NCMT

# AGT
# (Authorized Gas Tester)

COURSE MATERIAL

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# AGT

## AUTHORISED GAS TESTER

## AUTHORISED GAS TESTER.

**Introduction**

Gas testing involves testing for **toxic and flammable gases** using portable gas detection equipment and is an integral part of establishing a **Safe System of Work** in the oil and gas industry.

Gas tests are performed to confirm that the working environment is safe from the hazards of combustible or toxic gases; and to confirm that oxygen levels are within specified tolerances and safe to breath.

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## AUTHORISED GAS TESTER.

### Training Objectives.

After attending this section of the course you should be familiar with:

- Definitions (LEL, UEL, TLV-TWA, STEL)
- Toxic Gases, Oxygen Deficiency/ Enrichment
- H2S Affect and Counter Measurement
- Gas Testing Equipment Familiarization (Uses and Limitations,

Operating Instructions, warning and Cautions, Function Tests,

Readings Interpretations, etc.)

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AUTHORISED GAS TESTER.

### Why is Gas Testing Carried out?

Oil and gas production by its very nature, presents many hazards including the **release of flammable or toxic gases**. It is the aim of companies and operators to ensure that gas testing is carried out by competent personnel to enable an area to be declared free from toxic or flammable gases, therefore reducing the risk of fire, explosion, or asphyxiation of personnel.

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## AUTHORISED GAS TESTER.

### When is Gas Testing carried out?

Gas test may be requested by Area Authority as one of the worksite precautions in:

- PTW or Confined Space Entry Certificate (CSEC).
- Gas test is mandatory in hazardous areas in case of HWP.
- Continuous gas testing is also mandatory for naked flame works carried out in hazardous areas.
- Gas test may be required after tightness of flanges for leak test.
- Work which can cause an uncontrolled release of hydrocarbons or other flammable or toxic materials

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## AUTHORISED GAS TESTER.

### When is Gas Testing carried out?

- Gas alarm investigation, before confined space entry or hot work and other activities requiring it.
- Monitoring purging operations

The Gas Tester shall be familiarized with the correct locations of gas sampling where the gas is likely to exist, e.g. pits, sumps, manholes, flanges, valve glands/ stem, pump casings, vents, drains, etc.

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## AUTHORISED GAS TESTER.

### Who Carries out Gas Testing?

*A certified gas tester is an employee or Contractor who has passed successfully gas testing (course entitled "Gas Testing"), and has a valid certification.*

Authorised Gas Testers (AGTs) are responsible for carrying out gas testing duties in liaison with the other supervisory roles and in accordance with specified precautions. Also he is responsible for:

- Checking and monitoring gas testing devices for calibration due date.
- Making function and performance test at fresh air prior commencing actual.
- In case of malfunction of the instrument (gas testing device), he shall refer to Asset Safety and Loss Prevention Engineer

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## AUTHORISED GAS TESTER.

### Who Carries out Gas Testing?

An Authorised Gas Tester must :

- Be able to demonstrate the ability to survey potentially hazardous areas using the detection equipment available and be familiar with plant and process areas.
- Be aware of the capabilities and limitations of gas testing equipment.
- Be aware of and demonstrate knowledge of, the requirements of the Permit to Work Procedure relating to gas testing.

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## FLAMMABLE GASES

### The Chemistry of Fire


For a fire or explosion to occur, three components must be present:

- Fuel
- Oxygen
- Ignition Source / Heat

If any of these components are not present then fire is impossible.

**Fuel**

Almost any substance can be considered as fuel and burn under the right conditions.

Common fuels in the oil and gas industry are:

methane, oil and solid waste.

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## FLAMMABLE GASES

### Ignition Source / Heat

Some examples include, but are not limited to:

- The discharge of static electricity.
- Switching of electrical contacts.
- Pump bearings running hot, or
- Diesel engines taking in gas through their air intakes

They all have the potential to produce enough heat to ignite a surrounding gas.

### Flash Point

The flash point for a liquid is the lowest temperature at which it produces sufficient vapour to form an ignitable mixture with air. This means that the concentration of flammable vapour above the liquid is close to the Lower Explosive Limit (LEL).

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## FLAMMABLE GASES

### Lower Explosive Limit

The Lower Explosive Limit (LEL) refers to the lowest concentration of a gas in the atmosphere that will result in a flammable mixture. For example, the LEL of methane is 5% by volume. This means that if there is less than five percent by volume of methane in air, the mixture is too lean (weak) to support combustion.

### Upper Explosive Limits

The Upper Explosive Limit (UEL) refers to the highest concentration of a gas in the atmosphere, which results in a flammable mixture. For example the UEL of methane in air is 15% by volume. This means that if there is more than 15% by volume of methane in air, then the mixture is too rich (concentrated) to support combustion.

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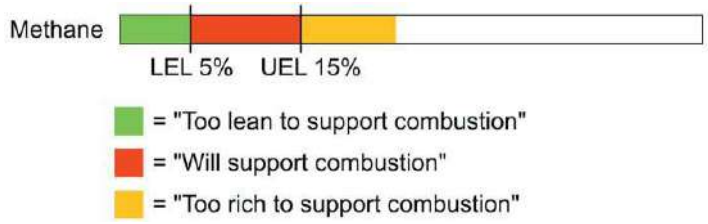
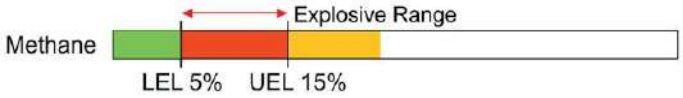
## FLAMMABLE GASES

A rich gas mixture would typically occur in a confined area such as an oil storage tank where the methane cannot disperse.




