Safety Engineering

Designing failure, Technical failure, Accidents

安全工程

设计失败，技术失败和意外事故

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- Choosing technology equipment under safety aspects
  选择安全的技术装备
- Designing failure
  设计失败
- Technical failure
  技术失败
- Accidents
  意外事故


> 1 m


> 2 m

Choosing technical equipment under safety aspects
选择安全的技术设备

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Gas-Pipes
通气管

- PVC-KG pipes are not admissible, since their design strength corresponds to a maximum of 0.5 bar.
  PN 1 is necessary!
  不能用PVC-KG管，因为它们的设计强度仅为0.5 bar. 必须用PN1管。
- Generally, steel pipes have to be used. Plastic pipes may be used outside of closed rooms.
  Plastic pipes have to be protected from mechanical and thermal damage.
  一般来说，必须要用钢管。塑料管可以用在外层，但是要防止机械和热力损害。
- PVC, PE, stainless steel or black steel
  PVC,PE,不锈钢或者黑铁（用生物气干燥后）
  (after drying the biogas)

Choosing technical equipment under safety aspects
选择安全的技术设备

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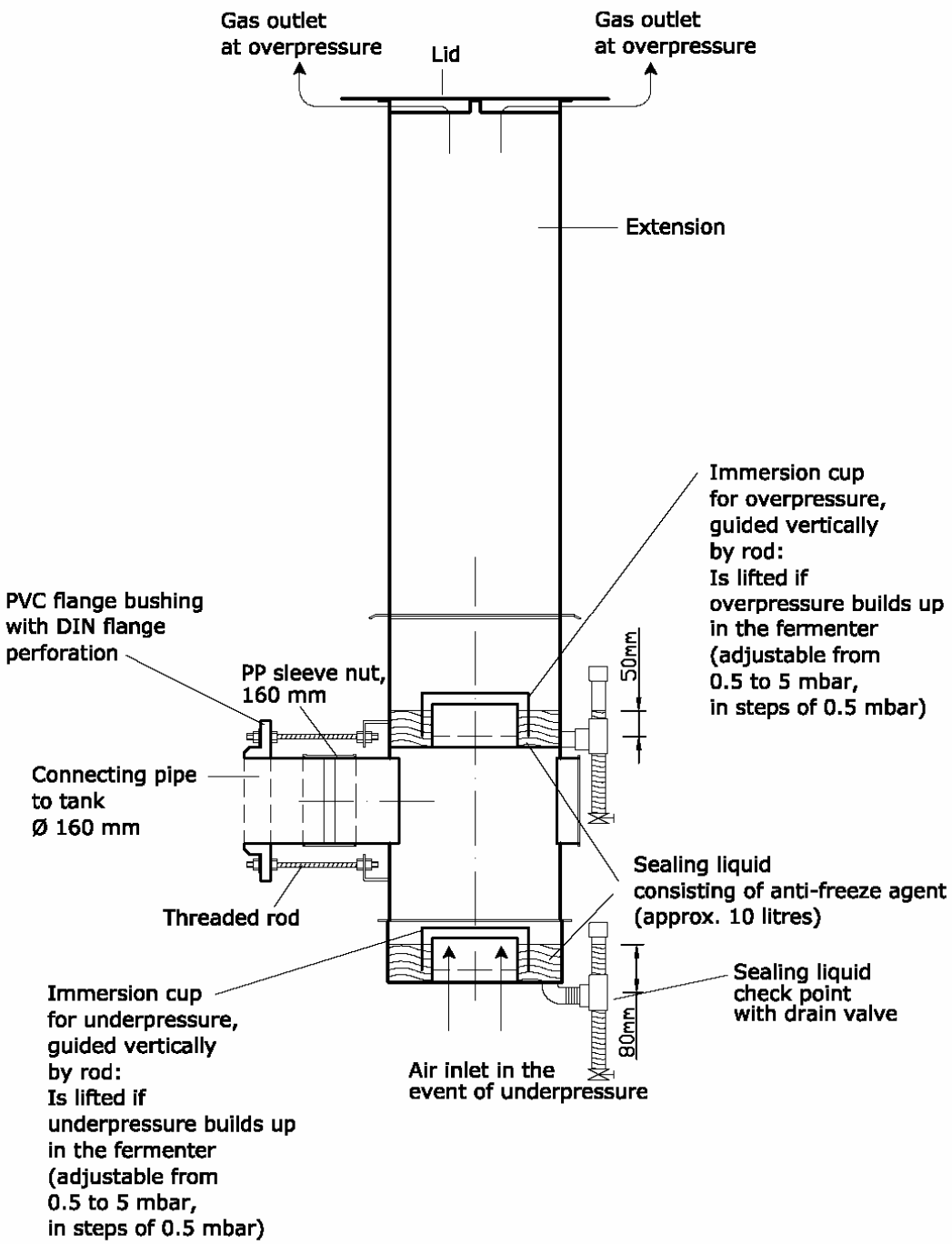
Overpressure / vacuum valve hydraulic (measuring pressure)
压力过大/液压真空管（测量压力）

