Canadian Gas Technician G3 Learning Module 4

Properties of Natural Gas

Learning Objectives

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

01

Chemical Composition

Describe the chemical composition of natural gas and its components

02

Physical Properties

Explain the physical properties of natural gas including specific gravity, heating value, and Wobbe Index

03

Gas Laws

Apply basic gas laws to understand pressure-temperature-volume relationships

04

Combustion Types

Distinguish between complete and incomplete combustion

05

Air Requirements

Calculate air requirements for proper combustion

06

Air Concepts

Understand primary and secondary air concepts

07

Combustion Products

Identify products of combustion and their significance

08

Distribution Systems

Explain natural gas distribution systems in Canada

09

Safety Considerations

Describe odorization requirements and safety considerations

10

Environmental Impact

Compare environmental impacts of natural gas versus other fuels

4.1 Composition and Characteristics

Chemical Composition

Natural gas is a fossil fuel formed over millions of years from decomposed organic matter under heat and pressure deep within the earth. It is found in underground rock formations, often associated with petroleum deposits.

Primary Component: Methane (CH_4)

Natural gas consists primarily of methane, the simplest hydrocarbon molecule containing one carbon atom and four hydrogen atoms.

Typical Composition of Natural Gas in Canada:

Component	Chemical Formula	Percentage (typical)
Methane	CH_4	85-98%
Ethane	C_2H_6	1-10%
Propane	C_3H_8	0-3%
Butane	C_4H_{10}	0-1%
Pentanes+	C_5H_{12}+	0-0.5%
Nitrogen	N_2	0-5%
Carbon Dioxide	CO_2	0-2%
Hydrogen Sulfide	H_2S	0-0.02%
Water Vapor	H_2O	trace

Regional Variations:

Natural gas composition varies by source and location across Canada:

Western Canada (Alberta, BC):

- High methane content (90-98%)
- Lower inert gases
- "Dry" gas (minimal heavier hydrocarbons)
- Consistent heating value

Eastern Canada:

- Some variation in composition
- May contain higher nitrogen content in some fields
- Generally consistent after processing

Processing:

Raw natural gas undergoes processing before distribution:

- Remove water vapor (prevents corrosion and freezing)
- Remove hydrogen sulfide (toxic "sour gas" to "sweet gas")
- Remove carbon dioxide (non-combustible)
- Extract heavier hydrocarbons (propane, butane for separate sale)
- Result: pipeline-quality "dry" natural gas

Hydrocarbons Series:

Understanding the hydrocarbon series helps explain natural gas properties:

- **Methane (CH_4):** 1 carbon, simplest
- **Ethane (C_2H_6):** 2 carbons
- **Propane (C_3H_8):** 3 carbons (LP gas)
- **Butane (C_4H_{10}):** 4 carbons (LP gas)
- **Pentane+ (C_5H_{12}+):** 5+ carbons (liquids)

As molecular size increases:

Heating value per unit volume increases

Boiling point increases

Specific gravity increases

Changes from gas to liquid at room temperature (butane+)

Physical Properties

State of Matter:

- Gas at standard temperature and pressure
- Remains gaseous at normal atmospheric conditions
- Does not liquefy unless extreme cold or high pressure

Color:

- Colorless in pure form
- No visual indication of presence
- Requires odorization for safety

Odor:

- Naturally odorless
- Mercaptan added for leak detection
- Distinctive "rotten egg" smell
- Odorant concentration: approximately 1 pound per 10,000 cubic feet

Toxicity:

- Non-toxic (methane itself not poisonous)
- Asphyxiant (displaces oxygen)
- Carbon monoxide produced by incomplete combustion is highly toxic
- Hydrogen sulfide (if present in raw gas) is extremely toxic

Flammability:

- Highly flammable within explosive range
- Lower Explosive Limit (LEL): 5% by volume in air
- Upper Explosive Limit (UEL): 15% by volume in air
- Auto-ignition temperature: 540°C (1,004°F)

Weight Relative to Air:

- Lighter than air
- Rises and disperses in open areas
- Can accumulate in enclosed spaces at ceiling level
- Important for leak detection and safety

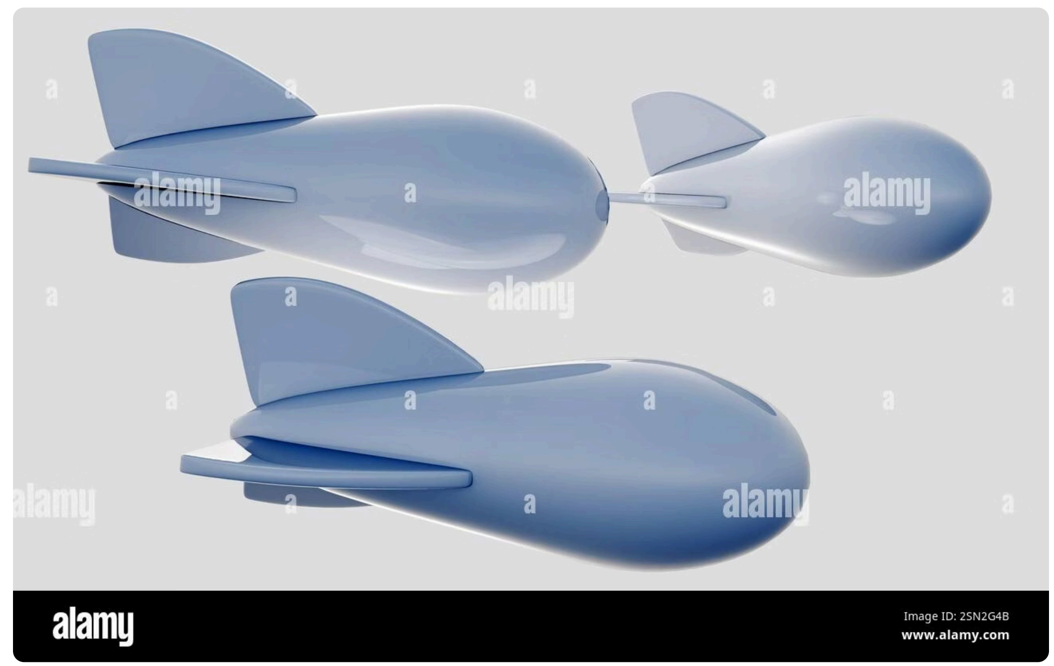
4.2 Specific Gravity

Specific gravity compares the weight of a gas to the weight of an equal volume of air.

