

Occupational Health, Safety and Environment Guidelines in the Operation of POME-based Biogas Installation



LIST OF ABBREVIATION

APAR	Fire Extinguisher
PPE	Personal Protective Equipment
USA	United States of America
ATEX	Atmosphere Explosive
B3	Hazardous and Toxic Materials
BOD	Biological Oxygen Demand
CAL	Covered Anaerobic Lagoon
CSTR	Continuously Stirred Tank Reactor
COD	Chemical Oxygen Demand
DG	NREEC Directorate General of New, Renewable Energy, and Energy Conservation
MEMR	Ministry of Energy and Mineral Resources of the Republic of Indonesia
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GHG	Greenhouse Gas
HDPE	High Density Polyethylene
OHS	Occupational Health and Safety
LCORE-INDO	Promotion of Least Cost Renewables in Indonesia Project
LH	Environment
MSDS	Material Safety Data Sheet
UU	Law
P2K3	Occupational Health and Safety Committee
Permen	Ministerial Regulation
Permenaker	Minister of Manpower Regulation
POM	Palm Oil Mill
GR	Government Regulation
OHSMS	Occupational Health and Safety Management System
SNI	Indonesian National Standards
SOP	Standard Operating Procedure
FFB	Fresh Fruit Bunches

FOREWORD

At present, there are more than 50 (fifty) POME-based biogas installations operating in Indonesia. POME-based biogas installations is a bioenergy-based installation that utilizes palm oil mill effluent, where biogas becomes the final product of an anaerobic biological process by microorganisms. Most biogas installations are used for energy, especially electricity for own use or even to be sold to PLN. Although many biogas installations have been operating in Indonesia, no safety guideline for the operation of biogas installations are available. The safety guidelines for each biogas installation can generally vary depending on each company's experience in biogas installations and the technology used. The safety aspect of biogas installations is very important, not only to protect workers and visitors in biogas installations, but also to protect the relatively high investment required by biogas installations.

In order to achieve sustainable, efficient and reliable biogas installation operations, the Directorate of Bioenergy, DG NREEC partners with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH through a joint project of The Promotion of Least Cost Renewables (LCORE-INDO) in drafting the Occupation Health, Security and Environment Guidelines in the Operation of POME-based Biogas Installations in Indonesia. The preparation of this guideline involves relevant stakeholders, such as the Ministry of Manpower, management of the Palm Oil Mill (POM) and biogas project developers who operate POME-based biogas installations. This guideline can be used as a general reference for stakeholders to make specific guidelines, for example technical instructions and SOPs that are more detailed in accordance with the needs of each company. Although this guideline is intended for POME based biogas installations, it can also be used as a reference for non POME-based biogas installations.

We realize that this guideline is still far from perfection. Therefore, we welcome constructive criticism and suggestions to improve this guideline in the future. We would like to thank all parties for your attention, support and cooperation in the preparation of this guideline. Hopefully this guideline can be useful for the biogas sector in Indonesia.

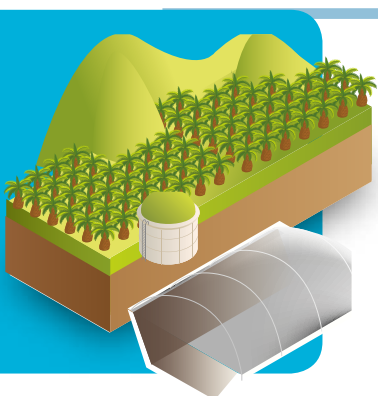
Jakarta, 31 December 2018

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Director General of New, Renewable Energy ,and Energy Conservation

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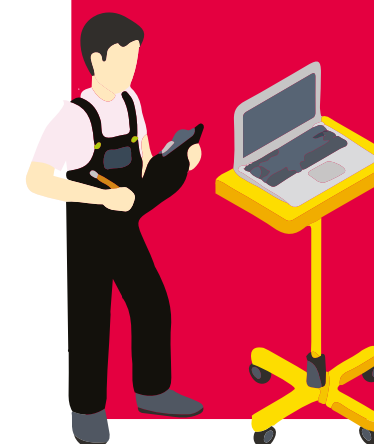


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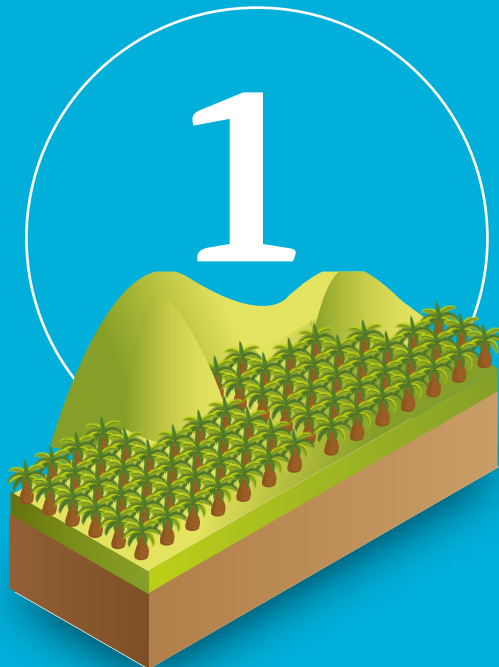
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Published by



CHAPTER 1



INTRODUCTION

- Purpose and Scope of the Guidelines
- Overview of OHSE Regulations in Indonesia
- A list of terminologies that aim to help the readers to understand the technical terms used in this guideline.
- Overview of the biogas installation, which consists of the biogas production process, the characteristics of biogas, and the biogas installation process.

1.1 PURPOSE AND SCOPE OF THE GUIDELINES

PURPOSE OF THE GUIDELINES

📖 This guideline aims to provide guidance on the operational safety standards for POME-based biogas installations to protect the health, safety and environment of workers at the installation.

⚠️ This guideline does not discuss the planning, commissioning and construction stages for biogas installations.

GUIDELINES TARGET

This guideline is intended for:



Palm Oil Mills (POM) with biogas installations

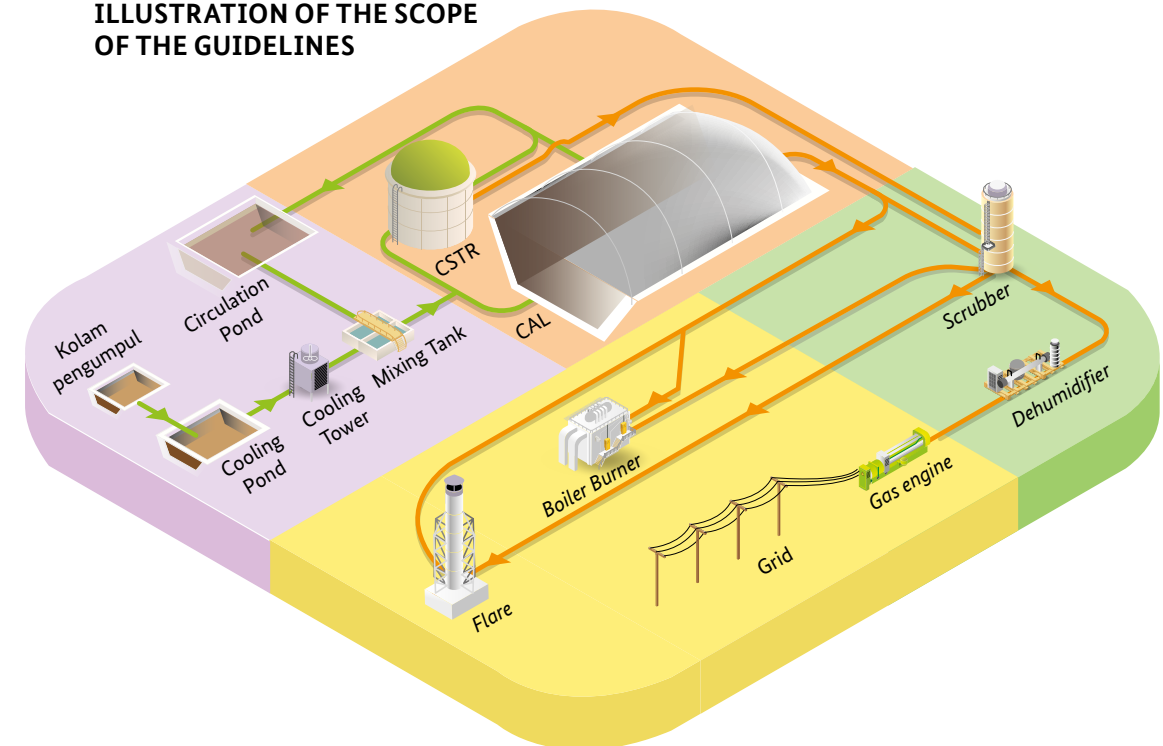


Biogas developers that operate biogas installations



Management and operators of POME-based biogas installations

ILLUSTRATION OF THE SCOPE OF THE GUIDELINES



Preliminary treatment
Conditioning of Palm Oil Mill Effluent to achieve the appropriate parameter values before entering the anaerobic digester

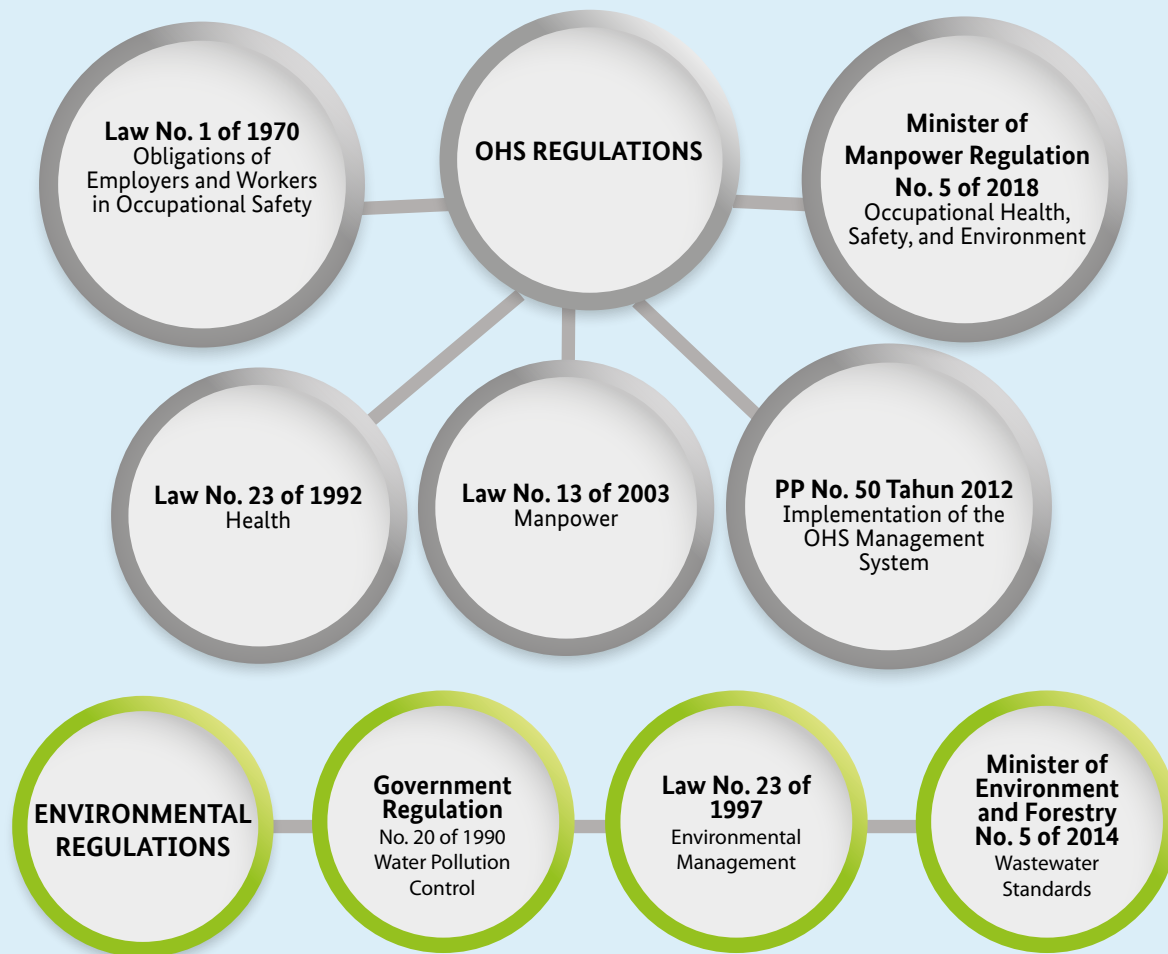
Anaerobic Digester
The decomposition of organic matter by bacteria to produce biogas

Biogas Conditioning
Biogas purification system to meet the requirements to enter the gas engine unit

Biogas Utilization
The process of converting biogas into energy

1.2 OVERVIEW OF OHS REGULATIONS IN INDONESIA

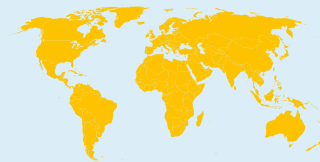
No specific Occupational Health and Safety Management System (OHSMS) for the biogas sectors are available in Indonesia at the time these guidelines were written. However, Indonesia has laws and ministerial regulations related to occupational safety, which are stated in:



In addition, the following regulations that can be used as OHS references for biogas installations in Indonesia:



List of other OHS regulations and standards in Indonesia and the world can be seen in [Appendix 1](#)



INTERNASIONAL

OHSAS 18001:2007 Standards that have been applied to the Occupational Health and Safety Management System. The OHSAS 18001 standard sets the minimum requirements for occupational health and safety management best practices

International Standard Organisation (ISO)

TC 255* related to the topic of biogas produced by anaerobic processes, gasification from biomass, and power to gas from biomass sources The ISO/TC 255 Standard will also discuss the environmental and safety aspects of biogas installations
*(currently being developed)



UNITED STATES OF AMERICA

Occupational Safety and Health Administration (OSHA)

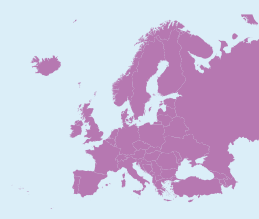
Regulations on the topic of safety and health

National Fire Protection Association (NFPA)

National Electrical Code, Life Safety Code, Fire Code, and National Fuel Gas Code

National Institute for Occupational Safety and Health (NIOSH)

Material Safety Data Sheet (MSDS)



EUROPE

European Union

ATEX* 137 (Directive 99/92/EC) concerning the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

ATEX* 2014/34/EU concerning the classification of work equipment (electrical) intended for use in potentially explosive atmospheres

* Explosive atmospheres directives



GERMANY

Sozialversicherung für Landwirtschaft, Forstern und Gartenbau (SVLFG) - Landwirtschaftliche Berufsgenossenschaft

Biogas regulations for a biogas system - "Technische Information 4 Sicherheitsregeln für Biogasanlage"

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BauA) Bundesministerium für Arbeit und Soziales (BMAS)

Technical Rules for Hazardous Substances (TRGS) – worker protection

Kommission für Anlagensicherheit (KAS)

Leaflet on additional gas consumption components - flare security

Berufsgenossenschaft Rohstoffe und chemische Industrie (BG RCI)

Example of zoning for biogas installations

ISO Independent, non-governmental international organization assigned to develop voluntary, consensus-based International Standards that support innovation and provide solutions to global challenges

UNITED STATES OF AMERICA

OSHA Agency of the Department of Manpower assigned to prepare and set standards by providing training, counseling, education and assistance NFPA

NFPA Global nonprofit organization that provides information sources through more than 300 consensus codes and standards, research, training, education, information dissemination and advocacy on fire, electricity and related hazards

NIOSH Section of the Center for Disease Control and Prevention under the Department of Health and Human Services in charge of developing recommendations for health and safety standards, information regarding safe levels of exposure to toxic substances, agents and hazardous physical substances, and assigned to conduct research on new health and safety issues

GERMANY

SVLFG A federal company under public law with self-government as the holder of agricultural social insurance. SVLFG is responsible for insurance in the agricultural sector, including personal accident insurance, old-age insurance for farmers, health insurance and long-term care

BauA Federal agency for occupational health and safety

BMAS Ministry of Manpower and Social Affairs

KAS Independent body that provides recommendations to the Federal Government or Federal Ministry that is responsible for matters relating to the safety of facilities related to the Federal Immission Control Act

BG RCI Professional association that has the legal mandate to prevent work accidents and work-related diseases and occupational health hazards. The association comprehensively supports the company in all aspects of occupational health and safety, conducts training, investigates the causes of accidents and inspects technical work equipment

(German Social Insurance for Agriculture, Forestry, and Horticulture, 2016)

1.3 DAFTAR ISTILAH



ANAEROBIC DIGESTION

Biological process that occurs when organic matter is decomposed by bacteria in the absence of oxygen to create biogas



BIOGAS INSTALLATION

Equipment and buildings consisting of the preliminary treatment unit, anaerobic digester, biogas conditioning, and utilization



BIOGAS

Gas which is the final product of an anaerobic biological process by microorganisms. The gas generally consists of methane, carbon dioxide and hydrogen sulfide which are flammable and corrosive



BOILER BURNER

Burners in boilers that use a mixture of biogas and oxygen as fuel



BLOWER

The unit that distributes biogas from the digester to the biogas conditioning and biogas utilization units



FLAME ARRESTER

Device to extinguish and stop the spread of fire into the gas system



SUBSTRAT

Raw materials for anaerobic digestion, for example livestock manure, Palm Oil Mill Effluent, or other agricultural wastes



EQUALISATION POND

Reservoir for sludge and oil spills resulting from palm oil treatment



COVERED ANAEROBIC LAGOON

Anaerobic pond equipped with HDPE membrane cover to capture the biogas produced



CONTINUOUS STIRRED TANK REACTOR (CSTR)

Closed anaerobic tank made of steel and equipped with an agitator. The tank cover can also be made of steel or HDPE membrane



BIOGAS SCRUBBING

The biogas desulfurization process, which is the removal of a part or all hydrogen sulfide gas contained in biogas which is corrosive



DEHUMIDIFIER

The unit used to separate biogas and vapor before the biogas enters the gas engine



ZONING SYSTEM

Areas with potential for explosions based on the duration explosive gases are present in the atmosphere. The longer the gas is present, the greater the risk of fire and explosion



ATEX

EU directives describing what equipment and work space is allowed in an environment with an explosive atmosphere



HOT WORK

Work that uses or produces flames or heat, for example pipe cutting, welding, grinding and so on



CONDENSATE

Liquid formed from condensed vapor produced in the biogas conditioning process using a dehumidifier



MACHINE ROOM

The room where the gas engine is stored



FLARE

An equipment used to burn off excess biogas that is not utilized



MATERIAL SAFETY DATA SHEET

Documents containing general descriptions of materials, physical and chemical properties, methods of use, storage and management of chemicals



FIRE EXTINGUISHER

Portable fire extinguishers are used or operated manually and directed at the fire source



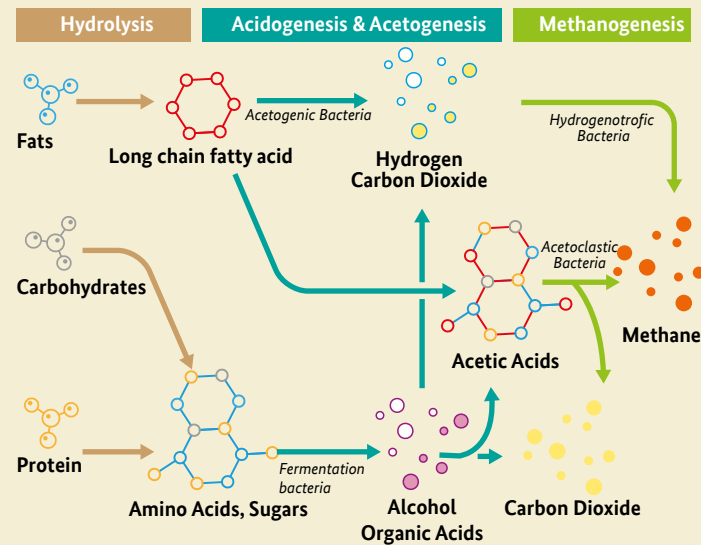
FIRE HYDRANT

Fire protection system equipped with hose and nozzle to channel pressurized water used for fire extinguishing and placed on the courtyard of a building

1.4 OVERVIEW OF BIOGAS INSTALLATIONS

Biogas refers to gas produced by anaerobic digestion of organic matter, gasification of biomass or power to gas from biomass sources and without further upgrading or purification (ISO 20675, 2018).

BIOGAS PRODUCTION PROCESS



Hydrolysis Phase

Long chain molecules, such as carbohydrates, proteins, and fats are broken down into monomers (watersoluble fragments) such as simple sugars, amino acids, and long-chain fatty acids by extracellular enzymes produced by fermented bacteria. Carbohydrates, proteins, and cellulose can be easily hydrolyzed, while lignin will degrade slowly due to the complexity of the chemical and physical composition of lignin itself

Acidogenesis Phase

In the acidogenesis phase, the monomer components formed at the hydrolysis stage will serve as food for acid-forming bacteria (fermentation). At this stage, the bacteria convert simple sugars and proteins into organic acids, alcohol, hydrogen, and carbondioxide

Acetogenesis Phase

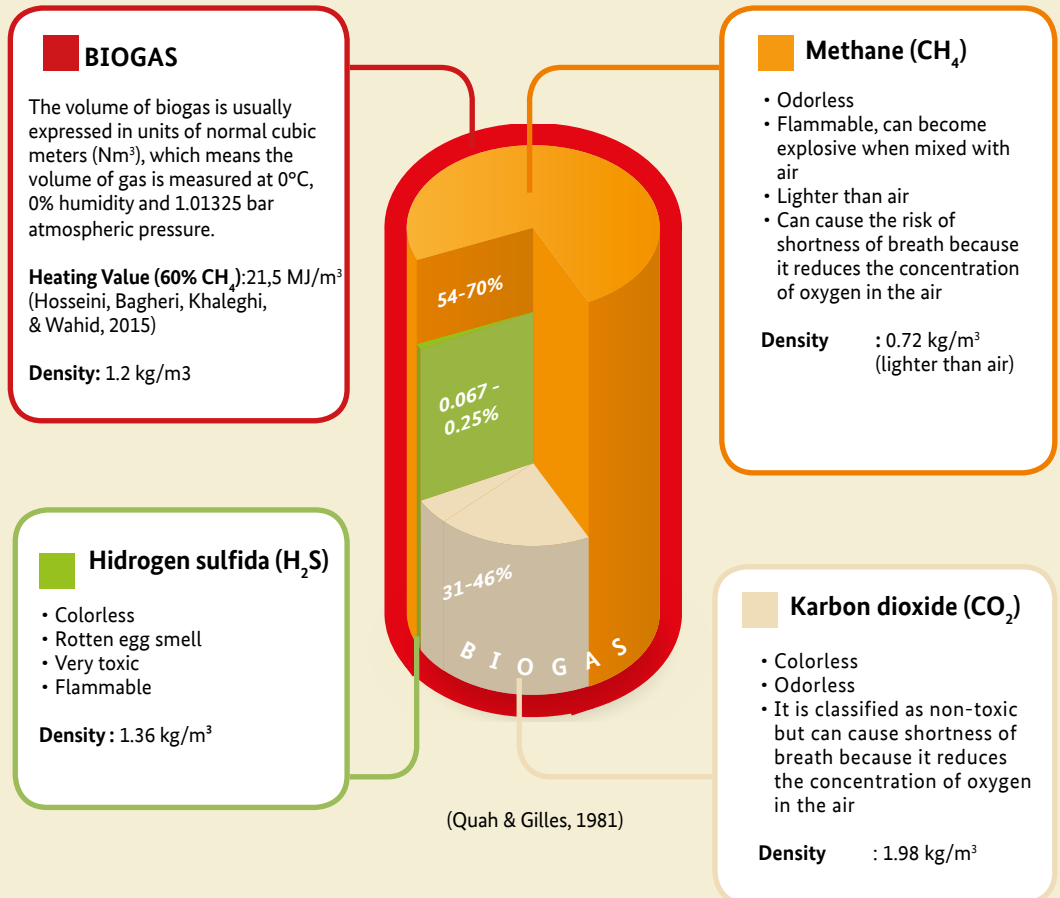
Products from the acidogenesis phase function as substrates for acetogenic bacteria. The acetogenic bacteria nverts organic acids to hydrogen and acetic acid

Methanogenesis Phase

In the methanogenesis phase, methane is produced by two different types of bacteria, i.e. hydrogenotrophic (methanogen) bacteria which convert hydrogen using carbon dioxide and acetoclastic bacteria which converts acetic acid. In addition to methane, the methanogenesis phase by the acetoclastic bacteria also produces carbon dioxide

CHARACTERISTICS OF BIOGAS

Biogas is produced through an anaerobic process when microorganisms, especially bacteria, degrade organic matter in the absence of oxygen. Some references on the composition of biogas can be seen in the table below.



