Explosion Protection Document for Gas Extraction Systems

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Summary:

Considerations and facts with regard to risk analysis within the scope of the explosion protection document in accordance with the „ATEX“ (EU Directive 99/92 - Regulation on Industrial Safety) – effects on gas operation in landfills and biogas plants

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* 99/92/EC Directive – ATEX 137 (118a) dated 16th December 1999
* 94/9/EC Directive – ATEX 95 (100a) dated 23rd March 1994
* Biogas- und Deponiegashandbuch (biogas and landfill gas handbook) of DAS – IB GmbH
(Course book: ISBN no.: 3-88312-296-3, 4th edition August 2005)

1. Background, basis: „ATEX“ Regulation on Industrial Safety

What does ATEX stand for:
ATmosphere EXplosible – explosible atmosphere
Four letters……..
…………..two comprehensive directives
ATEX 100a is known to the industrial sector, and is now entitled ATEX 95, better known as 94/9/EC Directive dated March 23rd 1994
„Directive on the Approximation of Laws of the Member States relating to Devices and Protection Systems for an appropriate Use in explosion-prone Areas“.
Since very recently, this decree applies both to electrical and non-electrical components in Europe.
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”. In Article (9) is written:” … the employer is to draw up an explosion protection document, or set of documents, which satisfies the minimum requirements … “

1.1 Implementation of the EU 99/92 Directive

The 99/92 Directive (ATEX 137) is addressed to operators. The operator needs to implement safety requirements, such as:
- Prevention of ex-mixtures, ignition sources, (…) and, if this is not realisable (..)
- Confinement of the effects of explosions.
In addition, the operator needs to develop an explosion protection document and zone divisions for his enterprise
For this purpose, he is expected to assess and document all areas according to the aforementioned zones.
- Set up danger signs (EX) (…)
- Assess risks, define probabilities and continuously update the explosion protection document

The new EU concept
Operators: 99/92 EU (ATEX 137) / Increase in the safety level and in health protection -> controls for the enterprise // Beneficiaries: employees / use of products / equipment at the workplace // Minimum requirements // The member states are allowed to define further regulations with regard to this directive, provided these do not contradict the directive
Manufacturers: 94/9/EU (ATEX 95) / Design / production of safe products and reduction of technical trade obstacles // Beneficiaries: living beings / design / construction / production, marketing and commissioning of products / equipment // Basic requirements / technical definitions // The member states may neither enact nor maintain contradicting national laws and further stipulations

1.2 Hierarchies of the bodies of rules

Regulations regarding work safety and health protection:
1. Directives of the European Community which the government needs to translate into national law
2. Laws and decrees of the national government
3. Accident prevention regulations and standards

Question for a German operator: How is, for example, the following contradiction settled?
GUV – R 127 (landfills) 5.13.7 „Gas mains and flexible tubing need to be designed at least for the PN 6 nominal pressure level.“
Safety rules biogas plants 2.7.1: „Tubing … and flexible connections need to boast at least a structural strength of 1 bar.
Answer: What have you stipulated in your explosion protection document for your plant within the scope of risk analysis?

This also brand new for the agencies and the authorities because the operator has to write the document with his personal safety standard and not the other way round. The operator knows his “Normal operation” on side and not a theoretically safety standard or regulation. The operator makes his definitions on safety standard and on the other hand he take the responsibility.

1.3 Explosion protection document for gas operation

The explosion protection document needs to be completed before work is taken up.

1.3.1 Basic requirements

Basic requirements on the explosion protection document

- Identification of dangers
- Detection of ex – dangers and assessment of ex-atmosphere
- Detection of areas (zones) with potentially explosive atmospheres
- Definition of criteria, according to which working tools are to be chosen for these areas - > 94/9/EC
- Detection of possible ignition sources!!
- Definition of the measures by means of which endangering may be prevented or which need to be undertaken in order to respond to a danger, estimation of the effects of explosion, where required („shot glass“)
- Risk assessment and measures aiming to reduce the risk
- Definition of the criteria for working tools (Ex – areas / zones)
- Separate descriptions of organisational measures: normal operation, maintenance, malfunction, start-up and shut-down processes (Start-Stop) etc.

