

## On-line monitoring of critical process parameters and process efficiency in anaerobic digesters



### Advanced features

- On-line, automatic measurements of volatile fatty acids (VFA), bicarbonate, alkalinity, pH and ammonia in one single run
- Second generation design with less moving parts, simple maintenance and requiring no special analytical skills
- Complete separation between electronics and wet part
- Rapid results (10 - 15 min.) allow true process monitoring, protection and optimization
- Dual range possibility for influent/effluent analysis
- Multiplexing up to eight (8) sampling points possible
- Incorporated industrial PC with AppliTek controller software
- Extended data communication and exchange features

### Application fields

On-line monitoring of critical process parameters in anaerobic digestion (liquid fraction):

- Industrial AD digesters
- Anaerobic wastewater treatment
- Anaerobic sludge treatment
- Pilot-scale AD reactors

### High analytical performance

- Direct, automatic titration (no volatilization possible)
- Close correlation with reference laboratory methods (for volatile fatty acids)
- Reduced reagent consumption by batch-wise operation principle and high precision titration techniques
- Factory configured, tested and calibrated

## Introduction

Anaerobic digesters are often perceived as self-regulating but require critical parameter monitoring in order to obtain optimal results. However, due to the expensive or time-consuming character of most analysis methods for anaerobic digestion, industrial digesters are usually not extensively monitored, except for a few parameters such as pH and gas flow. This is the reason why in reality commercial exploitation of full-scale digesters is often constrained. Operators prefer to keep the loading rate of the digester relatively low for safety precautions. Process efficiency, performance and biogas yield have become secondary in many of today's full-scale digesters.

Laboratory measurements such as GC-MS, used to determine individual volatile fatty acids, are highly selective methods but do not contribute to process control and transparency. Often they require lengthy preparation steps causing systematic analytical errors, not to speak of a high cost per analysis.

## Operational benefits

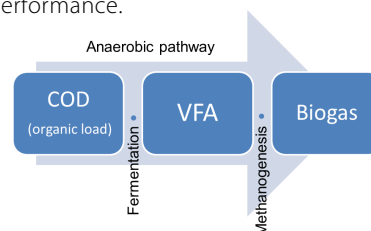
The idea of critical parameter monitoring, firmly set within the AppliTek policy, can now be applied to anaerobic digesters. The **AnaSense®** Anaerobic Control Analyzer is an easy-to-operate and highly robust on-line wet-chemical analyzer measuring a.o. volatile fatty acids (VFAs), the key component of anaerobic digestion, **enabling full control over the AD process:**

- Continuous monitoring of the AD process (almost real-time)
- Enabling higher loading rate for maximum CH<sub>4</sub> production
- Prevention of digester failure due to VFA accumulation
- Easy implementation within a dynamic control strategy
- Easy integration into corporate networks

## Critical parameters and process stability

On-line analyzers such as the **AnaSense®** have introduced new control alternatives in the typical operating problems in the dynamic anaerobic digestion (AD) process, with chemical and biochemical reactions taking place in both sequential and parallel pathways. Stability of the AD process has a firm relation with the balance that exists between the groups of bacteria and, most important, the efficiency. Temperature, gas flow and methane levels are important indicators of process performance, but are difficult for interpretation of the actual metabolic condition of the AD process.

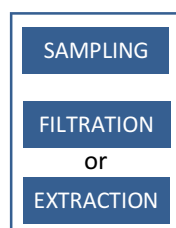
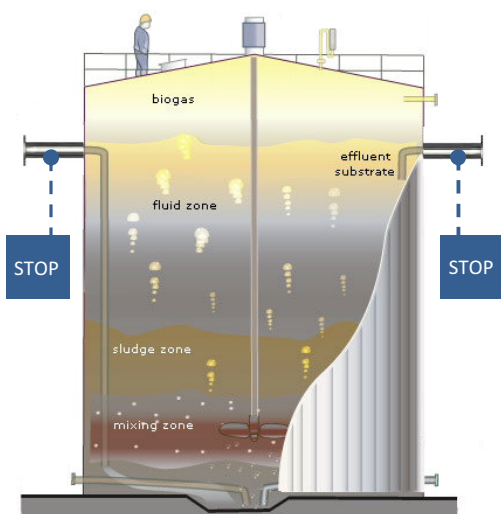
**Volatile fatty acids** (VFAs) are the intermediary products for the methanogenesis and commonly accepted as key to process stability and performance.



Still, AD process control strategies are often focused on keeping the **pH** of the process within a safe and neutral range of 6.5 – 7.5. pH cannot be used as a reliable indicator of failure (upset) since a high buffer capacity will tolerate a large accumulation of VFAs. This is expressed by the **alkalinity** value. Alkalinity is the buffering capacity of the digester. When acids accumulate, the alkalinity will gradually be exhausted. In anaerobic media, it is important to differentiate between **total / partial alkalinity**. The **bicarbonate** ion (HCO<sub>3</sub><sup>-</sup>) is the main source of buffering capacity to maintain the system pH in the neutral range. Methane-producing bacteria further reduce the bicarbonate to methane. **Ammonia** can be toxic to the process and is likely to slow down methanogenesis but at the same time can increase buffer capacity.