Specific gravity = Weight of gas / Weight of equal volume of air

Air = 1.0 (reference standard)

Natural Gas Specific Gravity: 0.60 to 0.70 (typically 0.60)



Interpretation:

- Natural gas is about 60% as heavy as air
- 0.60 specific gravity means natural gas weighs 60% of what air weighs
- Therefore, natural gas is lighter than air and rises

Comparison to Other Gases:

Gas	Specific Gravity	Relative to Air
Natural Gas	0.60	Lighter - rises
Air	1.00	Reference
Propane	1.52	Heavier - sinks
Carbon Monoxide	0.97	Similar to air
Carbon Dioxide	1.52	Heavier - sinks

4.3 Heating Value

Heating value is the amount of heat energy released when gas burns completely.

Gross Heating Value vs. Net Heating Value

Gross Heating Value (Higher Heating Value - HHV):

- Total heat released including latent heat of water vapor condensation
- Assumes water vapor in combustion products condenses
- Used in Canada for rating gas appliances
- Higher number

Net Heating Value (Lower Heating Value - LHV):

- Heat available when water vapor remains as vapor
- Does not include latent heat
- Used in some countries
- Lower number (about 10% less than gross)

Canadian Standard: Gross (Higher) Heating Value

Units of Measurement

British Thermal Unit (BTU):

- Amount of heat to raise 1 pound of water 1°F
- Common in North America
- Natural gas rated in BTU per cubic foot

Joules and Megajoules (MJ):

- SI (metric) unit
- 1 BTU = 1.055 kJ
- 1 MJ = 948 BTU
- Some Canadian references use MJ

Common Usage:

- Appliance input ratings: BTU/hr or MBH (thousands of BTU/hr)
- Gas billing: cubic meters
- Heating value: BTU/cubic foot or MJ/m^3

Natural Gas Heating Value

Standard Heating Value:

1,000 BTU per cubic foot

(approximate, commonly used for calculations)

- Actual range: 950-1,150 BTU/ft³
- Depends on composition

Metric:

- **37.3 MJ per cubic meter** (approximate)
- Range: 35-43 MJ/m³

Regional Variations:

Western Canadian natural gas (high methane):

- 1,000-1,050 BTU/ft³
- Higher heating value
- More consistent

Some eastern sources:

- May be slightly lower if higher inert content
- Generally standardized through blending

Why Heating Value Matters:

1. Appliance Input Rating:

- Determines appliance capacity
- Input (BTU/hr) = Flow rate (ft^3/hr) × Heating value (BTU/ft^3)
- Must match appliance requirements

2. Orifice Sizing:

- Orifice delivers specific heat input
- Based on heating value
- Different heating values require different orifice sizes

3. Billing:

- Utilities bill by volume (cubic meters or cubic feet)
- Energy content varies slightly
- Some utilities adjust billing for heating value

4. Efficiency Calculations:

- Output BTU / Input BTU = Efficiency
- Must use consistent heating value

Example Calculation:

A furnace rated 100,000 BTU/hr input:

- Heating value = 1,000 BTU/ft^3
- Gas flow required = 100,000 BTU/hr ÷ 1,000 BTU/ft^3 = 100 ft^3/hr

If heating value is actually 1,050 BTU/ft^3:

- Gas flow required = 100,000 ÷ 1,050 = 95.2 ft^3/hr
- Slightly less gas needed for same heat input

Heating Value of Components

Individual hydrocarbon heating values:

Component	Heating Value (BTU/ft^3)
Methane (CH_4)	1,013
Ethane (C_2H_6)	1,783
Propane (C_3H_8)	2,590
Butane (C_4H_{10})	3,373

Observation:

- Heavier hydrocarbons have higher heating values per unit volume
- Natural gas becomes "richer" with more heavier hydrocarbons
- Processing removes heavier components, making gas "leaner" but more consistent

4.4 Wobbe Index

The Wobbe Index (or Wobbe Number) is a critical parameter for gas interchangeability.

Definition

$$\text{Wobbe Index} = \text{Heating Value} / \sqrt{(\text{Specific Gravity})}$$

Purpose

The Wobbe Index determines whether different gas compositions will produce similar heat output through the same orifice at the same pressure.

Key Principle:

Gases with similar Wobbe Index are interchangeable	Appliances will produce similar heat output	No adjustment needed to orifices or pressure

Why It Works:

- Heating value determines energy content
- Specific gravity affects flow rate through orifice
- The ratio predicts actual heat delivery

Calculation Example

Natural Gas:

- Heating Value: 1,000 BTU/ft³
- Specific Gravity: 0.60
- Wobbe Index = 1,000 / √0.60 = 1,000 / 0.775 = 1,291

Different Natural Gas Source:

- Heating Value: 1,050 BTU/ft³
- Specific Gravity: 0.64
- Wobbe Index = 1,050 / √0.64 = 1,050 / 0.800 = 1,312

Interpretation:

- Wobbe Index difference = 21 (1.6%)
- Very similar gases are interchangeable
- No appliance adjustment needed
- Similar heat output through same orifice

Wobbe Index Ranges

Natural Gas in Canada:

- Typical range: 1,250-1,400
- Relatively consistent across country
- Utilities blend to maintain consistent Wobbe Index

Propane:

- Wobbe Index: approximately 2,100
- Much higher than natural gas
- NOT interchangeable without appliance conversion
- Different orifices required

Standard Tolerance:

- Utilities maintain Wobbe Index within ±4-5%
- Ensures appliances operate properly
- Prevents need for field adjustments

Practical Application

Gas Source Changes:

When utility changes gas source or supplier:

- Check Wobbe Index compatibility
- If within acceptable range, no action needed
- If significantly different, appliances may need adjustment
- Utilities responsible for maintaining compatible gas

Blending:

Utilities may blend gases from different sources:

Maintain consistent Wobbe Index

Mix lean gas with rich gas

Add inert gases if needed

Ensures customer appliances work properly

Appliance Certification:

- Appliances tested with specific Wobbe Index range
- Certified for natural gas meeting Canadian standards
- Important for imported appliances

4.5 Combustion Principles

Understanding combustion is fundamental to gas work. Proper combustion ensures safety, efficiency, and equipment longevity.

The Combustion Reaction

Complete Combustion of Methane:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Heat$$

One molecule methane + Two molecules oxygen → One molecule carbon dioxide + Two molecules water + Heat energy

In Words:

Methane combines with oxygen to produce carbon dioxide, water vapor, and heat.

Requirements for Combustion:

Fuel

(natural gas/methane)

Oxygen

(from air)

Ignition source

(spark, pilot, hot surface)

Proper mixture

(within flammable range)

Remove any element and combustion stops - this is the principle behind safety controls.