Mechanic device (reacting on increasing volume)
机修设备（体积有所增加)



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Principle of MT overpressure / vacuum valve with extension MT

mT过压原理/带有MT延伸部分的真空阀

Choosing technical equipment under safety aspects
选择安全的技术设备

Solid input device with piston pump equipped with 3 valves (PlanET)
用于输入固体的带有3个阀门的活塞泵

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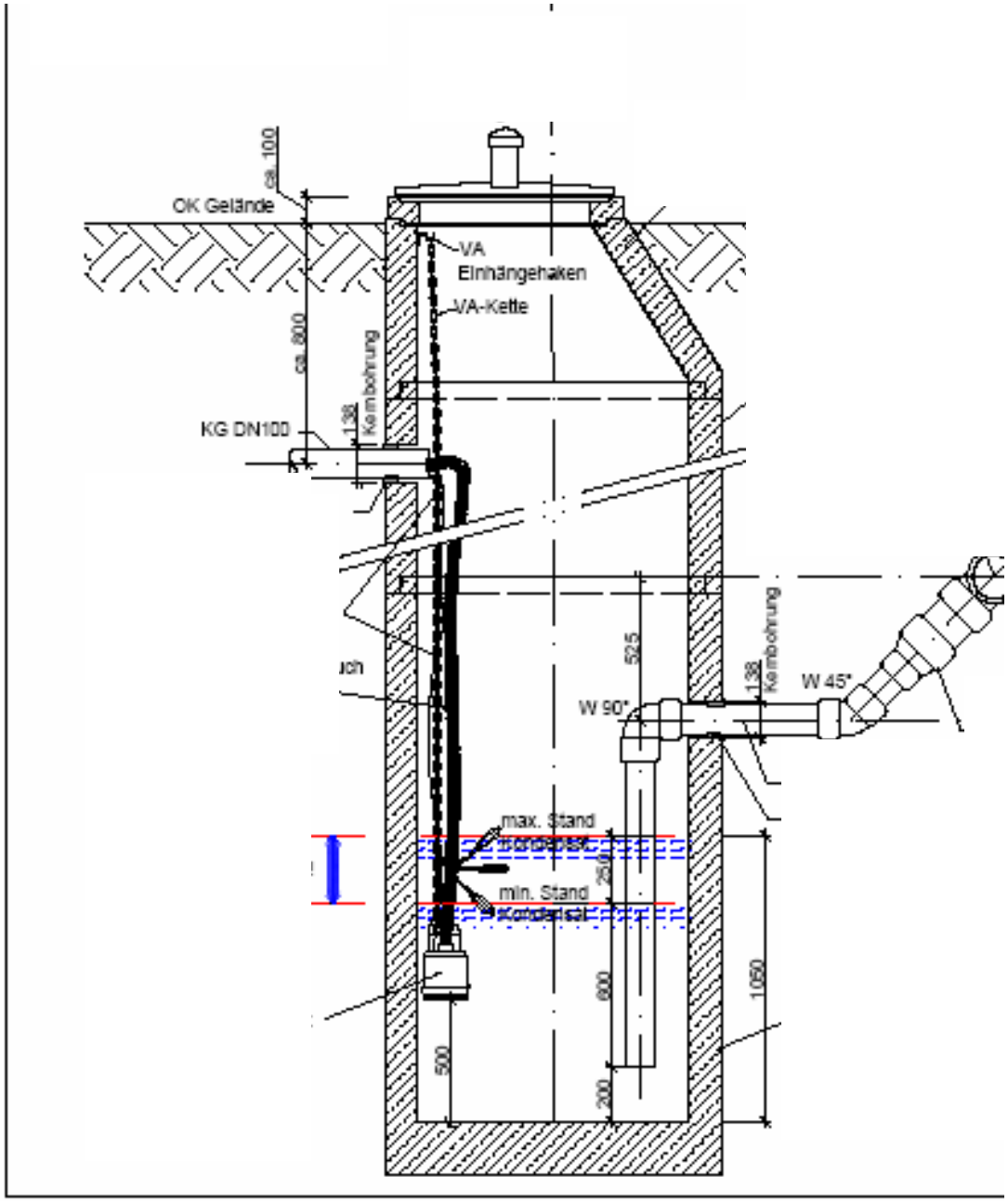
Fixing gas holder roof