### Explosive Range

The region between the Lower Explosive Limit and the Upper Explosive Limit is known as the Flammable or Explosive Range.

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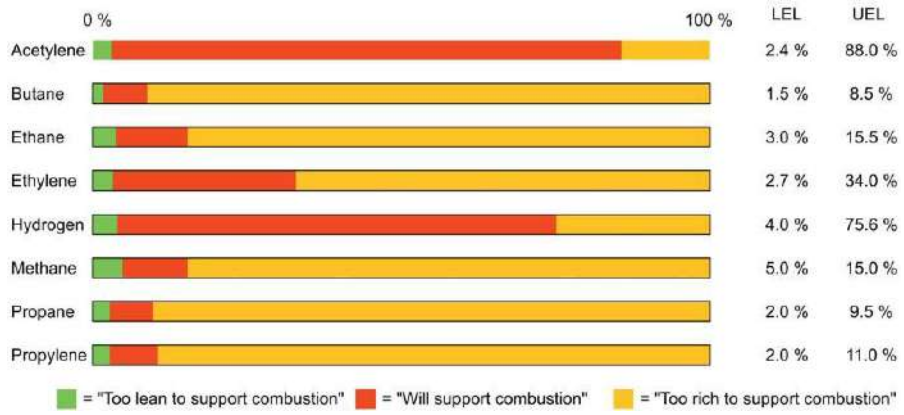
# FLAMMABLE GASES

## Common Gases

The LEL and UEL of some common gases are shown in the table.

The AGT is responsible for recording the percentage of LEL for the gas being tested.

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# TOXIC GASES

## Toxic Gases and Vapours

Many gases in the oil and gas industry may not be flammable but may still present a health hazard due to their toxicity; however,

many gases may be both flammable and toxic.

The concentration of toxic gases is expressed in parts per million (ppm), where one percent by volume equals 10,000 ppm.

Many toxic gases present health hazards in concentrations of less than 100 ppm.

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## TOXIC GASES

### Workplace Exposure Limit (WEL)

The occupational exposure limits for many toxic and hazardous substances are controlled by a Workplace Exposure Limit (WEL), which is defined as 'the approved exposure limit for any hazardous substance in relation to a specified reference period, when calculated by an approved method.'

The limits for each substance are given in parts per million (ppm) and milligrammes per metre-cubed for:

• **Long Term Exposure Limits (LTELs),** that is for an eight hour reference period, and

• **Short Term Exposure Limits (STELs**), that is for a fifteen minute reference period

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### Threshold Limit Value (TLV ):

TLV Threshold Limit Values are occupational exposure limits set by the American Conference of Governmental Industrial Hygienists (ACGIH).

For gases and vapors, TLV is stated as parts per million (PPM) of surrounding air, and for fumes, mists, and dusts as milligrams per cubic meter (mg/m3) of surrounding air. ACGIH classifies TLV :

(1) TLV-TWA- ( LTEL): time weighted average concentration for a normal 8-hour workday or 40-hour workweek.

(2) TLV-STEL: short term exposure limit, or maximum concentration of a substance

(a) for a continuous 15-minute exposure period,

(b) for maximum of 4 such periods per day,

(c) with at least one 60-minute exposure-free period between two exposure periods, and (d) provided the daily TLV-TWA is met

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## TOXIC GASES

### Toxic Gases

There are many toxic substances in the petrochemical industry, such as:

- Sulphur dioxide
- Chlorine
- Benzene, and
- H2S

**Sulphur Dioxide** is a toxic, corrosive, which is produced as a by-product of many industrial processes.

In appearance it is a colourless, with a strong suffocating odour.

The physiological effects of sulphur dioxide include eye, nose, throat and upper respiratory tract irritation at levels as low as 2 ppm.

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## TOXIC GASES

### Toxic Gases

**Chlorine** is a toxic, corrosive and heavy gas, which is greenish-yellow in appearance and has a suffocating odour. Chlorine is a skin and lung irritant:

- Low concentrations can cause burning eyes, coughing, sneezing and hoarseness
- High concentrations can cause pulmonary oedema – a condition in which fluid is accumulated in the lungs

**Benzene** is a highly flammable substance, toxic by inhalation, absorption through the skin and if ingested.

It is a known carcinogen and is also potentially hazardous to health.

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## TOXIC GASES

### Other Toxic Gases

Certain work activities can also produce toxic gases such as welding, burning and the use of chemicals. Under certain conditions entry may be permitted into areas where there are toxic gases present in excess of the WEL, provided breathing apparatus is worn and precautions are taken.

### Hydrogen Sulphide (H2S)

When testing for toxic gases at the installations, our primary concern is hydrogen sulphide (H2S). **Hydrogen sulphide is one of the most dangerous gases found in the oil and gas industry.** It is possible that a field can start producing H2S at any time; therefore caution must be exercised at all times, particularly in confined spaces.

