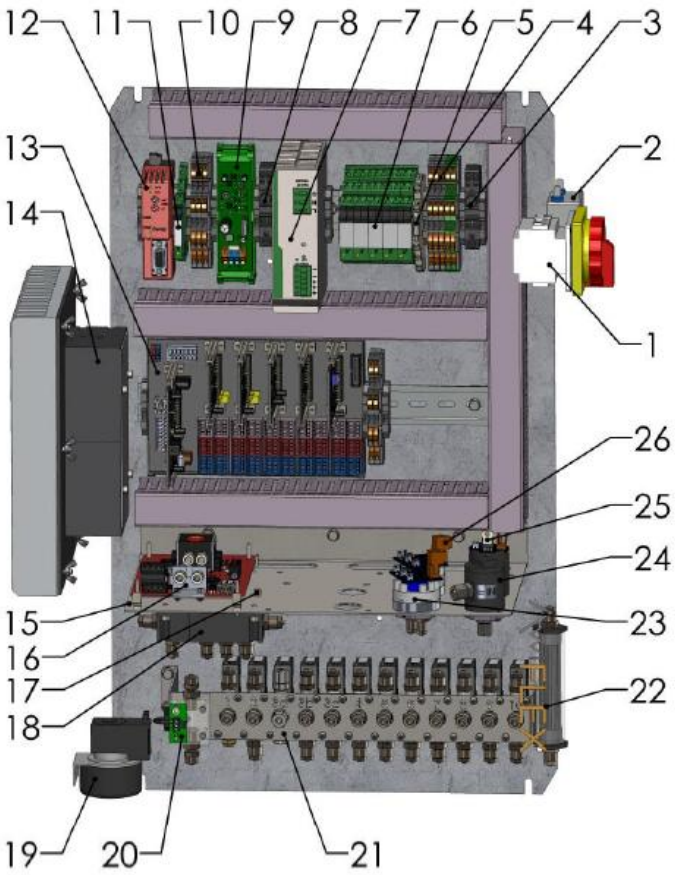


Illustration 6: (optional) components in the gas analysis system (depending on configuration).

1: Main switch
2: Line filter
3: Fuse terminal 100–240 VAC
4: Terminals 100–240 VAC
5: Relay feedback motor protection
6: Relay AwiDESULF
7: Power supply unit
8: Fuse terminal 24 VDC
9: AwiProtect
10: Terminals 24 VDC
11: Relay group error
12: Profibus module
13: AwiCore (PLC module)
14: Measuring gas cooler AwiCool
15: Mounting brackets sensors
16: Multi-gas sensor InfraFRED
17: Temperature sensor
18: AwiConnect incl. pressure sensor
19: Membrane pump
20: Water sensor AwiH2O
21: Valves
22: Hydrogen sulphide filter
23: Hydrogen sensor
24: Filter AwiClean
25: Oxygen sensor
26: Hydrogen sulphide sensor

The equipment shown here serves as an example, as the components are individually assembled according to customer requirements.
The gas analysis system is used for the discontinuous measurement of methane (CH_4), carbon dioxide (CO_2), oxygen (O_2), hydrogen sulphide (H_2S) and hydrogen (H_2). Hydrogen sulphide can be measured up to 5,000 ppm, hydrogen up to 2,000 ppm.

4.2.2.2.1. Main Switch Mains Disconnection Facility

The main switch functions as mains disconnection facility.

4.2.2.2.2. Terminal boxes for electrical connections

 DANGER
Dangerous electrical voltage is partly present at the terminals in the terminal box and the cables leading there. An incorrect connection may lead to electrical hazards and even death. For information on the allocation of the different terminals and the wiring in the terminal box, please refer to the electric diagram provided as part of the system. Check the connections afterwards.

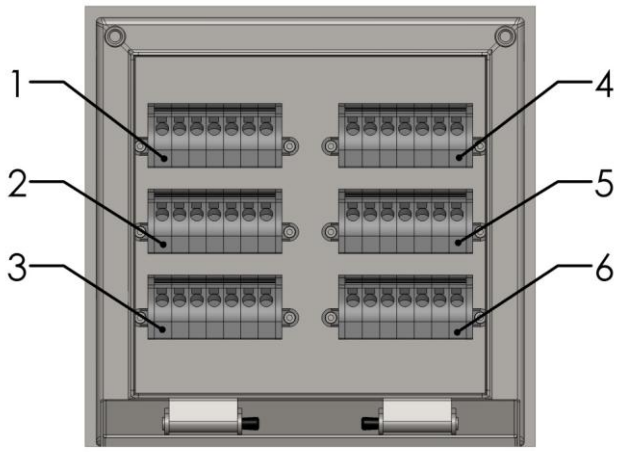
The Awite gas analysis system includes a terminal box for external connection.

