PLATFORM ZERO INCIDENTS
join the journey, break the pyramid

Gas Measuring

Version 2,
2025

DISCLAIMER

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ABOUT PLATFORM ZERO INCIDENTS

Platform Zero Incidents (PZI) is an initiative of the inland shipping sector. As the name suggests, PZI strives for 0 (zero) accidents in inland shipping. PZI wants to achieve this by:

- A platform where near misses and incidents are shared among members.
- Preventing recurrence of near misses/incidents by developing and promoting best practices based on research and analysis of (trends of) near misses/incidents.
- Building sustainable relationships with stakeholders.
- Increasing awareness and responsibility of safety within the industry.
- PZI will be the centre of expertise in the field of prevention of safety and environmental incidents in inland shipping.

This publication contributes to achieving the mission and vision of PZI. The document was developed by and for inland shipping.

It can be used for various purposes, such as:

- Reference work for crew members and fleet managers.
- Training of crewmembers.
- Safety meetings on board.
- Teaching materials for educational institutions.
- As a basis for procedures and work instructions.

If things are unclear or questions arise during the loading/unloading process, this should be discussed with the shore organisation.

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1. INTRODUCTION

1.1. Why this document?

Measuring the atmosphere is essential, primarily for the safety of personnel, but also for the environment. This Best Practice Guidance (BPG) provides you with knowledge on atmospheric measurement, as well as the interpretation of values and topics related to different types of equipment.
The document has been compiled—like all documents from the Platform Zero Incidents—by inland shipping experts, namely:

- Fleet-managers;
- QHSSE-managers;
- Equipment suppliers.

In addition, the development of this publication has taken into account the applicable laws and regulations, such as the ADN, BPR, and RPR.

1.2.How to use this document

This document is by no means intended to describe the only way of working, as every situation and every vessel is different. However, it can in making the best decisions under various circumstances.

This document can also be used as a reference for the safety management system, but also to guide and/or train crew and staff. Additionally, parts of the document can be used during safety meetings with crew and personnel. It can help raise safety awareness on board, thereby reducing the risk of accidents.

If you have suggestions to further improve this document, then please contact Platform Zero Incidents via info@platformzeroincidents.com.

2. WHY DO WE MEASURE?

When transporting goods, an environment can arise that is harmful to people and/or the environment. It is therefore important that it is clear what the composition of the air/atmosphere is and what measures can possibly be taken to prevent unsafe situations.

Legislation includes measures to limit the dangers. The ADN describes some legal obligations regarding the degassing and measuring of tanks, confined space, the environment of the living area and the wheelhouse. In addition, the employer is obliged to not let an employee work in a potentially dangerous environment (in Dutch: “ARBO-besluit”). It is important to determine what a hazardous environment is based on the established statutory limit values.

Entering Confined Space

In confined spaces (a space with limited openings for entry and exit, unfavourable ventilation, not designed for continuous staffing, or is entered irregularly), gases that are poisonous or sensitive to fire may be present. There may also be a lack of oxygen, for example due to rust formation and/or unfavourable ventilation. Before entering a confined space, it must first be established whether the tank can be accessed and what safety equipment is required to do this safely.

Repairs and Site Visit

Measurements are also important before repairs are carried out or visiting the yard, which must be carried out by a recognized expert (gas measurement specialist). For the above situations, see the procedures of the owner/office.

Signalling

It is important for the surrounding of the barge that proper signalling is maintained. Measurements are also required for this.

Degassing

Degassing is an event where potentially toxic or (slightly) flammable gases enter the outside air. Degassing to the outside air is prohibited in Europe for many substances. For substances that are not prohibited, degassing is permitted.

To provide security for the crew and the surrounding area, measurements must be carried out in order to take any necessary measures.

Seemingly Safe

An environment may seem safe, but in reality, it is not safe. This is called false safety. For example, when work has been done in a confined space and someone wants to enter the space again after a break. It may seem safe because in the meantime 'nothing has happened', but in reality, the mixture of gases may have changed inside the space. Or, for example, when the environment is not toxic, but has a shortage of oxygen. It is therefore important to continue to measure, even if it seems safe.