Characteristics of biogas compared to other gases

Parameter	Unit	Biogas (60% CH ₄)	Natural Gas	Propane	Methane	Hydrogen
Heating Value	kWh/m ³	6	10	26	10	3
Density	kg/m ³	1.2	0.7	2.01	0.72	0.09
Density relative to air		0,9	0.54	1.51	0.55	0.07
Ignition temperature	°C	700	650	470	595	585
Maximum flame propagation speed in air	m/s	0.25	0.39	0.42	0.47	0.43
Explosion range	% v / v	6 – 22	4.4 – 15	1.7– 10.9	4.4 – 16.5	4 – 77
Theoretical air consumption	m ³ / m ³	5.7	9.5	23.9	9.5	2.4

(German Social Insurance for Agriculture, Forestry, and Holticulture, 2016)

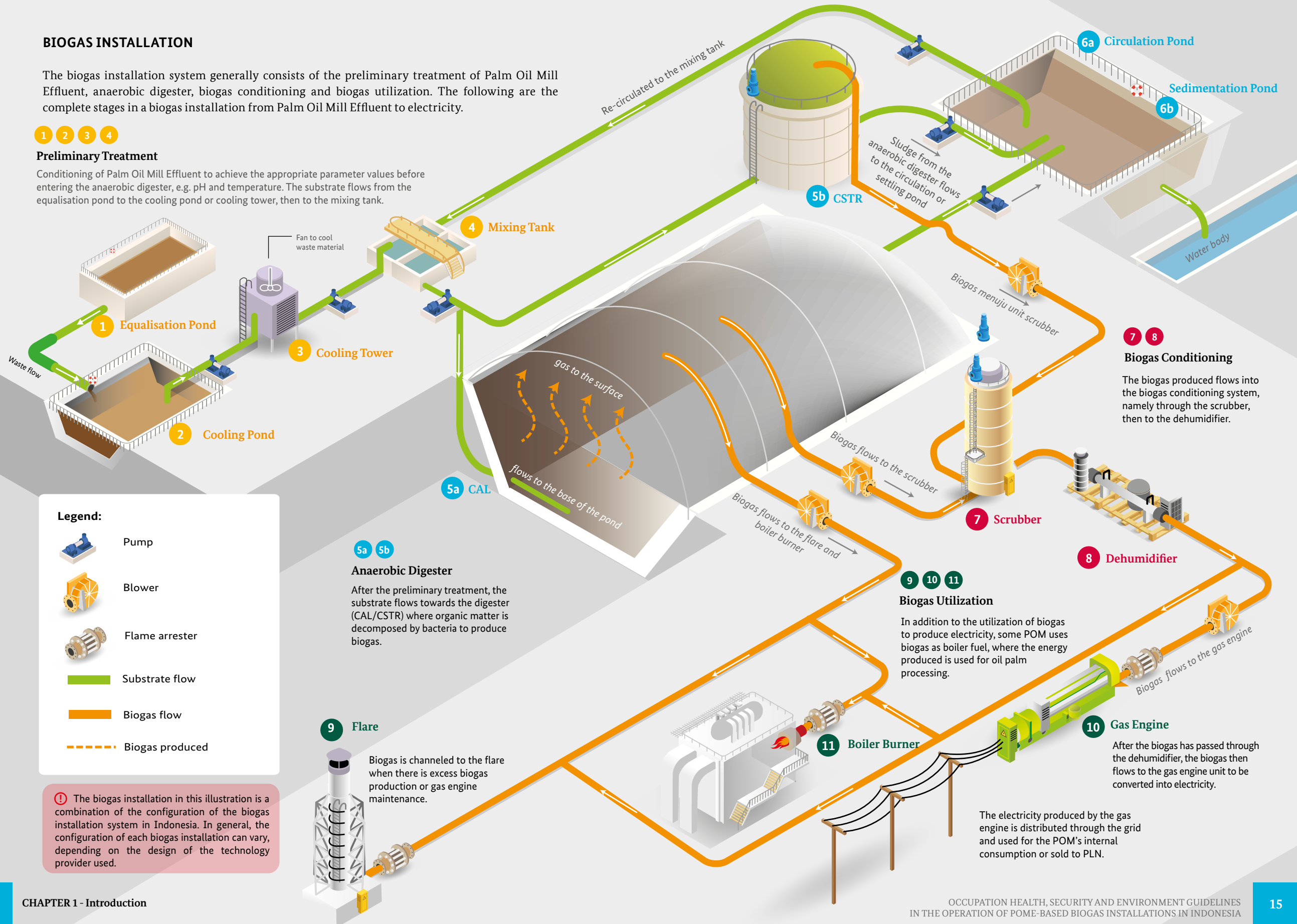
BIOGAS INSTALLATION

The biogas installation system generally consists of the preliminary treatment of Palm Oil Mill Effluent, anaerobic digester, biogas conditioning and biogas utilization. The following are the complete stages in a biogas installation from Palm Oil Mill Effluent to electricity.

1 2 3 4

Preliminary Treatment

Conditioning of Palm Oil Mill Effluent to achieve the appropriate parameter values before entering the anaerobic digester, e.g. pH and temperature. The substrate flows from the equalisation pond to the cooling pond or cooling tower, then to the mixing tank.



Legend:

-  Pump
-  Blower
-  Flame arrester
-  Substrate flow
-  Biogas flow
-  Biogas produced

⚠ The biogas installation in this illustration is a combination of the configuration of the biogas installation system in Indonesia. In general, the configuration of each biogas installation can vary, depending on the design of the technology provider used.

Biogas Conditioning

The biogas produced flows into the biogas conditioning system, namely through the scrubber, then to the dehumidifier.

Biogas Utilization

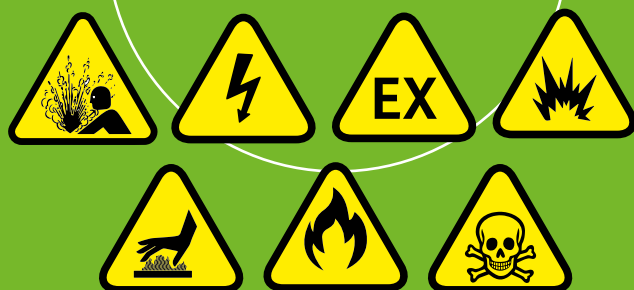
In addition to the utilization of biogas to produce electricity, some POM uses biogas as boiler fuel, where the energy produced is used for oil palm processing.

After the biogas has passed through the dehumidifier, the biogas then flows to the gas engine unit to be converted into electricity.

The electricity produced by the gas engine is distributed through the grid and used for the POM's internal consumption or sold to PLN.

CHAPTER

2



BIOGAS INSTALLATION RISK MANAGEMENT

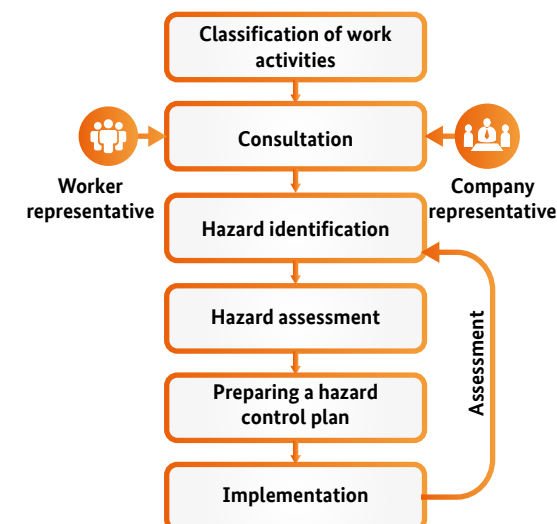
- Hazard identification describes the types of hazards that can be found in biogas installations, including safety symbols related to these hazards.
- Risk assessment describes risk assessment in the form of a risk matrix.
- Risk control describes the types of hazard control, namely technical, administrative, and personal controls in accordance with the identification of potential hazards.

The Hazard Identification, Risk Assessment, and Risk Control (HIRARC) model is the basis of risk management that needs to be applied to a company that has a potentially high level of hazards, including biogas installations. The model covers hazard identification, risk assessment, and risk control which can be used as a reference for the type of risk management applied for safe and reliable planning, management and operation of biogas installations.

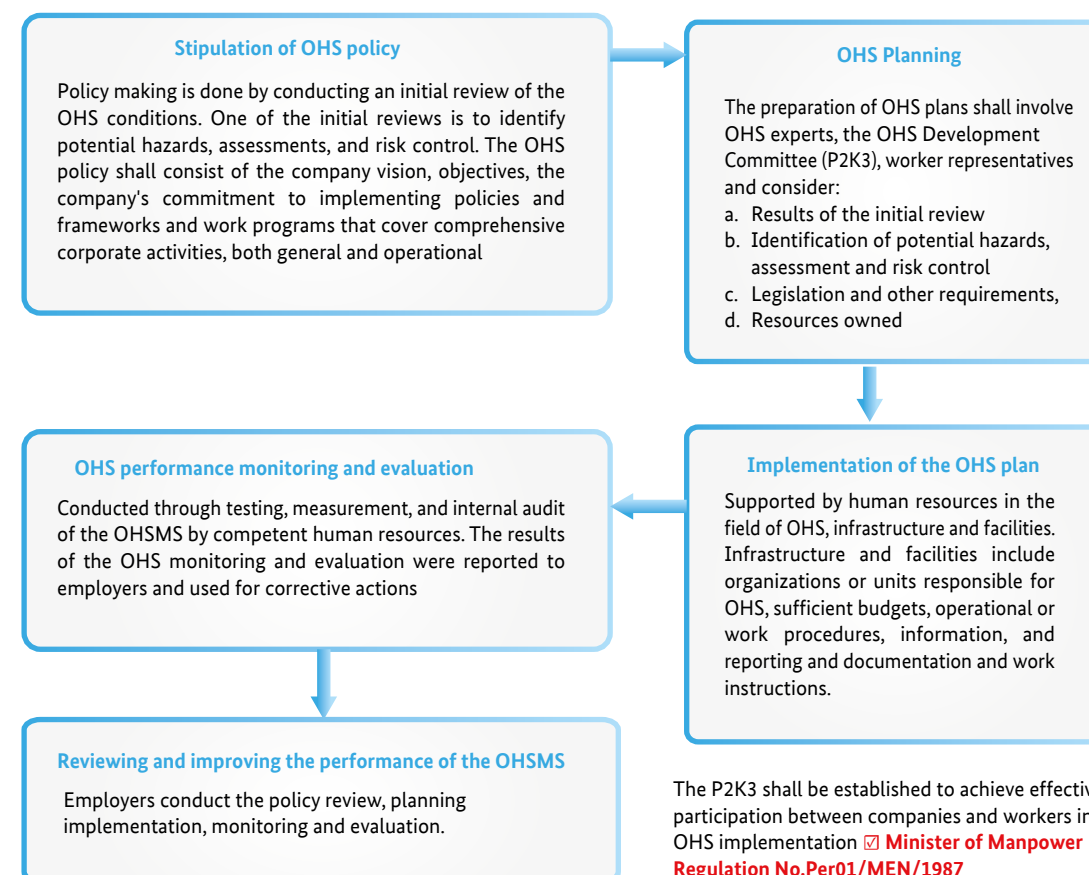
The HIRARC model is in line with the OHS policies on the implementation of the OHS management system based on **Government Regulation of the Republic of Indonesia No. 50 of 2012**.

❗ The regulation requires the application of the OHSMS in companies that employ at least 100 (one hundred) workers or laborers or companies that have a potentially high level of hazards.

Model HIRARC



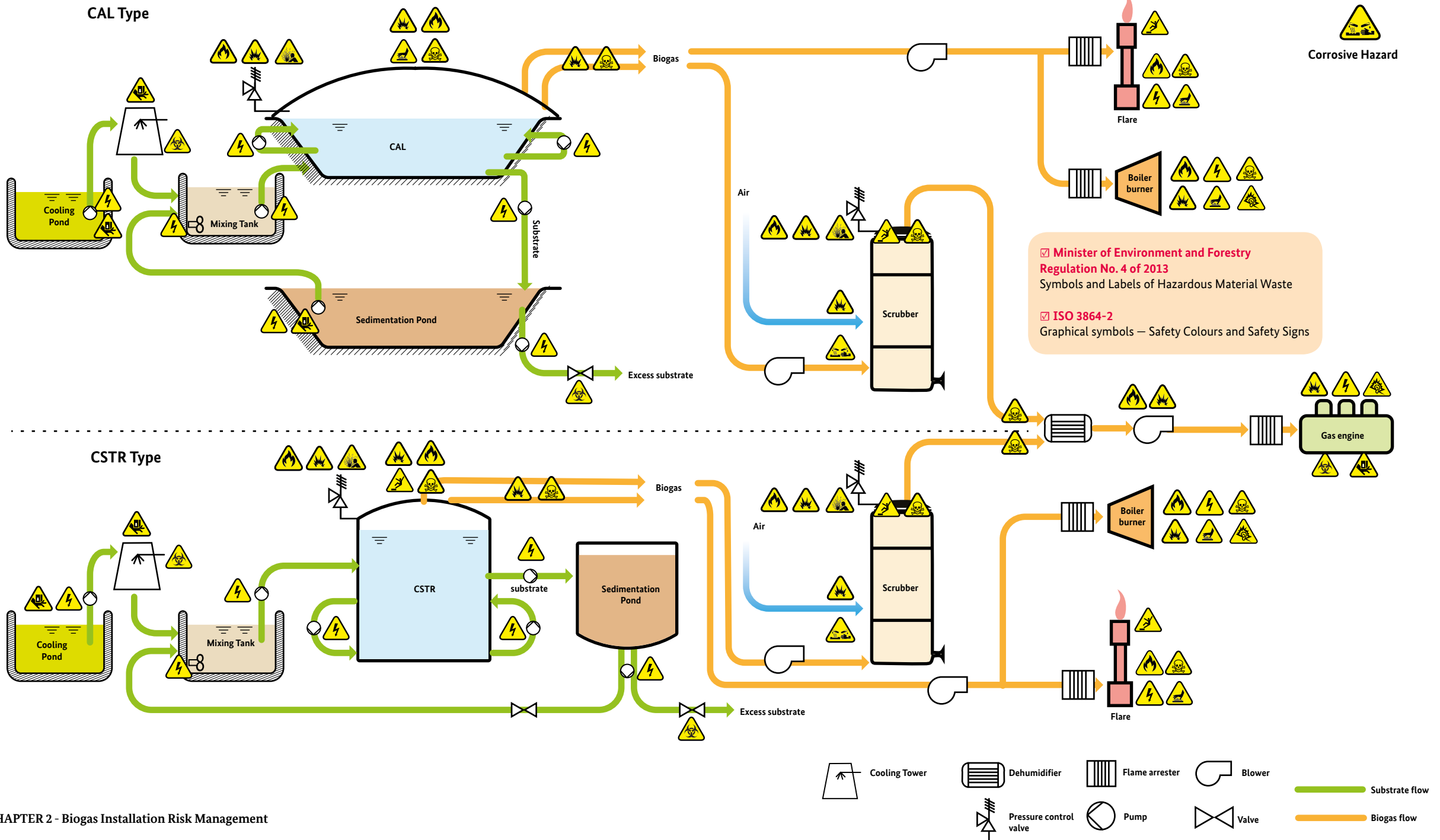
Government Regulation No. 50 of 2012 on the Implementation of the OHSMS



2.1 IDENTIFICATION OF POTENTIAL HAZARDS

A biogas installation is an installation that produces gases through a biological process under anaerobic conditions. The production and composition of the gas can be potentially hazardous because the characteristics of the gas are flammable and corrosive. The potential hazards that can occur in biogas plants include fire and explosion hazards, gas, electricity, hazardous substances (for example from chemical liquids), mechanical, environment hazards and danger from the surrounding environment. The hazard categories along with descriptions and safety symbols used in biogas installations are illustrated below..

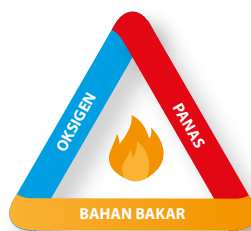
				
Biological Hazard	Hazardous Substances	Fire Hazard	Pressure Hazard	Height Hazard
				
Explosion Hazard	Hot Surface Hazard	Hazards from Electrical Equipment	Noise Hazard	Mechanical Hazard





2.1.1 FIRE AND EXPLOSION HAZARDS

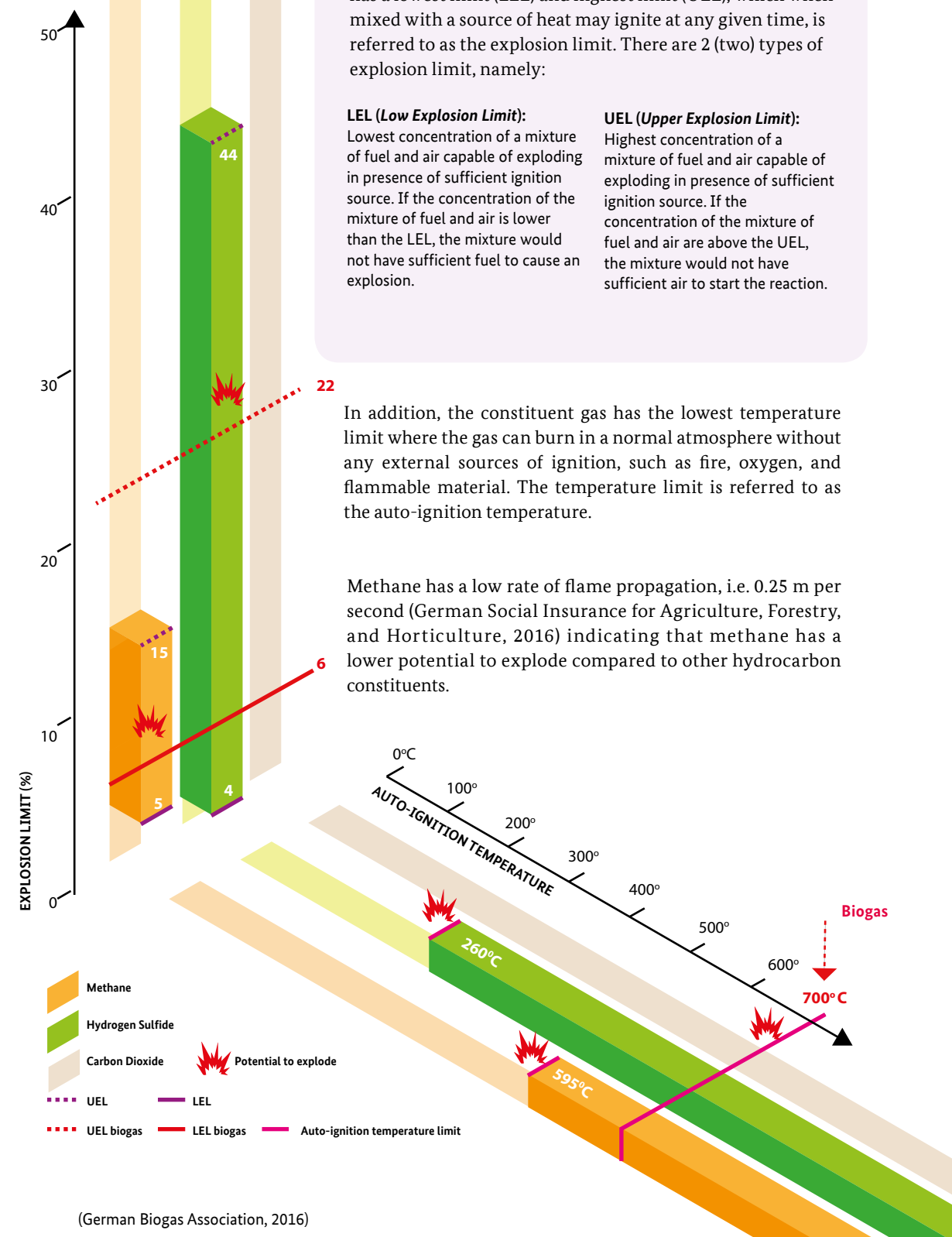
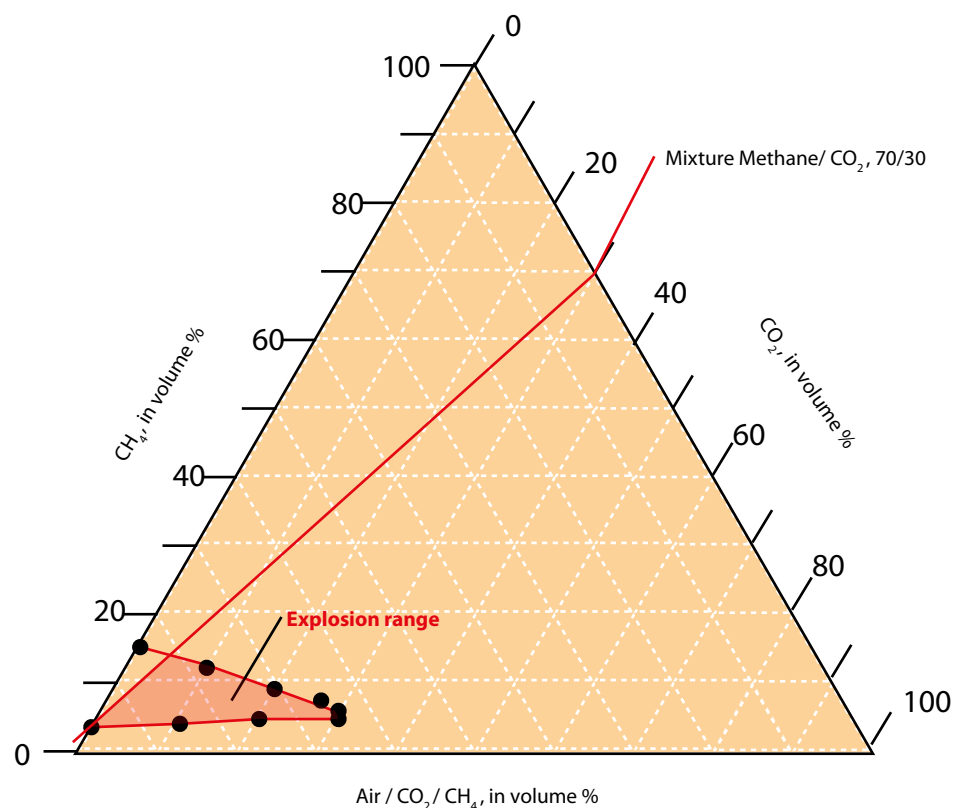
Fire and explosion hazards are a result of a rapid oxidation reaction from mixing 3 (three) elements, namely heat or spark, oxygen and flammable materials that produce heat and light. An illustration of the 3 (three) fire elements can be seen as in the following fire triangle.



BIOGAS EXPLOSION LIMIT AND ITS CONSTITUENT GASES

An explosion occurs due to a rapid increase in volume and release of energy in an extreme manner, usually with the generation of high temperatures and the release of gases. The rapid increase in volume will produce or cause pressure. The higher the pressure, the greater the damage caused. The illustration of the explosion triangle for biogas below shows that the biogas explosion limit varies with the presence of oxygen, according to the proportion of methane and carbon dioxide. The

Methane Explosion Limit is between the minimum (LEL = 5%) and maximum (UEL = 15%), where the concentration of methane is above 15% meaning that the mixture of methane and air does not explode, but will explode when mixed with more air. Conditions below the minimum limit of 5% mean that the mixture of methane and air cannot burn (Zabetakis, et. Al., 1959).



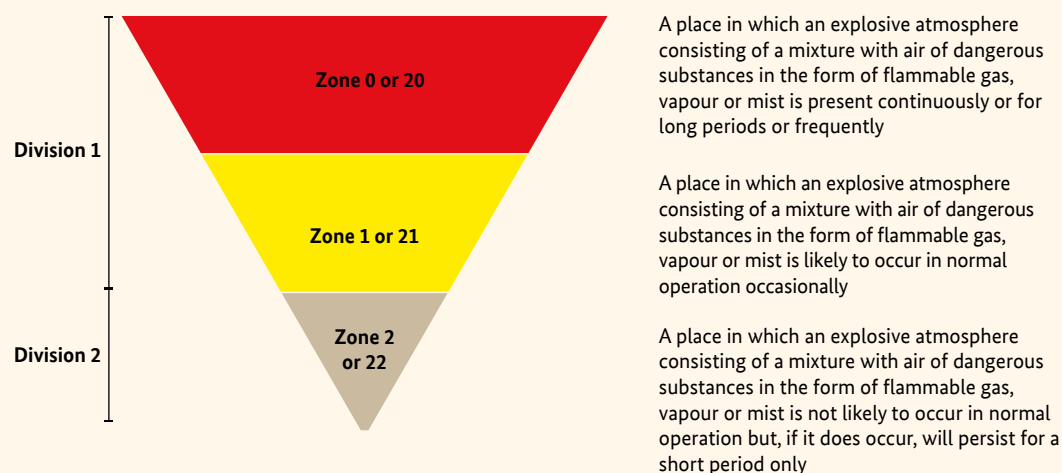
AREA CLASSIFICATION

Hazardous areas are defined as places that have a flammable concentration of gas, vapour, or dust. To avoid and protect the occurrence of ignition due to leakage of combustible substances, each work area requires classification of areas based on the concentration, temperature and intensity of flammable substances exposed to the atmosphere. The classification of areas that have the potential for explosion may refer to the class system and division (North American standard) or zoning system (European standards, from IEC and CENELEC *).

*International Electrotechnical Commission (IEC) and European Committee for Electrotechnical Standardization (CENELEC)

█ **Directives 99/92/EC or ATEX 137:** Workplace Directives The EU Directives specify the minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres¹ of flammable substances in the form of gases, vapours, mists or dust. All companies are directed to determine the classification of work areas that are potentially explosive.

1) Atmospheric conditions in work areas that are potentially explosive. Work areas in the corresponding atmospheric condition refer to an open air environment with an ambient temperature between -20°C to 40°C and a pressure of 0.8 - 1.1 bar

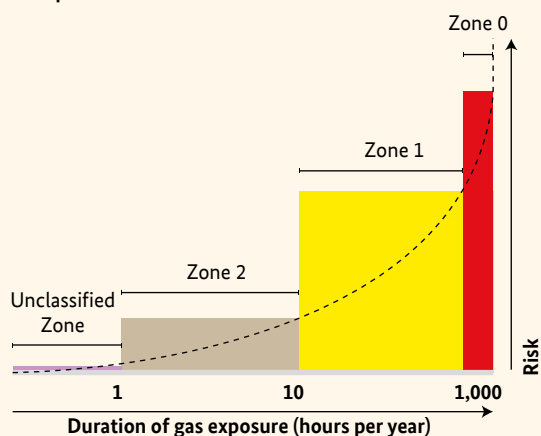


! ATEX 137 does not specifically mention the duration of gas exposure, hence the area classification for biogas installations is made based on evaluations of each management of the biogas installation and OHS division or consultant appointed by the management of the biogas installation. However, the recommended practice for area classification may refer to the American Petroleum Institute RP 505 regarding the Classification of Locations for Electrical Installations in Hazardous Areas, especially at Petroleum Facilities.

