Biogas design, planning and process engineering

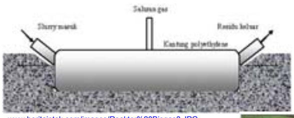
General Outline

- **Designing failures**
- Technical failures
- Plant attendance and daily operation
- Data recording
- Minor repairs – safety during repairs
- General maintenance

Why goes it so easy somewhere ?

+ Basic Skills, + Small Size, + No Tech

http://www2.bremen.de/info/bremen-pune/galerie_seiten/biogas.htm



www.beritaiptek.com/images/Reaktor%20Biogas3.JPG

Should I take Plastic Bags, Lagoons ?

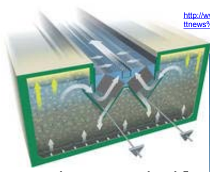
http://www.alibaba.com/catalog/100497726/Interflow_Anaerobic_Open_Pond_Reactor_Interflow_Aopr_The_Biogas_Technology.html

Is a Mixer needed,

Several Tanks,

Made of Concrete or Stainless Steel ?

http://www.folkecenter.net/gb/tech-trans/technologies/farm-biogas/



http://www.envirochemie.de/Detail.41.0.html?&no_cache=1&tx_ttnews%5Btt_news%5D=34&tx_ttnews%5BbackPid%5D=28&cHash=910cd43b67

No Moving Parts inside but high sophisticated, Intensive degradation …

Tall is beautiful ? http://images.google.de/url?q=http://www.exin-praha.cz/2006/covpopa.html&usg=AFQjCNH77oyS906l3mfpZ3kuBrv0nZZ94w

biogas-tower-reactor TU Hamburg-Harburg

All fits !… as the cases arises

Designing failures

- Intention of AD
- Benefit of AD
- Substrate
- Dimensioning
- Operation

Designing failures

- Intention of AD

  Health Care
  Wastewater Utilization
  Replacement of Firewood, LG
  Saving of Energy
  Increasing Ratio of Biomass Renewables

- Benefit of AD

  Health Care Costs of Public Budget
  Improvements in Living Standard
  Environmental Precautions
  Food processing at a lower price
  Achieve Business Approval
  Renewable Energy Business

Designing failures

- Substrate

  Kind and Composition
  Daily Mass or Volume
  Gas Production Rate
  Fate of Digestate

- Dimensioning

  Flow rate, Troughput
  Flowability, Handling
  Loading Rate (COD, VS)
  Hydraulic Retention Time, Biomass Recovery
  Substance Concentration
  Balance of AD
  Unchecked Production (Digestate, Energy)
  Reserve Capacity

Designing failures

- Operation

  Acceptance of Job, Sozial Standing
  AD Awareness Level
  Understanding (Intention, AD)
  Personal skills
  Level of Technology (regional, sectoral)
  Reasonable Availability (Maintenance, Spare Parts)
  Share in Outcome
  Profit

Intermediate Result I

Intention of AD

\+ Benefit of AD

\+ Substrate

\+ Dimensioning

Appropriate AD

\+ Operation

Energy Calculation I (Example)

Input:	
Potato Raw Material	97.610 t/a
Starch	4.495 t/a
Oil	636 t/a
Potato Sludge	6.583 t/a
Sum	109.324 m³/a
Total Solids:	
Potato Raw Material	20,0 % Input
Starch	60,0 % Input
Oil	100,0 % Input
Potato Sludge	30,0 % Input
Sum	22,7 % Input
Volatile Solids:	
Potato Raw Material	90,0 % TS
Starch	90,0 % TS
Oil	95,0 % TS
Potato Sludge	90,0 % TS

Energy Calculation II (Example)

Hydraulic Retention Time	**41,7 days**
Digester Volume (net)	**12.500 m³**
Organic Load Rate	**4,9 kgVS/m³/d**

Specific Gas Production Rate:

Potato Raw Material	600 m³/t VS
Starch	600 m³/t VS
Oil	1.000 m³/t VS
Potato Sludge	700 m³/t VS

Biogas Production:

Potato Raw Material	10.541.880 m³/a
Starch	1.456.380 m³/a
Oil	604.200 m³/a
Potato Sludge	1.244.187 m³/a

Energy Calculation III (Example)

Methane Content:

Potato Raw Material	58 %
Starch	60 %
Oil	65 %
Potato Sludge	62 %
Sum	59 %

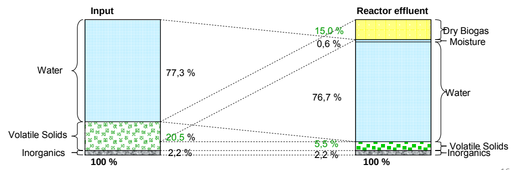
Calorific Value:	5,9 kWh/m³
Biogas Production:	13.846.647 m³/a
	1.581 m³/h
Biogas Power:	9.306 kW
Engine Power (installed) (3 Gas Engines)	10.500 kW
Engine Power (electric)	4.200 kW
Produced Energy (electric)	32.608.977 kWh/a
Engine Power (thermal)	5.250 kW
Produced Energy (thermal)	40.761.222 kWh/a

Mass Balance I (Example)

Input		Starch	Oil	Raw Potato	Sludge	Total
Input (t/a)		4.495	636	97.610	6.583	**109.324**
Input (t/d)		12,32	1,74	267,42	18,04	299,52
Total solids (%)		60,0%	100,0%	20,0%	30,0%	**22,7%**
Total solids (t/a)		2697,0	636,0	19622,0	1974,9	24829,9
Total solids (t/d)		7,4	1,7	53,5	5,4	68,0
Volatile solids (% TS)		90,0%	95,0%	90,0%	90,0%	**90,1%**
Volatile solids (t/a)		2.427	604	17.570	1.777	22.379
Volatile solids (t/d)		6,7	1,7	48,1	4,9	61
Water (t/a)		1.798	0	78.088	4.608	84.494
Water (t/d)		5	0	214	13	231
spec. Gas Production rate (m³/t VS)		600	1.000	600	700	
(dry gas, Normal conditions	1,18 kg/m³					
Biogas						
Gas production (m³/a)		1.456.380	604.200	10.541.880	1.244.187	13.846.647
Gas production (m³/d)		3.990	1.655	28.882	3.409	37.936
Gas production (t/a)		1.719	713	12.439	1.468	16.339
Gas production (t/d)		4,71	1,95	34,08	4,02	44,76
Water content:	4%	69	29	498	59	654
Wet Gas 37°C (t/a)		1.787	741	12.937	1.527	16.993
Wet Gas 37°C (t/d)		4,90	2,03	35,44	4,18	46,56