The terminal box offers connections for the following components:

- Power supply 100–240 VAC
- Cable externally

CAUTION
Insufficiently dimensioned cables can lead to fire and electrical hazards. Use only cables as specified.

4.2.2.2.3. Terminal Box AwiFLEX



1: Conductor connection X11	**4:** Conductor connection X14
2: Conductor connection X12	**5:** Conductor connection X15
3: Conductor connection X13	**6:** Conductor connection X16

Illustration 7: Terminal box Gas Analysis System AwiFLEX.

The terminal box illustrated here serves as an example only, as the number of feed-through terminals depends on the respective system setup.

4.2.2.2.4. Connection Cable 100–240 V for Power Supply

3-pin (3 x 1.5²) feed line 100–240 V

Specifications Connection Cable:

AWG16 (metric equivalent 1.5 mm²)

75°C / copper wire only (75°C / copper)

4.2.2.2.5. Connection cable for DI (digital inputs) and DO (digital outputs)

Specifications Connection Cable:

AWG19 (metric equivalent 0.75 mm²)

75°C / copper wire only (75°C / copper)

shielded

4.2.2.2.6. Connection cable AI (analogue inputs) and AO (analogue outputs)

Specifications Connection Cable:

AWG21 (metric equivalent 0.5 mm²)

75°C / copper wire only (75°C / copper)

shielded / twisted in pairs

4.2.2.2.7. Connection of analysis gas lines

On principle, the following applies: When carrying out maintenance work on the gas line, the gas analysis system must be turned off and the gas supply must be disconnected. The connections for the gas lines can be found on the left hand side on the outside of the system.

4.2.2.2.8. Hydrogen Sulphide Filter (optional)

A hydrogen sulphide filter is implemented in devices that are fitted with a hydrogen sensor. For these gas analysis systems, the colour of the filling needs to be checked. The unused filling material is black. A grey or white colouring is an indication that the filter needs to be changed. Awite offers replacement filters or refills. The replacement is done by AWITE in the course of the maintenance work. The filter has to be replaced after 12 months at the latest and independent of the colouring, however.

4.2.2.2.9. Detonation Flame Arrester

A detonation flame arrester is not necessary as the distance of the tubes to the ignition sources is correspondingly small. As the tubes are very small in diameter, they act as a deflagration flame arrester. The type examination certificate is available from Awite on request.

4.2.2.2.10. Connecting Tubes

The gas analysis lines between the condensate traps and the gas analysis system are to be checked on a regular basis for condensation discharges. There must be no condensate in the feeding tubes from the condensate traps to the gas analysis system, as this can cause disruptions and defects in the gas analysis system.

4.2.2.3 Spare Parts List

The operating safety of the gas analysis system can only be maintained by using original parts or approved spare parts for every repair operation that is carried out and by adhering closely to the instructions in this manual and the repair instructions. Spare parts lists are available at Awite.

4.2.2.4 Calibration

The calibration intervals depend on the sensors being used, the composition of the measuring gas and the measuring interval. Normally, after the initial check of the system, one calibration per year is sufficient.
If you require a higher accuracy of results or under heavy use, a calibration interval of 3–6 months is recommended.
The calibration can be carried out by Awite directly on-site or else by a partner of Awite. Please contact Awite for further information.

4.2.2.4.1. Accuracy, Service Life und Calibration of the Sensors

A warranty of 12 months including for the electro-chemical sensors can only be guaranteed under the accurate adherence of the surrounding conditions. Although all electrochemical sensors are equipped with a software overload safety stop, damages due to concentrations (hydrogen sulphide and hydrogen) that exceed the upper measuring range value over a longer time-span cannot be ruled out. So please take this into account when choosing the sensor. If concentrations are too high, we cannot give any warranty, as this might result in an excessive wear of the sensors. The life-span warranty applies to a minimal measuring interval of 30 minutes for a measurement at one measuring point, which means a maximum of 48 measurements per day. In case of several measuring points, the number of measurements is reduced accordingly. Through the use of an air adjustment (calibration with fresh air), the zero points of the sensors can be aligned. In this case, the oxygen sensor is adjusted to 21% in ambient air. An overview of the factors affecting the measurement accuracy is shown in Table 3. From these figures it is possible to calculate the measurement uncertainties based on the uncertainty of the calibration gases, the calibration intervals, and the ambient temperature.
If required, more comprehensive material on the subject of measurement accuracy is available at Awite.

Table 3: Errors in measurement and standard measurement uncertainties without taking into account the calibration gas. The values are listed as absolute values with the specified unit.

