BULLETIN

# GAS MONITORS & COMMON AGRICULTURAL GASES


## WHAT ARE GASES?

Gases are substances that do not exist as solids or liquids at room temperature. They can be used in a task (i.e., welding) or be produced by some other process occurring on the farm (i.e., composting). Gases can easily spread throughout a building, work area or other type of enclosure. Some gases are heavier than air and will settle in low lying areas, such as pits or trenches. They can be toxic, flammable or explosive.

Gases can have many different health effects and can have more than one type of hazard (i.e., hydrogen sulfide is highly flammable and toxic). Keep in mind that health effects will vary; gases can irritate your eyes, nose, throat, lungs, and skin or enter the bloodstream through the lungs where they can damage organs or body systems.

**DID YOU KNOW?**

**You can learn more about hazardous gases, Lower Explosive Levels, Upper Explosive Levels and more in the AgSafe Alberta WHMIS 2015, Pesticide, Veterinary Drug and Medicated Feed Awareness Course and Manual. Visit www.agsafeab.ca or click HERE to go directly to the course.**

## WHAT ARE HAZARDOUS GASES & OXYGEN DEFICIENT ENVIRONMENTS FOUND ON FARMS?

### Hydrogen sulfide ($H_2S$)

- Hydrogen sulfide ($H_2S$) results from organic materials breaking down in tanks, pits or ponds.
- It is a chemical asphyxiant, which means it interacts with the blood's hemoglobin to prevent oxygen from being carried to the body's vital organs and tissues.
- It is heavier than air and will settle in low lying areas.
- It has a rotten egg smell that can only be detected at low concentrations.
- High concentrations paralyze our sense of smell so we cannot detect it and can result in death instantly.
- Ventilation systems, wind and any air movement can cause the gas to travel, such as towards an open door or off a lagoon.
- To view the chemical profile for hydrogen sulfide, visit www.ccohs.ca or click HERE to go directly to it.

## Ammonia ($NH_3$)

- Ammonia ($NH_3$) is produced when the nitrogen compounds in manure decompose; it is found mostly in swine, poultry and rabbit housing but can be present in manure composting operations.
- It is a colorless gas with a very strong smell.
- Frequent exposure to recognizable ammonia gas levels can result in someone losing their sensitivity to it and they may no longer be able to detect high levels of ammonia (50 to 100 ppm)[1].
- Even low concentrations will irritate the eyes.
- To view the Chemical Profile for ammonia, visit www.ccohs.ca or click HERE to go directly to it.

**CAUTION**

**You cannot rely on your senses alone to keep you safe!**

## Methane ($CH_4$)

- Methane ($CH_4$) is produced by bacteria digesting organic material, such as manure.
- It is colorless, odorless and non-toxic, but it is combustible.
- It is lighter than air, so it will rise.
- If it is permitted to build in an enclosed area, it can cause explosions.
- To view the Chemical Profile for methane, visit www.ccohs.ca or click HERE to go directly to it.

## Carbon monoxide (CO)

- Carbon monoxide (CO) is a product of incomplete combustion; sources include:
  - Various appliances (i.e., furnaces, fireplaces, portable heaters, water heaters)
  - Motor vehicles
  - Power tools (i.e., generators, chain saws, welders)
  - Powered mobile equipment (i.e., tractors, skid steers, etc.)
- It may be produced when appliances, vehicles and powered mobile equipment are not working properly, are located in a low oxygen, poorly ventilated area and/or when operating in an enclosed area (i.e., cleaning a barn using a skid steer with all of the doors closed and the ventilation system turned off).
- It is colorless and odorless.
- It is a chemical asphyxiant, which means it interacts with the blood's hemoglobin to prevent oxygen from being carried to the body's vital organs and tissues.
- To view the Chemical Profile for carbon monoxide, visit www.ccohs.ca or click HERE to go directly to it.

## Carbon dioxide ($CO_2$)

- Carbon dioxide ($CO_2$) is produced by respiration in living organisms and by the process of combustion.
  - Open flames and unvented appliances (i.e., portable heaters) will contribute to carbon dioxide levels in an area.
  - Carbon dioxide is commonly used for the humane euthanasia of livestock.
  - Can be found in deadly concentrations in sealed silos as well as enclosed manure and grain storage areas.
- It creates oxygen deficiency, resulting in asphyxiations or suffocation.
- It is colorless and odorless.
- It is heavier than air and tends to accumulate in low lying areas.
- To view the Chemical Profile for carbon dioxide, visit www.ccohs.ca or click HERE to go directly to it.