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## TOXIC GASES

### Characteristics of H2S

- Is often referred to as sour gas.
- Has a distinct odour of rotten eggs at low concentrations.
- Can deaden human sense of smell at high concentrations.
- Is a colourless, flammable gas which may be liquefied under pressure.
- Is soluble in water, crude oil or petroleum fractions.
- Extremely corrosive.
- Burns with a blue flame producing sulphur dioxide (also a toxic gas).
- Slightly heavier than air and may accumulate in low lying areas and confined spaces.
- Easily dispersed by wind movements or air currents.
- EXTREMELY hazardous to health – deadly.

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## TOXIC GASES

### Effects of H2S on Personnel

When H2S is inhaled by an individual, it passes directly through the lungs into the bloodstream, it builds up almost instantly in the blood and the individual is quickly collapsed.

The areas of the brain that control breathing become paralysed, the lungs stop working and the person becomes asphyxiated.

The way in which H2S affects a person depends on the following:

- Intensity - the concentration of exposure
- Duration - the length of time the individual is exposed
- Frequency - how often the individual has been exposed
- Susceptibility - the individuals physiological make-up

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## TOXIC GASES

### Odour

H2S is generally recognised by its characteristic foul odour of rotten eggs at concentrations under 10 ppm. Concentrations of Less than 1 ppm can be detected by this odour, although prolonged exposure will deaden the sense of smell.

### Exposure Limits

Occupational Exposure Limits for H2S are as follows:

- Long-term exposure limit of 10 ppm (0.0005% by volume) over an 8 hour reference period
- Short-term exposure limit of 15 ppm (0.0010% by volume) over a 15 minute reference period

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# TOXIC GASES

## Measurement of H2S

Toxic gas detectors are calibrated to measure H2S in parts per million (ppm) of H2S in air, by volume ratio.

## Effects of H2S on Equipment

H2S is highly corrosive to steel and, at high stress levels extreme metal embrittlement may occur in a very short time.

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| Concentration (ppm) | Symptoms/Effects |
|---|---|
| 0.00011-0.00033 | Typical background concentrations |
| 0.01-1.5 | Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet. |
| 2-5 | Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. |
| 20 | Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness. |
| 50-100 | Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite. |
| 100 | Coughing, eye irritation, loss of smell after 2-15 minute. Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours. |
| 100-150 | Loss of smell (olfactory fatigue or paralysis). |
| 200-300 | Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure. |
| 500-700 | Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes. |
| 700-1000 | Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes. |
| 1000-2000 | Nearly instant death |

## TOXIC GASES

**Exposure to H2S.**

**Case Study.**

Entry Into Vessels With Irrespirable Atmospheres. (CONFINED SPACE)

A man was standing on a ladder ready to go down into a drain manhole to plug one of the inlet lines.

The drain contained some hydrogen sulphide so he had breathing apparatus ready but he had not yet put on the face-mask because he was well outside the manhole.

His feet were at ground level, he was about to put on a safety harness when his two companions heard a shout and saw him sliding into the manhole.

They were unable to catch him and his body was recovered from the outfall.

He had been overcome by hydrogen sulphide gas rising due to temperature from the drains although his face was 1.5m above ground level.

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## Asphyxiants

Gases such as nitrogen, hydrogen, methane etc., all act simply by diluting the air and so reducing the level of oxygen available.

These gases are known as Simple **Asphyxiants.**

Substances that affect the body's assimilation of inspired oxygen, such as carbon monoxide, prevent the uptake of oxygen in the blood. These gases are known as chemical asphyxiants.

More toxic asphyxiants, such as hydrogen sulphide (H2S) directly affect the respiratory centre of the brain, causing breathing to stop.

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## Long Term Health Impacts

Oxygen deprivation as a result of exposure to asphyxiants can cause permanent brain damage after only a short period of time.

Repeated exposure to even small amounts of toxic or flammable gases can also have long-term health impacts.

## Personal Protective Equipment – Regulatory Requirements

The last resort is the provision of Personal Protective Equipment (PPE).

The reason PPE is regarded as a last resort is because it is only effective if it is correctly fitted, maintained and properly used.

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## Asphyxiants

- Normal air contains 20.89% by volume of oxygen.
- The following table highlights the effects at other concentrations.

| Oxygen Content (%) | Effect |
|---|---|
| 14 | Breathing difficult, poor judgement |
| 10 | Unconsciousness |
| 8 | Death in 8 minutes |
| 4 | Death in 40 seconds |
| 0 | Death in 10 seconds |

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***Ignorance of the Dangers.***

- When a production area was being leak tested with nitrogen after a shutdown, a leak was found on a manway joint of a vessel. The nitrogen was depressurised and a fitter asked to remake the joint.
- While he was doing so the gasket fell into the vessel. Without thinking, the fitter squeezed the upper part of his body through the manway so that he could reach down and pick up the gasket.
- His companion saw his movements cease,
- realised he was unconscious and pulled him out
- into the open air where he soon recovered.

**HE WAS VERY LUCKY!!**

**Oxygen Enrichment**.

- Oxygen enrichment, that is, an atmosphere with an oxygen content above 23.5%, is highly dangerous for three main reasons:
- (1) Increased fire risk.
- (2) Compromises "intrinsic" safety of equipment.
- (3) Human intoxication!
- 'where does this additional oxygen come from?'

The answer to this is usually leakage from oxygen cylinders, damaged hoses or leaking fittings where gas welding or burning is being progressed. Nitrogen generators can also provide a source of oxygen.