Measured component	Physical unit	Measuring range (0 – final value of measuring range)	Resolution	Standard uncertainty 1 (U_1) (*)	Drift per year (D_Y)	Deviation per °C (D_T)
Methane	Vol.-% CH_4	100	0.1	0.2	1.5	0.1
Carbon dioxide	Vol.-% CO_2	100	0.1	0.2	1.5	0.1
Oxygen param.	Vol.-% O_2	25	0.01	0.02 at 1 0.5 at 21	1.3 or 2.6 at 1 (**)	0.005 at 1
Oxygen, electro-chem.		25	0.01	0.03 at 1 0.5 at 21	0.15 at 1 or 3.2 at 21	0.01 at 1 or 0.15 at 21
Hydrogen sulphide	Vol.-ppm H_2S	20	0.1	0.5	3	0.03
		200	1	5	16	0.3
		2000	1	25	160	3
Hydrogen electro-chem.	Vol.-ppm H_2	2000	1	25	80	3
		5000	1	50	400	6
	Vol.-% H_2	3	0.01	0.03	0.4	0.01
		15	0.1	0.2	1.2	0.05
		100	0.1	0.7	8	3
Hydrogen TCD	Vol.-% H_2	100	0.1	0.2	1.0	0.1

(*) Standard measurement uncertainty under lab conditions during successive measurements (repeatability)

(**) First value with constant gas humidity, second value with fluctuating gas humidity

4.2.2.5 Leaks in the Gas Analysis System

Despite the slow reaction of methane with oxygen compared to other gases (55 bar*m/s compared to 550 or 1415 bar*m/s with hydrogen and acetylene) at a similar maximum pressure (7.1 bar under normal conditions), the danger for persons at a control box volume of 60 l cannot be completely eliminated if only due to a deflagration, in the event that any explosive mixture would form inside through a possibly occurring tightness error and a subsequent ignition due to unfavourable conditions or an escape of the gas from the gas analysis system. The pipes inside are considered to be technically leak-tight. Due to the way they are constructed, the sensors can only be used with plug connections which are secured with spring terminals.

As an additional safety measure, the high-quality methane sensor that is integrated in the gas analysis system is used to track down possible leaks. In case of a leakage, the first valve will cut off the supply of measuring gas. Each measuring channel is filled for a maximum of 120 s with measuring gas and is subsequently flushed with air for at least 60 s. As the air for flushing is sucked out of the inside of the gas analysis system, the composition of the air inside the device casing can be measured every 2 minutes. Fresh air flows from outside into the device casing via a sintered metal frit (air filter). Upon detection of > 1.0% methane (= 20% LEL), all actuators will be shut down and the valve V1 cuts off the supply of measuring gas. Optionally, a potential-free contact is opened. Additionally, an error message is shown at the display. A potentially explosive atmosphere could thus be prevented behind valve V1 despite leakages. The gas path up to V1 is made with pressure-resistant pipes and clamp ring screw connections in a technically permanently leak-tight manner as described above.
For devices without methane sensor or with continuous methane measurement, the safety is ensured by other means (e.g. reduced number of potential leakage points, see risk assessment).

4.2.3 Control Cabinet

The control cabinet contains various relays and fuses for monitoring and controlling of e.g. stirrer, heating, temperature probe and the like. The emergency stop switch on the control box switches off the system. A detailed description of the structure is described in Illustration 8 through Illustration 12.

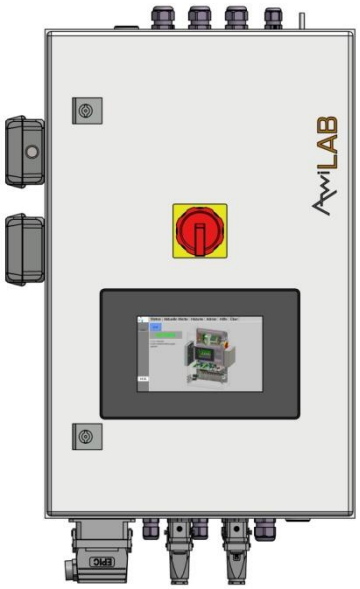
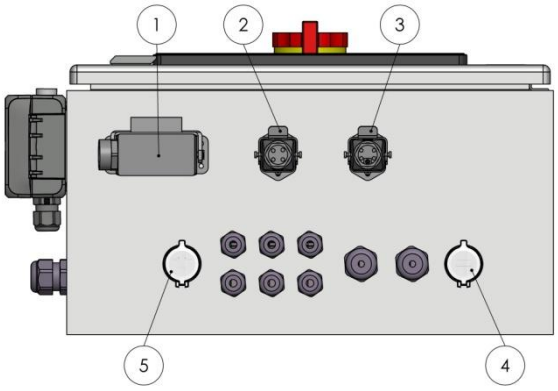
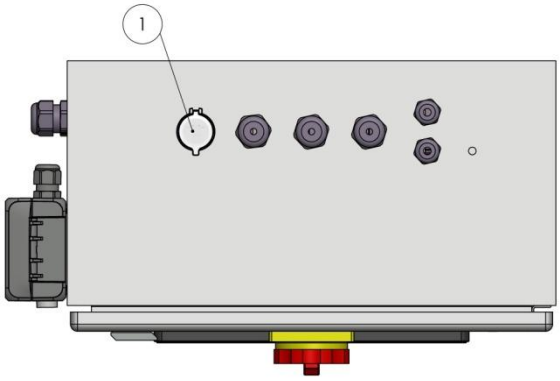


