Health & Safety Training – LFG - & Biogas

ACRONA Systems Ltd., CH - Aarau

in Celerina 8.VII. 2009

Wolfgang H. Stachowitz

DAS – IB GmbH, LFG- & Biogas - Technology, Kiel

DAS – IB GmbH
LFG - & Biogas - Technology

Biogas-, Sludge gas and Landfill gas technology:

- Consulting, planning, project management
- Training of system operators
- Expert i.a. in accordance with Article 29a of the Federal Immission Control Act; officially appointed and sworn expert at the "IHK zu Kiel"

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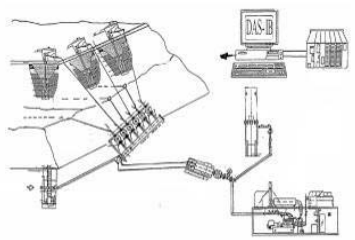

July 8 th 2009

Saftey Trainig & schooling LFG - and Biogassystems esp. microgas turbines - at Celerina, Switzerland

ACRONA SYSTEMS Ltd.

complete english ppt - presentation version as pdf - file (3240 kB)

http://www.das-ib.de/english/actual.htm

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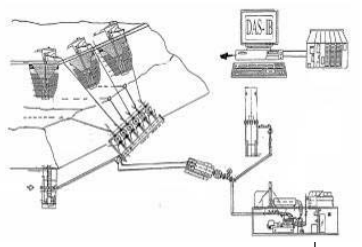


Work / job health and safety – overview of the day

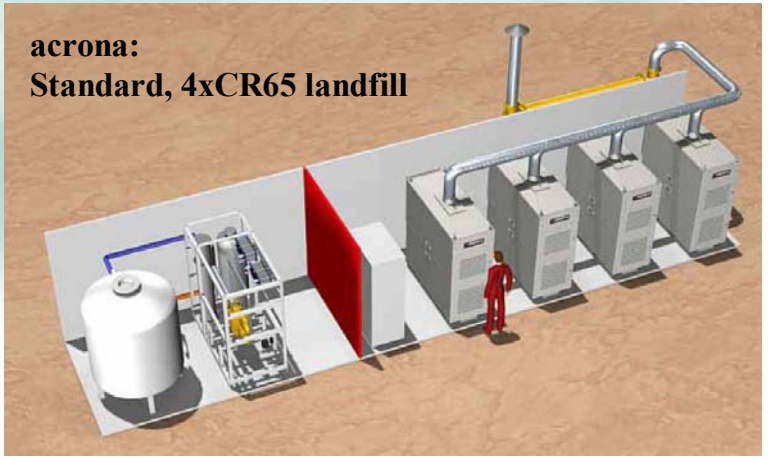
a) The formation of biogas and danger sources, risks and protection

b) Legal foundations

c) Examples of damage including explanations of the causes and possible remedial / corrective measures

d) Examinations, ignition sources, assessments, …

e) CE requirements



Work / job health and safety

A)

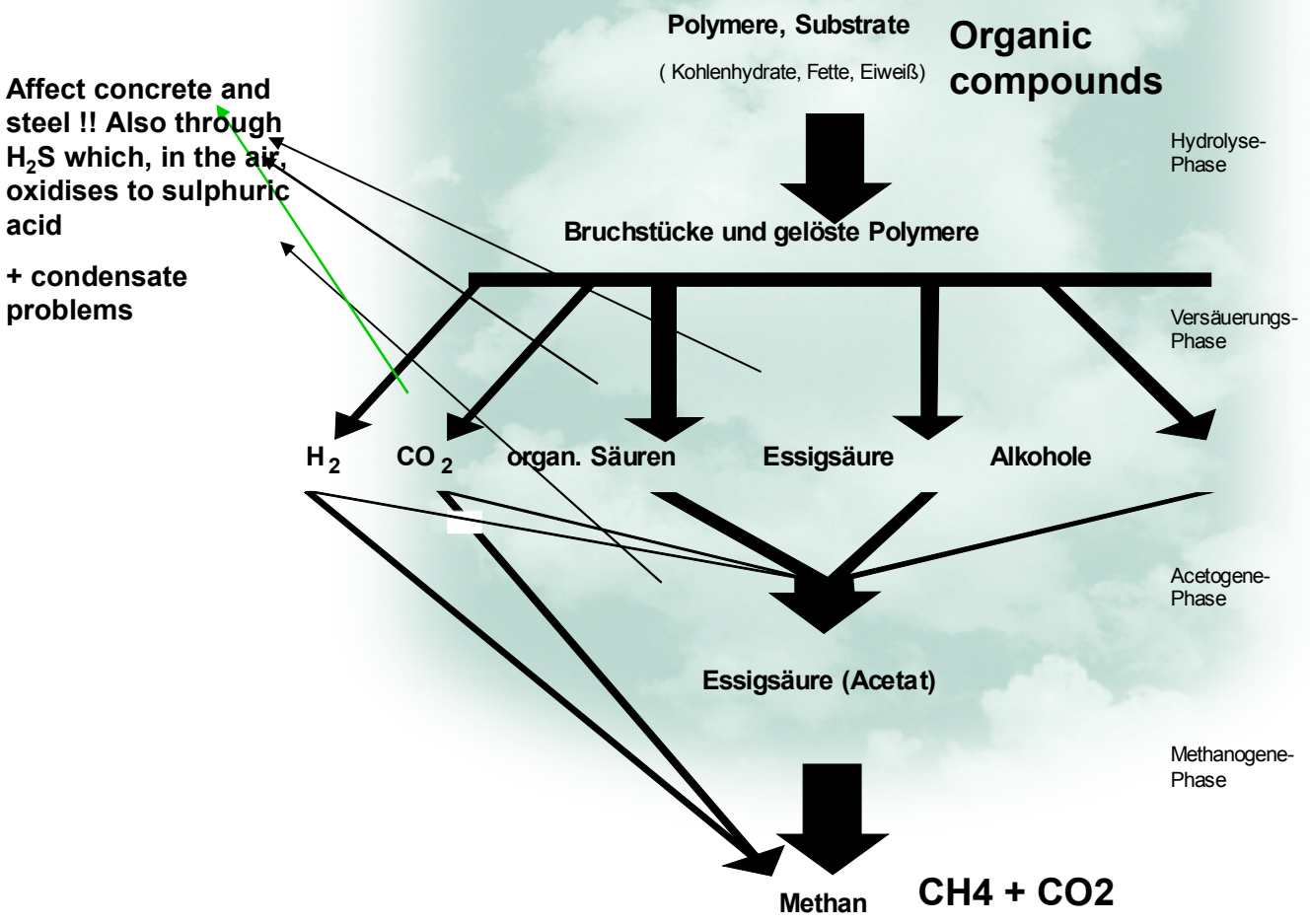
The formation of biogas

and

danger sources, risks and protection

.

Formation / phases of biogas formation



Formation of the biogases

The landfill gas composition changes in the course of time. Biogases in the digester (continuous operation) do not change. Shortly after deposition, aerobic conditions predominate near the surface. Later on, the individual degradation stages establish successively, until all stages are in an equilibrium in the fourth phase (stable alkaline fermentation).

At that moment, the landfill gas (LFG) consists of 55 % to 60% by volume methane and 40% to 45% by volume carbon dioxide. During the following decades, further phases will supervene.

The biogas will then consist of 50 to 70% by volume methane and 30 to 50% by volume carbon dioxide, and of traces of hydrogen sulphide (up to 20,000 ppm), hydrogen (< 1% by volume), ammonia (< 2% by volume) and water vapour / condensate (< 2 %– 7% by volume).
Approx. 50% by volume CH_4, e.g. for maize.

The higher, the warmer: thermophilic

Humidity and heat

Mesophilic: 30 / 32 to 42 °C most of the biogas plants and landfills // process-stable

Thermophilic: approx. 43 / 50 - 55 / 57 °C Biogas plants for the reduction of germs - > The gas yield is higher but more heat energy is required and sensitivity during malfunctions and breakdowns (ζ, Substrate ..)

? Optimum ?

Without heat (BGPs with heating system / insulation) and humidity (BGPs, e.g. dung or rainwater as the carrier) the necessary bacteria will not "function" and the degradation process will be interrupted - > mummification

It is a basic principle that the higher the ambient temperature, the faster the course of chemical reaction.

Limit: L. Pasteur

Components of the biogas

As regards both main components of the biogas, the following substance-specific details can be provided:

Methane (CH_4) is an odourless, non-toxic, colourless, energetic gas which is lighter than air. In concentrations between (4.4) / 5 – 15 (16.5) % in the air, it forms an explosive mixture. **Density 0.7 kg / Nm3**

Carbon dioxide (CO_2) is an odourless, colourless, non-combustible gas. A CO_2 concentration of 8-10% in air causes headache, vertigo, unconsciousness and respiratory paralysis in human beings or may even be lethal. As it is denser than air, it collects at ground level, in particular in ditches and pits. **Density 1.98 kg / Nm3 - > shafts !**

LFG: As far as **further components** are concerned, it can be said that, in fact, more than 100 components were detected, but that, in their entirety, they corresponded to less than a share of 1%, based on the dry landfill gas.

Hydrogen sulphide

Hydrogen sulphide (H_2S): personal health & safety

Operating limit values 5 ppm = 7 mg/m^3 = 1 / 2,000% by vol. and ex at > 4.3% by vol. to 45.5% by vol.

Experts have begun investigating the reasons for the disaster in a **biogas plant in Rhadereistedt near Zeven in Germany (district of Rotenburg)**. A police spokesman says that the experts are to examine the plant and the chemical composition of the processed substances. In the course of the accident on 8 November 2005, **four people died from the inhalation of highly concentrated hydrogen sulphide.**

The helpers were able to enter the area with heavy protective respirators only. Photo: zz

Hydrogen sulphide

Hydrogen sulphide (H_2S): personal health & safety

Operating limit values 5 ppm = 7 mg/m^3 = 1 / 2,000 % by vol. and ex at > 4.3% by vol. to 45.5 % by vol.

