CHAPTER 9

Introduction to Gas Appliances

Learning Objectives

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

1. Identify major categories of gas appliances and their applications
2. Interpret appliance rating plates and certification markings
3. Distinguish between venting categories and select appropriate venting
4. Calculate and apply input ratings, including de-rating requirements
5. Understand efficiency ratings (AFUE, thermal, combustion)
6. Apply clearance requirements to combustibles per CSA B149.1
7. Calculate combustion air requirements for appliances
8. Install appliances according to manufacturer instructions and code
9. Perform initial commissioning and testing of gas appliances
10. Document appliance installations properly

9.1 Appliance Categories

Gas appliances convert the chemical energy in natural gas or propane into useful heat for various applications.

Heating Equipment

Central Heating:

Forced Air Furnaces:

- Most common residential heating
- Heat exchanger plus blower
- Ducted air distribution
- 40,000 - 150,000 BTU/hr residential
- Up to millions BTU commercial
- Various efficiency levels (80-98% AFUE)

Boilers (Hydronic Heating):

- Heat water or produce steam
- Radiant heat distribution
- Baseboards, radiators, or in-floor
- 50,000 - 400,000 BTU/hr residential
- Larger for commercial/industrial
- 80-95%+ efficiency

Unit Heaters:

- Self-contained heating unit
- Direct space heating
- Common in garages, warehouses, shops
- 30,000 - 400,000 BTU/hr typical
- Vented or unvented (separated combustion)

Space Heaters:

Vented Space Heaters:

- Wall-mounted or floor-standing
- Direct vented or B-vented
- Zone heating
- 10,000 - 40,000 BTU/hr typical
- Supplemental heat

Vent-Free Space Heaters:

- No venting required
- Restrictions in Canada (limited or prohibited in some jurisdictions)
- Oxygen depletion sensor required
- Maximum size limitations
- CSA B149.1 restrictions

Infrared Heaters:

- Radiant heat
- High-intensity or low-intensity
- Industrial/commercial applications
- Outdoor heating (patios)
- Vented or unvented designs

Water Heating

Storage Tank Water Heaters:

- Most common residential

- 30-75 gallon capacity typical
- 30,000 - 75,000 BTU/hr input
- Various venting types
- Recovery rate important

Tankless (Instantaneous) Water Heaters:

- Heat water on demand
- No storage tank
- 120,000 - 199,000 BTU/hr residential
- Continuous hot water
- Higher efficiency potential
- Complex installation requirements

Commercial Water Heaters:

- Larger capacity storage
- Higher input rates
- Multiple units common
- Specialized applications

Indirect Water Heaters:

- Tank heated by boiler
- No direct gas burner
- Very efficient
- Common with hydronic systems

Cooking Appliances

Ranges:

- Combined cooktop and oven
- 30" and 36" widths common
- 65,000 - 75,000 BTU/hr typical total input
- Open burner or sealed burner

Cooktops:

- Counter-mounted burners only
- 4-6 burners typical
- 30,000 - 45,000 BTU/hr
- Various burner configurations

Wall Ovens:

- Built-in ovens separate from cooktop
- Single or double ovens
- 18,000 - 25,000 BTU/hr each
- Convection or conventional

Commercial Cooking Equipment:

- Ranges (heavy-duty)
- Griddles
- Fryers
- Ovens (standard and convection)
- Broilers
- Specialized equipment
- Much higher inputs than residential

Clothes Dryers

Residential Dryers:

- 30,000 - 35,000 BTU/hr input
- Vented to exterior
- Moisture removal
- Gas or electric ignition

Commercial Dryers:

- Laundromats and institutions
- Higher capacity
- 100,000+ BTU/hr
- Multiple units common

Other Appliances

Fireplaces and Fireplace Inserts:

- Decorative and/or heating
- Vented or vent-free (where permitted)
- Direct vent popular
- Gas logs in existing fireplaces
- 20,000 - 40,000 BTU/hr typical

Pool and Spa Heaters:

- Outdoor installation typical
- 100,000 - 400,000 BTU/hr
- Weatherproof construction

- Corrosion-resistant materials

Outdoor Appliances:

- Patio heaters
- Barbecues (built-in)
- Outdoor fireplaces
- Fire pits
- Weather-resistant construction

Generators (Standby):

- Emergency power
- Engine-driven
- Automatic start
- Whole-house or partial
- Varies greatly in size

9.2 Venting Categories

Appliances are classified by venting method, which affects installation requirements.