Illustration 8: Control Cabinet Front View



1. Motor control stirrer
2. Fermenter heater
3. Currently not allocated
4. USB connection
5. Ethernet port / network cable

Illustration 9: Control Cabinet Plan View Bottom



1. Ethernet port / network cable

Illustration 10: Control Cabinet Plan View Top

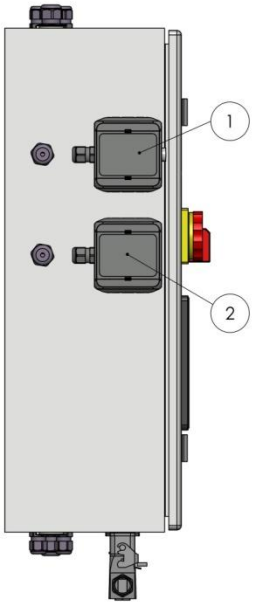


Illustration 11: Control Cabinet Side View Left

1. Sensor for ambient pressure and ambient temperature
2. Relative humidity sensor

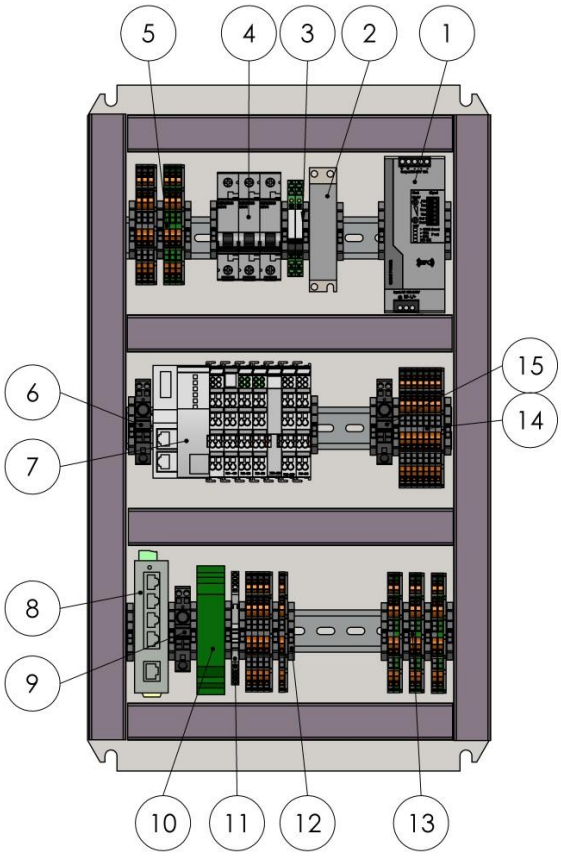


Illustration 12: Control Cabinet Interior View

1. Power supply unit
2. Solid state relay heater
3. Relay feedback fuses
4. Fuses
5. Terminals 230VAC
6. Fuse terminal
7. SPS
8. Ethernet switch
9. Fuse terminal
10. Stirrer control
11. Current transducer
12. Terminals 230VA
13. Terminals sensors / signals / bus
14. Terminals 24VDC
15. Fuse terminal

4.2.4 Control Cabinet Gas Collection

The control cabinet gas collection is used to switch the valve. In test mode, the valve to the gas storage bag is open. After reaching a preset and adjustable amount of gas, the valve switches over and delivers the gas into the exhaust air line. After analyzing the collected gas in the gas storage bag, the latter is completely emptied. The valve switches back to the direction of the gas storage bag, so that it can be refilled again.

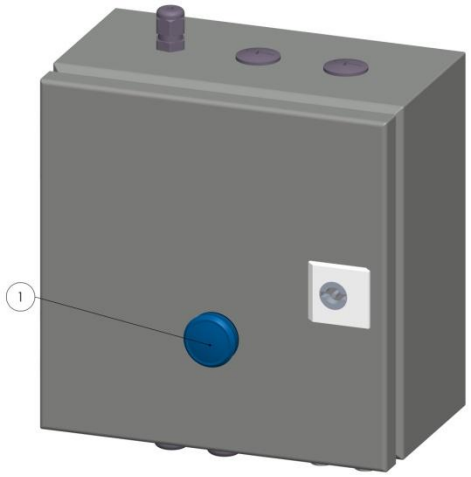


Illustration 13: Control Cabinet Gas Collection

1. Gas collection indicator lamp

If the indicator lights up, gas is directed into the gas bag and collected there. If the display is off, the gas bag is full and the gas produced is led directly into the exhaust air.

