CHAPTER 2

Safety Fundamentals

Learning Objectives

Upon completion of this chapter, students will be able to:

1. Select and properly use personal protective equipment (PPE) for gas work
2. Identify and assess hazards associated with natural gas and propane
3. Explain flammability limits and explosive ranges for natural gas and propane
4. Describe proper emergency response procedures for gas leaks and fires
5. Apply WHMIS 2015 requirements to gas industry work
6. Use gas detection equipment properly and interpret readings
7. Recognize symptoms of carbon monoxide exposure and understand prevention strategies
8. Implement lockout/tagout procedures for equipment servicing
9. Apply confined space entry procedures when required
10. Understand provincial occupational health and safety regulations

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2.1 Personal Protective Equipment (PPE)

Personal protective equipment is the last line of defense against workplace hazards. While engineering controls and safe work practices are preferred, PPE is essential when hazards cannot be eliminated.

Head Protection

Hard Hats/Safety Helmets

Required in construction environments and when overhead hazards exist.

Types:

- **Type 1:** Top impact protection (most common in construction)
- **Type 2:** Top and lateral impact protection
- **Class E (Electrical):** Up to 20,000 volts protection
- **Class G (General):** Up to 2,200 volts protection
- **Class C (Conductive):** No electrical protection, lightweight

When Required:

- New construction sites
- Commercial/industrial installations
- Working near overhead hazards
- Working below others
- Confined spaces with vertical access
- Utility work

Proper Use:

- Inspect before each use for cracks, dents, or wear
- Replace after impact, even if damage not visible
- Adjust suspension for secure, comfortable fit
- Don't modify (drilling holes, painting weakens protection)
- Replace every 5 years or per manufacturer recommendation
- Don't wear backwards unless designed for reverse wear

CSA Standard: CSA Z94.1 - Industrial Protective Headwear

Eye and Face Protection

Gas work involves multiple eye hazards: flying debris, chemical splash, UV radiation from flames, and particles from drilling or cutting.

Safety Glasses

Minimum eye protection for all work sites.

Requirements:

- CSA Z94.3 certified
- Side shields required
- Impact-resistant lenses
- Available in prescription
- Anti-fog coating recommended

When Required:

- All work sites (minimum protection)
- Using hand tools
- Working around others using power tools
- General service work

Safety Goggles

Provide better protection against impact, dust, and chemical splash.

Types:

- Direct vented (impact protection)
- Indirect vented (chemical splash and impact)
- Non-vented (maximum chemical protection)

When Required:

- Using chemicals (pipe dope, cleaners)
- Cutting or grinding operations
- Dusty environments
- Working with refrigerants or other pressurized liquids

Face Shields

Full face protection for high-risk operations.

When Required:

- Brazing or welding operations
- Grinding
- Using chemical cleaners
- Battery work
- Combined with safety glasses (face shield alone insufficient)

Proper Use:

- Clean lenses regularly
- Replace scratched or damaged lenses
- Store in protective case
- Don't wear on top of head (contaminates lenses)
- Ensure proper fit (no gaps)

Hearing Protection

Types:

Disposable Foam Earplugs

- Single use
- Noise Reduction Rating (NRR) 29-33 dB
- Must be inserted properly (roll, pull ear up and back, insert)
- Inexpensive, convenient

Reusable Earplugs

- Washable
- Pre-molded designs
- Various materials (silicone, rubber)
- More comfortable for extended wear
- Must be cleaned regularly

Earmuffs

- NRR 20-30 dB
- Quick on/off
- Work over glasses and hard hats
- More expensive but more durable
- Can be combined with earplugs for extreme noise

When Required:

- Operating power tools
- Working near loud equipment (boilers, compressors)
- Construction environments
- Generally required when noise exceeds 85 dBA for 8 hours
- Requirements vary by exposure time and intensity

Proper Use:

- Check NRR rating adequate for noise level
- Insert earplugs properly
- Ensure earmuff seal around ears
- Don't lift one side to hear (defeats protection)
- Replace foam plugs when dirty or compressed
- Clean reusable protection regularly

CSA Standard: CSA Z94.2 - Hearing Protection Devices

Hand Protection

Hands are most frequently injured body part in gas work. Proper gloves protect against cuts, burns, chemical exposure, and cold.

Work Gloves - General Purpose

Leather gloves:

- Abrasion and cut resistance
- Heat resistant (moderate temperatures)

- Good dexterity
- General installation work

Synthetic/fabric gloves:

- Cut-resistant materials (Kevlar, Dyneema)
- Good dexterity
- Some chemical resistance
- ANSI cut levels: A1-A9 (A9 highest protection)

When to Use:

- Handling pipe and fittings
- Using hand tools
- Working with sheet metal
- General construction work

Chemical-Resistant Gloves

Nitrile gloves:

- Excellent chemical resistance
- Puncture resistant
- Good dexterity
- Resistant to petroleum products, oils, pipe dope

Neoprene gloves:

- Broad chemical resistance
- Moderate temperature resistance
- Less dexterity than nitrile

When to Use:

- Applying pipe dope or sealants
- Handling chemicals
- Fuel oil work
- Cleaning with solvents

Insulated Gloves

When to Use:

- Cold weather work
- Handling extremely cold propane lines
- Working with cryogenic fluids

Electrical-Rated Gloves

When Required:

- Working on energized electrical circuits
- Must be rated for voltage being worked on
- Regular inspection and testing required
- Usually worn with leather outer protectors

Important: Most gas technicians are NOT qualified for electrical work beyond low-voltage thermostats. Electrical-rated gloves are mentioned for awareness but should only be used by qualified electricians.

Proper Selection:

- Choose gloves appropriate for hazard
- Ensure proper fit (too large reduces dexterity, too small restricts movement)
- Inspect before each use
- Replace when damaged, contaminated, or worn
- Never use damaged gloves
- Consider dexterity requirements vs. protection level

Foot Protection

Safety Boots/Shoes

Requirements:

- CSA Z195 certified
- Steel toe or composite toe (minimum 125 joules/90 pounds impact)
- Puncture-resistant sole plate (where required)
- Slip-resistant sole
- Ankle support
- Electrical hazard rated (where required)

Grade 1 (Green Triangle):

- Sole puncture protection with plate
- Toe protection
- Required on most construction sites

Grade 2 (Yellow Triangle):

- Toe protection only (no plate)
- Suitable for many service environments

Additional Features:

- Metatarsal guards (additional top-of-foot protection)
- Electrical hazard (EH) rating
- Slip-resistant soles (oil, chemical resistant)
- Waterproof construction
- Insulation for cold weather

When Required:

- All construction sites
- Commercial/industrial installations
- Where heavy objects handled
- Provincial requirements vary but generally required for gas work

Proper Use:

- Ensure proper fit and support
- Lace/fasten completely
- Replace when soles worn
- Keep clean and dry
- Break in gradually to prevent blisters
- Replace safety toe if impact occurs

CSA Standard: CSA Z195 - Protective Footwear

Respiratory Protection

Gas technicians may encounter situations requiring respiratory protection, though this is less common than in some other trades.