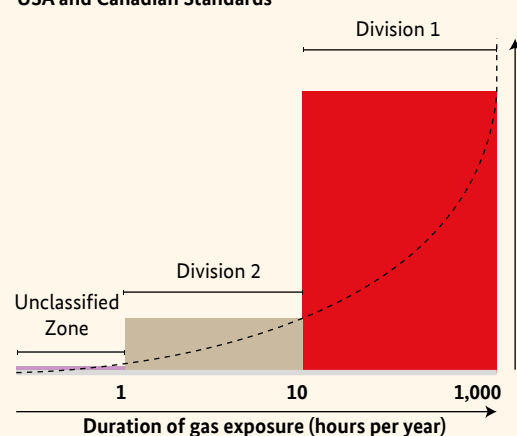
Chapter 3: Specific Hazards and Control; Area Classification in Biogas Installations

API RP 505

European Union Standards



USA and Canadian Standards



WORK EQUIPMENT

Hazardous areas are very closely related to the potential for fire or explosion that occur due to a spark from a mixture of flammable substances. Therefore, the work equipment (electrical) used needs to be adjusted based on the classification of hazardous areas to minimize the occurrence of sparks. The sources of sparks include equipment using batteries (cellular phones, radios, etc.), static electricity, electrical equipment sparks (motors and generators), strong electromagnetic radiation, and hot surfaces of electrical equipment. The selection of work equipment (electrical) in biogas installations is one of the mitigation measures for fire and explosion hazards to protect the assets and investments of biogas installations. The basic principle of selecting work equipment is to ensure that the work equipment is not a source of sparks or has a high surface temperature to trigger a flame.

WORK EQUIPMENT MARKING STANDARDS

North American Marking

NEC 500

Class 1, Division 1, Group A,B T4

```

graph TD
    A[Hazard Class] --> B[Area Type]
    B --> C[Material Group]
    C --> D[Temperature Code]
  
```

NEC 505

Class 1, Zone 0, AEx d IIC T4

Hazard Class

Area Type

Equipment developed for US standards

Explosive code for protection (d,e,i,m,n,o,p,q)

Gas group

Temperature Class

Penandaan Uni Eropa (ATEX/IECex)

CE	Ex	II	2	G	Ex	d	IIC	T4	Gb	
										Mark approved for devices certified by European Union authorities
										Specific marking for Explosion Protection
										Equipment Group
										Equipment Category
										G for gas, D for dust
										Explosion Protection
										Type of Protection
										Gas group
										Temperature Class
										Equipment Protection Level

☒ **ATEX 2014/34/EU**
Determination of the classification of electrical work equipment intended for use in potentially explosive atmospheres (Ex zones)

☑ ATEX 2014/34/EU
Determination of the classification of electrical work equipment intended for use in potentially explosive atmospheres (Ex zones)

2.1.2 HAZARDOUS SUBSTANCES

Hazardous substances refer to substances, material or mixtures with hazardous properties for health, e.g. Palm Oil Mill Effluent, H₂S, CO₂. The properties of hazardous substances are:



TOXIC

eg. H₂S, CO.



CORROSIVE

e.g. H₂SO₄, condensates in the dehumidifier unit. The hazardous substances can be solid, liquid, aerosol or gas.



EXPLOSIVE

Related to the use of reactive, flammable additional material, such as methane, refrigerants in the dehumidifier and consumables in the laboratory.



BIOLOGICAL HAZARDS

Risk of exposure to pathogenic bacteria due to contamination with Palm Oil Mill Effluent.

☑ **Minister of Manpower Decree No.187 of 1999**
Control of Hazardous Chemicals in the Workplace

☑ **Minister of Manpower Regulation No. 5 of 2018**
Occupational Health, Safety, and Environment

Substance	Characteristic	Exposure limit*(ppm)	Indication of exposure
	- Colorless - Odorless - Lighter than air	1,000 (NIOSH)	50,000 – 150,000 Potential to explode 500,000 ——— Asphyxia (NIOSH)
	- Colorless - Odorless - Heavier than air	5,000 (Minister of Manpower Regulation No. 5 of 2018)	250 - 350 ——— Normal concentration in outdoor ambient air 350 - 1,000 ——— Concentrations typical of occupied indoor spaces with good air exchange 1,000 - 2,000 ——— Complaints of drowsiness and poor air 2,000 - 5,000 ——— Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present 5,000 ——— Workplace exposure limit (as 8-hour TWA) > 40,000 ——— Exposure may lead to serious oxygen deprivation, resulting in permanent brain damage, coma, even death (Henderson, 2006)
	- Colorless - Extremely toxic - Heavier than air - Foul smell	1 (Minister of Manpower Regulation No. 5 of 2018)	0.01 – 1.5 ——— Rotten egg smell 2 - 5 ——— Nausea, tearing of the eyes, headaches 20 ——— Fatigue, loss of appetite, headache 50 - 100 ——— Slight conjunctivitis and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite Coughing, eye irritation, loss of smell after 2-15 minutes. 100 ——— Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Death may occur after 48 hours. 100 - 150 ——— Loss of smell 200 - 300 ——— Conjunctivitis and respiratory tract irritation after 1 hour 500 - 700 ——— Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes 700 - 1,000 ——— Rapid unconsciousness, immediate collapse within 1 to 2 breaths 1,000 - 2,000 ——— Nearly instant death (OSHA, 2018)
	- Colorless - Odorless - Tasteless	25 (Minister of Manpower Regulation No. 5 of 2018)	Carbon monoxide can interfere with blood oxygenation by binding to hemoglobin in the blood (Carboxyhemoglobin), hence inhibiting human respiration. < 100 ——— Does not cause any symptoms for 1 hour exposure 300 ——— Mild sinus symptoms at 4 hours exposure 400 ——— Headache, dizziness, nausea, pain, difficulty breathing >1,000 ——— Causes a coma (National Research Council, 2007)

Level of exposure allowed for 8 working hours.

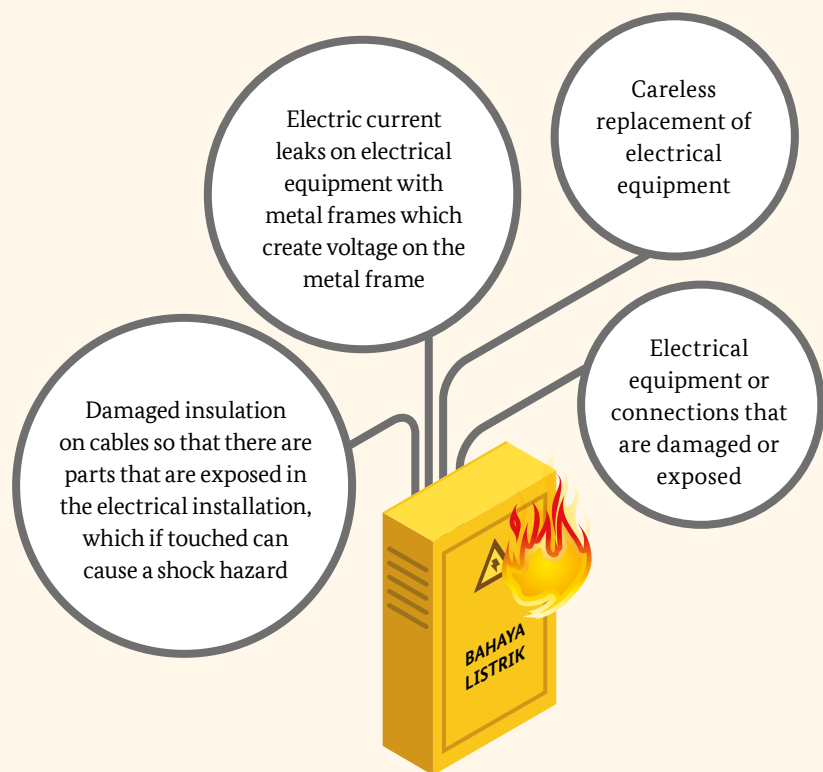


2.1.3 HAZARDS FROM ELECTRICAL EQUIPMENT

Electricity is a source of ignition that can cause sparks which result in electrical hazards, even explosions and fires. In biogas installations, electricity can be a trigger for explosions and fires due to the combustible substances contained in the constituent gases of biogas, namely methane and oxygen. Biogas installations use electrical equipment, such as controlling equipment, pumps, agitators, measuring equipment. The electrical equipment must meet applicable standards to prevent potential hazards.

PRIMARY HAZARDS refer to hazards directly caused by electricity, such as electric shock, fire or explosion. Electric shock can have a direct impact on human health, resulting in death.

SECONDARY HAZARDS refer to hazards indirectly caused by electricity, such as falling from a height.



✓ **Minister of Energy and Mineral Resources Regulation No. 2 of 2018**
Mandatory Application of the SNI in the Electricity Sector

✓ **Directorate General of Labour Inspection Decree No. 48 of 2015**
Electrical OHS Expert Competency Certification

✓ **Minister of Manpower Regulation No.12 of 2015**
Electrical OHS in the Workplace

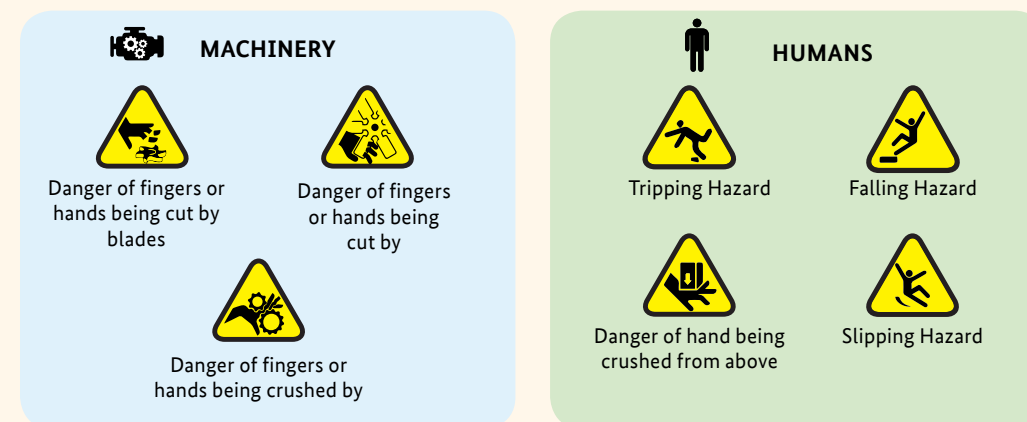
✓ **Minister of Manpower Regulation No.33 of 2015**
Electrical OHS Expert in the Workplace (Amendment to Minister Regulation No. 12 of 2015)

✓ **Directorate General of Labour Inspection and OHS Decree No. KEP. 47/PPK&K3/VIII/2015**
Training for Electrical OHS Expert Candidates



2.1.4 MECHANICAL HAZARDS

Mechanical hazards refer to hazards caused by machinery driven by propulsion, whether operated automatically or manually. The risk of accidents related to mechanical hazards will often occur during maintenance and repairs if adequate security measures are not taken. The mechanical hazards that occur in biogas plants can be caused by work that involves, among others:



✓ **Minister of Manpower Regulation No. 5 of 1985**
Lifting and Transporting OHS

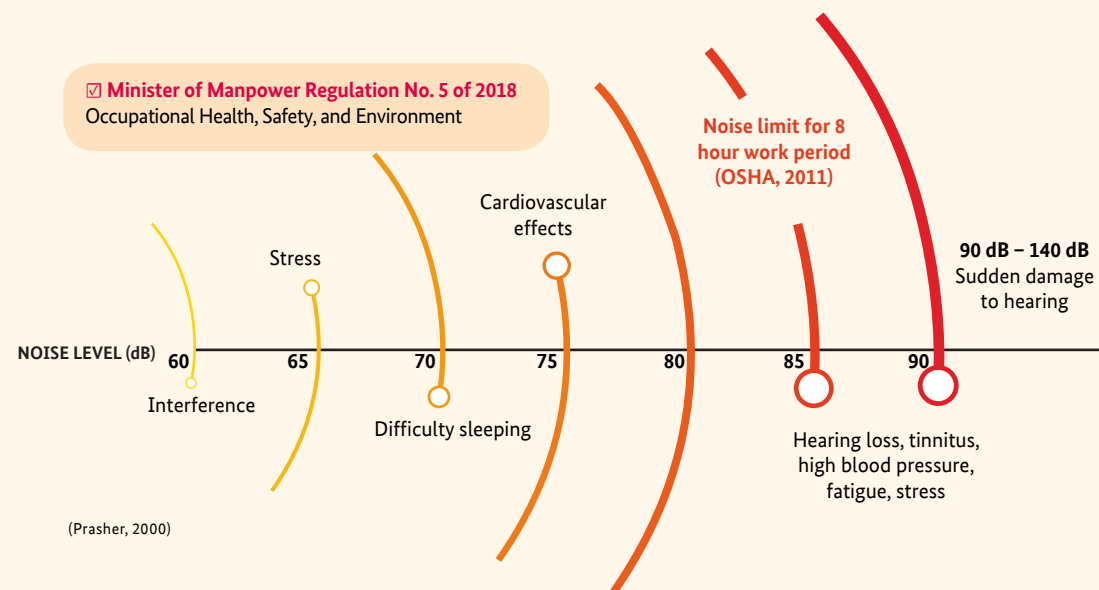
✓ **Minister of Manpower Regulation No. 9 of 2010**
Lifting and Transporting Machine Officers and Operators

□ **Minister of Manpower Regulation No. 38 of 2016**
Generator and Production Machines OHS
□ **Minister of Manpower Regulation No. 9 of 2016**
OHS for Work involving Heights



2.1.5 NOISE HAZARDS

Noise hazards include activities that have the potential to cause hearing loss, even to the point of causing deafness. Noise Hazards in biogas installations can be caused by work in areas that have high noise levels, for example in engine rooms and work that uses equipment that can cause noise. Damage due to noise can be permanent or incurable for the ears.





2.1.6 PRESSURE HAZARDS

Pressure hazards refer to hazards involving significant pressure energy sources, such as air, water, pneumatics and gas. The potential pressure can endanger the safety of employees, cause damage to other important installation components, and can even cause pollution of hazardous substances to the environment

Factors that influence system failure and high-pressure equipment



1. How high the pressure in the system is



2. The type of liquid or gas and whether it is flammable and explosive



3. Compatibility of the type of material and the pressurized system equipment



4. Age and condition of the equipment



5. The complexity and control of its operations

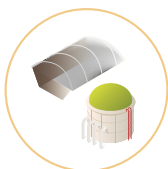


6. Applicable conditions, for example the process carried out at



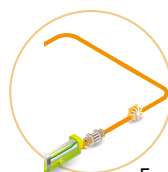
7. Human resources that maintain, test and operate the pressurized system equipment

Potential Pressure Hazards in Biogas Installations



Membrane pressure for CAL that exceeds the limit

Can cause HDPE membranes to tear or be lifted up. The recommended pressure limit for CAL membranes is 80% of the membrane operating pressure. In general, CAL is operated at a pressure of 2-3 cm water.



Pressure leak in corrosive pipelines and areas

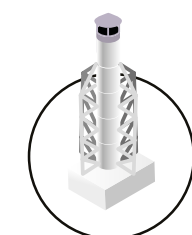
For example, the biogas pipeline leading to the dehumidifier unit can be corrosive due to the chemical (acidic) nature of the biogas added with the pressure from the blower. In addition, pressure hazards can occur if there is a blockage in the system, for example the biogas pipeline is filled with condensed water that is not discharged, palm oil substrate or fiber enters the biogas pipe leading to the scrubber, as a result the substrate entering the anaerobic digester unit is uncontrolled, and others. This can be caused by errors done by the operator, poor construction or maintenance that can lead to leaks or even explosions.

☑ **Minister of Manpower Regulation No. 37 of 2016**
OHS for Work with Pressure Vessels and Storage Tanks



2.1.7 THERMAL HAZARDS

Thermal hazards are associated with objects or substances that transfer energy as heat. Thermal hazards can cause irritation, mild to severe burns depending on the intensity of the thermal radiation and duration. In addition, thermal hazards can cause dehydration in individuals, for example due to an inspection of large area CAL.



Flare 800°C - 1.200°C

1200°C

1100°C

1000°C

900°C

800°C

700°C

600°C

500°C

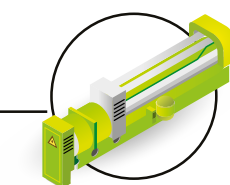
400°C

300°C

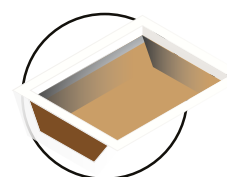
200°C

100°C

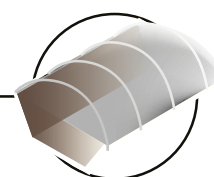
0°C



Discharge from the gas engine
300°C - 350°C



Heat from Palm Oil Mill Effluent
60°C - 85°C

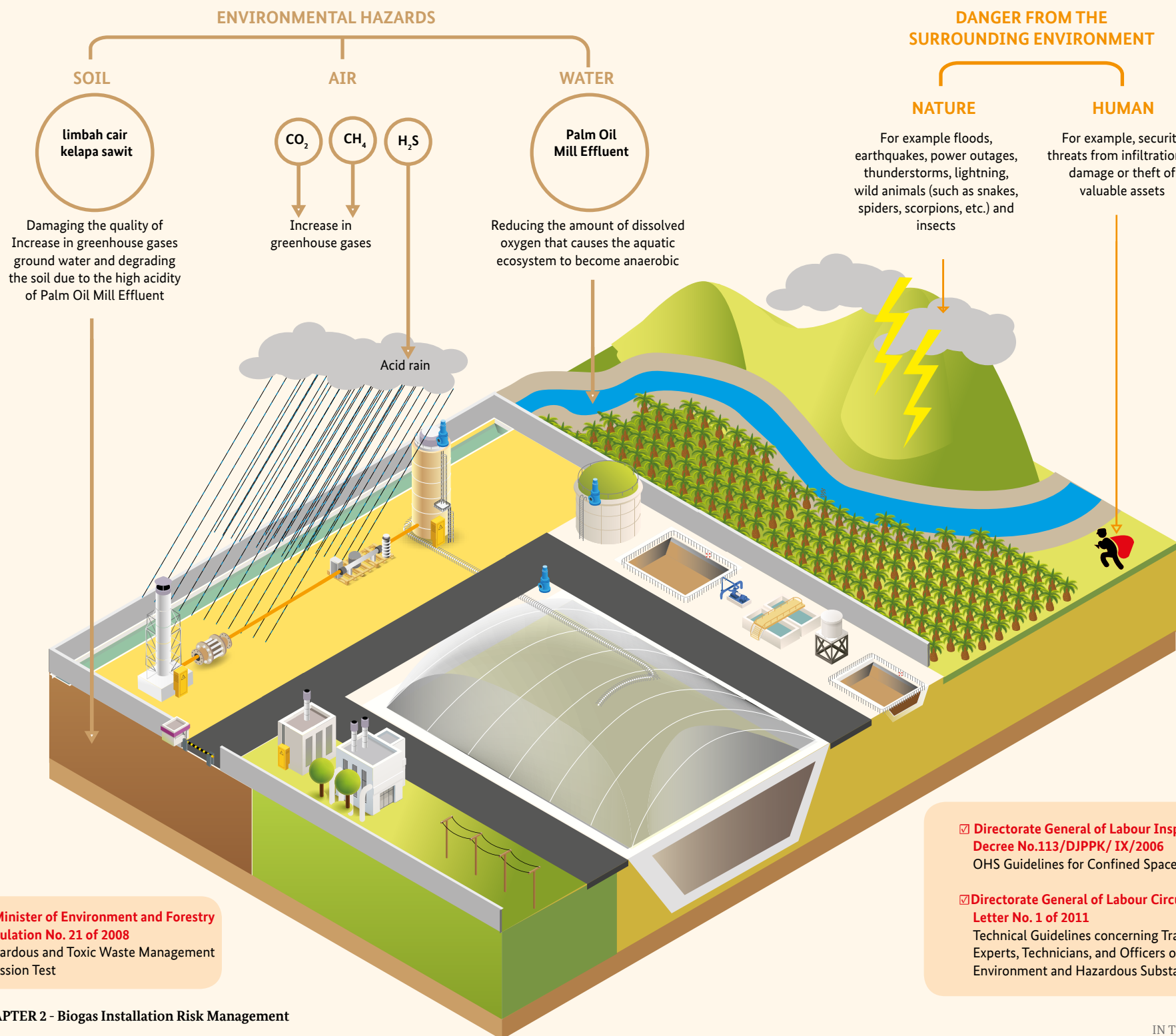


Heat on the membrane
during the day 60°C - 70°C



2.1.8 ENVIRONMENTAL HAZARDS

In principle, environmental hazards can be created by biogas released to air or the products resulting from treatment in installations (such as oil substrates) flowing to the surrounding water body. The environmental hazards from biogas installations can be divided into emissions to air, soil and water.



✓ **Minister of Environment and Forestry Regulation No. 21 of 2008**
Hazardous and Toxic Waste Management Emission Test

DANGER FROM THE SURROUNDING ENVIRONMENT

The potential hazards that can occur in biogas installations can be due to nature and humans, including:

DANGER FROM THE SURROUNDING ENVIRONMENT

NATURE

For example floods, earthquakes, power outages, thunderstorms, lightning, wild animals (such as snakes, spiders, scorpions, etc.) and insects

HUMAN

For example, security threats from infiltration of damage or theft of valuable assets

2.1.9 CONFINED SPACE HAZARDS

Confined space refers to a closed place where there is a risk of serious injury or death due to the following factors:

Chemical:



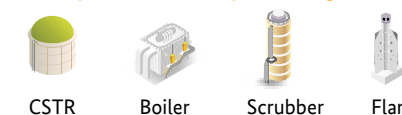
- Toxic gas
- Lack of oxygen
- Pungent smell from chemicals
- Burnt gas
- Exposure to dangerous chemicals

Physical



- Construction of a room, for example partitioned rooms, slippery, fragile construction
- Room condition such as extreme temperatures, noise

Examples of confined space in biogas installations



Criteria for Confined Spaces (OSHA, 2018):



Large enough for a person or part of the human body to enter and exit (limited)



Has physical and mechanical hazards that have the potential to become a trap or obstacle, as well as an internal configuration that could trap or asphyxiate a person



Has the potential to contain a hazardous atmosphere



Does not have permanent access



Does not have enough natural ventilation for a person to breathe normally



Mechanical ventilation, in addition to the natural ventilation system is required before a person can work safely in the space

✓ **Directorate General of Labour Inspection Decree No.113/DJPPK/ IX/2006**
OHS Guidelines for Confined Space

✓ **Directorate General of Labour Circular Letter No. 1 of 2011**
Technical Guidelines concerning Training for Experts, Technicians, and Officers on Work Environment and Hazardous Substances

✓ **Minister of Manpower and Transmigration Circular Letter No. 01/MEN/PPK/IV/2012**
Fulfillment of Occupational Health and Safety Requirements for Confined Space

✓ **Appendix 3.1 and 3.2**

2.2 RISK ASSESSMENT

Risk assessment measures the likelihood and severity of an accident, this can be done through qualitative measurement of the hazard, namely in the form of a risk matrix. The identified potential hazards can be avoided or minimized using this approach. In the risk matrix below, the risk score is calculated by multiplying the likelihood and severity. The risk score is used to prioritize actions needed to effectively manage potential hazards in the work area and all actions taken need to be documented.

			SEVERITY				
			Minor injuries or discomfort. No medical treatment or visible physical impact	Injuries or diseases that require medical treatment. Temporary	Injuries or diseases that require hospital care	Injuries or diseases that result in permanent disability	Death
			1 Not Significant	2 Low	3 Medium	4 High	5 Severe
PROBABILITY	Predicted to occur in normal conditions	5 Almost Certain	Medium	High	Very high	Very high	Very high
	Predicted to occur someday	4 Very Likely	Medium	High	High	Very high	Very high
	May occur someday	3 Likely	Low	Medium	High	High	Very high
	Unlikely to occur in normal conditions	2 Unlikely	Low	Low	Medium	Medium	High
	May occur, but will most likely not occur	1 Very unlikely	Low	Low	Low	Low	Low

- This risk category requires immediate action to control hazards.
- This risk category requires planning in controlling hazards and implementation of interim actions if needed.
- This risk category can be considered acceptable and may not require hazard control measures. However, if the hazard risks occur, control measures shall efficiently be implemented.

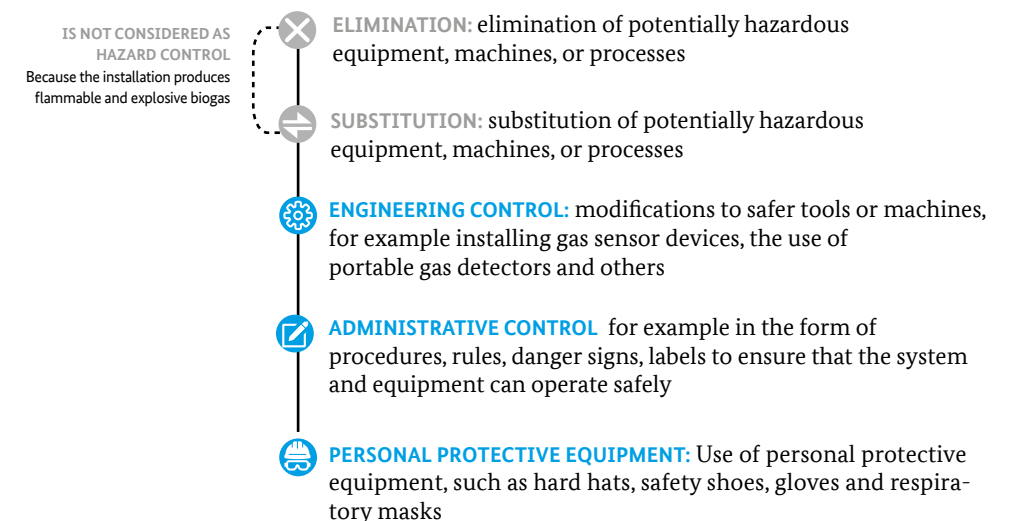
2.3 HAZARD CONTROL

The hazards identified in sub-chapter 2.1 requires measures to control the level of hazards that can occur in biogas installations. The objective of hazard control is to protect workers from health hazards and accidents in the workplace, minimize or eliminate occupational health and safety risks and assist an organization in providing safe and healthy working conditions.

FACTORS TO BE CONSIDERED TO EFFECTIVELY CONTROL AND PREVENT HAZARDS (OSHA, 2018):

- INVOLVE WORKERS**, because they have the best understanding of the conditions of the work environment, creation of hazards and insights on how hazards can be controlled.
- IDENTIFY AND EVALUATE** options or alternatives for controlling hazards, using the [OHS hazard control hierarchy](#) based on NIOSH.