Mass Balance II (Example)

Reactor effluent			
Total solids (t/a)			8.491
Total solids (t/d)			23
Volatile solids (t/a)			6.040
Volatile solids (t/d)			17
Water (t/a)			83.841
Water (t/d)			230
Output (t/a)	6 Monate:	46.166	92.331
Total solids (%)			9,2%



Substrate, Topics

Effluents from Animal Housekeeping:

- Feaces, urine,
- bedding material,
- waste water,
- trash

Municipal organic solid waste from:

- Food industry, Markets
- Kitchen, Restaurants, Catering,
- Gardening, Greenery, Parks

possibly including any kind of trash

Substrate, Topics

Liquid food waste, e.g.:

- Spoilt juice,
- Expired beverages,
- Liquid by-products,
- Waste water with high COD

mostly only VS, no fibrous solids

Energy crops, e.g.:

- Maize,
- Beets,
- Potatoes,
- Spoilt Crops, non-food-biomass

Substrate, Parameters

Effluents from Animal Housekeeping:

- Animal species, feed base
- If bedding material, what kind
- Age of Effluents (Maturity)
- TS, VS, TKN, Alkalinity, Particle size
- Kind and amount of Impurities (chains, ropes, fork-tines, stones)
- Load curve (differences in time and quantity)

Substrate, Parameters

Municipal organic solid waste **Liquid food waste**

- Pretreatment at source (Separation)
- Kind of Package
- Particle size
- Quantity of trash (metals, glas, chinaware, wires, ropes, stones)
- Load curve (differences in time and quantity)

+

Name of Company
Location
Name of Product Lab Analysis

Parameters	Unit	Value
Alkalinity (as CaCO3)	mg/L	
pH	pH units	
Ammonia-N	mg/L	
TKN	mg/L	
TN	mg/L	
Phosphorus (Total)	mg/L	
Sulfate	mg/L	
Sulfide (Soluble)	mg/L	
Sulfide (Total)	mg/L	
TDS	mg/L	
TS	%	
VS	%	
Protein Content	%	
Fat Content	%	
Ash Content	%	
Carbohydrates	%	
Calories	per fl oz.	
TOC	mg/L	
BOD (soluble)	mg/L	
COD (soluble)	mg/L	
COD (total)	mg/L	

Substrate, General operation

7 rules to run a digester

- Maintain constant feed rate and composition
- Avoid overfeeding and abrupt changes
- Avoid foaming Don´t:
  - add a substrate with a low pH value
    add substrate with a considerably high protein content
    overfeed the digester
    mix improper and/or inconsistent
- Mix as much as necessary and as little as possible
  Keep in mind: all in - all out.
- Maintain continuous mixing
- Choose an appropriate temperature
- Keep the temperature constant

!

Intermediate Result II

How to do

- Anticipatory waste management
  # what, when, how much
  # quality control
- Buffer tanks as required (at first, in between, at last)
- Blend of different substrates
- Operation control

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Beware of trash

Maintain constant feed

Maintain constant operation

Sedimentation

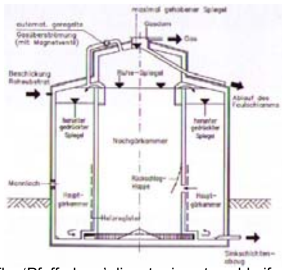
Grit removal

Maintain constant composition

Reliable Technology

Reliable Technology

Substrate and digester design



The 'Pfefferkorn' digester is not usable if swimming layers are to be expected

Source: Eder u. Schulz 2006, Biogas Praxis

General Outline

- Designing failures
- **Technical failures**
- Plant attendance and daily operation
- Data recording
- Minor repairs – safety during repairs
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Construction

How to differentiate the tanks ?

1. By function

2. By material
   - Concrete (in situ; precast; pre-stressed)
   - Steel (glass coated steel; stainless steel)
   - Others (fiberglass)

   in particular cases: Brick, PE, Synthetic rubber

Concrete or Steel Tank ?

- Main argument is the price – if the design is done properly
- Typical types of use
  - Concrete tanks as storage tanks or flat digester: diameter up to 30 m; height up to 8 m
  - Concrete tanks as high digesters: up to 14 m by 14 m diameter (500 kW-plant)
  - Steel tanks as high digester: height more than 15 m by 15 m diameter (for example 18*18 m for a 1 MW-plant)

Concrete tank under construction: Excursion „Concrete“

- Concrete is a mixture of water, gravel and cement.
- By using reinforced Concrete the good attributes of steel and the good attributes of concrete are combined
- Concrete: cheap, high compression strength
- Steel: high tensile strength
- Concrete is alkaline and protects the steel from corrosion

Construction failures

Holes in the tank wall

- Iron mold too hot
- water in the ready-mix-concrete insufficient

Construction failures

Seal of fittings in the wall insufficient

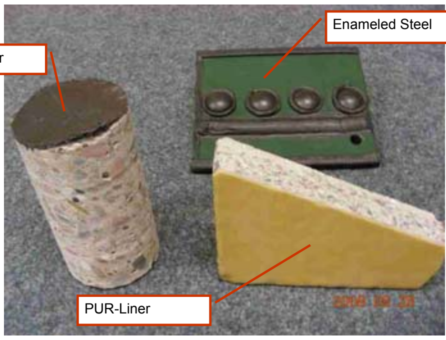
Too large Crack Width (e.g. inadequate reinforcement