The following symptoms in human beings were assigned to varying concentrations (**in ppm**) already after a relatively short exposure period:

0.003 - 0.02	- noticeable odour
3 -10	- clearly unpleasant odour
20 - 30	- strong foul smell of rotten eggs
30	- obnoxious sweetish putrid smell
50	- eye irritation and conjunctivitis
50 - 100	- irritations of the respiratory tract
100 - 200	- loss of the sense of smell
250 - 500	- toxic pulmonary oedema, cyanosis, haemoptysis, pneumonia
500	- headache, uncoordinated movements, vertigo, stimulation of the respiration, weakness of memory, loss of consciousness ("knock-down")
500 - 1000	– apnoea, immediate collapse, most severe nerve injuries, arrhythmic heart action, death.

Physiological damaging effects

Physiological damaging effects include poisoning effects (toxic = based upon poisoning) through certain gas components (carbon dioxide (CO_2), odourless, > 10 Vol % in air lethal; hydrogen sulphide (H_2S), strongly odorous, "rotten eggs" up to < 0.1 Vol % in air, odourless and lethal above this value; carbon monoxide (CO), faintly odorous < 0.5 Vol % < in air lethal or suffocation symptoms (oxygen content < 14 Vol %, critical value approx. 19 Vol %)) on human beings , animals and plants. Among others: danger of suffocation as a result of air displacement in basements, shafts or for example in border areas of mine landfills at atmospheric inversions. Physiological damaging effects directly threaten human life.

Toxicology and effects on the environment

Chemical damaging effects

Among the chemical damaging effects, mainly the occurrence of corrosion damage on gas-containing plant components (also containers) and on gas utilisation plants (here in particular gas motors) should be mentioned. The causes are halogens (chlorine and fluoric compounds) in landfills, organic silicon compounds and more and more sulphur in BGPs.

BGPs: organic acids - > water vapour - > condensate CORROSION!
CO_2: carbonation of reinforced concrete.
Sulphates: steel-corrosive
Hydrogen sulphide: corrosive - > condensate paths

Coatings < - > stainless steel < - > glass fibre reinforced plastic < - > HDPE

Biological desulphurisation!

Source: öbuv – Martin Paproth
Damage at the concrete platform structure

Condensate shafts

Operation and safety

Operation: filling levels / level indication MIN - / MAX - alarms

Clearance measurement: CH4, CO2, O2 and H2S

Ventilation device down to the bottom of the shaft (with a fuse) because of the displacement of CO_2

Ladders or climbing iron paths down to d < 5 m

Feeding devices (d >5m): tripod

Rescue lifting device with safety rope, safety harness, form A, and drop absorber

tripod for the attachment of the abseil and rescue devices

Pers. safety: O_2 > 20% by vol., CO_2 < 0.5% by vol., CH_4 < 0.5% by vol., H_2S < 5 ppm (operating limit values) - > portable ex- and continuously-measuring multiple gas warning device

Freely portable respirator and ex- hand lamp

2nd person always remains outside of the shaft

Personal safety,
Appendix to the explosion protection document

Personal safety:

Oxygen (O_2): < 17% by volume oxygen deficiency, only below reduction of the capacity to unconsciousness and death at approx. 6 – 8% by volume, therefore > 20% by volume

Carbon dioxide (CO_2): Maximum working-site concentration 5000 ppm = 9,100 mg/m^3 = 0.5% by volume, odourless; first adverse effects and damages from 1% by volume onwards

Methane (CH_4): 100 % LEL, ex = 4.4% by volume; limit value: 20% LEL = 0.9% by volume

Hydrogen sulphide (H_2S): formerly: maximum working-site concentration 10 ppm = 14 mg/m^3 = 1 / 1000% by volume and ex at > 4.3% by volume to 45.5% by volume, **new operating limit values: max. working-site concentration 5 ppm**

See in Germany: TRGS 900 (Technical Rules for Hazardous Substances) for "former" max. working-site concentrations and new operating limit values

For further information: **http://www.hvbg.de/d/bia/gestis/stoffdb/index.html**

Ternary (three component) diagram, atmospheric

For the explosion area methane / air / C02- N2 - mixture

Acc. to Tabasaran / Rettenberger (UBA – Forschungsbericht 12/1982, Nr. 10302207 Teil1)

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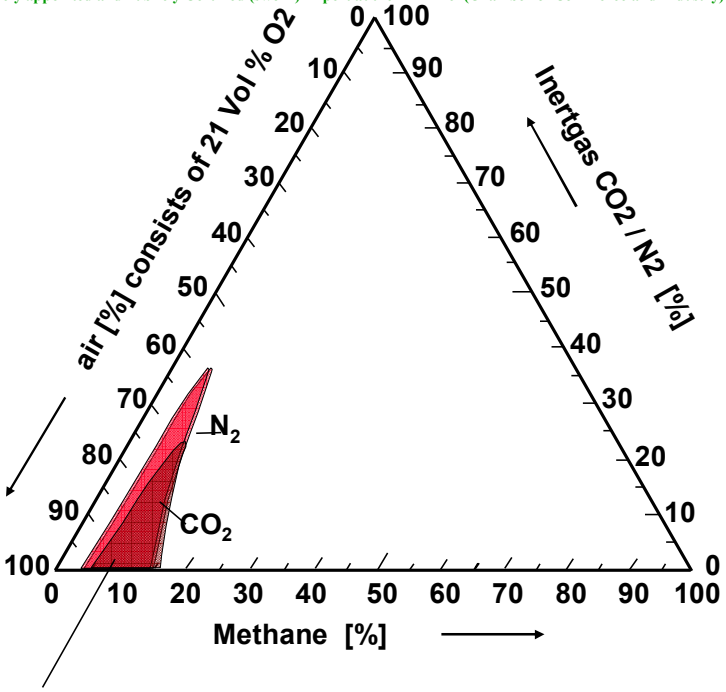
Biogas, sewage gas and landfill gas technology:
- Consultation, planning, projecting
- Training of operating personnel
- Expert services (among other things in accordance with § 29a BImSchG (Federal Immission Control Act) and a publicly appointed and Publicly Certified (sworn) Expert at the IHK Kiel (Chamber of Commerce and Industry)



Explosion area : Exceeding of 11,6 Vol % oxygen

and

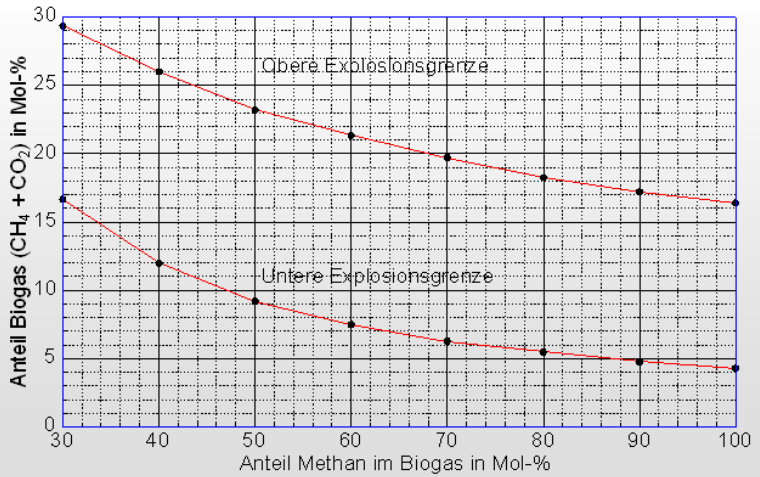
between 4,4* (5)**Vol % methane (100 % LEL) and 15 (16,5) Vol % methane (100 % HEL)

* IEC 60079-20 and PTB ** EN 50054

Eigenschaft „Explosionsfähig“:

BAM

Explosionsgrenzen trockener Biogase bestehend aus Methan und CO_2 in Abhängigkeit vom Methananteil (Berechnungsdiagramm)



Dr. Thomas Schendler
BAM, Abteilung "Chemische Sicherheitstechnik"

Internationale Bio- und Deponiegas Fachtagung, Weimar, 28./29.4.2005, Seite 17

B)

Legal foundations

.

Guiding principle, motto

No body of rules and regulations can replace
your thinking
and
your practical experience
("Hazard analysis by doing":
maintenance, checks, tests, optimisations etc.)
for the necessary safety
on your plant

Forecast of undesirable events

Who can help: prophets - palmists - fortune tellers - oracles or **risk analysis?**

However, the risk is the product of the:
Occurrence probability x significance of the event
PROBABILITY CONSEQUENCE (effects)
Function / product of

SAFETY prevails, when the risk is justifiable for you!

"Nothing is impossible"
or
"I take this liberty"

ATEX 137 (118), better known as the 1999/92/EC Directive dated December 16th 1999: „On minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres".

General trouble sources

1. Failure of plant components – technology in general
2. Energy failure incl. auxiliary energies – local grid
   Power outage EEG 2009 – only in Germany in these days
3. Human mistakes (not / wrong / inadmissible intervention)
4. Undesired substance combination (reacting substances)
5. Divergence of operational parameters: p, T, H, Q, pH, etc.

ORDER OF PRIORITY

for the regulations concerning occupational health and safety protection

Directives of the European Union which the state shall transpose into national law,

Laws and regulations of the state

Accident prevention regulations and standards

DIN standards and similar bodies of rules and regulations are quite often overestimated in their importance and do not represent legal provisions.