Types:

Dust Masks (N95, N99)

- Filters particulates only
- No protection against gases or vapors
- Single use
- Must be fit tested
- Required for dusty environments

Half-Face Respirators

- Filters or cartridges for specific contaminants
- Must be fit tested annually
- Requires medical clearance

- Various cartridge types:
    - Organic vapor (for solvents)
    - Acid gas (for combustion products)
    - Combination cartridges
    - Particulate filters

Full-Face Respirators

- Better protection than half-face
- Includes eye protection
- Same cartridge options
- Required medical clearance and fit testing

Supplied-Air Respirators (SAR)

- External air source
- Required for IDLH (Immediately Dangerous to Life or Health) atmospheres
- Confined space entry
- Special training required

Self-Contained Breathing Apparatus (SCBA)

- Carried air supply
- Emergency/rescue use
- Fire department equipment
- Extensive training required

When Required:

- Confined spaces with inadequate oxygen
- Presence of toxic gases above acceptable limits
- Environments with unknown air quality
- Specific operations identified in risk assessment
- Asbestos abatement (specialized protection)

Important Considerations:

- Facial hair prevents proper seal (clean-shaven required)
- Medical clearance needed
- Annual fit testing required
- Cartridges have limited life span
- Must understand limitations
- Provincial regulations strictly govern respiratory protection

CSA Standard: CSA Z94.4 - Selection, Use and Care of Respirators

High-Visibility Clothing

When Required:

- Working near traffic or moving vehicles
- Construction sites with equipment operation
- Utility work
- Low-light conditions
- Often required by site safety rules

Classes:

- **Class 1:** Low-risk environments, parking areas
- **Class 2:** Medium-risk, traffic under 50 km/h
- **Class 3:** High-risk, highway work, high-speed traffic

Types:

- Safety vests
- Traffic jackets
- Full rain suits with reflective striping

CSA Standard: CSA Z96 - High-Visibility Safety Apparel

Other PPE Considerations

Knee Pads:

- Protect knees during prolonged kneeling
- Install low appliances, water heaters
- Types: strap-on or built into work pants

Back Support Belts:

- Controversial effectiveness
- Not substitute for proper lifting technique
- May provide reminder to lift correctly
- Should not be relied upon for protection

Fall Protection:

- Required when working above 3 meters (10 feet) in most provinces
- Full-body harness required (not belt-type)
- Must be trained in use
- Anchorage point calculations required
- Rescue plan must be in place

- Specialized training required - discussed further in working at heights

Sun Protection:

- Sunscreen for outdoor work
- Wide-brimmed hats
- UV-protective clothing
- Important for all-day outdoor installations

2.2 Hazard Recognition

Recognizing hazards is the first step in preventing accidents. Gas work involves multiple hazard types that must be identified and controlled.

Flammability Hazards

Flammable Range (Explosive Limits)

Both natural gas and propane will only burn within specific concentration ranges in air.

Natural Gas (Methane):

- **Lower Explosive Limit (LEL):** 5% by volume in air
- **Upper Explosive Limit (UEL):** 15% by volume in air
- **Flammable Range:** 5% to 15%

Propane:

- **Lower Explosive Limit (LEL):** 2.1% by volume in air
- **Upper Explosive Limit (UEL):** 9.5% by volume in air
- **Flammable Range:** 2.1% to 9.5%

Understanding the Ranges:

Below LEL (Too Lean):

- Not enough fuel to burn
- Will not ignite
- Still dangerous as concentration can increase

Within Flammable Range:

- EXPLOSION HAZARD
- Any ignition source can cause fire or explosion

- Most dangerous condition

Above UEL (Too Rich):

- Too much fuel, not enough oxygen
- Will not ignite in this state
- Will explode as it mixes with air and enters flammable range
- Still extremely dangerous

Critical Safety Point: Propane's wider flammable range (2.1%-9.5%) compared to natural gas (5%-15%) means propane creates explosive mixtures more easily. Propane's LEL of 2.1% means only small amounts create explosive conditions.

Ignition Sources

Gas will not burn without an ignition source. Common ignition sources on job sites:

Open Flames:

- Pilot lights
- Matches, lighters
- Cutting/welding torches
- Space heaters
- Smoking materials

Electrical:

- Sparks from switches, outlets
- Static electricity
- Power tools (brushed motors)
- Electrical arcs
- Lightning
- Faulty wiring

Mechanical:

- Grinding sparks
- Metal striking metal
- Friction heating
- Hot surfaces

Other:

- Hot work (soldering, brazing)
- Vehicle exhaust systems
- Furnace combustion chambers

- Any surface above auto-ignition temperature

Auto-Ignition Temperatures:

- Natural Gas: 540°C (1,004°F)
- Propane: 493-549°C (920-1,020°F)

Any surface at or above these temperatures will ignite the gas without spark or flame.

Asphyxiation Hazards

Both natural gas and propane displace oxygen. In confined spaces or enclosed areas, this can create asphyxiation hazards.

Normal Atmospheric Oxygen: 20.9%

Effects of Oxygen Deficiency:

Oxygen %	Effects
19.5%	Minimum acceptable level (regulatory limit)
15-19%	Decreased ability to work, early symptoms
12-15%	Deeper breathing, faster heartbeat, poor coordination
10-12%	Very poor judgment, blue lips, nausea
8-10%	Unconsciousness, brain damage likely
6-8%	Death within 6-8 minutes
Below 6%	Death within seconds

High-Risk Scenarios:

- Confined spaces (tanks, vaults, crawlspaces)
- Trenches and excavations
- Unventilated rooms
- Basements with gas accumulation
- Tanks or vessels being purged with inert gas

Warning: Natural gas is lighter than air and rises; propane is heavier than air and settles in low areas. Both displace oxygen and can create asphyxiation hazards.