Construction failures

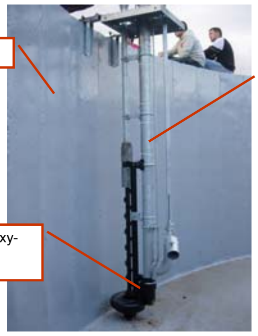
Chemical Corrosion

Construction failures

Corrosion Protection



Corrosion Protection: Concrete, Pump



Piping

	Biogas	Hot water	Substrate
Above ground	stainless steel	mild steel	PVC / PE / mild steel
Below ground	PE	mild steel	PVC / PE

Piping

Pipes made of PE
- (+) Medium- and UV resistant
- (+) Connections defined to be unbreakable
- (+) Cheap

- (-) Temperatures > 60° C
- (-) Easily deformed by pressure

Major Problems of Plastic Pipes

(If applicaton is inadequate)

Demolition by hot water and high pressure

Diffusion of inorganic compounds (Example: internal heating pipe)

Piping

Pipes made of PVC
- (+) Medium resistant
- (+) Easily assembled by adhesive – bonded joint
- (+) Cheap

- (-) Not UV resistant
- (-) Brittle at low temperatures
- (-) Less aging-resistant than other materials
- (-) Temperatures >60° C

Piping

Pipes made of mild steel
(+) Temperature resistant
(+) Easily assembled
(+) Very flexible installation
(+) Long life

(-) Less medium resistant than pipes made of plastic
(-) Corrosion

Piping

Pipes made of stainless steel
(+) Very long life
(+) Temperature resistant
(+) Medium resistant
(+) Thermal conductivity

(-) Expensive
(-) No installation underground

Piping

Under Construction pay attention to
- Mechanical damage
- Visible tank openings
- Correct assembling and tightness by manufacturer
- Frost protection

Pumps and Conveyors

Types of Pumps
- Positive-displacement pump
  → helical rotor pump
  → rotary lobe pump
- Centrifugal pump

Pumps and Conveyors

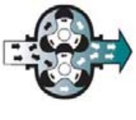
Helical rotor pump
(+) Substrates with high dry matter contents
(+) Self – priming pump
(+) High discharge pressures (up to 24 bar)

(-) Minor flow rate
(-) Long fibred materials
(-) High abrasion wear
(-) Assembly length

Pumps and Conveyors

Rotary lobe pump
(+) Self-priming
(+) Bigger particles and long fibred materials
(+) Pumping capacity about 800 m^3/h
(+) Discharge pressures to 12 bar

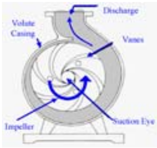
(-) High abrasion wear



Pumps and Conveyors

Centrifugal pump
(+) Good knowledge and experience
(+) Simple and tough construction
(+) High flow rates

(-) Minor total solid content
(-) Low discharge head
(-) Not self-priming



Major Problems of Centrifugal Pumps

(If applicaton is inadequate)

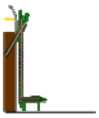
Corrosion/Abrasion

Blockage

Pumps and Conveyors

Solid input device

- Screw
- Fluid input device
- Piston pump
- Mixing pit



Screw Conveyor

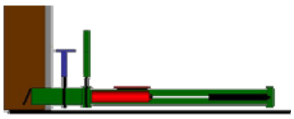
(+) High reliability
(+) Investment
(-) High abrasion
(-) Max. 12 m level

Fluid Input device

(+) Usable for high digesters
(-) Low reliability
(-) Low capacity
(-) High costs of operation

Piston Pump

(+) High reliability
(+) Usable for high digesters
(-) High investment

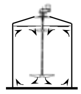


Mixing Pit

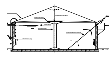
Type of Digester, Agitator, Mixer

- Horizontal digester
  plug flow, vertical mixing
  bypass reduced by high viscosity

- High upright digester
  complete mixing, homogeneous
  temperature, bypass possible



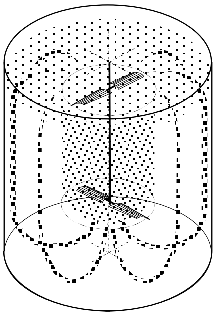
- Flat upright digester
  less mixed, zoning possible,
  bypass possible



Tall Digester, Top Mounted Mixer

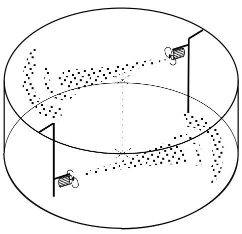
Operation Top Mounted Mixer

- Permanent=24 h/d
- 13-18 rds/m
- 11,5 – 30 KW
- Frequency inverter for low energy consumption

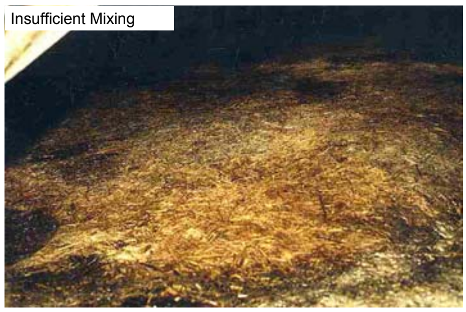


Top Mounted Mixer Lost

Flat Digester, Submerged Mixer



Submerged Mixer, Problem



Submerged Mixer, Problem

Corrosion, Abrasion

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Submerged Mixer, Problem

Complex repair and maintencance regarding personal security and emissions

Nowadays submerged mixer are used like disposables

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Intermediate Result

You must consider:

- Quality of the media (transported, mixed and stored)
  + structure, + viscosity, + abrasiveness,
  + temperature, + pressure, + pH-value, + stratification risk
- Changes in composition during AD of the media
- Quality of construction and technical equipment
  + acid protection, abrasion protection
- Dimension and Design of the equipment
  + reserve capacity, + sufficient internal cross section surface / volume, sedimentation zones
- Easy and safely maintenance and repair

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General Outline

- Designing failures
- Technical failures
- **Plant attendance and daily operation**
- **Data recording**
- **Minor repairs – safety during repairs**
- **General maintenance**

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Plant attendance and daily operation

Content

- Data recording
- Minor repairs – safety during repairs, example
- General maintenance – oil changes, lifetime expectance / warranties of equipment

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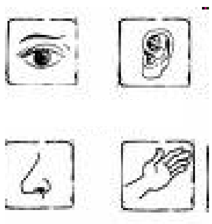
Plant attendance and daily operation



Use your senses !

