3. Gas hazards

Overview

Purpose

A gas technician/fitter must know how to investigate, detect, and remedy gas leaks, incomplete combustion, and the effects of corrosive vapours on gas-fired appliances and equipment in a safe and efficient manner.

Objectives

At the end of this Chapter, you will be able to:

- identify combustible gas indicators;
- describe how to investigate gas leaks;
- describe how to investigate incomplete combustion; and
- describe the effects of corrosive vapours.

Terminology

Term	Abbreviation (symbol)	Definition
Combustible gas indicator	CGI	Instrument for detecting gas-air (or vapour-air) mixtures to determine the explosive levels of the mixture
Lower explosive limit	LEL	The lowest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat)
Upper explosive limit	UEL	The highest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source (arc, flame, and heat)

Combustible gas indicators

A combustible gas indicator (CGI) is an instrument for detecting gas-air (or vapour-air) mixtures to determine the explosive levels of the mixture.

A combustible gas indicator can save lives. A gas technician/fitter should know how to use it and make sure that it is accurate. A gas technician/fitter must become thoroughly familiar with the

23) Match each Definition to one of the following categories of air.

a) Supplied to ensure that complete combustion has occurred:	Dilution air
b) Supplied from around the flames:	Excess air
c) Supplied to the combustion chamber in excess of the air required for perfect combustion:	Secondary air
d) Supplied to cool the hot vent gases:	Excess air
e) Provides a source of air to the draft control device:	Dilution air
f) Combustion, excess, and dilution air requirements added together:	Primary air
g) Supplied to mix with fuel gas before ignition:	Total air

24) Correctly complete the following sentence with the appropriate temperature provided:
The combustion process must maintain a temperature of approximately _____ °F (700 °C) for natural gas.
a) 1 000°F
b) 1 300°F
c) 1 200°F
d) 1 100°F

25) Correctly complete the following sentence with the appropriate number provided:
100 000 Btu/h requires _____ ft^3 combustion air.
a) 1 000 ft^3
b) 10 ft^3
c) 100 ft^3
d) 10 000 ft^3

26) Indicate True or False:
255 000 Btu/h requires 2 550 ft^3 combustion air.
a) True
b) False

operation and limitations of the indicator and should be satisfied that the instrument is in proper operating condition.

General guidelines

- Audio alarms correspond to a factory-set parts per million (ppm) level of gas. You can shut off the alarm in certain circumstances to avoid causing distress to the public.
- You should perform calibration regularly and according to manufacturer's instructions.
- Some CGI Units come with probes and hoses (including pumps and battery packs) for remote sampling. Always use the appropriate accessories when required.

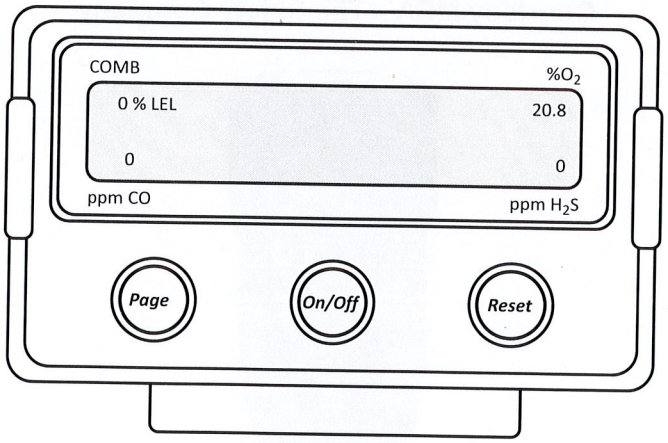
There are two basic types of CGIs: solid-state and filament. The solid-state type, which can sense gases at as little as 2–3 ppm of gas in air, is more commonly used and much more sensitive than the filament type.

Solid-state indicator

The solid-state CGI (Figure 3-1) is a small, light hand-held Unit. It comes with a light-emitting diode (LED) display, a digital readout, or an analogue dial indicator, and an audible alarm.

Some models are adjustable to detect several gases at one time. The readout indicates the gas level in ppm or percent of lower explosive limit (LEL). For each instrument, you need to check the manufacturer's manual to determine how to read the display and for the settings of the LELs of specific gases and vapours.

