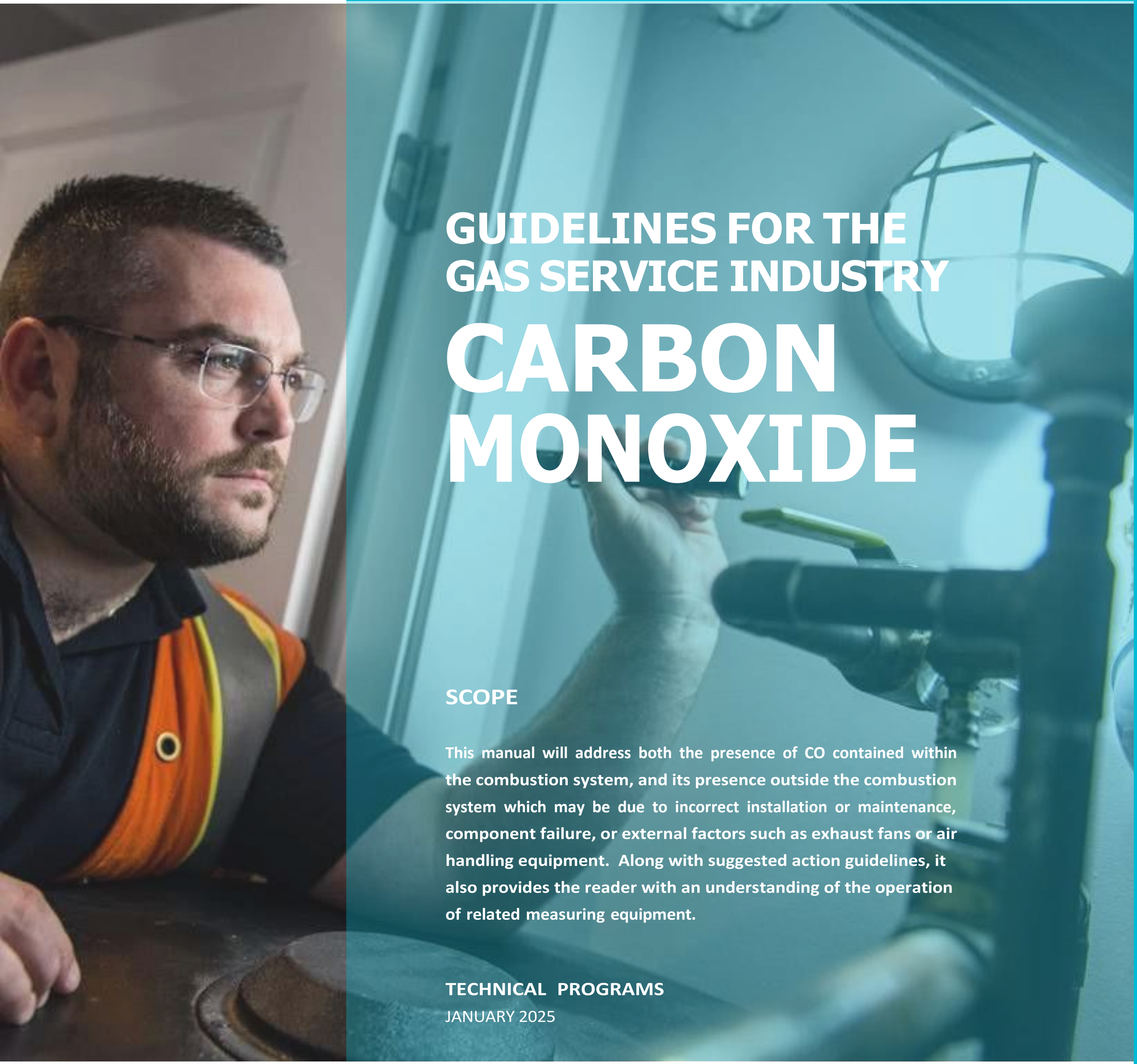

GUIDELINES FOR THE GAS SERVICE INDUSTRY

CARBON MONOXIDE

SCOPE

This manual will address both the presence of CO contained within the combustion system, and its presence outside the combustion system which may be due to incorrect installation or maintenance, component failure, or external factors such as exhaust fans or air handling equipment. Along with suggested action guidelines, it also provides the reader with an understanding of the operation of related measuring equipment.

TECHNICAL PROGRAMS

JANUARY 2025

TECHNICAL SAFETY BC

Safe technical systems. Everywhere.

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DEFINITIONS

Aldehydes

A class of gases formed by incomplete combustion of hydrocarbons. Aldehydes can produce a sharp, metallic taste in the mouth, and irritate the eyes and mucous membranes. If aldehydes are present, there is a strong possibility carbon monoxide is also being produced.

Auto-ignition temperature

The lowest temperature of a substance at which it spontaneously ignites in a normal atmosphere without an external source of ignition, such as a flame or spark.

Carbon monoxide

A colourless, odourless, very toxic gas (CO) that is formed as a product of the incomplete combustion of carbon or a carbon compound.

Carbon monoxide air-free

An “air-free” reading is calculated to determine what the CO concentration in flue gas would be if all the excess air were removed.

The CO reading is multiplied by the ratio of the atmosphere’s oxygen percentage (20.9) to the excess oxygen percentage in the flue gas.

The formula is

$$\text{Air Free CO ppm} = \text{Measured CO ppm} \times \left(\frac{20.9}{20.9 - O2\% \text{ in flue gas}} \right)$$

E.g.: If the measured CO is 50 ppm and the measured oxygen in the flue gas is 10.5%.

$$50 \text{ ppm} \times \left(\frac{20.9}{20.9 - 10.5} \right) = 100 \text{ ppm}$$

Category I appliance

An appliance that operates with a nonpositive vent static pressure and with a flue loss not less than 17%.

Note

This category consists of draft-hood-equipped appliances, appliances labelled as Category I, and fan-assisted appliances for venting into Type B vents.

Category II appliance

An appliance that operates with a nonpositive vent static pressure and with a flue loss less than 17%.

Category III appliance

An appliance that operates with a positive vent static pressure and with a flue loss not less than 17%.

Category IV appliance

An appliance that operates with a positive vent static pressure and with a flue loss less than 17%.

Dew point

The temperature (varying according to pressure and air content) below which water droplets begin to condense in a venting system.

Flame impingement

The striking of a burner flame against an object, such as flame impingement on the heat exchanger.

Heat deflection temperature

Or heat distortion temperature (HDT, HDTUL, or DTUL) is the temperature at which a polymer or plastic sample deforms under a specified load.

Hemoglobin

(Hb or Hgb) is a protein in red blood cells that carries oxygen throughout the body.

Hydrocarbon

An organic compound (such as benzene, methane, paraffin) made of two elements, carbon and hydrogen and found in coal, crude oil, natural gas, and plant life. Hydrocarbons are used as fuels, solvents, and as raw materials for numerous products such as dyes, pesticides, and plastics; petroleum is a mixture of several hydrocarbons.

Lower explosive limit (LEL)

The minimum concentration of combustible gas or vapour in air, expressed as a percentage by volume, that will ignite if a source of ignition is present.

Luminous flame

A visible yellow flame caused by a delay of carbon molecules finding oxygen and forming carbon dioxide. Luminous flames have a small blue colour zone around the burner port due to the hydrogen. Hydrogen burns at a greater speed and a lower temperature than carbon does. The remaining bright yellow “luminous” area is the burning of carbon particles. The slow burning particles become semi-solid and because of their higher temperature, produce an incandescent light. The carbon particles complete their combustion when they reach the outer surface of the yellow flame and find sufficient oxygen.

Stoichiometric ratio

The exact ratio between air and flammable gas or vapour at which complete combustion takes place.

Thermal efficiency

This indicates the extent to which the energy added by the heat source (furnace, boiler, etc.) is converted to an output. Thermal efficiency can be field calculated provided the heating value of the fuel is known and accurate measurement of flow through the heat exchanger is made.

Upper explosive limit (UEL)

The upper explosive limit of a vapour or gas; the highest concentration of the substance in air that will ignite when an ignition source (heat, arc, or flame) is present. At higher concentrations, the mixture is too “rich” to burn.