Carbon Monoxide (CO) Hazards

Carbon monoxide is produced by incomplete combustion of any carbon-based fuel. It is the leading cause of death from gas equipment in Canada.

Properties of CO:

- Colorless
- Odorless
- Tasteless
- Cannot be detected by human senses
- Slightly lighter than air (will mix throughout space)
- Toxic at very low concentrations

Sources in Gas Work:

- Improperly adjusted burners
- Blocked or inadequate venting
- Insufficient combustion air
- Cracked heat exchangers
- Spillage from draft hood appliances
- Backdrafting conditions
- Running vehicles in confined spaces
- Unvented or vent-free appliances

CO Toxicity:

Carbon monoxide binds to hemoglobin 200-250 times more readily than oxygen, preventing oxygen transport in blood.

Symptoms of CO Exposure:

CO Level (ppm)	Exposure Time	Symptoms
35 ppm	8 hours	CSA B149.1 maximum for continuous exposure
70 ppm	1-4 hours	Headache, fatigue
150 ppm	1.5 hours	Dizziness, nausea
400 ppm	1 hour	Headache, nausea, confusion
800 ppm	45 min	Unconsciousness
1,600 ppm	20 min	Death
3,200 ppm	5-10 min	Death
6,400 ppm	1-2 min	Death

Early Symptoms (often mistaken for flu):

- Headache
- Dizziness
- Nausea
- Fatigue
- Confusion
- Shortness of breath

Severe Symptoms:

- Vomiting
- Chest pain
- Loss of consciousness
- Seizures
- Death

High-Risk Situations:

- Combustion testing in confined spaces
- Working on equipment with suspected problems
- Multiple appliances in small mechanical rooms
- Start-up and commissioning
- Troubleshooting no-heat calls (equipment may be running improperly)

Protection Strategies:

- Always use combustion analyzer
- Never work in unventilated spaces with running equipment
- Use personal CO monitors
- Ensure adequate ventilation
- Test CO levels before and during work
- Evacuate at dangerous levels

Physical Hazards

Lifting Injuries:

- Gas equipment often heavy (furnaces 200+ lbs, water heaters 150+ lbs)
- Piping and fittings
- Proper lifting technique essential
- Use mechanical aids when possible

Cuts and Lacerations:

- Sharp sheet metal edges
- Pipe threading chips
- Cutting tools
- Proper gloves and handling techniques required

Burns:

- Hot pipes and equipment during service
- Soldering and brazing operations
- Steam and hot water in hydronic systems

- Contact with heat exchangers
- Propane cold burns (rapid expansion)

Struck-By Hazards:

- Falling objects on construction sites
- Swinging pipe or materials
- Tools dropped from heights
- Hard hat required in construction environments

Slips, Trips, and Falls:

- Wet or icy surfaces
- Cluttered work areas
- Ladders and scaffolds
- Working at heights
- Leading cause of workplace injuries

Electrical Hazards

Gas technicians frequently work with electrical systems and must understand electrical hazards.

Shock Hazards:

- 115V and 230V circuits at appliances
- 24V control circuits (generally safe but can startle)
- Potential contact with higher voltages in electrical rooms

Arc Flash:

- Explosive release of energy during electrical fault
- Can cause severe burns, hearing damage, blindness
- Requires specialized PPE and training
- Gas technicians should not work on high-voltage systems

Electrocution:

- Current through body can stop heart
- As little as 75 mA can be fatal
- Wet conditions increase risk
- Damaged cords and tools

CSST Bonding:

- Corrugated stainless steel tubing must be bonded per CSA B149.1
- Lightning strikes or electrical faults can arc through CSST causing rupture

- Bonding reduces this risk
- Electrical contractor may be required for bonding

Safe Practices:

- Assume all circuits are live until proven otherwise
- Use voltage tester before touching
- De-energize circuits when possible
- Use insulated tools
- Work in dry conditions
- GFCI protection on power tools
- Never bypass safety devices

Trench and Excavation Hazards

Gas service line installation involves trenching and excavation with significant hazards.

Cave-In Hazards:

- Soil failure is leading cause of excavation deaths
- Can occur suddenly without warning
- Cubic meter of soil weighs 1,500-2,000 kg
- Fatal burial can occur in seconds

Protection Required:

- Slope walls to safe angle (typically 1:1 or flatter)
- Shore with timber or aluminum supports
- Use trench box or shield
- Requirements depend on depth, soil type, water presence

Minimum Requirements (typical):

- Excavations 1.2m (4 ft) or deeper require protection
- Competent person must inspect daily
- Ladder required every 7.5m (25 ft) of trench
- Soil and materials kept 1m (3 ft) from edge

Underground Utilities:

- Contact provincial one-call service before digging (Ontario: ON1Call)
- Allow 3-5 business days for locates
- Mark planned excavation
- Hand dig near marked utilities
- Assume unmarked utilities present
- Report any strikes immediately

Atmospheric Hazards in Excavations:

- Oxygen deficiency
- Toxic gases (sewer lines, contaminated soil)
- Test atmosphere before entry if over 1.2m deep
- Ensure adequate ventilation

Water Accumulation:

- Reduces soil stability
- Drowning hazard
- Pump continuously if present
- Never enter water-filled excavations

Confined Space Hazards

Definition: A confined space is an enclosed or partially enclosed space that:

- Is not designed or intended for continuous human occupancy
- Has restricted entry or exit
- May contain or accumulate hazardous substances

Examples in Gas Work:

- Meter vaults
- Crawlspaces
- Attics with limited access
- Boiler rooms with inadequate ventilation
- Tanks and vessels
- Manholes and utility vaults

Hazards:

- Oxygen deficiency or enrichment
- Flammable atmospheres
- Toxic gases
- Engulfment
- Configuration (inability to escape)
- Temperature extremes

Entry Requirements:

- Confined space program required by employer
- Atmospheric testing before and during entry
- Continuous ventilation
- Permit system

- Attendant outside
- Communication system
- Rescue plan and equipment
- Specialized training

Never enter confined space without:

- Proper authorization and permit
- Atmospheric testing showing safe conditions
- Required PPE and equipment
- Established rescue plan
- Attendant present

2.3 Emergency Procedures

Every gas technician must know how to respond to emergencies. Quick, appropriate action can prevent injuries and save lives.