Category I Appliances

Characteristics:

- Draft hood equipped (natural draft)
- Non-positive vent static pressure
- Flue gas temperature > 140°F (60°C)
- Non-condensing
- Traditional design

Operation:

- Natural draft pulls combustion products through heat exchanger
- Draft hood dilutes flue gases with room air
- Creates negative pressure in vent
- Relies on buoyancy

Venting:

- Type B gas vent (double-wall)
- Single-wall vent connector (limited length)
- Vertical termination through roof

- Cannot use PVC or plastic
- Must terminate above roof per code

Efficiency:

- 78-82% AFUE typical
- Heat lost in flue gases
- Draft hood allows spillage potential

Examples:

- Older furnaces
- Atmospheric water heaters
- Standard boilers
- Most cooking appliances

Installation Considerations:

- Adequate combustion air critical
- Building depressurization can cause spillage
- Vent must be properly sized and installed
- Draft must be adequate
- Spillage testing required

Category II Appliances

Characteristics:

- Non-positive vent static pressure
- Flue gas temperature ≤ 140°F (60°C)
- May condense in vent
- Rarely seen (few manufacturers)

Venting:

- Special vent materials
- Corrosion-resistant
- Must handle condensation
- Specific to appliance

Notes:

- Uncommon category
- Mostly historical reference
- Check specific appliance requirements

Category III Appliances

Characteristics:

- Positive vent static pressure
- Flue gas temperature > 140°F (60°C)
- Forced or induced draft
- Non-condensing
- Power vented

Operation:

- Fan forces or induces draft
- Creates positive pressure in vent
- No draft hood
- More efficient than Category I

Venting:

- Special vent materials
- Single-wall metal or specific listed materials
- Can vent horizontally through wall
- Shorter vent runs possible
- Must withstand positive pressure

Examples:

- Some power-vented water heaters
- Older power-vented furnaces
- Commercial equipment

Installation:

- Follow manufacturer specifications exactly
- Electrical interlock required (vent fan)
- Vent material critical
- Termination specific to appliance

Category IV Appliances

Characteristics:

- Positive vent static pressure
- Flue gas temperature ≤ 140°F (60°C)
- Condensing
- High efficiency

- Forced or induced draft

Operation:

- Extracts maximum heat from combustion
- Flue gases cooled below water vapor condensation point
- Water vapor condenses in heat exchanger
- Latent heat recovered
- Fan creates positive vent pressure

Venting:

- PVC, CPVC, or ABS plastic (per manufacturer)
- Polypropylene
- Stainless steel
- Must resist condensate (acidic)
- Can vent horizontally through wall
- Direct vent option

Efficiency:

- 90-98% AFUE
- Highest efficiency category
- Condensate produced (must be drained)

Examples:

- High-efficiency furnaces (90%+)
- High-efficiency boilers
- Condensing tankless water heaters
- Modern residential equipment

Installation:

- Condensate drain required
- Must pitch for drainage
- PVC primer and cement per manufacturer
- Air intake often incorporated
- Specific termination requirements
- Electrical interlock

Condensate Management:

- Drain to floor drain, condensate pump, or outside
- May require neutralization (depending on local code)
- Trap required per manufacturer

- Cannot freeze
- Approximately 1 gallon per 100,000 BTU input

Direct Vent Appliances

Not a numbered category, but common design

Characteristics:

- Sealed combustion chamber
- Concentric vent (pipe within pipe)
- Combustion air drawn from outside
- Flue gases exhausted outside
- No room air used for combustion

Operation:

- Outer pipe brings combustion air in
- Inner pipe exhausts flue gases out
- Completely isolated from indoor air
- Can be Category III or IV

Venting:

- Horizontal through wall (most common)
- Vertical through roof (possible)
- Concentric termination
- Specific clearances to openings

Advantages:

- No combustion air from indoors (tight buildings)
- No spillage potential
- Can install in confined spaces
- More flexible installation

Examples:

- Direct vent fireplaces
- Direct vent water heaters
- Some furnaces
- Wall furnaces

Installation:

- Follow manufacturer termination requirements exactly

- Clearances to openings critical
- Must maintain slope for drainage
- Seal penetration properly

Power Vent vs. Direct Vent

Power Vent:

- Uses indoor air for combustion
- Vents through power vent fan
- Single pipe exhaust
- Separate combustion air from room

Direct Vent:

- Uses outdoor air for combustion
- Sealed combustion
- Concentric vent (usually)
- No room air involved

9.3 Certification and Approval

All gas appliances must be certified for use in Canada.

