

Biogas Association Roundtable Talk, 19th of October 2016, Bangkok



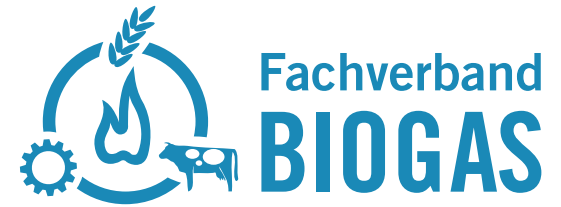
# FvB Biogas Safety Guidelines – Deep Dive Session on Crucial points

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**Biogas  
can do it!**

# Methodology for this session



- Input on:
  - Different topics regarding biogas hazards or characteristics
  - Typical safety measures
- Discussion on how this applies to Thailand

# Topics

- **Gas hazards**
- Explosion and fire hazards
- Sources of danger from the surrounding environment
- Hazards arising from inappropriate behavior
- Special operating conditions
  - Start-up/Commissioning
  - Maintenance and repair work
- Fire protection concepts
- Protective measures

# Gas hazards



## Biogas / biomethane composition

	Biogas	Biomethane (natural gas quality)
Methane (CH <sub>4</sub> )	50-75 %	> 97 %
Carbon dioxide (CO <sub>2</sub> )	25-45 %	< 3 %
Oxygen (O <sub>2</sub> )	2-4 %	< 0.5 %
Hydrogen sulfide(H <sub>2</sub> S)	< 0-6,000 ppm	< 5 ppm

ppm = parts per million =  $10^{-6}$  = 0,000 001 %

# Dangerous component of biogas

## Carbon dioxide (CO<sub>2</sub>)

- CO<sub>2</sub>: colorless, odorless, heavier than air
- MAC<sup>1</sup> 5000 ppm = 0,5 %; dangerous area above 8 Vol. %
- danger of suffocation

## Methane (CH<sub>4</sub>)

- methane is colorless, odorless and lighter than air
- danger of suffocation
- **explosive range 4,4 % - 16,5 %**

## Oxygen (O<sub>2</sub>)

- **O<sub>2</sub>-concentration below 18 Vol.-% is dangerous**

## Ammonia (NH<sub>3</sub>)

- ammonia is colorless, pungent smelling and lighter than air
- danger of fire 15 % - 30 %
- MAC<sup>1</sup> 20 ppm = 0,002 %
- 30 - 40 ppm = irritation of mucous membranes, respiratory tract and eyes
- **1000 ppm = 0,1 % = difficulty in breathing, unconsciousness**

## Hydrogen Sulfide (H<sub>2</sub>S) :

- H<sub>2</sub>S is colorless, smelling like rotten eggs
- heavier than air, strong blood and nerve poison
- MAC<sup>1</sup> 10 ppm = 0,001 %
- 50 ppm 0,005 % = irritation of the respiratory tract
- **200 ppm 0,02 % = paralyzed sense of smell**
- **700 ppm 0,07 % = respiratory arrest (death)**

# Safety Measures

- If the possibility of gas leakage is given, employees should always measure the gas concentrations in the atmosphere with special gas measuring devices.
- The hazardous atmosphere should be diluted by air ventilation
- If working procedures in hazardous atmospheres can not be avoided, employees must wear filter masks and in special cases breathing apparatus



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# Explosion hazards

When are explosion hazards present?  
“Explosion Triangle“

**Biogas**  
explosive range:  
6 - 22 Vol.-%

**Air (oxygen)**  
> 11,6 Vol.-%

**Source of ignition**  
Ignition temperature:  
700 ° C





# Explosion / deflagration



Input pipe

Ignition protection system?