INTRODUCTION

INTRODUCTION

For many gas fitters, carbon monoxide (CO) related contact most commonly occurs after the triggering of a CO alarm, which typically results in the attendance of either fire/rescue services or a gas utility technician.
Customers utilizing propane and not serviced by a utility may contact a licensed gas contractor directly, as they may be the only available technical resource.

This document provides information and guidelines for gas fitters and gas contractors to develop their own protocols for use when installing, servicing, or performing maintenance on gas appliances.

Testing for CO concentrations in flue gases, conditioned airstreams, and ambient atmospheres provides the gas fitter with important information regarding the status of the appliance's combustion system; informed analysis of CO levels and associated parameters will allow the gas fitter to determine if an appliance is operating safely. The degree of thermal efficiency may also be assessed as part of a flue gas analysis.

This manual will address both the presence of CO contained within the combustion system, and its presence outside the combustion system which may be due to incorrect installation or maintenance, component failure, or external factors such as exhaust fans or air handling equipment. Along with suggested action guidelines, it also provides the reader with an understanding of the operation of related measuring equipment.

ATTRIBUTES OF CARBON MONOXIDE

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Carbon monoxide is produced from the incomplete combustion of fossil fuels and possesses the following physical properties:

Properties of Carbon Monoxide

Colourless	Cannot be seen.
Tasteless	Cannot be detected through the sense of taste.
Odourless	Cannot be detected by sense of smell, However, CO can also be accompanied by aldehydes. Aldehydes' odour can somewhat resemble vinegar, which can be detected by the sense of smell, and may also result in a metallic taste in the mouth.
Non-irritating	Carbon Monoxide will not cause irritation. However, aldehydes usually present with higher levels of CO will irritate the eyes, nose, and mucous membranes.
Specific gravity	Slightly lighter than air (Sg 0.975). It may, but not always collect near the ceiling, and mixes freely with air.
Flammable (explosive) limits	CO is flammable between concentrations of 12.5% to 74% when mixed with air. Its ignition temperature is 609ºC (1128ºF).
Toxic	Can cause death if enough is absorbed into the bloodstream.

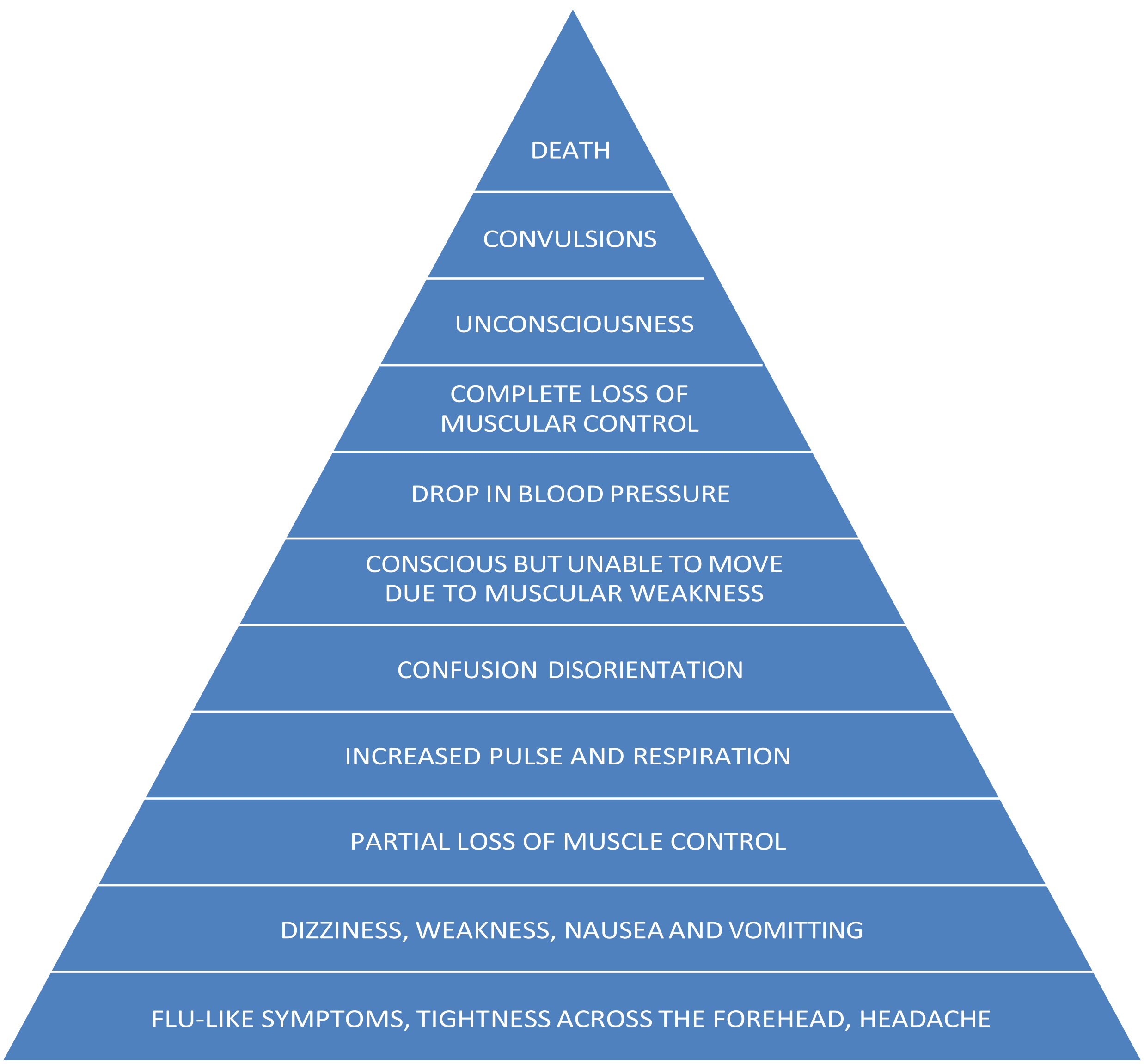
*Concentrations (*ppm)*	*Observations and Health Effects*
1 to 3	Normal.
25	Occupational exposure limit averaged over 8 hour period.
30 to 60	Exercise tolerance reduced.
100	15-minute short-term exposure limit (STEL).
60 to 150	Frontal headache. Shortness of breath on exertion.
150 to 300	Throbbing headache, dizziness, nausea, and impaired manual dexterity.
300 to 650	Severe headache; nausea and vomiting; confusion and collapse.
700 to 1000	Coma and convulsions.
1200	Immediately dangerous to life and health (IDLH).
1000 to 2000	Heart and lungs depressed. Fatal if not treated.
Above 2000	Rapidly fatal.

*1 ppm = 1 part of gas per million parts air by volume

Carbon Monoxide Infiltration

Carbon monoxide is inhaled and absorbed from the lungs into the bloodstream. Hemoglobin in the blood is responsible for transporting oxygen from the lungs to the body.

If given the choice, hemoglobin will link up with carbon monoxide instead of oxygen. CO is absorbed into the bloodstream 250 times faster than oxygen, raising the level of carboxyhemoglobin very quickly. If this occurs, a lack of oxygen to the body will produce CO poisoning; CO asphyxiates the victim. If the blood oxygen is reduced enough, it can result in unconsciousness, brain damage or death.



CO POISONING SYMPTOMS

Factors Affecting Carbon Monoxide Absorption

Some of the major variables that affect the amount of carbon monoxide absorbed into the body are:

- Concentration – The concentration of carbon monoxide in the free air.
- Exposure – The length of time an individual is exposed to CO.
- Physical Activity – The higher the rate of respiration, the more carbon monoxide will be inhaled.
- Physical Health – People that are ill, especially those with heart or respiratory ailments, have increased susceptibility. Individuals who smoke also have an increased susceptibility to CO.
- Age – Infants and the elderly are more susceptible to carbon monoxide.
- Sex – Females are more affected than males. If a women is pregnant, carbon monoxide can have an effect on the fetus.
- Altitude – The higher the altitude, the greater the effect of carbon monoxide poisoning.