Certification Marks

CSA (Canadian Standards Association):

- Most common certification in Canada
- Blue CSA mark with flame logo
- Indicates compliance with Canadian standards
- Tested for safety
- Different marks for different products

AGA (American Gas Association) / CGA (Canadian Gas Association):

- Blue star seal
- Certifies performance
- Common on cooking appliances
- Now mostly replaced by CSA

UL/ULC (Underwriters Laboratories):

- Safety certification
- Both U.S. (UL) and Canadian (ULC) marks
- Some appliances carry both CSA and ULC

ANSI (American National Standards Institute):

- Standards reference
- Not certification mark itself
- Standards adopted by certifying bodies

Requirements:

- Must have recognized certification mark
- Installed per listing and manufacturer instructions
- Uncertified appliances not permitted
- Used appliances must retain certification marking

Rating Plate Information

Required Information on Rating Plate:

1. **Manufacturer Name and Model Number**
    - Identifies appliance
    - Required for service
    - Parts ordering
2. **Certification Mark**
    - CSA, AGA/CGA, ULC
    - Confirms approval
3. **Gas Type**
    - Natural gas or propane (LP)
    - May show both if convertible
    - Critical for proper operation
4. **Input Rating**
    - BTU/hr or kW
    - Manifold pressure
    - Orifice size (sometimes)
5. **Elevation (De-rating)**
    - Maximum elevation without de-rating
    - De-rating requirements if applicable
    - Important in mountainous areas
6. **Electrical Requirements**
    - Voltage (115V, 230V typical)
    - Amperage
    - Must match supply
7. **Venting Information**
    - Category (I, III, IV)

    - Vent material requirements
    - Vent diameter
    - Maximum/minimum vent length
8. **Clearances**
    - Minimum clearances to combustibles
    - Required for safe installation
9. **Serial Number**
    - Unique identifier
    - Manufacturing date (encoded)
    - Warranty reference
10. **Other:**
    - Efficiency rating (AFUE for furnaces/boilers)
    - For water heaters: recovery rate, first hour rating
    - Special instructions or warnings

Interpreting Rating Plates

Example Furnace Rating Plate:

```
Manufacturer: XYZ Heating Company
Model: ABC-100
Serial: 12345678

Certification: [CSA Logo]

Gas Type: Natural Gas (NAT) - Propane (LP) Field Convertible
Input: 100,000 BTU/hr NAT @ 3.5" W.C.
       100,000 BTU/hr LP @ 10" W.C.

Output: 95,000 BTU/hr (95% AFUE)

Electrical: 115V / 60Hz / 15A

Venting: Category IV, PVC Sch 40, 3" diameter
         Max Vent Length: 60 ft equivalent

Clearances:
  Front: 24" for service
  Sides: 3" to combustibles
  Rear: 1" to combustibles
  Top: 12" to combustibles
  Flue: 1" clearance

Elevation: Suitable for use up to 2000 ft (600 m)
           See manual for de-rating above 2000 ft

For installation and service, see manual provided
```

Reading This Plate:

- High-efficiency condensing furnace (Category IV, 95% AFUE)

- 100,000 BTU input, 95,000 BTU output
- Requires 3" PVC vent
- Can burn either natural gas or propane (with conversion)
- Different manifold pressures for each fuel
- Needs 115V electrical
- Specific clearances must be maintained
- De-rating required above 2000 feet elevation

9.4 Input Rating and Efficiency

Understanding input, output, and efficiency is essential for proper appliance selection and operation.

Input Rating

Definition:

- Rate at which appliance consumes fuel
- Measured in BTU/hr (or kW in metric)
- Based on heating value of gas
- Total energy entering appliance

Determining Input:

- Stamped on rating plate
- Can calculate: (gas flow in CFH) × (heating value)
- Natural gas: CFH × 1,000 BTU/ft³
- Propane: CFH × 2,500 BTU/ft³

Example:

- Gas flow: 100 ft³/hr natural gas
- Heating value: 1,000 BTU/ft³
- Input: 100 × 1,000 = 100,000 BTU/hr

MBH Notation:

- M = thousands (Roman numeral)
- BH = BTU/hr
- 100 MBH = 100,000 BTU/hr
- Common shorthand

Output Rating

Definition:

- Useful heat delivered by appliance
- Always less than input (losses occur)
- Measured in BTU/hr

Heat Losses:

- Up the vent (flue gases)
- Cycling losses
- Jacket losses (heat exchanger surface)
- Pilot light (standing pilot systems)

Example:

- Input: 100,000 BTU/hr
- Vent losses: 18,000 BTU/hr
- Cycling losses: 2,000 BTU/hr
- Output: 80,000 BTU/hr

Efficiency Ratings

AFUE (Annual Fuel Utilization Efficiency):

Used For:

- Furnaces
- Boilers
- Annual average efficiency

Includes:

- Steady-state efficiency
- Cycling losses
- Pilot light losses (if standing pilot)
- Jacket losses
- Real-world operation

Calculation:

- (Useful heat output / Energy input) × 100
- Seasonal average, not instantaneous

Ranges:

- Old atmospheric: 55-65% AFUE

- Standard efficiency: 78-82% AFUE
- Mid-efficiency: 83-89% AFUE
- High-efficiency: 90-98% AFUE

Interpretation:

- 80% AFUE = 80% of fuel energy becomes useful heat
- 20% lost up vent and through cycling
- Higher AFUE = lower operating costs

Thermal Efficiency:

Used For:

- Water heaters
- Commercial equipment
- Steady-state measurement

Definition:

- Efficiency during continuous operation
- Does not include cycling or standby losses

Calculation:

- Similar to AFUE but steady-state only
- (Output / Input) × 100

Ranges:

- Standard water heaters: 75-85%
- High-efficiency: 90-96%

Energy Factor (EF) for Water Heaters:

- Includes standby losses
- More comprehensive than thermal efficiency
- Replaced by Uniform Energy Factor (UEF) in newer ratings

Combustion Efficiency:

Definition:

- Efficiency of combustion process only
- Measured with combustion analyzer
- Stack loss calculation

Factors:

- Stack temperature
- Excess air (O_2 level)
- Fuel type

Use:

- Field measurement during service
- Verify proper combustion
- Tune-up indicator

Typical Values:

- Well-tuned atmospheric: 75-82%
- Power burners: 78-85%
- Condensing: 90-98%

Not Same as AFUE:

- AFUE includes cycling and other losses
- Combustion efficiency higher than AFUE
- Both important metrics

Capacity vs. Efficiency

Don't Confuse:

- Input (capacity) = size
- Efficiency = percentage of fuel converted to useful heat
- High efficiency doesn't mean high capacity
- Can have small high-efficiency or large low-efficiency

Example:

- Furnace A: 60,000 BTU input, 95% efficient = 57,000 BTU output
- Furnace B: 100,000 BTU input, 80% efficient = 80,000 BTU output
- B has higher output despite lower efficiency (because larger input)

9.5 De-rating Requirements

Appliances must be de-rated (reduced input) in certain situations.

Altitude De-rating

Why Required:

- Air is thinner at higher elevations
- Less oxygen available for combustion
- Over-firing can occur if not de-rated
- Incomplete combustion risk

When Required:

- Check rating plate for maximum elevation
- Typically 2,000 feet (600 m) without de-rating
- Above this elevation, de-rate per manufacturer

De-rating Factors:

- Usually 4% reduction per 1,000 feet above rated elevation
- Manufacturer specifications vary
- Some appliances altitude-compensating (no de-rating needed)

Example:

- Furnace rated for 2,000 ft maximum without de-rating
- Installed at 4,000 ft elevation
- Excess elevation: 4,000 - 2,000 = 2,000 ft
- De-rating: 2,000 ÷ 1,000 × 4% = 8%
- Original input: 100,000 BTU/hr
- De-rated input: 100,000 × 0.92 = 92,000 BTU/hr

How to De-rate:

- Change orifices to smaller size
- Reduce manifold pressure
- Or combination
- Follow manufacturer instructions
- Document de-rating

Certification:

- De-rated appliances may need re-certification
- Check with authority having jurisdiction
- Maintain documentation

Propane Conversion De-rating

Why Sometimes Required:

- Propane has higher heating value (2,500 vs 1,000 BTU/ft³)
- Propane burns hotter
- Some appliances require de-rating when converted to propane

When Required:

- Check manufacturer conversion instructions
- Some appliances: same input both fuels
- Some appliances: must reduce input on propane
- Affects heat exchanger temperature

Example:

- Furnace: 100,000 BTU/hr on natural gas
- Conversion kit: de-rate to 85,000 BTU/hr on propane
- Smaller orifices AND lower manifold pressure
- Protects heat exchanger from overheating

Process:

- Follow conversion kit instructions exactly
- Change orifices
- Adjust manifold pressure
- May need different orifices than simple conversion would suggest
- Verify with combustion test

Load De-rating

Not Typically Required but Possible:

When Considered:

- Oversized equipment for load
- Cycling problems
- Comfort issues

Options:

- Reduce input by changing orifices
- Two-stage or modulating controls
- Proper sizing in first place (better)

Caution:

- May void warranty
- May violate certification
- Consult manufacturer
- Generally not recommended

9.6 Installation Fundamentals

Proper installation is critical for safety, efficiency, and appliance longevity.

Manufacturer's Instructions

Critical Requirement:

- Must follow manufacturer's installation instructions
- Part of appliance certification
- Code requires compliance
- Provided with appliance

Instructions Include:

- Clearances to combustibles
- Venting requirements
- Combustion air requirements
- Gas connection specifications
- Electrical connection
- Specific installation steps
- Commissioning procedures

If Instructions Lost:

- Download from manufacturer website
- Request from manufacturer
- Cannot install without instructions
- Required for inspection

Location Requirements

General Requirements:

Accessibility:

- Service access required
- Sufficient clearance for maintenance
- Door or panel access to controls

- Clearance for component removal

Protection:

- Protected from physical damage
- Not in traffic areas
- Protected from weather (if outdoor installation)
- Secure mounting

Ventilation:

- Adequate combustion air
- Room ventilation if required
- Not in sealed rooms (unless direct vent)
- Consider appliance requirements

CSA B149.1 Restrictions:

Not Permitted in:

- Bedrooms
- Bathrooms (with exceptions for direct vent)
- Closets (with exceptions)
- Storage rooms (with restrictions)
- Areas with corrosive atmosphere
- Locations subject to flooding

Permitted With Restrictions:

- Utility rooms (adequate combustion air)
- Basements (ventilation, protection from damage)
- Attics (accessibility, ventilation)
- Garages (elevated or protected from vehicle impact)
- Outdoors (weatherproof construction)

Support and Mounting

Floor-Standing:

- Level and stable
- Adequate floor support (structural capacity)
- Vibration isolation if needed
- Anchor if required by code or manufacturer

Wall-Mounted:

- Support adequate for weight
- Proper anchors for wall type
- Level installation
- No stress on gas connections

Suspended:

- Support from structure (not piping)
- Adequate hangers
- Seismic restraint (where required)
- Vibration isolation

9.7 Clearances to Combustibles

Clearances protect combustible materials from heat.

Why Clearances Required

Heat Transfer:

- Appliances generate heat
- Heat radiates and conducts
- Combustible materials can ignite
- Clearances provide safety margin

Combustible Materials:

- Wood framing
- Wood paneling
- Drywall (paper-faced)
- Plastic
- Insulation
- Carpet
- Most building materials

Non-Combustible:

- Concrete
- Masonry
- Steel
- Glass
- Ceramic tile

Clearance Requirements

Source of Requirements:

- Manufacturer specifications (primary)
- CSA B149.1 (code minimums)
- Most restrictive applies

Typical Clearances (Example Furnace):

- Front: 24-30" (service access)
- Sides: 3-6" to combustibles
- Rear: 1-3" to combustibles
- Top: 6-12" to combustibles
- Vent connector: 6" to combustibles (single-wall)

Zero-Clearance Appliances:

- Specifically designed and listed
- Can install against combustibles
- Follow manufacturer instructions exactly
- Common in fireplaces and inserts

Clearance Reduction Methods

When Clearances Cannot Be Met:

Option 1: Use Approved Protection

Manufacturer-Approved Shields:

- Metal shields with air space
- Typically 1" air space behind shield
- Reduces required clearance by 50-66%
- Must follow specific design

Example:

- Required clearance: 18"
- With approved shield: 9" or 6"
- Shield must be installed per specifications

CSA B149.1 Reduction Methods:

- Sheet metal with air space
- Specific construction details
- Certified reduction percentage
- Tables provided in code

Option 2: Relocate Appliance

- Better solution if practical
- Maintains full clearances
- No special protection needed

Option 3: Remove Combustibles

- Replace with non-combustible materials
- Concrete board
- Masonry
- Metal

Never:

- Assume clearances can be reduced without approval
- Install closer than specified without proper protection
- Use unapproved protection materials
- Rely on insulation alone

9.8 Combustion Air Requirements

Adequate air is essential for safe and efficient combustion.

Air Requirements

Two Types of Air:

Combustion Air:

- Air for burning fuel
- Oxygen for combustion
- Consumed by appliance
- Exits through vent

Dilution/Ventilation Air:

- Air for draft hood dilution (Category I)
- Room ventilation
- Not consumed
- Mixes with room air

Total Air Requirements:

- Must provide both
- Calculations based on appliance input
- Location (confined vs. unconfined space)
- Inside or outside air source

Confined vs. Unconfined Space

Confined Space (CSA B149.1 Definition):

- Space with less than 1.5 m^3 (50 ft^3) per 1,000 BTU/hr of total input
- Example: 100,000 BTU/hr appliance in room smaller than 150 m^3 (5,000 ft^3)
- Requires openings for combustion air

Unconfined Space:

- Space with 1.5 m^3 (50 ft^3) or more per 1,000 BTU/hr
- Example: 100,000 BTU/hr appliance in room larger than 150 m^3 (5,000 ft^3)
- Generally has adequate infiltration (older buildings)
- May still need openings (tight buildings)

Modern Consideration:

- Modern buildings are tight
- Even "unconfined" spaces may need openings
- Best practice: provide dedicated combustion air
- Direct vent appliances eliminate this concern

Calculating Combustion Air Openings

CSA B149.1 Methods:

Method 1: All Air from Inside Building

Two Permanent Openings Required:

- One near ceiling
- One near floor
- Each opening minimum size based on appliance input

Sizing:

- Minimum 100 cm^2 per 10 kW (220 in^2 per 100,000 BTU/hr)
- If using single combustion air opening: double the size
- Openings to adjacent unconfined space

Example:

- Furnace: 100,000 BTU/hr
- Water heater: 40,000 BTU/hr
- Total: 140,000 BTU/hr
- Each opening: 140 × 220 ÷ 100 = 308 in²
- Convert: 308 ÷ 144 = 2.1 ft² = approximately 18" × 18"

Method 2: All Air from Outdoors (Direct)