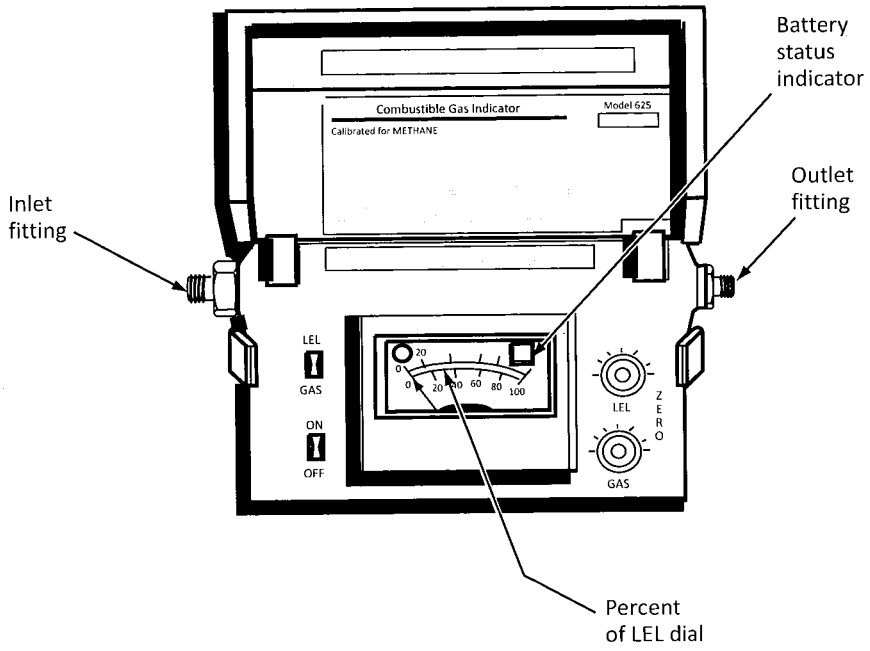
Figure 3-1
Combustible gas indicator (solid-state type)



Filament-type indicator

The filament-type indicator (Figure 3-2) works on the principle of catalytic combustion. The meter draws the air-and-gas mixture through the sampling inlet and across the detector filament. The filament consists of a catalytic material that ignites the mixture at a low temperature and then registers the percent of explosive limits on a dial.

Figure 3-2
Filament-type indicator



Be aware that the filament type is not as sensitive as the solid-state type (Figure 3-3) and must be purged manually before sampling.

Figure 3-3
Hand-held portable CGI
Courtesy MSA—The Safety Company

Conversion charts

Each indicator is calibrated to a specific gas, and conversion charts are available if you wish to use to check for other gases or vapours.

Because each manufacturer makes many different models, you should be sure you have the correct instrument for the job at hand. An instrument calibrated for a known gas at the manufacturer's plant (a standard calibration) is usually most suitable. However, a CGI that is calibrated for one specific gas (such as hydrogen or methane) may or may not read correctly on other substances. Therefore, make sure you have a CGI that can read the gas you are testing for.

Table 3-1 shows the common types of gases a combustible gas indicator can test for. Table 3-2 shows a typical conversion chart.

Table 3-1
Sample of gases to be tested

Gases		
Acetone	Halon	Naphtha
Alcohol	Hydrogen sulphide	Natural gas
Ammonia	Industrial solvents	Propane
Butane	Jet fuel	Refrigerant
Carbon monoxide	Lacquer thinners	Smoke
Gasoline	Methane	Steam

Table 3-2
Conversion chart

Combustible gas	**Multiply % LEL reading by**
Acetone	1.1
Acetylene	0.7
2,3 Dimethylpentane	1.2
Ethane	0.7
Gasoline (unleaded)	1.3
Hydrogen	0.6
Methane	0.5
Methanol	0.6
n-Pentane	1.0
Propane	0.8

The following relative responses to selected combustible gases are typical of an instrument calibrated using Pentane.

Accessories

Carefully consider which accessories you choose to use. When in doubt, consult the manufacturer's manual.

Do...
• When probing overhead, use a non-conducting probe in case you touch a "hot" electrical circuit. • No CGI will operate when filled with liquid. Should you be sampling enclosed vessels, which may contain liquids, be sure there is a liquid trap in the sampling system to prevent the liquid from entering the indicator. • Use the hoses provided.

Calibration

For most Units, calibration test kits are available. Periodically check the indicator calibration to ensure the indicator is working correctly. Refer to the manufacturer's manual for correct settings.

CGI dos and don'ts

There are correct and incorrect methods of operating a combustible gas indicator. The following are some dos and don'ts to follow when using a CGI:

Do...	Do not/never...
• Follow the proper instructions for the care and maintenance of your CGI. • Always read the instruction book that accompanies each instrument. In it you will find complete instructions, possible troubles and remedies, and an exploded diagram of all parts with their stock number. • Use the supplied accessories. • Check the battery periodically. • Be aware of how temperature and pressure can affect the explosive range readings. • Turn the indicator off when not in use.	• If the CGI has flashback arresters, do not remove them. • Use the indicator for sampling gasoline vapours containing TEL (tetraethyllead), unless the indicator has received approval for this application. • Let the sampling hose or probe reach into a liquid.

Investigating gas leaks

First and foremost, when responding to a gas leak call, your concern is safety. The following information about what to do in the event of a gas leak call is based on safety first. Remember that you can replace property, but not lives!