Gas Leak Response

Immediate Actions:

1. **Evacuate the Area**
    - Get everyone out immediately
    - Don't stop to gather belongings
    - Evacuate to safe distance (minimum 100m/300ft for large leaks)
    - Account for all occupants
2. **Eliminate Ignition Sources**
    - DON'T operate electrical switches (on or off)
    - DON'T use phones inside building (including cell phones)
    - DON'T start vehicles
    - DON'T use flashlights (unless explosion-proof)
    - No smoking, matches, lighters
3. **Stop Gas Flow (if safe to do so)**
    - Shut manual valve at meter or tank
    - Only if valve is accessible without entering hazard area
    - Don't risk life to shut off gas
4. **Call for Help**
    - Call 911 from safe location outside
    - Call gas utility emergency number (natural gas)
    - Call propane supplier emergency number (propane)
    - Provide clear information:
        - Nature of emergency
        - Address and location

        - Number of people involved
        - Injuries (if any)
        - Your callback number
5. **Ventilate (if safe)**
    - Open doors and windows from outside if possible
    - Don't enter building to ventilate
    - Natural ventilation only (don't use fans which could create sparks)
6. **Prevent Re-Entry**
    - Keep everyone away from building
    - Warn approaching people
    - Wait for utility or fire department clearance

What NOT to Do:

- Don't search for leak source in emergency
- Don't try to repair leak immediately
- Don't re-enter building until cleared by authorities
- Don't turn utilities back on yourself

After Emergency:

- Don't operate gas system until repaired and tested
- Proper repair by licensed technician required
- Testing and inspection required before restart
- Document incident
- Report to regulatory authority if required

Fire Response

If Fire Involves Gas Equipment:

1. **Evacuate Immediately**
    - Sound alarm
    - Get everyone out
    - Close doors behind you (don't lock)
    - Don't use elevators
2. **Call 911**
    - From safe location
    - Provide clear location and details
    - State gas is involved
    - Report any injuries
3. **Shut Off Gas (only if safe)**
    - Only if you can do so without risk
    - Shut exterior valve or tank valve
    - Don't enter burning building

Small Fire (if safe to fight):

- Use appropriate extinguisher (Class B or ABC)
- Only fight fire if:
    - You have been trained
    - You have proper extinguisher
    - Fire is small and contained
    - You have clear escape route
    - You are not risking your safety
- If fire grows or you feel unsafe, evacuate immediately

Never attempt to extinguish:

- Gas leak fire (unless you can shut off gas first)
- Large or spreading fires
- Fires in occupied areas
- Fires blocking escape routes

After Fire:

- Gas system must be professionally inspected
- Damaged components must be replaced
- Complete testing before restart
- Document for insurance and authorities

Carbon Monoxide Emergency

Symptoms Present:

1. **Evacuate Immediately**
    - Get all occupants outside into fresh air
    - Leave doors and windows open for ventilation
2. **Call 911**
    - Report suspected CO poisoning
    - Number and condition of affected people
    - Address and location
3. **Seek Medical Attention**
    - Anyone with symptoms needs medical evaluation
    - CO exposure causes delayed effects
    - Blood test can confirm CO exposure
4. **Don't Re-Enter**
    - Wait for emergency responders
    - Building not safe until source identified and corrected

High CO Readings (no symptoms yet):

1. **Shut Down Equipment**
    - Turn off all gas appliances
    - Shut off gas supply if possible
2. **Ventilate**
    - Open windows and doors
    - Leave building if levels high (>100 ppm)
3. **Call Utility or Service Provider**
    - Report dangerous condition
    - Request emergency service
4. **Test and Monitor**
    - Use CO detector to monitor levels
    - Ensure levels decreasing
    - Document readings

Don't restart equipment until:

- Source identified and corrected
- Complete combustion test performed
- Safe CO levels confirmed
- Written clearance provided

Electrical Emergency

Shock Victim:

1. **Don't Touch Victim** if still in contact with electricity
2. **Shut Off Power**
    - Breaker or disconnect
    - If not possible, call 911
3. **Once Safe:**
    - Check breathing and pulse
    - Perform CPR if trained and necessary
    - Call 911 if not already done
    - Keep victim warm and calm
    - Wait for emergency responders

Electrical Fire:

- Use Class C extinguisher
- Shut off power if possible
- Don't use water
- Evacuate if fire not controlled immediately

Personal Injury

Serious Injury:

- Call 911 immediately
- Don't move victim unless in immediate danger
- Control bleeding with pressure
- Keep victim warm
- Stay with victim until help arrives
- Document incident

Minor Injury:

- Administer first aid
- Clean and bandage wounds
- Report to supervisor
- Document incident
- Seek medical attention if any doubt

First Aid:

- Know location of first aid kit
- Maintain current first aid certification
- Standard First Aid with CPR Level C recommended

Evacuation Procedures

Know Before You Need It:

- Location of exits
- Evacuation routes
- Assembly points
- Emergency equipment locations
- Emergency contact numbers

During Evacuation:

- Follow established routes
- Assist others if safe to do so
- Don't use elevators
- Close doors behind you
- Report to assembly point
- Account for everyone
- Don't re-enter until cleared

Incident Reporting

Required Reports:

- All injuries (no matter how minor)

- Near misses (could have caused injury)
- Property damage
- Gas releases
- Fires
- Dangerous conditions

Report To:

- Employer/supervisor (immediately)
- Regulatory authority (as required)
- Workers' compensation board (injuries)
- Customer (incidents at their property)

Documentation:

- Date, time, and location
- People involved
- Witnesses
- Sequence of events
- Contributing factors
- Corrective actions
- Photos if appropriate

2.4 Workplace Safety Regulations

Provincial Occupational Health and Safety Acts

Every province has occupational health and safety legislation governing workplace safety. While specifics vary, common principles include:

Employer Responsibilities:

- Provide safe workplace
- Provide safe equipment and procedures
- Provide training and supervision
- Provide PPE at no cost to worker
- Establish safety programs
- Investigate incidents
- Report serious incidents to authorities

Worker Responsibilities (3 Rights and 1 Duty):

Right to Know:

- Hazards in workplace
- Safe work procedures
- How to protect yourself

Right to Participate:

- In safety programs
- Through health and safety committees
- In workplace inspections

Right to Refuse:

- Unsafe work
- Without penalty
- With investigation of concern

Duty to:

- Use PPE as required
- Follow safe work procedures
- Report hazards and incidents
- Work safely

Supervisor Responsibilities:

- Ensure workers follow procedures
- Provide instruction and training
- Monitor workplace for hazards
- Investigate incidents
- Enforce safety rules

Internal Responsibility System (IRS)

Everyone shares responsibility for workplace safety:

- Management provides resources and leadership
- Supervisors ensure compliance
- Workers work safely and report hazards
- Joint health and safety committees facilitate cooperation

WHMIS 2015 (Workplace Hazardous Materials Information System)

WHMIS is Canada's hazard communication standard for workplace chemicals. It aligns with the Globally Harmonized System (GHS).