Two Permanent Openings:

- One near ceiling connected to outdoors
- One near floor connected to outdoors
- Each opening to outdoors

Sizing:

- Minimum 50 cm² per 10 kW (110 in² per 100,000 BTU/hr) if vertical ducts
- Minimum 100 cm² per 10 kW (220 in² per 100,000 BTU/hr) if horizontal ducts
- Smaller than indoor method (more effective)

Example:

- Total input: 140,000 BTU/hr
- Vertical ducts: each opening 140 × 110 ÷ 100 = 154 in² = 1.07 ft²
- Approximately 12" × 12" each opening

Method 3: Mixed (One from Inside, One from Outside)

- Complex calculation
- Refer to CSA B149.1 tables
- Less common

Method 4: Mechanical Ventilation

- Powered ventilation
- Must provide adequate CFM
- Interlocked with appliances
- Requires engineering
- Special provisions per code

Combustion Air Duct Requirements

Material:

- Metal (galvanized steel typical)
- Minimum 26 gauge

- Sealed joints

Installation:

- Slope for drainage
- Screen at termination (1/4" mesh)
- No dampers or obstructions
- Protected from damage

Termination:

- Outdoors away from windows/doors
- Minimum 3 ft from forced air intakes
- Minimum 12" above grade (snow)
- Protected from wind (minimizes pressurization effects)

Maintenance Access:

- Cleanable
- Screens removable
- Periodic inspection required

Special Considerations

Direct Vent Appliances:

- Don't use room air
- No combustion air openings needed
- Sealed combustion
- Simplifies installation

Tight Buildings:

- Modern construction very tight
- Even unconfined spaces may need combustion air
- Exhaust fans create negative pressure
- Consider make-up air for exhaust systems

Depressurization:

- Exhaust fans (kitchen, bath, dryer)
- Central vacuum
- Fireplaces
- Can overcome natural draft
- Cause Category I spillage
- Direct vent or power vent eliminates this concern

Building Pressurization Test:

- Use manometer or draft gauge
- Measure pressure with exhaust equipment on
- -3 Pa (-0.01" W.C.) or more negative = concern
- May need make-up air or power-vented appliances

9.9 Appliance Inspection and Commissioning

Proper commissioning ensures safe and efficient operation.

Pre-Start Inspection

Visual Inspection:

Appliance:

- Physical damage during shipping or installation
- All covers and panels installed
- Access panels secure
- No loose parts

Gas Connection:

- Proper pipe size
- Shut-off valve accessible
- Drip leg installed (if required)
- All joints tight
- Leak tested

Electrical:

- Proper voltage supply
- Correct amperage circuit
- Ground wire connected
- No damaged wiring

Venting:

- Proper material for category
- Correct diameter
- Proper slope (condensing appliances)
- No gaps or leaks
- Proper termination

- Clearances maintained

Combustion Air:

- Openings adequate size
- Screens clean
- Ducts connected
- Not blocked

Clearances:

- Verified to combustibles
- No violations
- Proper protection if clearances reduced

Initial Start-Up Procedure

Step-by-Step:

1. Verify Gas Supply:

- Meter/tank has gas
- Service valve open
- Pressure adequate
- Appliance valve open

2. Set Thermostat/Control:

- Call for heat/operation
- Manual mode if available
- Bypass delays if testing

3. Observe Ignition:

- Pilot lights (if standing pilot)
- Igniter glows (if HSI)
- Spark visible (if DSI)
- Main burner ignites
- Time from call to ignition normal

4. Observe Flame:

- Proper flame characteristics
- Blue flame
- Stable
- No yellow tipping (or minimal)

- No lifting or flashback
- Even across burner

5. Verify Blower/Pump Operation:

- Blower starts (furnace)
- Circulator runs (boiler)
- Appropriate delay
- Proper rotation
- No unusual noise

6. Check Pressure:

- Manifold pressure at rating plate value
- Inlet pressure adequate
- Adjust if needed

7. Temperature Rise (Furnaces):

- Measure supply air temperature
- Measure return air temperature
- Calculate rise: Supply - Return
- Compare to rating plate range
- Typical: 40-70°F rise

8. Combustion Testing:

- Insert probe in flue
- Allow readings to stabilize
- Record: O_2, CO_2, CO, stack temperature
- Calculate efficiency
- Verify acceptable limits

9. Cycle Test:

- Allow appliance to complete full cycle
- Verify proper shut-down
- Restart and verify operation
- Multiple cycles

10. Safety Tests:

- Verify limits operate (test if possible)
- Verify pressure switches
- Check rollout switches
- Test flame sensor (simulate failure if possible)

Acceptance Criteria

Combustion:

- O_2: 5-9% typical
- CO: < 100 ppm air-free (CSA B149.1)
- CO_2: Natural gas 8-10%, Propane 10-12%
- Stack temperature: Per appliance type