Stoichiometric Combustion

Stoichiometric combustion means perfect combustion with exactly the right amount of oxygen no excess, no deficiency.

Theoretical Air Requirement:

For methane (CH_4):

- 2 molecules O_2 required per molecule CH_4
- Air is approximately 21% oxygen, 79% nitrogen
- Therefore need approximately 9.5 molecules of air per molecule CH_4

Volume Basis (practical calculation):

For complete combustion of 1 cubic foot of natural gas:

Theoretical air required: 9.5 cubic feet

- This is the absolute minimum
- Real appliances require more (excess air)

Why Excess Air is Needed:

Perfect mixing impossible in practice:

- Some air doesn't contact fuel
- Flame temperature variations
- Physical limitations of burner design
- Safety margin

Typical Excess Air:

Appliance Type	Excess Air	Total Air/Fuel Ratio
Atmospheric burner	40-60%	13-15:1
Power burner	15-30%	11-12:1
Sealed combustion	30-50%	12-14:1

Example:

- Theoretical air: 9.5 ft^3
- 50% excess air: $9.5 \times 1.5 = 14.25$ ft^3
- Total air needed: 14.25 ft^3 per ft^3 of gas

Primary and Secondary Air

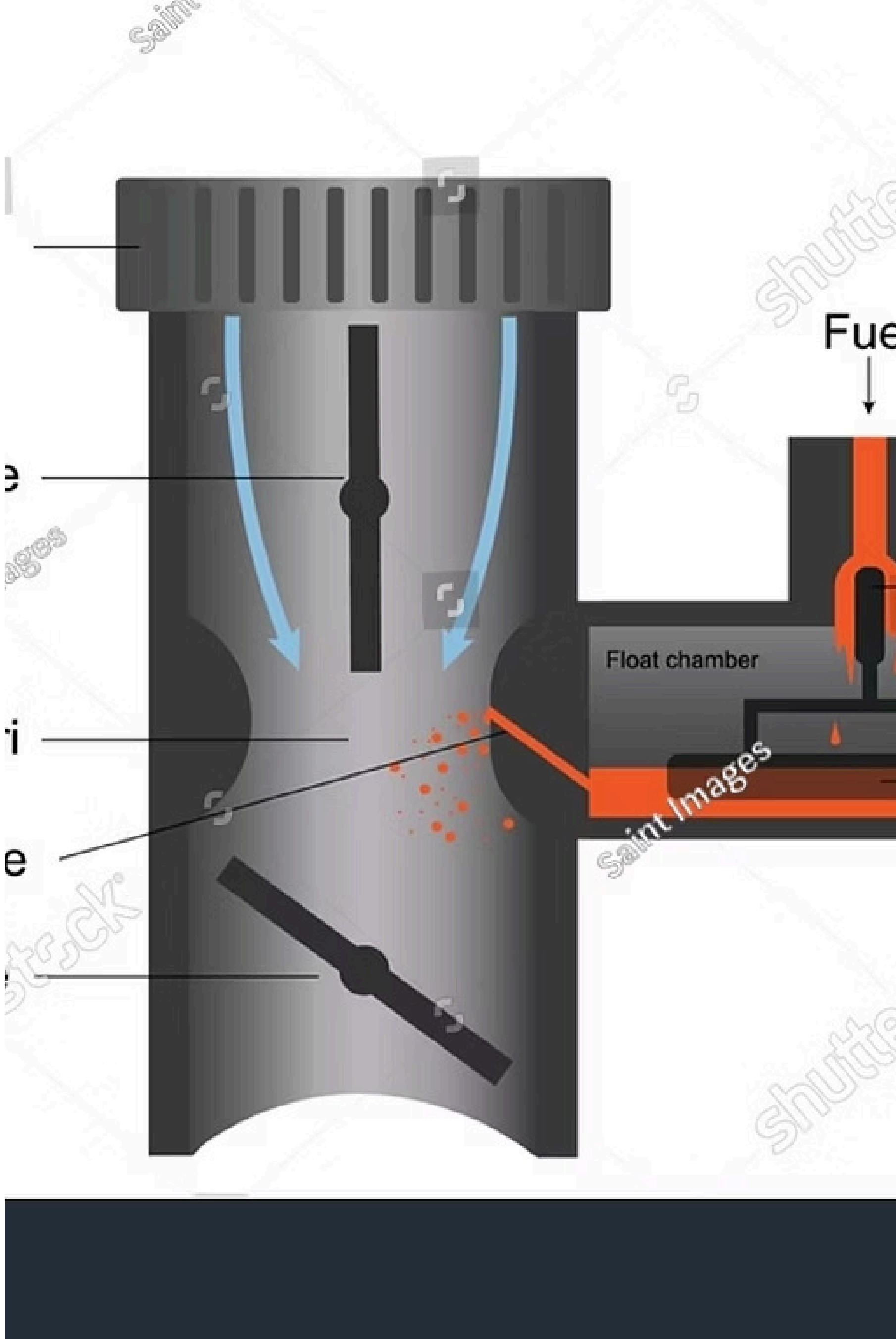
Gas burners use two air sources:

Primary Air:

- Mixed with gas BEFORE combustion
- Drawn through venturi by gas jet
- Creates air-gas mixture
- Amount controlled by air shutter
- Typically 40-60% of total air (atmospheric burners)

Secondary Air:

- Drawn into flame during combustion
- Comes from surrounding burner area
- Completes combustion
- No control mechanism
- Must be available from room/combustion air supply



Primary Air Adjustment:

Too Little Primary Air:

- Yellow, lazy flame
- Flame lifting possible
- Incomplete combustion
- Soot formation
- Carbon monoxide production
- Lower efficiency

Too Much Primary Air:

- Sharp blue flame
- Flame lifting (blows off ports)
- Noisy combustion (roaring)
- Flashback possible
- Cooler flame (heat loss)

Correct Primary Air:

- Stable blue flame
- Soft flame, not lifting
- Minimal yellow tipping
- Complete combustion
- Maximum efficiency

Power Burners:

Fan forces air into combustion chamber

Air and gas premixed

Precise control of air-fuel ratio

Higher efficiency possible

Less dependent on secondary air

Better combustion control

Complete vs. Incomplete Combustion

Complete Combustion:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Heat$$

Products:

Carbon dioxide (CO_2)

colorless, non-toxic gas

Water vapor (H_2O)

condensation in flue

Heat energy

useful output

Nitrogen (from air)

passes through unchanged

Characteristics:

- Blue flame
- Maximum heat output
- Safe products
- No visible smoke or soot

Incomplete Combustion:

$$2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O + Heat$$

(less heat than complete)