**Fire in the control cabinet ► explosion/deflagration  
in a CHP-building**

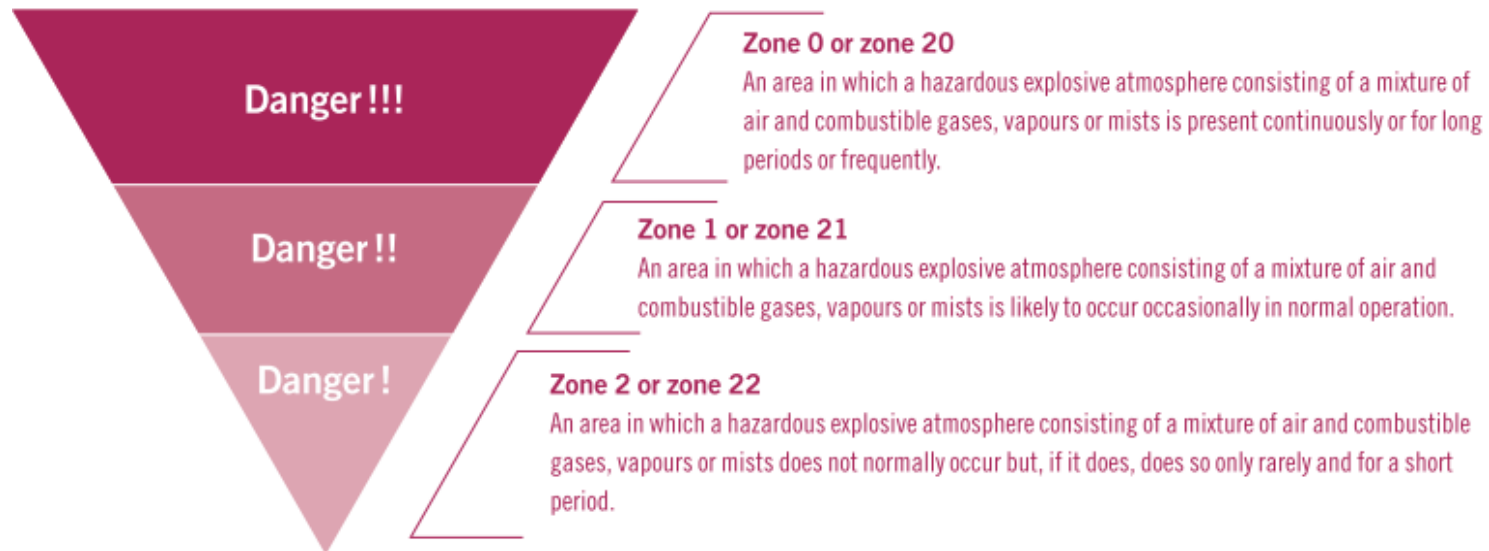


# Prevention of hazards



- Explosion hazards must be determined and assessed. In particular, it must be determined **where** potentially explosive atmospheres can occur.
- **Potentially explosive areas have to be classified into**  
➔ **Ex-zones = Ex-Zone-Document is necessary for all biogas plants!**
- 
- Potentially explosive areas must be identified **by appropriate signage.**

## Ex-Zoning





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# Hazards from the environment

- Weather-related hazards:
  - Flooding
  - Earthquakes
  - Storms
  - Ice and/or snow
  - Power outage
  - Heavy rainfall



# Safety Measures

- Tear-resistant gas storage membrane (for special conditions)
- While planning of the biogas plant take into account the local conditions (e.g. hillside)
- In the case of possible floodings a retaining wall might be appropriate

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# Hazards from inappropriate behavior

- Potential hazards arising from inappropriate behaviour must also be taken into account in the operation of a biogas plant.
- These include, for example:
  - action by unauthorised persons
  - dangers from personnel (operating errors, on-call service not working, deliberate failure to carry out fault rectification measures, sabotage, etc.)



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# Hazard assessment for specific operating states

- It is not appropriate to consider start-up/shut-down or maintenance work on a continuously running biogas plant as normal operation.
- Statistical evaluations of personal injuries at biogas plants reveal a significantly high accident rate in connection with maintenance work and start-up or shut-down procedures.
- These operating states should therefore be considered separately, with their own specific operating instructions.

# Hazards during start-up

- Explosive areas may occur inside tanks due to remaining oxygen and first amounts of produced biogas
- Incompletely filled tanks could lead to an uncontrolled escape of biogas
- Feedstock materials which are mixed beforehand can lead to an acid-base-reaction which leads to the production of H<sub>2</sub>S
- ...

# Safety measures during start-up

- Draw up a start-up plan before starting commissioning and to follow it closely.
- Gas pipes must be tested if gas tight. Test: Ensure that pressure holds for defined time
- Make sure all work in the pipework and digester is finished before filling the digester for the first time
- Weigh the feedstock materials properly, if organic loading rate rises too fast the process can quickly become overloaded.
- It should also be noted that during start-up of the plant an explosive gas mixture is temporarily present because of the increase in the proportion of methane in the biogas (with a volume fraction of 6–22% biogas in air!!!).