3. WHAT DO WE MEASURE?

You usually do not see them, but they are everywhere: gases. You inhale a gas mixture that we call "air", you cook food on the gas stove and drink a glass of soda in which carbon dioxide (CO2) bubbles up.

The term ‘gas’ comes from the word chaos. Gas is a cloud of molecules that move randomly and chaotically and that constantly collide with each other and the environment. Gases fill every available volume and due to the particularly high speed at which gases move, they quickly mix with the atmosphere in which they are released. A gas can also be formed from a solid or liquid substance, for example by heating.

Gases can have lighter, heavier or roughly the same density as air. Gases can have an odour but can also be odourless. Gases can have a colour but can also be colourless. If you cannot see, smell or touch it, it does not mean that it is not there. In order to determine which and how many gases there are in a space, we have to measure.

If we are talking about measuring, we want to know how much of a certain type of gas is present in a room to determine whether there are any risks. The three major dangers that gases entail are:

Danger of poisoning – Toxic Gases

Danger of fire and/or explosion – Flammable Gases

Danger of Suffocation - Oxygen deficiency

Now that we know that measurements are important, we will go deeper into what is measured in this chapter.

3.1.Toxicity

Toxicity is often referred to in 'degree of toxicity'. This concerns whether the substances in the air are present in such a way that they are toxic to humans. The effect already occurs when exposed to even very low concentrations that are inhaled, swallowed or absorbed by the skin. In order to know whether working safely in a space and how long work can be done safely, it is important to look up the limit value in, for example, the Chemical Data Sheet book. This value is indicated by the MAC value (Maximum Accepted Concentration). The limit value is the maximum permitted concentration of a (hazardous) substance in the individual breathing zone; previously this was called the MAC value (Maximum Acceptable Concentration).

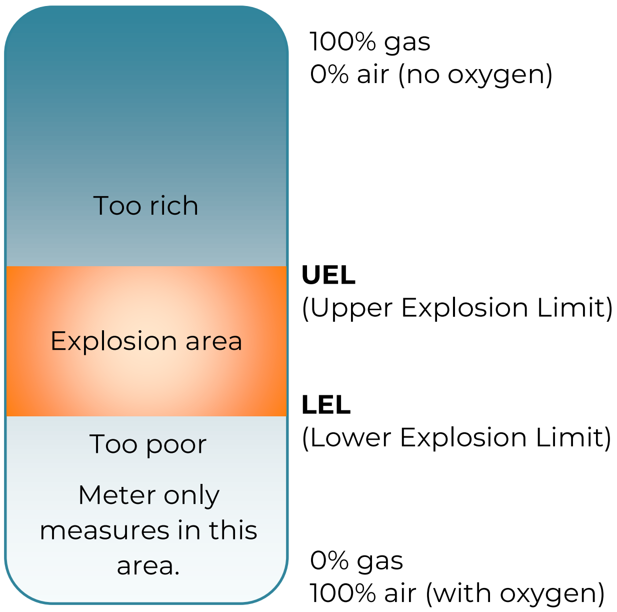
3.2.Explosion Danger

Explosion hazard occurs when a combustible substance is present in the air. This means that a combination of a combustible substance and oxygen is present. This can occur in gases, mists and substances.

The mixing ratio of gas/vapor and oxygen in which a flammable mixture is formed, is not the same for every gas. In the literature the explosion limit is indicated by the abbreviation L.E.L. (LEL), from "Lower Explosive Limit". In addition to the LEL value, there is also a maximum gas concentration: UEL value (Upper Explosive Limit).

A LEL sensor indicates the number of percentages from the lower explosion limit (% LEL; Lower Explosion Limit).

Usually it is thought that an explosion only occurs if direct fire is present. Ignition sources such as hot surfaces, mechanical sparks, or electrical installations and electrical equipment are often overlooked.



3.3.Oxygen (O2)

People need oxygen to be able to breathe. Our (outside) air consists of approximately 20.9% oxygen. With a higher oxygen percentage (for example 23%), substances can be ignited more quickly. At a lower percentage (for example, below 19.5%) it can cause respiratory problems and suffocation leading to death.

But beware, an acceptable percentage of oxygen does not mean that the air is safe. After all, what does the remaining air consist of?