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## Personal Protective Equipment – Regulatory Requirements

Employers are therefore required to ensure that PPE is appropriate for the risk or risks involved and are aware of the conditions at the place where exposure to the risk may occur.

Examples of PPE include:

- Safety footwear
- Safety helmet
- Hearing protection
- Eye protection
- Fire retardant/chemical resistant coveralls
- Gloves, and
- Respiratory Protective Equipment **(RPE) / SCBA**

## Personal Protective Equipment (CONT).

**Respirators.**

- This class of RPE purifies the surrounding air being breathed into the lungs through the nose and mouth. The contaminated air is drawn through a filter, chemical, or combination of filter and chemical, that removes the harmful substances before they can cause harm to the health of the wearer.
- The amount of protection offered to the wearer depends upon the efficiency of the filter and concentration within atmosphere, and time.
- Filter respirators are only filters -they must not be used in oxygen-deficient atmospheres.

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Personal Protective Equipment (CONT).

**BREATHING APPARATUS.**

- Breathing Apparatus (BA) has its own supply of air from an uncontaminated source.
- The air that is breathed by the wearer is supplied either from cylinders direct to the wearer or by a compressor and/or cylinders that are situated well away from the hazardous substances causing the respiratory hazards, via an airline to the wearer.
- Most BA used is of the "Positive Pressure type".
- This type of set maintains a pressure inside the mask or hood that is above atmospheric pressure at all times when worn. This prevents the entry of toxic or hazardous atmospheres to the breathing zone of the wearer should the mask become dislodged, or the mask not form a total seal against the contours of the wearer's face.

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## TOXIC GASES

### Selecting PPE – Controlling Risks from Hazardous Gases

For example: Benzene is known to irritate the skin and eyes and to be carcinogenic if swallowed or inhaled, therefore PPE should include:

- An atmosphere-supplying respirator
- Eye protection
- Chemical resistant gloves, and
- Chemical resistant coveralls

### Selecting PPE – Fitting and Ergonomic Factors

PPE will not be effective unless it fits the wearer, and this is not just a case of determining the right size of boots, gloves or coveralls.

For example, if Respiratory Protective Equipment depends on a face seal, then it will be ineffective if the worker has facial hair or stubble.

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## PROPERTIES OF GASES

### Gas Cloud Movement

Vapours in air move from place to place under two influences:

- Gravity, where gases are heavier than air they flow in a similar way to that of liquids.
- Normal turbulence and ventilation, where gases are lighter than air

### Gas Behaviour

In the event of a leak, combinations of gases remain mixed until each component is separated. This separation can take several hours and may be caused by many factors including condensation, gravity or air movement, depending on local ambient conditions. Hydrocarbon gases are often at high pressure, and have constituents that are both lighter and heavier than air. When gas is under pressure a relatively small leak can result in very rapid and large gas concentrations forming.

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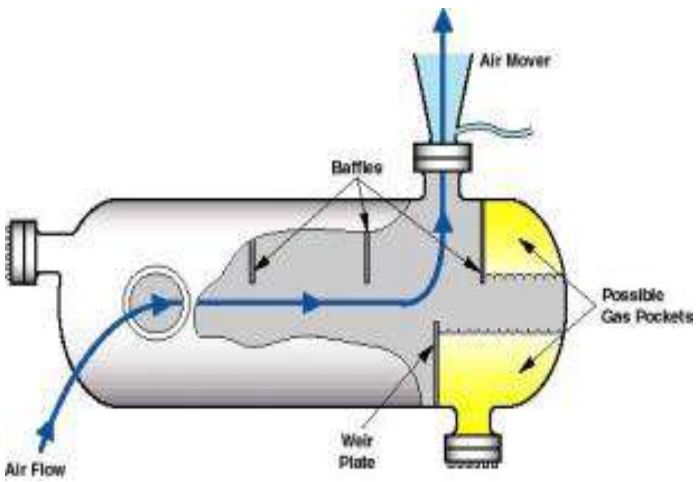
## PROPERTIES OF GASES

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## PROPERTIES OF GASES

### Physical Properties

**Relative Density:**

Gases that have a low relative density are lighter than air. For example, methane under normal conditions will rise. They will tend to collect beneath objects or surfaces, which prevent them from rising upwards.

Gases that have a high relative density such as hydrogen sulphide or pentane will fall to the ground and tend to gather in low lying areas or in drains.

In practice, other factors such as temperature and pressure can affect relative density.

**Velocity:**

The velocity of a gas escape or leak into the surrounding air will lead to a disturbance called turbulence, which causes the gas to mix with the surrounding air and increases the potential for an explosive mixture to develop.

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## PROPERTIES OF GASES

### Physical Properties

**Temperature:**

In general, heating of gases will lead to a reduction in density causing the gas to rise. Cooling will have the opposite effect.

**Pressure:**

Some gases are kept in a liquid state by being pressurised, such as liquefied petroleum gases containing butane and propane. As a pressurised liquefied gas escapes into the surrounding atmosphere its pressure decreases and its temperature drops. This causes its relative density to increase and the gas to fall.

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## PROPERTIES OF GASES

### Physical Properties

**Evaporation:**

Liquefied Petroleum Gas (LPG) contains propane and butane, which will evaporate when exposed to the atmosphere. As liquids evaporate their temperature drops, this causes their density to increase.