  CO absorbed in the bloodstream is cumulative. The healthy human body has difficulty removing carbon monoxide from the bloodstream and requires five hours to reduce the level by half. When physical health is compromised prior to exposure, the time needed to recover increases dramatically, and puts additional strain on the body's ability to process CO.

When a gas fitter is commissioning an appliance, the process should include a discussion with the occupants regarding what is to be expected once the appliance is operational. The differences between a leak of natural gas (rotten egg – mercaptan odour), and other "gas smells" should be explained (see aldehydes), along with odours associated with the initial "burn in" of the appliance. Whenever a gas fitter is servicing a gas appliance, the occupants should be questioned regarding the operation of their appliances, and any reports of unusual odours, pilot outages, short cycling, etc. need to be investigated.

If an occupant complains of a "gas smell", it also needs to be determined if the odour is, in fact, related to unburned natural gas, combustion products, or an unrelated source.

Other signs which may indicate CO is entering the living space include:

- Dead or dying houseplants
- Condensation on windows
- Discolouration around heating vents
- Discolouration or heat damage around the gas appliance burner compartment, including heat damage to wiring and external components
- Discolouration or heat damage around the draft hood of a vented appliance
- Missing or incorrectly installed fan compartment doors on forced-air furnaces
- Plugged or missing combustion/ventilation air supplies
- CO alarm has been or is sounding periodically
- Flames rolling out of combustion chambers
- Reports from first responders or medical personnel

CO poisoning is often mistaken for the flu or food poisoning. Comments from occupants regarding ongoing illnesses that coincide with appliance usage are cause for further investigation. Remember that CO can also be produced from incorrectly functioning oil furnaces, woodstoves, or fireplaces; any fuel-burning device can produce CO under the right conditions.

Allowing a vehicle to idle or using power equipment in a garage attached to a living space may allow CO to enter the occupied space. Propane powered generators can produce excessive amounts of CO without showing any outward signs, such as running rough, black, sooty exhaust.

CARBON MONOXIDE PRODUCTION

CARBON MONOXIDE PRODUCTION

Complete combustion of natural gas or propane produces carbon dioxide (CO_2), water vapour (H_2O) and heat. When fossil fuels such as natural gas or propane burn incompletely due to a lack of an adequate supply or mixing of oxygen to produce CO_2, CO forms.

Natural Gas complete combustion:

$CH_4 + 2O_2 = CO_2 + 2H_2O$ + Heat

Natural Gas incomplete combustion:

$2CH_4 + 3O_2 = 2CO + 4H_2O$ + Heat

Propane complete combustion:

$C_3H_8 + 5O_2 = 3CO_2 + 4H_2O$ + Heat

Propane incomplete combustion:

$2C_3H_8 + 9O_2 = 4CO_2 + 2CO + 8H_2O$ + Heat

CO may also be produced by sources that use hydrocarbons other than a natural gas or propane appliance. These include:

- Solid-fuel (wood, pellet, or coal) fireplaces or stoves
- Kerosene or oil direct-fired space heaters
- Oil furnaces
- Charcoal barbeques
- Gasoline or diesel powered generators, pressure washers, pumps
- Motor vehicles

Causes of Incomplete Combustion

Complete combustion of natural gas or propane results in a sharp, blue flame, with an inner cone and outer envelope. Incomplete combustion due to inadequate air supply produces a soft, yellow flame with poor definition. The yellow flame is composed of incandescent carbon particles which have not combined with oxygen molecules. They form soot when deposited on a solid surface. Orange flecks appearing above a sharp blue flame should not be mistaken for incomplete combustion; typically, these are the result of dust particles being consumed by the flame.

Incomplete combustion may be caused by:

- Flame impingement, which occurs when a flame strikes an object and cannot extend far enough to complete the combustion process. Impingement disrupts the flame pattern, but may not produce a yellow, sooty flame. Dislodged burners or refractory, misplaced fire logs or decorative embers can produce impingement.
- Overfiring or underfiring an appliance, either through incorrect manifold pressures or orifice sizing.
- Poor mixing of gas and air resulting from the incorrect adjustment of, or plugged or restricted, primary air shutters.
- Plugged furnace heat exchangers, or boiler flue passages or coils.
- Missing, inadequate, or plugged combustion air supplies, or building depressurization.
- Restricted or blocked chimney flues, or the installation of undersized or incorrect venting.
- Recirculation of flue gases containing CO_2 through a flame can crack the CO_2, producing CO.
- Incorrect adjustment of some types of industrial burners may result in quenching of the flame head.

Venting Systems

Although all appliance standards permit the production of limited amounts of CO, a properly functioning venting system will remove the combustion products to the outdoors. Damage to, or deterioration of, the vent can permit combustion products to enter the occupied space. Flue gas can enter buildings when gas appliances are sidewall vented close to adjoining occupancies.

Venting systems can be damaged/compromised by:

- Mechanical impact or stresses
- Corrosion
- Temperatures in excess of the venting material's certification rating range

Mechanical impacts may damage or dislodge vent connections; areas containing vents should not be used for storage.

Mechanical stress from incorrect support of the vent, or settling of the structure, can permit vent sections to separate. Plastic (S636) venting systems may separate if joints are not properly prepared prior to gluing, or if the incorrect glue or primer is used.

Consideration for expansion and contraction of the vent must be made in accordance with manufacturer's certified instructions. Plastic venting which is rigidly restrained may produce enough force to result in damage to the vent system.

Flue gas condensate is acidic and corrosive. Appliances attached to metal venting (other than ULC-609 Stainless Steel) must be designed, installed, and operated in a manner which limits "wet time" within the vent. "Wet time" refers to the period during operation when the products of combustion cool to the dew point (approximately 125°F or 52°C), allowing condensate to form within the vent. Category III appliances are usually vented with stainless steel venting materials.

Signs of corrosion include rust staining of the vent, or appliance vent connection, or deposits of white crystals evident on the vent; standard and mid-efficient furnace heat exchangers can also be damaged through excessive "wet time".

Typical causes include:

- Oversizing of the heating appliance
- Underfiring of the appliance
- Incorrect adjustment of thermostat heat anticipators
- Incorrect temperature rise through the appliance
- Oversizing of the venting system
- Excessive use of single-wall vent connectors

A properly sized, installed, and maintained heating appliance connected to a B-vent or chimney liner limits the production of condensate.

If Category I appliances are common vented and one appliance is removed at a later date, such as the replacement of a mid-efficient furnace to a high efficiency furnace, the existing venting must be verified to be adequate for the remaining appliance(s). It is the gas fitter's responsibility to ensure that the appliance is installed and operated in accordance with the manufacturer's certified installation instructions.

For forced-air furnaces, firing rate, manifold pressure, external static pressure (ESP), temperature rise, and heat anticipator values are typically specified by the manufacturer.

For boilers, manufacturer's specifications typically include firing rate, manifold pressure, return water temperature, temperature rise, and water treatment requirements.

An appliance or venting system showing signs of damage from corrosion warrants investigation into the underlying causes which resulted in the corrosion. Simply replacing the damaged components and walking away is irresponsible.

Category IV high-efficiency appliances (HEP's) have been vented with plastic piping since their inception. HEP's typically exhaust their products of combustion through plastic venting which has been assembled through a solvent welding process and is capable of withstanding positive vent pressures. Polypropylene venting materials are typically connected with a mechanical joining/locking system.

CO would only enter the occupied space if a failure were to occur in the appliance, venting, or if a CO-rich exhaust plume was directed or drawn into a building.

Prior to the revision of the Canadian Standard for Type BH Gas Venting Systems ULC-S636 in 2008, and the adoption of the 2010 CSA B149.1 installation code, appliance manufacturers specified the use of various types of plastic pipe for venting their products. These types included older systems known as Plexvent, Selvent or Ultravent, ABS (both solid and cellular core), PVC, and CPVC.

Cellular core ABS was never an approved/accepted venting material for use in British Columbia, but noncompliant installations have been documented over the years. The current requirements of the ULC-S636-08 Standard, and the CSA B149.1 installation code, specify the listed systems available for venting appliances based on the flue gas temperature. **Technical Safety BC Directive "D-G5 070628 5 Revision: 05 Plastic Venting"** further clarifies the requirements as well as requirements for previously installed existing systems.