New EU concept

99/92/EC (ATEX 137) (Ordinance on Occupational safety) Employer

Increase of safety level and health protection - > Provisions for the enterprise

Beneficiaries: workers
Use of products / equipment in the workplace

Minimum requirements

The member states are allowed to define further provisions within the scope of this directive, provided that these provisions are not contradictory to the directive.

94/9/EC (ATEX 95)

Manufacturer

Design / production of safe products and reduction of technical trade barriers

Beneficiaries: creatures
Design, construction / production, marketing and commissioning regarding products / equipment

Basic requirements / technical determinations

The member states must neither release nor maintain contradictory national laws and further provisions

Demands on manufacturers and operators

99/92/EC (ATEX 137)		94/9/EC (ATEX 95)
Employer / OPERATOR		MANUFACTURER
Determination of the zoning		Definition of the field of application
Selection of suitable equipment		Assignment to a category
Zone 0 / 20	←	Category 1
Zone 1 / 21	←	Category 2
Zone 2 / 22	←	Category 3
Compliance with the installation instructions		Compliance with the relevant standards
Implementation of a hazard analysis	←	Implementation of an ignition-source analysis
Establishment of an explosion protection document		Establishment of the certificate / declaration of conformity
Regular revision		Assurance of the implementation, e.g. QM

Zone 1

Previous definition: includes areas in which a dangerous explosible atmosphere, caused by gases, vapours or mist must occasionally be anticipated.

New: **A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.**

Zone 2

Previous definition: includes areas in which a dangerous explosible atmosphere, caused by gases, vapours or mist must rarely be anticipated and only for a short period of time.

New: **A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.**

Demands on manufacturers and operators

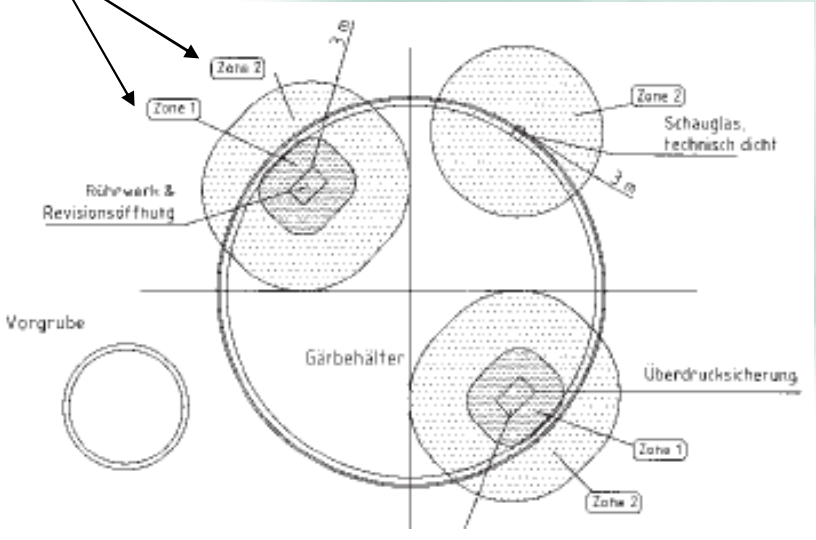
99/92/EC (ATEX 137) Employer / OPERATOR

Determination of the zoning

Selection of suitable equipment

Zone 1 / 21

Zone 2 / 22



94/9/EC (ATEX 95) MANUFACTURER

Definition of the field of application

Assignment to a category

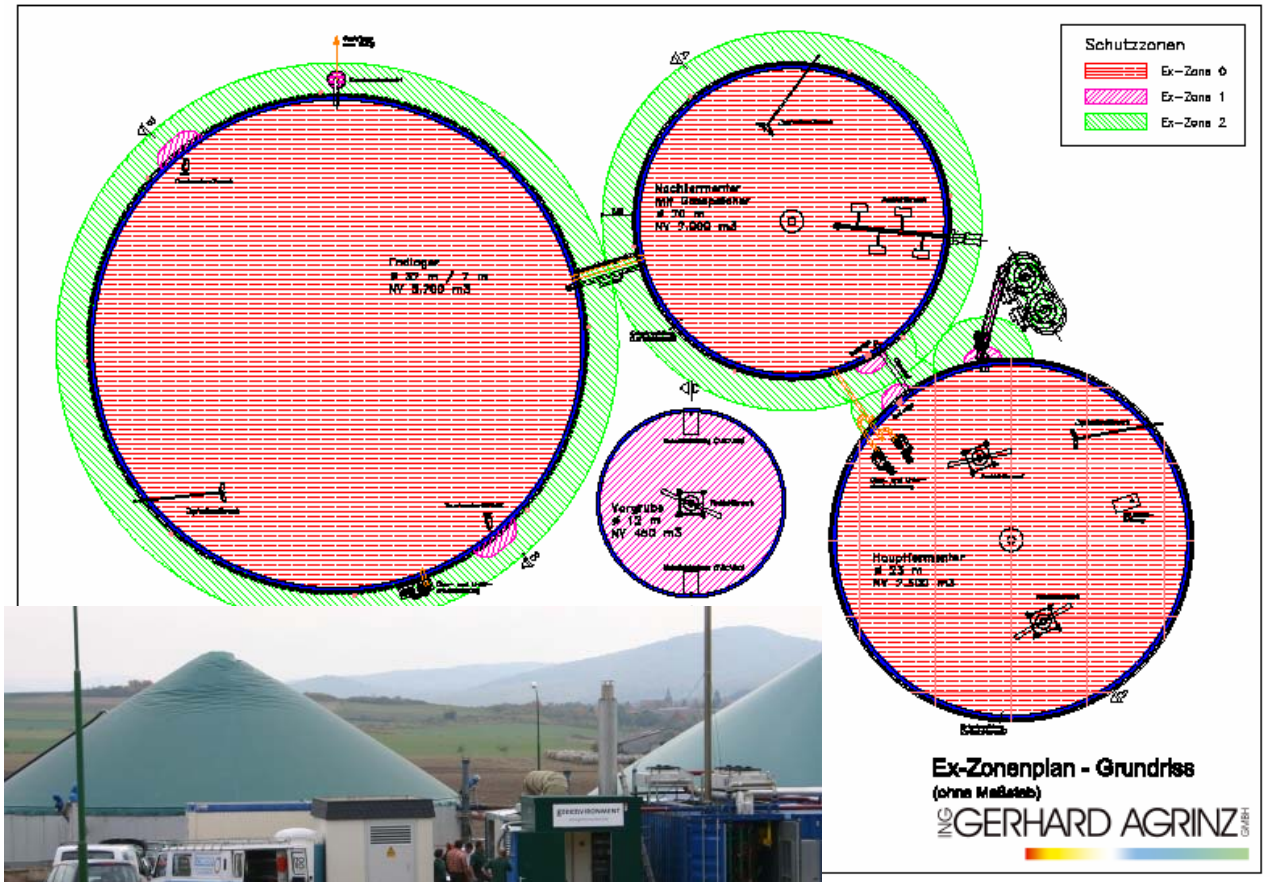
Category 2

Category 3

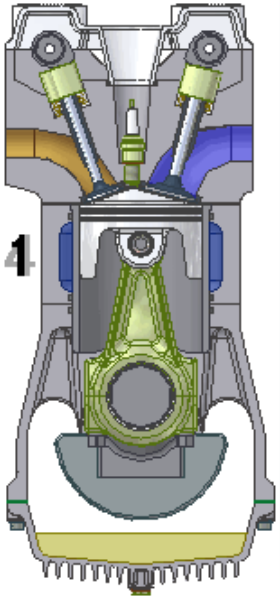
Which certificates / declarations of conformity can be provided by you as the manufacturer?

Which declarations of conformity do you, as the manufacturer, establish, e.g. roof, inspection glass, overpressure safety control device, ex-motor with FC, ...

Demands on manufacturers and operators – crazy Austrians



Does your gas system / do your devices (turbines) have an approval for category 1 (zone 0 – gas) down to and including the turbines / gas engine ?



Normal operation of gas engines:

- 40 Vol % of methane
- NO explosive atmosphere

What is NORMAL according to EC 99/92 ?

Normal operation is the state in which the machines and systems are used and operated within the limits of their design parameters.

2 different booster systems 500m3/h each

Booster station: „EX“ and „Normal“ but gas tight

What is NORMAL? Should everything be ex-protected or gas-tight

Who is the decision – maker – your client reg. to EC 99/92

In Article (9) it is written:" … the employer [=operator] is to draw up an explosion protection document, or set of documents, which satisfies the minimum requirements … "decision – maker"

ORDER OF PRIORITY

for the regulations concerning occupational health and safety protection

Accident prevention regulations and standards, bodies of rules and regulations

Can be applied – but it is not a must, as they do not represent legal provisions in the EU.

ORDER OF PRIORITY

for the regulations concerning occupational health and safety protection

DIRECTIVE 1999/92/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

SECTION II

OBLIGATIONS OF THE EMPLOYER

Article 3

Prevention of and protection against explosions

With a view to preventing, within the meaning of Article 6(2) of Directive 89/391/EEC, and providing protection against explosions, the employer shall take technical and/or organisational measures appropriate to the nature of the operation, in order of priority and in accordance with the following basic principles:

— the prevention of the formation of explosive atmospheres, or where the nature of the activity does not allow that,

— the avoidance of the ignition of explosive atmospheres, and

— the mitigation of the detrimental effects of an explosion so as to ensure the health and safety of workers. These measures shall where necessary be combined and/or

Explosion prevention

Primary explosion protection:
Through the prevention of the formation of an explosive atmosphere

e.g.:
Monitor and optimise gas plants with regard to operation, inertisation, safety-related control, meaning concentration limitation below the lower and above the upper explosion limit, aeration & measurement

Secondary explosion protection
Through the prevention of the ignition of an explosive atmosphere
For ignition sources please refer to - > EN 1127-1

Tertiary explosion protection
Through the prevention / reduction of effects
e.g. compression-proof (shockproof) material

Safety – contents:

For biogas plants / sewage gas plants / landfill gas plants

Explosion protection

Electrical engineering

Pressure equipment

Fire prevention

Machine Directive / CE – Caution: 2006/42/EC from 29 Dec. 2009

Occupational safety

Pipe work construction

ORDER OF PRIORITY

for the regulations concerning occupational health and safety protection

DIN standards and similar bodies of rules and regulations are quite often overestimated in their importance.