Or even less complete:

$$CH_4 + O_2 \rightarrow C + 2H_2O + Heat$$

(even less heat)

Products:

Carbon monoxide (CO)

highly toxic, colorless, odorless

Free carbon (C)

soot, visible smoke

Unburned hydrocarbons

Water vapor

Less heat released

Characteristics:

- Yellow or orange flame
- Visible smoke or soot
- Lower heat output
- Dangerous products

Causes of Incomplete Combustion:

Insufficient Air:

- Blocked air intakes
- Inadequate combustion air supply
- Poor primary air adjustment
- Negative building pressure

Poor Mixing:

- Dirty burners
- Improper burner adjustment
- Damaged burner ports
- Wrong orifice size

Flame Quenching:

- Flame contact with cold surfaces
- Heat exchanger too close to flame
- Deposits on heat exchanger

Excess Gas Pressure:

- Too much gas through orifice
- Overwhelms available air
- Rich mixture

Venting Problems:

- Backdrafting
- Products recirculate
- Depletes oxygen

Carbon Monoxide Production:

Even small amounts of CO are dangerous:

35

ppm

continuous exposure limit (CSA B149.1)

70

ppm

causes headaches in 1-4 hours

400

ppm

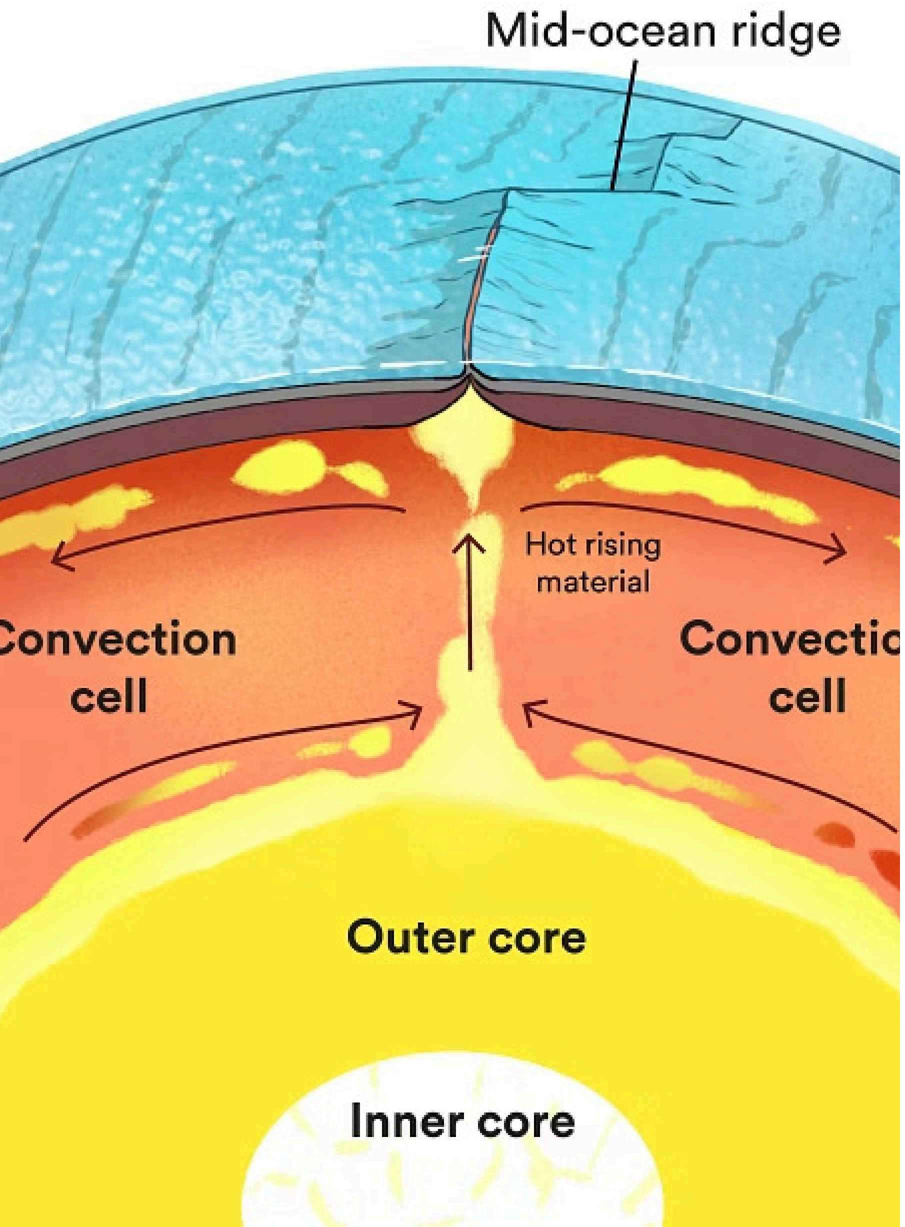
dangerous in 1 hour

1600

ppm

fatal in 20 minutes

This is why combustion testing is critical on every service call.



Flame Characteristics

Proper Flame (Natural Gas):

- Clear blue color
- Inner cone distinct
- Stable, not lifting
- Minimal yellow tips at outer edge
- Soft, quiet combustion
- No soot formation

Flame Zones:

1. Primary Combustion Zone (inner cone):

- Light blue
- Hottest part (1,980°C / 3,600°F for methane)
- Primary air combustion

2. Secondary Combustion Zone (outer mantle):

- Darker blue/purple
- Secondary air completes combustion
- Slightly cooler

Problem Flames:

Yellow Flame:

- Insufficient air
- Incomplete combustion
- Soot formation
- CO production
- Needs adjustment

Floating/Lifting Flame:

- Flame not on port
- Hovers above burner
- Excessive primary air
- Wrong orifice size
- Possible ignition failure

Flashback:

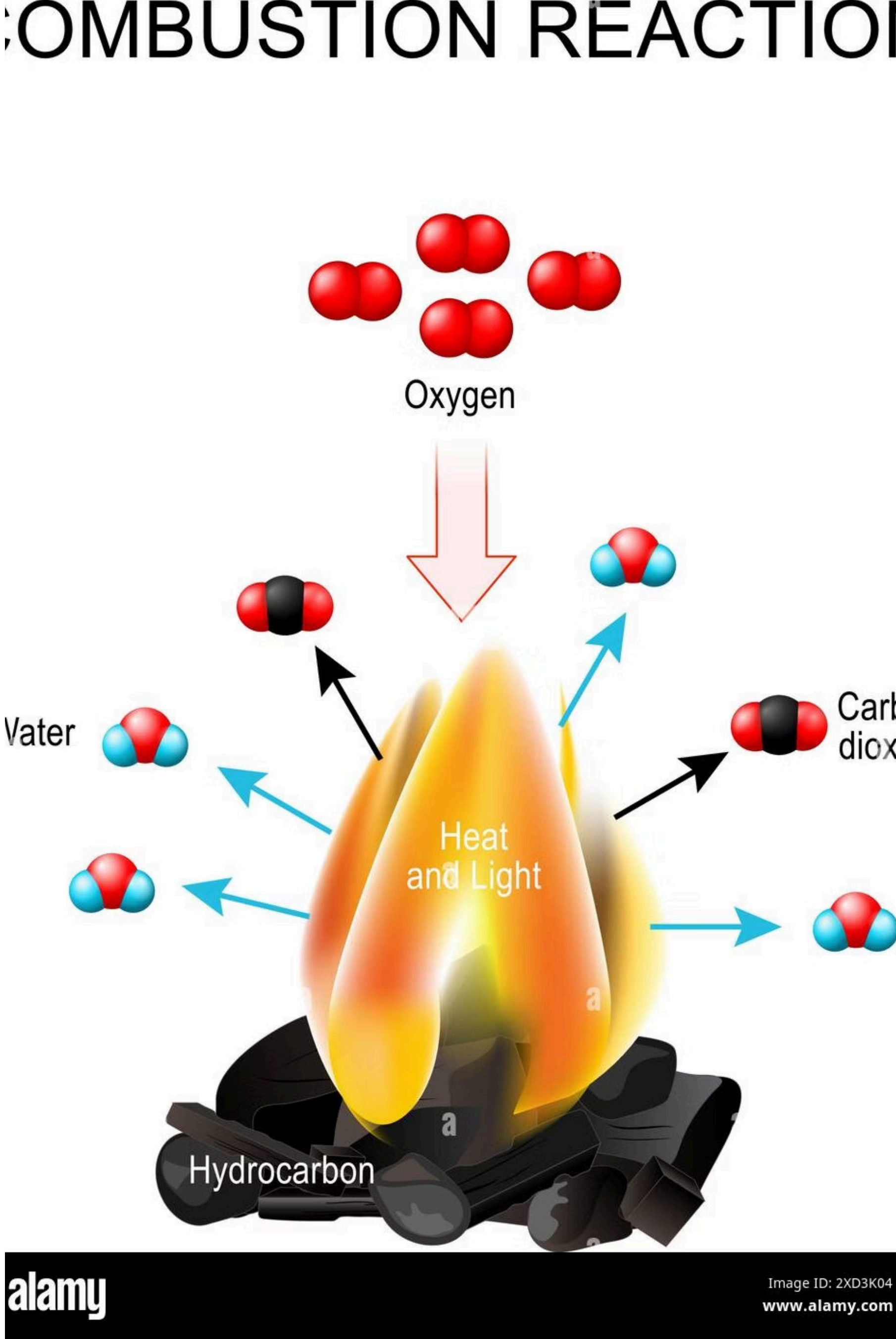
- Flame burns inside burner
- Excessive primary air
- Gas velocity too low
- Dangerous condition
- Shut off immediately

Impingement:

- Flame contacts surfaces
- Incomplete combustion
- CO production
- Equipment damage
- Misaligned burner or damaged heat exchanger

4.6 Products of Combustion

Understanding combustion products is essential for safety and proper venting.



Normal Products (Complete Combustion)

1. Carbon Dioxide (CO_2)

Properties:

- Colorless, odorless gas
- Non-toxic at low concentrations
- Heavier than air (SG = 1.52)
- Normal atmospheric level: 400 ppm (0.04%)

In Flue Gas:

- Natural gas: 8-10% CO_2 (complete combustion)
- Propane: 10-12% CO_2
- Higher CO_2 indicates better combustion (less excess air)
- Maximum practical: about 11-12% for natural gas

Significance:

- Indicates combustion efficiency
- High CO_2 = less excess air = higher efficiency
- Too high may indicate insufficient air
- Measured by combustion analyzer

2. Water Vapor (H_2O)

Properties:

- Colorless (visible as steam when condensed)
- Non-toxic
- Lighter than air as vapor

Quantity Produced:

- About 1 gallon of water per 100,000 BTU burned
- 100,000 BTU/hr furnace produces 1 gallon/hr
- Significant moisture load

Significance:

- Must be vented (prevents condensation damage)
- Condensing furnaces extract latent heat from water vapor
- Non-condensing vents must stay above dew point
- Source of "steam" visible from flues in cold weather

3. Nitrogen (N_2)

Properties:

- Inert gas
- Passes through combustion unchanged
- Makes up 79% of air

Significance:

- Dilutes combustion products
- No harmful effects
- Affects vent sizing (volume of products)

4. Heat Energy

- Useful output (approximately 1,000 BTU per ft^3 natural gas)
- Transferred to heat exchanger
- Remaining heat exits via flue

Harmful Products (Incomplete Combustion)

1. Carbon Monoxide (CO)

Properties:

- Colorless, odorless, tasteless
- Highly toxic
- Slightly lighter than air (SG = 0.97)
- Cannot be detected by human senses

Toxicity:

- Binds to hemoglobin 200-250 times more readily than oxygen
- Prevents oxygen transport in blood
- Accumulative effect
- Fatal at high concentrations
- Symptoms: headache, nausea, confusion, death

Acceptable Levels:

- Ambient air: 35 ppm maximum continuous (CSA B149.1)
- Flue gas: 100 ppm air-free maximum (most appliances)
- Lower is always better
- Goal: < 50 ppm in flue gas

Production:

- Any incomplete combustion
- Insufficient air
- Flame impingement
- Poor mixing
- Backdrafting

Prevention:

- Adequate combustion air
- Proper burner adjustment
- Clean heat exchangers
- Proper venting
- Regular maintenance
- Combustion testing

2. Soot (Free Carbon)

Properties:

- Fine black particles
- Unburned carbon
- Deposits on surfaces

Effects:

- Insulates heat exchanger (reduces efficiency)
- Blocks flue passages
- Dirty appearance
- Indicates combustion problems
- Often accompanies CO production

Causes:

- Insufficient air
- Improper adjustment
- Dirty burners
- Over-firing

3. Unburned Hydrocarbons

Properties:

- Organic compounds that didn't combust
- Can include methane, formaldehyde, others
- Some may be irritants

Significance:

- Indicates incomplete combustion
- Energy loss
- Potential health concerns
- Usually accompanies CO and soot