[1] Fabian, E.E. (2019, March). Detecting Ammonia in Poultry Housing Using Inexpensive Instruments. Extension.psu.edu. Retrieved 2023, October 19 from https://extension.psu.edu/detecting-ammonia-in-poultry-housing-using-inexpensive-instruments.

## Nitrogen dioxide ($NO_2$)

- Nitrogen dioxide ($NO_2$) is formed by the natural fermentation of nitrogen containing plant matter, such as silage, shortly after it is put into a silo or silage pit.
    - Nitrogen dioxide levels typically peak around three days after placement and should begin to decrease after that period.
- It is a chemical asphyxiant, which means it interacts with the blood's hemoglobin to prevent oxygen from being carried to the body's vital organs and tissues.
- It has a bleach-like odor and may be visible as a reddish-brown cloud or fog.
- Wind and air movement can cause the gas to travel.
- It is heavier than air, so it will settle in low lying areas.
- High concentrations can cause sudden death or pulmonary edema which may be fatal or cause chronic respiratory health problems.
- It causes a burning sensation in the nose, throat and chest.
- Exposure may result in fluid developing in the lungs up to 12 hours after an exposure and/or permanent lung damage.
- Silo Filler's Disease primarily affects farmers and results from breathing in nitrogen dioxide from silage.
- To read more about nitrogen dioxide, visit www.epa.gov or click HERE to go directly to it.

**CAUTION**

**Atmospheres that are or may become explosive would require intrinsically safe equipment to be used, such as an intrinsically safe gas monitor. Intrinsically safe equipment has been certified as not being a source of ignition.**

## Oxygen Deficient Environment

- The normal air around us contains almost 21% oxygen. Air that contains less than 19.5% oxygen is called oxygen deficient.
- Hypoxia is the term used when there is not enough oxygen reaching the tissues in someone's body (low blood oxygen).
- Some causes and considerations of an oxygen deficient environment include:
    - Rusting metal in an enclosed area (rusting is an oxidation process that uses up the available oxygen).
    - Combustion processes (all sources of combustion consume oxygen).
    - The displacement by other gases (such as welding gases, leaking gas lines, carbon monoxide, etc.).
    - The rotting of organic matter as micro-organisms consume oxygen and produce flammable methane gas that can also displace oxygen.
- Low levels of oxygen can cause poor judgment, lack of coordination, behavior changes, dizziness, fatigue and ultimately collapse and death.

# IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH) WORK ENVIRONMENTS

The term Immediately Dangerous to Life or Health (IDLH) is explained by the Alberta Government[2] as meaning circumstances in which the atmosphere is deficient in oxygen or the concentration of a harmful substance in the atmosphere:

a) is an immediate threat to life,
b) may affect health irreversibly,
c) may have future adverse effects on health, or
d) may interfere with a worker's ability to escape from a dangerous atmosphere.

WorkSafe BC[3] gives us another, easier to understand way to think about IDLH conditions:

- Where there is known toxin or chemical in the air at a concentration known to be IDLH.
- Where there is a known toxin or chemical in the air and the concentration is not known or has the potential to be IDLH.
- A confined space where the air has not been tested for toxins, chemicals, oxygen levels, etc.
- Any place where the air is oxygen deficient.
- Firefighting activities.
- Any place where toxins or chemicals in the air are above 20% of their lower explosive limit (LEL).

Entering into an IDLH environment or potentially IDLH environment will require special training and additional safety measures to be taken. Practical experience is especially important and can typically be obtained through in-person training. Confined space and hydrogen sulfide ($H_2S$) training courses both typically offer this type of hands-on experience and can often be taken from a training provider in your area.

[2] Occupational Health and Safety Code, Statutes of Alberta. (2023, March 31). Retrieved 2023, October 19 from https://kings-printer.alberta.ca/documents/OHS/OHSCode_March_2023.pdf.
[3] WorkSafeBC. (2014, April). Breathe Safer - How to use respirators safely and start a respirator program. Lower Mainland; WorkSafeBC Publications

# WHEN ARE GAS MONITORS NEEDED?

In order to know if your farm will need to use gas monitors, you must first perform thorough, farm-specific hazard assessments to identify where and when toxic, explosive or oxygen deficient environments exist or could potentially exist.

Once the hazard assessments are completed, you will need to evaluate the risks to determine which gases you'll need to test and monitor for. Testing and monitoring are critical, as they protect the health and safety of your farm team.

Personal gas monitors are a type of personal protective equipment, this means that it is the least effective of all the hazard controls measures and is only selected after all other hazard control measures have been considered, and those measures found to be appropriate have been put into place. All forms of personal protective equipment should only be used as a last resort and must always be used in combination with other hazard control methods.