DIN standards and similar bodies of rules and regulations do not represent legal norms, are subject to changes and do, in no way, provide comprehensive information about the so-called generally acknowledged rules of technology

(cp. BGH NJW 1998, 2814 – Institut für Sachverständigenwesen e.V. "Todsünden des Sachverständigen" p. 15 ff)

Machinery Directive 2006/42/EC
former 98/37/EC

Within the scope of the Machinery Directive, you (as a manufacturer) will now have to carry out:

a risk assessment

instead of

a hazard analysis,

latest from December 29th 2009

Responsibilities

The employer is responsible for the implementation of the risk assessment,

the operator is responsible for the implementation of the safety-related evaluation / estimation.

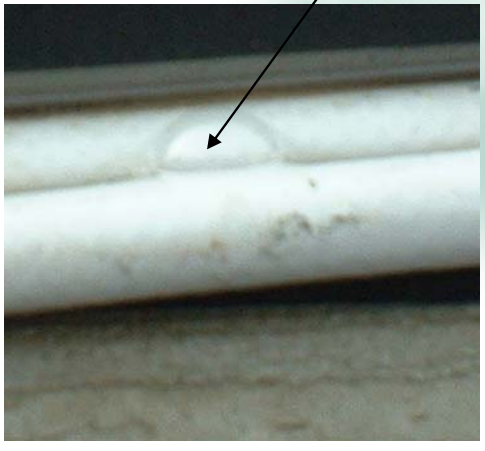
DVGW (The German Technical and Scientific Association for Gas and Water)

Good body of rules as it is easy to handle for gas tightness tests

DVGW – worksheet G 469 pressure test method for gas supply ducts and plants (July 1987) A3 and A4 (operating gas)

Leak tests to prevent the formation of an explosive atmosphere

Leak tests (e.g. in accordance with DVGW (The German Technical and Scientific Association for Gas and Water), G 469 A4: inspection method with operating pressure and foaming agents



Lightning protection

Currently DIN EN 62305: lightning protection (Oct. 2006 –
substitute for DIN VDE 0185 from November 2002 to 2005)

Protection angle method
* Up to a height of approx. 10 m, α is approx. 45° at protection class / category

Lightning protection with potential equalisation
Costs for additional measurements rpt.: approx. 75 euros per plant component, e.g. CHP container

The risk (R) for lightning damage results from:

R = N * P * δ

N: frequency of a lightning strike
P: probability of damage
δ : damage factor for quantitative assessment – amount of damages, extent

"Residual" / Remaining risk lightning strike

Germany: approx. 4.5 dead persons p.a. through lightning strikes

Lightning strikes p.a.:

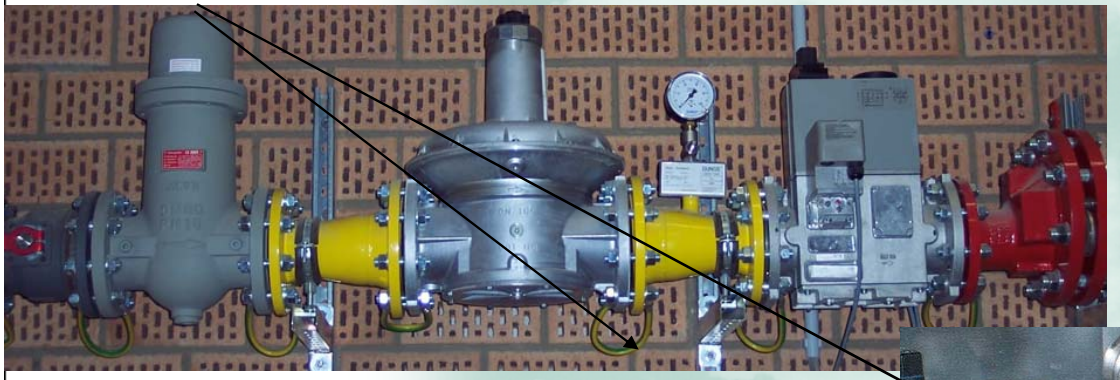
- **D approx. 2,000,000**
- **CH approx. 350,000**
- **A approx. 700,000**

Number of lightning's p.a.:
dark blue (8,500)

dark rose (77,000)

Source GEO 12/2005

Earthing and potential equalisation



Test certificates!! At the takeover of the plant or subsequent to regular checks! Depending on the soil class and on the measured earth wire circuit resistances

ATEX – what is behind it

ATmosphere EXplosible – explosible atmosphere

Four letters ……

…… two important directives

ATEX 100a – known in this industrial sector, now ATEX 95 or better known as Directive 94/9/EC dated 23 March 1994

„…. Devices and protective systems …..“ Implementation through the 11th GPSGV (Equipment and Product Safety Act) in Germany

ATEX 137 (118), also referred to as Directive 99/92/EC dated 16 December 1999

" … minimum requirements regarding the health protection and safety of the employees …"

And was integrated into the Ordinance on Occupational Safety (BetrSichV) dated 27 September 2002

Änderung: Bundesgesetzblatt 74 vom 30.XII.2004

ATEX 95 (94/9/EC)

Since 1 July 2003, only those resources which meet the requirements of this Directive may be placed in circulation .

Zone	potential explosive atmosphere :	**Category acc. to ATEX 95**	Equipment safety must be ensured
20 / 0	must be taken into account permanently, frequently and in the long term	**1**	even when device errors are unusual
21 / 1	must casually be taken into account	**2**	when device errors are to be expected
22 / 2	must not be taken into account, but if so, only over a short period of time	**3**	during normal operation

ATEX 137 (99/92/EC) - >
BetrSichV (Ordinance on Occupational Safety)

ATEX 137 / BetrSichV is addressed to operators

Implement safety requirements, such as:

Prevention of ex-mixtures, ignition sources, … and if this is not possible …

limit the consequences of explosions

In addition, the operator shall ensure zoning in his plant - > Establish an explosion protection document **until Dec 31st 2005 in accordance with Article 27(1)**

For this purpose he shall:

*** Assess and document all areas according to the aforementioned zones**

*** Set up danger signs (W21) …**

*** Assess risks, define probabilities,**

*** Revise the explosion protection document regularly**

How to identify and prevent explosion hazards - > possible sequence

a) Do inflammable materials e.g. gas exist?

b) Can an explosive atmosphere develop through sufficient supply of air (mixture) (sources and amounts)

NO ? - > No measures, no zones, no explosion protection document

YES ? - > An explosion protection document shall be established and measures must be undertaken !
The sequence is as follows:
A) Measures to avoid this explosive atmosphere, e.g. ventilation

B) Measures to prevent the ignition sources

C) Prevent consequences (e.g. "technical measures" such as pressure proved protection, indoor air monitoring or "organisational measures", for example no permanent workspace in order to "reduce the hazard to an acceptable level"

C)

Examples of damage including explanations of the causes and possible remedial / corrective measures

sensitisation

Explosion in a BGP

Biogasanlage in Nusbaum explodiert

Betriebsgebäude wird schwer beschädigt / Verletzt wird bei dem Zwischenfall niemand

NUSBAUM. In der Nacht zum 1. März explodierte in Nusbaum das Betriebsgebäude einer Biogasanlage. Verletzt wurde niemand. Schäden für die Umwelt blieben ebenfalls aus.

„Einer meiner Kollegen war vor Ort als das Betriebsgebäude explodierte und rief mich sofort auf meinem Handy an. Als ich bei der Anlage ankam, stand er natürlich noch immer unter Schock aber war unverletzt. Wir können wirklich vom Glück reden, dass er sich zur Zeit der Explosion nicht im Betriebsgebäude befand, sondern bei einem der Silos beschäftigt war. Sonst wäre wahrscheinlich Schlimmeres passiert", erklärt Alfons Otten einer der insgesamt fünf Betreiber der Anlage. Nach der Explosion gleicht das Gelände einem Trümmerfeld. Die Front des Betriebsgebäudes wurde durch die Wucht der Verpuffung völlig zerstört, überall sind Teile des Mauerwerks verstreut. Ein ähnliches Bild bietet sich auf der Rückseite des Gebäudes. Eine Metalltür, die aus ihren Angeln gerissen und einige Meter weit geschleudert wurde, erinnert nur noch an ein verknittertes Stück Alu-Folie. Lediglich die Silos, in denen die zur Biogasproduktion unerlässlichen Stoffe wie Gülle und Mist lagern, sind unbeschädigt. „Die Silos sind so stabil gebaut, dass es sehr unwahrscheinlich ist, dass hier etwas hätte passieren können. Daher sind auch keine Umweltschäden durch auslaufende Gülle entstanden", sagt Otten. Der Sachschaden am Betriebsgebäude beläuft sich nach Angaben der Polizei nach ersten Schätzungen auf etwa 1 Mio. Euro. Mehr Innenteil.