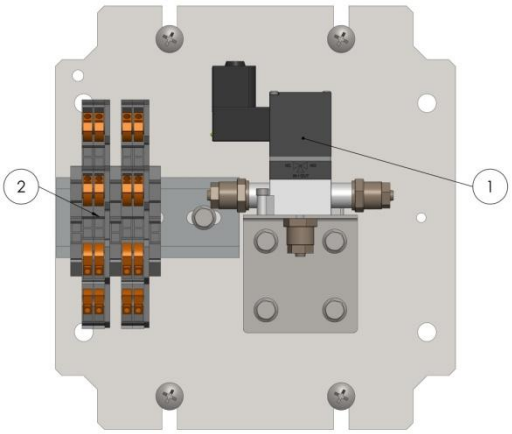


Illustration 14: Control Cabinet Gas Collection Interior view

1. Valve for gas collection / exhaust air
2. Terminals for valve and lamp

4.2.5 Gas meter

A drum gas meter of the type TG0.5/5 is used to determine the amount of gas produced. The material (PVC) is resistant to biogas. The measuring range is 1–60 l/h. A full revolution of the pointer corresponds to 0.5 litres of gas. The quantity of gas produced is transferred to the evaluation unit via a pulse generator (Illustration 15, item 5).

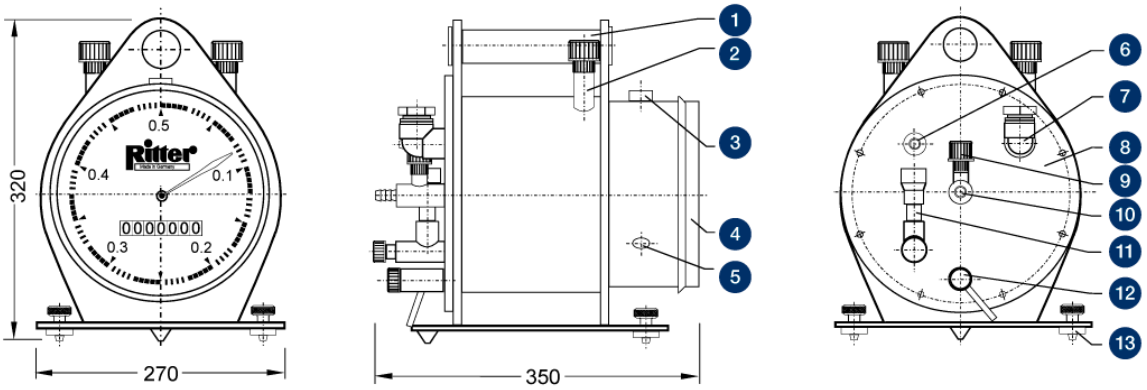


Illustration 15: Gas meter

1. Carrying handle
2. Recording unit for: Thermometer gas / thermometer barrier fluid / manometer
3. Spirit level
4. Removable anti-glare cap
5. Connection pulse generator
6. Gas outlet
7. Filler neck
8. Removable rear wall
9. Manometer connection
10. Gas inlet
11. Filling level indicator
12. Discharge neck
13. Height-adjustable device base

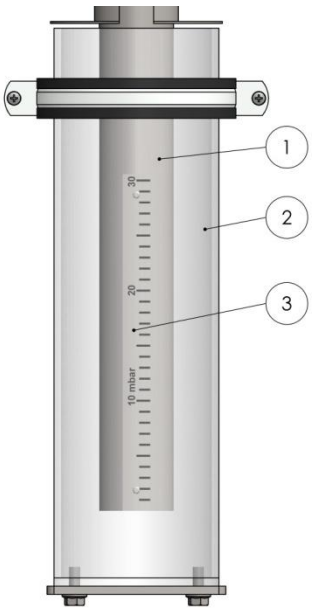
The gas produced in the fermenter is fed to the drum gas meter via the analysis gas line and connected to the gas inlet (No. 10). From the gas outlet (No. 6), the analysis gas line leads into the control cabinet gas collection.

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.

For advice on installing, maintenance and cleaning the gas meter, see attachment

4.2.6 Overpressure Protection

The overpressure protection is a safety precaution. If there is too much pressure or foaming in the fermenter, e.g. by clogged piping or power failure, the gas/substrate may escape into a water storage tank via the overflow pipe.