HIERARCHY OF HAZARD CONTROL IN BIOGAS INSTALLATIONS



- USING THE HAZARD CONTROL PLAN** to oversee the control and implementation of the OHS hazard control hierarchy, followed by supervision of hazard control in accordance with the plan.
- DEVELOPING A WORKER PROTECTION PLAN** during emergencies and non-routine activities
- EVALUATING HAZARD CONTROL EFFECTIVENESS** to determine whether hazard protection or other more effective forms of hazard control is still needed.

2.3.1 TECHNICAL HAZARD CONTROL

In principle, technical control is an effort to minimize the occurrence of potential hazards by technical engineering, i.e. by using hazard detection equipment. In addition, technical control of hazards can be carried out during the engineering design process and selection of work equipment specifications. If safety issues are found after the operation of the biogas installation, adjustments to the specifications of the hazard detection equipment can be made immediately. In addition to the layout, the minimum distance between units or adequate equipment is also important as a form of overcoming losses from an explosion or fire hazard.



ENGINEERING DESIGN

1. Design and layout of the biogas installation

This is one of the technical hazard control measures carried out at the planning stage during the construction of a biogas installation. The basic principle of the layout in a biogas installation is the direction of the prevailing wind, i.e. if there is a gas leak, the gas will always move or flow according to the direction of the prevailing wind. Therefore, the location or position of the equipment as a source of ignition should not be placed under the wind of a gas source, e.g. flare positioned under the CAL or CSTR tank.

- The layout for biogas installations** can be determined by referring to the gas production installation reference, namely (Global Asset Protection Services LLC, 2015):
- High hazard activities
 - Source of fire
 - Wind conditions
 - The importance of facilities for sustainable operations
 - Equipment replacement and installation time
 - Fire and explosion exposure
 - Emergency treatment and access
 - Future expansion

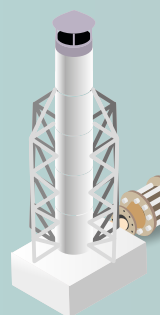


INSTALLATION OF PROTECTIVE EQUIPMENT AND MEANS FOR ACTIVE DETECTION OF FIRE HAZARDS, FOR EXAMPLE:

1. Use of flame arresters

Prevents open sparks and extinguishes the fire quickly at a limited scope, hence fires or explosions can be prevented. Flame arresters are usually used in biogas installations that are connected to the biogas distribution system, for example sparks in flares can ignite if there is a biogas leak on the distribution pipes to the flare or the flare itself. In order to prevent sparks from spreading in the biogas reactor, the flame arrester should be installed at the end of the biogas distribution pipe before being connected to the flare, gas engine or boiler burner.

prevailing wind direction



*Anticipating potential hazards if the flare collapses
 ** Anticipating potential thermal hazards (German Social Insurance for Agriculture, Forestry, and Horticulture, 2016)

Recommended minimum distance between units =
 $1.5 \times \text{flare height (m)}$
 6 m**



2. Lightning rod

Biogas installations usually have a large and open area with potential for lightning during the rainy season. Lightning is a natural phenomenon that usually occurs in the rainy season which is potentially damaging if not controlled. The principle of lightning control is to channel electrical currents in the clouds to the Earth. Lightning rods provide a series of paths that function as a way for lightning to reach the surface of the earth, without damaging the objects it strikes. Lightning rods need to be installed as necessary to protect biogas installations from damaging lightning strikes.

✓ **Minister of Manpower Regulation No. 31 of 2015**
 Supervision of Lightning Protection Systems

✓ **SNI 03 - 7015 - 2004**
 Lightning Protection System in Buildings



3. Selection of electrical work equipment

Areas surrounding the CAL or CSTR, biogas distribution pipes and gas engine rooms are areas that are likely to contain biogas which is said to be a hazardous explosive atmosphere.

✓ **European Union Directives 2014/34 EU**
 for electrical work equipment and instruments used



2. Installation of fire alarms and detectors

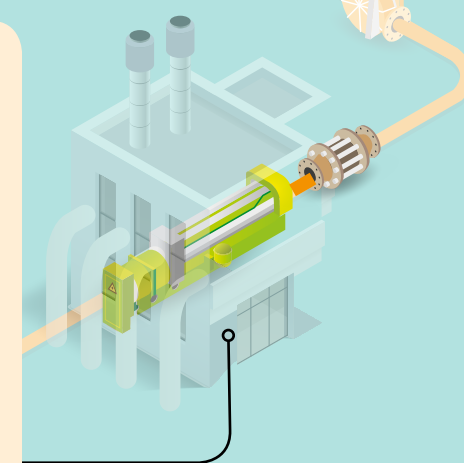
Fire alarms give a sign or signal when a fire is detected in the form of a special alarm with a minimum sound level of 65 dB.

The types of detectors are heat, smoke, flames and gas fires detectors. Biogas installations generally need to be equipped with gas and smoke detectors in the engine room. If gas and smoke leak occurs, the detector automatically stops the gas engine, hence the source of ignition is eliminated and potential explosion or fire hazard can be avoided.

✓ **Minister of Manpower Regulation No.2 of 1983**
 Automatic Fire Alarm Installations

✓ **Minister of Public Works Regulation No.26/PRT /M/2008**
 Technical Requirements for Fire Protection System in Buildings and the Environment

✓ **SNI 03 - 3985 - 2000**
 Procedures for Planning and Installing Fire Detection System and Fire Alarms to Prevent Fire Hazards in Houses and Buildings



TECHNICAL HAZARD CONTROL ON FIRE

The establishment of fire fighting units in biogas installations is determined based on the classification of the level of potential fire hazards. Biogas installations are included in the Classification of Moderate Fire Hazard Risk III based on **Minister of Manpower Decree of the Republic of Indonesia No. KEP 186/MEN/1999** namely the category of workplaces with high potential for fire. When a fire occurs, it can release high heat, hence the fire can spread quickly.



OUTDOOR HYDRANT

✓ **Minister of Public Works Regulation No.26/PRT/M/2008**

Technical Requirements for Fire Protection Systems in Building and Environment

✓ **SNI 03 - 1735 - 2000**

Procedures for Planning Building Access and Environmental Access for Fire Hazard Prevention in Buildings

1. Submitting plans and system specifications

to the fire department to be reviewed and approved before the construction

Paved roads are available

to be accessed by fire trucks

3. Mark fire department's access

with red or yellow triangles with a minimum of 150 mm on each side and placed on the outer section of the wall with the following sign: "ACCESS TO FIRE EXTINGUISHER - DO NOT BLOCK", with a minimum height of 50 mm

4. Placement of hydrants

The placement of hydrants is adjusted to the potential hazards. The distance of the hydrant is ± 100 m, and 500 feet (170 m) for the **NFPA 24***. For certain areas with high potential for fire hazards, the placement can be closer.

BUILDING AREA	NO. OF HYDRANTS	WATER SUPPLY	TIME
 < 1,000 m²	 2	At least 38 liters/second at 3.5 bars 19 liters/second at 3.5 bars	45 minutes
 Every subsequent increase from 1,000 m²	+ Addition of 1 hydrant	Additional 1,200 liters per minute (for each subsequent fire hydrant)	45 minutes

- If more than one outdoor hydrant is needed, the hydrants must be placed along the access points (fire truck access points with a minimum width of 4 meters) and within a distance of 50 meters from the fire hydrant.
- The outdoor hydrant pillar must be installed at a distance of at least 6 meters from the edge of the building, whereas **NFPA 24***, paragraph 7.2 concerning "Number and Location" states that hydrants shall be placed at least 12 meters from the building to be protected

3 TYPES OF FIRE EXTINGUISHERS



Fire extinguishers that are permanently installed for buildings, such as building hydrants, outdoor hydrants



Fire extinguishers that are permanently installed to a vehicle



Fire extinguishers that are portable or light



FIRE PROTECTION SYSTEM

For a comprehensive explanation on the fire protection system, please see **Minister of Public Works Regulation No. 26/PRT/M/2008** concerning Technical Requirements for Fire Protection Systems in Buildings and the Environment, among others:



General provisions



Access and water supply for fire extinguishing



Rescue facilities



Passive fire protection system



Active fire protection system*



Building utilities



Fire prevention in buildings



Management of fire protection system in buildings



Supervision and control

* Upright Pipe System, Automatic Sprinkler System, Fire Extinguisher, Detection System and Fire Alarm



5. Installation of fire extinguishing pumps

Placed at least 15 m away from the nearest building.

The pump installed must meet **SNI 03-6570-2001** concerning Permanently Installed Pumps for Fire Protection

✓ **Minister of Manpower Instruction No. 11/M/BW/1997**
OHS Special Supervision for Fire Fighting

✓ **Minister of Manpower Decree No. KEP 186/MEN/1999**
Provisions for the Fire Fighting Unit in the Workplace

*Standard for the Installation of Private Fire Service Mains and Their Appurtenances



APAR

✓ **Minister of Manpower and Transmigration Regulation No: PER.04/MEN/1980** concerning the Requirements for the Installation and Maintenance of Fire Extinguishers. Below is a table that explains about the material group. The table below describes fires and the type of fire extinguishers that can be used.

xxx : Damaging
xx : Hazardous
x : Can not be used

vvv : Very Good
vv : Good
v : Can be used

! The production and use of ozone depleting substances, including Halon, has been prohibited in accordance with the ✓ **Minister of Industry Regulation No. 33/M-IND/PER/2007** concerning the Prohibition of Producing Ozone Layer Destructive Substances and Producing Goods Using Ozone Layer Destructive Materials

FIRE		FIRE EXTINGUISHER USED WHEN A FIRE STARTS							
GROUP	TYPE OF MATERIAL BURNT	I 9 l Water	II 9 l Foam	III Tetrachool coolstop chloorbroom methaan 1 l	IV CO ₂	V P ² +PK ³ 12 kg	VI PG ⁴ 12 kg	VII PM ⁵ 12 kg	VIII B,C,F ⁶ HALC 1.4 kg
SOLID EXCLUDED METAL	1. Fire on the surface of materials such as wood, paper, textiles, and others.	vv	v	vv / xxx	v	v	vvv	x	v
	2. Fire to the interior section and materials such as: wood, majun, charcoal, rock and others	vv	v	xxx	x	x	vvv	x	x
	3. Fire and rare and valuable items in museums, etc.	vv	xx	xx / xxx	v	v	vvv	x	v
	4. Fires and materials that can easily be degraded when heated: rubber, foam, plastic, etc.	vv	x	xxx	x	x	vv	x	x
LIQUID AND GAS	1. Fires from gasoline, benzene, paint, tires, lacquer, asphalt, grease, oil etc. (which cannot mix with water)	xxx	v	v / xxx ¹	vv	vvv	vv	x	vv
	2. Fire and alcohol and similar substances that can dissolve in water	x	x	v / xxx ¹	vv	vvv	vv	x	vv
	3. Flowing gas	x	x	v / xxx ¹	v	vvv	vv	x	v
	4. Substances that form flammable gases when mixed with water such as carbide, phosphite, etc.	xxx	xxx	v / xxx ¹	v	vvv	vv	x	v
ELECTRICAL APPARATUS WITH VOLTAGE	Connecting panels, connecting boxes, telephone exchanges, transformers, and others	xxx	xxx	vv / xxx ¹	vvv	v	vvv	x	vvv
METAL	Magnesium, Natrium, Kalsium, Alumunium	xxx	xxx	xxx	x	xxx		vvv	xxx

1. Don't use in a small, closed room with people
2. P Sodium bicarbonate
3. PK Soda Ash
4. PG Fire extinguisher powder
5. PM for burning metals

6. May damage the item itself
7. Hazardous because the liquid splashes out
Flammable materials

8) Type of Halon

Bromotr fluoramethana
Bromochlorodifluoremethana
Carbon Dioxide
Dibromodifluoromethana
Carbon Tetrachlorida
Methyl bromide

Formula

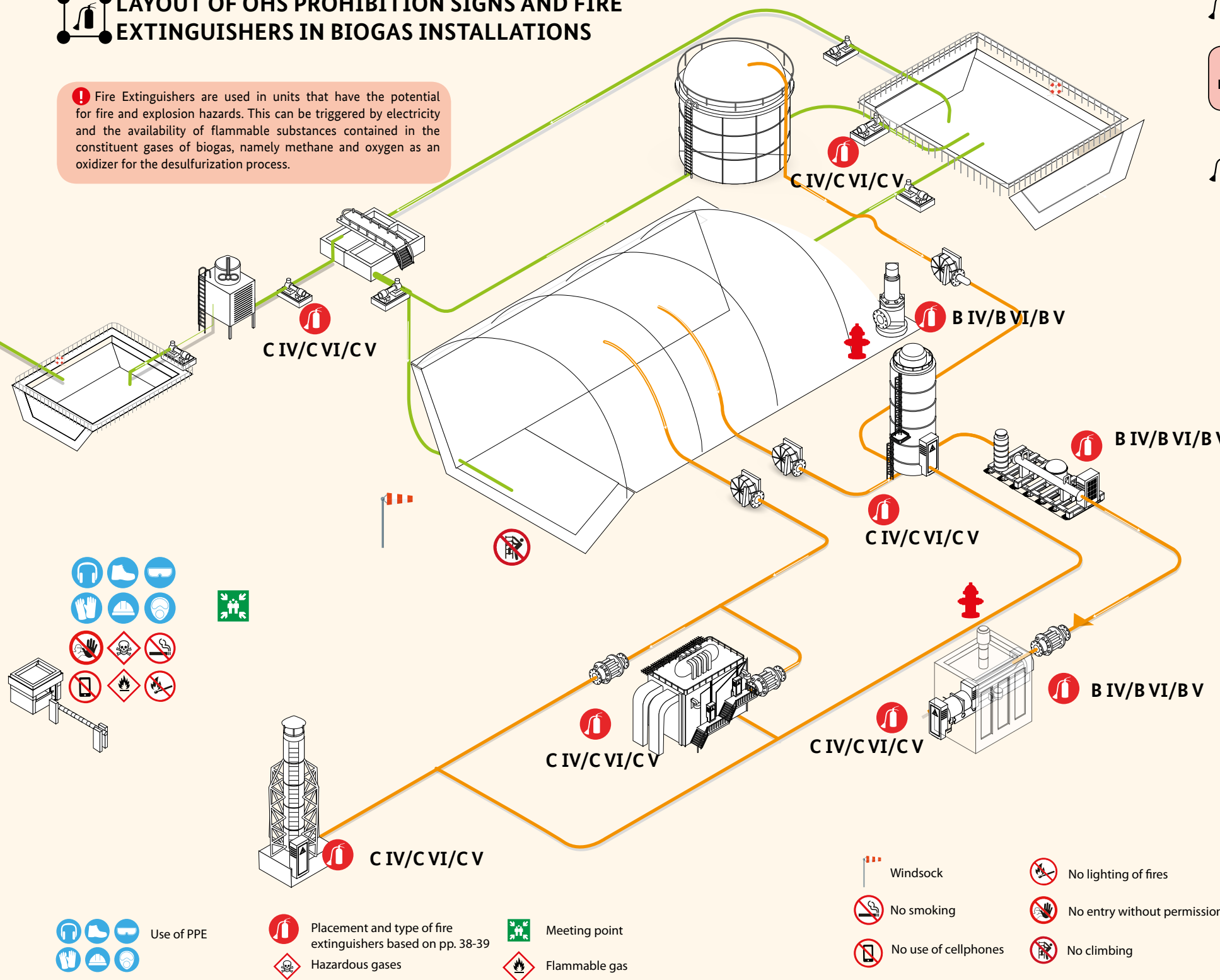
BrF₃/B.T.M
CBrClF₂/B.C.F
CO₂
CBr₂F₂
CCl₄
CH₃Br

Halon No.

1301
1211
-
1011
104
1001

LAYOUT OF OHS PROHIBITION SIGNS AND FIRE EXTINGUISHERS IN BIOGAS INSTALLATIONS

! Fire Extinguishers are used in units that have the potential for fire and explosion hazards. This can be triggered by electricity and the availability of flammable substances contained in the constituent gases of biogas, namely methane and oxygen as an oxidizer for the desulfurization process.



FORMULA TO DETERMINE NUMBER OF FIRE EXTINGUISHERS NEEDED

$$\text{TOTAL FIRE EXTINGUISHERS} = \frac{\text{Size of Room (m}^2\text{)}}{\text{Protected area per Fire Extinguisher (m}^2\text{)}}$$

INSTALLATION OF FIRE EXTINGUISHERS

- Each fire extinguisher must be placed in a position that is easy to see, easy to access and grab, equipped with an installation sign
- Installation and placement of fire extinguishers must be in accordance with the type and classification of the fire
- The distance between fire extinguishers must not exceed 15 meters, unless otherwise stipulated by the OHS supervisor or expert staff

For a comprehensive explanation, please see [Minister of Manpower and Transmigration Regulation No: PER.04/ MEN/1980](#) concerning the Installation and Maintenance of Fire Extinguishers

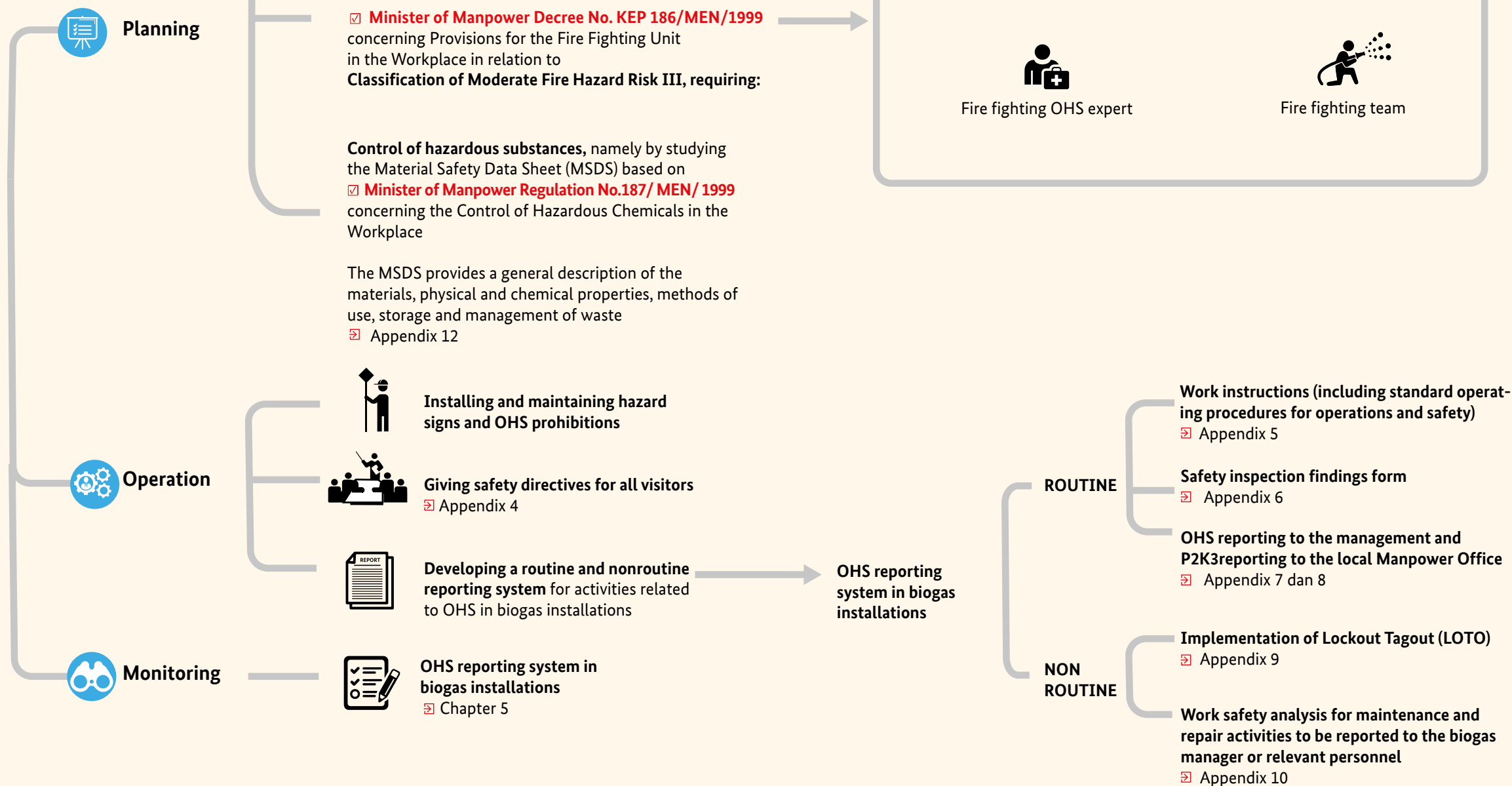
EMERGENCY RESPONSE SYSTEM DURING A FIRE

- Technical procedures in emergency conditions** These technical Procedures can vary for each biogas installation, depending on the configuration system of the biogas installation
- Emergency action plan, namely:**
 - Emergency response in the form of a fire alarm
- Determining the emergency rescue lanes and setting meeting points**
- Training and simulation** for fire emergencies conducted by the Fire Fighting Team



2.3.2 ADMINISTRATIVE HAZARD CONTROL

The following are recommendations on the type of hazard control organization based on the stages of the occupational health, safety and the environment management system, namely:

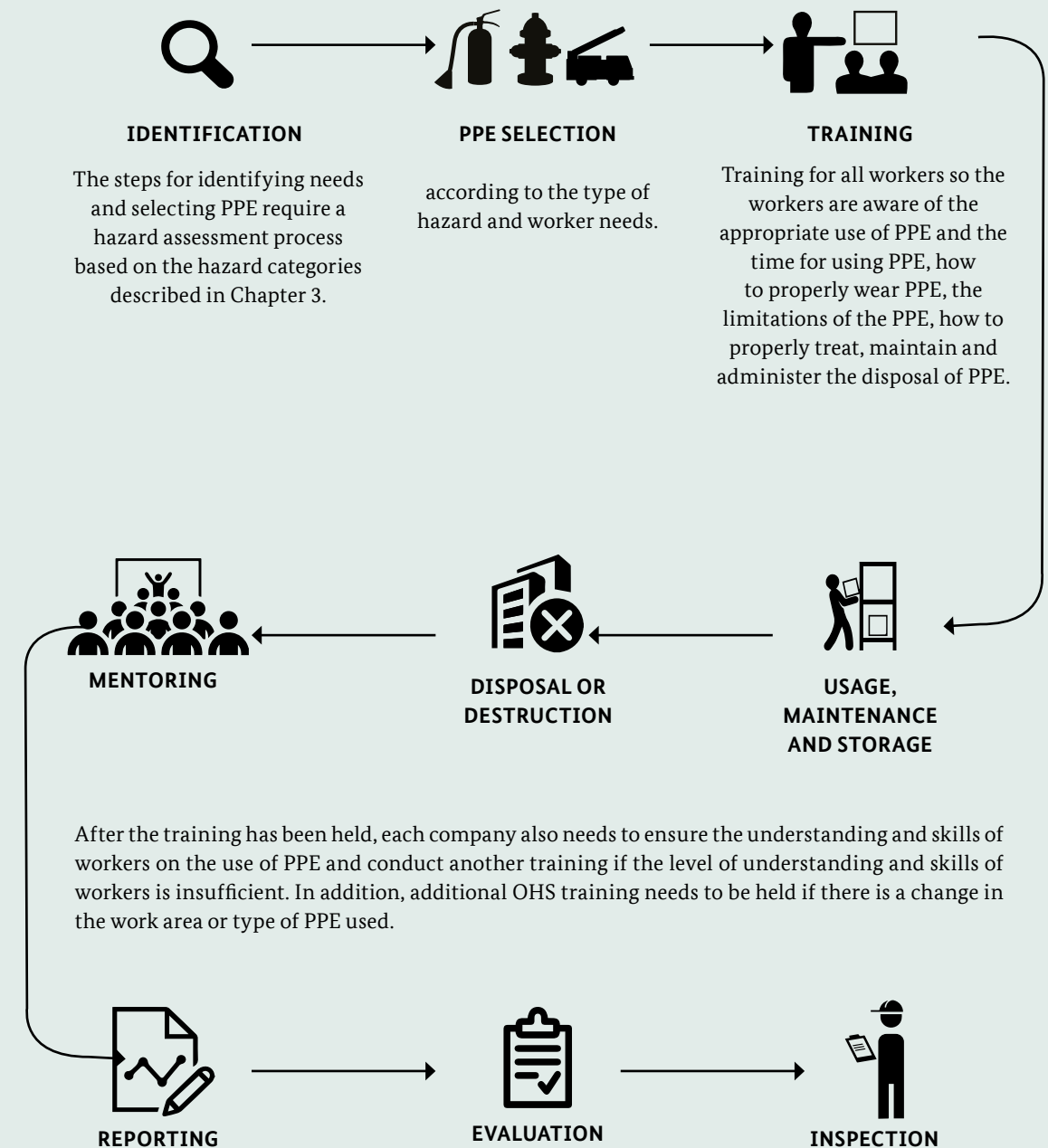


2.3.3 PERSONAL HAZARD CONTROL (PERSONAL PROTECTIVE EQUIPMENT/ PPE)

This is the last stage as a form of protection for personnel from exposure to hazards at an acceptable level by providing PPE.



The Minister Regulation also stated that workers or other people entering the work area must use PPE in accordance with potential hazards and risks in the work area. Therefore, every company is required to manage PPE in the work area, including determining the type of risk, for example the potential hazards due to exposure to certain gases in a biogas installation unit must be identified in determining the respiratory protective equipment to use.



Safety aspects in the work area need to be regularly reviewed if there are changes in the conditions of the work area, work equipment or operating procedures that can potentially cause hazards. This periodic review needs to include reviewing records of accidents to evaluate the trends of accidents at a location (OSHA, 2004). This can serve as the basis for improving the specifications of the PPE used.

A reference regarding the type of PPE used is the safety standards that have been developed by the American National Standards (ANSI) (OSHA, 2004).