Eine Metalltür (im Vordergrund) wurde durch die Wucht der Explosion aus den Angeln gerissen und meterweit geschleudert. Ein anwesender Betreiber befand sich zur Zeit der Explosion glücklicherweise nicht in unmittelbarer Nähe des Gebäudes. *Foto: Scholl*

Condensate shaft in the building, incorrect measurement of the filling level at the gas holder, no FAIL – SAFE deactivation of the CHP to negative pressure

sensitisation

Explosion in a GBS

Drainage on the pressure side / Condensate drainage

sensitisation
Explosion in a GBS

sensitisation

Explosion in a GBS

sensitisation
Explosion in a GBS

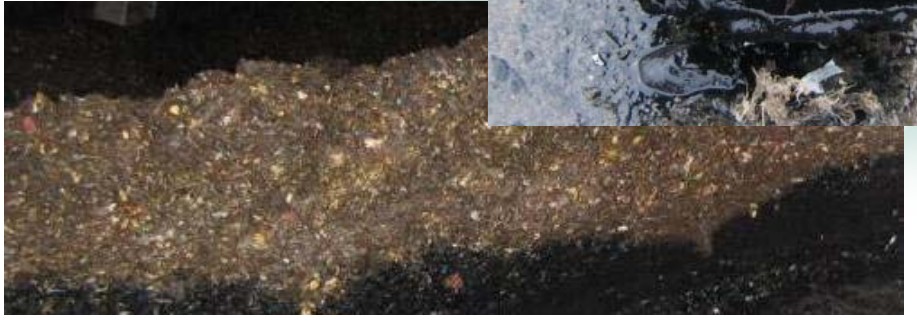
What is missing ??

No explosion although the blower was operated with landfill gas– no flame traps / arrestors in the pipe work

No explosion although the blower was operated with landfill gas– no flame traps / arrestors in the pipe work

sensitisation

Stirring unit damage / material damage



Protection / hazard analysis

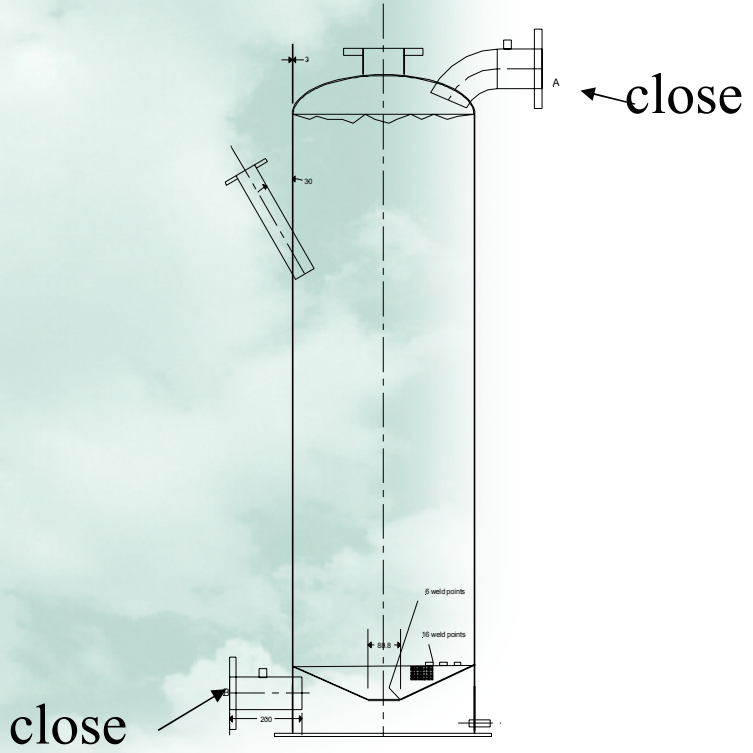
Sequence of the maintenance regarding the replacement of the activated carbon?

Do not only carry out measurements (ex- gas warning sensor) but also make sure correct functioning during the subsequent workflow (e.g. disconnection gas supply / triggering of optical and acoustic warnings etc.)

Steps to exchange the active coal in the siloxan filter

as

Shut off the filter



as

First Step

Flush the vessel with nitrogen

Replacement of Activated Carbon

as

ACRONA SYSTEMS

Gas to the outside

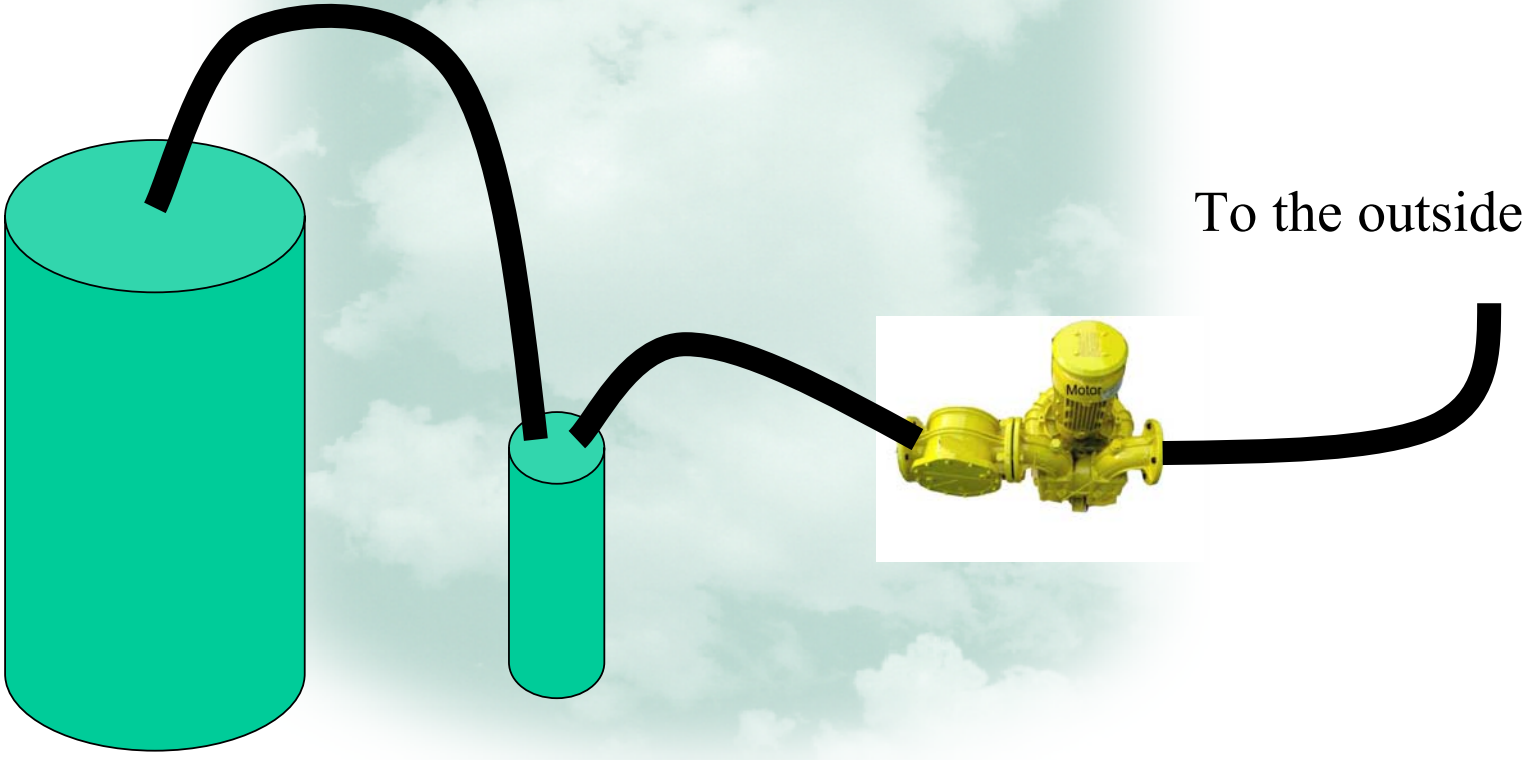
- Use a pressure reducing valve and a pressure relief valve