It is the responsibility of the installing or servicing gas fitter to ensure that the venting system is appropriate for the appliance it is connected to, and that the appliance continues to operate with a flue gas temperature not exceeding the listed value of the venting material.

SIGNS OF CORROSION

Elevated flue gas temperatures result from a reduction in heat transfer between the products of combustion and the heated medium (air or water). In water heaters and boilers, this may result from silting or scaling of the water side of the heat exchanger.

High return water temperatures or an accumulation of dirt on burner fan blades can also cause elevated flue gas temperatures.

For air-handling equipment, dirty or partially plugged filters, or accumulations of dust and dirt on the conditioned side of the heat exchanger may also lead to higher temperatures.

In both cases, the situation compounds as the appliance continues to operate for longer periods of time at the elevated temperatures in an attempt to satisfy the demand for heat.

Some appliances are now equipped with a high-temperature cut-out which senses the flue gas temperature at the outlet; service calls resulting from the functioning of the cut-out need to include an evaluation of the conditions leading to the high temperatures.

Plastic venting which has been heated to its Heat Distortion Temperature (HDT) can soften and distort. The degree of distortion is dependent on the temperature, duration, and degree of mechanical loading. Other signs of overheating include discolouration, and separation of piping from the fitting socket. As with the activation of a high-temperature cut-out, a gas fitter must investigate the reasons leading to damage of the venting system.

UNSAFE VENTING

Direct-vent heaters may allow CO to enter the occupied space if the viewing or access panel(s) are removed and not reinstalled correctly. Sealing gaskets which have deteriorated or are incorrect for the application also provide a path for combustion products to enter the space. Never attempt to repair sealing systems with anything other than parts or products specified by the manufacturer. Instructions regarding correct assembly, torqueing of fasteners or curing of sealants, must be followed to ensure separation of flue products from the living space.

HEAT DISTORTION TO PLASTIC VENTING

CAUTION

Never attempt to repair sealing systems with anything other than parts or products specified by the manufacturer.

Instructions regarding correct assembly, torqueing of fasteners, curing of sealants, must be followed to ensure separation of flue products from the living space.

Building Depressurization

Appliances which are not direct-vent can be affected by building depressurization, especially at the start of a call-for-heat cycle. If adequate make-up air is not supplied, mechanical exhaust equipment (bathroom fans, kitchen fans, dryers, ventilators) may cause depressurization of the structure to the point where appliance vents are reversed and products of combustion spill within the structure. Combustion air supply systems are not sized to act as make-up air for other sources of depressurization.

If another fuel-burning appliance (oil furnace, wood stove, fireplace) is installed without its own adequate air supply, it may reverse a natural gas vent to obtain sufficient combustion air.

Increasing the energy efficiency of a building by weather-stripping doors, replacing windows and/or sealing air leaks without considering if adequate make-up and combustion air are available can lead to gas vents acting as air supplies rather than vents.

Occupants may deliberately block combustion air inlets in response to cold drafts. Adding bathroom fans, or replacing a kitchen exhaust fan with a higher-capacity model may also lead to inadequate air supply.

A renovation which results in the appliances being isolated in a sealed room without sufficient combustion and ventilation air is a common cause resulting in appliance back drafting.

Depressurization may also occur within a mechanical room if return air ducting is poorly constructed or sealed, or service panels on the negative-pressure side of air handling equipment are missing or incorrectly secured.

Although natural-draft appliances are equipped with draft diverters which are designed to prevent downdrafts from entering the combustion chamber, a strong downdraft may actually interfere with burner operation to the point of producing excessive CO.

At the start of a heating cycle, an atmospheric appliance will have a significantly more difficult time establishing draft in the vent if it is opposed by cold outside air being drawn down the vent through depressurization.

A common symptom reported to a gas fitter refers to “a pilot light that keeps going out on the water heater.” In many cases, the initial assumption is a fault with the water heater’s pilot safety system, leading to replacement of the thermocouple, pilot burner, gas valve, or the entire water heater. In many of these cases, the fault is not with the water heater, but depressurization interfering with the stability of the pilot light, main burner, or both. The safety system is actually functioning correctly; the cause has been misdiagnosed

If a water heater is located close to a forced air furnace, and they are isolated in a mechanical room, depressurization can occur if the return-air ducting is poorly sealed and the furnace blower is operating. Incorrectly installed or missing filter access panels or filter rack caps can also produce the same result.

Remember that these conditions may only appear when the furnace room door is closed; the problem usually disappears when the doors are opened and the system is allowed to balance with the rest of the structure.

Appliances with access from garages can be at risk for these conditions, as the building authorities require solid, tight-fitting doors with automatic closers to be installed at the access point. If these doors are not kept closed and in good repair, there is also the risk of exhaust gases from vehicles in the garage being drawn into the structure.

Central vacuum systems, although not usually operated for extended periods of time, usually have the power unit vented to the outdoors, or are located in a garage separate from the living area.

Portable air conditioners are growing in popularity; when connected to provide cooling, they utilize an exhaust vented to the outdoors which will contribute to building depressurization.

As noted earlier, the operation of mechanical exhaust equipment can disrupt the venting of atmospheric gas appliances, oil furnaces, fireplaces, and woodstoves.

Typically, new construction has been evaluated by building code officials to ensure adequate combustion and make-up air is provided to the structure; renovations and upgrades can result in a shortfall of replacement air which can impact the combustion and venting of atmospheric appliances.

Many homes are now equipped with heat or energy recovery ventilators (HRV's). HRV's increase energy efficiency and comfort levels by extracting warm, humid air from the living space and passing it through an air-to-air heat exchanger before exhausting it to the outdoors.

The HRV tempers incoming fresh air with heat scavenged from the exhaust flow. After installation, the HRV must be balanced in accordance with the manufacturer's instructions to ensure the amount of replacement outside air is matched to the volume being exhausted. If the system is not balanced, or additional mechanical exhaust is installed without allowance for increased make-up air (e.g., a larger capacity kitchen exhaust fan), depressurization may occur.

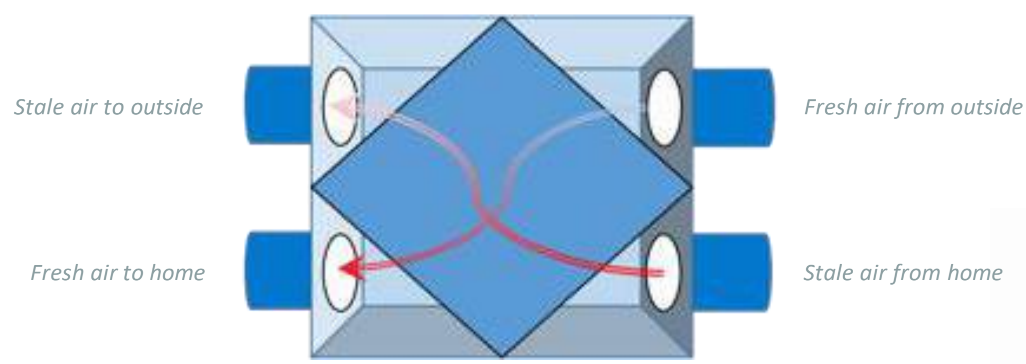
If the inlet air grille and filters are not maintained in accordance with the manufacturer's instructions and become restricted or blocked, the HRV will become an additional mechanical exhaust, increasing the chances of down drafting of atmospheric appliances.

As the majority of HRV's operate with a variety of fan speeds, it is important to verify airflows as detailed in the manufacturer's instructions.

A gas fitter must be aware of the factors which may lead to depressurization and its effect on atmospheric appliances. Combustion and ventilation air supplies are to be checked for obstructions, whether deliberate, e.g., "plugged by the occupant in order to stop a cold draft", or through lack of maintenance; an accumulation of debris on the inlet grille screen restricting or stopping the airflow.

A check for adequate venting of atmospheric appliances requires:

1. All doors and windows to be closed.
2. Solid fuel appliance dampers to be closed.
3. Atmospheric gas appliances shut down. Appliances equipped with pilot lights may be set to the "Pilot" position.