2.4 MINIMUM SAFETY FACILITIES IN BIOGAS INSTALLATIONS

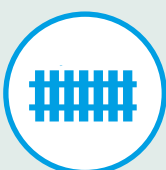
 Safety facilities during engineering design

 Safety facilities during operations

Floaties



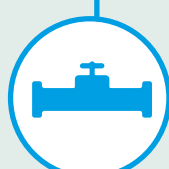
Life jackets for those working in open waste ponds



Fences for the biogas installation area. Areas in Palm Oil Mill Effluent tanks such as cooling ponds, mixing tanks



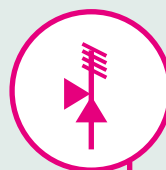
Lifting crane for submersible pumps in cooling ponds or mixing tanks



Block valve in the suction for pumps below the water level



Lightning rod in the appropriate location



The digester and scrubber is equipped with a pressure control valve



Instrumentation system to manage the oxygen level in the bioscrubber



Windsock



Portable blowers to reduce the concentration of biogas in confined spaces or when performing hot work procedures



Flame arresters on flares, gas engines, and boiler burners



Electrical equipment in Zone 0 and Zone 1 shall at least follow the ATEX standard applicable for the zone



First Aid Kit especially mosquito repellent spray and medicine for those stung by poisonous insects



Two units of 25 kg fire extinguishing chemical powder in the engine room



Permanent smoke detectors in gas engine rooms and portable gas detectors for operators

CHAPTER

3



SPECIFIC HAZARDS AND CONTROL

- Discussion of hazards and the types of technical and organizational hazard control for each specific area in a biogas installation.
 - The types of hazard control include operations and maintenance activities carried out in the area.
- ① The potential hazards and hazard control described in this chapter generally apply for biogas installations. However, each biogas installation may have different design and technology. Therefore, the biogas installation manager should develop their own illustrations of specific hazards and type of hazard control based on their respective installation configurations.

This 1.8 MW biogas-based power plant is owned by PT. Austindo Nusantara Jaya (ANJ) Tbk and operated by PT. Austindo Aufwind New Energy (AANE). AANE is the first independent power producer in Indonesia to operate a power plant while commercially selling electricity.



3.1 PRELIMINARY TREATMENT 1 2 3

During the preliminary treatment, the substrate (in the form of Palm Oil Mill Effluent) is conditioned to achieve optimum parameter values before entering the anaerobic digester.

Characteristics of Palm Oil Mill Effluent (Directorate of Agricultural Product Processing, 2006)

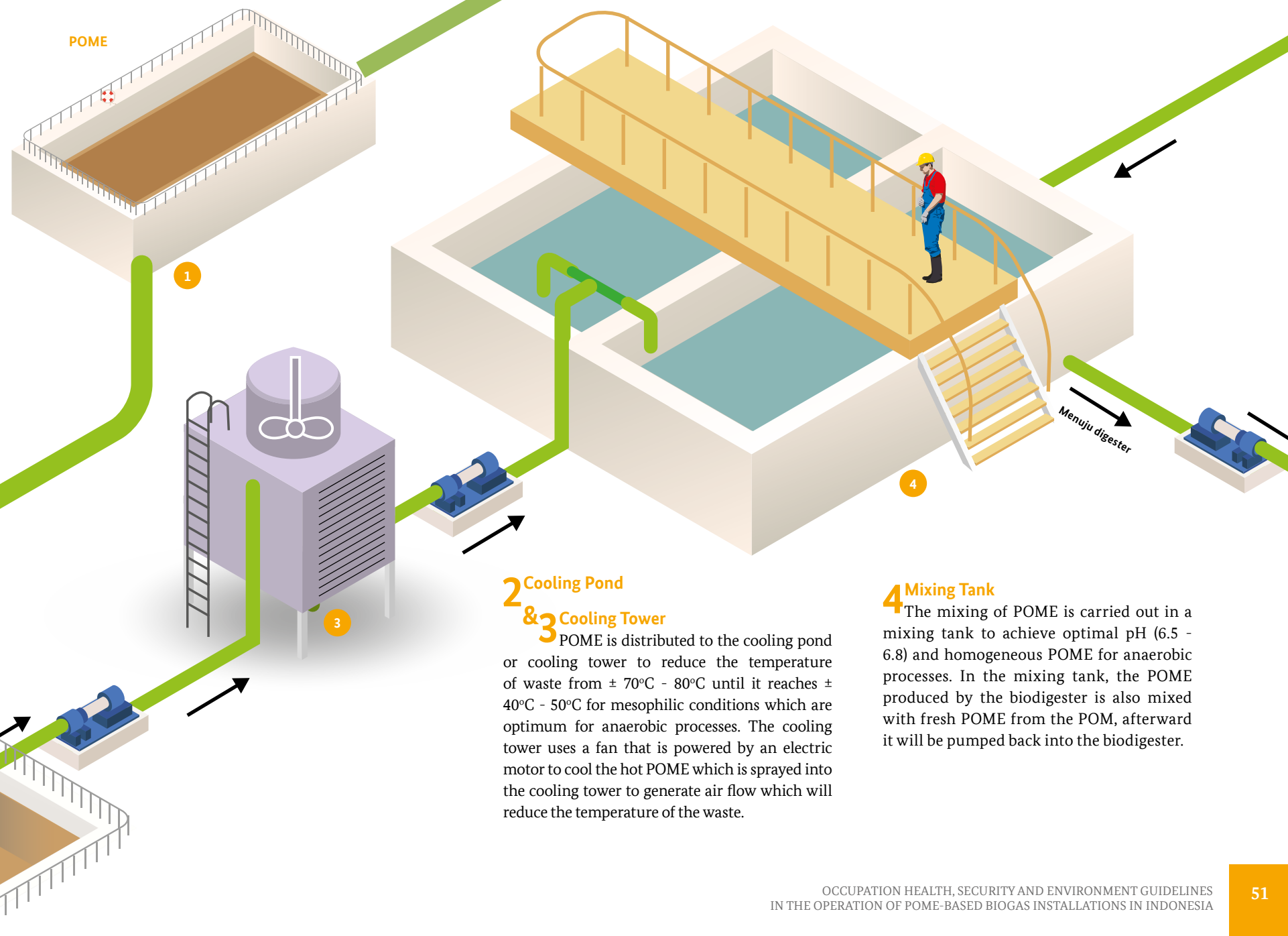
pH	: 3.3 - 4.6	Suspended solids	: 1,330 - 50,700 ppm
BOD	: 8,200 - 35,000 ppm	Oil and Grease	: 190 - 14,720 ppm
COD*	: 15,103 - 65,100 ppm	Total N	: 12- 126 ppm

*For some biogas installations in Indonesia, the COD entering the pre-treatment unit can reach 100,000 ppm

1 Equalisation Pond

The POME resulting from the processing of FFB from the POM is distributed to the Equalisation Pond.

! The preliminary treatment configuration of each biogas plant can vary depending on the expected optimal parameter value before entering the anaerobic digester, for example temperature and pH parameters.



2 Cooling Pond & 3 Cooling Tower

POME is distributed to the cooling pond or cooling tower to reduce the temperature of waste from $\pm 70^{\circ}\text{C} - 80^{\circ}\text{C}$ until it reaches $\pm 40^{\circ}\text{C} - 50^{\circ}\text{C}$ for mesophilic conditions which are optimum for anaerobic processes. The cooling tower uses a fan that is powered by an electric motor to cool the hot POME which is sprayed into the cooling tower to generate air flow which will reduce the temperature of the waste.

4 Mixing Tank

The mixing of POME is carried out in a mixing tank to achieve optimal pH (6.5 - 6.8) and homogeneous POME for anaerobic processes. In the mixing tank, the POME produced by the biodigester is also mixed with fresh POME from the POM, afterward it will be pumped back into the biodigester.

COOLING POND AND COOLING TOWER

ACTIVITIES carried out in the cooling tower area include operating the pump for cooling POME and the cooling fan. For maintenance, it is necessary to inspect and clean the pumps, fans and interior of the cooling tower, including checking for leakage in the pipes.

-  Technical Hazard Control
-  Organizational Hazard Control
-  Operational activities
-  Maintenance activities

PPE required



OM Leakage or seepage of POME

-  Using HDPE lining at the bottom of the pond
-  Periodical checks for seepage or leakage in the pond

OM Slipping and falling into the pond while walking around the pond

-  Installing a fence around the cooling pond
-  Maintaining the cleanliness of stairs and paths around the cooling pond

OM Exposed to electric shock from pump cables and cooling tower panels

-  Installing cable insulation according to SNI
-  Implementing LOTO during maintenance

M Exposed to POME (with a high temperature of 60°C -85°C) in open conventional cooling towers

-  Using a closed and environmentally friendly cooling tower system

M Hit by a spinning fan

-  Implementing LOTO during maintenance

M Falling from the ladder during media cleaning

-  1. Using a body harness when climbing the cooling tower
-  2. Using a scaffolding

O Contamination by pathogenic bacteria from waste water granules inhaled by operators in open cooling towers

OM Exposure to high acid oil

-  Using a closed and environmentally friendly cooling tower system

EX Biogas has not been produced in the cooling system, hence there is no potential for explosion. The cooling system is an **Unclassified Zone**.

BAK PENGADUK



ACTIVITIES carried out in the mixing tank are the operation of pumps and agitators to control feeding and mixing POME in the mixing tank and taking POME samples for testing COD, pH and temperature. For maintenance, it is necessary to inspect pumps and agitators on a regular basis and inspect the pipes and mixing tanks for leakage. Other potential hazards to be aware of are if the location of the mixing tank is adjacent to a pond or an anaerobic digester so that there is a risk of exposure to methane or hydrogen sulfide.

PPE required



Working with a partner



O M Falling into the mixing tank, drowning

- Installing a fence surrounding the mixing tank

M POME Leakage

- Fixing the leak
- Periodical checks for seepage or leakage in the mixing tank



O M Hit by a rotating agitator when taking a waste sample

- Installation of valves for sampling



M Slipping and falling when lifting the pump and submersible agitator

- Installation of railings and chain blocks to lift submersible pumps

PALM OIL MILL EFFLUENT DISTRIBUTION

PPE required



Working with a partner



O M Exposed to electric shock from the pump cable

- Installation of cable insulation according to SNI
- Implementing LOTO during maintenance



O M Pollution of POME into the surrounding environment when cleaning pipes from sediment due to the formation of struvite (magnesium ammonium phosphate) in pipes or accidental

- Use a by-pass flexible hose to dispose POME in the pipes to pump it back to the pond
- Disposing POME in the pipes before carrying out maintenance



M Slipping and Falling due to POME

- Building a bordes in areas with piping



M POME leakage due to clogged pipes or inappropriate distribution piping specifications

- Using HDPE pipes for distributing POME
- Periodic checks for leakage in the distribution pipes



M Fires when connecting pipes by thermal welding

- Checking for gas using a portable gas detector and ensuring that a blower is available when welding
- The procedures for hot work and pipe connecting is carried out by competent operators



O Hot and burning pumps because due to operation without POME

- Installation of a level switch to manage the pump based on the POME level



O M Exposed to POME (with a high temperature of 60°C-85°C) when there is a leakage in the pipes

- Periodical checks for leakage in distribution pipes



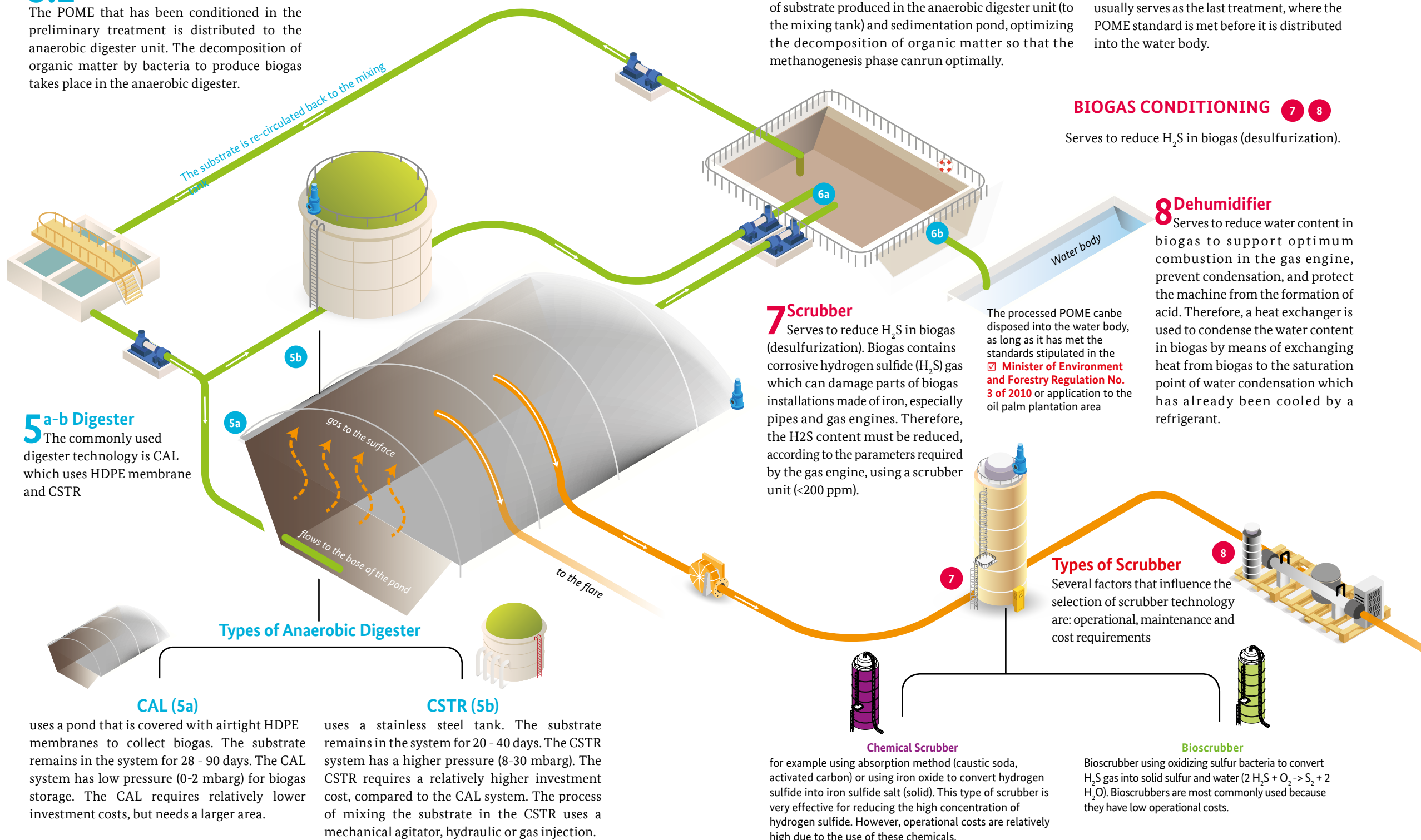
The chance for biogas to be produced in the mixing tank is very slim, hence there is no potential for explosion. The mixing tank is an Unclassified Zone.



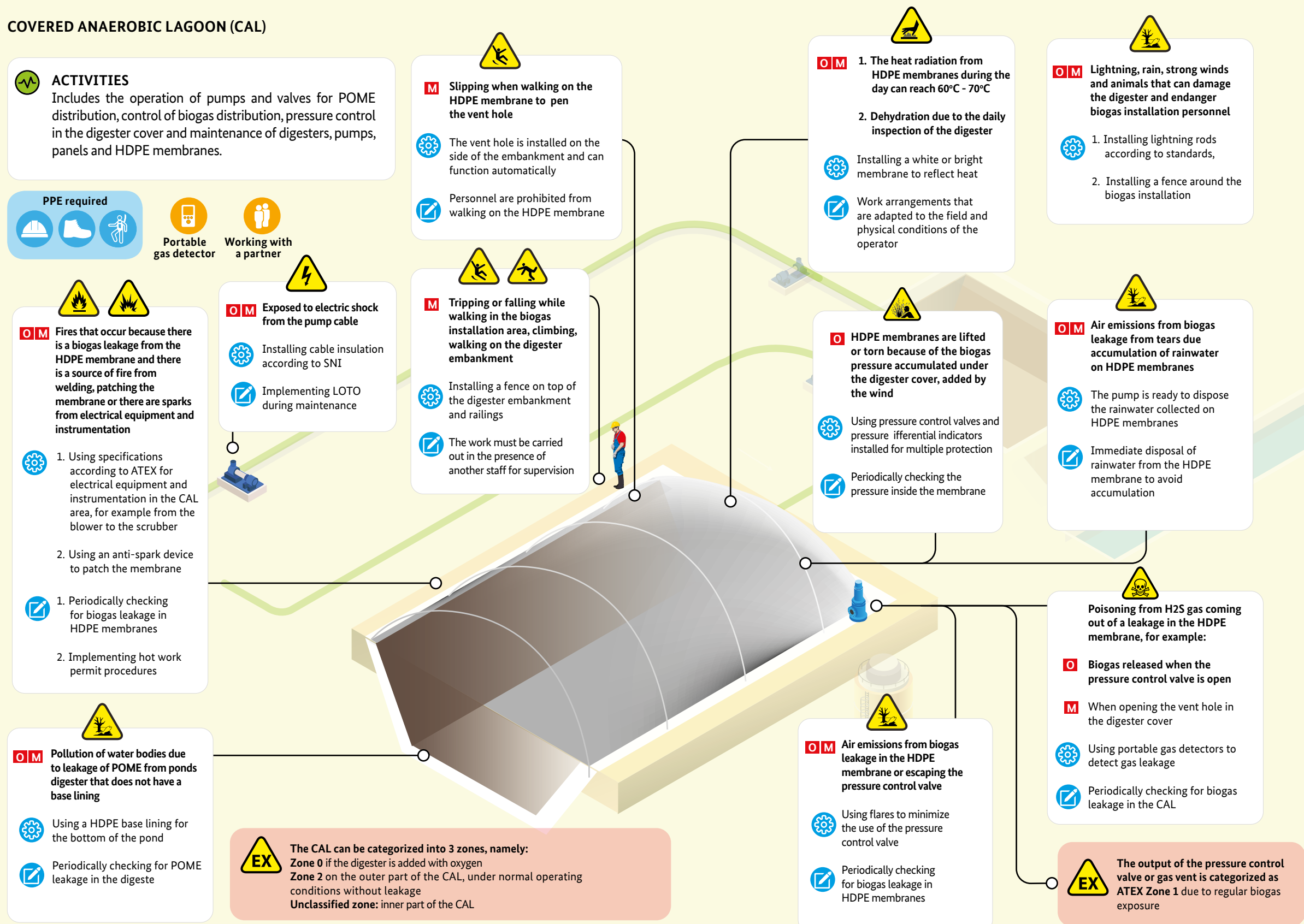
The chance for biogas to be produced in the mixing tank is very slim hence there is no potential for Explosion. Therefore, the POME distribution system is not included in the Unclassified Zone

3.2 ANAEROBIC DIGESTER 5a 5b 6a 6b

The POME that has been conditioned in the preliminary treatment is distributed to the anaerobic digester unit. The decomposition of organic matter by bacteria to produce biogas takes place in the anaerobic digester.



COVERED ANAEROBIC LAGOON (CAL)



CONTINUOUSLY STIRRED TANK REACTOR (CSTR)



ACTIVITIES

Includes the operation of pumps and valves for POME distribution, control of biogas distribution, pressure control in the digester closing and maintenance of digesters, pumps, panels and CSTR tanks. Before maintenance is carried out, a total cleaning of the interior part of CSTR is necessary by disposing all palm oil mill effluent, then washing with water and total cleaning of sediment or solids to the interior parts of the CSTR in dry conditions. After that, it is necessary to check the atmospheric conditions in the CSTR and making sure that there are no harmful gases (CH_4 or even H_2S) that are potentially dangerous by using a portable gas detector.

PPE required



Portable gas detector



Working with a partner



The output of a pressure control valve or gas vent is categorized as ATEX Zone 1 due to regular biogas exposure

O M

Lightning, rain, strong winds and animals that can damage the digester and endanger biogas installation personnel



1. Installing lightning rods according to standards
2. Installing a fence around the biogas installation



O

H_2S gas poisoning from a leakage in the HDPE membrane, for example the release of biogas when the pressure control valve is open

M

When opening the vent hole in the CSTR



Periodically using portable gas detectors to check for biogas leakage in the CSTR



Periodically checking for biogas leakage in the CSTR



O M

Air emissions from biogas leakage in the CSTR or released from the control valve



Using flares to minimize the use of the pressure control valve



Periodically checking for biogas leakage in the CSTR

O M

Tripping or falling while walking in the CSTR, climbing the CSTR, walking on the CSTR



1. Installing a fence around the CSTR
2. Using a body harness when working at height

M

Shortness of breath and poisoning when entering a CSTR which still contains biogas



Using blowers to dispose biogas from the CSTR and using portable gas detectors to measure H_2S and CO_2



The implementation of the procedures for confined space permit and only entering the CSTR upon meeting the standards for H_2S and CO_2 gas threshold values based on the portable gas detector measurements

O

Exposed to steam from leakage in steam pipes in thermophilic systems



Ensuring that the steam pipe insulation is according to standards



Periodically checking for leakage of steam in the pipes

O M

Exposed to electric shock from the pump cable



Installing cable insulation according to SNI



Implementing LOTO during maintenance

O M

Explosion due to biogas pressure which accumulates under the digester cover and the pressure control valve is not functioning



Using pressure control valves and pressure differential indicators installed for multiple protection



Periodically checking the pressure inside the CSTR and maintaining the pressure control valve



The CSTR can be categorized into 3 zones, namely:
Zone 0 if the digester is added with oxygen
Zone 2 on the outer part of the CSTR, under normal operating conditions without leakage
Unclassified zone inside the CSTR

BIOGAS CONDITIONING: SCRUBBER



ACTIVITIES

Activities carried out in the scrubber area are the operation of pumps for spraying chemicals or Palm Oil Mill Effluent to reduce H₂S and maintenance of scrubbers if already saturated or reduced in efficiency.

PPE required



Portable
gas detector



Working
with a partner



M Wedged under the scrubber media when removing the media for cleaning or replacement

Maintenance of scrubbers according to the procedures of the manufacturer



M Shortness of breath and poisoning when entering a scrubber that still contains biogas for maintenance

1. Using a portable blower to remove biogas from the scrubber
2. Measuring H₂S and CO₂ using a gas detector

Implementing the procedures for confined space permit and only entering the scrubber upon meeting the standards for H₂S and CO₂ gas threshold values based on the portable gas detector measurements



O M Fires and explosions that occur because of a biogas leakage from the scrubber and there is a source of fire from welding or there are sparks from electrical equipment and instrumentation

Using specifications according to the ATEX for electrical equipment and instrumentation in the scrubber area, such as air blowers, biogas flow meters, and oxygen instrumentation or H₂S analyzers

1. Periodically checking for biogas leakage in the scrubber
2. Implementing procedures for hot work



M If exposed to acid rain, the by-product of the bioscrubber process in the form of solid sulfur can dissolve and become hazardous substances

Preparing a storage place for solid sulfur that is equipped with a roof
Management and disposal of sulfur waste according to the procedures



M H₂S exposure when opening the upper and bottom scrubber manholes

Measuring H₂S using a portable gas detector
Periodically checking for biogas leakage in the scrubber



M Lightning strike when carrying out maintenance

Installing lightning rods according to standards



O M Tripping or falling while climbing stairs when walking on the scrubber

Installing a fence around the scrubber and railing



O Explosion due to excessive oxygen input into the scrubber (exceeding the LEL) and at the same time, a biogas leakage exposed to a source of fire, for example a spark is triggered by a blower that is incompatible with the ATEX

Installing flow meters and PLC to maintain the limit of air entering the scrubber (according to the design of the technology provider)



M Pollution of water bodies due to scrubber waste water containing sulfur

Building a tank for the sedimentation of sulfur
Separating sulfur and flowing acidic water into the tank after the reactor has a pH above 7



O M Air emissions from biogas leakage in the scrubber

Using portable gas detectors
Periodically checking for biogas leakage in the scrubber



O M Exposed to electric shock from air blower and biogas cables

Using specifications according to ATEX for electrical equipment and instrumentation in the digester area
Implementing LOTO during maintenance



O Explosion due to scrubber pressure caused by a blockage in the pipes and clogged biomedica. This can cause the piping connection to the leak

Installing a pressure switch on the inlet and outlet of gas pipes on the scrubber connected to the PLC to turn off the gas blower in the case of pipe blockage

Periodically checking the scrubber pressure



Scrubbers can be categorized into 3 zones, namely:
Zone 0 : inside of the scrubber
Zone 1 : pressure control valve
Zone 2 : outer part of the scrubber under normal conditions without gas leakage



Emergency
eyewash shower



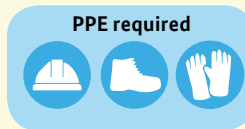
Emergency
eyewash

DEHUMIDIFIER



ACTIVITIES

Dehumidifiers generally use refrigerants to cool the biogas so that condensation takes place, hence steam can be separated from the biogas and released in the form of condensate.



Portable gas detector



Working with a partner



OM Exposed to electric shock from panels and cables

- 1. Installing cable insulation according to SNI
- 2. Using specifications according to ATEX for electrical equipment and instrumentation
- Implementing LOTO during maintenance



OM Fires that occur because of a biogas leakage from the dehumidifier and there is a source of fire from smoking, welding or there are sparks from electrical equipment and instrumentation

- Using specifications according to the ATEX for electrical equipment and instrumentation
- 1. Implementing procedures for hot work
- 2. Periodically checking for biogas leakage in the gas pipe



O Pollution of water bodies due to acidic condensate water

- Flow of condensed water to the tank and pond that has high alkali, for example a mixing tank or into a pond after the anaerobic digester



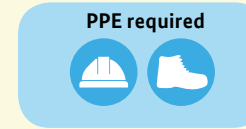
M Refrigerant leak in the refrigerator

- Periodically checking for leakage of refrigerants by monitoring the refrigerant pressure. If the pressure drops, there is an indication of leakage

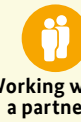


Biogas exposure only occur if there is a leakage in the dehumidifier, hence it is categorized as ATEX Zone 2

DISTRIBUSI BIOGAS



Portable gas detector



Working with a partner



OM Fire due to biogas leakage from the gas pipeline (due to blower vibration, hence the connection becomes loose)

M There is a source of fire from welding or there are sparks from electrical equipment and instrumentation

- Using specifications according to ATEX for electrical equipment and instrumentation in biogas distribution systems, for example blowers, biogas flow meters, gas analyzers
- 1. Implementing hot work procedures
- 2. Periodically checking for biogas leakage in the pipes

OM Potential for pipe expansion due to temperature fluctuations

- 1. Using HDPE pipes for biogas distribution
- 2. Using uPVC pipes. If PVC pipes are used, they should be planted to avoid direct sun exposure
- Periodically checking for biogas leakage in the pipes



O Methane emissions and H₂S gas that comes out of leaks in gas pipes, valves, connection

- Using portable gas detectors to detect gas leakage
- Periodically checking for biogas leakage in the gas pipes



OM Tripping or falling due to the biogas pipes

- Building a bordess in the areas passed by the gas pipeline



The biogas distribution system can be categorized into 2 zones, namely:
Zone 1 if the type of material used in the biogas distribution system is nonstainless
Zone 2 if the type of material used in the biogas distribution system made of stainless steel

3.3 BIOGAS UTILIZATION 9 10 11

The biogas produced by a digester can be utilized using a gas engine and boiler burner or directly combusted in the flare.