固定的储气罐顶部



condensate tank without gas-emission

无气体排放的冷凝容器

→no ex-zone

→无前区

Choosing technical equipment under safety aspects
选择安全的技术设备

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CHP-room
CHP房间

- Compressor → Ex-zone 1
  压缩机→ 前区1
- Monitoring compartment air
  控制隔间空气
  lower explosive limit **LEL**: 4,4% methane
  最低爆炸极限LEL: 4.4%甲烷
  upper explosive limit **UEl** : 16,5% methane
  最高爆炸极限UEI: 16.5%甲烷
  pre-alarm 20% LEL
  预警器 20% LEL
  main-alarm 40% LEL
  主警器 40% LEL
  (all electrical devices have to be switched off)
  必须关掉所有的电器设备
- Air input / output
  空气输入/输出
- ventilated input
  通风输入
- ventilated output → explosion protection necessary
  通风输出→必须进行防爆保护
- Alarm
  警报器

Biogas pipe
→ stainless steel, PE
生物气管
→ 不锈钢，PE

Substrate pipe
→ PE
底物输送管
→ PE

Waste Water
→ PVC
废物废水
→ PVC

Choosing technical equipment under safety aspects
选择安全的技术设备

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Biogas plants handle substrates that are hazardous to water. Contamination and other disturbance of water has to be avoided (WHG, VAwS, JGS)

生物气工厂处理水体有毒的底物基质，避免污染物和其他水体干扰物。

- Site: distance to water >20 m

  场地：和水体间距大于20 m
- Substrate pipes need to be double-walled or constructed as suction pipe

  底物基质输送管必须是双壁或者是中空管构造。
- Tanks: waterproof, they have to be double walled or equipped with a welded plastic liner

  容器：防水，必须是双管或者有焊接的塑料内层
- have to be protected from mechanical damage

  必须防止机械损伤
- A wall has to provide the volume to collect the content of the biggest tank

  必须有足够的体积来保证最大容器的容量
- Pipes: Depending on the substrate, pipes have to be installed above ground or double walled

  管道：取决于底物基质，管道必须置于地面上或者是双管
- Storage capacity > 6 month (JGS)

  存储容量 > 6 个月（JGS)

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选择安全的技术设备

VAwS

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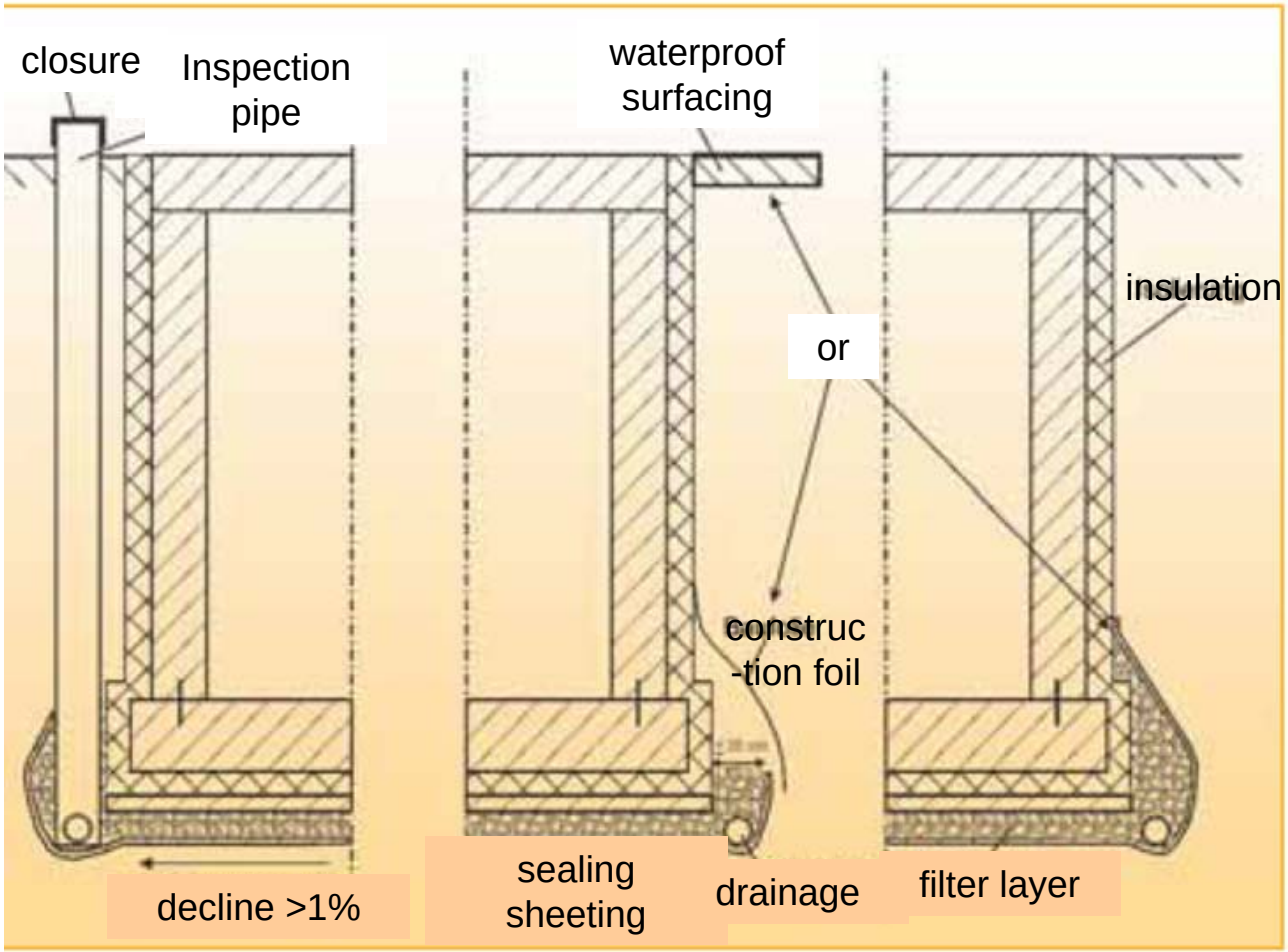