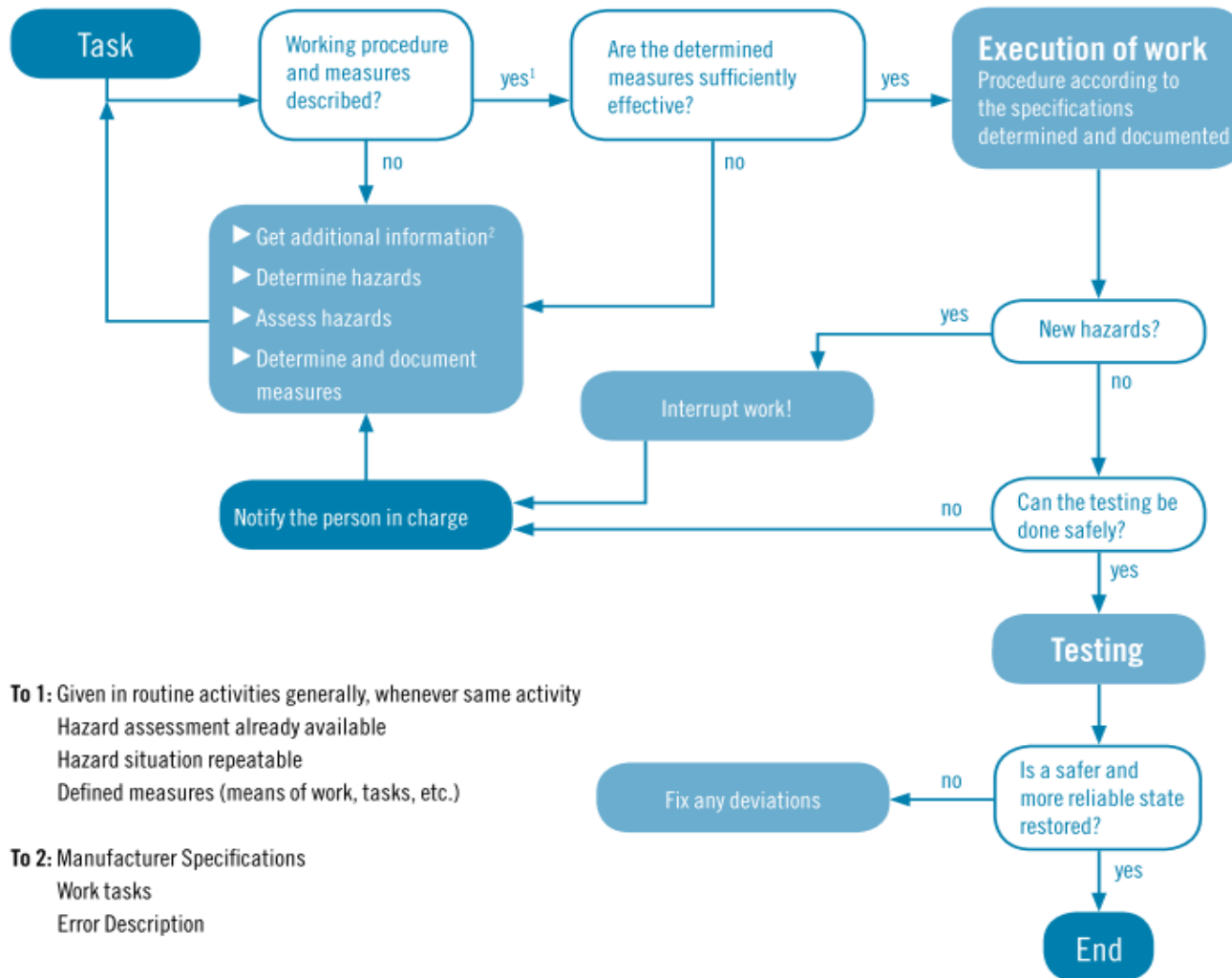
# Hazards during maintenance work

- Lack of qualified (or unexperienced) service companies
- Welding or flexing inside hazardous atmospheres
- Unallowed activating of devices which are out of service for special reasons
- Wrong and non suitable working equipment / tools
- ....

# Safety measures during maintenance work

- Establishing and marking or cordoning off areas where a risk of fire/explosion or a health hazard is to be expected.
- Shutting down electrical and other non-explosion protected systems.
- Removal of biogas from parts of the plant.
- Selection of appropriate explosion-proof equipment and tools.
- Clearance measurement, i.e. the determination of the concentration of hazardous materials or oxygen content using appropriate measuring techniques in a certain area. The purpose of this is to classify the surrounding atmosphere as safe for employees or to initiate further protective measures.
- Use of appropriate personal protective equipment.
- Ensuring adequate ventilation.
- Appointment of a supervisor.

# Safety measures during maintenance work





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- **Fire protection concepts**
- Protective measures

# Fire prevention concept

- Structural, technical and organisational fire prevention measures should be taken into account when designing and planning a biogas plant.
- Considering specially national guidelines for fire protection.