9 Flare

The excess biogas which is not utilized in the gas engine or boiler burner will be combusted in the flare. This can occur during the peak harvest season and the amount of FFB processed by POM is above average, hence the biogas produced exceeds the capacity of the gas engine or boiler burner. In addition, excess production of biogas can occur if the gas engine is undergoing routine maintenance or repair. Biogas installations that do not have gas engines or boilers, must always use flares to manage biogas. The advantages of biogas cannot be directly discharged into the atmosphere due to its flammable and toxic characteristics. In addition, release of biogas emissions directly into the atmosphere can cause greenhouse gas effects due to its high methane content.

11 Boiler Burner

Biogas is distributed to the biogas burner installed on the POM boiler as fuel to produce steam. The steam is used for processing FFB in the POM. By utilizing biogas in boiler burners, the shells that are usually needed for boiler fuel can be reduced and can then be sold.

10 Gas Engine

The conditioned biogas is then distributed using a blower to the gas engine. The gas blower serves to maintain pressure according to the gas engine needs, i.e. 150-200 mBar. Gas engines are types of internal combustion engines that use gas fuel such as natural gas or biogas. The biogas that enters the gas engine must have a moisture content of less than 80% and a H₂S concentration of less than 200 ppm, depending on the gas engine specifications. The gas engine converts energy contained in biogas into electrical energy with an efficiency of 36 - 42%.

The electricity produced by the gas engine is distributed through the grid and used for the POM's internal consumption or sold to PLN

BIOGAS UTILIZATION: FLARE



ACTIVITIES

Includes operating valves for gas control and control panels as well as maintenance and cleaning of surfaces and film arresters of impurities.



Portable
gas detector



Working
with a partner



- OM**
1. Biogas leakage from flare pipes
 2. There is a source of fire from welding or there are sparks from electrical equipment and instrumentation



Using specifications according to ATEX for electrical equipment and instrumentation, e.g. electrical panel



1. Periodically checking for biogas leakage in the flare
2. Implementing hot work permit procedures



- OM**
- Heat radiation from flare flames which can reach 800°C - 1,200°C or from the flare body



Placing flares by considering the radius of heat radiation to the surrounding environment, i.e. 6 meters (German Social Insurance for Agriculture, Forestry, and Horticulture, 2016)



- M**
- Tripping or falling while climbing the flare stairs or when carrying out activities on the flare



- M**
- Wedged under or knocked (for closed flares)



Installation of railings on stairs



- OM**
- Methane emissions and H₂S gas that come out of leaks in gas pipes, valves, fitting



Using portable gas detectors to detect gas leakage



Periodically checking for biogas leakage in the gas pipes by using the flow meter



- OM**
- A spark in the gas pipe



Installing flame arresters on the pipe connections leading to the flare



Periodically cleaning the flame arresters



- OM**
- Exposed to electric shock from panels and instrumentation



Using specifications according to the ATEX for electrical equipment and instrumentation



Implementing LOTO during maintenance



- OM**
- The panel or cable is on fire due to flare flames



The cable uses heatresistant insulation and a closed panel to protect it from fire



Zone 0, because the flares are planned to operate during the operation of the biogas installation

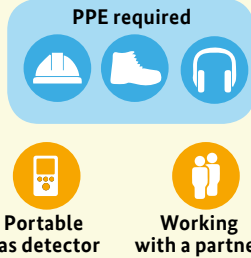


GAS ENGINE



ACTIVITIES

Related to the gas engine in the form of gas distribution control to the gas engine, gas engine operation and maintenance, engine radiator, electrical panel and handling of toxic and hazardous waste.



M Environmental pollution caused by carelessly disposed toxic and hazardous waste (e.g. used oil)

- Providing used oil storage tanks
- Following procedures for handling toxic and hazardous waste



O CO gas emissions from gas engine exhaust

- Using the gas engine with high efficiency



O M A spark in the gas pipe

- Installing flame arresters on the pipe connection leading to the gas engine
- Periodically cleaning the flame arresters



O M 1. Fire from a biogas leak from a gas pipe leading to the gas engine

2. There is a source of fire from welding or there are sparks from electrical equipment and instrumentation

- 1. Using specifications according to ATEX for electrical equipment and instrumentation in the gas engine area
- 2. Installation of a fixed-mounted smoke detector, fire alarm
- 1. Implementing hot work procedures
- 2. Periodically checking for leakage in the gas pipes using a portable gas detector



O Hearing loss due to gas engine noise above 85 dB



M Stuck or wedged in the rotating part of the gas engine

- Ensuring that the gas engine cover is always used



O Methane emissions and H₂S gas that comes out of leaks in gas pipes, valves, connection to the gas engine

- 1. The recommendation given is to install a fixed-mounted gas detector (H₂S, CO, CH₄, CO₂)
- 2. Installing exhaust fans
- Periodically checking for biogas leakage in the gas pipes



O M Exposed to electric shock from the gas engine panel

- Installing cable insulation according to SNI
- Implementing LOTO during maintenance



O Exposure to hot air exhaust radiation from the gas engine with a temperature of 300°C -350°C

- 1. Exhaust pipe insulation in the room
- 2. Finding the safest point to dispose hot air emissions from the gas engine



In gas engines, the biogas flow is controlled through the gas engine regulator according to the gas engine's need for gas. In a closed system with minimum potential for biogas leakage, the gas engine is in **ATEX Zone 2**

BOILER BURNER



ACTIVITIES

Related to the boiler burner in the form of gas distribution control to the boiler burner and maintenance.

APD yang digunakan



Detektor gas portabel



Bekerja dengan pendamping



O Heat radiation when opening the boiler burner door



M Stuck or wedged in the blower fan

Implementing LOTO during blower maintenance



M Methane and H₂S gas emissions that are released from leakages in gas pipes, valves, gas pipe connections and blowers

Periodically checking for biogas leakage using a portable gas detector



- O M**
1. Biogas leakage from gas pipes or burners
 2. There is a source of fire from welding activities, sparks from electrical equipment and instrumentation



1. Using specifications according to ATEX for electrical equipment and instrumentation in the boiler burner area
2. Installing flow meters connected to the PLC and inverter frequency to maintain oxygen input for the burner



1. Implementing hot work procedures
2. Periodically checking for leakage in the gas pipes



O M Exposed to electric shock from the boiler burner panel along with instrumentation



Installing cable insulation according to SNI



Implementing LOTO during maintenance

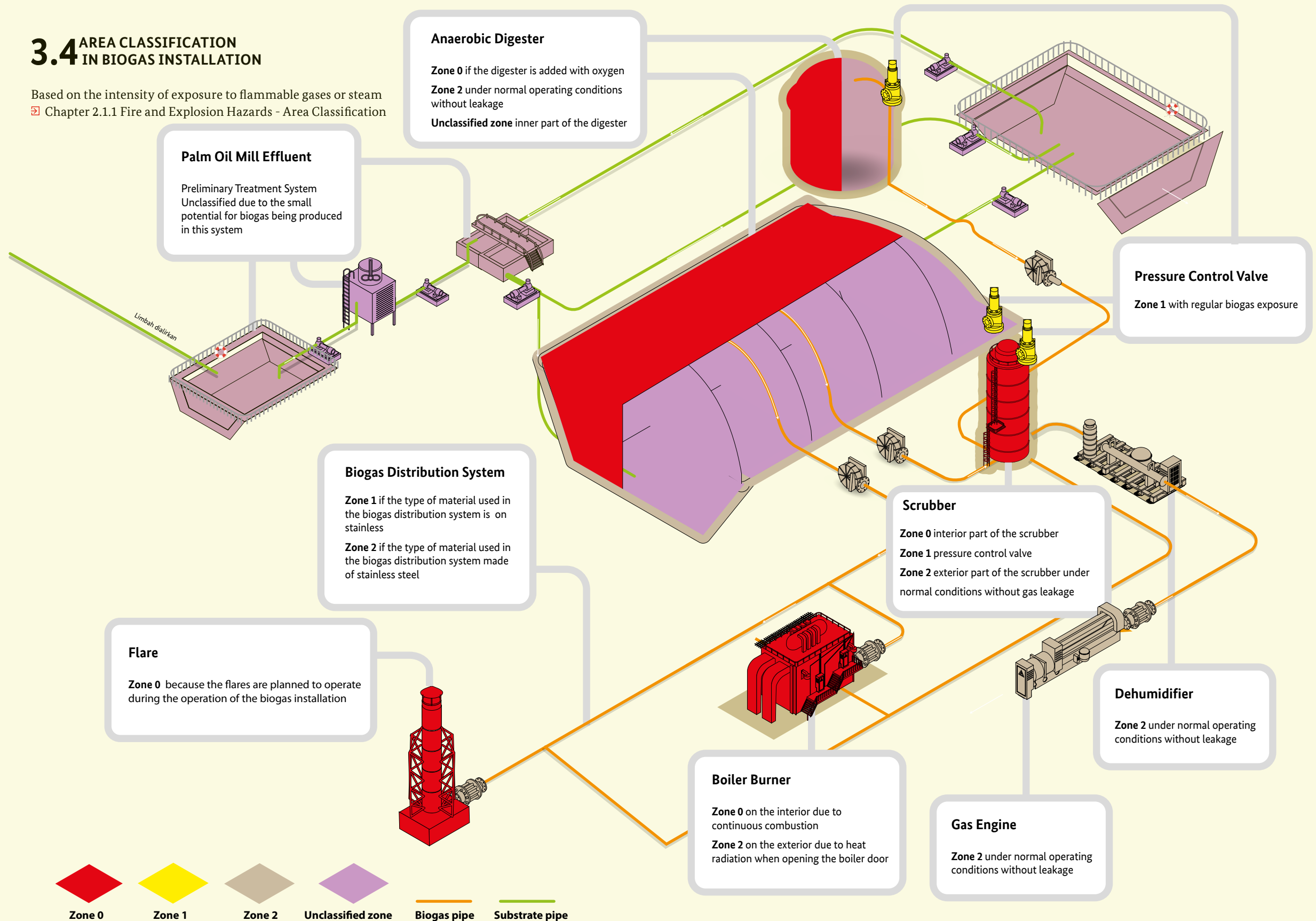


The boiler burner is designed so that the biogas is directly combusted in the burner, hence no biogas is released. Boiler burners can be categorized into 2 zones, namely:

ATEX Zone 0 on the inner part the boiler burner due to continuous biogas exposure
ATEX Zone 2 on the outer part of the boiler burner due to exposure to heat radiation when opening the door

3.4 AREA CLASSIFICATION IN BIOGAS INSTALLATION

Based on the intensity of exposure to flammable gases or steam
 Chapter 2.1.1 Fire and Explosion Hazards - Area Classification



CHAPTER

4



OHS MONITORING, TESTING AND REPORTING

The safety monitoring and audit must be carried out in each area of the biogas installation to ensure that the biogas plant can be operated safely:

4.1 SAFETY MONITORING AND TESTING

Table 4.1 Example of a weekly safety inspection form in the work area

Working area:		Date:
Location:		Verifier:
Pedestrian Route:		
Yes	No	
		Holes, obstacles or other hazards are covered or safe from potential hazards.
		There are safe routes for pedestrians in areas that are passed by heavy equipment, vehicles or other motorized equipment.
		The emergency exit route is marked and can be clearly identified.
Comment:		
Safety equipment (eyewash, First Aid Kit, Fire Extinguisher):		
Yes	No	
		All safety equipment is labeled and ready to use.
		All emergency/safety equipment is checked and ready to use.
		Emergency eyewash placed in an area near the biodigester or in a location where corrosive materials is used.
		Eye wash and emergency showers are inspected and tested every month.
		Fire extinguishers are inspected every month and tested every year.
		First aid kits are provided and monitored adequately at work sites.
Comment:		
Storage of Chemicals		
Yes	No	
		Sufficient storage for chemicals used in the work area
		Flammable liquids are stored in storage cabinets for flammable materials.
		Corrosive materials are stored in storage cabinets for corrosive materials.
		All chemical containers are labeled with the material names and hazard warnings.
		Material safety data sheets (MSDS) are available for chemicals used or stored in the work area.
		Pressurized gas cylinders are well protected to prevent them from falling during storage or use.
		Pressurized gas is stored with a protective cover.
		Incompatible gas is stored in a separate location.
Comments:		

Equipment		
Yes	No	
		Sufficient storage space is provided for tools and equipment.
		Tools are checked before each use.
		Damaged tools and equipment are not used.
		Portable tools have been effectively grounded.
		Sufficient space is provided around and between equipment to enable passing, service, storage and safe disposal of waste.
		All equipment is permanently bolted to the floor or secured to prevent movement during use.
		Engine guards are provided for all potential pinch points and on rotating/ twisting parts to protect the operator.
		Material handling equipment (backhoe, truck, crane, hoist, sling) are routinely inspected prior to being used and are not used if there is damage.
		Fall protection device is used and checked to work at height.
		Ladders, scaffolds and ramps are used for the intended purpose and are equipped with fences, supports and appropriate safety features.
		Ladders, scaffolding and ramps are in good condition.
		The ladder is securely installed
Comments:		
Hot Work (pengelasan dan pemotongan)		
Yes	No	
		There is a procedure (permit) for hot work activities.
		Flammable materials are moved outside the work area or protected during hot work activities.
		Welding guards are used when welding.
		There are supervisors for hot work outside the specified welding area.
		PPE/fire extinguishers are available in the work area.
		Equipment is kept in good condition.
Comments:		
Confined Space		
Yes	No	
		Confined space is identified and labeled in the work area.
		There is a procedure (permit) used to enter confined spaces.
		There is a procedure applied for emergency handling of confined spaces.
		There is a person on standby other than those who enter confined spaces.
		Suitable equipment is available in the work area.
Comments:		

Material Storage		
Yes	No	
		Sufficient and suitable space is provided for material storage.
		Material storage does not block areas for walking or exit.
		Sufficient storage space for material to be stored.
		Materials are stacked or arranged on a shelf in a safe manner to avoid the risk of falling.
		Material is not excessively stored in the work area.
Comments:		
Biodigester		
Yes	No	
		Suitable electrical installations are provided for the type of equipment used.
		The bordess is well maintained to avoid hazards.
		The biodigester cover and pipeline is in good condition.
		The biodigester cover is free of weeds and garbage.
		Drainage and other concrete structures are clearly visible and are marked for easy identification.
		Security fence around the area is in good condition and maintained.
		The pump is locked and maintained in clean condition and free of dirt.
Comments:		
Personal Protective Equipment		
Yes	No	
		The suitable type and size of PPE is available for each type of work.
		Employees use PPE that is suitable for their work.
		The PPE used is clean and in good condition.
		Sufficient space is provided for PPE storage.
		There are regulations for cleaning and/or sanitizing PPE.
		The gas detector is available and calibrated.
Comments:		
Fire Safety		
Ya	Tidak	
		Flammable liquids are stored in a closed container when not in use.
		Fire Extinguishers are available and used for flammable liquids and gases.
Comments:		

Emergency Conditions		
Ya	Tidak	
		Emergency evacuation routes and meeting points are determined and displayed in the work area.
		Evacuation drills are conducted regularly.
		Emergency procedures are determined for the area and the employees are aware of the procedure.
Comments:		
Flaring Area		
Ya	Tidak	
		The security fence is in good condition and the door is locked.
		Fire extinguishers are available in the area (inspected and tested).
		Pipes and accessories are in good condition.
		Ensuring that the inspected electrical panel has been closed again
		Sufficient space is provided for PPE storage.
		The flaring area is in good condition.
		Warning signs are placed in the area.
		A temporary hose or extension cable is placed in the area.
Comments:		

Table 4.2 Frequency of Inspection and Testing of Safety Equipment

Testing Object	Inspection and Testing Frequency	Reference regulations in Indonesia
Fire Extinguisher	Twice a year	☒ Minister of Manpower Regulation No. 4 of 1980 Requirements for the Installation and Maintenance of Fire Extinguishers
Safety equipment (e.g. gas alarms, ventilation systems and inerting equipment)	Weekly, monthly and annually	☒ Minister of Manpower Regulation No.2 of 1983 Automatic Fire Alarm Installations
Outdoor Hydrant	Inspection every 3 months, testing every year	☒ Minister of Public Works Regulation No.26/PRT/M/2008 Technical Requirements for Fire Protection Systems in Building and Environment
Fire extinguishing pump	Inspection every week, testing every year	
Electrical installation testing	• Prior to submission to the owner/user • After changes/improvements • Periodically once a year	☒ Minister of Manpower Regulation No.12 of 2015 Electrical OHS in the Workplace
Pressure vessels and storage tanks	First inspection and/or testing during: • Planning; • Manufacturing; • Prior to being used or when it has never been examined and/or tested; • or Installation, change or modification. Periodic inspection/testing every 2 years	☒ Minister of Manpower Regulation No. 37 of 2016 OHS for Work with Pressure Vessels & Storage Tanks
Lightning ProtectionSystem	Before handing over the Lightning Protection System and installer to the user; • After there is a change or repair of a building and or Lightning Protection System; • Periodically every two years; • After there is damage due to lightning strikes;	☒ Minister of Manpower Regulation No.2 of 1989 Supervision of Lightning Protection Systems

! In addition to the inspection and testing of safety equipment, the management of the biogas installation must inspect and test other instrumentations that support the safety aspects in the operation of biogas installations based on instructions from technology providers, such as flow meters, flame arresters, etc.

4.2 ENVIRONMENTAL MONITORING AND MANAGEMENT

The environmental monitoring and management of the biogas installation refer to ☒ **Minister of Environment and Forestry Regulation No. 16/2012** concerning the guidelines for preparing environmental documents. Table 5.2 below provides an example of a checklist on the environmental monitoring and management of biogas installations. In addition, every company that owns or operates a biogas installation is expected to report GHG reduction inventory data for biogas installations currently in operation.

☒ Appendix 13

Table 5.2 Examples of filling out the environmental monitoring and management plan based on the Minister of Environment and Forestry Regulation No. 16/2012

Type of impact	Cause	Source of impact	Impact standard			Environmental Management efforts	Location	Responsible implementers	Management Timeline
			Regulation	Standards					
				Parameter	Amount				
Reduction in air emission quality	Residual gas from generator combustion	Biogas generator	☑ Minister of Environment Regulation No.21 of 2008 Appendix A	Particulate CO NO ₂ SO ₂ Opacity	30 mg/Nm ³ 500 mg/Nm ³ 400 mg/Nm ³ 150 mg/Nm ³ -	• Carrying out routine preventive maintenance • Greening the installation area • Providing masks for the generator operator	Installation area	Implementer: Maintenance Dept. General Affairs Dept. OHS Dept. Supervisor: District Environmental Agency	In accordance with the schedule
Reduction in ambient air quality	Biogas generator activities	Gas produced by the biogas generator combustion	☑ Government Regulation No.41 of 1999	SO ₄ CO ₂ NO ₂ O ₃ HC PM ₁₀ TSP	900 µg/Nm ³ 30000 µg/Nm ³ 400 µg/Nm ³ 235 µg/Nm ³ 160 µg/Nm ³ 150 µg/Nm ³ 230 µg/Nm ³	• Carrying out routine preventive maintenance • Greening the factory area • Providing masks for the generator operator	Installation area	Implementer: Maintenance Dept. General Affairs Dept. OHS Dept. Supervisor: District Environmental Agency	In accordance with the schedule
Noise	Biogas generator	Operating the biogas generator	☑ Minister of Environment and Forestry Regulation No.48 of 1996 -Noise Level	Offices, Industrial Areas, Residential & Housing	65 db (A) 70 db (A) 55 db (A)	• Using earplugs at the noise locations • Regularly carrying out routine preventive maintenance • The generator is placed in an isolated or soundproofed room to reduce noise	• In front of the office • Operational area of the biogas generator • Residential Area	Implementer: Maintenance Dept. OHS Dept. Supervisor: District Environmental Agency	In accordance with the schedule
Odor	• Wastewater • <i>Scrubber</i>	Product of installation activities (POME)	☑ Minister of Environment and Forestry Regulation No. 50 of 1996	H ₂ S NH ₃	0,02 ppm 2 ppm	• Planting trees that can reduce odor • Using methane capture installations to anaerobic ponds to capture methane	Installation location Effluent ponds	Implementer: Maintenance Dept. OHS Dept. Supervisor: District Environmental Agency	In accordance with the schedule
Hazardous and Toxic Waste	Biogas generator and scrubber	The presence of sulfur residues, used oil, batteries, oil filters, TL lamps and contaminated goods resulting from the biogas generator operations	☑ Government Regulation No.101 of 2014	N/A	N/A	• Collecting sulfur, oil, batteries, filters, TL lamps and used rags to the TPS LB3 and handing it over to a licensed 3rd party	• Operational area of the biogas generator • Scrubber • TPS LB3	Implementer: Maintenance Dept. OHS Dept. Supervisor: District Environmental Agency	Routine

4.2.1 Types of reporting for environmental monitoring and testing

In line with the Minister of Environment Decree No. 13 of 2010 concerning UKL/UPL and ☒ **Government Regulation No. 27 of 1999**, all business activities must report the implementation of the Environmental Management-/Monitoring Effort or Environment Management-/Monitoring Plan at least twice a year or each semester to the local District/City Environmental Agency and relevant agencies. This is needed so the government can monitor the changes in environmental quality within and around the business location. The main points that need to be provided in the report are:

- Company Identity
- Business and Activity Summary
- Implementation of Environmental Management
- Implementation of Environmental Monitoring



APPENDICES

1. List of OHS Regulations
2. Example of a Filled-In Risk Management Form for Biogas Installations
- 3.1 Example of Permit for Entering Confined Space
- 3.2 Example of Checklist to Enter Confined Space
4. Example of Safety Instruction Illustration
5. Example of Work Instruction
6. Example of Safety Inspection Findings Form
7. Accident or Incident Reporting Flow
8. Example of P2K3 Quarterly Report Format
9. LOTO Principles and Format
10. Example of Occupational Safety Risk and Work Area Analysis Reporting
11. Hot Work Procedures
12. Material Safety Data Sheet
13. Example of Biogas Installation GHG Inventory Form PT. XYZ

APPENDIX 1: LIST OF INDONESIANS AND INTERNATIONAL OHS AND ENVIRONMENT REGULATIONS

REGULATIONS CONCERNING THE OHS MONITORING, TESTING, AND REPORTING

Minister of Manpower Regulation No.1 of 1981	Obligation to Report Work-Related Diseases
Minister of Manpower Regulation No.333 of 1989	Diagnosis and Reporting of Work-Related Diseases
Presidential Decree No.22 of 1993	Diseases resulting from Work Relations
Minister of Manpower Regulation No.3 of 1998	Procedures for the Reporting and Examination of Occupational Accidents
Directorate General of Industrial Relations Disputes & Labor Supervision Decree No. 84 of 1998	Method for Filling the Accident Report Form and Statistics Analysis

INTERNASIONAL SAFETY REGULATIONS

NFPA 54	National Fuel Gas Code: Guidelines for the Design of Gas Piping
NFPA 85	Boiler and Combustion Systems Hazards Code
NFPA 101	Minimum Requirements for New and Existing Structures to Protect the Building Residents from Fire, Smoke, and Toxic Fumes
NFPA 704	Standard System for the Identification of the Hazards of Materials for Emergency Response
NFPA 497	Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors: Classified Locations for Digester, Vents and Biogas Treatment Area
NFPA 820	Standard for Fire Protection in Wastewater Treatment and Collection Facilities: Recommended Locations for Digester Relevant to Buildings and Other Equipment, Classification of Digester, Ventilation and Biogas Treatment Area

OTHER INTERNATIONAL SAFETY REGULATIONS	Description
API 2000	Ventilation: Venting Atmospheric and Low-Pressure Storage Tanks
NEC 70	National Electrical Code: Intrinsic Safety Requirements

APPENDIX 2:

EXAMPLE OF A FILLED-IN RISK MANAGEMENT FORM FOR BIOGAS INSTALLATIONS

No.	Area	Example of Activities	Hazard Category	Risk assessment			Hazard impact	Type of hazard control		
				Probability (L)	Severity (S)	Risk Score (L x S)		Technical	Administrative	PPE
1.	Cooling pond	Walking in the cooling pond or cooling tower area	Mechanical	5	1	5	Slipping or falling into the cooling pond	Installing a fence surrounding the cooling pond	Cleaning the cooling pond or cooling tower area	Safety shoes, helmet
2.	Mixing tank	Activating the mixing tank agitator	Electrical	5	1	5	Electrocution and fire burns	Installing cable insulation according to SNI	Implementing LOTO during maintenance	Safety shoes, helmet
3	CAL	Opening the vent hole in the digester cover	Hazardous substances	5	1	5	Inhaling biogas	Using portable gas detectors	Periodically checking for leakage	Safety shoes, helmet, mask
4		Patching a leaking HDPE membrane	Fire and explosion	5	4	20	Fire	Using specifications according to ATEX for electrical equipment and instrumentation	Implementing hot work procedures	Safety shoes, helmet
5	....	....	....	....	....	....	....	....	....	....