3.4.Nitrogen (N2)

Despite the fact that our 'air' consists of almost 21% oxygen and 78% nitrogen, an increase in nitrogen (or decrease of oxygen) is very dangerous for humans, as a result of which it can suffocate. The danger of nitrogen is that this gas is completely odourless and colourless and of course expels oxygen. Nitrogen is a fraction heavier than air and will therefore slowly sink under the air in a tank. A 'nitrogen blanket' is meant to expel the oxygen from the cargo tank and thereby minimize the risk of explosion.

In measurements, we often speak of a nitrogen measurement, for example when flushing cargo tanks prior to loading. What is meant by this, is that we try to determine the oxygen content in a nitrogen environment.

3.5.Hydrogen Sulphide (H2S)

Hydrogen sulphide (H_2S) is a colourless gas at atmospheric pressure and room temperature with a smell of rotten eggs. The gas is heavier than air. At high concentrations of hydrogen sulphide (dangerous!) one can no longer rely on smell perception, because this substance at a low concentration can no longer be smelled by temporary paralysis of the olfactory nerve. H_2S reacts violently with oxidants. H_2S is flammable and with air or oxygen it forms an explosive mixture (LEL 4.3 Vol-%).

3.6.Carbon Monoxide (CO)

Carbon monoxide (CO) is an odourless but toxic and combustible gas. CO is released by, among other things, incomplete incineration, rust formation, scalding and decay processes. The substance impedes oxygen absorption in the body.

CO is often located in ballast tanks, anchor chain containers, cofferdams, front and after peak and engine rooms. these spaces should certainly be measured for the presence of CO before they are entered and/or hot work is carried out.

When transporting edible oils, and in particular crude unrefined oils (e.g., crude palm oil) and wheat/grains, the presence of CO occurs regularly.

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4. KNOWLEDGE OF THE GAS AND PROPERTIES

Each substance has specific properties. In the previous chapter, a number of common gases have already been named with some properties, these are called physical properties. For example, how easy it dissolves in water, how heavy it is, how easily it ignites, etc. The properties can be found in the chemistry chart book.

Example physical properties Methanol:

Boiling point, °C	65
Melting point, °C	-98
Flash point, °C	11
Auto-ignition temperature, °C	382
Explosive properties/limits, volume% in air	5.5-44
Minimum ignition energy, mJ	0.14
Specific conduction, pS/m	$1.5*10^5$
Vapor pressure in mbar at 20 °C	128
Relative vapor density (air = 1)	1.1
Relative density at 20 °C of saturated vapor/air mixture (air = 1)	1.01
Relative density (water = 1)	0.8
Solubility in water, g/100 ml	Fully
Log P octanol/water	-0.7

4.1.Flash Point

The flash point of a flammable is the lowest temperature at which the substance can ignite when it comes into contact with an ignition source. The flash point should not be confused with the auto-ignition temperature. That is the temperature at which a vapor/air mixture spontaneously ignites (see H3.2).

The flash point is characteristic of the chance that a spark or hot object will cause a fire.

4.2.Auto-ignition

The auto-ignition temperature is the lowest temperature at which, at a pressure of 1 atmosphere and an average oxygen content in the air, a substance ignites spontaneously and also continues to burn.

4.3.Relative Vapor Density

The density of the gases is compared with the density of air. If a gas is heavier than air it drops down. If a gas is lighter, it rises upwards (think of a helium balloon). And there are gases that have about the same weight as air. These will float. The weight of gases relative to air is shown in vapor density.

Air has the density of 1.0, so;

A vapor density < 1.0 will rise up

A vapor density > 1.0 will drop down

4.4.Sources for Physical Properties

On the basis of the information from the Chemical Data Sheet book, WIK (workplace instructions) and/or an SDS (Safety Data Sheet), the captain determines which measures must be taken to control the risks. Consider, for example, the personal protective equipment to be used and the measures to be taken in the event of accidents. It is important that we know the physical properties so that we know where to measure and on which values we should pay attention.

MSDS

An MSDS or material safety data sheet is a structured document with information about the risks of a hazardous substance, and recommendations for its safe use.