The cold and therefore heavy gas released during evaporation behaves like a 'slow-motion' liquid and will flow at a low level along floors.

The reverse effect can occur with hot, lighter than air gases, which may be buoyant for several minutes after release.

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## PROPERTIES OF GASES

### Dispersion

The nature of the initial dispersion will affect the behaviour of the escaping gas. In the absence of air movement or any confining structure, the dispersion of gas from a source of release will initially be determined by the momentum of the released gas, its density relative to air, or both.

Gas escaping with high velocity, for instance a leak from a pressurised line or container, will behave initially as a jet directed away from the source of release. As the distance from the source of release increases, the momentum of the jet will decay until, eventually, the dispersion of the gas will be controlled by buoyancy effects.

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## CONFINED SPACE ENTRY

### Build up of Gases in Confined Spaces

Hazardous concentrations of gases or vapours can arise from sources both inside and outside confined spaces, for example from:

- An operation performed inside the confined space, eg. welding
- Oxygen enrichment of the atmosphere caused by leaks of oxygen into the CS
- A process which has previously been carried out in the CS
- Sludge deposits that are disturbed during inspection / cleaning
- Adjoining plant due to ineffective isolation, or
- Migration from another area

## CONFINED SPACE ENTRY

### Testing Confined Spaces

Tests should check for the presence of gas or toxic fumes, and the adequacy of oxygen and air supply. An acceptable result must be obtained before work in any area proceeds.

Where possible, all tests should be conducted from outside the CS. When this is impractical the following basic rules should be adhered :

- Wear approved breathing apparatus
- Know what type of gas or vapours are to be expected
- Ensure all isolations to the confined space have been implemented
- Provide ready exit / entry routes for rescue team
- Wear an approved safety harness, with lifeline attached, before entering a CS
- Ensure there is at least one Standby Person on the outside, ready to raise the alarm in the event of an emergency.
- The Standby Man should always be in sight and call, of the Authorised Gas Tester

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## CONFINED SPACE ENTRY

### Further Considerations

Other considerations: chimney stacks that may still contain flue gases, and the oxidation process which may cause rust. Rust can reduce the content of oxygen present in the atmosphere.

Where purging activities have been carried out, the atmosphere in the vessel may still contain inert gases that have displaced the original contents and the atmosphere within could be oxygen deficient. the gas may not be uniform inside a confined space and may be present in different concentrations at various levels. Gas may also collect behind obstructions such as baffle plates or bulkheads, or may be trapped in sludge deposits in the vessel.

After any test, the Authorised Gas Tester should record the maximum and minimum readings on the Entry Certificate.

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## CONFINED SPACE ENTRY

### Oxygen

Oxygen is a non toxic gas which represents 20.9% of the air we breathe. However, if the Oxygen content of the atmosphere falls below or rises above this level, as may be the case in a storage tank, or vessel, the human body will suffer from oxygen starvation or intoxication.

### Oxygen – too little

Too little oxygen could result from purging with inert gas to remove flammable or toxic gas or vapour, or the formation of oxidant products such as rust on the inside surface of a vessel.

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## CONFINED SPACE ENTRY

### Oxygen – too much

Too much oxygen has a poisonous effect on the body as well as representing an increased fire hazard, this could for example occur in the vicinity of leaking gas welding equipment.

### Work involving air or gas lines

It is important to isolate and remove all air / gas lines that are not being used,

Note; no gas / air cylinders other than breathing apparatus sets are allowed in confined spaces.

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## PORTABLE GAS DETECTION EQUIPMENT

### Introduction

Portable and personal gas detectors are a convenient means of detecting the presence gases and vapours; and ensuring that oxygen levels are safe.

Portable gas detectors are preferred:

- For testing an atmosphere in a confined space for toxic gases.
- For tracing leaks, and
- To give early warning of the flammable gases in case hot work.

But it only monitor a small area around the operator and rely on the operator to take remedial action such as alerting other personnel to any danger .

In some circumstances a fixed detection system will be more appropriate to provide a range of automatic actions in the event of an emergency.

All gas monitors have specific operating instructions and limitations, These instructions should be read and clearly understood before using the gas detector.

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## PORTABLE GAS DETECTION EQUIPMENT

### Types of Portable Gas Detectors

Types of detector commonly used in the industry are:

- Catalytic combustion, Infrared(IR), Electrochemical, PID
- Toxic (H2S), electrochemical
- Oxygen, electrochemical

Manufacturers supply electronic instruments to customer requirements; they may detect one specific gas or a combination of gases.

Although the manufacturer and model may vary from site to site, all combination detectors are designed to:

measure oxygen, toxic (H2S) and flammable gases.

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## PORTABLE GAS DETECTION EQUIPMENT

### Gas Detector Principles of Operation

Mixtures of flammable gases and air cannot be ignited unless the concentration of gas exceeds the LEL. However, the mixtures will 'burn' on the surface of a catalyst, even those approaching zero percent.

yielding heat in direct proportion to the gas or vapour concentration.

This process is called **surface or catalytic combustion.** the heat released by catalytic combustion can be displayed in analogue or in digital format.

A more recent development is a type of instrument using solid-state sensors (semi-conductors).

Such instruments do not commonly provide a meter or digital read-out but produce an audible or visual alarm or both, at one or more pre-selected alarm levels.