If the farm finds that the use of personal gas monitors are required, it will need to develop a policy for when personal gas monitors will be used, what types of servicing or maintenance will be performed, what type of training is needed to use one, what type of recordkeeping will need to occur, etc. The farm will also need to create procedures for things like the general use, calibration and bump testing of the specific personal gas monitors it uses.

**CAUTION**

**The proper operation of gas monitors is essential, so anyone using personal gas monitors will need to be trained in their use, care, maintenance, limitations, etc.**

# GAS MONITOR BASICS

## Gas Monitor

- A gas monitor, also called a gas detector or direct-reading instrumentation device will contain one or more sensors to detect the presence of different types of gases.
- These are valuable tools for detecting and measuring gases, vapors, aerosols, and fine particulates suspended in air.
- Depending on the gas monitor used, they provide real-time or near real-time measurements.

## Fixed Gas Monitors

- Fixed monitors are primarily to protect a building, to detect catastrophic leaks, or to be an early warning of gases leaking from a system.
- These will only detect gas levels that diffuse into it, so if it is placed at one part of a room or building, it will not detect the levels at other points in the room or building.
    - For this reason, you cannot rely solely on fixed gas monitors; it is recommended to use fixed gas monitors in combination with personal gas monitors.

## Portable Gas Monitors

- Equipment used to test the air prior to entering an area that could have a hazardous atmosphere and may or may not be worn by a person.
- These will only detect gas levels that come into contact with the sensors.
- It will alarm when the alarm levels set on the equipment are reached.

## Personal Gas Monitors

- A type of portable gas monitor.
- This type of gas monitor is a form of personal protective equipment because it is worn by people and is designed to protect them when going into and/or working in an area where hazardous gases or a hazardous atmosphere may exist or develop.
- These will only detect gas levels that come into contact with the sensors as the person moves around.
- These monitors will sound when gas levels reach a dangerous level.
- They can be used to sample gases before entering a work area.

**RESOURCES**

**To learn more about hazard identification, assessment, elimination & control, as well as policies, procedures, inspections and steps to take when selecting different types of personal protective equipment, refer to the AgSafe Alberta FarmSafe Plan Manual. You can download it for free at www.agsafeab.ca. Click HERE to go directly to the manual.**

## Single-Gas Monitors

- Single-gas monitors detect only one hazardous gas at a time, such as nitrogen dioxide ($NO_2$) or ammonia ($NH_3$).

## Multi-Gas Monitors

- Multi-gas monitors have more than one sensor and are able to detect a range of gases at the same time, such as oxygen ($O_2$), hydrogen sulfide ($H_2S$), carbon monoxide (CO), and the Lower Explosive Levels (LEL) of a variety of combustible gases.

# DIFFERENT TYPES OF GAS MONITORS

What a gas monitor detects, how it detects it, the environment it is designed to be used in, how it is used, how it is maintained and the cost of one can vary greatly. There are many types of gas monitors available, each of which is designed for a specific monitoring purpose.

It is not important that you understand how each one works, but it is important that you recognize there are differences between the types of gas monitors and how they work.

- Catalytic Bead Sensors
- Photoionization Detectors (PIDs)
- Metal Oxide Semiconductors (MOS)
- Tunable Diode Laser Spectroscopy (TDLAS)
- Open Path Detectors
- Infrared (IR) Detectors
- Electrochemical Sensors
- Ultrasonic Detectors
- Colorimetric Gas Detection Tubes
- Flame Ionization Detectors (FIDs)

**DID YOU KNOW?**

**A fixed, single gas monitor such as the carbon monoxide detectors found in most homes will only detect the presence of carbon monoxide, it cannot detect the presence of other gases. While the presence of carbon monoxide and low oxygen levels go hand in hand, it cannot warn you of low oxygen levels in a root cellar or enclosed grain bin.**

# EXPIRY OR END-OF-LIFE?

Whether or not an instrument such as a detector or monitor expires or has an End-Of-Life will depend on that particular item. For example:

- A household carbon monoxide or smoke detector will typically have a sticker showing the date when the detector expires.
- A gas monitor may have a defined End-Of-Life, for example, this can be 24 months after its "turn on" date. This type of monitor may have a Remaining Life indicator which shows the remaining time left on the gas monitor before its End-Of-Life is reached (this may be displayed in months, days, or hours) and an End-Of-Life indicator. When the End-Of-Life indicator comes on, it is time to replace the gas monitor.
- Some gas monitors may not have a pre-defined life expectancy. One manufacturer states on its website that most medium to high end monitors can last between 5 to 10 plus years, depending on how well a monitor is maintained, how much it is used, and the environment that it is used in[4].