4. Nitrogen Oxides (NOx)

Properties:

- Formed at high combustion temperatures
- Includes NO and NO_2
- Respiratory irritants
- Contribute to smog formation

Significance:

- Environmental concern
- Low-NOx burners available
- Trade-off with efficiency
- Generally lower concern in residential equipment

5. Sulfur Dioxide (SO_2)

Properties:

- Produced if sulfur in fuel
- Highly corrosive
- Respiratory irritant
- Distinctive sharp odor

Significance:

- Modern natural gas highly desulfurized
- Primarily concern with oil or untreated gas
- Can corrode venting
- Minimal in Canadian natural gas

Measuring Combustion Products

Combustion Analyzer Measurements:

Oxygen (O_2):

- Indicates excess air
- Higher O_2 = more excess air
- Typical: 5-9%

Carbon Dioxide (CO_2):

- Indicates combustion completeness
- Higher CO_2 = less excess air (more efficient)
- Natural gas: 8-10%
- Propane: 10-12%

Carbon Monoxide (CO):

- Indicates incomplete combustion
- Measured in ppm
- Air-free reading (corrected for O_2)
- Must be < 100 ppm (ideally < 50 ppm)

Stack Temperature:

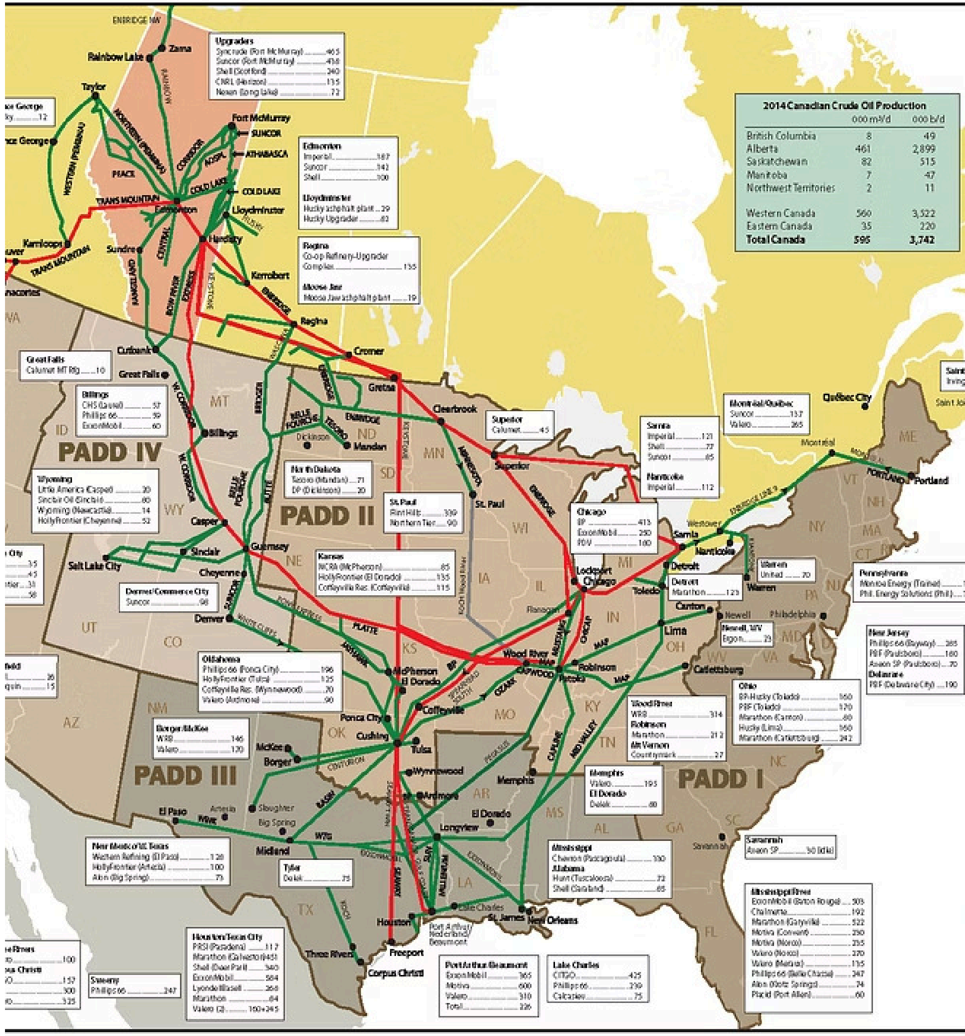
- Temperature of flue gases
- Indicates heat exchanger efficiency
- Used in efficiency calculations
- Typical: 300-500°F non-condensing

Calculated Efficiency:

- Based on O_2, stack temperature, ambient temperature
- Combustion efficiency (flue loss)
- Not same as AFUE (seasonal efficiency)

4.7 Natural Gas Distribution in Canada

Production and Processing



Major Production Regions:

Western Canada Sedimentary Basin:

- Alberta: largest producer (>70% of Canadian production)
- British Columbia: significant producer
- Saskatchewan: smaller production
- Conventional and unconventional sources

Other Regions:

- Nova Scotia: offshore production (Sable Island)
- Ontario: small production
- Newfoundland: offshore (Hibernia)
- Northwest Territories: potential development

Processing Steps:

01

Extraction:

- Wells drilled to gas formations
- Natural pressure drives gas to surface
- Associated gas (with oil) or non-associated

02

Field Separation:

- Remove water and condensate
- Initial processing at wellhead

03

Gas Processing Plant:

- Remove hydrogen sulfide (sweetening)
- Remove CO_2
- Remove water vapor (dehydration)
- Extract natural gas liquids (ethane, propane, butane)
- Result: pipeline-quality natural gas

04

Compression:

- Increase pressure for transmission
- Multiple compressor stations along pipeline

Transmission System

Transmission Pipelines:

High-Pressure Long-Distance:

- 400-1,000 PSI typical
- Large diameter (36-48" common)
- Carbon steel pipe
- Welded construction
- Cathodic protection against corrosion
- Right-of-way through rural areas

Major Canadian Pipelines:

- **TC Energy (formerly TransCanada):** Transcontinental system
- **Enbridge:** Ontario and Quebec
- **Alliance Pipeline:** Western Canada to US
- **Westcoast Energy:** BC system
- Many regional systems

Compressor Stations:

- Located every 60-100 km
- Maintain pressure along pipeline
- Gas turbine or electric motor driven
- Remote monitoring

Regulation:

- **National Energy Board (NEB):** Federal oversight
- Provincial regulators
- Safety standards
- Environmental protection

Distribution System

Pressure Reduction:

Gas pressure reduced in stages:

1. Transmission Pressure:

400-1,000 PSI

2. High-Pressure Distribution:

60-200 PSI

- Steel pipe
- Serves large loads
- Industrial/commercial customers
- Gate stations reduce from transmission pressure

3. Medium-Pressure Distribution:

15-60 PSI

- Steel or polyethylene pipe
- Residential and commercial areas
- District regulator stations reduce pressure

4. Low-Pressure Distribution:

5-15 PSI (typical 7" W.C.)