The flowchart in Figure 3-4 summarizes the steps to take when responding to a gas leak call.

Step 1—Prepare

a) Prepare the combustible gas indicator by:
- purging it in clean air (if required); and
- switching it on.

b) Other useful pieces of equipment to bring to the call include:
- leak detection soap solution (bubbles);
- a pressure gauge or manometer;
- a safety flashlight (Class 1); and
- a pipe wrench.

Step 2—Knock

a) When arriving at the premises with the suspected leak, knock on the door. Do not use the doorbell, as this could cause ignition if gas is present in the area of the doorbell's power source.

Step 3—Communicate

a) Identify yourself.
b) Inquire about the situation to obtain further facts.
c) Inform them:
- not to smoke;
- not to use any appliances;
- not to operate any electrical switch; and
- not to use any phone, pager, or cell phone in the building.

Step 4—Take a reading

a) Determine whether the gas supply is natural gas or propane to know where to take the reading:

If ...	Then...	Reason
The natural gas appliances are in the basement.	A good place to test is, in the basement stairwell, immediately after you enter the building, near the top of the door.	Natural gas is lighter than air, with a specific gravity of approximately 0.60. Consequently, it tends to rise or follow any path of least resistance.
The supply is propane.	A good place to begin testing for propane leaks is at floor level.	The specific gravity of propane is greater than that of air, it is heavier and will tend to collect at lower levels.

b) Take the reading:

If the CGI reading...	Then...
Is above the LEL, which indicates that the concentration of fuel is near or above the explosive limits	• There is no time to waste. • You must make safe immediately and calmly. • Follow the steps below for when the reading is above the LEL.
Is well below the LEL, which is 4% for natural gas and 2.4% for propane	• There is a problem, but you have some margin for safety. • Proceed with caution. • A reading below LEL indicates that the immediate area you are in has a margin of safety; however, the immediate area of the leak could be above the LEL. • Follow the steps below for when the reading is well below the LEL.

Step 5—Make safe immediately

a) Take actions based on the reading levels:

Steps for make safe when...	Action	Description
The reading is above the LEL.	1) Evacuate the occupant(s)—including you!	• In larger buildings, you should notify and instruct the building manager to activate the emergency evacuation plan. • Stay calm, but positive, when directing people.
	2) Do not cross-ventilate.	• When gas concentrations are near the explosive limits, cross-ventilating is dangerous—it is possible that you might move potentially explosive concentrations of gas to a possible source of ignition. For this reason, it is not considered safe practice to cross-ventilate when the UEL reading is at a critical point. • In such concentrations, it is also not recommended to open basement windows from inside or outside.
	3) On your way out, turn off service riser valve or propane cylinder/ tank shutoff valve.	• Do not return to the building with a wrench to turn off the main shutoff valve. Several deaths in the industry have occurred from such actions. • If you happen to have a wrench with you as you exit the building and you pass by the service riser, you can shut it off. However, by the time you get to your vehicle, call for

Steps for make safe when...	Action	Description
		help, and locate your tools, as some time will have passed and the inside situation may have worsened.
	4) Call for help using a telephone located at a safe distance from the area of the leak.	• In your calls to the fire department, police, and gas utility supplier, provide the: • property address; • actions taken; • information on the suspected cause; • types of crew and equipment required; and • any other backup personnel required.
	5) Do not return to the building.	• Keep everyone, after evacuation, at a safe distance from the hazard area. If an explosive mixture is present in a building, no one, not even the gas technician/fitter, should go near it after vacating the building. There have been too many situations where the gas technician(s)/fitter(s) return to the building to shut off the gas and inadvertently create ventilation, only to have the building explode. Several deaths in the industry have resulted from such actions. • Following building evacuation, stay clear and keep others at a safe distance. Remember that buildings are replaceable, lives aren't.
The reading is well below the LEL.	1) Remain calm.	• The guidelines for making safe when the reading is below LEL are less drastic than for when there is imminent danger.
	2) Operate exhaust fans, opening windows and doors, and forced air ventilation, if available.	• Fresh air ventilation will keep concentrations low. • Forced air ventilation can take many forms. Most buildings or homes have a portable cooling fan.

Steps for make safe when...	Action	Description
	3) If gas is concentrating in a basement with a below LEL, open windows on each end of the basement (suggested).	• Mount the portable cooling fan in one window, in such a manner as to blow air out of the window. • Make-up air will exhaust through the opposite window, creating a cross-draft. This cross-draft tends to draw the gas from the leak or infiltration source and dilute it in the air stream. It will then exhaust through the opposite window. • Remember, fans normally do not have spark-proof motors, so gas concentrations must be below the LEL at all times. • For propane, the lower you can place the fan to the floor, the better it will move the propane.