Operation:

- Ignites reliably
- Burns steadily
- Proper flame appearance
- No unusual noise or vibration
- Controls function properly
- Safeties operate

Performance:

- Adequate heat output
- Temperature rise within range
- Pressure settings correct
- Efficiency acceptable

Safety:

- No gas leaks
- No spillage (Category I)
- No CO production in space
- All safeties function

Documentation

Record:

- Date and time of commissioning
- Manifold pressure
- Inlet pressure
- Combustion test results (all parameters)
- Temperature rise
- Any adjustments made
- Abnormalities noted
- Technician name and license
- Provide copy to customer

Customer Education:

Explain:

- How to operate appliance
- Thermostat/control use
- Filter changing (furnaces)
- Maintenance needs
- When to call for service
- Safety features
- Warranty information

Chapter Summary

Gas appliances convert fuel energy into useful heat through combustion. Major categories include heating equipment (furnaces, boilers, space heaters), water heaters (storage and tankless), cooking appliances, dryers, and specialty equipment (fireplaces, pool heaters, outdoor appliances). Each type has specific installation and performance characteristics.

Appliances are classified by venting category based on vent pressure and temperature. Category I (draft hood, non-condensing) requires Type B vent through roof. Category IV (positive pressure, condensing) uses PVC venting and achieves 90-98% efficiency by extracting latent heat from water vapor. Direct vent appliances use sealed combustion with outdoor air, eliminating spillage potential and combustion air requirements from living space.

All appliances must carry CSA, AGA/CGA, or ULC certification marks and rating plates showing input, gas type, electrical requirements, venting specifications, and clearances. Input ratings may require de-rating for high altitude (typically 4% per 1,000 feet above rated elevation) or propane conversion. Efficiency ratings include AFUE (annual average for furnaces and boilers), thermal efficiency (steady-state for water heaters), and combustion efficiency (field measurement).

Installation requires following manufacturer instructions for location, clearances to combustibles (reduced only with approved protection), and adequate combustion air. CSA B149.1 specifies calculation methods based on confined or unconfined space, with openings sized per total appliance input. Modern tight buildings often require dedicated combustion air even in apparently unconfined spaces.

Proper commissioning includes pre-start inspection, systematic start-up procedure, manifold pressure verification, combustion testing, and documentation. Acceptable combustion shows CO under 100 ppm air-free, proper O_2 and CO_2 levels, and efficient operation. Customer education on operation and maintenance completes the installation process.

Review Questions

Multiple Choice

1. A Category IV appliance is characterized by:
    - a) Natural draft and non-condensing
    - b) Positive vent pressure and condensing
    - c) Negative vent pressure and condensing
    - d) Positive vent pressure and non-condensing
2. AFUE stands for:
    - a) Actual Fuel Use Efficiency
    - b) Annual Fuel Utilization Efficiency
    - c) Approved Fuel Unit Efficiency
    - d) Average Furnace Use Efficiency
3. The typical de-rating factor for altitude is:
    - a) 2% per 1,000 feet
    - b) 4% per 1,000 feet
    - c) 6% per 1,000 feet
    - d) 10% per 1,000 feet
4. A confined space is defined as having less than:
    - a) 50 ft^3 per 1,000 BTU/hr
    - b) 100 ft^3 per 1,000 BTU/hr
    - c) 500 ft^3 per 1,000 BTU/hr
    - d) 1,000 ft^3 per 1,000 BTU/hr
5. Category I appliances use which type of vent?
    - a) PVC
    - b) Type B gas vent
    - c) Single-wall metal only
    - d) Flexible aluminum
6. The maximum acceptable CO reading in flue gas per CSA B149.1 is:
    - a) 50 ppm air-free
    - b) 100 ppm air-free
    - c) 200 ppm air-free
    - d) 400 ppm air-free
7. Direct vent appliances:
    - a) Use indoor air for combustion
    - b) Vent vertically through roof only
    - c) Use sealed combustion with outdoor air
    - d) Don't require venting
8. A furnace with 100,000 BTU/hr input and 80% AFUE has an output of:
    - a) 100,000 BTU/hr
    - b) 90,000 BTU/hr
    - c) 80,000 BTU/hr
    - d) 70,000 BTU/hr
9. Combustion air openings to outdoors are typically _____ the size of openings to indoors:
    - a) The same size as

    - b) Half the size of
    - c) Double the size of
    - d) Four times the size of
10. The CSA certification mark indicates:
    - a) Appliance efficiency rating
    - b) Compliance with Canadian safety standards
    - c) Warranty period
    - d) Made in Canada

True or False

11. All gas appliances must have a recognized certification mark to be installed in Canada.
12. High-efficiency condensing appliances can vent with PVC pipe.
13. Clearances to combustibles can be reduced without manufacturer approval if protected with metal shielding.
14. Modern tight buildings may require combustion air openings even in unconfined spaces.
15. Input rating and output rating are the same for all appliances.