Three Key Elements:

1. Labels

All hazardous products must have labels with:

- Product identifier (name)
- Supplier identifier
- Hazard pictograms
- Signal word (Danger or Warning)
- Hazard statements
- Precautionary statements

Pictograms (standardized symbols in red diamond):

- Flame (flammable)
- Flame over circle (oxidizer)
- Gas cylinder (compressed gas)
- Corrosion (corrosive)
- Skull and crossbones (acute toxicity)
- Health hazard (serious health effects)
- Exclamation mark (irritant, less serious health effects)
- Environment (aquatic toxicity)
- Exploding bomb (explosive)

2. Safety Data Sheets (SDS)

16-section standardized documents providing detailed hazard and safety information:

- **Section 1:** Identification
- **Section 2:** Hazard identification
- **Section 3:** Composition/information on ingredients
- **Section 4:** First-aid measures
- **Section 5:** Fire-fighting measures
- **Section 6:** Accidental release measures
- **Section 7:** Handling and storage
- **Section 8:** Exposure controls/personal protection
- **Section 9:** Physical and chemical properties
- **Section 10:** Stability and reactivity
- **Section 11:** Toxicological information
- **Section 12:** Ecological information
- **Section 13:** Disposal considerations
- **Section 14:** Transport information
- **Section 15:** Regulatory information
- **Section 16:** Other information

Employer must:

- Obtain SDS for all hazardous products
- Make SDS readily available to workers
- Update SDS regularly (every 3 years or when new information available)

3. Worker Education

All workers must receive WHMIS training:

- Before working with hazardous products
- When new hazards introduced
- Regular refresher training

Training must cover:

- How to read labels and SDS
- Safe handling, storage, and disposal
- Emergency procedures
- Health effects
- PPE requirements

Common Hazardous Products in Gas Work:

- Pipe thread compounds (pipe dope)
- Cleaning solvents
- Adhesives and sealants
- Compressed gases
- Refrigerants
- Oils and lubricants
- Primers and cleaners for plastic pipe

2.5 Gas Leak Detection and Response

Proper gas leak detection is fundamental to gas technician work. Every installation must be tested, and technicians must be able to locate leaks quickly and safely.

Detection Methods

1. Odor Detection

Natural gas and propane are odorized with mercaptan (smells like rotten eggs or sulfur) for safety.

Advantages:

- No equipment required
- Immediate detection
- Wide area sensing

Limitations:

- Not reliable for small leaks
- Olfactory fatigue (nose becomes desensitized)
- Some people have reduced sense of smell
- Odor can fade in some situations (scrubbing)
- Cannot quantify leak size
- Not acceptable as sole leak test method

Never rely on odor alone for leak testing.

2. Soap Bubble Solution

Most reliable method for pinpointing small leaks.

Procedure:

- Mix leak detection solution (commercially available or mild dish soap and water)
- Apply to suspected leak points
- Bubbles indicate leak
- Brush or spray application

Advantages:

- Highly sensitive
- Visual confirmation
- Inexpensive
- Safe
- Accepted by code and inspectors

Disadvantages:

- Time consuming for large systems
- Requires access to joint
- Messy
- Not practical for entire system testing
- Freezes in cold weather

Best Use:

- Verifying specific joints
- Final inspection of test points

- Small systems
- Verification after electronic detection

3. Electronic Combustible Gas Detectors

Use sensors to detect combustible gases and display concentration.

Types:

Catalytic Bead Sensors:

- Oxidizes gas on heated element
- Measures temperature change
- Reads % LEL (Lower Explosive Limit)
- Requires oxygen to function
- Can be poisoned by silicones or sulfur

Infrared Sensors:

- Detects gas by light absorption
- More stable than catalytic
- Works without oxygen
- More expensive
- Less sensitivity to low concentrations

Semiconductor Sensors:

- Changes electrical resistance in presence of gas
- Very sensitive
- Less specific (responds to many gases)
- Lower cost
- Faster recovery

Reading and Interpreting:

- Usually display % LEL
- 10% LEL = 10% of concentration needed for explosion
- Some display ppm (parts per million)
- Understanding scale critical

Example:

- Natural gas LEL = 5% by volume = 50,000 ppm
- Detector reading 10% LEL = 0.5% gas in air = 5,000 ppm
- Detector reading 100% LEL = explosive mixture present

Using Electronic Detectors:

- Calibrate per manufacturer instructions
- Zero in fresh air before use
- Move probe slowly (2-3 cm/sec)
- Hold near suspected leak
- Work methodically
- Check all joints and connections
- Document results

Advantages:

- Fast screening of large systems
- Quantitative results
- Can detect very small leaks
- Immediate response
- Records for documentation

Disadvantages:

- Requires maintenance and calibration
- Battery dependent
- Can give false readings (other chemicals)
- Must be used properly to be effective
- More expensive than bubble test

Best Use:

- Surveying installed systems
- Emergency response
- System commissioning
- Routine inspections
- Finding general leak area (then pinpoint with bubbles)

4. Pressure Testing

Most reliable method for new installations or after modifications.

Procedure (covered in detail in Chapter 8):

- Isolate section to be tested
- Cap appliances or close valves
- Apply test pressure per code
- Monitor pressure over time
- Acceptable pressure drop per CSA B149.1

Advantages:

- Tests entire system
- Quantifies system tightness
- Required by code
- Documented results
- High confidence

Disadvantages:

- Requires equipment
- Takes time (test duration)
- May not pinpoint leak location
- Must isolate appliances

Best Use:

- New installations
- Modifications and additions
- After repairs
- Regulatory requirement
- Quality assurance

Leak Investigation Procedure

Systematic approach prevents missing leaks:

1. Gather Information

- Where odor detected?
- When first noticed?
- Any recent work on system?
- Any changes in operation?
- Building alterations?