It is therefore very important that an MSDS is requested. The producer/supplier also has the duty to provide the MSDS. A MSDS can often also be requested via a freight broker. When searching for MSDS online, there is always a risk that it is not appropriate or incorrect.

The sections from an MSDS are:

S1 - Identification of substance and organization
S2 - Hazard(s) identification
S3 - Composition/information on ingredients
S4 - First-aid measures
S5 - Fire-fighting measures
S6 - Accidental release measures
S7 - Handling and storage
S8 - Exposure controls/personal protection
S9 - Physical and chemical properties
S10 - Stability and reactivity
S11 - Toxicological information
S12 - Ecological information
S13 - Disposal considerations
S14 - Transport information
S15 - Regulatory information

Chemical Data Sheet

It is emphasized that the chemistry chart mentions the hazardous properties of the substance and that this does not automatically reveal the extent of the risks when using the substance. Risks when working with chemical products are not only dependent on the hazardous properties of the product, but also on prevailing working conditions. In this context, consideration should be given in particular to the risk of exposure and the duration of the employee to a vapor or mist, to a liquid or to a solid substance, and in particular to powders.

The Chemical Data Sheet book has been developed for laboratory technicians working in a laboratory environment. The working conditions there are different than we have on board.

Workplace instructions

A work instruction is similar to a Chemistry Chart. The substance and hazard properties are also mentioned here. However, a workplace instructions is written in line with the working conditions on board. The advantage is also that, for example, the measuring tube of different brands to be used is indicated, as well as the PID lamp to be used with the corresponding correction factor.

5. HOW DO WE MEASURE?

5.1. PPM, mg/m3 and Volume Percent

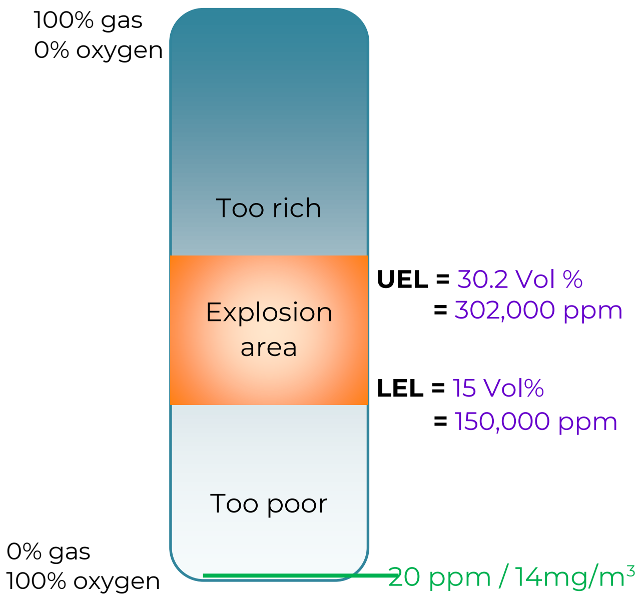
The limit values for toxicity are usually given in mg/m³, while the measuring equipment often gives the values in Parts Per Million (PPM). There is a relationship between ppm and mg/m³ at 20°C and an air pressure of 1013 mbar. To convert the values, a conversion factor can be used. In some cases, the conversion factor is already shown on the information sheets, but it can also be calculated. Below the calculation is shown.

The concept of volume percentage (abbreviated as % vol or vol.-%) or volume percentage is a measure of the concentration of a substance in a mixture. It is the ratio of the volume of the substance to the total volume, expressed as a percentage.

Example calculation ammonia:

(The material information must always be looked up in the safety data sheet.)

Given information	
Boiling point, °C	38
Melting point, °C	-58
Flash point, °C	n.b.[2)]
Auto-ignition temperature, °C	651
Explosive limits, volume % in air	15 – 30.2
Minimum ignition energy, mJ	680
Vapor pressure in mbar at 20°C	483
Relative vapor density (air = 1) (NH_3)	0.6
Relative density at 20 °C of saturated vapor/air mixture (air = 1)	0.8
Relative density (water = 1)	0.9
Solubility in water, g/100ml	Fully
Log P octanol/water (ber.)	-1.3
Limit value (as NH_3)	20 ppm 14mg/m³
MAX TGG-15min. (as NH_3)	50 ppm 36mg/m³
Gross formula	H_2NO
Relative molecular mass	35.1
Conversion factor from mg/m³ to ppm	1.463
Conversion factor from ppm to mg/m³	0.684



If the conversion factor is given
We read in the Chemical Data Sheet book that for ammonia a limit value of 14 mg/m^3 applies and we are going to measure the gas in the tank to see if this is being met. We must first know how many ppm this is.