# CALIBRATION OF PERSONAL & PORTABLE GAS MONITORS

Calibrating your personal or portable gas monitor will ensure that it is accurately detecting gas levels. This is done by exposing the sensors to a known concentration of test gas (or calibration gas) for a specific amount of time. The reading from the test gas becomes the gas monitor's reference point for future readings.

Using the wrong type of test gas or expired test gas can result in inaccurate readings (and have potentially fatal consequences). Always ensure that the correct test gas is used and that it has not expired.

How responsive gas monitor sensors are may vary with the environmental conditions they will be used in. For this reason, it is best for personal or portable gas monitor users to perform calibrations in environmental conditions that are the same, or as close to, the actual conditions of the work environment as possible.

Calibration will need to occur on a regular basis and in accordance with the manufacturer's guidelines; this is because calibration drift can occur, and other factors can affect how the personal or portable gas monitor functions. Always follow the manufacturer's guidelines for proper calibration of your specific personal or portable gas monitor.

[4] Honeywell. (n.d.). What is the life expectancy of Honeywell portable monitors? Retrieved 2023, October 20 from https://sps-support.honeywell.com/s/article/What-is-the-life-expectancy-of-Honeywell-portable-monitors.

# CALIBRATION DRIFT

Calibration drift is when a gas monitor's reference point shifts, and as a result the reading will shift and be unreliable. Calibration drift happens to all sensors over time, so calibration checks and full calibration will need to be performed.

While some of these factors may depend on the type of personal or portable gas monitor used, calibration drift commonly occurs because of:

- Exposure to certain chemicals or compounds in the work environment that may cause degradation of components or coat the sensors.
- Exposure to very high concentrations of target gases and vapors.
- Exposure to solvent vapors and highly corrosive gases.
- Exposure to very high concentrations of dusts and other airborne particles.
- Exposure to high humidity levels.
- Being splashed, soaked or dropped in water.
- Use in extreme temperatures (very hot or very cold temperatures).
- Rough use, handling or storage conditions (i.e., the gas monitor gets knocked around in a cab or dropped on the ground).
- The normal degradation of sensors and drift in electronic components that occurs over time.

If a personal or portable gas monitor is exposed to or suspected of being exposed to one of the conditions noted above, the user should verify the personal gas monitor's function by performing a calibration. If the personal gas monitor is not successfully calibrated (i.e., there is a failure message), refer to the manufacturer's instructions for servicing and sensor replacement.

# CALIBRATION CHECK

A calibration check verifies that the sensor(s) and alarms on a personal gas monitor respond within the manufacturer's acceptable limits by exposing it to a test gas. During a calibration check, the user will compare the test gas concentration to the reading on the personal gas monitor. If the results are found to be within the manufacturer's acceptable limits, the calibration check has verified the gas monitor's accuracy.

If the calibration check results are not found to be within the manufacturer's acceptable limits, a full calibration will need to be performed.

# FULL CALIBRATION

A full calibration is a process that adjusts a personal or portable gas monitor's reading to coincide with the known concentrations of zero and span gases. This results in two steps:

1. **Zero calibration**, sometimes called zero suppression, is where the personal gas monitor is exposed to the ambient or "zero grade" air. Each sensor registers to zero and the $O_2$ sensor is calibrated to a value of 20.9%.
2. **Span calibration** is where each sensor expects to be exposed to a known concentration of gas. As each sensor calibrates, the personal gas monitor adjusts to the calibration gas and known values if needed to ensure that the gas concentration values are accurately registered and displayed.

It is important to note that if a sensor has degraded beyond an acceptable level, it will have reached its End-Of-Life and will no longer pass a calibration. Any servicing that is performed, such as the replacement of sensors, must be performed as per the manufacturer's instructions and by a qualified person.

# GENERAL CALIBRATION RULES[5]

The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) outlines the following basic calibration rules for personal and portable gas monitors:

1. Follow the manufacturer's guidelines for proper calibration.
   a. The correct type and concentration of calibration test gas, sample tubing, flow regulators, and calibration adapters are essential for proper calibration.
   b. Personal gas monitor users should conduct any testing to verify the operation of the gas monitor in an environment that is the same as (or similar to) the working conditions.
2. Only use a certified, unexpired traceable test gas.
   a. The personal gas monitor will only be as accurate as the test gas used to calibrate it.
   b. Ensure the supplier can provide a certificate of analysis for every test gas cylinder.
   c. The concentration of the test gas, particularly reactive gases such as hydrogen sulfide and chlorine, will only remain stable for a limited period of time.
   d. Never use a test gas after its expiration date.
3. Train personal or portable gas monitor users on the proper calibration methods.
   a. Most personal or portable gas monitors are designed to be field calibrated with detailed instructions provided in the manufacturer's user manual, training videos, or computer-based training modules.
   b. Employers must ensure everyone responsible for using, handling and calibrating personal or portable gas monitors is trained and competent.