Step 6—Cut off ignition sources

a) When gas concentrations are below the LEL, you can safely cut off potential ignition sources by:
   - opening the master breaker at the electrical panel; and
   - turning off valves on lines supplying the various gas appliances.

Step 7—Determine source of leak

Note that odorants are not completely effective as a warning agent in all cases. You can properly odorized propane at a concentration of 1/5th of its LEL and properly odorized natural gas with the average nose at a concentration of approximately 500 ppm.

An older style combustible gas indicator, operating on the 0–100 LEL (0.5%) range, can detect concentrations of natural gas down to 1 000 ppm. In other words, the average nose may be twice as sensitive as the standard catalytic combustion scale on a combustible gas indicator. The nose and CGI together can help determine the source of a gas leak.

a) Determine the source of the leak:

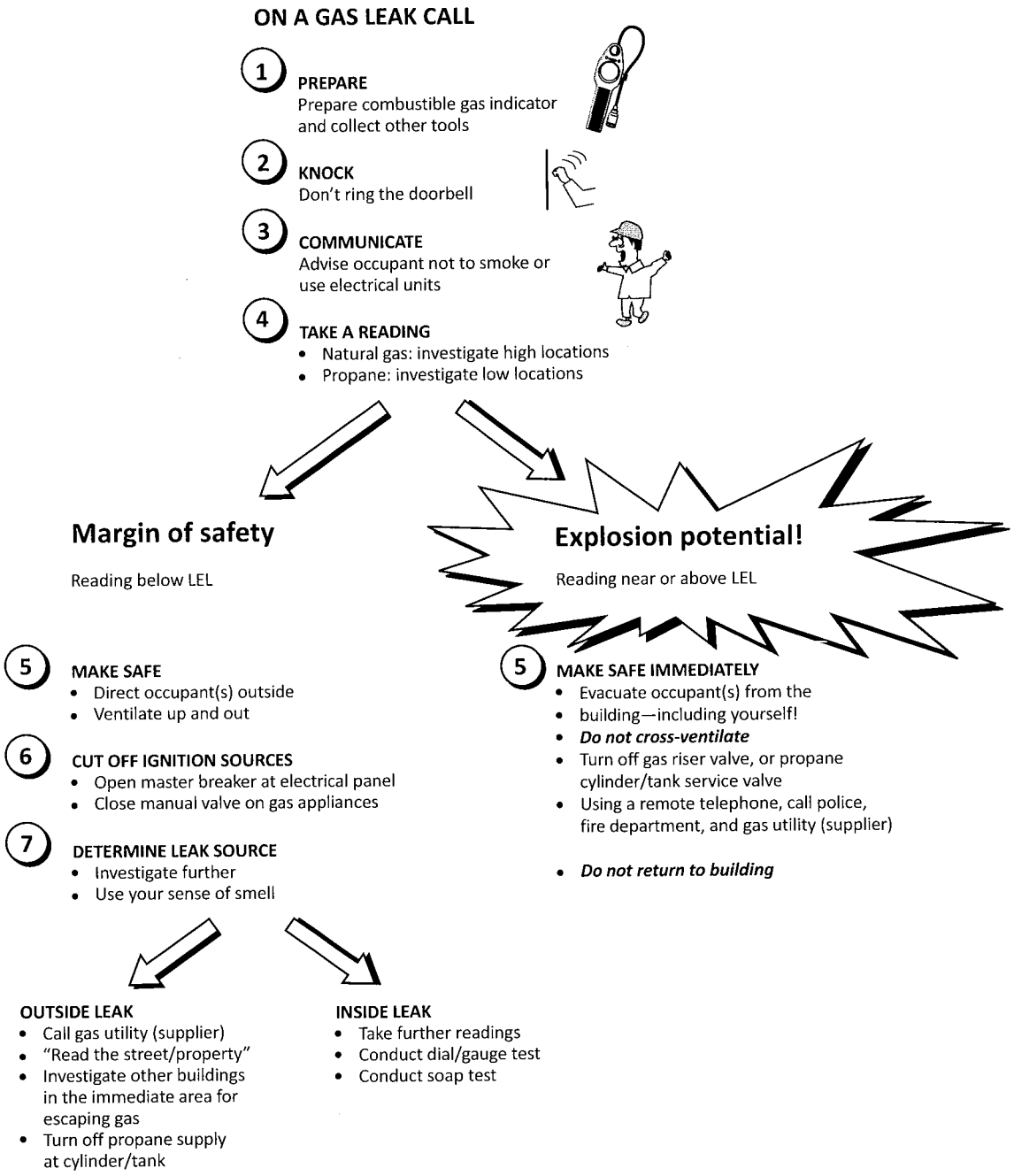
For a smell...	Then the source is...	Description
Faint smell and strong reading	Likely an outside, below-ground leak that has infiltrated the building	• Once it escapes from a below-ground piping system, gas diffuses through the soil atmosphere seeking a venting location. It often finds its way into conduit systems, sewer lines, manholes, vaults or pits, as well as building foundations. Methane, the major component of natural gas, has the smallest molecular structure of the combustible gases in the Paraffin series. These small molecules, often with pressure behind them, permit natural gas to seep through very small cracks, fixtures, or other openings in building foundations, thus creating potential hazards. Once it reaches the surface, it diffuses rapidly through the atmosphere. • Gas-related accidents can result from infiltration of gas into confined spaces from outside sources. As gas travels through soil from a leak source, the odorant compounds (mercaptans) tend to adhere to the soil particles; soil acts as a filter for the odour molecules. By the time gas infiltrates buildings, the odour may be entirely absent. • Follow steps below for outside, below-ground leak.
Strong smell	Likely a leak inside the building	• If there is a noticeable smell of fuel and the reading is below the LEL, you are safe to continue to monitor the free atmosphere in the basement. • Follow steps below for inside leak.