2. Safety First

- Eliminate ignition sources
- Ensure adequate ventilation
- Use intrinsically safe equipment
- Evacuate if concentration high
- Call utility if major leak

3. Trace Gas System

- Start at meter/tank

- Follow piping systematically
- Check all connections
- Include all branches
- Don't skip areas

4. Check Common Leak Points

- Threaded connections
- Union fittings
- Valves and regulators
- Flexible connectors
- Appliance connections
- Meter connections
- Tank connections
- Damaged piping

5. Use Multiple Methods

- Electronic detector to locate area
- Bubble test to pinpoint
- Pressure test to verify repair

6. Document

- Location of leak
- Apparent cause
- Repair method
- Verification test results
- Photos if appropriate

7. Verify Repair

- Pressure test after repair
- Bubble test specific repair
- Monitor for period of time
- Provide documentation

Leak Classification and Response

Minor Leak:

- Small concentration
- Not immediately hazardous
- Can be repaired on normal schedule
- Monitor until repaired

Action:

- Tag and document
- Schedule repair
- Advise customer
- Ensure adequate ventilation

Major Leak:

- Significant gas release
- Potentially hazardous
- Requires immediate action

Action:

- Shut off gas
- Evacuate if necessary
- Eliminate ignition sources
- Ventilate
- Emergency repair
- Don't restore service until safe

Emergency Leak:

- Immediate danger
- Evacuation required
- Fire/explosion risk

Action:

- Evacuate immediately
- Call 911
- Call utility/supplier
- Shut off gas from outside if possible
- Establish safety perimeter
- Wait for emergency responders

2.6 Carbon Monoxide Safety

Carbon monoxide kills more people than any other product of combustion. Every gas technician must understand CO production, detection, and prevention.

Sources of Carbon Monoxide

Incomplete Combustion Causes:

1. Insufficient Air

- Blocked air intakes
- Insufficient combustion air openings
- Negative building pressure
- Sealed buildings

2. Poor Air-Fuel Mixture

- Improper orifice size
- Wrong gas pressure
- Dirty or maladjusted burners
- Incorrect conversion (natural gas to propane)

3. Flame Impingement

- Burner misalignment
- Flame contact with cool surfaces
- Deposits on burners

4. Venting Problems

- Blocked vents
- Undersized vents
- Backdrafting
- Spillage
- Corroded vents
- Improper termination

5. Equipment Problems

- Cracked heat exchangers
- Failed heat exchangers
- Deteriorated gaskets
- Warped components

6. Other Sources

- Vehicle exhaust (attached garages)
- Portable generators
- Unvented space heaters
- Barbecues used indoors
- Construction heaters

Detection and Measurement

CO Alarms (Residential):

- Required by code in dwellings with fuel-burning appliances
- CSA 6.19 certified
- Installed per manufacturer instructions
- Near sleeping areas
- Not in mechanical rooms (delayed alarm)
- Replace per manufacturer (typically 5-7 years)
- Not substitute for proper equipment maintenance

Professional CO Analyzers:

- Used by technicians for combustion testing
- Electrochemical sensors
- Measure CO in ppm
- Also measure O_2, CO_2, flue temperature
- Calculate efficiency
- Essential tool for gas technicians

Measurement Points:

- Flue gas (combustion products)
- Ambient air (room where appliance located)
- Near appliances
- In living spaces

Acceptable Levels per CSA B149.1:

- Ambient air (continuous): 35 ppm maximum
- Flue gas: 100 ppm air-free maximum for most appliances
- Some appliances have different limits (check manufacturer specifications)

Taking Measurements:

- Allow analyzer warm-up period
- Zero in fresh air
- Insert probe into flue per manufacturer instructions
- Wait for stable reading
- Record all measurements
- Document ambient CO before and during testing

Prevention Strategies

Installation:

- Proper combustion air provisions per code
- Correct venting per manufacturer and code
- Proper appliance sizing
- Quality workmanship
- Complete testing before leaving job

Maintenance:

- Annual inspection and cleaning
- Burner cleaning and adjustment
- Venting inspection
- Combustion testing
- Heat exchanger inspection
- Air intake inspection

Customer Education:

- Importance of maintenance
- CO alarm requirements
- Symptoms of CO exposure
- Never ignore CO alarm
- Proper appliance ventilation
- Dangers of unvented appliances
- Vehicle idling in garages

Building Considerations:

- Adequate combustion air
- Proper make-up air
- Understanding house depressurization
- Exhaust fan coordination
- Sealed combustion appliances in tight buildings

Response to CO

CO Alarm Activation:

1. Evacuate building immediately
2. Call 911 or fire department
3. Get fresh air
4. Seek medical attention if symptoms present
5. Don't re-enter until building cleared
6. Professional inspection required before restart

High CO Readings During Testing:

1. Shut down equipment immediately
2. Determine source
3. Check for spillage
4. Ventilate area
5. Do not restart until corrected
6. Complete combustion test after correction

Symptoms in Occupants:

1. Evacuate to fresh air
2. Call 911
3. Medical evaluation required
4. Don't re-enter building
5. Professional investigation required

Documentation

Every service call should document:

- Ambient CO level
- Flue gas CO level
- O_2 and CO_2 levels
- Temperature
- Calculated efficiency
- Any concerns or corrections
- Signature and date

This protects:

- Customer (proof of proper service)
- Technician (proof of proper procedures)
- Company (liability protection)
- Future technicians (baseline data)

2.7 Confined Space Safety

Gas technicians occasionally need to enter confined spaces. This requires specialized training and procedures.

Confined Space Definition

A confined space:

- Is enclosed or partially enclosed

- Is not designed for continuous occupancy
- Has restricted entry or exit
- May contain hazards to health or safety

Examples:

- Meter vaults
- Manholes
- Tanks and vessels
- Crawlspaces (some)
- Trenches over 1.2m deep
- Attics with restricted access
- Small mechanical rooms

Confined Space Program Requirements

Employers must:

- Identify all confined spaces
- Assess hazards
- Develop entry procedures
- Provide training
- Provide equipment
- Maintain entry permits
- Conduct rescue drills

Before Entry:

- Permit required
- Atmospheric testing
- Hazard control
- Entry procedures established
- Rescue plan in place
- Equipment checked

Atmospheric Hazards

Testing Required For:

1. **Oxygen level** - must be 19.5% to 23%
2. **Flammable gases** - must be below 10% LEL
3. **Toxic gases** - must be below exposure limits (CO, H_2S, etc.)