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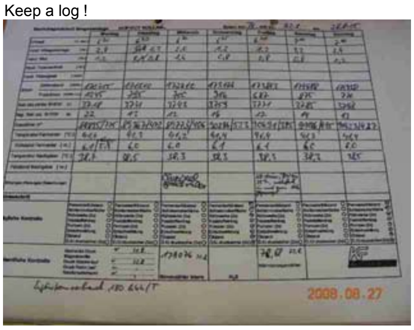
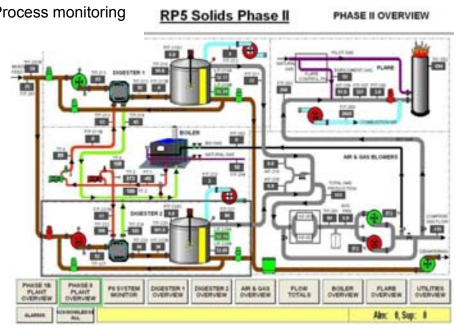
Plant attendance and daily operation

Keep a log !



Plant attendance and daily operation

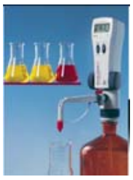
Process monitoring



Plant attendance and daily operation

Collecting data I

- FOS / TAC (similar to IA/PA)
  Monitoring of the fermentation process to predict digester problems by measuring two puffer capacities of the substrate.
- The amount of sulfuric acid is determined during titration. First the buffer capacity of inorganic carbon is depleted at pH 5 (TAC) and with reaching pH 4.4 the buffer capacity of the volatile solids is depleted (FOS). With the amount of depleted sulfuric acid TAC and FOS are calculated by an empiric formula.
- TAC: total inorganic carbon
- FOS: volatile organic acids
- Normally a critical value is reached if FOS/TAC is < 0,3. But the long term development has to be watched closely. Some plants working with energy crops may reach 0,4 to 0,6 without problems.



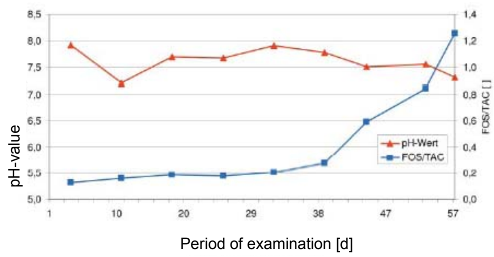
FOS/TAC (IA/PA)

Determination of FOS / TAC on side by the operator

FOS / TAC (IA/PA)

Date	Volume probe [ml]	pH-value	Acid consumption to pH 5 (TAC) amount A [ml]	Acid consumption from pH 5 to pH 4,4 (FOS) amount B [ml]	FOS [ml/l]	TAC [ml/l]	FOS/TAC
1.1.06	50	8,1	13,5	0,75	174	1350	0,13
2.1.06	50	8,1	13	0,75	174	1300	0,13
3.1.06	50	8,05	12,5	0,75	174	1250	0,14
4.1.06	50	8,04	12,75	0,75	174	1275	0,14
5.1.06	50	8,07	13	1	257	1300	0,20
6.1.06	50	8,15	12,5	0,75	174	1250	0,14
7.1.06	50	8,15	12,75	0,75	174	1275	0,14
9.1.06	50	8,1	12,75	0,75	174	1275	0,14
10.1.06	50	8,12	12,75	0,75	174	1275	0,14
11.1.06	50	8,07	13,25	0,75	174	1325	0,13
12.1.06	50	8,1	12,5	0,75	174	1250	0,14
13.1.06	50	8,2	12,5	0,75	174	1250	0,14
14.1.06	50	8,1	13	0,5	91	1300	0,07
15.1.06	50	8,1	13,25	0,75	174	1325	0,13
17.1.06	50	8,1	12,75	0,75	174	1275	0,14

FOS / TAC (IA/PA)



Source: Rieger und Weiland 2006, Biogas J. 4/06

Cautions on mixing food waste with manure Part I

When mixing different types of food waste as well as food waste with manure it is important to avoid an acid-base reaction. When this occurs there is a risk of emitting harmful gases, such as ammonia and hydrogen sulphide, in dangerous concentrations.

For example, adding a protein rich organic waste with a pH value between 8 and 9 to a substrate with a low pH value may cause H_2S emissions and/or CO_2 emissions. Adding nitrogen rich organic waste to a substrate with a high pH-value may cause NH_3 emissions.

In order to avoid this, mixing tanks should be emptied every day and the mixing tanks should be ventilated to draw off any gas. For mix tanks in buildings, gas monitoring equipment should be installed to measure ammonia and hydrogen sulphide.