HEAT RECOVERY VENTILATOR

4. Start up all mechanical exhaust equipment, and any other vented gas appliance(s).
5. Continuously monitor ambient air levels while performing this test.
6. After five minutes, start each atmospheric appliance in turn. With a smoke tube, taper, incense stick, or similar, check for spillage of outside air and/or combustion products at the draft hood and burner deck.
7. Monitor each draft hood for approximately five minutes to determine if venting is established.
8. Shut down mechanical exhausts, and return the atmospheric appliances to their normal states.

If correct venting is not established due to the effects of mechanical exhaust, sufficient make-up air must be added to the structure. Depending on the local building authority, the air may have to be tempered through the use of a duct heater or fan-coil. The gas fitter must take steps in the interim to ensure appliances vent effectively. Options include disconnection or securing of circuit breakers controlling exhaust fans or dryers, or the blocking of windows in positions to provide temporary air supplies.

NOTE: See Appendix "C"

HVAC industry professionals may be utilized to perform additional testing to determine effective permanent make-up air solutions. Natural Resources Canada, in partnership with the Heating, Refrigeration, and Air Conditioning Institute of Canada, have created the Residential Air System Design Technician (RASDT) and Residential Hydronics Design Technician (RHDT) Designations. Individuals holding these designations have been certified in the design and commissioning of residential ventilation systems, and can provide analysis and advice on the effects of depressurization on a structure. Local building authorities may also provide information on resources available within their jurisdictions.

The Canadian Standards Association (CSA) Group (with input from regulators), the HVAC industry, and other interested parties, have produced a Canadian standard: F300 Residential depressurization. This standard describes a method to identify when residential depressurization can cause a health risk, and provides solutions to prevent or mitigate the buildup of products of combustion within the house. The standard is available for purchase through CSA's website: **Shop CSA - Standards.**

Unvented Appliances

Cooktops, ranges, and ovens are capable of generating excessive CO, especially if the equipment is in poor repair, or is used incorrectly. Unvented cooking appliances should NEVER be used for space heating, and should be serviced regularly.

Exhaust fans should be used when the appliance is in operation, and the fan should be vented to the outdoors. Placing pots or griddle plates on stove top burners will produce a maximum amount of CO while the pot and contents heat up. Once the cooking temperature is reached, the amount of CO generated drops considerably. Oven pans must be kept clear of foil as the foil may obstruct secondary air openings to the burner and cause excess CO to be produced.

Range burners should never be operated without the correct support grates in place; using grates other than what is specified by the manufacturer can cause excessive impingement and/or quenching of the flame. Lazy, yellow, luminous flames indicate a problem with burner operation.

Possible causes include:

- Incorrect oversized orifice installed
- Adjustable spud orifice has been set for natural gas; appliance is operating on propane
- Incorrect manifold pressure
- Incorrect supply system pressure
- If equipped with a primary air shutter, the shutter is not sufficiently open, or the ports are blocked with lint or debris
- Damaged, warped, or missing spreader bars on oven or broiler burners
- Installation of a replacement burner which does not meet the manufacturer's specifications

Plugged or Damaged Heat Exchangers

Appliance heat exchangers, whether air-to-air, or air-to-liquid, require regular inspection and maintenance to operate safely and efficiently. In some cases, errors in the installation or configuration of the appliance may need to be corrected in order to provide safe, dependable performance moving forward.

PLUGGED AND CORRODED BOILER HEAT EXCHANGER

If a gas fitter discovers an appliance with a significantly obstructed heat exchanger, additional investigation is required to determine the root cause(s) leading to plugging. The client should be asked relevant questions, and appliance records should be examined, to provide background information on:

- Frequency of service
- Quality and type of service performed
- Attendance of utility (Fortis, etc.) technicians
- CO alarm activation (if present in the occupancy)
- Attendance of First Responders
- Complaints of illness indicating CO exposure

Atmospherically-vented boilers or hot water heaters (HWH), particularly low-mass finned tube, are susceptible to plugging on the burner side if systems are not correctly designed, installed, operated, and maintained. Combustion-side restrictions lead to a cascading effect which can result in a significant amount of CO being produced by the appliance.

Scaling or silting on the water side of a boiler or HWH may lead to client complaints of high gas bills, lack of hot water, lack of heat within the space, or tripping of safety limits. Reduction of heat transfer on the combustion side can also produce the same complaints, but with the addition of a significant hazard.

Restricted or plugged flue passages lead to incomplete combustion and CO production. With the appliance unable to provide the amount of heat required to satisfy demand, it continues to operate in an attempt to satisfy the call for heat. This typically results in elevated CO production until the flue passages are plugged to the point where the flame-rollout switch (if present) opens, or the control wiring is damaged by heat and flames and the gas valve is disabled. This scenario is cited in many cases involving CO fatalities.

Boilers which provide domestic, pool or spa heating, as well as space heating are susceptible to these conditions year-round, not just during the heating season.

Points for the gas fitter to consider when analysing a plugged heat exchanger on a boiler or HWH:

- Is the inlet or return water temperature within the manufacturer's specifications? Water temperatures below required minimums can lead to condensation and scaling on the fire-side of heat exchangers.
- Is the appliance equipped with an internal bypass to maintain the required temperature rise? If so, is it functioning correctly? Scale, sludge, or mechanical failure can cause these to quit working, and allow excessive amounts of cool water into the boiler.
- Has a manual bypass been installed? If so, has it been adjusted to maintain an acceptable temperature rise through the boiler?
- Has the appliance been installed in accordance with the manufacturer's certified instructions? In many cases, the manufacturer requires the use of heat exchangers to isolate the boiler from excessive amounts of cool water passing through the coils.
- Is the firing rate correct? Underfiring can produce extended periods of condensing, leading to scale buildup on the coils.
- How clean is the combustion air supplied to the appliance? Are there excessive amounts of lint or pet dander being drawn into the combustion chamber? Not only can the debris plug primary air ports on an atmospheric boiler, or deposit in the coils, it can also foul inducer fans on the downstream side further reducing efficiency and affecting the combustion process.

Points to consider when analysing a plugged or damaged heat exchanger on a forced-air furnace:

- Does a visual inspection of the heat exchanger(s) reveal holes, rust staining or separated seams?
- Is there soot present on exchanger surfaces?
- Is the flame pattern on an atmospheric furnace disrupted when the circulating fan operates?
- Is there increased CO over ambient air present in the circulating airstream as measured at hot-air outlets?
- Is there evidence of flame roll-out, or heat damage, at the burner compartment?
- Are the temperature rise and static pressure across the heat exchanger within the manufacturer's specifications?

NOTE: See Appendix "B"

CARBON MONOXIDE LEVELS

AMBIENT AND FLUE GAS

CARBON MONOXIDE LEVELS – AMBIENT AND FLUE GAS

Ambient Carbon Monoxide

Flue gas analysis is a diagnostic tool which provides the gas fitter with important information regarding the safety and efficiency of a gas appliance.

All appliance standards include a maximum amount of CO which may be produced by an appliance; the most current values are included in Appendix "A" at the end of this document.

Although there is less risk of CO entering the occupied space from a sealed-combustion appliance, testing is required to confirm the appliance is operating as intended by the manufacturer, and that exhaust gas temperatures and CO content are at acceptable levels.

Care must be taken that flue gas containing excessive CO is not drawn into an occupied space through open windows and doors, or air handling equipment.

A gas fitter responding to a client call regarding CO must first ensure their own safety prior to entering the occupied space or mechanical room.

Typically, a utility technician or fire personnel will be the first on-scene, and will deal with the immediate life-safety issues. In outlying or unorganized areas, the gas fitter may be the only technical resource available, and may be called upon to manage all aspects of a CO emergency.

CAUTION

If the gas fitter suspects their client is being exposed to CO, advise them to:

- Call 911 or their emergency number – if available.
- Open all doors and windows.
- Get fresh air immediately outside.
- Seek medical attention if needed.
- Turn off any appliances that they suspect are faulty.

A gas fitter must determine the safety of the environment they are planning on entering.