Second Step

Prepare the work place

Connect the blower with empty barrel

Replacement of Activated Carbon



ACRONA SYSTEMS

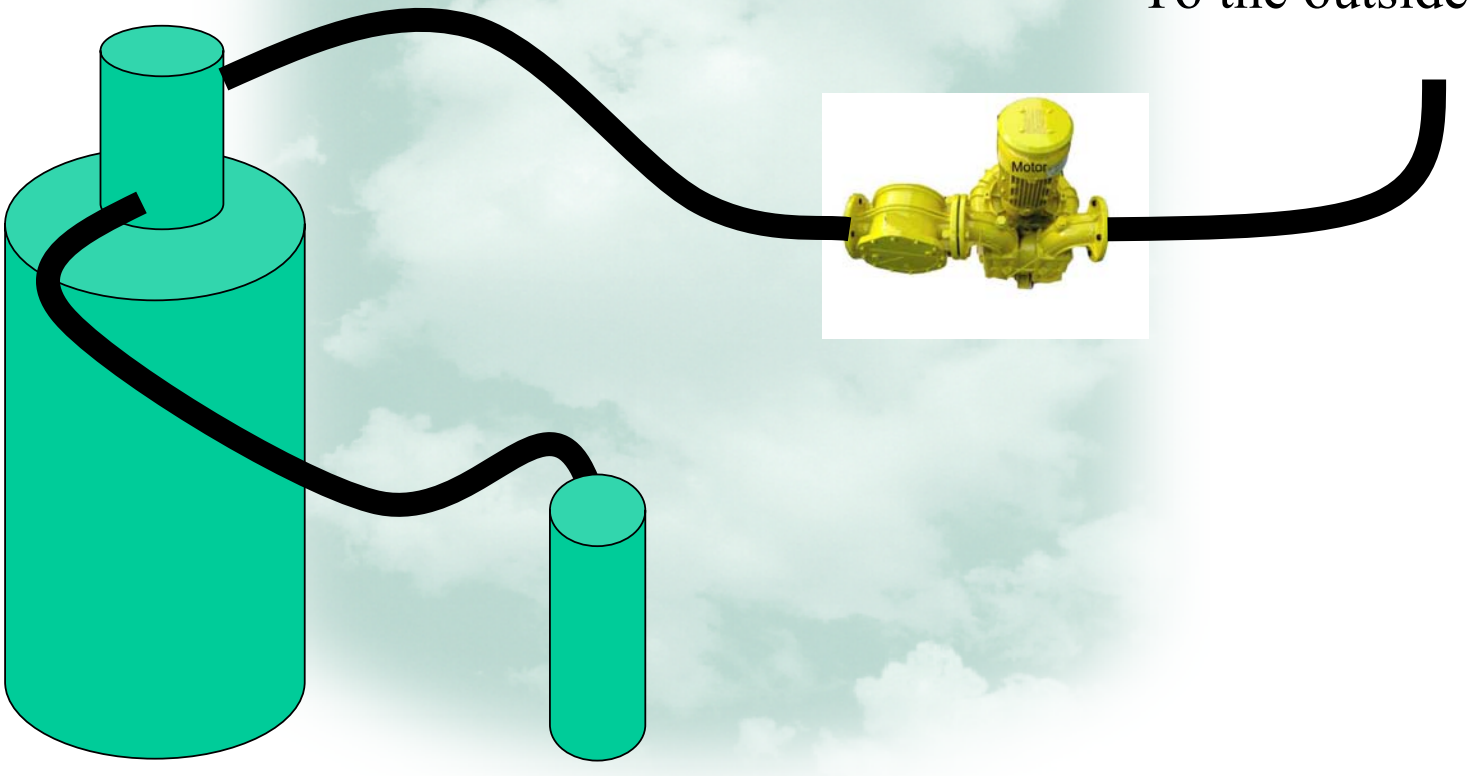
Fill the filter with new carbon

Replacement of Activated Carbon

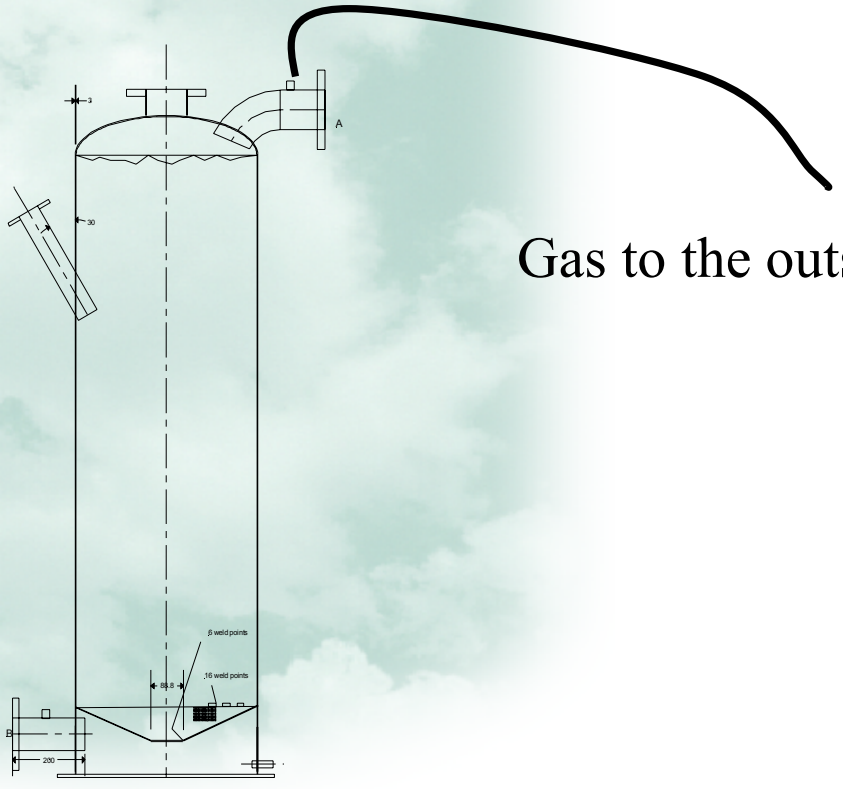
as

ACRONA SYSTEMS

To the outside



Flush again the vessel with biogas



Gas to the outside

Safety considerations

How can make the micro-turbine plants safer.

Gas detector / sensor

Ex-Room

Solenoid-valve / slum shut valve

Gas detector is connected with the solenoid valve and the compressor, turbine located outside the Ex-Zone

Protection / hazard analysis

**Construction failure: -
air ventilation system!**

Transverse / cross ventilation? In the condensate shaft

MBT breakdown / disaster- Göttingen - Deiderode

Our task:
to determine the cause of damage

In August 2007, the proceedings for the gathering of evidence were discontinued because. ..

MBT breakdown / disaster- Göttingen - Deiderode

What reasons could be excluded for the breakdown / disaster ?

The following points could be excluded as the cause of damage:

*** No changes in the foundation of the digesters**

*** No procedural failures**

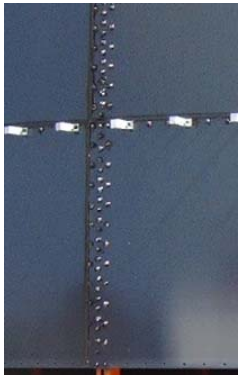
•No explosion

(meaning that a fermenter / digester failure is likely)

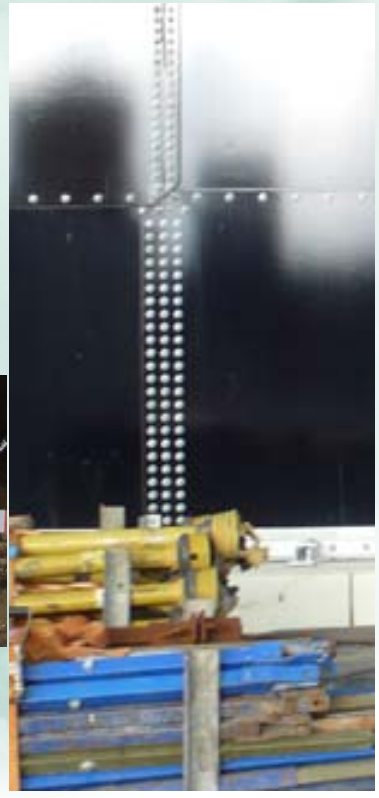
BGP breakdown – disaster Riedlingen

BGP breakdown – Riedlingen –
MBT breakdown Deiderode

"Similarities"



Dec. 2007



Harvestore / Farmatic

GLS Tanks: BGA Riedlingen

GLS Tanks: BGA SAZA

KBU / Wolf : MBA Deiderode

Protection against overpressure, e.g. overfilling

Photos of an overfilled digester. It is visible that the fermenter was overfilled until exceeding the water cup at the central stirring unit. The fermenter was not destroyed. In the transition region between the wall of the tank and the roof membrane, the roof panel was deformed and the pressure could be relieved in the screw joint via a "predetermined breaking point". - > burst disc !

Fire by accident (CHP units) but no trouble with the gas pipes

Height towards the ceiling? Insulation?

exhaust gas temperatures,

Amounts of exhaust gas

Leaking exhaust gas pipe

below

Explosion in the mechanical room of a BGP

Photo - source:

By courtesy of

R. Lange, Eng.consult –
April 2007

Gas holder membrane "patched" – Biogas in the intermediate roof – exit via "draft fan" – explosion in the operating room

Deflagration in a shaft / manhole

Photo - source:

By courtesy of

Toni Baumann I2008

Works in a shaft at the digester gas compartment without measurements or ventilation – and how would you have worked?

Without overpressure protection …

Photo - source:

By courtesy of

Toni Baumann II2008

Cause and effect ..

D)

Examinations, ignition sources, assessments, …

.

What are:

"experts" – what are the skills of "experts" – what are "experts" liable for

As an explanation regarding the specific fields according to Article 29a BImSchG (Federal Immission Control Act) in Germany:

1: Design (strength, dimensioning) of plants and pipes ..
2: Construction of plants (system performance test, conformity) …
3: Process control and design of plants ..
4: Maintenance of plants
5: Design and examination of the statics of structural plants
6: Material (examination and assessment)
7 / 8: Supply with energy and media
9: Electrical engineering
10: I&C (Instrumentation & Control) and PLC
11: ….Hazard analysis
12: … Ecotoxicological properties
13: Consequences of breakdowns ..
14: Operational dangers and defence plans

What are:

"experts" – what are the skills of "experts" – what are "experts" liable for

As an explanation regarding the specific fields according to Article 29a BImSchG (Federal Immission Control Act):

15: Fire protection …

16: Explosion protection …

17: Safety management and business organisation

Who examines what, how useful is that, on what terms & conditions?

And who is liable?

Hazard analysis and risk assessment

Dangerous explosive atmosphere > 10 l

- Medium ?
- Operations? (When: definition normal operation)
- How frequently ?

Ignition sources

- Potentially endangered components
- Ignition source during normal operation / malfunction?
- Incendivity

Risk assessment

- Combination of likeliness and consequences (explosion or deflagration / burning)
- Likeliness / probability of an ex-atmosphere (zone definition)
- Likeliness of the ignition source (category)

Reasons for fires and explosions on the basis of 10,000 events in selected industrial countries, source "Wissenschaftliche Grundlagen des Brand- und Explosionsschutzes", Kohlhammer 1996

Reason	proportion in %
Defective electrical devices and installations	23
Smoking	18
Fire raising	15
Hot surfaces	7
Unshielded (open) flames	6
Welding and cutting	5
Friction	4
Self-ignition, sparks and firing	3 each
…	
Lightning strikes	0.8

General information regarding the risk potential "gas holders" – "gas tanks"

Comparison biogas holder:
Volume of 480 m³, 50 % by vol CH4, net calorific value Hu = 5 kWh/m³

Liquid gas holders / tanks contain propane gas
As a result of compression, the gas is liquid. A liquid gas tank usually used for domestic supply has a storage capacity of 6 m³, corresponding to approx. 3,000 kg liquid gas. Net calorific value Hu = 12.87 kWh/kg.