Source: Biogashandbuch Bayern

Folie16

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Welded plastic liner and monitoring pipe

焊接塑料内层
和监测管

Choosing technical equipment under safety aspects
选择安全的技术设备

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Tanks and other devices has to be protected from mechanical damage

必须防止容器和其他的设备受机械损伤

Designing failure
设计失败

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Distance of the CHP container to windows is too small

CHP容器和窗户之间的距离太小

Designing failure
设计失败

Input:	输入	
Potato Raw Material	土豆原材料	97.610 t/a
Starch	淀粉	4.495 t/a
Oil	油	636 t/a
Potato Sludge	土豆污泥	6.583 t/a
Sum	总和	109.324 m³/a
Total Solids:	总固体	
Potato Raw Material	土豆原材料	20,0 % Input
Starch	淀粉	60,0 % Input
Oil	油	100,0 % Input
Potato Sludge	土豆污泥	30,0 % Input
Sum	总和	22,7 % Input
Volatile Solids:	挥发性固体	
Potato Raw Material	土豆原材料	90,0 % TS
Starch	淀粉	90,0 % TS
Oil	油	95,0 % TS
Potato Sludge	土豆污泥	90,0 % TS
Hydraulic Retention Time	水力停留时间	**41,7 days**
Digester Volume (net)	消化体积（net）	**12.500 m³**
Organic Load Rate	有机物负荷率	**4,9 kgVS/m³/d**
Specific Gas Production Rate:	气体产生率	
Potato Raw Material	土豆原材料	600 m³/t VS
Starch	淀粉	600 m³/t VS
Oil	油	1.000 m³/t VS
Potato Sludge	土豆污泥	700 m³/t VS
Biogas Production:	生物气产量	
Potato Raw Material	土豆原材料	10.541.880 m³/a
Starch	淀粉	1.456.380 m³/a
Oil	油	604.200 m³/a
Potato Sludge	土豆污泥	1.244.187 m³/a
Methane Content:	甲烷含量	
Potato Raw Material	土豆原材料	58 %
Starch	淀粉	60 %
Oil	油	65 %
Potato Sludge	土豆污泥	62 %
Sum	总和	59 %
Calorific Value:	热值:	5,9 kWh/m³
Biogas Production:	生物气产生	13.846.647 m³/a
		1.581 m³/h
Biogas Power:	生物气电力	9.306 kW
Engine Power (installed) (3 Gas Engines)	发动机电力 （3个气体发动机）	10.500 kW
Engine Power (electric)	发动机电力 （电）	4.200 kW
Produced Energy (electric)	产生能量 （电）	32.608.977 kWh/a
Engine Power (thermal)	发动机电力（热）	5.250 kW
Produced Energy (thermal)	产生能量 （电）	40.761.222 kWh/a