Test:

- Before entry

- Continuously during occupancy (if required)
- After breaks in occupancy
- If conditions change

Ventilation:

- Forced ventilation usually required
- Continuous during occupancy
- Cannot rely on natural ventilation
- Exhaust to safe location

Entry Procedures

Required Elements:

1. **Entry permit** documenting:
    - Space identification
    - Atmospheric test results
    - Hazards present
    - Control measures
    - Entry team
    - Duration
    - Signatures
2. **Attendant:**
    - Remains outside
    - Maintains contact with entrants
    - Monitors conditions
    - Initiates rescue if needed
    - Cannot enter to rescue
3. **Communication:**
    - Continuous contact
    - Method established (voice, radio, signals)
    - Check-in schedule
4. **Equipment:**
    - Atmospheric monitor
    - Ventilation equipment
    - PPE as required
    - Retrieval equipment
    - Lighting (explosion-proof if needed)
    - Rescue equipment
5. **Rescue Plan:**
    - Cannot rely on 911 response time
    - Self-rescue or non-entry rescue preferred
    - Retrieval equipment required
    - Trained rescue team
    - Regular drills

Training Requirements

All entrants, attendants, and supervisors must be trained in:

- Hazard recognition
- Testing procedures
- Entry procedures
- Emergency procedures
- Equipment use
- Rescue procedures

Training must be:

- Before first entry
- When conditions change
- When procedures change
- Annually (minimum)
- Documented

Most Common Fatal Mistake

Untrained rescue attempts kill more people than initial incidents.

Never enter confined space to rescue without:

- Proper training
- Proper equipment
- Atmospheric monitoring
- SCBA or SAR
- Backup personnel
- Call 911 immediately in emergency

2.8 Lockout/Tagout Procedures

Lockout/tagout (LOTO) prevents equipment from starting unexpectedly during service.

When Required

- Servicing equipment with stored energy
- Clearing blockages
- Working on electrical systems
- Any time unexpected start could cause injury

Energy Sources to Control

Electrical:

- Disconnect and lock out
- Verify de-energized
- Discharge capacitors

Gas:

- Close and lock valve
- Relieve pressure
- Verify no flow

Mechanical:

- Block moving parts
- Relieve springs
- Support suspended components

Hydraulic/Pneumatic:

- Isolate pressure sources
- Relieve pressure
- Block cylinders

Thermal:

- Allow cooling
- Drain hot fluids
- Block steam lines

Gravity:

- Block suspended loads
- Support before disconnect

Lockout Procedure

1. **Notify affected people**
2. **Identify energy sources**
3. **Shut down equipment normally**
4. **Isolate energy sources**
5. **Apply lockout devices**
6. **Verify isolation** (test equipment)
7. **Relieve stored energy**

Lockout Devices

Locks:

- Each worker applies own lock
- Unique key (no duplicate for same lock)
- Only worker who applied can remove

Tags:

- Identify who locked out
- Date and time
- Reason for lockout
- Contact information
- "Do Not Operate"

Devices:

- Circuit breaker lockouts
- Valve lockouts
- Plug lockouts
- Various adapters for different equipment

Tagout

Tagout alone is acceptable only if lockout not physically possible. Tags must:

- Be substantial (won't tear easily)
- Be standardized
- Identify person
- Warn against operation

Removing Lockout

Only worker who applied lock can remove it

Before removing:

1. Ensure work complete
2. Tools and materials removed
3. Covers and guards replaced
4. All personnel clear
5. Notify affected people

Special case: If worker unavailable (shift change, etc.):

- Supervisor may remove with authorization
- Verify work complete
- Verify area safe
- Document reason
- Notify worker

Group Lockout

When multiple workers on same equipment:

- Each worker applies own lock
- Supervisor may coordinate
- All locks must be removed before restart

Stored Energy

Always relieve or block stored energy:

- Capacitors (electrical)
- Springs (mechanical)
- Compressed gas (pneumatic)
- Hydraulic pressure
- Elevated components (gravity)
- Rotating masses (inertia)

Chapter Summary

Safety is the foundation of professional gas work. Personal protective equipment, hazard recognition, and emergency response procedures protect workers and the public. Natural gas and propane have specific properties that create flammability, asphyxiation, and carbon monoxide hazards that must be understood and controlled.

Provincial workplace safety legislation establishes rights and responsibilities through the Internal Responsibility System. WHMIS 2015 provides hazard communication for chemical products. Proper gas leak detection uses multiple methods including electronic detectors and bubble solutions. Carbon monoxide prevention requires proper installation, maintenance, and testing.

Specialized procedures govern confined space entry, lockout/tagout, and excavation work. Every technician must maintain current knowledge through regular training and practice of emergency procedures. Safe work practices, proper PPE use, and thorough hazard assessment prevent accidents and ensure successful careers in the gas industry.

Review Questions

Multiple Choice

1. Natural gas has a Lower Explosive Limit (LEL) of:
    - a) 2.1%
    - b) 5%
    - c) 10%
    - d) 15%
2. At what oxygen concentration must work stop in a confined space?
    - a) 23%
    - b) 20.9%
    - c) 19.5%
    - d) 18%
3. According to CSA B149.1, the maximum continuous ambient CO level is:
    - a) 9 ppm
    - b) 35 ppm
    - c) 70 ppm
    - d) 100 ppm
4. Which CSA standard governs protective footwear?
    - a) Z94.1
    - b) Z94.3
    - c) Z195
    - d) Z96
5. Propane's flammable range is:
    - a) 2.1% to 9.5%
    - b) 5% to 15%
    - c) 1% to 5%
    - d) 10% to 20%
6. Electronic gas detectors typically display readings in:
    - a) ppm only
    - b) % LEL only
    - c) Either % LEL or ppm depending on model
    - d) % by volume
7. The most reliable method for pinpointing small gas leaks is:
    - a) Odor detection
    - b) Electronic detector
    - c) Soap bubble solution
    - d) Pressure testing
8. WHMIS pictograms appear in what color?
    - a) Red diamond with black symbol
    - b) Yellow triangle with black symbol
    - c) Orange circle with black symbol
    - d) Blue square with white symbol
9. A confined space attendant must:
    - a) Enter if rescue needed

- b) Remain outside at all times
- c) Perform atmospheric testing
- d) Supervise the work inside

10. Excavations _____ or deeper typically require cave-in protection:
    - a) 0.6m (2 ft)
    - b) 1.2m (4 ft)
    - c) 1.8m (6 ft)
    - d) 2.4m (8 ft)

True or False

11. Propane is heavier than air and will settle in low areas.
12. Face shields can be worn alone without safety glasses.
13. An employer can remove a worker's lockout device if the worker is unavailable.
14. Carbon monoxide alarms in homes eliminate the need for annual appliance maintenance.
15. Soap bubble solution must be applied to all joints during pressure testing.