### Schematic overview of a typical implementation of the AnaSense®:

Samples are taken from influent and effluent sample take-off points (STOP) to a sampling/filtration system and then into an overflow vessel. Fresh sample is automatically transferred to the analytical stage by a peristaltic pump. The analyzer's internal controller software controls the valves for each sample line. Analysis data is ready to be communicated by industry standard outputs.



## Analysis and liquid handling

The **AnaSense®** runs a chemical analysis based on a proprietary acid/base titration. From the obtained titration volumes, respectively the concentrations are calculated and displayed on the controller screen:

- Volatile fatty acids (total, VFA) as acetate equivalent
- Total alkalinity (TA) as  $\text{CaCO}_3$
- Partial alkalinity (PA) as  $\text{CaCO}_3$
- Bicarbonate (Bic) as  $\text{CaCO}_3$
- pH

Optionally an additional titration with sodium hydroxide can be started to monitor ammonia levels. For manure samples or samples with any potential risk of foaming, the addition of an anti-foaming reagent is strongly advised. All actions of the analysis cycle are controlled by the industrial PC, including automatic addition of reagents and samples to the analysis vessel. The controller software can also control the valve train for selection of different sample lines with specific sample preconditioning systems — please check the technical specifications on page 4.

**Second generation design** The **AnaSense®** is equipped with a new analyzer enclosure consisting of a solid steel back, combined with an ergonomic ABS hinged part containing the actual wet part. Wet-chemical components are revised for optimal operation and low maintenance:

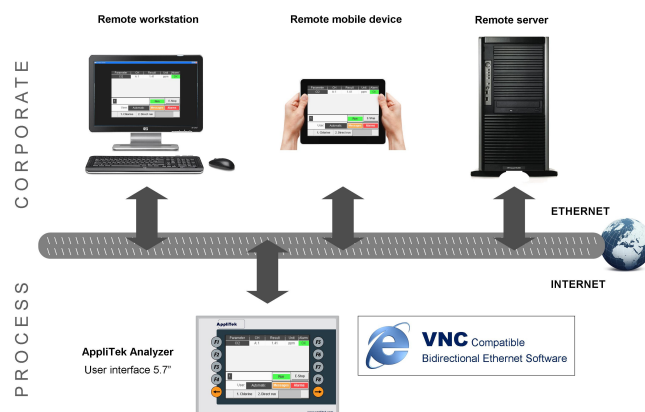
- Less moving parts: injection dispensers are omitted
- Factory calibrated (additional validation functionality)
- Transparent door allows instant visual inspection
- Reduced environmental footprint (60% weight reduction)
- Integration in an IP65 rated protective cabinet possible



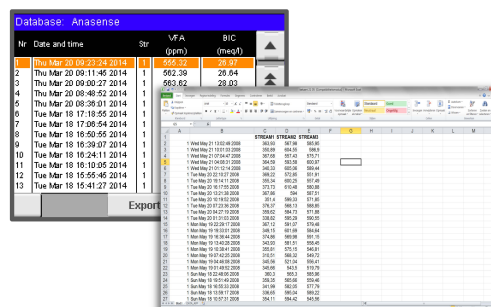
*Image - inside the wet part of the AnaSense®: titration vessel with pH electrode, long-life peristaltic pumps for sample and drain.*

## Data exchange and supervision

All actions and logs of the **AnaSense®** are controlled by the industrial PC. The incorporated software flexibility minimizes physical operator intervention. The analyzer screen (the client) can remotely be taken over by means of LAN Ethernet software (such as VNC software). Authorized users can carry out all manual operations and settings from a remote PC, such as troubleshooting before doing any physical intervention and capturing cross-platform screenshots for reports.



*Screenshots, below: a history of the last 1,000 analysis results can be visualized in a chronological data table and equally be exported as Microsoft Excel files through the sealed USB port.*



## Analysis of multiple streams

The controller software of AppliTek on-line analyzers gives you the possibility to run multiplexed analysis. Multiplexing enables you in theory to monitor *up to 8 streams sequentially*, reducing the cost per sampling point. There are two possible scenarios where multiplexing would be applied for the **AnaSense®**:

**Comparing digester inlet and outlet** Two sample lines are combined with sample preconditioning units, controlled by the analyzer. Dual measuring range configuration is needed.

**Sequentially monitoring several digesters** Sample streams are passing through a valve train mounted outside the analyzer, with each stream controlled by the controller software. Maximum eight (8) analogue outputs are available for communicating the results. When more individual results need to be communicated, we recommend using the controller's MODBUS feature.