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## PORTABLE GAS DETECTION EQUIPMENT

### Catalytic Detectors - Disadvantages

Catalytic detectors have a number of disadvantages including:

• They will not indicate the presence of either flammable dusts or fibres

• They require a level of more than 10 percent oxygen to work correctly

• They can give false readings in gas rich atmospheres, that is, above the Upper Explosive Limit (UEL), and

• The catalyst can be poisoned by trace gases such as hydrogen sulphide

An additional problem is that the metal screen can be blocked, which can result in drift of the zero point, and loss of sensitivity; therefore it needs regular calibration and replacement.

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## PORTABLE GAS DETECTION EQUIPMENT

### Infrared (IR) Detectors - Principles of Operation

The operating principle is based on the absorption of infrared light by hydrocarbon.

If a volume of gas between an IR source and detector contains hydrocarbon molecules, then these molecules will absorb some of the infrared light decreasing the total IR radiation detected.

The amount of absorption indicates the concentration of hydrocarbon in the gas.

Infrared detectors can be either point or open-path.

For point detectors a short beam is used to illuminate a volume of gas that has suffused into a measurement chamber.

For open-path sensors the source of infrared light is a powerful narrow beam that illuminates the space between source and detector. Alternatively, a mirror is positioned at the end of the path, and this reflects the beam back to the detector.

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## PORTABLE GAS DETECTION EQUIPMENT

### Infrared (IR) Detectors – Advantages and Disadvantages

The **advantage** of IR detectors is that they:

- Do not require oxygen to operate
- Cannot be poisoned by trace gases such as silicones and hydrogen sulphide, and
- Are not ambiguous above the LEL
- No frequent calibration required to ensure accurate operation.

The **disadvantages** are that they:

Open-path detectors enable large spaces to be easily monitored but the alignment of source and detector requires great care and, objects in the beam can give false readings.

Be aware that if the sun is low in the sky, stray radiation can cause interference with the beam.

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## PORTABLE GAS DETECTION EQUIPMENT

### Toxic (H2S), electrochemical

work by allowing gases to diffuse through a porous membrane to an electrode where it is chemically oxidized. The amount of current produced is determined by how much of the gas is oxidized at the electrode, indicating the concentration of the gas. Also, since the diffusion barrier is a physical/mechanical barrier, the detector tended to be more stable and reliable over the sensor's duration and thus required less maintenance than other early detector technologies.

many of the most common toxic gases including hydrogen sulphide, carbon monoxide, sulphur dioxide, chlorine, and others measured in this way.

"EC" sensors are compact, require very little power, and generally have a long life span. The detection technique is very straightforward in concept. Gas that enters the sensor undergoes an electrochemical reaction that causes a change in the electrical output of the sensor. The difference in the electrical output is proportional to the amount of gas present.

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## PORTABLE GAS DETECTION EQUIPMENT

### Portable Gas Detectors - Sampling

Portable gas detectors may have their capabilities extended by utilising additional sampling attachments such as tubes and probes.

Only sample probes or sensors recommended by the manufacturer should be used.

When manual aspirators and sample probes are used they should be checked to ensure that they are fitted correctly and are leak free.

spot checks should be carried out at different levels using a sample probe, with an aspirator if required.

Sample probes allow detection to be carried out from a safe distance and are also ideal for testing flanges or inaccessible areas for leaks.

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## PORTABLE GAS DETECTION EQUIPMENT

### When to Use An Aspirated Detector

Non-aspirating detectors rely on normal air movements to carry samples through vents to the sensors.

Aspirated detectors use motorised or manual pumps to actively draw in samples of the air to be tested.

Aspirated detectors should be used to test for the presence of gases in remote or inaccessible places such as:

• Drains and other low-lying voids where heavier clouds may collect, and

• The lagging of the clad pipeline

They should also be used where the air is very still, such as in a confined space, or very turbulent, such as when testing for a leak from a flange on a windy day.

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## PORTABLE GAS DETECTION EQUIPMENT

### Portable Gas Detectors - Basic Checks

Before using detection equipment some basic checks should be carried out:

- Check the calibration date
- Check for visual signs of damage
- Check the battery is sufficiently charged
- Check the aspirator bulb and sample probe for leaks
- Check that the sensor head membranes are clean and are not blocked
- Check that the readings in a clean air environment are within tolerance

before starting tests.

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## AUTHORISED GAS TESTER.

### Basic Checks *(cont).*

- At switch on, and after a warm up period, check the meter readings "in normal fresh air" prior to using the meter at a work site. (IMPORTANT)
- Oxygen meter should read 20.9% (v/v), hydrocarbon readings should be 0% LEL and H2S should read 0ppm.
- The correct "Extension Probes", should always be used to maintain the required (safe distance) from point of EXPOSURE.
- This prior testing is MANDITORY.
- Each time an instrument is used to test the atmosphere in a "confined space", a (function check for oxygen and flammable gas) must be carried out and the response time of the instrument must be determined.

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## PORTABLE GAS DETECTION EQUIPMENT

### Portable Gas Detectors – general considerations

Re-calibration and checking shall only be carried out by competent personnel.

Under no circumstances should you carry out repairs or make adjustments yourself if you are not competent and authorised to do so.

Only use the instrument for its designed purpose, making sure that the manufacturer's instructions are fully adhered to.

What type atmosphere it may be used in, ensure it is suitable and correct?

Any limitations the equipment might have, "Correct application".