- Steel or PE pipe in street
- Service regulators at each customer
- Legacy systems in some older cities

5. Customer Service Pressure:

5-7" W.C. (typical)

- Regulator at meter
- Delivers gas at appliance pressure
- Individual service line to building

Distribution Piping Materials:

Steel Pipe:

- Mains in streets
- Coated for corrosion protection
- Cathodic protection
- Legacy systems

Polyethylene (PE) Pipe:

- Modern standard for distribution
- Corrosion-proof
- Flexible
- Fused joints (no leaks)
- Yellow jacket for easy identification
- Depth requirements in CSA B149

Service Lines:

Connection to Main:

- Tap into distribution main
- Corporation stop or tapping valve
- Transition from PE to steel often at property line

Materials:

- PE pipe most common
- Steel if required by utility or code
- Must be traceable (yellow tracer wire if PE)

Installation:

- Minimum depth per code (typically 18" below frost line)
- Protected from damage
- Marked at surface
- Clear of other utilities

Utility Responsibilities vs. Customer Responsibilities

Utility Owns and Maintains:

- All mains
- Service line to meter (typically)
- Meter and regulator
- Emergency response
- Pressure maintenance

Customer Owns and Maintains:

- Piping downstream of meter
- All appliances
- Interior installations
- Must use licensed contractor for work

Meter Set:

- Transition point
- Service line enters
- Meter measures consumption
- Regulator reduces pressure
- Shut-off valve(s)
- Utility access required

4.8 Odorization

Natural gas is naturally odorless - odorization is required for safety.

Odorant Characteristics

Mercaptan (Methyl Mercaptan or Ethyl Mercaptan):

- Chemical formula: CH_3SH (methyl) or C_2H_5SH (ethyl)
- Sulfur-containing compound
- Extremely distinctive odor
- "Rotten egg" or "sulfur" smell
- Detectable at very low concentrations

Detection Threshold:

Humans can detect at 1-2 parts per billion

Well below LEL (50,000 ppm)

Provides early warning

Can smell gas long before dangerous concentration

Concentration:

- Approximately 1 pound per 10,000 cubic feet of gas
- Higher concentration in winter (gas more compressed)
- Sufficient to detect 1/5 of LEL

Odorization Requirements

CSA Z662 (Oil and Gas Pipeline Systems):

- Requires odorization of gas distributed to public
- Must be distinctive and unpleasant
- Detectable at 1/5 LEL (1% by volume for natural gas)

Purpose:

- Early leak detection
- Public safety
- Required by regulation

Injection Points:

- City gate stations (where gas enters distribution)
- Processing plants
- Automatically controlled
- Monitored for consistency

Odor Fade

Definition:

- Loss of odorant over time or conditions
- Gas becomes less odorous

Causes:

Adsorption:

- Odorant absorbed by pipe walls
- New pipe particularly susceptible
- Rusty pipe
- Condensate in pipe

Oxidation:

- Odorant reacts with oxygen
- Rust in pipe
- Contamination

Dilution:

- Mixing with unodorized gas
- Air infiltration

Significance:

- Rare in modern systems
- Could delay leak detection
- More common in old systems
- PE pipe minimizes this issue

Industry Monitoring:

- Regular odor intensity tests
- Maintain adequate odorant levels
- Adjust injection rates as needed

Public Education

Utilities Promote:

"Smell gas? Act fast!"

Recognition of gas odor

Proper response procedures

Annual reminders

Bill inserts

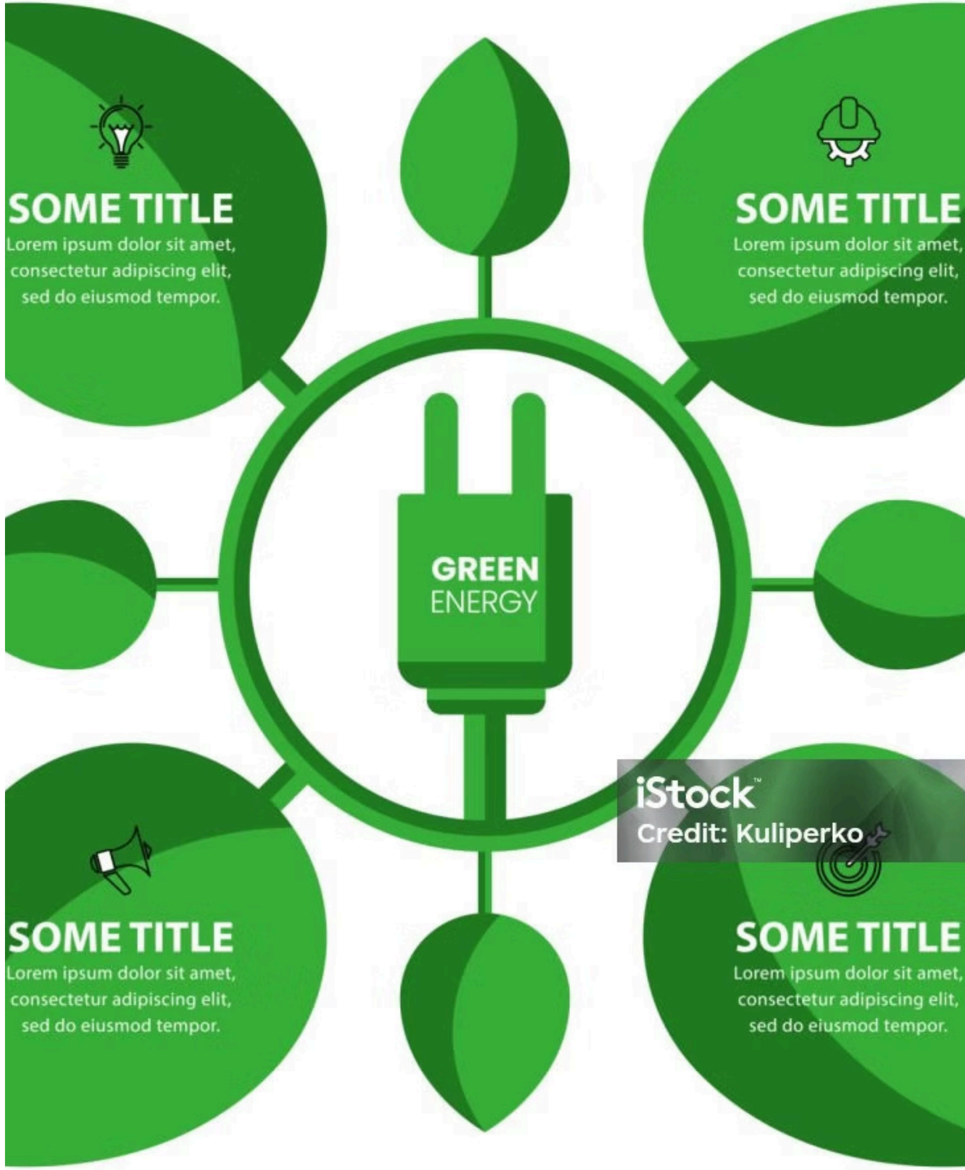
Some People Can't Smell:

- Olfactory impairment
- Medical conditions
- Smoking effects
- Age-related changes
- Cannot rely solely on odor

This is why:

- Electronic detection needed professionally
- CO alarms supplement but don't detect gas
- Multiple safety layers important
- Education on other signs (hissing, dead vegetation, etc.)

4.9 Environmental Considerations



Greenhouse Gas Emissions

Carbon Dioxide (CO_2) Production:

Complete combustion of methane:

- Produces CO_2 and H_2O
- 117 pounds CO_2 per million BTU (approximately)
- Lower than coal or oil per unit energy
- Still contributes to greenhouse gas emissions

Methane (CH_4) as Greenhouse Gas:

- Potent greenhouse gas (25-30x more potent than CO_2 over 100 years)
- Leaks from production, transmission, distribution
- Industry efforts to minimize fugitive emissions
- Pipeline maintenance
- Leak detection programs

Natural Gas vs. Other Fuels

CO_2 Emissions Comparison (per million BTU):

Fuel	CO_2 Produced (lbs)	Relative
Coal	220	100% (highest)
Oil	160	73%
Natural Gas	117	53% (cleanest fossil fuel)

Other Emissions:

- Lower sulfur oxides (SOx) than oil or coal
- Lower nitrogen oxides (NOx) than oil or coal
- Lower particulate matter
- No ash or solid waste

Efficiency Advantage:

- Modern gas furnaces: 90-98% efficient
- Modern boilers: 85-95% efficient
- Combined cycle power generation: up to 60% efficient
- Less waste = fewer emissions per useful energy

Environmental Benefits

Compared to Other Fossil Fuels:

Cleanest burning fossil fuel

No on-site storage (no spill risk)

No soot or ash disposal

Reliable supply

Efficient combustion

Air Quality:

- Minimal particulate emissions
- Lower smog precursors
- Reduced acid rain contribution
- Cleaner indoor air

Infrastructure:

- Underground distribution (minimal visual impact)
- Established pipeline network
- High safety record
- Efficient delivery system

Role in Energy Transition

Current Role:

- Reliable baseload energy
- Backup for renewable intermittency
- Heating in cold climates
- Industrial processes
- Electricity generation

Future Considerations:

- Bridge fuel during transition
- Renewable natural gas (RNG) potential
- Hydrogen blending research
- Carbon capture technology
- Continued infrastructure use

Renewable Natural Gas (RNG):

- Produced from organic waste
- Chemically identical to natural gas
- Can use existing infrastructure
- Reduces net greenhouse gas emissions
- Growing in Canada

4.10 Gas Quality Standards

Quality Specifications

Gas utilities must deliver gas meeting specifications:

Heating Value:

- Must fall within specified range
- Typically 950-1,100 BTU/ft^3
- Consistent heating value
- Appliances designed for range

Wobbe Index:

- Maintained within narrow range
- Ensures appliance compatibility
- ±4-5% typical tolerance

Pressure:

- Consistent delivery pressure
- 5-7" W.C. typical at customer meter
- Within appliance operating range

Contaminants:

- Minimal water vapor
- No hydrogen sulfide
- Low nitrogen and CO_2
- No solids or liquids

Dewpoint:

- Water dewpoint below ambient temperature
- Prevents condensation in pipes
- Prevents freezing
- Prevents corrosion

Monitoring and Testing

Utility Responsibilities:

- Regular gas quality testing
- Monitor heating value
- Check odorant levels
- Verify pressure delivery
- Respond to quality issues

Customer Impact:

- Consistent appliance performance
- No field adjustments needed
- Appliance efficiency maintained
- Safety assured

Records:

- Maintain quality data
- Available to regulators
- Document variations
- Trend analysis

Chapter Summary

Natural gas is primarily methane (CH_4) with small amounts of heavier hydrocarbons and inerts. Its physical properties include specific gravity of 0.60 (lighter than air), heating value of approximately 1,000 BTU/ft^3, and a Wobbe Index of 1,250-1,400. These properties determine appliance performance, piping requirements, and safety considerations.

Complete combustion requires proper air-fuel mixture producing carbon dioxide, water vapor, and heat. Incomplete combustion produces dangerous carbon monoxide, requiring adequate combustion air, proper burner adjustment, and effective venting. The stoichiometric air requirement is 9.5:1, with practical installations using 40-60% excess air.

Natural gas is distributed through extensive pipeline networks from western Canadian production to customers nationwide. Pressure is reduced in stages from transmission (400-1,000 PSI) to customer service (5-7" W.C.). Odorization with mercaptan provides leak detection, and quality standards ensure consistent appliance performance.

As the cleanest-burning fossil fuel, natural gas produces lower emissions than coal or oil. Modern high-efficiency equipment and proper combustion further reduce environmental impact. Understanding gas properties enables safe, efficient installations and effective troubleshooting.

Review Questions

Multiple Choice

1

The primary component of natural gas is:

- a) Propane
- b) Ethane
- c) Methane
- d) Butane

2

Natural gas has a specific gravity of approximately:

- a) 0.60
- b) 1.00
- c) 1.52
- d) 2.00

3

The gross heating value of natural gas is approximately:

- a) 500 BTU/ft^3
- b) 1,000 BTU/ft^3
- c) 2,500 BTU/ft^3
- d) 5,000 BTU/ft^3

4

The Wobbe Index is calculated by:

- a) Heating value × Specific gravity
- b) Heating value ÷ Specific gravity
- c) Heating value ÷ √(Specific gravity)
- d) √(Heating value) ÷ Specific gravity