Personal gas monitors are available either as a single CO gas monitor or a multi-gas monitor can be purchased with CO as one of the selected gases. Common options are Oxygen, CO, Hydrogen Sulfide, and Combustible Gas (Lower Explosive Limit).

The Canadian Standards Association (CSA) C22.2 NO. 152-M1984 (R2016) - Combustible Gas Detection Instruments standard is a recognized standard for monitors used in Canada.

A combustion analyzer may also be used to determine the air quality in the space. Gas sampling tubes and pumps (either manual or automatic) are also an option. Sampling tubes have the advantage of not requiring calibration or bump testing prior to use, and there are no sensors to replace.

Regardless of which system is used, the gas fitter must follow all of the instructions provided by the manufacturer regarding storage, calibration, training, maintenance, and repair.

Any measuring or monitoring device must be zeroed in clear outside air prior to testing being performed inside a structure. Failure to do so may result in serious injury or death. Carbon monoxide is commonly referred to as “The Silent Killer”.

WorkSafeBC (WSBC), through Section 5.48 of the Occupational Health and Safety Regulation, has set the

CO DETECTOR

eight hour time weighted average (TWA) for CO at 25 parts per million (PPM). Eight-hour TWA is defined as “the time weighted average (TWA) concentration of a substance in air which may not be exceeded over a normal eight hour work period”.

WSBC’s short term exposure limit (STEL) is 100 PPM. STEL is defined as “the time weighted average (TWA) concentration of a substance in air which may not be exceeded over any 15 minute period, limited to no more than four such periods in an 8-hour work shift with at least one hour between any two successive 15 minute excursion periods”.

CAUTION

Upon entering the building, the gas fitter must test for CO. If an ambient CO level is measured at more than 100 PPM, the gas fitter must leave the area and notify any affected occupants while leaving the building. The gas supply must be turned off outside the building. Local emergency services must be notified. The gas fitter may attempt to evacuate the building, but must not expose themselves to CO levels above 100 PPM, regardless of duration.

If the readings throughout the building are less than 10 PPM, and the gas appliances and other sources such as vehicles, wood or coal fireplaces, smoking or barbeques, have been eliminated as the source of CO, the CO levels may be considered as acceptable.

If ambient air testing at any location within the building indicates a CO level between 10 and 70 ppm, the building should be ventilated and evacuated until the CO source has been eliminated.

If ambient air CO levels are between 71 and 100 ppm, and gas appliances are the suspected source, the gas fitter must shut off the gas supply to the appliances and attempt to ventilate the building. Local emergency services may be required to assess the need for evacuation. The gas fitter must minimize the time spent working in these conditions, as the STEL is 15 minutes for a CO level of 100 ppm.

A gas appliance that produces CO levels in ambient air must be investigated to determine if the cause can be corrected prior to the gas fitter leaving the site. If not, the appliance is to be shut-off, the reasons explained to the occupant(s), and the appropriate jurisdiction notified in accordance with section 54 of the Gas Safety Regulation:

Unrepairable Appliance

54 (1) A person who finds any appliance or gas equipment beyond repair or in an unsafe condition must

- **(a)** place the appliance or gas equipment out of service, and
- **(b)** promptly notify a safety officer of its condition and location.

54 (2) If the initial notification under subsection (1) (b) is verbal, it must be promptly confirmed by a written statement setting out the facts.

Reporting requirements are detailed in Information Bulletin: **NO: IB-GA 2017-03** "Incident and Hazard Reporting to Technical Safety BC Gas". This bulletin is available on **Technical Safety BC's website**. Occupants exhibiting signs of CO exposure should be referred to emergency medical services to determine the severity of their exposure, and the degree of treatment needed.

UNSAFE APPLIANCE

Investigating Ambient Carbon Monoxide Causes

Prior to entering the building, ensure the measuring device has completed its calibration in fresh air. Learn more from the client regarding any circumstances leading to the suspicion of CO exposure. Other sources of CO need to be investigated, such as:

- Solid fuel fireplaces and stoves
- Barbecues (natural gas, propane, and charcoal)
- Attached garages and idling vehicles
- Candles
- Smoking habits and frequency

The gas fitter should assess each gas appliance in turn, without making any adjustments or changes. Appliances, their venting systems, and combustion/make-up air supplies are to be examined for problems and possible safety hazards which may be causing CO to enter the occupied space. Refer to previous sections of this manual for information regarding building depressurization and venting issues.

Ovens and range tops discharge flue gases directly into the living space. An oven may have a flue gas sample taken from the flue outlet as follows:

1. Set the temperature to 177ºC (350oF), allow the oven to reach temperature and begin cycling.
2. The oven should cycle for at least five minutes.
3. Insert the analyser's probe as far as possible into the outlet and sample the gases for an additional five minutes, or until a stable reading is recorded.

Range top burners can have their combustion products sampled with the probe held above the burner at a point where excessive heat will not damage the probe.

If a gas range is suspected of producing ambient CO levels in excess of 10 ppm, further investigation is needed. If an oven's flue gas sample is greater than 400 ppm after warm-up, the gas supply must be shut off as per the "Unrepairable Appliance" section noted previously.

A reading less than 400 ppm, but greater than 250 ppm indicates the oven is in need of service or repair, and should be addressed. Readings less than 250 ppm also suggest service should be performed to reduce CO levels. All occupants should be advised that the exhaust fan (if vented to the outdoors) should be in operation while using the oven and/or range top burners. If an exhaust fan is a recirculating type, or no exhaust fan is installed, a window in the same space as the appliance should be open while using the oven or range.

Flue Gas Carbon Monoxide

Flue gas analysis is important in helping the gas fitter determine the relative condition of a gas appliance, and whether there are issues resulting in the excessive production of CO.

Flue gases have a more direct path into the occupied space from appliances which are not direct-vent, but this should not allow the gas fitter to ignore CO levels outside of manufacturer's (or the certification standard's) limits.

Excessive CO in a sealed-combustion appliance usually points to problems with the combustion system which can reduce efficiency and/or heating capacity, significantly shorten the life of the appliance, and damage components or the venting system.

Plugged or restricted flue passages or chimneys, or building depressurization, can result in flue gases entering the living space. Vented appliances must effectively remove all combustion products to the outdoors, regardless of whether or not they contain CO.

Whenever the manufacturer provides set-up instructions and/or target combustion efficiency parameters, the appliance shall be adjusted to those values. Manufacturers typically build in a safety factor to their values to establish a buffer between normal operation and potentially unsafe or damaging performance.

Attempting to "tweak" additional efficiency from an appliance by reducing excess air towards the stoichiometric ratio can result in the production of large amounts of CO if fuel/air mixing deteriorates, or the amount of combustion air delivered to the burner is reduced through dirt buildup on fan blades, airboxes or louvers.

Carbon Monoxide is flammable at the lower explosive limit (LEL) of 12.5% and has an ignition temperature of 609ºC (1128º F). An additional hazard is the possible formation of free hydrogen gas during the incomplete combustion process.

Hydrogen has an LEL of 4% and will auto-ignite at 495ºC (923º F). Care must be taken to ensure adequate excess air is available for the combustion process. The presence of oxygen in flue gases is an important indicator of adequate combustion air.

Sampling of combustion gases needs to take place as close to the combustion chamber as possible, and without the addition of dilution air from draft hoods or barometric dampers.

Depending on the style of sampling probe, it can either be dropped down the draft diverter opening towards the combustion chamber, or inserted through a hole drilled in the flue collar as close as possible to the chamber. For furnaces with clamshell style heat exchangers, a sample can be taken from the top of each flue passage.

For mid-efficiency appliances equipped with inducer fans, the sample can be taken from a hole drilled in the flue collar/vent connection. Many manufacturers of high-efficiency appliances are now including sampling ports on the flue outlet; some are also including a port on the combustion air inlet fitting.

If a manufacturer includes combustion analysis values in their installation/servicing instructions, an accessible sampling point must be provided.

S636 certified plastic venting systems provide "access tees", which include a ½" FIP branch and plug. A standard S636 tee can also be used, with the use of a bushing with a ½" FIP tapping.