Limit value: 14 mg/m^3
Conversion factor from mg/m^3 to ppm: 1.463
Calculation example:

14 mg/m^3 x 1.433 = 20 ppm

So now we know when we measure below 20 ppm that we remain below the limit of 14 mg/m^3.

The other way around, of course, is that we can first measure the gas. Suppose we measure 30 ppm:

Conversion factor from ppm to mg/m^3: 0.684

30 ppm x 0.684 = 20.52 milligrams per m^3

This is therefore above the limit value of 14 mg/m^3.

If the conversion factor is not given, you can calculate it
With gas there is 1 molecule present on 24 dm^3 (or 1 on 24,000cm^3)
Molecular mass of ammonia: 35.1 grams (or 35,100 milligrams)

The formula for the conversion factor:

1 ppm = $\frac{\text{Molecular mass}}{24}$ = mg/m3

Calculation example:
1 ppm = $\frac{35.1\text{ g}}{24\text{ dm3}}$ of $\frac{35{,}100\text{ mg}}{24{,}000\text{ cm3}}$ = 1.463 milligram per cm^3

1 ppm = 1.463 milligram per cm^3

Or vice versa
1 mg/m^3 = $\frac{mg}{m^3} = \frac{24}{35.1} = 0.684\text{ ppm}$

1 mg/m^3 = 0.684 ppm

5.2. Before You Start Measuring

Before starting with measurements, keep the following points into account:

- Make sure you have the information of the right substance. The substance name must exactly match the correct shipping name.
- Know which information is relevant for correctly interpreting measured values. This often requires a correction. See the applicable LEL and PID tables.
- Select the correct PPE for performing a measurement.
- Consult an expert in case of doubt or questions about product properties.
- Check if the product information is not too old. Request a recent SDS; a SDS may not be older than 5 years.
- An MSDS must come from the manufacturer of the relevant cargo of that trip.
- Select the correct meter (suitable for the product).
- Before you measure, check the equipment. See Chapter 6 Equipment.
- Read the instructions carefully.
- Remove the meter from the charger, check the moisture filter and switch on the meter. (warm-up time measuring cells approx. 30-120 sec.)
- Check battery, alarm settings and the pump alarm.
- If necessary, a fresh air calibration in an expected clean environment (outside, upwind and for example not near an exhaust).

5.3. The Measuring Process

- Ensure that the meter display is visible at all times to observe fluctuations/deviations.
- Always carry out measurements at different heights and locations.
- In tanks you measure from above and straight down, therefore you do not know how the situation is in a corner or behind a truss. Take the highest measured value as a starting point.
- When measuring in a tank during degassing/ventilating, wait at least 15 minutes after the fan has stopped so that the atmosphere in the tank can first stabilize for a reliable measurement.
- Make sure that the hose is long enough and that the hose does not have any kinking or is pinched.
- Make sure you measure long enough to completely flush the hose.
- Always use a floating ball on the hose to prevent liquids from being sucked up.
- During the first 2 hours after starting the degassing on deck, measure near the opening with a baffled grid and take into account wind direction and wind strength.
- At least 12 Vol.% Oxygen (O_2) is required for a good LEL measurement (except for the infrared LEL-sensor). (See the instructions for the device in question).
- Stop measuring if the meter exceeds 50% LEL (to prevent damage to the meter).

5.4.Registration

Follow the procedure and the corresponding form for gas measurement (from the office) and record the measured values. The registration is legally required and is important for being able to interpret the state of for example cargo tanks during degassing.

To register measured values, procedures are available. Think also of this when filling out work permits and the like.

In the unlikely event that an accident occurs, an authority institution and insurer will always ask for the measured values.