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## PORTABLE GAS DETECTION EQUIPMENT

### Temperature Effects

When taking portable gas detection equipment from a warm to a cool environment, it is important to allow the equipment temperature to stabilise to avoid condensation (the formation of vapour) which may otherwise interfere with the operation of the gas detector.

### Limitations of Portable Gas Detectors

Gas detection equipment may not be sensitive to a specific gas, for example H2S detectors may not detect methane and furthermore, adverse readings may be generated by the presence of gases other than those for which the detector is calibrated.

It is important to note that some substances such as solvents or silicones may also adversely affect detectors and you should check the manufacturer's specifications before use.

If contamination is suspected, the detector must be returned for checking and re-calibration.

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## PORTABLE GAS DETECTION EQUIPMENT

### Erratic Indications

Erratic indications on detection equipment may point to contamination, an equipment malfunction or some atmospheric disturbance.

In such cases carry out the test again.

Where there are doubts a check should be made with another gas detector of the same type. Suspect equipment should be returned for checking and re-calibration

### Environments that affect readings

The presence of very low concentrations of combustible gas can produce indications that may be mistaken for 'zero drift'. In such circumstances, the equipment should be removed to a clean air environment and re-checked.

Dust or saturated steam may physically block the flame arresters of certain types of gas detection equipment.

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## PORTABLE GAS DETECTION EQUIPMENT

### Off-Scale Readings

'off-scale' may indicate the presence of a potentially explosive atmosphere. It will then be necessary to flush the detection equipment with clean air and to cross-check for the presence of gas by taking the reading again, or by using another type of gas detection apparatus.

When using portable gas detection equipment, it is necessary to be aware that some flammable gases and vapours are also toxic.

### Warning Systems

All types of portable gas detectors, have visual and / or audible warnings to alert the operator to the presence of unwanted gases.

### Personal Gas Detectors

Personal gas detectors are small portable devices worn on the outside of the coverall and typically contain a single sensor for a specific gas.

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## PORTABLE GAS DETECTION EQUIPMENT

### Fixed Gas Detectors

Fixed gas detectors have two principal parts:

• A sensor, and

• A wall/ceiling-mounted junction box

The junction box contains the components necessary to process the output from the sensor before it is sent to a Central Control Unit.

If a sensor detects a dangerous gas level at any time, the control unit raises the alarm.

Fixed gas detectors can be point detectors or open-path detectors.

Additionally, they are not specific to a particular gas, for example steam or water vapour can produce false readings and alarms.

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## GAS TESTING PROCEDURES

### Process Plant

Particular attention must be given to flanges, screwed connections, gaskets, drains and vents, valve glands and pump seals, when performing tests.

The AGT should be aware of the types of fluid that run through the process equipment, or are adjacent to the proposed area of work.

### Gas Testing in Support of Work Activities

In any potentially flammable or toxic area or whenever a gas risk may exist at the worksite, the applicable signatory in accordance with the Permit to Work System will indicate that gas testing is required.

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## GAS TESTING PROCEDURES

### The Permit to Work System

The applicable signatory will advise on the Work Permits where a gas test is required.

In some cases before a Work Permit is issued an initial gas test MUST be made.

The results of this gas test must be recorded on the Work Permit or Entry Certificate.

The AGT will sign to signify that all gas tests made are within specified limits.

Subsequent gas tests may be required at intervals after the initial gas tests.

The applicable signatory will identify any additional requirements related to the frequency of the gas tests.

The results of these tests are also recorded on the Work Permit or Entry Certificate.

Gas tests where specified, must be repeated at the time of Work Permit re-validation and when the site is reoccupied after a major work break.

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## GAS TESTING PROCEDURES

### Continuous Gas Monitoring

The normal requirement following the initial gas test will be continuously monitored during the work activity.

These tests are additional to the requirements for initial, re-validation and subsequent gas tests involving an AGT.

Where continuous monitoring is required, this shall be carried out using a portable or personal gas detector positioned adjacent to the job.

These detectors will normally be left with the Person in Charge of the Worksite, who can appoint a Competent Person to continuously check the gas detector readings during the work.

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## GAS TESTING PROCEDURES

### Practical Gas Testing

The area for gas testing must be as wide with many readings from as many places as possible until confidence is achieved that the samples taken are truly representative of the whole area.

The AGT should also be aware of the effects caused by:

- Open doors to the module
- Temperature / heat barriers at roof level
- Stagnant or flowing air patterns around the work site
- Movement of sands or sludge which may contain trapped pockets of gas

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## GAS TESTING PROCEDURES

### Practical Gas Testing

The AGT should also consider testing the following areas:

- In spaces near walls and large vessels
- In spaces where circulating air currents can pick up gas
- Close to potential sources of gas release for example, near vessels, hydrocarbon systems, voids and vents
- At the end of exhausts, in flues and service ducts
- Near drains and liquid surfaces
- And, where air movements may be negligible and gas could collect in clouds, for example in very congested areas

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- Oxygen tests are carried out at all levels.
- Tests for Hydrogen Sulphide should be carried out at all levels. The gas is however heavier than air and will tend to concentrate at lower levels. If this gas is suspected then wearing of full **self contained breathing apparatus is recommended.**
- If a meter reading outside of normal values is found, the cause should be investigated and problem rectified prior to the start of work, and also STOP on-going work.
- If a flange has to be split or a man-way door opened, ensure that the vessel or pipework has been fully depressurised then crack the flange/door, inset **a probe** into the crack and test prior to removing completely.