APPENDIX 3.1:

EXAMPLE OF PERMIT FOR ENTERING CONFINED SPACE

Company Name :	Filled on:	Time:
Work Site:	Valid until:	Time:
Work Activity:		

CONFINED SPACE HAZARDS: (✓)

- ☐ Lack of oxygen (<19.5%)
- ☐ Toxic gas or steam > PEL
- ☐ Trapped
- ☐ Electrical hazard
- ☐ Fire hazards (gas, vapor, oxygen)
- ☐ Hot/cold (circle one)
- ☐ Hazardous configuration
- ☐ Rotating or moving equipment
- ☐ Chemical hazards
- ☐ Others_____

EQUIPMENT NEEDED:(✓)

- ☐ Respirator
- ☐ Safety clothes
- ☐ Hearing protection
- ☐ Anti explosives lighting
- ☐ Fire Extinguisher
- ☐ Harnesses
- ☐ Emergency Safety Equipment
- ☐ Resuscitator - Inhalator
- ☐ Emergency Respirator
- ☐ Others:_____

COMMUNICATION

- ☐ Direct
- ☐ Radio/Transmitter
- ☐ Others_____

EMPLOYEE DATA

- Entering : _____ ☐ Employee Rescue
- Partner : _____ ☐ Rescue of Non-Entering Employee
- Supervisor: _____ ☐ External Rescue contact number # _____

PREPARATION FOR ENTERING

- ☐ Notify employees affected by the work
- ☐ Isolate hazardous energy
- ☐ Implement the LOTO procedure
- ☐ Isolation Verification
- ☐ Securing the location with a flag
- ☐ Cleaning, drying the room
- ☐ Building the ventilation needed
- ☐ Review hazards and work procedures
- ☐ Inform the emergency team
- ☐ Safe atmospheric test
- ☐ Additional permit has been obtained
- ☐ Using appropriate PPE
- ☐ Work communication plan
- ☐ Others_____

ATMOSPHERIC TEST

Test is conducted prior to entering the closed space

Continuous monitoring? ☐ Yes ☐ No

Test Frequency: : _____ Examiner Name : _____

Examiner Name: _____ Examiner ID # : _____

Examiner ID # : _____

ACCEPTABLE CONDITIONS FOR ENTERING:

TEST	PEL	✓	1	2	3	4	5	6	7	8	9
Min. O ₂	19.5%	☐									
Max. O ₂	23.5%	☐									
Flammability	10% LFL	☐									
Carbon monoxide	35 ppm	☐									
H ₂ S	10 ppm	☐									
Sulfur Dioxide	2 pm	☐									
Poison		☐									
Temperature		☐									
Others		☐									

Instrument #1: _____ Model/type: _____ ID Number: _____

Instrument #1: _____ Model/type: _____ ID Number: _____

Notes: _____

APPROVAL

I certify that the necessary entry requirements have been fulfilled and it is safe to start work in this space.

Time : _____

Approval by : _____

Name : _____

Permit Revoked : _____

Signature : _____

NOTES :

Date/ Time work completed : _____

Verified by : _____

Permit revoked ☐

APPENDIX 3.2:
EXAMPLE OF CHECKLIST TO ENTER CONFINED SPACE

Langkah #	Proses	Selesai
1.	Isolating the space from all hazards	
	Removing unauthorized personnel from the site	
	Using LOTO	
	Closing the inlet, etc.	
2.	Ventilate the room (if needed)	
4.	Filling-in the permit to enter the confined space	
5.	Evaluating the room	
6.	Atmospheric test	
	Input atmospheric test data in the entry permit	
	Placing complete permit on or near the PRCS*	
7.	Entering the room and doing the work	
	Are there any supervisors?	
	There are personnel on standby at the entrance	
	Safety harness	
	Required PPE	
	Conducting another atmospheric test as needed	
8.	When the work is completed:	
	Removing all personnel, equipment, and dirt from the space.	
	Closing the room	
	Revoking the entry permit	
	Reviewing the work with a supervisor (hazards, issues, etc.)	
9.	Archiving permits that have expired and been revoked	

APPENDIX 4:
EXAMPLE OF SAFETY INDUCTION ILLUSTRATION

GUIDELINES FOR THE VISIT



Visitors must always be accompanied by a biogas staff representative. Methane is a flammable and explosive gas

PROHIBITION TO LIGHT FIRES OR SMOKE IN THE BIOGAS INSTALLATION AREA



Smoking is prohibited in all facilities in the biogas installation area



Do not light fires in the biogas installation area

TYPE OF CLOTHES AND DEVICE TO BE USED IN THE SITE

Visitors are recommended to wear clothing with the following characteristics:



Long-sleeved shirt, trousers and closed shoes



Hats or umbrellas to be worn at all times for protection from direct sunburn, sunburn, heat strokes, etc.



Sunscreens should also be used.



Safety vest must be worn at all times for visibility purposes during an emergency

FOOD AND BEVERAGE



Do not eat in facilities that are in operation or undergoing construction.



Drink lots of water, the weather is very hot and humid in the biodigester open area to prevent dehydration

HEALTH RECORDS



Visitors with specific health records are recommended to bring medicine that they commonly use in the event of an emergency

STAY ALERT TO ANIMALS



There are dangers of wild animals like poisonous snakes, monitor lizards, lizards, spiders, scorpions and wild bees. These animals are usually found at the site. Please avoid or take additional precautions when walking through the bush. and dense areas with vegetation

ELECTRONIC EQUIPMENT



Considered as a source of hazard (source of ignition) or security threat in certain areas (fenced flare areas). Therefore, the use of cellular phones, taking pictures with flash requires permission

APPENDIX 5:
EXAMPLE OF WORK INSTRUCTION IN UNIT XXX

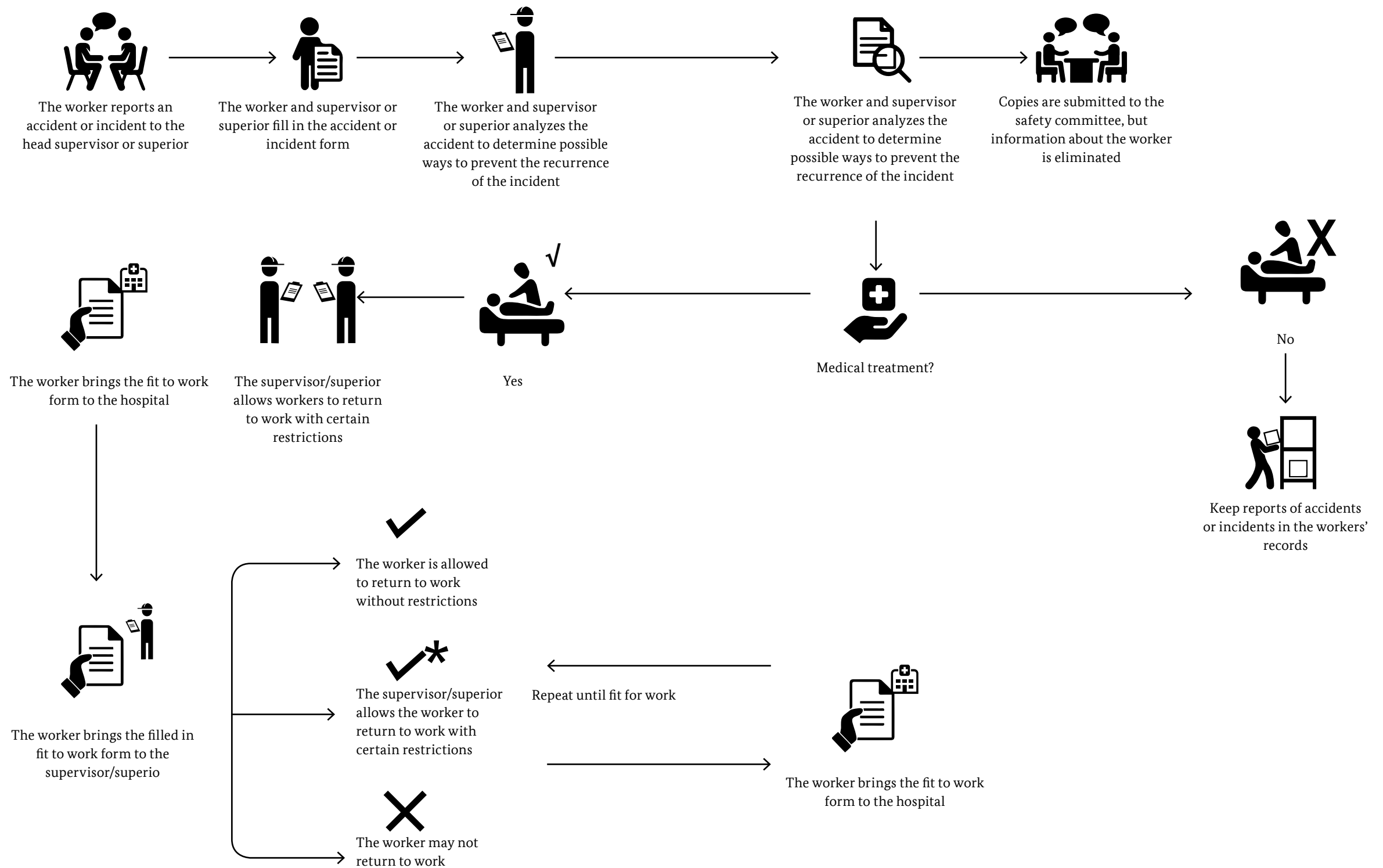
Company Name /company logo:	Date:	Revision:
Unit: xxxx (with photos)	Description of equipment/ instrumentation	Parameter
OHS symbol	Prohibition sign	Personal protective equipment (PPE) used
Work Instruction: Starting the work: Operation: Ending the work:		

APPENDIX 6:
EXAMPLE OF SAFETY INSPECTION FINDING FORM

CORRECTIVE ACTION: The following findings are documented in your area during occupational safety and health inspections. Please observe each finding and take corrective action to be followed up on that date.

FINDINGS	CORRECTIVE ACTION	FOLLOW-UP ON (DATE)

APPENDIX 7:
ACCIDENT OR INCIDENT REPORTING FLOW



APPENDIX 8:
P2K3 QUARTERLY REPORT FORMAT

Occupational Health and Safety Development Committee

Company :.....

Address :.....

No

:

To

Appendix

:

Head of Manpower Office

Subject

:

Quarterly report

at-

OCCUPATIONAL HEALTH AND SAFETY DEVELOPMENT COMMITTEE

COMPANY

:

ADDRESS

:

P 2 K 3 REPORT

A. COMPANY DATA

1. Company Name :

2. Type of Business :(based on KLUI)

3. Address :Telp/Fax :Email :

4. Total Workers

:

Male

=

.....

people

Female

=

.....

people

TKA

=

.....

people

Total

=

.....

people

Kepesertaan BPJS Tenaga Kerja membership = people

5. P2K3 establishment : date year

6. Management : people

(enclose the P2K3 Organization Chart that has been approved by the local Manpower Office).

B. OHS DATA

7. OHS Personnel Data (type/classification, total and validity)

a. Ahli K3

b. Doctor Examining Workers

c. Auditor SMK3

d. Paramedic/ Officer/ Technician/ Operator

8. Institution/Unit/Organization Data (other than P2K3):

a. Fire Fighting Unit

Total members

:

.....

people

b. Emergency response unit

Total members

:

.....

people

c. First aid unit

Total members

:

.....

people

d. Others (if any)

:

.....

9. OHS Infrastructure and Facilitis Data (type/classification, total and validity)

a. Equipment/Engine/Cranes/Installation Equipment

☐ Lifting crane

☐Steam Powered Machine and Pressure Vessels

☐ Generation and production machine

☐ Electrical

☐ Fire fighting

☐ Personal Protective Equipment and Devices

b. Hazardous Material

c. Occupational Healthcare Services

d. Sanitation and Hygiene Facilities

e. Welfare Facilities (Canteen/Dining Room, Prayer Room, Lactation, Recreation, and others)

f. Standard Operation Procedure (SOP)/ Safety Data Sheet (SDS)

g.Signs/Posters

h. Others (mention).....

10. Work Accidents & Work-Related Diseases Data

a. Statistics

b. Accident Frequency Rate & Accident Severity Rate

11. OHS Award Data

a.Z ero Accident Award

b. OHS Management System (OHSMS)

c. HIV/AIDS Prevention and Management Program in the Workplace

C. OHS ACTIVITIES

12. P2K3 monthly meeting : conducted_____ (enclosed)____

13. Safety Policy : available_____ (enclosed)____ N/A

14. Program/Rencana Kerja : available_____ (enclosed)____ N/A

15. Pelaksanaan Program/Rencana Kerja : dilakukan_____ (enclosed)____ N/A

16. Facilitation/Counseling/Research Implementation

a. Material

:

.....

b. Resources persons

:

.....

c. Participants

:

.....

17. Work procedures, process and work environment evaluation

a.Hazard potential :

b. Accident/Injury potential:

c.Control Measures :

18. Work accident/work-related disease analysis

19. Result of the equipment condition/company hygiene/work ergonomyl/ work environment/work nutrition inspection etc

20. Occupational healthcare services

a. Worker medical examination :

b. Occupational Health Program (Prevention of HIV/AIDS, Drugs in the Workplace and others)

c. etc

D. OBSTACLES

E. RECOMMENDATIONS

..... 20.....

P2K3 Secretary

Approved

P2K3 Chairman

Cc:

Company Directors

Head of Manpower Office for Province.....

Director General of Labor Supervision cq. Director of OHS Norm Supervision, Ministry of Manpower and Transmigration

Regulations issued by the Ministry of Manpower can be accessed at <https://jdih.kemnaker.go.id/index.php>

1. All personnel must comply with the prohibitions and restrictions of this procedure. Failure to follow and comply with this procedure can result in disciplinary action and dismissal.
2. No individual shall attempt to start, activate, or use equipment that has undergone the LOTO (lockout and tagout) procedure for service and maintenance activities.
3. No individual shall attempt to move lockout and tag devices.
4. The double block and bleed must be used in all piping systems when available.
 - Special care must be taken if a work involves an active electrical device or in a system containing hazardous chemicals, hot liquids, compressed gases or steam. Additional personal protective equipment and special work instructions may be needed, depending on the hazard conditions occurring. These requirements will be reviewed by the relevant managers and authorized employees during the Pre-job Briefing before carrying out the work.
5. All LOTOs will need a lock and tag operating system to be applied to energy isolation equipment and devices. The tag operating system, itself, can only be used when a lockout device cannot be physically applied to an energy isolation device.
6. Authorized employees shall use a private lock and tag on the lockbox after all operating systems have implemented the LOTO procedure.
7. The LOTO procedures cannot be used for machines, equipment and/or systems that are not operating, and if there are no short-term plans to reinstate those machines or equipment. Use a different label to indicate that the machine or equipment is not operating.
8. The check valve cannot be used as an energy isolation device.
9. If the control switch is placed far away, the lockout/tagout device must be placed on each switch to ensure that the switch is on or off. This must be done before continuing the LOTO. The lockout device will be the last device removed when cleaning the LOTO. The Tag operating system, itself, can ONLY be used when a lockout device cannot be physically applied to an energy isolation device.

10. LOTO procedures must be used every time an external company is contracted to work. If the LOTO procedure applicable for the contractor requires additional protection or is more stringent than what is provided by this procedure, the respective manager, or authorized party, must develop procedures that can be agreed by all parties and fully comply with the applicable OHS requirements.
11. When the electrical system grounds need to be used, the system will be the last device to be activated and the first device to be removed from the LOTO. The grounding device may only be operated by qualified electrical personnel.
12. This procedure does not apply to equipment that operates with cables and plugs when the plug is removed and the plug is in the exclusive control of the person doing the work.
13. Anyone who sees a violation of this procedure must immediately notify the respective manager
 - All employees shall be trained on the lockout/ tagout procedures.

DANGER

TAG# _____

DO NOT OPERATE

LOTO# _____ **TANGGAL** _____

EQUIPMENT _____

POSITION _____

MP SIGNATURE _____

VALIDITY _____ **TIME** _____

NOTES

APPENDIX 10:

EXAMPLE OF OCCUPATIONAL SAFETY RISK AND WORK AREA ANALYSIS REPORTING

Occupational Safety Risk and Work Area Analysis	Type of Work: Repair of HDPE membranes	Page 1 of 1 JSA NO.	DATE:
			REVIEW:
	Worker position:	Supervisor:	Analyzed by:
Organization:	Location	Department:	Reviewed by:
NEEDED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Gas detector, self-contained breathing apparatus, safety goggles, harness and safety ropes/lanes, safety vests, leather gloves, steel shank boots			
BASIC SEQUENCE	HAZARD POTENTIAL	RECOMMENDED ACTIONS OR PROCEDURES	
Preparation: - Isolate the repair site with clear security signs. - Take precautions, such as portable fire extinguishers and on-site self-contained breathing apparatus, wind direction signs like windsock.	- CH ₄ and H ₂ S gas released from the tear	- Use a gas detector to check methane and hydrogen sulfide levels before working - Approach the repair site from above the wind direction - Do not use hand tools or equipment that can produce sparks	
Patch the HDPE membrane tear with black tape	- CH ₄ and H ₂ S gas released from the tear	- Use a gas detector to check methane and hydrogen sulfide levels before working - Approach the repair site from above the wind direction - Do not use hand tools or equipment that can produce sparks	
- Place the HDPE membrane overlay on the tape. - Perform welding properly to cover all HDPE overlays with existing membranes	- CH ₄ and H ₂ S gas released from the tear	- Use a gas detector (dragger) to detect gas leaks - Observe the wind direction. The work position shall always be above or across the wind direction. - Use a self-contained breathing apparatus when the gas release is out of control. - Hot work permits must be enforced. 9 kg portable fire extinguisher standby 2 EA dry powder	
- Perform a leak test at all welding points with soap water - After passing the leak test, consider that the work has been done correctly	- CH ₄ and H ₂ S gas released from the tear	- Use a gas detector (dragger) to detect gas leaks - The work position shall always be above the wind (opposite direction of the wind) or crossing the wind (away from the source of fire). - Use a self-contained breathing apparatus when the gas release is out of control	
Double check to ensure that there is no gas leak from the patched area and the work has been completed.	N/A		

APPENDIX 11:
HOT WORK PROCEDURES

Hot work refers to all types of work that produces a source of fire, for example burning flames, molten metals, sparks, and specific heated work surfaces. The purpose of applying the heat work standard is to protect employees from injury and property from serious damage due to work involving sources of fire or heat. Hot work This standard applies to all hot work activities carried out in power generation facilities, electric substations, field transmissions, and distribution facilities. Failure to comply with this standard can pose danger for companies, facilities, employees and contractors. Therefore, each company must develop procedures in accordance with site-specific compliance with this standard. Companies can prepare safety related policies that are more stringent than the policies identified in this standard.

This standard is based on the best practices and requirements according to the ANSI Z49.1-2005, NFPA 51B-2003, OSHA 29CFR 1910 Subpart Q, and American Welding Society guidelines.

All operational companies must develop and implement hot work, which shall at least include the following:

POLICY STIPULATION

- The written program contains an explanation of the scope, objectives, responsibilities, authorities, regulations, and techniques applied to carry out hot work and considerations for implementing this procedure, including:
- Specific statements regarding the purpose of using the procedure
- Special measures for preparing the work area to ensure the safety of the heat produced
- Special requirements for the selection and use of Personal Protective Equipment (PPE)
- Specific requirements to consider preparations that must be made before carrying out work, e.g. determining the type of gas and the amount of smoke produced, ventilation requirements and respirators used.

IMPLEMENTATION PROCEDURE

- **Fire prevention** : Moving or protecting all equipment that can potentially burn from a hot work area.
- **Hot work permit** : To ensure that the environment is safe from potential fires by considering the hazards for hot work activities.
- **Firefighters** : The Fire Extinguisher which consists of a portable fire extinguisher, fire hose, a bucket of water, a sandbox
- **Fire observer** : Personnel who have been trained to use fire fighting equipment and understand potential fire hazards in the industry. Assigned to supervise hot work activities and continue to inspect the location for up to 30 minutes after the hot work activity has been completed.

SAFE WORK AREA

The location is at a radius of 10.7 m from the hot work site. This location must be sterilized from fire hazards during hot work activities for up to 30 minutes after the hot work has been completed.

- **Specific hazards** Facilities or locations with hazard potential are require to have special work procedures, for example: storage of explosive materials, coal or hydrogen systems
- **Authorization :** Site inspection to determine what preparation should be done before the hot work is carried out. See Appendix A for examples of authorization permits.
- **Restricted Area :** Areas where hot work may not be carried out.
- **Eye Protection:** The eye protection used must be in accordance with hot work to be carried out. Refers to the ANSI Z87.1 standard concerning eye and face protection.
- **Protective Clothing :** Personnel carrying out the hot work shall use aprons and leather gloves.
- **Ventilation :** For hot work sites in confined spaces or areas with poor ventilation. Mechanical ventilation is needed to reduce the concentration of gas or steam in a hot work site.
- **Respiratory protection:** If mechanical ventilation is not sufficient, a suitable respirator must be used to reduce gas exposure.
- **Secure and store cylinders and engines:** When there is a potential for fire or explosive atmosphere at a site.
- **Hazardous atmosphere:** Work will be prohibited at that location if the atmosphere tested is> = 10% of the Lower Explosive Limit (LEL).

MONITORING AND EVALUATION

Consists of the implementation policies, an explanation of the roles and responsibilities of each personnel for hot work procedures. All personnel including contracted personnel involved in hot work activities must be trained and knowledgeable in procedural elements. Specific identification needs to be done for the hot work inspection process. Management is expected to be active during the audit or inspection process:

- Operation supervisors carry out periodic inspections to ensure the equipment is in good condition.
- The inspection record includes the date of inspection, the workers involved, and the person conducting the inspection.
- An annual audit will be carried out to assess the effectiveness of the hot work procedure. The audit must be carried out by an external expert.

EXAMPLE OF HOT WORK PERMIT

Permit for Cutting and Welding

This permit complies with the predetermined rules listed on the back side of this tag.

The use of welding equipment has been approved by:

(Project engineer or Maintenance Supervisor)

Date _____ Start Time _____ Finish Time _____

Work Site _____ Welder _____

Time when work has been completed and inspected _____ (2-4 hours after the work has been completed)

By _____

Position _____

Submit to Supervisor after work has been completed

Post at the work site

Ensure that the following conditions are met within a radius of 10.7 meters from the work site:	
1. The floor is clean and free of flammable materials	
2. Floors made of flammable material have been wetted or covered with wet sand or covered with fire-resistant material.	
3. Flammable liquids have been cleaned and flammable materials have been shifted or protected by fire-resistant or protective materials made of metal.	
4. All holes in the wall and floor have been covered.	
5. Cable trays are identified and protected.	
6. Conveyors are locked or secured.	
7. . In closed or confined space: There are no flammable materials in it	

Note: The cutting and welding equipment must be in good condition in accordance with the regulatory requirements. All fire observer requirements have been met and the work covered by this permit has been completed. The area can be classified as safe from fires 30 minutes after the work has been completed.

Fire Watch Signature

Finish Date and Time

APPENDIX 12: MATERIAL SAFETY DATA SHEET

MATERIAL SAFETY DATA SHEET (MSDS) METHANE – CH₄ (Please ensure that this MSDS is received by an appropriate person)

Date: January 2017
Ref. no.: MS042

Version2

1 PRODUCT AND COMPANY IDENTIFICATION

PRODUCT IDENTIFICATION

Product Name METHANE
Chemical Formula CH₄
Trade Names Methane (N2.5)
Methane (N3.5)
Colour Coding Signal Red (A.11) body with a Black band round the centre of the cylinder
Valve Nerki – Brass 5/8inch left hand female
Company Identification African Oxygen Limited
23 Webber Street
Johannesburg, 2001
Tel. No: (011) 490-0400
Fax No: (011) 490-0506

**EMERGENCY No. 0860 020202 or (011) 873 4382
(24 hours)**

2 COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name Methane
Chemical Family Paraffins
CAS No. 74-82-8
UN No. 1971
ERG No. 115
Hazchem Warning 2A flammable gas

3 HAZARDS IDENTIFICATION

Main Hazards All cylinders are portable gas containers, and must be regarded as pressure vessels at all times. Methane poses hazards to personnel through its flammability. All the precautions necessary for the safe handling of any flammable compressed gas must be observed in working with Methane.

Adverse Health Effects Methane is classified as a simple asphyxiant. It is practically physiologically inert, except when it lowers the partial pressure of oxygen in the air enough to cause systemic effects due to oxygen-deficiency.

Chemical hazards No known hazards
Biological Hazards No known effect
Vapour Inhalation No known effect
Eye contact No known effect
Skin contact No known effect
Ingestion No known effect

Label Elements

Hazard Pictograms



Signal Word: Danger

Precautionary Statements:

P210: Keep away from heat/sparks/open flames/hot surface. No Smoking
P377: leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381: Eliminate all ignition sources if safe to do so.
P403: Store in well ventilated place.

Hazard Statements:

H220: Extremely flammable gas.

4 FIRST AID MEASURES

The conscious person who becomes aware of nausea and pressure on the forehead and eyes should go promptly to an uncontaminated area and inhale fresh air or oxygen. However, in the event of a massive exposure the victim may become unconscious or symptoms of asphyxiation may persist. In that case the person should be removed to an uncontaminated area, and given artificial respiration and then oxygen, after breathing has been restored. Treat symptomatically thereafter.

5 FIRE FIGHTING MEASURES

Extinguishing media Dry powder. Carbon dioxide. Fog-water spray. (In the absence of fog equipment a fine spray of water may be used).

Specific hazards Highly flammable. May form explosive gas mixtures with air. Is a simple asphyxiant.

Emergency actions If possible, shut off gas flow at source. Evacuate area. Post warning to prevent persons from approaching with lit cigarettes or open flames. Using water, keep all cylinders in the vicinity of the fire cool. Remove cylinders from the vicinity of the fire if possible. Allow small fires on cylinders to remain burning if they are not posing a hazard. CONTACT THE NEAREST AFROX BRANCH.

Protective clothing Exposed fire fighters should wear approved self-contained breathing apparatus with full mask.

Environmental precautions. As the gas is lighter than air, ensure that it is not trapped in confined spaces. This could lead to the formation of a highly explosive gas-air mixture. Ventilate all confined spaces using forced-draught if necessary. Ensure that all electrically powered equipment is flameproof.

6 ACCIDENTAL RELEASE MEASURES

Personal precautions. As Methane is a simple asphyxiant care should be taken when entering confined spaces where leaks have occurred. Do not enter any potentially hazardous area with any source of ignition such as a lit cigarette or match.

Environmental precautions. Methane does not pose a hazard to the environment. An explosive gas-air mixture could be formed when leaks occur, so eliminate all forms of ignition.

Small spills Small leaks should be extinguished by shutting off the source of supply, e.g. closing the valve on the cylinder, or tightening the gland nut. If unable to stop small leaks the cylinder should be moved into the open, well away from any source of ignition. Should a small leak have ignited, use a multi-purpose dry powder or carbon dioxide extinguisher. Should there be no extinguisher available, a welders glove or heavy cloth, soaked in water may be used to extinguish the flame.