1.3.2 Structure of the explosion protection document

Describing information:

- Designation of the department
- Naming of the person in charge
- Characterisation of the structural and local conditions
- Plant and process description
- Safety-related characteristic values of the substances employed
- Safety strategy and protective measures
- Requirements in the event that deviations from normal operation are ascertained (maintenance, malfunction, emergency cases …)
- Safety guarantee for employees in „boundary areas" - > coordination

1.4 Zone divisions, definitions

Zoning is a method aiming to analyse and classify the environment, in which an explosible gas atmosphere may occur, in order to facilitate the selection of devices (electrical and non-electrical devices) which may be operated safely in this type of environment, taking into account explosion groups and temperature classes.

In most practical situations in which flammable substances are used, it is difficult to ensure that an explosible gas atmosphere will never develop.
It is just as difficult to fully exclude the possibility of ignition sources when working with electrical tools. - > Probabilities!!

The first step consists in the evaluation of these probabilities via the definition of zones. - > Explosion protection document in accordance with the EU 99/92 Directive (ATEX)!!

This requires closer examination of each component of the process plant which contains flammable materials and could therefore represent a source of release.

Definition in accordance with EN 60079-10 and EU 99/92
Zones:
Areas at risk are divided into the following zones, depending on the frequency and duration of the existence of an explosible gas atmosphere:

Zone 0
Previous definition: includes areas in which a dangerous explosible atmosphere exists <u>permanently or in the long term</u> as a result of gases, vapours or mist.
<u>New:</u> **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 present continuously or for long periods or frequently.**

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.**

Division into zones should only be effected by persons who are aware of the properties of flammable substances, the process and the working tools, where required in coordination with the responsible safety-, electrical-, mechanical and other engineers.

New plants: According to 94/9/EU (“ATEX 95”) Zoning is binding prior to the start-up from July 1st 2003 onwards!
In order to get things straight as regards the employment (zone) of the new working tool.

Existing plants: 99/92/EG ATEX 137 - > transition deadline for operators until December 30th 2005, binding from July 1st 2003.
DOCUMENTED !

1.5 Danger estimate / risk assessment / protective measures

Does an explosible atmosphere exist in your plant of > approx. 5 l?
- Medium ?
- Operation (when: definition normal operation)?
- How often ?

Do ignition sources exist in your plant?
- Potentially endangered components
- Ignition source during normal operation / malfunction?
- Ignition effect

Your risk assessment:
- Combination of probability and effects (explosion or deflagration, burning...)
- Probability of the ex-atmosphere (zone definition)
- Probability of the ignition source (category)

Risk assessment ….. is … the probability of the occurrence of a damage.

- Frequency and duration of dangerous exposure // Avoidance of the ex-mixture
- Probability of the occurrence of a danger incident // Avoidance of the ignition source
- Possibilities with regard to prevention or limitation / effects of damage

Protective measures:

- Primary: Prevention of the development of the explosible atmosphere
- Secondary: exclusion, limitation of the effects of potential ignition sources (free of ignition sources)
- Tertiary: Reduction, limitation, leading-off of the effects (effect limitation)

When does the danger estimate in the explosion document need to be updated?

- Preliminary evaluation (basis)
- Subsequent to state-of-the-art modifications
- At changes in the plant
- Subsequent to occupational accidents, „incidents“ / malfunction, …
- Subsequent to modifications of „controls“: decrees, laws, ...
- At new acquisitions

Attention:

.. Optical and acoustical alarming before explosion conditions are reached …

often falls into oblivion!

1.6 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!

Comparison: events resulting in the death of a person:
insect bites > lawnmowering > trip with the car from Munich – Hamburg > >> biogas accidents

1.7 Ignition sources

Check / analyse for: the existence of effective ignition sources:

- 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, cathodic 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 <u>non-conductive</u> materials (plastic) – bunch discharges, separating processes
- Lightning stroke - > direct and indirect (induction)
- Electromagnetic waves 10,000 Hz – 3, 000, 000, 000, 000 Hz (HF)
  - > radio transmitters, welding machines
- 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

2. Risk analysis within the scope of the explosion protection document

Danger analysis: the iterative way towards safety:

Start -> Determination of the operation as directed (risk – acceptance) > Danger identification >Risk assessment > Risk analysis >Risk evaluation > Safe?
> No > Measures to be undertaken to limit the risk or go to start
>Yes! END

3. Implementation with regard to landfill gas / biogas operation

3.1 Formation of biogases

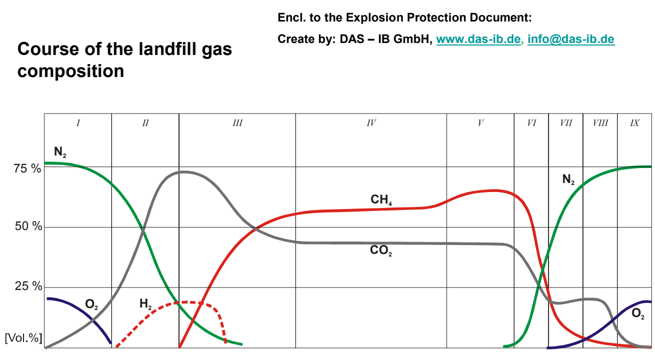
Methane fermentation which also constitutes the basis of the formation of biogases (landfill gas, for example), is an important link in nature's substance

circle. It represents the last stage of a series of fermentations resulting in the conversion of complex, high molecular organic material into gaseous end products, such as methane and carbon dioxide.
With only a few exceptions, all organic natural substances may be submitted to this anaerobic conversion process. A large number of microorganisms, (bacteria) which are in complex dependency participate in this process. Natural places where such mixed populations can be found are swamps, rice fields, moors, sludge layers in lakes, rivers and seas, the rumen of cows etc. In such a manner, approx. 300 to 400 million Mg of methane are produced annually.
Landfill gas develops in the landfill body, meaning that the term „landfill gas“ comprises any gaseous metabolic products which result from microbial conversion processes in the landfill body, as well as deposited substances which turned into the gaseous phase. According to this definition, landfill gas, along with fermentation and marsh gas belongs to the group of biogases which, for the most part, are composed of methane and carbon dioxide.

3.2 Composition of biogases

The composition of landfill gas changes in the course of time. Biogases in the biogas plant (continuous operation) do not. Subsequent to deposition, aerobic conditions prevail near the surface. Later on, the individual degradation stages establish themselves one after another, until all stages are balanced in the fourth time phase (stable methane fermentation). At that moment, the landfill gas consists of 55 to 60% of methane and of 40 to 45% of carbon dioxide. During subsequent decades, further phases will follow.
Besides methane and carbon dioxide (the main components), landfill gas contains a large number of trace substances. These may either result from biological conversion processes or from their deposition in the landfill body and, because of their vapour pression, they may tend to convert into the gaseous phase. O_2, CFCs, Cl, F, Si, S, H_2S, NH_3, …..
Besides sulphuric compounds, O_2 in the form of atmospheric oxygen (air dosage) needs to be mentioned (as far as biological gas cleaning (desulphurisation) is concerned) with regard to biogas plants.

3.3 Chronological course of landfill gas formation



(Farquhar/Rovers 1973) and long term model of Franzius 1981 and Rettenberger& Mezger 1992

3.4 Explosive atmosphere of the biogas / landfill gas

Explosible gas atmosphere according to EN 60079-10:
Mixture of air and a flammable material in the form of gas, vapour, or dust (under atmospheric conditions) in which, subsequent to ignition, the fire spreads over the entire mixture which is still unused.

You may find the three-component diagram for biogases under point 4, appendices of this lecture – see appendix 4.1.
This means, it is imperative that, besides a methane content of between approx. 4.4 and 16.5 vol %, an oxygen content of > approx. 11 vol % exists simultaneously in order to produce an explosible atmosphere. Any other areas are considered to be either „inert“ or „flammable“.
Explosion-prone area according to EN 60079-10:
Area, where an explosible gas atmosphere exists or can be anticipated, the extent of which is such that measures regarding the construction method, installation or use of electrical working tools need to be undertaken.

3.5 Practical implementation for the enterprise / the operator

Structuring of landfill gas plants / biogas plants with regard to explosion protection-relevant areas as a basis for division into zones

A landfill gas extraction system may be divided into three areas with regard to the assessment of explosion protection measures to be undertaken:

I. Gas-containing plant components under suction pressure
   the risk: introduction of atmospheric oxygen
II. Gas-containing plant components under overpressure conditions
   the risk: escape of biogases into the free atmosphere, enclosed areas or possibly into shafts
III. Environment of the gas-containing plant components
   As regards the risk, see point II.