1. Overflow pipe
2. Water storage tank
3. Scaling

Illustration 16: Overpressure Protection

Water must be filled into the water tank. The scale on the overflow pipe indicates the pressure in millibars [mbar], which is generated depending on the water level.

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 that corresponds 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.

4.2.7 Condensate Traps

The condensate traps are installed in the measuring gas lines. Condensate that might accumulate inside the line is collected in the container. Following regular visual checks, the condensate must be emptied manually.

 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.

4.2.8 Other components

4.2.8.1 Gas bags

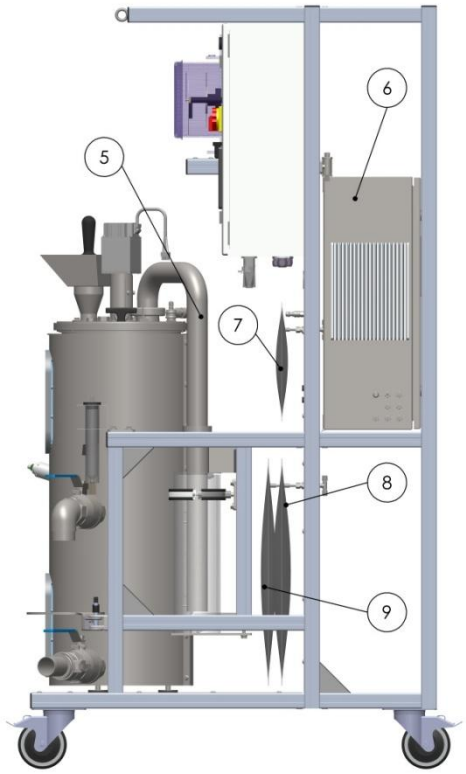


Illustration 17: Position of gas bags in the overall system

Three gas storage bags are integrated in the system. One 15 l, one 5 l, and one 2 l storage bag. The 15 l bag (item 8) is filled with inert gas and serves to equalize the pressure after the gas collection bag has been emptied by the gas analysis. The 5 l bag (item 9) is used to collect the produced gas for later gas measurement. The 2 l bag (item 7) serves to equalize the pressure in the fermenter for e.g. sampling over the sampling neck or during substrate insertion.

4.2.8.2 Analysis gas line

Pressure-resistant pipes are recommended as analysis gas lines:

- Diameter: 4/6 mm
- Material: resistant plastic (depending on the site of operation, stainless steel pipes may be obligatory)

All connections on the system, on the condensate trap and on the gas analysis system are implemented as hose screw connections for these pipe cross-sections.

4.3 Ambient Conditions for Operation and Storage

4.3.1 Ambient Temperature

In the interior of the gas analysis system, the temperature can be 15°C higher than the ambient temperature. Therefore, the ambient temperature for the device must be between +5°C and +35°C in order to guarantee an exact measurement of the sensors and not to damage the electronic components. The gas analysis systems are calibrated at 25°C. All detailed specifications refer to this temperature, any deviations that occur under significantly changed temperature conditions are sensor-related.


CAUTION

The temperature inside the device can be up to 15°C higher than the ambient temperature. Excessively high temperatures can lead to damage to components and reduce the service life of sensors. Sub-zero (°C) temperatures can destroy electrochemical sensors. This affects the measuring function and gas leakage can occur. Install the system in spaces with temperatures between +5°C and max. +35°C. The temperature in the control box must not exceed +50°C.

4.3.2 Ambient Humidity

The relative humidity must be kept between 0 and 80%.

4.3.3 Installation Height

The gas analysis system can be operated in areas which are located up to 2000m above sea level (normal height null, NHN).

4.3.4 Humidity and Dust

The system is dust- and splash-proof.

4.3.5 Measuring Gas Pressure

The pressure in the measuring lines must be at atmospheric pressure ±20mbar (normal operation). Pressure outside this range is not allowed because the sensors may be damaged and measured values may be changed. With higher or lower pressure, corresponding measures must be taken (pressure regulator, precision pressure regulator, available from Awite).


WARNING

The highest possible rated pressure is 100 mbar. In case of an error (e.g. precision pressure regulator faulty), this must not be exceeded. This may result in leakage and consequent explosion. For higher pressures, it is necessary to implement further safety measures as otherwise the safety of the gas analysis system cannot be guaranteed.

4.3.6 Measuring gas, fresh air and exhaust air requirements

It has to be assured that no polluted flushing air or ambient air can be sucked in by the gas analysis system and that the exhaust air hose remains free and unobstructed at all times.


CAUTION

Water, particles and dirt can clog pipes, sensors and valves. As a result, monitoring functions may be impaired and the measuring function is impaired. Check the condensate traps daily.