b) Take appropriate action based on the source:

Once you determine the leak source as...	Action	Description
Outside, below-ground	1) You should call the gas utility (supplier) to have the area tested.	• Keep in mind that time is of the essence. Either one of these may happen: • The outside leak may have been present for a considerable period, with gas slowly infiltrating the building. • A major break, service pull, or other problem may have occurred; gas may just be starting to enter the building.
	2) At this point you should go outside to "assess the situation on the street".	• You may perceive evidence of recent construction or other activity that could have damaged the pipeline or underground propane service line.
	3) Shut off the propane cylinder/tank service valve if the gas supply to the premises is propane.	• Take all precautions.

Once you determine the leak source as...	Action	Description
Inside If there is a noticeable smell of fuel and the reading is below the LEL, you are safe to continue to monitor the free atmosphere in the basement.	1) Check: • all conduit entry points; • the gas service entry; • below-grade cracks in the basement walls; • floor drains and sump pump holes; • ceiling atmosphere; • the piping; • low-lying areas; • fittings and manifolds of appliances; and • other points where gas could leak or collect.	• Use the findings to determine the location of the leak.
	2) You can also: • take dial-gauge/ manometer test reading; • do soap test; and • shut off all appliances at service valves and listen for the sound of gas passing.	• Take additional actions to help determine the location of the leak.

Figure 3-4
Steps to take when responding to a gas leak call



Investigating incomplete combustion

If, when responding to an odour call, you determine that the odour is not a natural gas or propane leak, you should check for carbon monoxide. Carbon monoxide is a colourless, odourless, toxic gas with a specific gravity of 0.98.

Whilst carbon monoxide is odourless by itself, the creation of aldehydes and sulphur dioxide, which are irritating and toxic substances may cause a pungent odour that sometimes accompanies CO.

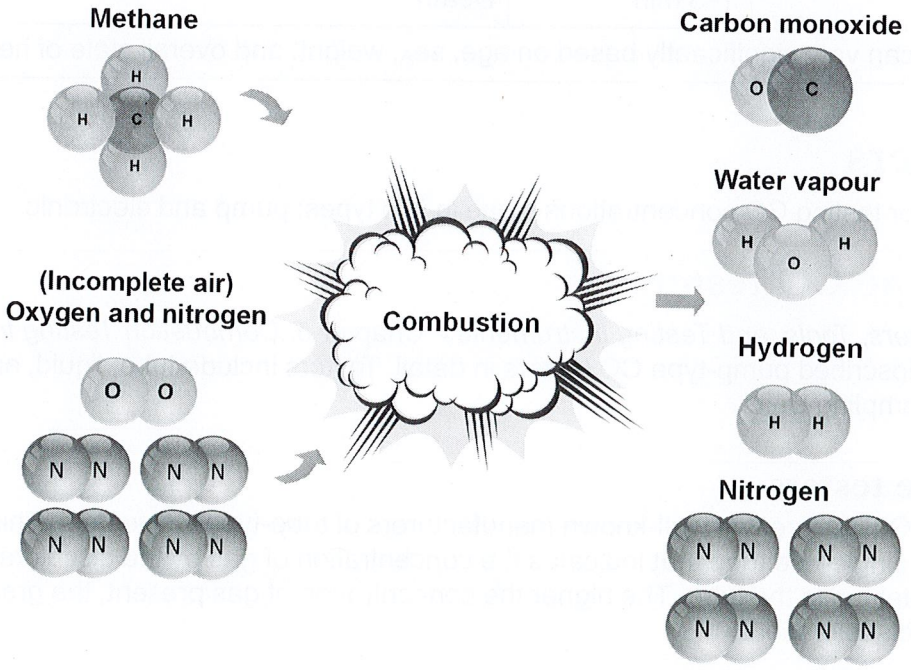
Technicians/Fitters should test for carbon monoxide as they enter a structure any increase over outside ambient levels should be investigated to determine the source.