**Where & when to Test (cont).**

- Behind weir plates or baffles in a confined space
- All pipe flanges.
- Vents and drains not plugged or capped off.
- Loop seals leading to drain systems.
- Screwed fittings.
- Valve packing's.
- Pump seals.
- Around lubrication reservoirs (pumps / motors) etc.

When welding is to be done on fixed piping systems, it is often "advisable to drill a hole" at the weld point for gas testing purposes. (Obviously this is done after decommissioning, mechanical isolation and preparation has taken place).

There may also be solid and liquid hydrocarbons still present.

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## GAS TESTING PROCEDURES

### Air Movement

The AGT should commence tests upwind of the work area to a minimum radius of 5m from the work site, working in towards the risk spot and around all potential sources of release.

This test pattern will account for air movements around the area caused by a HVAC system, any prevailing wind etc.

A thorough gas test of the complete area will involve testing above head height and at floor level to give the best possible chance of detecting gases with different relative densities.

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## GAS TESTING PROCEDURES

**Remember, the main points of gas testing are:**

- Test area - 5m radius around work site
- Commence upwind of work site
- Take nothing for granted
- If in doubt restart test
- Identify potential hazards within the area and inform the applicable signatory of these hazards
- Never sign the authorised paperwork until you are 100% certain of full compliance with Work Permit requirements
- Always look, listen, advise and report
- Where any indication of gas is detected, do NOT assume it is harmless just because it is within the acceptable limit, check further

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## CASE STUDIES

### The Wrong Way to do it!

A tank that had contained light hydrocarbons was to be worked on.

It had not been properly cleaned before work started. It had been filled with water and then emptied. Some hydrocarbons remained in the crevices.

The results were as follows:

- No tests were made for combustible gas
- A welder working near the vent accidentally ignited the vapour
- 6 people were killed and 29 injured

The correct procedures for tank cleaning were not in place or had not been followed.

The Permit to Work Procedure should have initiated gas testing before welding started. Continuous gas monitoring should have occurred around the tank outlets (vents). This accident was totally avoidable.

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## CASE STUDIES

### The Right Way to do it

An old gas line had been out of use for 12 years. It had to be modified for re-use.

For the previous two years it had been blanked at one end and open at the other.

A flange was welded on the open end without incident.

The next job was to fit a 1" branch 60 metres from the open end. A hole was drilled in the pipe and a gas test proved negative.

A few hours later, immediately before welding, a repeat gas check indicated the presence of flammable gas. It is believed that the gas was in the pipe for 12 years and started migrating when the hot work caused a rise in temperature.

It may seem reasonable to assume that a line, redundant for 12 years, would not require a gas test.

Fortunately; the people involved here took a different view.

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**Remember:**

***Sensor poisoning.***

Hydrocarbon "sensors" may be poisoned by:

- Silicones
- Sulphur compounds
- Welding fumes
- Chlorine
- High levels of hydrocarbons,? (Flooding) carefully consider the placement of the meter at a worksite to prevent contamination.

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***Hot Work Testing:***

- Comprehensive and continuous gas testing is necessary. Initial tests close to the work place should be carried out with a flammable-gas detector fitted with aspirator / Pump system.
- Perform Pre-checks and confirm integrity of equipment, by blocking "probe inlet" to pull vacuum for conformation.
- Only after the immediate area has been certified clear should the tester move in an "outward direction" and additionally, in all directions but predominantly upwind.
- Remember the three dimensional aspect of a worksite and the fact that gases can be blown around objects or obstructions. Heavier/lighter than air gases should be checked for.
- Check drainage, sewer bells, screwed fittings, valve packing's / glands / joints, etc. in general area.

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## AUTHORISED GAS TESTER.

- A detector or detectors! should remain on site in positions which would enable it to provide early warning of a gas release. (Static / continuous monitoring)
- General conflict between permits / Tasks, should be noted.

***Toxicity Checks:***

- Use the correct toxic gas detector, or chemical stain tubes.
- Again take representative samples and be prepared for frequent or continuous testing.
- Results should be within occupational exposure limits
- Remember that some gases are not toxic but will displace or deplete the air and oxygen (e.g. Nitrogen (Inert gas), or Carbon Di-oxide, (Oxidiser). (very dangerous for confined spaces).

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## Summary.

Gas tests can be broken down into three types:

1. Flammable gas tests.
2. Toxic or harmful gas tests.
3. Oxygen content tests.

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## Summary.

Ensure that the meter is capable of detecting the gas searched for at the correct concentration.

- Always pre-check the tester or analyser, (in fresh air atmosphere)
- Consider carefully where and when to test and the type of test to be carried out (**diffusion or aspirated**).
- Hydrogen sulphide is highly toxic (poison). Always follow company methods of testing and control when this gas is suspected.
- 20.9% oxygen is required for normal breathing. Always check the atmosphere thoroughly. Low oxygen levels in a confined space can be fatal and oxygen levels above 22% are a fire hazard, "ENRICHED" atmosphere.
- Nitrogen is used to make a system safe, but always be aware of the dangers of high nitrogen concentrations in an atmosphere, (DEFICIENCY)!!!!!
- Also that the low levels of oxygen created by purging, will affect certain detectors.

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# THANK YOU


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