## Structural fire protection

Heat insulation for fermenters / tanks:

- normally inflammable B 2 DIN 4102
- Flame-resistant B 1 DIN 4102

## Technical fire protection

Portable extinguisher for fireclasses A, B and C  
CO<sub>2</sub>-extinguisher  
Flame detector

## Organisational fire protection

Labelling

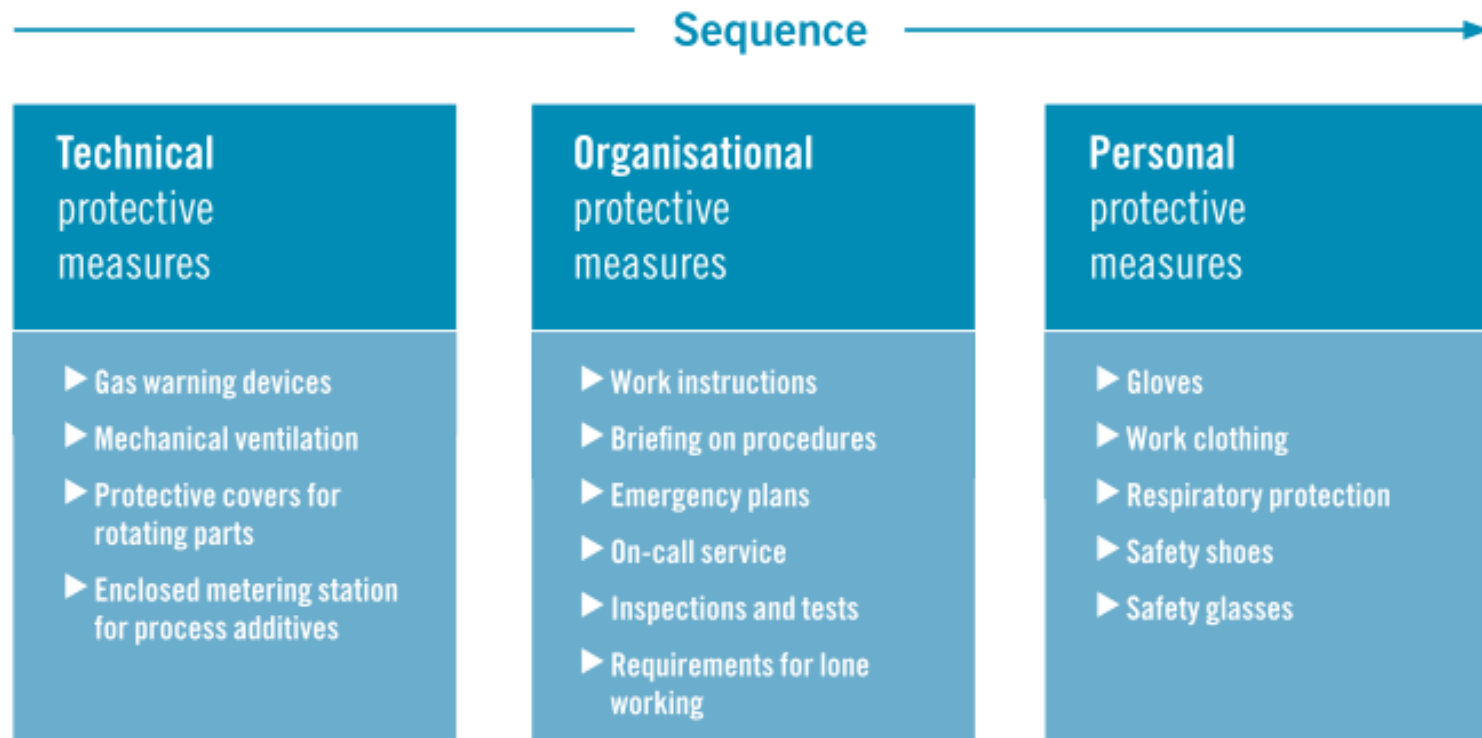


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# Protective measures

## T-O-P Principle



# Protective measures: risk assessment

- The focus of a hazard assessment is **to protect and to reduce the exposure to risk and hazards of employees.**
- The **employer must** determine, evaluate, and **minimize the hazards** and must consider the acquired knowledge by
  - the design and selection of work tools
  - as well as the design of workplaces
  - work and production processes
  - work procedures
- **When has the risk assessment to be updated?**
  - First analysis before start up
  - At regular intervals, in particular: changes to regulations or in the state of the art
  - If facilities are substantially expanded or rebuilt
  - In the case of significant changes in the organization of work
  - After accidents, near-accident and work related diseases

# Protective measures

- **Safety instructions for entering tanks and pits**
  - Clearance measurements of dangerous areas
  - Ventilation of the tank and pit
  - Rescue elevator with safety rope and fall adsorber
  - Personal safety equipment: portable Ex-Zone and multi-gas detector
  - Portable breathing apparatus
  - Second person outside of the tank/pit for safety measures



Thank you for your attention!