ESCO Press publication *Carbon Monoxide a Clear and Present Danger* provides additional information on carbon monoxide testing and investigation.

Carbon monoxide is a product of incomplete combustion (Figure 3-5). It is a direct and cumulative poison. Carbon monoxide bonds with blood hemoglobin to form carboxyhemoglobin. Carbon monoxide bonds with hemoglobin 200 times easier than oxygen. CO replaces oxygen in the blood until it completely overcomes the body. Death from CO occurs rapidly at high concentrations. The victim inhaling the toxic concentration of the gas becomes helpless before realizing that danger exists. Chronic exposure to low levels of carbon monoxide can compound preexisting health conditions and is often misdiagnosed as flu-like symptoms, i.e., headache, nausea, vomiting, head stuffiness, and fatigue.

Figure 3-5 shows how incomplete combustion produces carbon monoxide.

Figure 3-5
Carbon monoxide produced from incomplete combustion



Dwyer, B., Leatherman, R., Manclark, B., Kimball, K., and Rasmussen, E. (2003). *Carbon Monoxide a Clear and Present Danger*. Washington, DC: ESCO Press.

Table 3-3 shows the toxic symptoms experienced with the various concentrations of CO.

Table 3-3
Concentrations of CO and toxic symptoms

Concentration of CO in air	Inhalation time	Toxic symptoms developed*
200 ppm	2–3 h	Slight headache, tiredness, dizziness, and nausea
400 ppm	1–2 h	Frontal headache
	3+ h	Life-threatening
800 ppm	45 min	Dizziness, nausea, and convulsions
	2 h	Unconsciousness
	2–3 h	Death
1 600 ppm	20 min	Headache, dizziness, and nausea
	60 min	Death
3 200 ppm	5–10 min	Headache, dizziness, and nausea
	30 min	Death
6 400 ppm	1–2 min	Headache, dizziness, and nausea
	10–15 min	Death
12 800 ppm	1–3 min	Death
*Symptoms can vary significantly based on age, sex, weight, and overall state of health.		

CO testers

Instruments for testing CO concentrations come in two types: pump and electronic.

Pump-type CO testers

Unit *2 Fasteners, Tools, and Testing Instruments* > Chapter *5. Combustion Testing Instruments* has already described pump-type CO testers in detail. Testers include tube, liquid, and continuous sampling Units.

Tube-type testers

Draeger and Gastec are two well-known manufacturers of tube-type CO testers. This type of tester uses a single-use tube that indicates the concentration of gas by the discoloration of a dry chemical contained in the tube. The higher the concentration of gas present, the greater the extent of the discoloration.

Liquid-type testers

Another common CO tester is the liquid-type Unit. This type of tester is partially filled with a liquid that absorbs CO. The higher the concentration of CO present, the greater the expansion of the liquid. The amount of expansion is measured on a scale on the side of the tube. Unlike the tube tester, the liquid tester can help take several samples without having to change the chemicals.

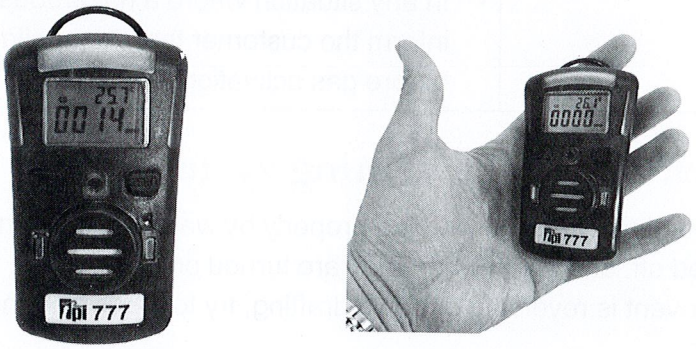
Continuous sampling testers

These testers take a continuous sample of the gas through a sampling tube inserted into the area being tested. Readings are displayed on a dial indicator. Some Units provide a printout of the readings for future reference.

Electronic CO testers

Electronic CO testers, like the Bacharach Monoxor® III Unit (Figure 3-6), are light-weight, portable, hand-held solid-state instruments with continuous readout digital displays. They can measure and display CO levels from 0 to 2 000 ppm. To take a reading, the operator inserts the attached sensor probe into the flue or airspace being sampled and reads the indicated value on the tester display.

Figure 3-6
Continuous sampling CO Analyzer
Image courtesy of TPI



Common causes

As technicians/fitters, you should test for carbon monoxide upon entering a structure and investigate any increase over outside ambient levels to determine the source.

After ensuring that no immediate hazard exists, check the following sources that commonly cause odour calls that are not gas leaks:

Step 1—Check products of combustion

a) Check the products of combustion on all vented appliances (on an air-free basis). You are looking for high levels of carbon monoxide (CO).