5.5.After Measurement

- Flush the pump until the oxygen is at 20.9% and all other readings are zero (with the hose attached).
- Switch the meter off and put it back (make sure it's clean) into the charger with a clean moisture filter.
- Report deviations and damages. Sometimes it must be recalibrated, or a sensor replaced (for example, if it has become when the LEL-sensor gets too hot by offering too much combustible gas).
- Wear a personal meter (see chapter 6) when entering the room/cargo tank/etc.

6. EQUIPMENT

It is very important that the right equipment is used for a measurement. Measurement of gases is done with a gas detection meter. A gas detection meter contains sensors. These can detect the gas. A gas meter can contain one or more different sensors. There are sensors that measure the amount of gas with a specific hazard. These are sensors that detect for example combustible gases or a sensor that can detect toxic gases. These sensors tell you the amount of gas that is present but cannot indicate which gas is present. The moment you take a measurement and the meter indicates that you measure 10% LEL, you know that there is flammable substance present. But by which gases this danger is caused, you cannot determine with this sensor.

There are also sensors that can measure a specific gas (Oxygen, H_2S, CO_2). This sensor can only measure that specific gas and does not say anything about the other gases and hazards in the space. If your meter indicates that there is 20.9% oxygen present, this does not say anything about the other gases that are present in a room.

Personal measuring instruments

Various portable measuring instruments are available for detecting product concentrations and dangerous atmospheres, oxygen and toxic gases. Although gas detection meters and sensors generally operate on the same principle, it's important to familiarize yourself with the operating instructions for the equipment you use. Wear these instruments when entering a confined space and on deck during loading/unloading operations.

Different values

Also, meters can differ in the values shown even in exactly the same conditions. This is something that we cannot do anything about, but it can lead to dangerous situations. It is therefore important that the users of the meters have some knowledge of the gas measurement. A gas measurement may only be carried out by an ADN-expert.

General points for measuring equipment

Each measuring instrument must:

- Be suitable for the required test.
- To be sufficiently accurate for the required test.
- Be of an approved type.
- To be properly maintained and;
- Regularly checked against standard samples (calibration).

Additional on the use of meters:

- Know and understand the manual of the measuring instrument.
- Use the correct measuring instrument and sensors or measuring tubes for the right gas.
- Know the limitations of the measuring instrument.
- Know what you measure and how to interpret the values.
- Consider possible correction factors.
- The suction hose affects the measurement. Both the length (response time) and the material (absorption of gas). Every extra meter of hose can result in a delay of 10-30 seconds. This is different per brand/type of meter and depends among other things on the pump capacity.
- When switching off the combi meter, all sensors, including the H_2S and CO, must be reset to 0 PPM before the device is switched off. Let the pump run as long as it is necessary to flush the room with sensors with enough clean air ... WITH THE HOSE STILL ATTACHED!
- If possible, always place a moisture filter, even if the meter is not switched on.

Specific features of each meter type are listed below, supplementing the manuals (and videos) that accompany the meters.

The models shown in this document are just a few examples of the many types and styles of meters available on the market.

6.1.Oxygen Meter

The oxygen meter is also called O_2/OX/OXY meter.

- Perform a fresh air calibration prior to measurement in an expected clean environment (no wheelhouse or near exhaust) to establish a reference point of 20.9 Vol.%.
  If this is not possible, do not perform a fresh air calibration. The "non-clean" air would be seen as clean air, the measurement is therefore not reliable. Most sensors "memorize" the values of the last calibration and offer a option at the start up to perform the calibration automatically or manually. If the values are correct, this is not necessary.
- ALWAYS leave the (Combi-) meter in the charger when it is not being used. In most cases, the operation is based on a measuring cell with an electrolyte that always uses electricity. Therefore, the lithium-ion battery is empty after approx. 4 days when it is not being charged. So this is normal.
- Most oxygen sensors are not suitable for measuring oxygen in a nitrogen environment. Check with your supplier before measuring the oxygen percentage in a cargo tank, for example, which is under nitrogen. Suitable sensors are available for this purpose.

6.2.Toxicity meter

Toxicity meters or TOX or toximeters occur in different forms. There are chemical indicator tubes with a hand pump, electrochemical sensors and PID sensor.