Short Answer

16. List the three worker rights under occupational health and safety legislation. (3 marks)
17. Explain why you should never rely on odor alone to detect gas leaks. (3 marks)
18. What are the three key elements of WHMIS 2015? (3 marks)
19. List four common sources of carbon monoxide in gas appliance installations. (4 marks)
20. Explain the difference between LEL and UEL. (4 marks)

Long Answer

21. Describe the complete procedure for responding to a suspected gas leak in a residential home. Include safety considerations, evacuation procedures, and steps to secure the situation. (10 marks)
22. Explain why carbon monoxide is so dangerous to human health. Include how it affects the body, typical symptoms at different exposure levels, and why it cannot be detected by human senses. Discuss prevention strategies for gas technicians. (12 marks)
23. A homeowner calls you to service their furnace that is "making them feel sick." When you arrive, you notice the occupants have headaches and nausea. What are your immediate actions and concerns? Detail your systematic approach to this call including safety considerations, testing procedures, and recommendations to the homeowner. (12 marks)

Practical Exercises

Exercise 1: PPE Selection

For each scenario, identify all required PPE:

1. Installing furnace in new construction
2. Servicing water heater in residential basement
3. Pressure testing gas piping system
4. Working in mechanical room with running equipment
5. Digging trench for gas service line

Exercise 2: Gas Detector Calibration and Use

Using an electronic combustible gas detector:

1. Review manufacturer's instructions
2. Perform calibration check
3. Zero in fresh air
4. Test response with leak source
5. Practice systematic leak survey technique
6. Document findings

Exercise 3: Emergency Response Drill

Role-play the following scenarios with proper procedures:

1. Customer calls reporting gas odor in house
2. You detect high CO levels during service call
3. You discover active gas leak while working
4. You find unconscious person in mechanical room

Exercise 4: SDS Review

Obtain Safety Data Sheets for:

1. Pipe thread compound (pipe dope)
2. PVC primer and cement
3. Cleaning solvent used in shop Review each SDS and identify:

- Health hazards
- Fire hazards
- Required PPE
- First aid measures
- Storage requirements

Exercise 5: Confined Space Assessment

Inspect your training facility and identify:

1. Spaces meeting confined space definition
2. Hazards present in each space
3. Required atmospheric testing
4. Required permits and procedures
5. Entry equipment needed
6. Rescue procedures

Case Studies

Case Study 1: The Hidden Danger

Scenario: A technician responds to a no-heat call. The furnace is in a small mechanical room with a closed door. The homeowner mentions they keep the door closed to reduce noise. The technician enters, starts diagnostics, and begins feeling dizzy and nauseous after 10 minutes.

Questions:

1. What is the likely problem?
2. What should the technician do immediately?
3. What safety equipment should have been used?
4. What might be wrong with the furnace?
5. What recommendations should be made to the homeowner?
6. How could this situation have been prevented?

Case Study 2: The Shortcut

Scenario: An experienced technician needs to replace a gas valve on a commercial boiler. The electrical disconnect is in a locked electrical room, and the maintenance person with the key won't be available for two hours. The technician decides to just close the gas valve, replace the valve, and test operation. While testing, sparks occur and the technician receives a minor shock.

Questions:

1. What procedure was violated?
2. What injuries could have occurred?
3. What is the proper procedure?
4. What if lockout was impossible?
5. What would you document?
6. What are the potential legal consequences?

Case Study 3: Trench Collapse

Scenario: Two workers are installing a gas service line in a 1.5m (5 ft) deep trench. The soil is sandy and the trench walls are vertical. One worker is in the trench connecting pipe while the other is on the surface. The walls suddenly collapse, partially burying the worker in the trench.

Questions:

1. What regulations were violated?
2. What is the immediate response?
3. What protection should have been provided?
4. Who can perform the rescue?
5. What notifications are required?
6. How could this be prevented?

Case Study 4: Multiple Gas Alarms

Scenario: You respond to a home where the CO alarm has activated twice in the past week. The homeowner reset it both times because "nothing seemed wrong." They have a forced-air furnace and gas water heater, both about 15 years old. Current CO reading in the living room is 45 ppm with all equipment operating.

Questions:

1. Is this an emergency situation?
2. What are your immediate actions?
3. What equipment and testing will you use?
4. What are possible causes?
5. What will you tell the homeowner?
6. What if you can't find the source?
7. What documentation is required?

Case Study 5: Right to Refuse

Scenario: You are sent to install a furnace in a new home. When you arrive, the basement is partially flooded with 30 cm of water. Other trades are working in the water wearing rubber boots. The general contractor tells you "everyone else is working, just put on boots and get it done."

Questions:

1. What are the hazards?
2. Can you refuse this work?
3. What is the proper procedure for refusal?
4. What if your supervisor insists you proceed?
5. What protections do you have?
6. What would be required to make this work safe?

Key Terms

Asphyxiation: Condition caused by lack of oxygen, leading to unconsciousness and death.

Auto-ignition Temperature: Temperature at which a substance will spontaneously ignite without external ignition source.

Carbon Monoxide (CO): Colorless, odorless toxic gas produced by incomplete combustion.

Combustible Gas Indicator (CGI): Electronic device that detects presence of flammable gases.

Confined Space: Enclosed or partially enclosed space not designed for continuous occupancy with restricted entry/exit.

Explosive Range: Concentration range between LEL and UEL where gas-air mixture can ignite.

Internal Responsibility System (IRS): Workplace safety system where everyone shares responsibility.

LEL (Lower Explosive Limit): Minimum concentration of gas in air that will burn.

Lockout/Tagout (LOTO): Procedure to isolate energy sources during equipment service.

Mercaptan: Sulfur-containing odorant added to natural gas and propane for leak detection.

NIOSH: National Institute for Occupational Safety and Health (U.S. research organization).

Olfactory Fatigue: Reduced ability to detect odors after prolonged exposure.

PPE: Personal Protective Equipment - equipment worn to reduce exposure to hazards.

SDS: Safety Data Sheet - standardized document providing chemical hazard information.

UEL (Upper Explosive Limit): Maximum concentration of gas in air that will burn.

WHMIS: Workplace Hazardous Materials Information System - Canada's hazard communication standard.

End of Chapter 2