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Cautions on mixing food waste with manure Part II

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Additionally, the following tests may be performed before mixing materials to get an idea as to whether there will be any dangerous reactions:

1. pH-Value of the waste sample.
2. Take 5 ml of the waste sample and add 0.5 ml of NaOH (50% concentration). Ammonia may be emitted. It can be detected by smell and a qualitative observation can be made.
3. Take 5 ml of the waste sample and add 0.5 ml Acetic Acid (concentrated). Foam and hydrogen sulphide may be created. You can asses the qualities and amount of foam and smell hydrogen sulphide if it is emitted.
4. To see the effects of mixing the waste with the substrate take 5 ml of the waste sample and add 5 ml of substrate from the mixing tank. Cover the cup with a sight glass. Place a pH strip or litmus paper under the glass. You can detect alkaline or acidic gas emissions by observing the litmus paper. If the gases are close to neutral the mixture should be relatively safe. Also, potential foaming issues can be detected.

Plant attendance and daily operation

Collecting data II

Sensors/actors (Field level)

Pressure transmitters

Temperature Sensors

Level limit switch

Flow rate transmitters

Sensors/Actors I

- Specification of the measurements components
  - High mechanical resistance to overload and aggressive media
  - High-precision (Δ p or Δ T) and long-term stability ceramic measuring cell (level)
  - Resistant to climatic changes (outdoor application) housing, with protection grade from IP65 to IP67
  - 4.20 mA (analog), digital, Profibus or RS485 output or input signal, with integrated overvoltage protection.
  - Certified to ATEX 1 GD EEx ia certification, FM and CSA
  - Stainless steel, aluminium or plastic

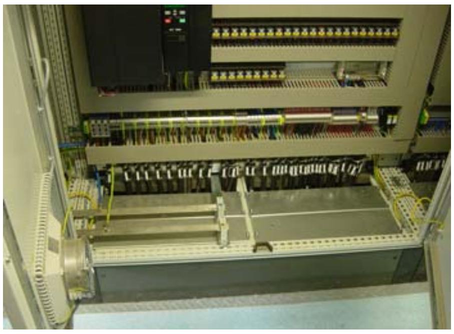
Sensors/Actors II

- Specification of Apparatus
  - Function (design Equipment)
  - High resistance to aggressive input substrate
  - Components, technical date, power?
  - Signal cable O/I potential-free or 4-20 mA or Profi-Bus or HART, RS485 CAN
  - Calculation of consumption and average power rate
  - Connection to the pipe systems or to the switch-board
  - Start up strategy with direct or Y- Δ or frequency inverter, emergency operation
  - Dimension of the cable → device size (fuse, switchboard)
  - Measure of the voltage, current, active-, passive-, apparent power etc.

Sensors/Actors III

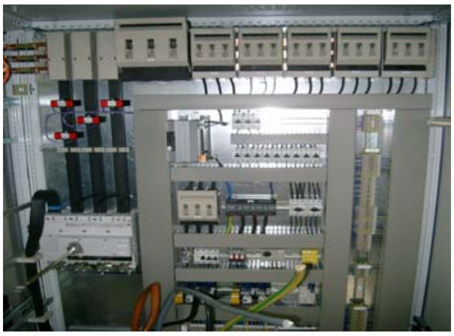
- Limit of field level (Switchboard)
  - The low voltage distributor device (connection of electrical consumers, TN-S system, L1/L2/L3/N/PE)
    - 400 V standard low-voltage network
    - 230 V network
    - 230 V UPS (uninterruptible power supply) network
    - 24 V direct current (apply to all measuring and control equipment)
  - Grounding, lightning protection, potential equalization
  - Power installations, (cable runs, power, low-voltage and signal cables will be separated min 30 cm)
  - Reactive current compensation device
  - Emergency device, (operation scenario)

Switchboard I

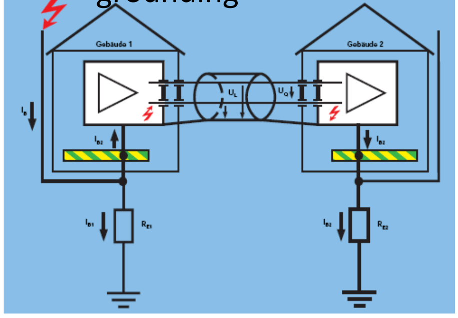


Switchboard II

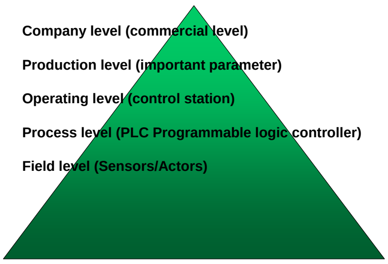
Switchboard III



Potential equalization, grounding



Data recording and processing, Levels



Company level (commercial level)

Production level (important parameter)

Operating level (control station)

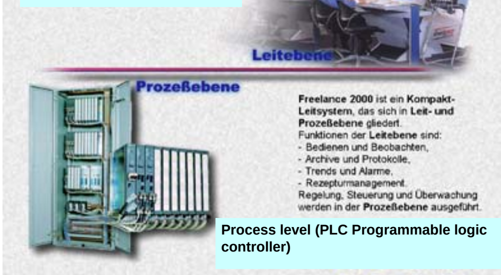
Process level (PLC Programmable logic controller)

Field level (Sensors/Actors)

(Piece of paper with observations)

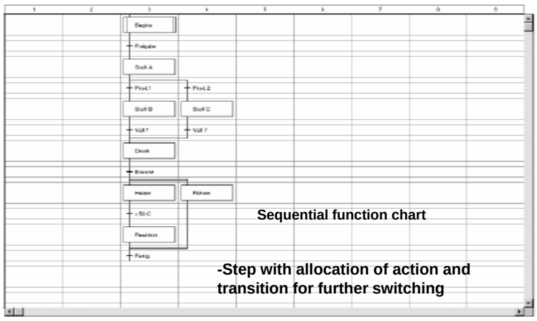
PLC and Control Station

Operating level (control station)