Large spills Stop the source if it can be done without risk. Eliminate all sources of ignition and static discharges. Restrict access to the area until completion of the clean-up procedure. Post relevant warning signs. Wear adequate protective clothing when working near the source of the leak. Ventilate the area using forced-draught if necessary. Ensure that all equipment is flameproof.

7 HANDLING AND STORAGE

Do not allow cylinders to slide or come into contact with sharp edges. Methane cylinders may be stacked horizontally provided that they are firmly secured in order to prevent rolling. Ensure that equipment is adequately earthed. Conspicuous signs should be posted in the storage area forbidding smoking or the use of naked lights. Use a "first-in - first-out" inventory system to prevent full cylinders from being stored for excessive periods of time. Compliance with all relevant legislation is essential. Keep out of reach of children.

Page 1 of 2

MATERIAL SAFETY DATA SHEET (MSDS) METHANE – CH₄

(Please ensure that this MSDS is received by an appropriate person)

Date: January 2017
Ref. no.: MS042

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8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational exposure hazards No known effect.

Engineering control measures. Engineering control measures are preferred to reduce exposures. General methods include mechanical ventilation, process or personal enclosure, and control of process conditions. Administrative controls and personal protective equipment may also be required. Use a suitable flameproof ventilation system separate from other exhaust ventilation systems. Exhaust direct to outside. Supply sufficient replacement air to make up for air removed by exhaust system.

Personal protection Use self-contained breathing apparatus when fighting large fires.

Eyes. Use safety glasses when working with cylinders.

Hands. Use suitable protective gloves when working with cylinders.

Feet. Wear protective footwear when working with cylinders.

10 STABILITY AND REACTIVITY

Conditions to avoid Overheating of cylinders. Keep sparks and flames away from cylinder, and under no circumstances allow a torch flame to come into contact with any part of the cylinder. Never test for leaks with a flame. Use soapy water when testing for leaks. Never use cylinders as rollers or supports, or for any other purposes other than the storing of Methane.

Incompatible materials. Methane is non-corrosive and may be contained at ambient temperatures by most common metals used in installations designed to have sufficient strength for the working pressures involved.

Hazardous Decomposition Products. No hazardous compounds are formed when Methane / air mixtures burn.

11 TOXICOLOGICAL INFORMATION

Acute Toxicity No known effect
Skin & eye contact No known effect
Chronic Toxicity No known effect
Carcinogenicity No known effect
Mutagenicity No known effect
Reproductive Hazards No known effect
For further information see Section 3, Adverse Health Effects

12 ECOLOGICAL INFORMATION

As Methane is lighter than air it will disperse rapidly in open areas. It does not pose a hazard to the ecology.

13 DISPOSAL CONSIDERATIONS

Disposal Methods Small amounts may be blown to the atmosphere under controlled conditions. No sources of ignition should be in the vicinity. Large amounts should only be handled by the gas supplier.
Disposal of packaging. The disposal of containers must only be handled by the gas supplier.

14 TRANSPORT INFORMATION

ROAD TRANSPORTATION

UN No. 1971
Class 2.1

Skin. No known effect.

9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DATA

Chemical Symbol CH₄
Molecular Weight 16.04
Specific volume @ 20°C & 101.325 kPa 1474,0 ml/g
Relative density of gas @ 101.325 kPa (Air=1) 0.555
Flammability limits in air 5.0 – 15.4% (by vol)
Auto ignition temperature 537°C
Colour None
Taste None
Odour Sweet, oil-type

Subsidiary risk Asphyxiant
ERG No 115
Hazchem warning 2 A Flammable gas

SEA TRANSPORTATION

IMDG 1971
Class 2.1
Label Flammable gas

AIR TRANSPORTATION

ICAO/IATA Code 1971
Class 2.1
Subsidiary risk Flammable gas
Packaging instructions 200
- Cargo Forbidden Maximum quantity
- Passenger
allowed 150 kg
- Cargo Forbidden
- Passenger

15 REGULATORY INFORMATION

EEC Hazard class Flammable gas
Refer to SANS 10234 Supplement.

16 OTHER INFORMATION

Bibliography
Compressed Gas Association, Arlington, Virginia
Handbook of Compressed Gases - 3rd Edition
Matheson. Matheson Gas Data Book - 6th Edition
SABS 0265 - Labelling of Dangerous Substances

17 EXCLUSION OF LIABILITY

Information contained in this publication is accurate at the date of publication. The company does not accept liability arising from the use of this information, or the use, application, adaptation or process of any product described herein.

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For product and safety enquiries please phone

**EMERGENCY N°:
0860020202 (24 hr)**

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MATERIAL SAFETY DATA SHEET (MSDS) HYDROGEN SULPHIDE (H2S)

Please ensure that this MSDS is received by the appropriate person

DATE: April 2011	Version 2
Ref. No.: MS033	
1 PRODUCT AND COMPANY IDENTIFICATION	
Product Name	HYDROGEN SULPHIDE
Chemical Formula	H2S
Trade Name	Hydrogen Sulphide
Company Identification	African Oxygen Limited 23 Webber Street Johannesburg, 2001 Tel. No: (011) 490-0400 Fax No: (011) 490-0506
EMERGENCY NUMBER	086011185 or (0660 02 02 02) (24 hours)
2 COMPOSITION/INFORMATION ON INGREDIENTS	
Chemical Name:	Hydrogen Sulphide
Chemical Abstract Service Number (CAS No.):	07783-06-04
UN No.:	1053
ERG No.:	117
3. HAZARDS IDENTIFICATION	
Main Hazards	in concentrations of 20 to 50ppm, hydrogen sulphide irritates the eyes. Slightly higher concentrations irritate the upper respiratory tract and, may result in pulmonary edema. Inhalation of 500ppm for 30 minutes produces headache, dizziness, excitement, staggering, and gastroenteric disorder, followed in some cases by bronchitis and bronchial pneumonia. Concentrations above 600ppm can be fatal within 30 minutes through respiratory paralysis. Although the foul odor of hydrogen sulphide is readily detectable in low concentrations, it becomes unreliable as a warning of dangerous concentrations of gas since continuous inhalation leads rapidly to olfactory fatigue.
Vapour Inhalation	Hydrogen sulfide reacts with enzymes in the bloodstream and inhibits cellular respiration resulting in pulmonary paralysis, sudden collapse and death. Continuous exposure to low (15-50 ppm) concentrations will generally cause irritation to mucous membranes, and may also cause headache, dizziness or nausea. Higher concentrations (200-300 ppm) may result in respiratory arrest leading to coma or unconsciousness. Exposures for more than 30 minutes at concentrations greater than 700 ppm have been fatal. Continuous inhalation of low concentrations may cause olfactory fatigue or paralysis of the sense of smell. Thus, detection of hydrogen sulfide by its odor is not effective.
Eye Contact	Low concentrations will generally cause irritation to the conjunctiva. Repeated exposure to low concentrations is reported to cause conjunctivitis, photo phobia, corneal
	bulbar, tearing, pain and blurred vision.
Skin Contact	May irritate the skin upon contact
Ingestion	Ingestion is unlikely. Hydrogen sulfide will irritate the mucous membranes causing a burning feeling with excess salivation likely. Irritation of the gastrointestinal tract may also occur.
4 FIRST AID MEASURES	
Inhalation:	Very toxic by inhalation. May cause damaging effects to central nervous system, metabolism and gastrointestinal tract. Prolonged exposure to small concentrations may result in pulmonary oedema. Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped. Delayed adverse effects possible.
Skin/Eye:	Remove contaminated clothing. In case of frostbite spray with water for at least 15 minutes. Apply a sterile dressing. Immediately flush eyes thoroughly with water for at least minutes. Obtain medical assistance.
Ingestion:	It is not considered a potential route of exposure
5 FIRE FIGHTING MEASURES	
Extinguishing media Suitable	extinguishing media: all known extinguishants can be used.
Specific Hazards	Exposure to fire may cause containers to rupture/explode. Hazardous combustion products: If involved in a fire, the following toxic and/or corrosive fumes may be produced by thermal decomposition: Sulfur dioxide. Suitable extinguishing media: all known extinguishants can be used.
Emergency Actions	stop flow of product if possible. Move away from the container and cool with water from a protected position. Do not extinguish a leaking gas flame unless absolutely necessary. Spontaneous/explosive re-ignition may occur.
Protective Clothing	Use a self contained breathing apparatus and chemically protective clothing.
6 ACCIDENTAL RELEASE MEASURES	
Personal Precautions	Evacuate area. Eliminate ignition sources. Ensure adequate air ventilation. Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe.
Environmental Precautions	Do not allow the product from entering sewers and storm water drains.
Methods for cleaning up	Ventilate area. Keep area evacuated and free from ignition sources until any spilled liquid has evaporated, that is ground free from frost

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MATERIAL SAFETY DATA SHEET (MSDS) HYDROGEN SULPHIDE (H2S)

Please ensure that this MSDS is received by the appropriate person

7 HANDLING AND STORAGE	
Ensure equipment is adequately earthed. Purge air from system before introducing gas. Do not allow backfeed into the container. Cylinders should be stored upright and prevented from falling. Suck back of water into the container must be prevented. Use only properly specified equipment, which is suitable for this product, its supply pressure and temperature. Contact your gas supplier if in doubt. Keep away from ignition sources (including static discharges). Secure them away from flammable or combustible materials; in a dry, well ventilated constructed of non-combustible material with firm level floor. Keep container below 50 deg. Celsius in a well ventilated place. Use the "first in – first out" inventory system to prevent full cylinders from being stored for excessive period of time. Compliance of all relevant legislation is essential. Keep away from children	
8 EXPOSURE CONTROLS/PERSONAL PROTECTION	
Occupational exposure hazards	Hydrogen
sulfide – TLV: 10ppm; STEL: 15ppm	
Engineering control measures	Filling or withdrawal from a Hydrogen Sulfide cylinder must be performed in a well ventilated area and if possible should be in a forced ventilation system or using a hood over the valve.
9 PHYSICAL AND CHEMICAL PROPERTIES	
PHYSICAL DATA	
Chemical Symbol	H2S
Molecular Weight	34.08 g/mol
Melting point @ 224 kPa	-86°C
Appearance/Colour:	Colourless gas
Odour:	Rotten eggs
Relative density, Gas @ 101.325kPa @ 25°C	1.188
Specific Volume @ 21.1°C, 101.325 kPa	70.11dm³/kg
Dielectric constant; Gas @ 0°C, @ 101.325kPa	1.004
10 STABILITY AND REACTIVITY	
Conditions to avoid	avoid heat, flames, sparks and other source of ignition. Minimise contact with material. Avoid inhalation of material or combustion by products. Keep out of water suppliers and sewers.
Incompatible Materials	Do not store reserve stocks of hydrogen sulphide cylinder with cylinders containing oxygen or other highly oxidising or combustible materials.
11 TOXICOLOGICAL INFORMATION	
Acute Toxicity	unknown
Skin & eye contact	unknown
Chronic Toxicity	unknown
Carcinogenicity	unknown
Mutagenicity	unknown
Reproductive Hazards	unknown
12 ECOLOGICAL INFORMATION	
General: Toxic to water organisms.	
13 DISPOSAL CONSIDERATIONS	
Disposal methods	
Avoid discharge to atmosphere. Do not discharge into any place where its accumulation could be dangerous. Toxic and corrosive gases formed during combustion should be scrubbed before discharge to atmosphere. Do not discharge into areas where there is a risk of forming an explosive mixture with air. Waste gas should be flared through a suitable burner with flash back arrestor. Contact supplier if further guidance is required	
14 TRANSPORT INFORMATION	
UN No.	1053
Class	2.3
ADR/RID Item Nr.	2.2 deg. TIF
ADR/RID Hazard Nr.	263
Labelling ADR	Label 6.1 Toxic Substance Label 3 Flammable
substance	
Other transport information	Avoid transport on vehicles where load space is not separated from the driver's compartment. Ensure vehicle driver is aware of potential hazards of the load and knows what to do in the event of an accident or an emergency. Before transporting product containers ensure that they are firmly secured and valve outlet cap, nut or plug (where provided) is correctly fitted. Valve protection device (where provided) is correctly fitted. Ensure that there is adequate ventilation. Comply with applicable transport regulation.
15 REGULATORY INFORMATION	
Risk phrases	R26 Very toxic by inhalation
Safety phrases	S (1/2) Keep locked up and out of reach of children S9 Keep container in a well ventilated place S16 Keep away from ignition sources – No smoking S28 After contact with skin, immediately wash with plenty of ... (to be specified by manufacturer) S36/37 Wear suitable protective clothing and gloves S45 In case of accident or if you feel unwell, seek medical advice immediately S61 Avoid release into environment; refer to special instructions/material safety data sheet
Reference: SANS 10265	
16 OTHER INFORMATION	
Ensure all national/local regulations are observed. Ensure operators understand the asphyxiation hazard.	
Bibliography Compressed Gas Association, Arlington, Virginia Handbook of Compressed Gases – 3 rd Edition Matheson Gas Data Book – 6 th Edition	
EXCLUSION OF LIABILITY	
Whilst AFROX made best endeavour to ensure that the information contained in this publication is accurate at the date of publication, AFROX does not accept liability for an inaccuracy or liability arising from the use of this information, or the use, application, adaptation or process of any products described herein.	

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MATERIAL SAFETY DATA SHEET (MSDS) CARBON DIOXIDE

(Please ensure that this MSDS is received by an appropriate person)

DATE: March 2017 Version: 4 Page 1 of 3
Ref. No.: MS093

1 PRODUCT AND COMPANY IDENTIFICATION

Product Name	CARBON DIOXIDE
Chemical Formula	CO ₂
Trade Names	Technical Carbon Dioxide Industrial Carbon Dioxide Food Carbon Dioxide Instrument Grade Carbon Dioxide Laser Grade Carbon Dioxide Pharmaceutical Grade Carbon Dioxide Carbon Dioxide (N4.5) Medical Carbon Dioxide
Colour coding	With the exception of Medical CO ₂ , all other grades have Green (H.07) bodies, with relevant grades stencilled or denoted by decals, on the bodies of the cylinders. Medical CO ₂ has a Green (H.07) body with a French Grey (H.30) shoulder.
Valve	All above grades are fitted with 3S-Brass 0.860-inch by 14 tpi right-hand male valve
Company Identification	African Oxygen Limited 23 Webber Street Johannesburg, 2001 Tel No: (011) 490-0400 Fax No: (011) 490-0506
EMERGENCY NUMBER	0860 020202 or (011) 873 4382 (24 hours)

2 COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	Carbon Dioxide
Chemical Family	Carbon Anhydride
Synonyms	Carbonic Acid Gas
CAS No.	124-38-9
UN No.	1013
ERG No.	120
Hazard Warning	2 C Non flammable Gas

3 HAZARDS IDENTIFICATION

Main Hazards

Carbon dioxide does not support life. It can act as a simple asphyxiant by diluting the concentration of oxygen in air below the levels necessary to support life. As it is heavier than air it will tend to concentrate at lower levels.

Adverse Health Effects

Carbon dioxide acts as a stimulant and depressant on the central nervous system. Increases in heart rate and blood pressure have been noted at a concentration of 7.6 percent, and dyspnea (laboured breathing), headache, dizziness and sweating occur if exposure at that level is prolonged.

Chemical Hazards

Carbon dioxide is relatively non-reactive and non-toxic. In the presence of moisture it can aggressively bring about corrosion in a variety of steel materials.

Biological Hazards

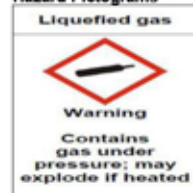
The greatest physiological effect of carbon dioxide is to stimulate the respiratory centre, thereby controlling the volume and rate of respiration. It is able to cause dilation and constriction of blood vessels and is a vital constituent of the acid-base mechanism that controls the pH of the blood.

Vapour Inhalation

At concentrations of 10% and above, unconsciousness can result in one minute or less. Impairment in performance has been noted during prolonged exposure to concentrations of 3% carbon dioxide even when the oxygen concentration was 21%.

Label Elements

Hazard Pictograms



4 FIRST AID MEASURES

Eye/Skin Contact	No known effect.
Ingestion	(See Section 3 above) Prompt medical attention is mandatory in all cases of overexposure to carbon dioxide. Rescue personnel should be equipped with self-contained breathing apparatus. Gaseous carbon dioxide is an asphyxiant. Concentrations of 10% or more can produce death or unconsciousness. Lower concentrations may cause sweating, headache, rapid breathing, increase heartbeat, shortness of breath, dizziness, mental depression, visual disturbance, shaking. Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from contaminated area is most important. Unconscious persons should be removed to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen.

5 FIRE FIGHTING MEASURES

Extinguishing Media

Carbon dioxide is an extinguishing medium.

Specific Hazards

Carbon dioxide does not support life. It can act as a simple asphyxiant by diluting the concentration of oxygen in the air below the levels to support life.

Emergency Actions

If possible, shut off the source of excess carbon dioxide. Evacuate area. All cylinders should be removed from the vicinity of the fire. Cylinders that cannot be removed should be cooled with water from a safe distance. Cylinders that have been exposed to excessive heat should be clearly identified and returned to the supplier. CONTACT THE NEAREST AFROX BRANCH.

Protective Clothing

Self-contained breathing apparatus. Safety gloves and shoes, or boots, should be worn when handling cylinders.

Environmental Precautions

Carbon dioxide is heavier than air and could accumulate in low-lying areas. Care should be taken when entering a potentially oxygen-deficient environment. If possible, ventilate the affected area.

6 ACCIDENTAL RELEASE MEASURES

Personal Precautions

Do not enter any area where carbon dioxide has been spilled unless tests have shown that it is safe to do so.

Environmental Precautions

As carbon dioxide is classified as a "greenhouse" gas, any spillage should be avoided at all times.

Small Spills

Shut off the source of escaping carbon dioxide. Ventilate the area.

Large Spills

Evacuate the area. Shut off the source of the spill if this can be done without risk. Restrict access to the area until completion of the clean-up procedure. Ventilate the area using forced-draught if necessary.

7 HANDLING AND STORAGE

Do not allow cylinders to slide or come into contact with sharp edges. Carbon dioxide cylinders should be stacked vertically at all times, should be firmly secured in order to prevent them from being knocked over. Use a "first-in first-out" inventory system to prevent full cylinders from being stored for excessive periods of time. Keep out of reach of children.

MATERIAL SAFETY DATA SHEET (MSDS) CARBON DIOXIDE

(Please ensure that this MSDS is received by an appropriate person)

DATE: March 2017 Version: 4 Page 2 of 3
Ref. No.: MS093

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Hazards

As carbon dioxide is a simple asphyxiant, avoid any areas where spillage has taken place. Only enter once testing has proved the atmosphere to be safe, and remember that gas is heavier than air.

Engineering Control Measures

Engineering control measures are preferred to reduce exposure to oxygen-depleted atmospheres. General methods include forced-draught ventilation, separate from other exhaust ventilation systems. Ensure that sufficient fresh air enters at, or near, floor level.

Personal Protection

Self-contained breathing apparatus should always be worn when entering area where oxygen depletion may have occurred. Safety goggles, gloves and shoes, or boots, should be worn when handling cylinders.

No known effect. Skin

9 PHYSICAL AND CHEMICAL

PROPERTIES

PHYSICAL DATA

Chemical Symbol	CO ₂
Molecular Weight	44.01
Specific volume @ 20°C & 101.325 kPa	547 ml/g
Density gas @ 101.325 kPa & 20°C	1.839 kg/m ³
Relative density (Air=1) @ 101.325 kPa	1.522
Colour	None
Taste	Acidic
Odour	None

10 STABILITY AND REACTIVITY

Conditions to avoid

The dilution of oxygen in the atmosphere to levels which cannot support life. Never use cylinders as rollers or supports, or for any other purpose than the storing of carbon dioxide. Never expose the cylinders to excessive heat, as this may cause sufficient build-up of pressure to rupture the cylinders.

Incompatible Materials

As dry carbon dioxide is inert it may be contained in systems constructed of any of the common metals that have been designed to safely withstand the pressures involved.

Hazardous Decomposition Products

None

11 TOXICOLOGICAL INFORMATION

Acute Toxicity	TLV 5000 VPM
Skin & eye contact	No known effect
Chronic Toxicity	No known effect
Carcinogenicity	No known effect
Mutagenicity	No known effect
Reproductive Hazards	No known effect

(For further information see Section 3. Adverse Health effects)

12 ECOLOGICAL INFORMATION

Carbon dioxide is heavier than air and can cause pockets of oxygen-depleted atmosphere in low-lying areas. It does not pose a hazard to the ecology.

13 DISPOSAL CONSIDERATIONS

Disposal Methods

Small amounts may be blown to the atmosphere under controlled conditions. The gas supplier should only handle large amounts.

Disposal of Packaging

The gas supplier must only handle the disposal of cylinders.

14 TRANSPORT INFORMATION

ROAD TRANSPORTATION

UN No	1013
ERG No	120
Hazchem warning	2C Non-flammable Gas

SEA TRANSPORTATION

IMDG	101
------	-----

Class	
Packaging group	
Label	Non-flammable Gas
AIR TRANSPORTATION	
ICAO/IATA Code	1013
Class	2.2
Packaging group	
Packaging instructions	
- Cargo	200
- Passenger	200
Maximum quantity allowed	
- Cargo	150kg
- Passenger	75kg

15 REGULATORY INFORMATION

EEC Hazard class Non-flammable

Risk Phrase	Description	Safety Phrase	Description
R44	Risk of explosion if heated under confinement	S2	Keep out of reach of Children
R58	May cause long-term adverse effects in the environment	S3	Keep in a cool place
		S9	Keep container in a well-ventilated place
		S36	Wear suitable protective clothing
		S38	In case of insufficient ventilation, wear suitable respiratory equipment

National legislation OHSAct and Regulations 85 of 1993
Refer to SANS 10234 for explanation of the above.

16 OTHER INFORMATION

Bibliography

Compressed Gas Association, Arlington, Virginia
Handbook of Compressed Gases – 3rd Edition
Matheson, Matheson Gas Data Book – 6th Edition
SABS 10234 – Globally Harmonized System of classification and labelling of chemicals (GHS)

17 EXCLUSION OF LIABILITY

Information contained in this publication is accurate at the date of publication. The company does not accept liability arising from the use of this information, or the use, application, adaptation or process of any products described herein.

APPENDIX 13:

EXAMPLE OF BIOGAS INSTALLATION GHG INVENTORY FORM PT. XYZ

Tahun:

Bulan	TBS (ton/bulan)	POME entering the digester (m ³ POME/month)	ton COD/m ³	COD Removal (%)	Electricity produced (MWh/month)	Operating time (day/month)
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total						

Reports shall be submitted to:
 Directorate of Bioenergy - DG NREEC
 Jl. Pegangsaan Timur No. 1
 Menteng Jakarta 10320
 Tel/Fax : 021-31924585
 Email : tekling.bioenergi@esdm.go.id

BIBLIOGRAPHY

- Department of Occupational Safety and Health Malaysia. (2008). Guidelines for hazard identification, risk assessment, and risk control (HIRARC). Putra Jaya: Ministry of Human Resources Malaysia.
- Direktorat Pengolahan Hasil Pertanian. (2006). Pedoman Pengelolaan Limbah Industri Kelapa Sawit. Jakarta: Ditjen Pengolahan dan Pemasaran Hasil Pertanian (Ditjen PPHP)
- German Biogas Association. (2016). Guidelines for the safe use of biogas technology. Freising, Germany: Fachverband Biogas e.V.
- German Social Insurance for Agriculture, Forestry, and Horticulture (SVLFG). (2016). Technische Information 4 Sicherheitsregeln für Biogasanlagen. Kassel: Sozialversicherung für Landwirtschaft, Forsten und Gartenbau (SVLFG).
- Global Assest Protection Services LLC. (2015). GAPS Guidelines 2.5.2: Oil and Chemical Plant Layout and Spacing. Connecticut.
- Henderson, B. (2006, July 1). Retrieved from OHS Online: <https://ohsonline.com/Articles/2006/07/Carbon-Dioxide-Measures-Up-as-a-Real-Hazard.aspx?Page=4>
- Hosseini, S., Bagheri, G., Khaleghi, M., & Wahid, M. (2015). Combustion of biogas released from POME and the effect of hydrogen enrichment on the characteristic of the biogas flame. *Journal of Combustion*.
- ISO 20675. (2018). Biogas - Biogas production, conditioning, upgrading, and utilisation - Terms, definitions, and classification scheme. Switzerland.
- Kissell, Fred N; , Pittsburgh Research Laboratory (National Institute for Occupational Safety and Health). (2006). Handbook for methane control in mining. Pittsburg: Dept. of Health and Human Services, Center for Disease Control and Prevention.
- National Research Council. (2007). Emergency and Continuous Exposure Guidance Level for Selected Submarine Contaminants: Volume 1. Washington D.C.: The National Academies Press.
- NIOSH. (2018, Sept 16). Retrieved from Centers for Disease Control and Prevention: <https://www.cdc.gov/niosh/ipcsneng/neng0291.html>
- OSHA. (2004). Personal Protective Equipment.
- OSHA. (2011). Retrieved from <https://www.osha.gov/Publications/laboratory/OSHAfactsheet-laboratorysafety-noise.pdf>
- OSHA. (2018, May 9). Retrieved from Hydrogen Sulfide: <https://www.osha.gov/SLTC/hydrogensulfide/hazards.html>
- OSHA. (2018, July 3). Source: Hazard prevention and control: <https://www.osha.gov/shpguidelines/hazard-prevention.html>
- OSHA. (2018, Nov 28). Retrieved from Confined Space: <https://www.osha.gov/SLTC/confinedspaces/>
- Permenaker 5. (2018, July 12). Retrieved from Occupation Health, Safety and Environment: https://jdih.kemnaker.go.id/data_puu/Permen_5_2018.pdf
- Prasher, D. (2000). Noise Pollution Health Effects Reduction (NOPHER) : An European Commission Concerted Action Workplan. *Noise Health*, 79-84. Retrieved from <http://www.noiseandhealth.org/text.asp?2000/2/8/79/31748>
- Quah, S., & Gilles, D. (1981). Practical experience in production and use of biogas. *Proceeding of the national workshop on oil palm by-product utilisation*, 119-125.
- TRGS 900. (2016). Technische Regeln für Gefahrstoffe.
- Zabetakis, M., Lambiris, S., & Scott, G. (1959). *The combustion*. Pittsburgh: The Combustion Institute.

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