6.2.1.Chemical Indicator Tubes with Hand Pump

When using chemical indicator tubes, note the following points:

- Know exactly which gas is to be measured.
- Large standard deviation of 5 to 30%.
- Some tubes only react when the limit concentration is exceeded.
- Inaccurate and therefore only to be used as INDICATION!
- It needs exactly the right amount of air, usually 100ml per pump stroke.
- Warranty date (shelf life) of tubes is ± 2 years.
- For every measurement a new tube is needed, so high in consumption.
- Many different types of tubes needed for use on board on tanker carrying various products.
- Often the tubes from different manufacturers cannot be used in a pump of a different brand (there are exceptions that do fit and are allowed).
- Not every manufacturer has an equally large assortment of tubes to be able to measure many different substances.
- ALWAYS read the operating instructions in the packaging of the box with measuring tubes. This contains essential information regarding the tubes and the execution of a correct measurement. It shows what the tube can do, but also what it cannot do. And the latter is often disappointing.
- Also pay attention to the storage temperature of the tubes.

When using the hand pump, pay attention to the following points:

- Test the pump and the extension hose for leaks by inserting a unopened new tube and make a pump stroke. The pump must then remain in a squeezed and the same position for about 15 seconds.
- Read the instruction card of the tube carefully and determine the number of pump strokes, opening time of the pump and which discoloration should take place.
- Reset stroke counter.
- Break off the tips of the tube and place the tube in the pump with the arrow pointing towards the pump.
- Perform measurement by squeezing pump or pulling out until indicator on the pump completely discolours for full pump stroke.
- **STOP:** - When the number of pump strokes has been reached.
  - The tubes for ¾ is discoloured (Compare the discoloration with an unused tube.) In this case, write down the number of pump strokes.
- Keep track of exactly how many pump strokes you make. After each measurement, set the stroke counter to 0 again!
- After the measurement, flush the pump with clean air by making a number of pump strokes without a tube (DO NOT DIRECTLY POINT TO SOMEONE, THE DUST FROM THE TUBES ALSO CONTAIN CHEMICALS!)
- Store the used tube with chemical waste and keep in mind that the tips are razor-sharp.

6.2.2.PID sensor - Photo Ionisation Detector - PID

A PID meter continuously detects the concentration of organic compounds (VOCs) present, toxic gases and/or vapours expressed in parts per million (PPM). However, a PID meter does not detect gas specifically, all VOCs in the gas sample to be measured are displayed as one common values on the display of the PID-detector.

A PID meter measures by "ionizing" the molecule of a substance with a special UV lamp. This happens at the molecular level. The PID meter actually measures positive and negative particles of a substance, it does something with pluses and minuses, simply put. The substance itself does not change, there is no combustion or the like.

There are roughly 3 types of UV lamps that are used for this, the most common is the so-called 10.6eV. This can measure the most common VOCs, but for example no Methanol or Acrylonitrile. Here is a 11.7eV lamp needed, but this lamp is much more expensive and only lasts about 6 months. PID sensors are also very moisture-sensitive, so always use a clean moisture filter.

When a measurement has to be carried out for the presence of toxic gases with the aid of a PID meter, it is important that the user ensures in advance that the relevant lamp in the meter responds to the substance to be measured and the associated correction factor for conversion must also be known. Only use the correction factors that the meter manufacturer has determined. These have been determined in their laboratory with their meters.

The PID meter does not "know" what it measures, so we have to "tell" the meter. With pure substances this is not difficult, it only becomes difficult when we have to deal with a mixture of hydrocarbon compounds. The composition of this is often difficult to determine and complex calculation methods are then required to carry out this measurement. To keep this simple, you use values on the display, which are not converted. The settings of the measuring gas in the device must then be equal to the gas to which it is calibrated. This is almost always Isobutylene in a PID meter. However, this can also be a different calibration gas if required.

The advantage of a PID meter is that it can also be used for continuous measurements and leak detection. This is virtually impossible with tubes.

6.2.3.Electrochemical Sensors

Electrochemical sensors, or product specific meters, are available in the combination gas meters and as separate personal safety meters.