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Energy calculation
能量计算

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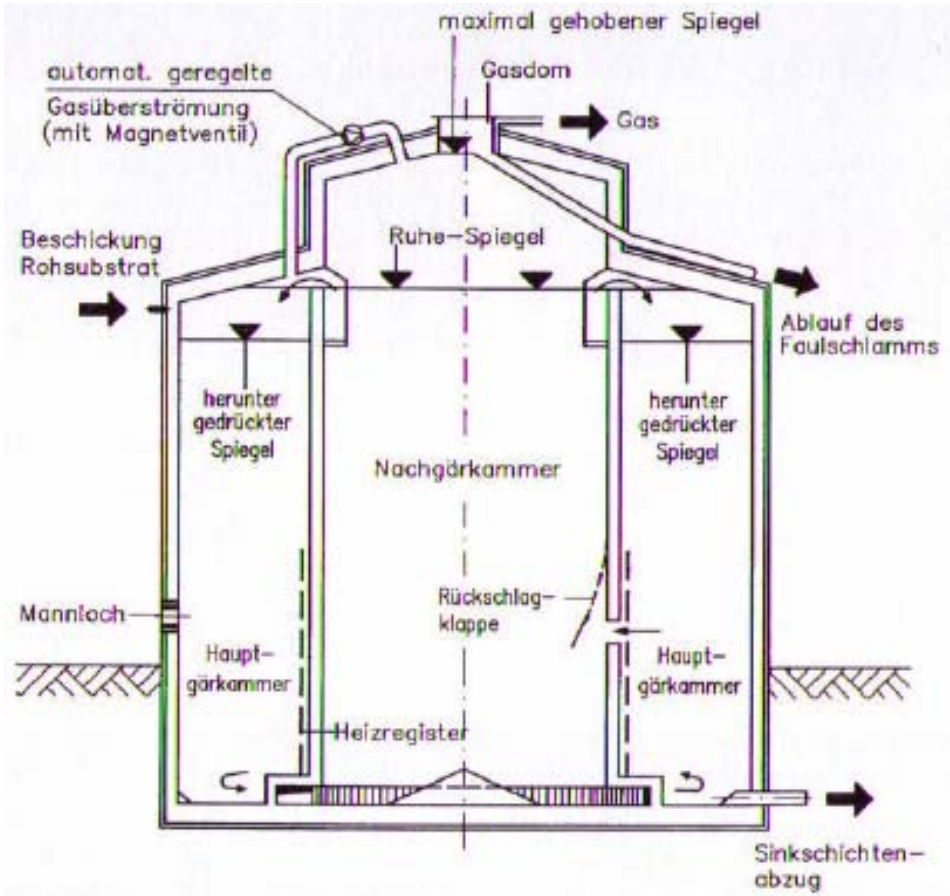
Engine Power (thermal)	发动机电力（热）	5.250 kW
Produced Energy (thermal)	产生能量 （热）	40.761.222 kWh/a

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	19522,0	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
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%

Designing failure
设计失败



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

如果没有游动层，沼气池无法使用

Source: Eder u. Schulz 2006, Biogas Praxis

Designing failure
设计失败

Designing failure
设计失败

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Designing failure
设计失败

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Designing failure
设计失败

Designing failure
设计失败

Designing failure
设计失败

Technical failure
技术失败

Broken shaft of the central stirrer
断轴中央搅拌器

Technical failure
技术失败


Technical failure
技术失败

Technical failure
技术失败

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技术失败


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Technical failure
技术失败

Technical failure
case study 355
技术失败实例研究 355

- Gas holder roof collapsed:
  储气罐顶倒塌
- The secondary digester was not equipped with a safety device
  二级沼气池没有配备安全装置
- Starting operation without qualified company
  没有资历的公司进行运作
- The digester was equipped with a fracture disk
  沼气池的盘片损坏
- Condensate tank < 70 mbar
  冷凝槽 < 70 mbar
- The biogas flare did not switch off automatically
  沼气照明没有自动关掉
- The vacuum device in the gas pipe was not adjusted.
  通气管道真空装置未作调整

case studie 401
实例研究 401

-Problem: odor emission

问题：气味排放

-implementation of the horizontal tank as primary digester

主消化卧式贮罐安装

-elongation of the retention time

延长停留时间

-improvement of the mixing

改进混合性能

→digestate is better decomposed and less smelling

→消化物分解更好，气味更少

→mixing tank should be equipped with a cover

→搅拌罐应配备顶盖

→improvement of the storage tank (elongation of the conducting pipe

→蓄水池的改进（延长导引管）

→installation of a biogas flare

→生物气燃烧装置

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