Calculated energy content of both holders:

Propane holder:

$$3.000kg \cdot 12,87\frac{kWh}{kg} = 38.610kWh$$

Biogas holder:

$$480m^3 \cdot 5\frac{kWh}{m^3} = 2.500kWh$$

Ignition sources part I

Hot surfaces - > T4, methane > 500 °C
Flames and hot gases (form, structure, residence time)
Mechanically produced sparks - > rubbing, striking, abrading
Electrical plants - > sparks (switching operations, loose connections, compensating currents), hot surfaces (component)

Electrical currents, cathodes corrosion protection

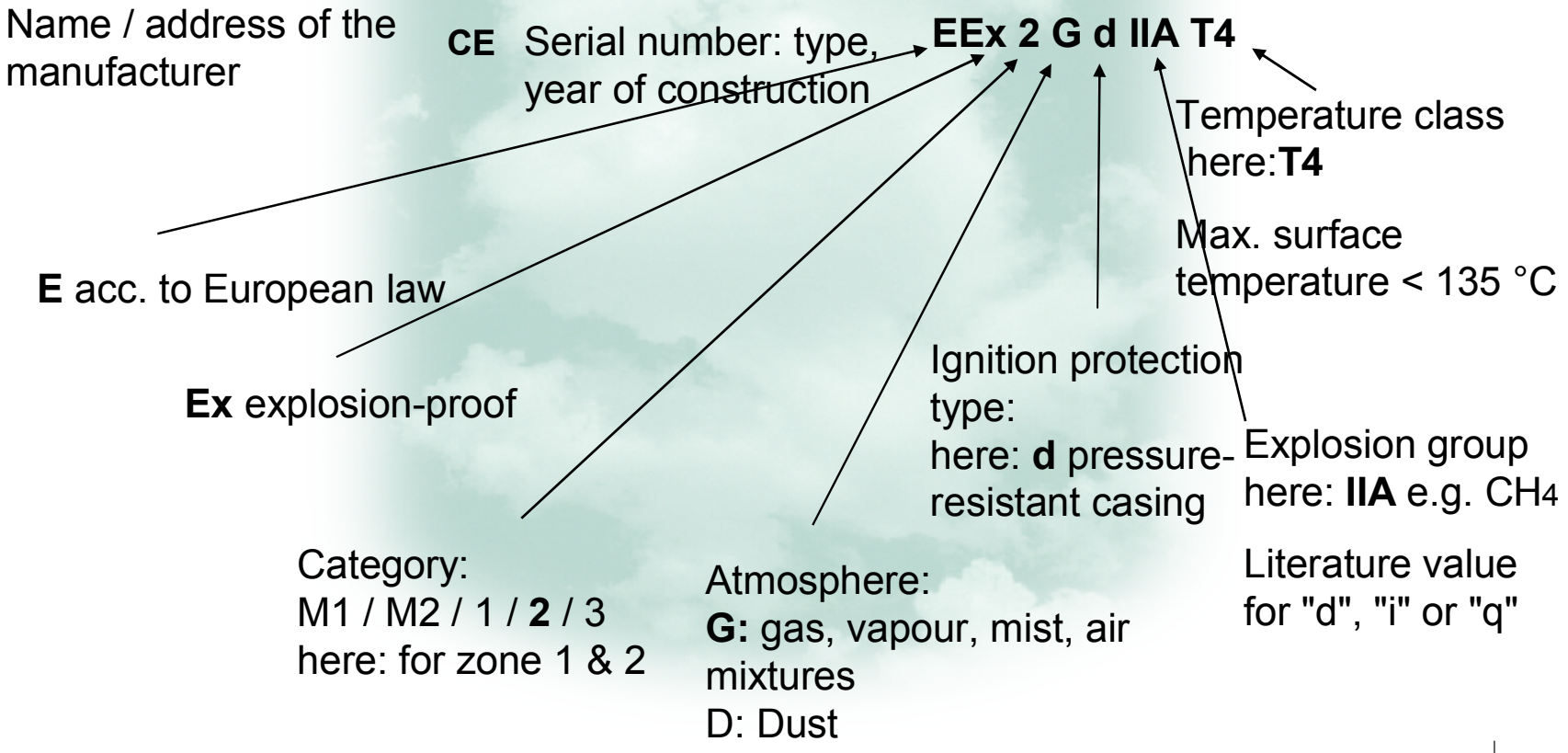
- > stray, return currents (welding facilities)
- > body contact or earth fault
- > magnetic induction (> I, HF)
- > lightning stroke, Static electricity
- > discharge of charged conductive parts which are arranged in an isolated fashion
- > charged parts made of non-conductive materials (plastic) – bunch discharges, separating processes

Ignition sources part II

Lightning stroke - > direct and indirect (induction)
Electromagnetic waves 10,000 Hz – 3, 000, 000, 000, 000 Hz (HF)
- > radio transmitters, welding machines
Electromagnetic waves 10,000 Hz
- 3, 000, 000, 000, 000 Hz (HF)
- > radio transmitters, welders
Electromagnetic waves 300,000,000,000 Hz – 3,000,000,000,000,000 Hz -> focusing, strong laser radiation
Ionising radiation - > X-ray, radioactive radiation
Ultrasonic
Adiabatic compression and impulses
Exothermic reaction, including self-ignition of dusts

94/9/EC

Marking of equipment in accordance with Annex II, Clause 1.0.5



Where required "x" - > see operating instructions / manuals

Demands on manufacturers and operators

99/92/EC (ATEX 137)		94/9/EC (ATEX 95)
Employer / OPERATOR		MANUFACTURER
Determination of the zoning		Definition of the field of application
Selection of suitable equipment		Assignment to a category
Zone 0 / 20	←	Category 1
Zone 1 / 21	←	Category 2
Zone 2 / 22	←	Category 3
Compliance with the installation instructions		Compliance with the relevant standards
Implementation of a hazard analysis	←	Implementation of an ignition-source analysis
Establishment of an explosion protection document		Establishment of the certificate / declaration of conformity
Regular revision		Assurance of the implementation, e.g. QM

Demands on manufacturers

GUIDELINES ON THE APPLICATION OF COUNCIL DIRECTIVE 94/9/EC OF 23 MARCH 1994 ON THE APPROXIMATION OF THE LAWS OF THE MEMBER STATES CONCERNING EQUIPMENT AND PROTECTIVE SYSTEMS INTENDED FOR USE IN POTENTIALLY EXPLOSIVE ATMOSPHERES
4.1.2.3:

It is important to underline in this context how machinery having a potentially explosive atmosphere inside under operating conditions, but having no interface to external potentially explosive atmospheres has to be considered. Such machines, as an integral whole, do not fall under scope of the ATEX Directive 94/9/EC (see also chapter 4.1.2.2 and 4.1.2.4).

FAIL – SAFE / PLC ?

Test: What does "FAIL – SAFE" mean?

EN 954-1 March 1997, since July 2007: EN ISO 13849-1: The ability of a technical system to remain in a safe state or to return immediately to a safe state in the event of certain failures .

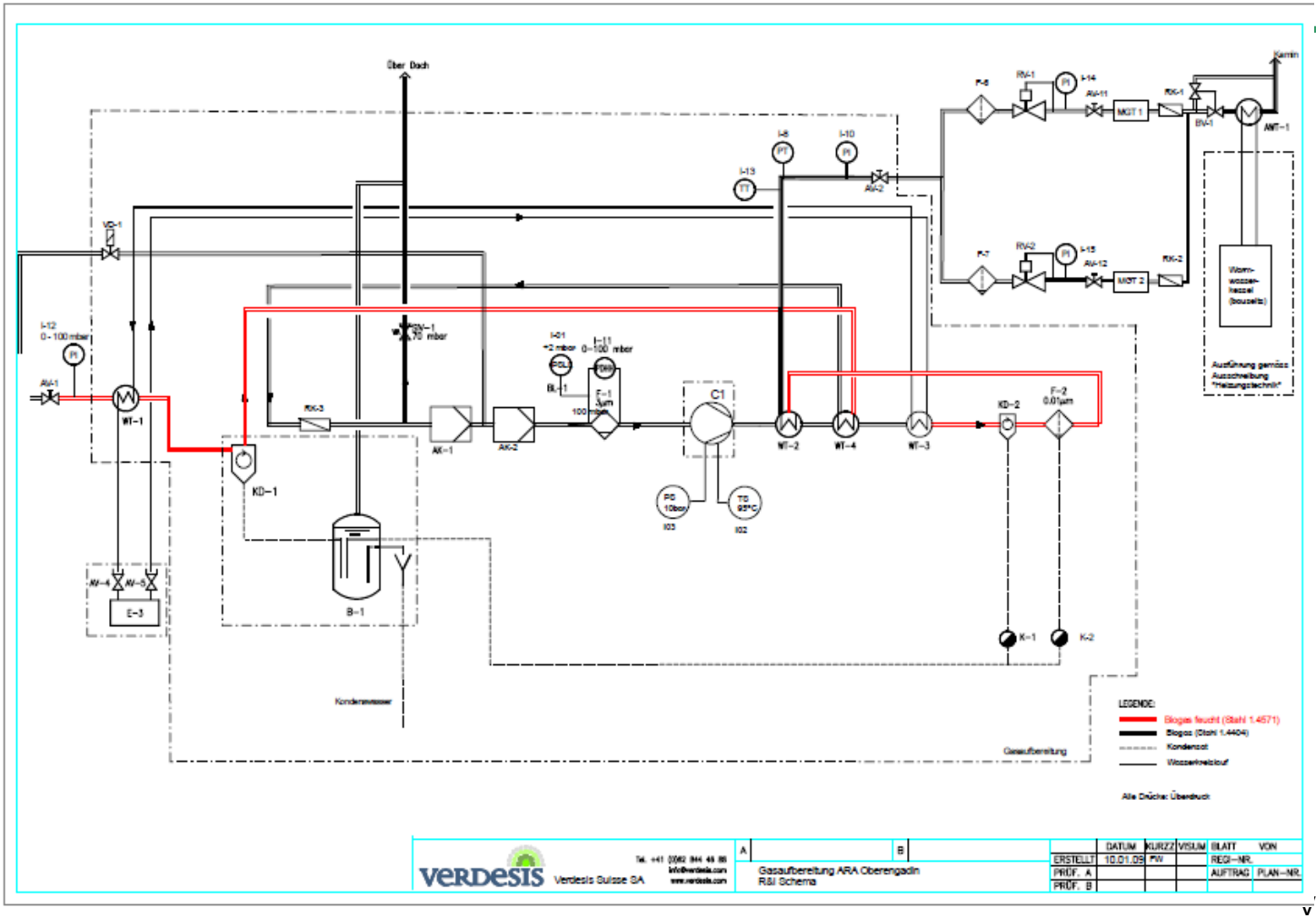
Caution. EN 60204-1, November 1998, revised June 2007:

9.2.5.4.2 Emergency stop: (version 1998) 9.2.5.4.3 EMERGENCY STOP (version 2007)

For the emergency stop function in an emergency case ("emergency stop chains" – author's comment) of stop category 0 (uncontrolled stop:…e.g. through energy deactivation) only hard-wired electromechanical components must be used. Furthermore, its operation shall not depend on electronic logic (hardware or software) or on the transmission of commands over a communications network or data link.

Or e.g. "Siemens" F – Series PLC

FAIL – SAFE / PLC ?



Ground plan for fire brigade use

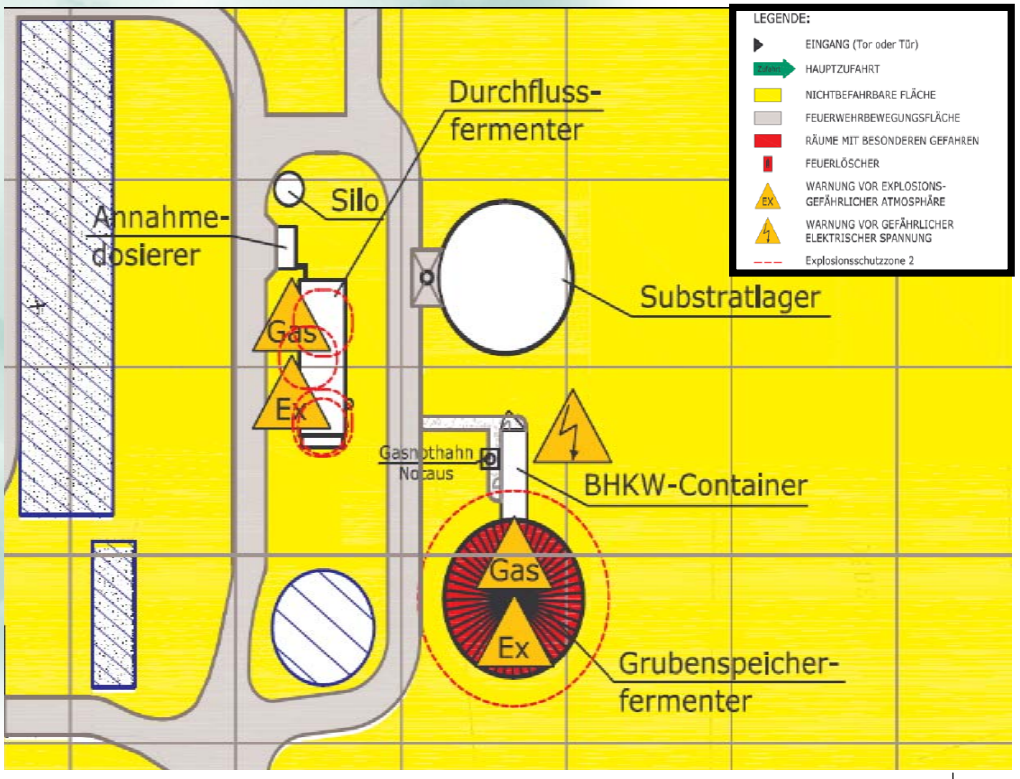
As far as biogas plants are concerned, it should be ensured that, besides the specifications according to DIN 14095, in particular the positions of:

The emergency switch of the general gas system (not only for the CHP or turbine or flare),

and the position of the slam shut valve for the gas supply

The fire water supply and retention

are marked in the ground plan for fire brigade use.



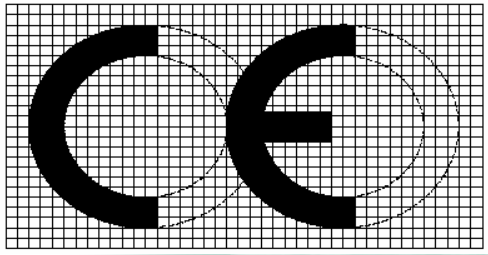
E)

CE requirements

CE labelling
Certificates of conformity regarding 94/9/EC, Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

CE-Konformitätskennzeichnung

- Die CE-Konformitätskennzeichnung besteht aus den Buchstaben "CE" mit folgendem Schriftbild:



Confusion Everywhere

CE guidelines usually apply to
*** First time marketing of new products**
*** The proper use of the product**

CE directives include, among other things:
*** Basic safety requirements**
*** Conformity assessment procedures**
*** Formal requirements (e.g. technical documentation)**
*** ….**

CE labelling
Certificates of conformity regarding 94/9/EC,
Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

What is a machine?

… the entirety of interconnected parts … one is movable … or the entirety works …

NEW: …. An entirety of machines….which, in order to interact, are arranged and activated in such a manner that they function as a whole.

CE labelling merely confirms the conformity with directives.

The application of harmonised standards is optional.

Confusion Everywhere

CE labelling
Certificates of conformity regarding 94/9/EC, Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

What is a machine?

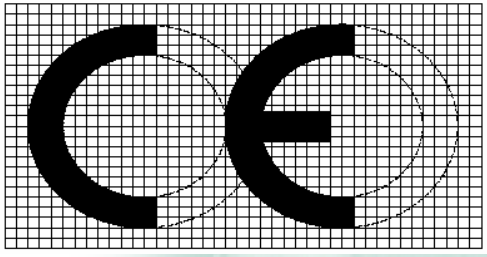
… the entirety of interconnected parts … one is movable … or the entirety works …

Are these machines – and if so, how many??

CE labelling
Certificates of conformity regarding 94/9/EC, Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

CE-Konformitätskennzeichnung

- Die CE-Konformitätskennzeichnung besteht aus den Buchstaben "CE" mit folgendem Schriftbild:



acrona: Vacarisses, 1xCR65 landfill

Advantage 1 CE label for example for a CHP / turbine container: full conformity of all integrated components (devices, machines etc.)

Disadvantage 1 CE label for example for a CHP / turbine container: When components are replaced (gas filters, valves etc.), only identical makes / produts and types must be used (no possibility to improve the plant)

CE labelling
Certificates of conformity regarding 94/9/EC, Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

The producer (manufacturer) of a machine / plant which is subject to the Machinery Directive, or his agent, is obligated to:

Carry out a risk analysis, in order to determine all hazards outgoing from his machine.

Design and manufacture the machine taking this analysis into account.

The user / operator must be informed about the residual risks.

Technical producer / manufacturer documentation

•Prior to issuing the EC Declaration of Conformity, technical documentation should be created, in which the individual stages of development and construction of the machine are described. The technical documentation should include the following:

* Specifications about the basic requirements of the Machinery Directive taken into account during the development and construction of the machine.

•Reference to the standards or technical specifications applied

•Descriptions of the measures regarding the prevention of risks emanating from the machine

Technical producer / manufacturer documentation & instructions

Operating instructions should be attached to each machine. Among other things, these operating instructions describe the residual risks which may occur during operation, maintenance, repair etc. and which cannot be prevented by technical, constructive measures.

Minimum specifications of the operating instructions:

- **Set-up and documentation (technical!) with a risk and a hazard analysis**
- **Installation**
- **Proper / improper use "Normal operation"**
- **Start-up**
- **Maintenance and repair / service**

CE labelling
Certificates of conformity regarding 94/9/EC, Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

Modifications “news” from 2006/42/EU

- Contract documentation – "stricter" requirements
- Construction and production processes … Consideration of the foreseeable incorrect application and use
- Documentation management
- Internal training & schooling
- Clarification regarding the risk analysis (hazard analysis) subject-matter
- Need for a "CE agent“ in each company
- ….

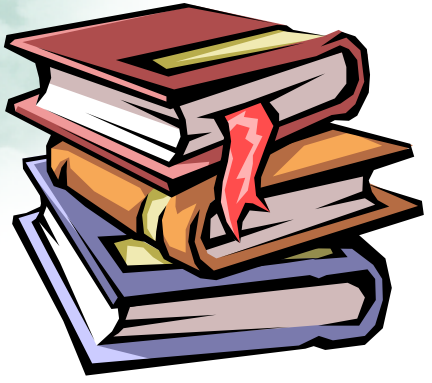
CE labelling
Certificates of conformity regarding 94/9/EC, Machinery Directive 89/392/EEC from December 29th 2009 2006/42/EC

Open question:

When is it justified to obtain CE labelling?

KNOWLEDGE + CE labelling = safe

Any questions left?



Knowledge is key and is available when you know where to find it:

www.das-ib.de