## Technical specifications

### Analytical unit

#### Analysis method

Acid/base titration

#### Parameters

Volatile fatty acids (total), bicarbonate, alkalinity (total), alkalinity (partial), pH

Optional: ammonia

#### Standard measuring ranges

One combination, factory set:

VFA: 10 – 500 mg/L as acetate equivalent

Bicarbonate: 0-55 meq/L or 5,500 mg/L as CaCO<sub>3</sub>

Alkalinity \*: 0-55 meq/L or 5,500 mg/L as CaCO<sub>3</sub>

VFA: 10 – 500 mg/L as acetate equivalent

Bicarbonate: 0-500 meq/L or 50,000 mg/L as CaCO<sub>3</sub>

Alkalinity \*: 0-500 meq/L or 50,000 mg/L as CaCO<sub>3</sub>

VFA: 50 – 10,000 mg/L as acetate equivalent

Bicarbonate: 0-100 meq/L or 10,000 mg/L as CaCO<sub>3</sub>

Alkalinity \*: 0-100 meq/L or 10,000 mg/L as CaCO<sub>3</sub>

\*Alkalinity: as total and partial alkalinity

#### Standard measuring range (other)

One measuring range, factory set:

Ammonia: 2 - 3.5 g/L

#### Cycle time

10 - 15 minutes (depending on range)

#### Calibration

Factory calibrated

#### Cleaning

Automatic, free adjustable sequence

#### Detection limit

Better than 30 mg/l

#### Precision / Repeatability

Better than 3% full scale for standard solutions

### Environmental data

#### Ambient operating conditions

10 °C – 30 °C +/- 4 °C deviation at 5 - 95% relative humidity non-condensing

(50 °F – 86 °F +/- 7.2 °F deviation)

#### Reagent temperature

Keep between 10 °C - 30 °C (50 °F - 86 °F)

#### Sample pressure

By external overflow vessel

#### Sample flow rate

Fast loop sample supply required - minimal flow rate depends on application

#### Sample particulates

Maximum size 200 µm, < 0.1 g/l

### Options / add-on units

#### Sample preconditioning systems

**EZ-Size®** self-cleaning microfiltration unit, various pore sizes, requiring fast loop

**EZ-Settler®** automatic sampling-settling system for saturated or dirty matrices

**EZ-Slurry®** automatic extraction unit for samples with high viscosity and organic load

#### Parameter: ammonia

By additional titration cycle

#### Manual/automatic validation

With additional validation solution(s)

#### Reagent level detection

Installed on reagent containers; alarms are generated by controller software

#### Multiple streams

**ModuPlex®** 2 or 3 streams (8 on demand)

#### Outdoor cabinet

IP65

### Reagents

#### Reagent containers (included)

Outside cabinet: min. 2, up to 4

Containers come with torqueless screw caps.

#### Titration solutions

Sulphuric acid ≤ 10 L / 30 days \*

Sodium hydroxide ≤ 10 L / 30 days \*

\*Based on 1 set of analysis results/hour

#### Anti-foaming solution

Max. 0.5 L / 30 days

#### Cleaning solution (recommended)

Tap water or specific chemical solution

### Mechanical data

#### Protection class

Analyzer cabinet: IP55

Touch screen/Industrial PC: IP65

#### Cabinet and materials, hinged part

Thermoform ABS / Door: plexiglass

#### Cabinet and materials, wall section

Galvanized steel, powder coated

#### Dimensions

69 cm (27.2") x 46.5 cm (18.3") x 33 cm (13")

(H X W X D)

#### Total weight

25 kg (55 lbs.)

### Control and communication

#### User interface / controller

Industrial PC with 5.7" TFT colour user interface, compact flash memory

Backlit touchscreen, brightness adjustable

#### Data handling, logging and security

- Standard Ethernet 10 M (RJ45) NE 2000
- Communication ports supporting Ethernet connectivity to MODBUS TCP/IP
- Log files with 1,000 values/results are stored
- Easy export to spreadsheet files
- Sealed USB port for data or result graph download and program upload
- User interface with administrator access and menu keys activated/inactivated
- Data retention in case of power failure, initialization program for safe status after restart

#### Analogue outputs

Maximum 8, active 4 – 20 mA, max. 500 Ohm load

#### Alarms (digital outputs)

- Titration alarm (potential free contact)
- Sensor alarm (potential free contact)

#### MODBUS TCP/IP, MODBUS-RS232 -RS485

Optional

### Utilities

#### Power

220 - 240 VAC, 2 A, 50 Hz

Max. power consumption: 120 VA

Other voltages available on request

#### Instrument air (purging)

Dry and oil free according to ISA-S7.0.01-1996 quality standard for instrument air

#### Tap water

For rinsing, calibration and/or dilution

#### Drain

Atmospheric pressure, vented, min. Ø 64 mm

#### Earth connection

Dry and clean earth pole with low impedance (< 1 ohm) using an earth cable of > 2.5 mm²

### Certification

#### CE approval

Certified to CE approval

#### Factory Acceptance Test (FAT)

At AppliTek NV, Belgium.