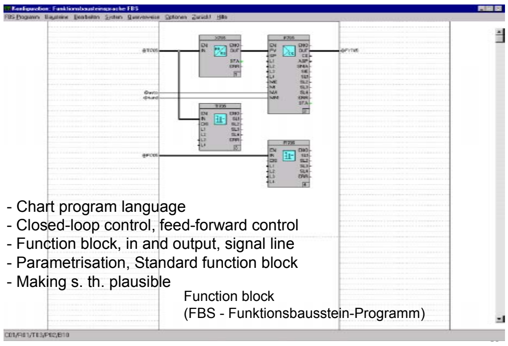


Process level (PLC Programmable logic controller)

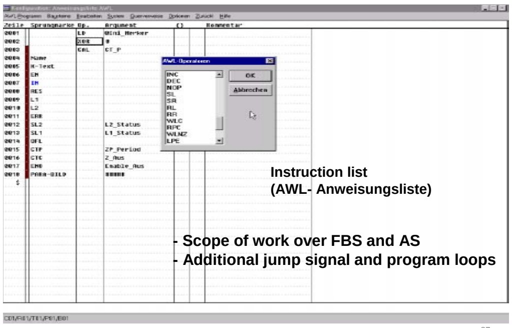
Programmable logic controller I



Programmable logic controller II



Programmable logic controller III



Operating level, Modes

- Process operation
  - Operating modes LOCAL (manual) / REMOTE (automatic)
    - <u>LOCAL:</u> components are controlled by manual switch device, emergency-off function still active, measuring points „Z"
    - <u>REMOTE</u>: components are controlled only over PLC and control station. Emergency function still active
    - <u>REMOTE (manual locked)</u>: dito, Programmed locks and limit-state switch-offs without any restriction
    - <u>REMOTE (manual not locked)</u>: dito, Programmed locks and limit-state switch-offs are not effective. (Only for trained and experienced operators)
    - <u>REMOTE (automatic operation),</u> driver is exclusively controlled and monitored from PLC.

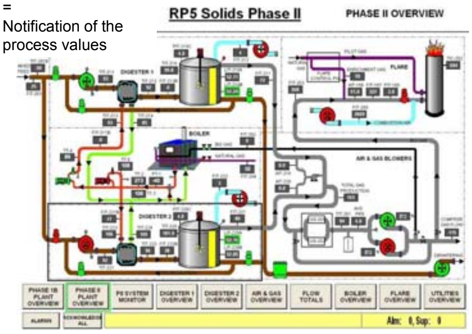
Operating level, Modes

Operating level, Modes

Operating level, Process monitoring

=

Notification of the process values



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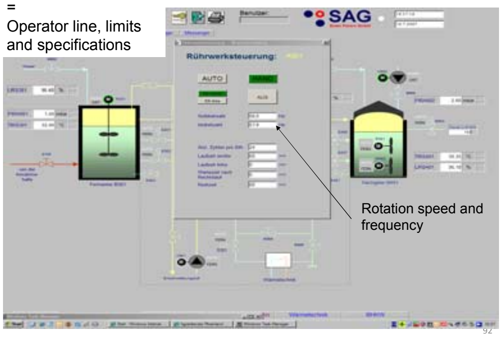
Operating level, Process monitoring

=

Operator line, limits and specifications



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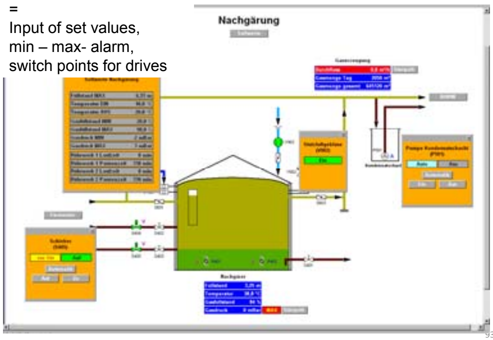
Operating level, Process monitoring

=

Input of set values, min – max- alarm, switch points for drives



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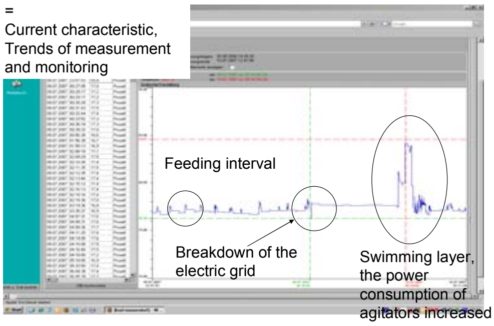
Operating level, Process monitoring

=

Current characteristic, Trends of measurement and monitoring



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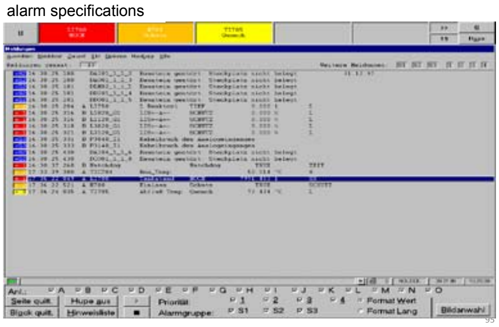
Operating level, Process monitoring

=

alarm specifications



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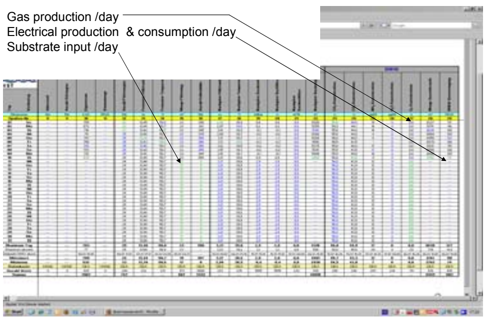
Production level, Log I

Gas production /day
Electrical production & consumption /day
Substrate input /day



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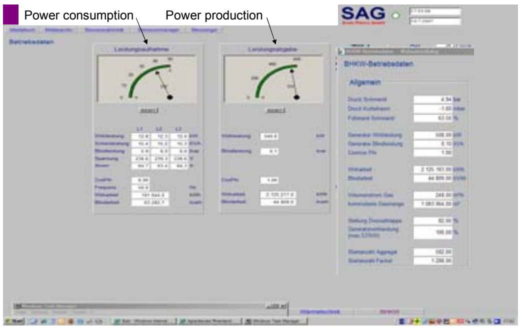
Production level, Log II

Power consumption Power production



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Minor repairs

e.g.