If...	Then...
A vented appliance : • produces more than 400 ppm of CO air-free; and • cannot be adjusted to produce less.	• Disconnect and red-tag the appliance. Under normal operation, an appliance should produce less than 50 ppm of CO (air-free). • In any situation where a hazardous condition exists, inform the customer that the appliance needs repair before gas activation is possible. Vented appliances should never produce more than 400 ppm of CO on an air-free basis.
The products of combustion test are normal.	• Check the house atmosphere for CO. • If the inside atmosphere CO level exceeds 35 ppm, ventilate the building and shut off the appliances. • In any situation where a hazardous condition exists, inform the customer that the appliance needs repair before gas activation is possible.

Step 2—Check appliance venting system

a) Check that the venting system is working properly by watching the venting action with the appliances turned off, and again when they are turned on.

b) If the chimney or vent is reversing or down drafting, try to determine the cause by checking for the following:
   - an active fireplace or open fireplace damper;
   - exhaust fans;
   - adequate combustion and ventilation air;
   - proper chimney or vent height;
   - proper termination location; and
   - proper rain cap on Type B vent.

Step 3—Check other fuel-burning appliances

a) Check other fuel-burning appliances such as gas ovens, gas ranges, gas fireplaces, gas water heaters, wood stoves, wood furnaces, or oil-fired vented appliances in the building.

b) heck the sizing of the venting system to ensure it is appropriate for the number and types of appliances. Check the condition of the venting system and clean out any obvious debris in the chimney cleanout.

Step 4—Check furnace heat exchanger

a) Check the furnace heat exchanger for cracks. If you find cracks, inform the customer that the heat exchanger needs replacement or that a new furnace is required.

b) Check the furnace for a secondary heat exchanger. If there is one installed, examine it to determine whether it is an acceptable type and whether it is in good condition.

Step 5—Check appliance input

a) Clock the gas meter and determine the input for each vented residential gas appliance.
b) Check all industrial and commercial equipment, if installed.
c) Check for other causes of odours, when unable to find, such as:

- paint and solvent fumes;
- kerosene heaters; and
- auto engines operating.

If you still are unable to find the source for the customer's odour complaint, then report your findings to your supervisor, who will determine if further action is required.

Effects of corrosive vapours

Experience has shown that contaminants in the combustion air almost always causes corrosion of gas-fired equipment.

Corrosive substances

The most common corrosive element is a member of the family of substances known as chlorinated hydrocarbons. These materials are solvents, cleaners, or refrigerants. When heated, the molecules of these compounds break down to form a variety of substances, some of which are very corrosive.

Be suspicious of the following:

- materials used for degreasing metal parts;
- materials used for cleaning jewelry, electronic components, etc.;
- glues of many types, except those with a water base;
- solvents for removing grease, wax, or printing ink;
- propellants used in aerosol sprays;
- freon-type refrigerants;
- paint and varnish strippers;
- dry cleaning solvents;
- swimming pool chlorine;
- kitty litter; and
- bleaches.

When used in a solvent form, the above materials are often clear, colourless, watery liquids. They are normally nonflammable and relatively nontoxic. When mixed with glues, they are difficult or impossible to identify without testing.

Solid substances do not usually cause corrosion.

For positive identification, you need to know the chemical constituents of the suspect materials. The easiest way is to read them off the container label. If the chemical name of a solvent-type

substance contains the letters chlor or fluor, you can be almost certain you have found the problem material. Some known corrosion-causing substances are listed below:

- chlordane;
- refrigerants;
- methylene chloride;
- perchloride;
- trichlorophenol; and
- trichlorfon.

Chemistry of corrosion

The equation below shows, in a simplified manner, one of the possible reactions that can occur when a chlorinated hydrocarbon (methylene chloride, in this example) is heated in air:

$$CH_2Cl_2 + O_2 = CO_2 + 2HCl$$

methylene chloride + oxygen = carbon dioxide + hydrogen chloride

In this reaction, the methylene chloride combines with oxygen to produce the gases carbon dioxide and hydrogen chloride.

Hydrogen chloride gas is very soluble in water. In the presence of the slightest trace of water, it forms hydrochloric acid. This acid can attack the following appliances and heating system components:

- furnace heat exchangers;
- water heaters;
- Unit heaters;
- furnaces;
- boilers with finned tubes; and
- swimming pool heaters.

At the beginning and end of each burner cycle, the heat exchanger is relatively cool. Water in the combustion products can condense in small amounts during these two brief times. The hydrogen chloride dissolves in this water to form hydrochloric acid. This acid is extremely corrosive and will attack almost all metals.