A condensate tee should not be used, as condensate draining out of the tee can flood the analyser's trap, causing nuisance shutdowns and possibly damaging the instrument.

If a manufacturer does not specify combustion analysis values, the following can be used as a general guide:

	ATMOSPHERIC DRAFT APPLIANCE	INDUCED DRAFT APPLIANCE	CONDENSING APPLIANCE (90%+)	POWER BURNER
O2	4% - 9%	7% - 9%	5% - 7%	3% - 6%
CO2	6.5% - 8%	6.5% - 8%	7% - 8.5%	8.5% - 11%
STACK TEMP.	163ºC - 260ºC (325ºF - 500ºF)	163ºC - 204ºC (325ºF - 400ºF)	< 52ºC (125ºF)	160ºC - 299ºC (320ºF - 570ºF)
DRAFT	-0.02" wc - -0.04" wc	-0.02" wc - -0.04" wc	As per manufacturer's specifications	As per manufacturer's specification
CO	< 50 ppm air-free	< 50 ppm air-free	< 50 ppm air-free	< 100 ppm air-free

CARBON MONOXIDE ALARMS

CARBON MONOXIDE ALARMS

CAUTION

CO alarms can provide an additional level of protection for occupants where fuel-burning appliances are located. They are not a substitute for regular inspection and maintenance of gas appliances by qualified gas fitters, but do provide extra monitoring in-between service intervals. They are also not a substitute for smoke alarms, although some manufacturers are now producing models which combine both functions in a single unit.

The BC Building Code requires CO alarms to be installed in new construction where fuel burning appliances are installed. The City of Vancouver is the only jurisdiction in the province requiring CO alarms in all residential occupancies that contain a fuel burning appliance and/or an attached garage. Outside of Vancouver, there is no requirement for alarms to be installed in dwellings built prior to the changes to the Building Code.

It is strongly recommended that all occupancies with gas-fired appliances install CO alarm(s) in accordance with the current BC Building Code specifications:

- CO alarm(s) installed in every bedroom or within 5 meters (16 feet) of each bedroom door.
- If a fuel-burning appliance, such as a fireplace, is located inside a bedroom, the CO alarm should be installed within the bedroom.
- The CO alarms shall:
  - Conform to CAN/CSA 6.19, Residential Carbon Monoxide Alarming Devices
  - Be equipped with an integral alarm that satisfies the audibility requirements of CAN/CSA 6.19
  - Be battery operated or hardwired, and
  - Have no disconnect switch between the overcurrent device and the CO alarm, where the CO alarm is powered by the dwelling unit's electrical system, and
  - Be mechanically fixed at a height as per manufacturer's recommendations
- Units combining smoke and CO alarms are acceptable

CAN/CSA 6.19 is the recognized Canadian standard for CO alarms intended for use in ordinary locations in residential occupancies. This includes dwelling units, recreational vehicles and mobile homes, and unconditioned areas. The recognized Canadian standard for multi-criteria smoke alarms (which combine smoke and CO detection in a single device) is CAN/ULC S531. With these devices, the CO alarm portion must meet CAN/CSA 6.19. Always look for the listing information on the device and its packaging, locate and install it in accordance with the manufacturer's instructions. Also, test and maintain the device as directed in the instructions; these devices have a service life and will need replacing on or before the date marked on the unit.

If an alarm fails to operate correctly when the test button is pushed, refer to the troubleshooting section in the manual. An alarm which is not operating correctly, or displaying an "end of life" message will not respond to CO and must be replaced immediately.

CO alarms sound different from smoke alarms when they activate. By introducing a new emergency device into the home, it is important that everyone in the household knows the difference between an alarming smoke alarm and an alarming CO alarm. According to the CO alarm standard, a CO alarm signal consists of four very quick beeps followed by a five second pause and the pattern is repeated. This contrasts with a smoke alarm's signal as defined by the smoke alarm standard CAN/ULC S531, which consists of three beeps followed by a 1.5 second pause, and then this pattern is repeated.

Occupants need to know the difference between an actual alarm sound versus the low battery or end of life warnings for both their smoke and CO alarms. Owners should consult their instruction manual to obtain further information on the characteristics of the audible and/or visual signals for each device.

CAUTION

Do not ignore any activation of a CO alarm!

Although the alarm can be triggered by gases or conditions other than CO, an activation must be investigated to determine the cause. Dismissing an alarm signal as a nuisance may result in injury or death. Never disable or remove a CO alarm if it's activated. A significant number of CO incidents have escalated due to occupants ignoring or defeating a CO device in alarm mode.

APPENDIX "A-C"

APPENDIX “A”

Selected Canadian Gas Appliance Standards

Note that the values given below are “maximum” levels; the gas fitter should attempt to adjust and tune each appliance to produce the minimum amount of CO while still keeping the adjustments in line with the manufacturer’s certified instructions.

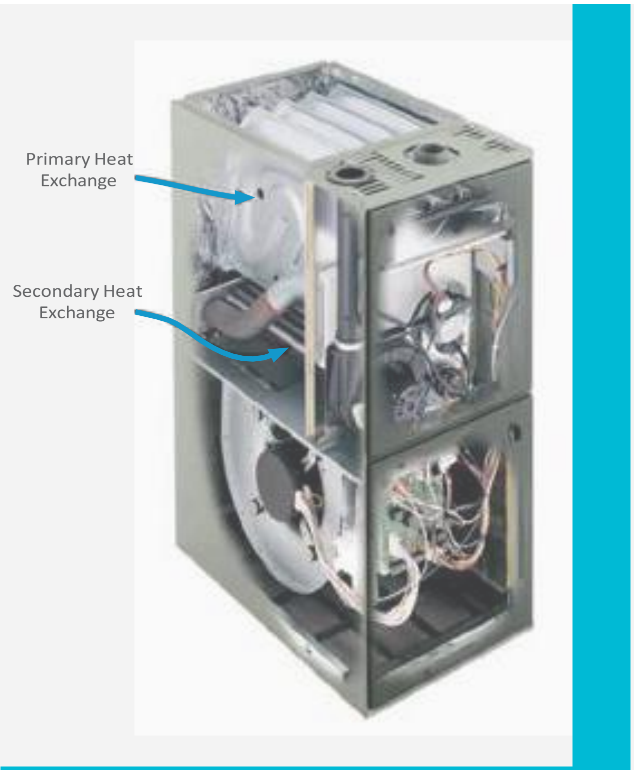
Allowable CO Levels

CSA NUMBER	CURRENT CANADIAN STANDARD	AN APPLIANCE SHALL NOT PRODUCE A CONCENTRATION OF CARBON MONOXIDE IN EXCESS OF:
ANSI Z83.25-2017/CSA 3.19-2017	Direct gas-fired process air heaters	5 ppm Maximum Average Concentration added
CSA/ANSI Z21.13:22 /CSA 4.9-22	Gas-fired low pressure steam and hot water boilers	400 ppm air-free
CSA/ANSI Z21.88:19/CSA 2.33:19	Vented gas fireplace heaters	200 ppm air-free for gravity vent and 400 ppm air-free for direct vent and power vent appliances
ANSI Z83.11-2016/CSA 1.8-2016	Gas food service equipment	800 ppm air-free
CSA/ANSI Z21.47:21/CSA 2.3:21	Gas-fired central furnaces	400 ppm air-free
ANSI Z21.60-2017/CSA 2.26-2017	Decorative gas appliances for installation in solid-fuel burning fireplaces	400 ppm air-free
CSA/ANSI Z21.5.1:22/CSA 7.1:22	Gas clothes dryers, volume I, type 1 clothes dryers	400 ppm air-free
ANSI Z83.8-2016/CSA 2.6-2016	Gas unit heaters, gas packaged heaters, gas utility heaters, and gas-fired duct furnaces	400 ppm air-free
CSA/ANSI Z21.10.3:19/CSA 4.3:19	Gas-fired water heaters, volume III, storage water heaters with input ratings above 75,000 Btu per hour, circulating and instantaneous	400 ppm air-free
CSA/ANSI Z21.1-2018/CSA 1.1-2018	Household cooking gas appliances	800 ppm air-free
ANSI Z83.4-2017/CSA 3.7-2017	Non-recirculating direct gas-fired heating and forced ventilation appliances for commercial and industrial application	5 ppm Maximum Average
CSA/ANSI Z21.58:22/CSA 1.6:22	Outdoor cooking gas appliances	800 ppm air-free
ANSI Z21.97-2017/CSA 2.41-2017 (R2022)	Outdoor decorative gas appliances	800 ppm air-free
ANSI Z21.86-2016/CSA 2.32-2016	Vented gas-fired space heating appliances	200 ppm air-free
ANSI Z83.7-2017/CSA 2.14-2017	Gas-fired construction heaters	200 ppm air-free

APPENDIX "B"

Suggested Method to Inspect the Heat Exchanger of a Residential Furnace

The primary heat exchanger in a furnace can be made from rolled steel of two mirror image parts seamed together like a clam shell or use tubing. Condensing furnaces will use a device that looks similar to a car radiator for the secondary heat exchanger.