Points of attention:

- H_2S and CO sensors are often cross-sensitive on many other substances, such as alcohols and high concentrations of H_2S. This means that an H_2S sensor can react to the presence of carbon monoxide and vice versa.
- The CO sensor can also react to the application of a large amount of combustible gas to the catalytic LEL sensor. After all, a combustion takes place in the measuring cell for LEL (filament) and then CO is released logically.
- A CO measurement will mainly be important when entering confined spaces, such as ballast tanks, front and rear peaks, etc.
- Make sure that the paper dirt filter on the sensor is clean.

H_2S personal measurement

At refineries and when transporting products that are known to contain H_2S, a personal H_2S detector must be worn on top of the clothing at chest height during loading/unloading and operations (connecting/dismounting and measuring/sampling).

6.3.Explosion Meter

There are 2 types of LEL sensors, a catalytic and an infra-red. The former burns the drawn-in air by means of a filament. The infra-red lamp does not do this. This is also called a process meter, because it can measure the risk of explosion not only in percentages of the LEL, but also in volume percentages, i.e. more than 100% of the lower explosion limit. The infra-red Explosion Hazard Meters can also take a measurement in an environment with little oxygen.

At a concentration higher than 5-10% LEL an acoustic and optical alarm is given. When 100% of the lower explosion limit is measured, this means that the mixture can be ignited. For such an ignition only a source of sufficient energy is needed.

Points to take into account for the most common LEL sensors, which "burn" the vapours (different from infra-red):

- Caustic and oxidizing gases can damage the measuring element (e.g. Ammonia).
- Measuring element can be poisoned, e.g. silicone vapours.
- Some explosion meters are not suitable for measuring mists of flammable liquid. Measuring cell is seriously damaged and is unusable.
- For some meters a moisture filter must always be installed, even if the meter is not switched on.
- If there is insufficient oxygen for proper combustion, the catalytic LEL sensor will become contaminated and provide an unreliable measurement. A minimum of 12 vol% oxygen is required for accurate measurement (the gas mixture is combusted in the measuring cell). Be aware of this when the tanks are under nitrogen!
- Always combine a catalytic LEL measurement with an O_2 measurement.

LEL sensors that work with an infra-red light are not affected by the above-mentioned issues. However, these sensors do not respond to a number of flammable substances (ammonia, acetylene and hydrogen) than a sensor that works on the basis of combustion. There are meters on the market where both types of LEL sensors are present

6.4.Maintenance

For properly working meters it is important to carry out regular maintenance. Below are a number of points to take into account:

- Before each use, check if the meter is in good condition.
- Moisture is harmful to gas detection equipment.
- The manual contains instructions for bump tests and calibrations.
- Sensors have a limited life span, even under normal conditions. The warranty period is also often limited. This can vary per brand.
- When offering large amounts of combustible gas, the sensors can get damaged, so that they are no longer reliable or usable.
- Hoses; length (at least the cavity of the tank + 1 m) and quality/state of floating ball at the end (so that the hose does not hang in the liquid).
- Leave the meter on and flush until the values are back to the original values. Leave the hose with floating ball on it and also rinse it.
- Ensure the gas detection meter and hose are clean after measuring before storing. See the manual for this.
- Store measuring tubes cool and dark (see manual). Make sure that the measuring tubes are suitable for the substance to be measured.
- Ensure that the hose is also clean for storage after measurement. See the manual for this.
- ALWAYS ensure that a moisture filter is installed and replace it regularly, as it may become contaminated and clogged.

LAWS, REGULATIONS AND STANDARDS

- BPR Art. 4 and 6
- RPR 3.18, 4 and 6.04
- http://www.ccr-zkr.org/13020500-nl.html#02
- ISGINTT Chapter 2.4 “Gas Measurement” and Chapter 11.4 “Gas Freeing”, Version 2023
- REACH

CONSULTED SOURCES

- RAE-Benelux
- Dräger Nederland B.V. - Marine & Offshore
- Manual VHF Maritime

REVISION MATRIX

Version nr.	Changes	Date
1	First version	October 13th, 2020
2	Layout update Change regarding degassing Replacement of MAC value and MSDS General revision of text Removal of correction tables	July 15th, 2025