**DID YOU KNOW?**

**Bump tests should be performed before every use.**

# BUMP TESTS

A bump test, also called a function check, verifies that:

- Gas can get to the personal gas monitors sensor(s).
- Each sensor responds to its target gas.
- The personal gas monitors alarms are working.

**DID YOU KNOW?**

**A bump test verifies performance; it does not provide a measure of the gas monitor's accuracy.**

A bump test involves using what is called a challenge gas (a single or mixed gas blend depending on the gas monitor). The sensor(s) are exposed to the challenge gas at a concentration and for an amount of time that will activate all of the alarm settings. If a personal gas monitor fails a bump test, do not use it! It should immediately be taken out of service and given to someone qualified to complete inspection and recalibration.

Bump tests should be performed as per the manufacturer's instructions. As things can go wrong and personal gas monitors can be affected by rough handling, vibration, drops, moisture, extreme temperatures, contamination, mechanical failures, etc., a bump test should be performed before every use.

Bump tests are typically thought of as a type of field test, meaning that they are performed in a clean area at the location where the gas monitor will be used. Bump tests ensure that the gas monitor is working properly and has not been damaged during transport.

# CHOOSING A PERSONAL OR PORTABLE GAS MONITOR

Choosing the right gas monitor can be challenging. Some considerations to factor in are:

- **How accurate is the gas monitor?** The more accurate the readings, the safer the person using it will be.
- **Does it detect the gas(es) you need it to?** Refer back to your hazard assessment(s) for the gases that you will need to be monitoring and/or testing for. If explosive gases may be present in the work area, the gas monitor will need to be extrinsically safe.
- **What is the response time?** Faster response times allow the person using it to act quickly.
- **Does it have protection from things like radio frequency interference, dust and water?**
- **Does it have data logging capabilities that will support recordkeeping?**
- **What are the alarms like?** Is it easy to distinguish a warning alarm from a danger alarm? Will the alarm be immediately recognized when it goes off in the work environment?
- **How resistant is it to being dropped or exposed to harsh environments?** Is it impact resistant? How well will it handle corrosive gases like ammonia in a barn? What is the temperature range it works in? What is the humidity range it works in?
- **How user-friendly is it?** The easier it is to use, the better. Read the Manufacturer's User Manual, watch any videos relating to its use, care & maintenance that are available, and if possible, take any online or in-person training offered by the manufacturer relating to its use.
  - Is it easy to operate?
  - Is the display easy to read?
  - Will it be easy to use if the person using it is wearing gloves?
  - How big and bulky is it? Is it overly large or heavy?

[5] U.S. Department of Labor Occupational Safety and Health Administration. Safety and Health Information Bulletin: Calibrating and Testing Direct-Reading Portable Gas Monitors. Retrieved 2023, October 20 from https://www.osha.gov/publications/shib093013 .

# QUESTIONS TO ASK THE SUPPLIER OR MANUFACTURER

Additional questions to ask the supplier or manufacturer include:

- **What does the total cost of ownership look like?**
- **Does it meet the current CSA Group standard and any other applicable standards?**
- **What is the cost and availability of replacement sensors, test gas, challenge gas, and other items that you may need (i.e., testing stations)?**
- **What are the personal gas monitors servicing requirements, and does it have a warranty?** If it needs to be sent away for warranty work, repairs or maintenance, where is the repair and maintenance facility (i.e., can it be arranged through the supplier, is it sent somewhere in Canada or does it have to be sent somewhere internationally)?
    - What are the warranty details, for example, is the warranty tied to the manufacture date and does the shelf-life affect the warranty (i.e., does the warranty cover one year of shelf life and one or more years after activation)?

# ADDITIONAL SOURCES OF INFORMATION

Alberta Occupational Health and Safety Code, Part 4: Chemical Hazards, Biological Hazards and Harmful Substances.

Work Safe Alberta, Workplace Health and Safety Bulletin: Use of Combustible Gas Meters at the Work Site

CSA Standard CAN/CSA 22.2 NO. 152-M1984 (R2016) Combustible Gas Detection Instruments