- Small leakage
- Replace wearing parts
- Oil change
- Engine calibration
- Replace broken parts

= anything outside the Digester
= anything outside a health-dangerous or explosive atmosphere

98

Minor repairs → Rotary lobe pump

Change of lobes

99

Minor repairs → Rotary lobe pump

100

Minor repairs → Rotary lobe pump

101

Minor repairs → Others

Replace Sealing

Broken Conveyor Rack

102

Serious repairs announce themselves

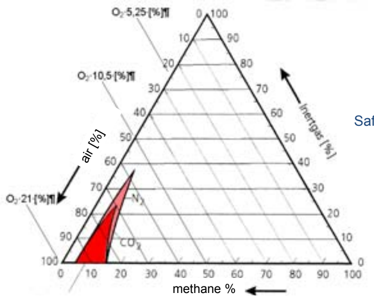
Serious repairs, because of....

Disregards

Insufficient technique

Repairs: SAFETY FIRST !

H2S ☠
NH3 ☠
CO2 ☠
CH4 💣



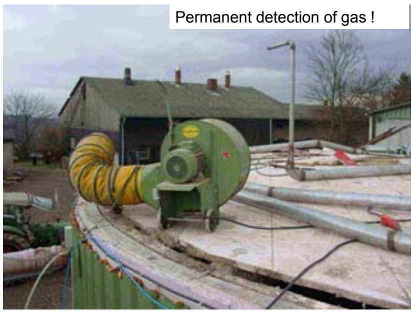
Safety during repairs

Explosion area:
Exceeding of 11,6 Vol% oxygen
and
between 4,4 Vol% methane (100% LEL) and
16,5 Vol% methane (100% UEL)

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

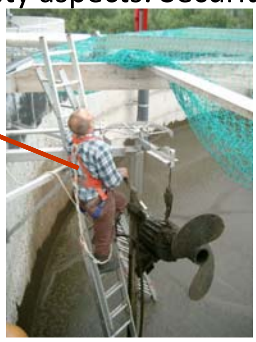
Safety aspects: Ventilation

Permanent detection of gas !



Safety aspects: Security

Safety Harness



Safety aspects: Risk appraisal

This looks risky

Removal of Sand in the digester

General maintenance
Check / Control of the biogas plant

Abkürzungen: "tgl."=täglich, "wtl."=wöchentlich, "mtl."=monatlich, "jhrl."=jährlich
"!" bedeutet: muss noch durchgeführt werden
"ok" bedeutet: wurde plangemäß durchgeführt
"-" bedeutet: wurde nicht durchgeführt
" " (leer) bedeutet: muß nicht durchgeführt werden

Kontrolle	01.04	02.04	03.04	04.04	05.04	06.04	07.04	08.04	09.04	10.04	11.04	12.04	13.04	14.04	15.04
Schlammoberfläche(tgl.)	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok
BHKW Ölstände(tgl.)	ok	ok	ok	ok	-	-	ok	ok	ok	ok	ok	ok	-	ok	-
Unter-/Überdruck-Sicherung(en)(tgl.)	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok	ok
BHKW Batterieflüssigkeit(mtl.)												-		ok	
BHKW Ladeluftkühler(mtl.)												-		ok	
BHKW Batterieladezustand(mtl.)												-		ok	
Systemdruck Heizung(wtl.)	ok							-			ok				
Kondensatschacht(wtl.)	ok							-		ok					
Rührwerk 1(tgl.)	ok	ok	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	ok	ok	ok
Rührwerk 1(tgl.)	ok	ok	ok	ok	-	-	-	-	-	-	ok	ok	ok	ok	-
Gasspeicher 1(tgl.)	ok	ok	ok	ok	-	-	-	-	-	-	ok	ok	ok	ok	-
Gasmotor 1(tgl.)	ok	ok	ok	ok	-	-	ok	ok	ok	-	-	-	ok	ok	-
Pumpe 1(tgl.)	ok	ok	ok	ok	-	-	ok	-	ok	ok	ok	ok	ok	ok	-
Hand-Schieber / Klappen 1(mtl.)															
Automatische Schieber / Klappen ...(wtl.)		-	ok							-	ok				
Gaswarnmelder 1(jhrl.)															
Rauchmelder 1(jhrl.)															
Strömungswächter 1(jhrl.)															
NOT - Aus 1(jhrl.)															

Kontrolle	16.04	17.04	18.04	19.04	20.04	21.04	22.04	23.04	24.04	25.04	26.04	27.04	28.04	29.04	30.04
Schlammoberfläche(tgl.)	ok	ok	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	ok	ok	ok
BHKW Ölstände(tgl.)	-	-	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	-	ok	ok
Unter-/Überdruck-Sicherung(en)(tgl.)	ok	ok	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	ok	ok	ok
BHKW Batterieflüssigkeit(mtl.)															
BHKW Ladeluftkühler(mtl.)															
BHKW Batterieladezustand(mtl.)															
Systemdruck Heizung(wtl.)			ok							ok					
Kondensatschacht(wtl.)		ok							-	ok					
Rührwerk 1(tgl.)	ok	ok	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	ok	ok	ok
Rührwerk 1(tgl.)	-	-	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	-	ok	ok
Gasspeicher 1(tgl.)	-	-	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	-	ok	ok
Gasmotor 1(tgl.)	-	-	-	ok	ok	ok	ok	ok	-	ok	ok	ok	-	ok	ok
Pumpe 1(tgl.)	-	-	ok	ok	ok	ok	ok	ok	-	ok	ok	ok	-	ok	ok
Hand-Schieber / Klappen 1(mtl.)			-	ok											
Automatische Schieber / Klappen ...(wtl.)			ok							ok					
Gaswarnmelder 1(jhrl.)															
Rauchmelder 1(jhrl.)															
Strömungswächter 1(jhrl.)															
NOT - Aus 1(jhrl.)															