PRIMARY AND SECONDARY HEAT EXCHANGER

Many furnaces fail by developing cracks in the sheet metal, cracks along welded seams, or holes due to rust or corrosion.

Heat exchangers can fail by becoming overheated. The heat exchanger is protected from overheating by a carefully adjusted high limit. The high limit causes the furnace to cycle to its off position when the temperature of the air in the plenum exceeds the limit set by the technician.

Plugged air filters accelerate heat exchanger failure. A furnace filter neglected for several heating seasons will block the flow of air through the heat exchanger. The internal temperature of the furnace may exceed the continuous operating design temperature without reaching the high limit setting. Broken welds and cracks may result.

A notable number of heat exchangers have been known to fail from abnormal rust accelerated by the presence of chlorinated compounds. A chlorinated compound is any compound to which a chlorine molecule is attached. Many household products are chlorinated such as detergents, bleach, solvent and paint thinners. When these compounds mix with humidity, hydrochloric acid is formed and is drawn into the furnace where the acid produces rust and salt deposits. The salt deposits re-combine with moisture from the air to continue the corrosive process and rapidly ruin a heat exchanger.

Rust may occur due to condensate leaks onto the heat exchanger from an air conditioner coil, from humidifier leaks, or simply from location of the furnace in a damp or wet location.

Steps involved for inspecting a furnace's heat exchanger:

1. Look for flame disturbances.

   Start the furnace and observe any changes in the flame pattern as the circulating air blower starts operating. Look for floating flames, flame roll-out or flame distortion. These conditions indicate a possible split seam, open crack, severe deterioration of the heat exchanger or gasketing material, or physical separation of the connected parts. If a flame disturbance occurs after the blower comes on, it is a good indication that a problem may exist in the lower portion of the heat exchanger (up-flow furnace). If this is the case, proceed to Step 4.

NOTE: Ensure that there are no outside drafts that could be causing the flame disturbance.

2. Measure CO levels in the airstream.

   With the furnace operating, measure the CO level in the return air duct near the furnace and record the value. Next, measure the CO level in the supply ducting leaving the furnace. Record this value. If there is no measurable difference in the CO level in the return and supply airstreams, it is likely the furnace is not leaking CO into the airstream. If the CO in the supply air ducting is greater than the CO in the return air, it is likely that the furnace is supplying the CO through the heat exchanger. If this scenario is encountered, proceed to Step 4.

3. Measure oxygen levels in the vent.

   Induced draft furnaces are less likely to leak products of combustion into the circulating air stream than a natural draft furnace due to the negative pressure inside the heat exchanger created by the inducer fan. Insert the flue gas analyzer probe into the vent. Observe the oxygen level. If a significant increase occurs when the circulating fan is energized, it is possible that the heat exchanger is damaged. Proceed to Step 4.

4. Visually inspect the heat exchanger.

   Occasionally holes formed by rust or cracks can be seen with the eye or with the aid of a mirror, but often only 20% of the total surface of the heat exchanger is visible to view, even with a mirror once a furnace is installed. Some holes or cracks are visible only when thermal expansion causes the cracks to open, which can be difficult to observe when the furnace is operating. If the furnace fails any of the three preceding steps, careful attention should be made to the visual inspection. This may require the removal of the circulating fan to see the bottom of the heat exchanger and cutting an access door into the supply plenum to see the top of the heat exchanger. Pay particular attention to welds, seams, joints and discoloured spots on the heat exchanger(s). If the burners are removed, a flashlight may be directed into each heat exchanger and visually inspected from the outside, looking for signs of light. If available, an inspection camera could be inserted into each heat exchanger.

Clause 4.21 of the CSA B149.1-Natural gas and propane installation code lists requirements that must be followed if a heat exchanger is found to be defective.

APPENDIX "C"

SUGGESTED CHECKLIST FOR DEPRESSURIZATION

Details

Address:	Date:	Invoice #:
Contractor Name:	Contractor Licence #:	Contractor Email:
Gas fitter Name:	Gas fitter Certification #:	Phone:

Gas Appliances

	Appliance Type	Input (MBH)	Direct Vent	Venting Material	Evidence of Downventing	Vent Condition
Appliance 1			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 2			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 3			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 4			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 5			☐ Yes ☐ No		☐ Yes ☐ No	
Comments:						

Solid and Liquid Fueled Appliances

	Appliance Type	Input (MBH)	Direct Vent	Venting Material	Evidence of Downventing	Vent Condition
Appliance 1			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 2			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 3			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 4			☐ Yes ☐ No		☐ Yes ☐ No	
Appliance 5			☐ Yes ☐ No		☐ Yes ☐ No	
Comments:						

Combustion and Ventilation Air

Combustion air supply for the gas appliances	Size:	Meets code requirements ☐Yes ☐No
Ventilation air for gas appliances ☐Yes ☐No ☐Not Required	Size:	Meets code requirements ☐Yes ☐No
Make-up air supplied to building ☐Yes ☐No ☐Not Required	Size:	Meets code requirements ☐Yes ☐No
Make-up air supply type ☐Static ☐Fan ☐Not Required	Is a balancing report on file ☐Yes ☐No	
Is a heat recovery ventilator (HRV) installed ☐Yes ☐No	Are all filters in place and clean ☐Yes ☐No	
Are all air supply inlet grilles free of lint, debris, etc. ☐Yes ☐No	Are air supply inlet grilles free of lint, debris, etc.☐Yes ☐No	
Maintenance records available ☐Yes ☐No		
Comments:		

Mechanical Exhaust Equipment

Mechanical exhaust	Type: Kitchen fan, bathroom fan, dryer, etc.	Capacity (CFM)
Exhaust 1		
Exhaust 2		
Exhaust 3		
Exhaust 4		
Exhaust 5		
Comments:		

PERFORM THE FOLLOWING TEST

1. All doors and windows to be closed.
2. Solid fuel appliance dampers to be closed.
3. Atmospheric gas appliances shut down. Appliances equipped with pilot lights may be set to the “Pilot” position.
4. Start up all mechanical exhaust equipment, and any other vented gas appliance(s).
5. Continuously monitor ambient air levels while performing this test.
6. After five minutes, start each atmospheric appliance in turn. With a smoke tube, taper, incense stick, or similar, check for spillage of outside air and/or combustion products at the draft hood and burner deck.
7. Monitor each draft hood for approximately five minutes to determine if venting is established.
8. Shut down mechanical exhausts, and return the atmospheric appliances to their normal states.

Atmospheric Vented Gas Appliances

Exhibit spillage at draft hood after 5 minutes ☐Yes ☐No	Comments:
If “Yes” to above, additional air supply added ☐Yes ☐No	Comments:
If additional air supply added, is it permanent or temporary ☐Permanent ☐Temporary	

Gas Cooking Appliances

Is an exhaust system installed ☐Yes ☐No	Comments:
If “Yes” to above, is it vented outside ☐Yes ☐No	Comments:
Have the hazards of using a cooking appliance for space heating been discussed with the occupant ☐Yes ☐No	
Have all gas appliances been left in a safe operating condition ☐Yes ☐No	

NOTES

TECHNICAL SAFETY BC

Safe technical systems. Everywhere.