Pragmatic implementation: see discussion included in the lecture at the end of the presentation or give us a ring: # 49 / 431 / 683814 or write an email: info@das-ib.de

3.6 Nothing is impossible / I take this liberty / Discover the possibilities

This means that the operator of a gas plant is thus enabled, on the experience gained with his own enterprise on which he may exert influence by carrying out maintenance works, inspections, optimisations etc., „to assess and act in a safety-related manner“ in view of and within the scope of the explosion protection document (risk analysis).
And those who are scared…..rely on „expertise“.

And this is what remains in the end: more independence and creative potentialities regarding internal regulations. „Define“ the zones here and then employ tools for these zones in accordance with 94/9/EC!

4. Appendices of the explosion protection document (extract)

4.3 Safety-related characteristic numbers
Landfill gas: Mixture of methane, nitrogen, carbon dioxide and oxygen
Ignition temperature: 537 °C (methane 595 / 650)
Explosion area: approx. (4.4) 5 – 15 (16.5) vol %
Density ratio: approx. 1 – 1.25 (CO_2 approx. 2 // CH_4 approx. 0.7)

For methane
Ignition group: T1 (> 450°C, ignition temperature of the flammable substance)
Explosion group IIA
Minimum ignition energy: 0.28 mWs (0.28mJ)
Max. pressure of the blast (overpressure) for methane: 7.06 bar
Classification in accordance with IEC report 60079-20, source Tab. 56 D-116; gases-vapours. Dräger company and Redeker / Schön. 6th addendum: Safety-related characteristic numbers of flammable gases and vapours, 1990

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:
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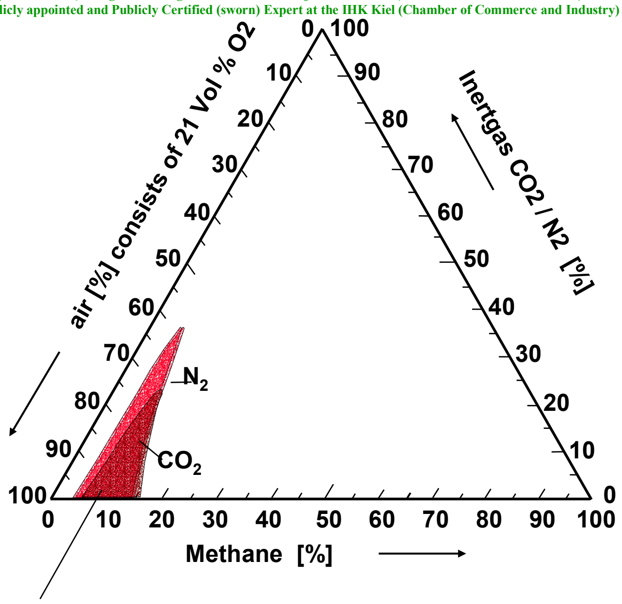

Explosion area : Exceeding of 11,6 Vol % oxygen
and
between 4,4* (5)**Vol % methane (100 % LEL) and 15 (16,5) Vol % methane (100 % HEL)

* IEC 60079-20 and PTB ** EN 50054

4.4 Personal protection
Personal protection: (See also lecture: Fundamentals of landfill gas technology by DAS-IB GmbH)

Oxygen (O_2): < 17 vol% lack of oxygen, below this value reduction of the physical conditions, unconsciousness and death at approx. 6 – 8 vol%, therefore > 20 vol%

Carbon dioxide (CO_2): Maximum working site concentration 5,000ppm = 9,100 mg/m^3 = 0.5 vol%, odourless, from 1 vol% onwards first impairment and injuries

Methane (CH_4): 100% LEL, Ex = 4.4 vol%; limit value: 20% LEL = 0.9 vol%

Hydrogen sulphide (H_2S): Maximum working site concentration 10ppm = 14 mg/m^3 = 1 / 1,000 vol% and ex at > 4.3 vol% to 45.5 vol%