When maintenance work is carried out on the gas pipe, the gas analysis system is to be switched off and the ball valve at the measuring gas extraction point has to be closed.

 CAUTION
Work on the gas pipe may result in gas leakage. This can lead to exceeding of occupational limit values. Switch off the device during maintenance work and close the ball valve during gas sampling.

4.3.7 Calibration Gas Connection

Calibration gas cylinders have much higher pressures than the rated pressure of 100 mbar in the device. Therefore a sufficiently safe pressure control section has to be implemented.

 WARNING
Calibration gas is under high pressure. The device is designed for a maximum rated pressure of 100 mbar. Excessive pressure can lead to leakage and thus risk of explosion. Set pressure regulator before the precision pressure regulator to max. 100 mbar. Install the whole calibration gas system (calibration gas cylinders, connection lines, fittings, and process analysis device) in a sufficiently large space or with sufficient ventilation. Check the calibration gas system for leak tightness.

5 Preparation of the overallsystem for use

 DANGER
Depending on the size of the surrounding room, leakage of even small amounts of biogas can create an explosive or harmful atmosphere. Do not place in small, very airtight rooms.

 WARNING
This is a complex measuring, control, regulation and laboratory device. Incorrectly performed installation, electrical installation, initial operation and maintenance can lead to hazards and may even lead to death due to electric shock or risk of explosion. The respective work on the system may therefore only be performed by trained specialist personnel. The specialist personnel must have read and understood the Instruction Manual and follow its instructions.

5.1 Transport and Storage

This system must be protected against impermissible loads or damages by e.g. humidity, vibration, or shock. In the event of mechanical defects with electrical or electronic components, the system must not be put into operation. The same environmental conditions as those pertaining to operation apply to a possible storage of the system before installation and commissioning (see chapter 4.3).

5.2 Installation

The installation must be performed only by qualified personnel. They must be well familiar with the contents of this manual and any other provided manuals and repair instructions as well as with the safety instructions and specifications on the devices. In addition, the applicable national, local and system-specific regulations and provisions must be considered. An over-voltage protector must also be provided for by the operator. The dimensions of the system are given in Table 1 in chapter 4.2. Unused inlets on the system have to be leak-proofed and closing elements have to be screwed in tightly. There must be enough space so that the fermenter can be operated and cleaned and the control cabinet and gas analysis system can be controlled easily. For devices with a cooler, there has to be enough space for the circulation of air around the heat sink (at least 30cm).


CAUTION

In the event of a malfunction, the system can be brought into a safe electrical state by de-energizing. The device therefore has to be installed in such a way that the main switch operation is not impeded.

Please note: In the de-energized state, gas can continue to be produced. It is discharged through the gas meter and past the gas bags.

5.2.1 Main Switch Mains Disconnection Facility

The main switch functions as mains disconnection facility.

5.2.2 Control cabinets for electrical connections

 DANGER
Electrical voltage is present in the control cabinets and the cables leading there. An incorrect connection may lead to electrical hazards and even death. For information on the allocation of the different terminals and the wiring in the control cabinets, please refer to the electric diagram provided as part of the system. Check the connections afterwards.

 CAUTION
Incorrectly dimensioned cables can lead to fire and electrical hazards. Use only cables as specified.

5.2.2.1 Connection Cable 230 V for Power Supply

- 3-pin (3 x 1.5²) feed line 230 V

  Specifications Connection Cable:

  AWG16 (metric equivalent 1.5 mm²)

  75°C / copper wire only (75°C / copper)

 Note
A backup fuse of 16 A must be provided by the customer. An over-voltage protector must also be provided for by the operator.

5.2.3 Potential Equalization

The system must be grounded. A screw is provided above the control cabinet, on the right side of the module frame for connecting the grounding cable. The grounding cable must have a minimum cross section of 6 mm² (AWG 10).

WARNING

A non-connected grounding can lead to undefined voltages and electric shock. To unload voltages, connect the potential equalization to the provided connections with the defined cross-section.

5.2.4 Information on Cable and Lines Routing

Please note the following for the on-site running of cables:

- Use shielded lines for all signals
- Implement shield on one side on-site
- Separate laying of data and power cables.

5.2.5 Connection Exhaust air – Discharge of the Measuring Gas

The discharge of the measuring and fermenter gas from the installation room of the overall system into the open normally occurs via a technically permanently leak-tight pipe as the gas amount is very low. At least two connections are provided on the back of the overall system for the exhaust air line (hose screw or pipe screw connection). If several exhaust air pipes are provided, then these must not be combined in order to prevent the measuring and fermenter gas from being pushed back into the device. When the discharge reaches the open, at least one hose with an internal diameter of 8 mm has to be used. This makes sure that no condensate accumulates in the duct, which could lead to blockage by freezing in winter. The customer should prepare a corresponding feed through the wall. Since the fermenter gas is saturated with water vapour at room temperature and condenses water below this temperature, a water reservoir may have to be placed at the lowest point of the fermenter exhaust air.