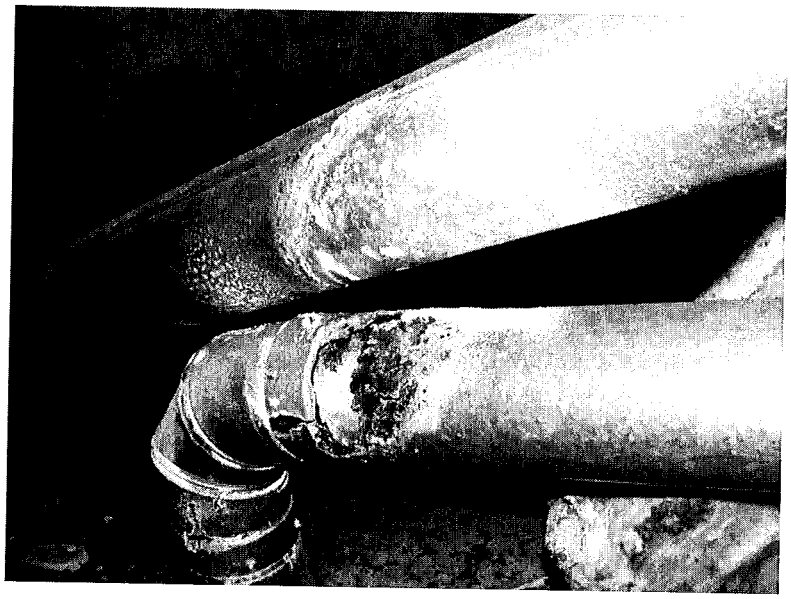
In water heaters during high draws, the heat exchanger temperatures are quite low. More condensation occurs during this time and, therefore, corrosion rates may be very high. Unit heaters and furnaces are next in vulnerability. Boilers are often least affected, because the inner surfaces are nearly always hot enough to prevent condensation. However, boilers with finned tubes, and swimming pool heaters, frequently have condensation problems caused by excessive water flow through the appliances.

Spotting corrosion

In appearance, the corrosion looks like ordinary rust—it can be a fine red powder or large rusty scales or flakes. See Figure 3-7.

One of the additional characteristics of this type of corrosion is the presence of whitish, powdery streaks that run down and dry on galvanized vents (aluminum vents are less affected). In cases of fresh corrosion, the streaks will be wet and appear oily. The inner surfaces show a slight amount of white powder. They tend to last fairly well, but get thinner and thinner with time.

Figure 3-7
Corroded venting due to leaking



Corrective measures

Do not install an appliance in a room that has an atmosphere containing corrosive vapours, such as that found in a dry-cleaning establishment.

When you find corrosion to be causing the deterioration of gas-burning equipment, you must take corrective measures before replacing the equipment. In industrial applications, it is often impossible to cure the problem completely. The chlorinated hydrocarbon causing the corrosion is often crucial to plant operation, with no acceptable replacement substance. However, where possible, encourage the customer to find a replacement.

You can usually reduce the problem by reducing the amount of corrosive substance that is allowed to evaporate. Some helpful steps include the following:

1) Store, transfer, and use the solvent in a closed, fan-ventilated room. Obviously, no gas-fired equipment should be in the room. Doors leading to this room should be well-sealed and closed at all times.
2) Try to avoid open containers of solvent. Often, you can find many small containers of solvent around the plant or in the home that are not really needed.
3) If you are to replace heating systems, consider:
   - Direct vent and roof-mounted heaters. They are best, as long as all combustion air comes from outdoors.

Be aware, however, that often there are vents, exhaust fans, etc., that dump contaminated air at roof level. None of these vents or exhaust fans should be anywhere near the intake of a roof Unit or direct vent appliance; otherwise corrosion will occur.

- Hot water or steam heating is the next best choice. Place a boiler or water heater in an enclosed area away from the solvent. To avoid condensation problems, pay careful attention to finned-tube boiler installations.

Assignment Questions – Chapter 3

1) Which of the following is a type of combustible gas indicator?
   a) Handheld type
   b) Pump type
   c) Filament type
   d) Wand type

2) How are combustible gas indicators calibrated?
   a) By applying a known concentration of gas to the instrument, then checking the response
   b) By applying an unknown concentration of gas to the instrument, then checking the response
   c) By checking the response of the instrument at a test point

3) What must be the first concern when responding to a gas leak call?
   a) Response time
   b) Type of odour present
   c) Safety (public and personal)

4) Where is a good place to test when checking combustible gas if the natural gas appliances is located in the basement?
   a) In the basement stairwell
   b) At the front door of the house
   c) At the vent termination of an appliance

5) Indicate True or False:
   One of the methods to ventilate combustible gas is to open the doors and windows.
   a) True
   b) False

6) Which of the following is not a location that should be checked when testing for combustible gases?
   a) All conduit entry points
   b) Below grade cracks in basement walls
   c) Around windows and doors
   d) Floor drains