Maintenance Plan CHP

To avoid:
e.g. broken Piston-Rods,
worn-out Valves,
blocked Heat Exchangers

Information Maintenance plan:

Intervals at/after	Maintenance stages		Execution
50 Oh (operating hours)	E1	After commissioning and E5, E6, E7	Authorized trained stuff
Daily	E2	Daily check routine	Operator
1,500 Oh	E3	Inspection	Authorized trained stuff
3,000 Oh	E4	Extended inspection	Authorized trained stuff
12,000 Oh	E5	Intermediate overhaul	Authorized trained stuff
24,000 Oh	E6	Extended intermediate overhaul	Authorized trained stuff
48,000 Oh	E7	Major overhaul	Authorized trained stuff

Details of the Maintenance plan:

Approx. 50 working hours after first commissioning resp. recommissioning an oil change is necessary. Subsequently the oil have be to changed at the given interval.

The given periods are average values for normal operating conditions and approved maintenance. These are standard values without guarantee commitments. If there are stronger conditions it can be necessary that the maintenance interval must be shorter. Stronger conditions are caused by frequently starts, long working hours at low power level, extremely fast and frequently load alternation and frequently work with overload and bad gas quality.

Under special conditions (part load operation) the maintenance interval can be longer.

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Pro2 – maintenance plan for motorplants type 620

Desciption of activities	E1	E2	E3	E4	E5	E6	E7
1. management by operator/client							
Visual check of the total plant **(daily)**							
Check display instruments **(daily)**							
Check vibrations **(daily)**							
Check running noise **(daily)**							
Check reattachments **(daily)**							
Check impermeability **(daily)**							
Keep of the operating journal **(if necessary)**							
Trouble shooting after co-ordination with Pro2 **(if necessary)**							
Message to Pro2 after operation disturbance **(if necessary)**							
Message to pro2 after operational abnormalities **(if necessary)**							
Transfer journal to Pro2 **(if necessary)**							
Receipt goods (oil, spare parts) **(if necessary)**							
Check lube oil level and refill oil if necessary/**(daily)**							

General maintenance

Oil change

periodically analysis of the oil (pH-value, sulfur)

The interval of oil change depends on
→ the concentration of sulfur in the gas / oil
→ the buffer capacity of the inserted oil

Every operator has to determine the necessary interval of oil change of his engine by himself!

2. IC gas-engine							
Visual check of the total plant	x	x	x	x	x	x	x
Test an function run	x		x	x	x	x	x
Checking the lube oil level	x	x	x	x	x	x	x
Checking the coolant level	x	x	x	x	x	x	x
Leak check on engine, lines and engine drain	x	x	x	x	x	x	x
Checking the engines for vibrations and running noises	x	x	x	x	x	x	x
External visual inspection	x	x	x	x	x	x	x
Checking the valve clearance	x		x	x	x	x	x
Checking the starter battery	x		x	x	x	x	x
Checking the spark plugs			x	x	x	x	x
Checking the engine venting feature					x	x	x
Changing the lube oil filter	x			x	x	x	x
Checking and record operational data and performance characteristics	x	x	x	x	x	x	x
Replacing the air filter inserts, cleaning the air filter housing					x	x	x
Checking ignition timing					x	x	x
Checking the governor			x	x	x	x	x

Desciption of activities	E1	E2	E3	E4	E5	E6	E7
Checking crank case pressure			x	x	x	x	x
Checking, cleaning and adjusting gas-mixer-system			x	x	x	x	x
Checking the pick up (ignition, rpm, electronic controler)					x	x	x
Checking the engine mount					x	x	x
Checking the starter and ring gear					x	x	x
Checking, cleaning the coolant and exhaust gas heat exchangers					x	x	x
Replacing cylinderheads					x	x	x
Cleaning the combustion compartments, checking the cylinder liners					x		
Replacing cylinder liners						x	x
Checking and cleaning the coolant controler					x	x	x
Replacing the coolant hoses and pipe connectors					x	x	x
Cleanning the lube oil cooler						x	x
Checking and leaning the intercooler						x	x
Checking and cleaning the cooling pump						x	x
Checking the valve mechanism						x	x

Replacing the conn. rod bearings,						x	x
Pleuelbuchsen prüfen, ggf. erneuern replacing if necessary						x	x
Checking fittings and regulators						x	x
Replacing pistons						x	x
Replacing piston rings						x	x
Checking the engine alignment andcoupling							x
Measuring the crankshaft							x
Replacing the main bearing							x
Replacing the crankshaft sealing rings							x
Checking and cleaning geartrain and control system							x
Checking camshaft, replacing if necessary							x
Replacing camshaft bearing							x
Replacing lubeoil pump							x
Cleaning, checking the oil pressure holding valve							x
Checking an cleaning the turbocharger	**Regard manufacturers operating Instructions, regard documentation,**						

Desciption of activities	E1	E2	E3	E4	E5	E6	E7
3. Generator							
Check cable conetions					x	x	x
Lubrication of the generator bearings	**Regard manufacturers operating Instructions, regard documentation**						
Adjust Cos.-Phi-Regelung controler				x			x
Adjust voltage controler				x			x
4. Gasleitungssystem							
Complete leak check				x			x
Adjust gas-mixer-system				x			x
Adjust zero-pressure-controller				x			x
Check the shut-off valves				x			x
Changing gasfilter	x			x			x
Check gas-pressure-monitoring				x			x
Clean deflagration-protection-system				x			x

Operation and Maintenance

• Keep access free

• Safe Stands

Operation and Maintenance

• Safety equipment functioning well

Operation and Maintenance

- Maintenance on time

Maintenance expired

Thank you for your attention