WARNING

The exhaust gas may be combustible and harmful to health. This may lead to fire, explosion and poisoning. Under no circumstances must the exhaust gas be released inside the building unless an appropriate controlled ventilation facility exists

Please note: Biogas contributes to the greenhouse effect and thus to climate change. If possible, do not discharge gas into the atmosphere.


DANGER

The gas analysis system measures/rinses alternately with measuring gas and ambient air. A connection of the exhaust pipes can lead to an entry of the measuring gas into the device interior. This creates an explosion hazard. You may lead the exhaust gas without further measures only into gas-bearing areas and with an assured durable over- or underpressure of up to 20 mbar max.

5.3 Initial Operation

Prior to the initial operation of the overall system, it needs to be checked whether the operating conditions comply with the guidelines provided in this manual and all points in the Operating Manual have been observed.

6 Product Liability

Awite does not assume liability for damages caused by faulty measuring and test results.

Please follow the General Terms and Conditions (AGB), which are available in their current version at http://www.awite.de/Agb.

7 Document and Change History

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

8 Appendix

8.1 CE Declarations of Conformity

CE Declaration of Conformity for Devices Not Intended to be Installed in an Ex-Zone

CE

EG-Konformitätserklärung (original)

EC Conformity Declaration (translation)

Awite Bioenergie GmbH

Hersteller, Manufacturer:

Awite Bioenergie GmbH, Grünseiboldsdorfer Weg 5, D-85416 Langenbach

Produkt, Product:

Laborfermentersystem/Laboratory Fermenter System

Typenbezeichnng, Type designation:

Awilab Digester Serie 1

Das bezeichnete Gerät inklusive Zubehör entspricht der EU-Richtlinie:

The denoted device including accessories corresponds to the EU guideline:

2006/42/EG

Es entspricht außerdem folgenden EU-Richtlinien bzw. hält deren Schutzziele ein:

It also corresponds to the listed EU guidelines or complies with their protection targets:

2014/34/EU, 2014/30/EU, 2014/35/EU, 2011/65/EU

Normen (auszugsweise), Standards (in part):

EN 61010-1:2010, EN 61010-2-081, EN 61326-1:2006,
EN ISO 12100-1:2010, EN 13463-1:2009, EN 60204:2014

Kennzeichnung, Marking:

CE Ex II 2/- G IIA

Gasführende Leitungen mit brennbarem oder explosivem Gas (Zone 2 oder 1 im Inneren der Leitung) dürfen an das Gerät an der vorgesehenen Stelle angeschlossen werden. Das Gerät selbst ist außerhalb einer gefährlichen Atmosphäre zu montieren.

Gas pipes with combustible or explosive gas (zone 2 or 1 inside the pipe) may be attached to the device at the designated and appropriate place. The device itself is to be installed outside of a hazardous atmosphere.

Langenbach, 3. Januar 2018, 3th January 2018

Dr.-Ing. Ernst Murnleitner
(Geschäftsleitung und Ansprechpartner bei Rückfragen,
Management and contact person for queries)

8.2 IEC Declaration of Conformity

Konformitätserklärung (original)

Conformity Declaration (translation)

Awite Bioenergie GmbH

Hersteller, Manufacturer:

Awite Bioenergie GmbH, Grünseiboldsdorfer Weg 5, D-85416 Langenbach

Produkt, Product:

Laborfermenter-System, Laboratory Fermenter System

Typenbezeichnng, Type designation:

Awilab Digester Serie 1

Normen (auszugsweise), Standards (in part):

IEC 61010-1, IEC 61326-1, ISO 12100-1, IEC 60204

Gasführende Leitungen mit brennbarem oder explosivem Gas (IEC 60079-10 Zone 2 oder 1 im Inneren der Leitung) dürfen an das Gerät an der vorgesehenen Stelle angeschlossen werden. Das Gerät selbst ist außerhalb einer gefährlichen Atmosphäre zu montieren.

Gas pipes with combustible or explosive gas (IEC 60079-10 zone 2 or 1 inside the pipe) may be attached to the device at the designated and appropriate place. The device itself is to be installed outside of a hazardous atmosphere.

Langenbach ,
3. Januar 2018, 3th Januar 2018

Dr.-Ing. Ernst Murnleitner
(Geschäftsleitung und Ansprechpartner bei Rückfragen,
Management and contact person for queries)

8.3 User's Manual Ritter Gas Meter

Is attached as an attachment.