Short Answer

16. Explain the difference between AFUE and combustion efficiency. (4 marks)
17. List four pieces of information that must be shown on an appliance rating plate. (4 marks)
18. Why must some appliances be de-rated when converted from natural gas to propane? (3 marks)
19. What is the purpose of combustion air openings, and why are two openings required? (4 marks)
20. Describe the characteristics that distinguish a Category IV appliance from a Category I appliance. (5 marks)

Long Answer

21. A furnace rated 100,000 BTU/hr input is to be installed at 5,000 feet elevation. The rating plate indicates it's suitable for use up to 2,000 feet without de-rating, and requires 4% de-rating per 1,000 feet above that elevation.
    - Calculate the excess elevation
    - Calculate the required de-rating percentage
    - Calculate the de-rated input
    - Explain why de-rating is necessary at high altitude
    - Describe how de-rating would be accomplished (10 marks)
22. Describe the complete commissioning procedure for a new high-efficiency condensing furnace. Include:
    - Pre-start inspection items
    - Step-by-step start-up procedure
    - Measurements and tests to perform
    - Acceptance criteria for combustion
    - Safety tests required

    - Documentation requirements
    - Customer education topics (15 marks)
23. A utility room measures 8 ft × 10 ft × 8 ft high and contains a furnace (100,000 BTU/hr) and water heater (40,000 BTU/hr). Determine if this is a confined or unconfined space and calculate the required combustion air openings if combustion air is to be provided from outdoors through vertical ducts. Show all calculations and explain your work. (12 marks)

Practical Exercises

Exercise 1: Rating Plate Interpretation

Given various appliance rating plates:

1. Identify manufacturer and model
2. Determine gas type(s) permitted
3. Note input rating
4. Identify venting category
5. List clearance requirements
6. Determine electrical requirements
7. Check for altitude limitations
8. Identify efficiency rating

Exercise 2: Combustion Air Calculation

For given room and appliance loads:

1. Calculate room volume
2. Determine confined vs. unconfined
3. Calculate required opening sizes
4. Design combustion air system
5. Sketch installation
6. Specify materials and termination
7. Document calculations

Exercise 3: Appliance Commissioning

On training appliance or actual installation:

1. Complete pre-start checklist
2. Perform systematic start-up
3. Check manifold pressure
4. Adjust if needed

5. Perform combustion testing
6. Record all measurements
7. Verify temperature rise (furnace)
8. Test safeties
9. Complete documentation
10. Identify any issues

Exercise 4: Clearance Verification

In lab or using photos:

1. Identify appliance clearances required
2. Measure actual clearances
3. Determine if compliant
4. Identify violations if any
5. Recommend corrections
6. Calculate clearance reduction if appropriate
7. Sketch proper installation

Exercise 5: Efficiency Comparison

Compare various appliances:

1. Different AFUE ratings
2. Calculate annual fuel usage for each
3. Calculate operating costs
4. Determine payback period for higher efficiency
5. Consider installation cost differences
6. Make recommendations

Exercise 6: Venting Category Identification

For various appliances:

1. Identify venting category
2. Determine appropriate vent material
3. Identify termination requirements
4. Note special requirements
5. Compare different categories
6. Understand application of each

Case Studies

Case Study 1: Insufficient Combustion Air

Scenario: You're called to service a furnace that "keeps shutting down." The furnace is in a small utility room (6' × 8' × 7' high = 336 ft³) with a tightly sealed door and no combustion air openings. Appliances: Furnace 100,000 BTU, Water heater 40,000 BTU (total 140,000 BTU). The furnace is Category I with draft hood. You observe spillage at the draft hood during operation.

Questions:

1. Is this a confined or unconfined space? (Show calculation)
2. What is causing the spillage?
3. Calculate required combustion air openings for indoor air source
4. Calculate required combustion air openings for outdoor air source
5. What immediate safety concerns exist?
6. Can the appliances operate safely without modification?
7. What are the correction options?
8. What do you tell the homeowner?

Case Study 2: Wrong Appliance for Application

Scenario: A homeowner had a handyman install a "really good deal" water heater he bought online. You're called because it won't stay lit. You find a U.S.-market water heater (40,000 BTU input, natural gas, 3.5" W.C. manifold pressure) installed in Canada on a propane system (11" W.C. supply pressure). The rating plate shows no CSA mark, only UL certification. The water heater has natural gas orifices and is connected to propane supply.

Questions:

1. What certification problems exist?
2. Why won't the water heater stay lit?
3. What pressure and orifice problems exist?
4. Is this installation legal in Canada?
5. Can this water heater be used in Canada?
6. What are the safety risks?
7. What is the proper correction?
8. What do you tell the homeowner?

Case Study 3: Clearance Violation

Scenario: During an inspection, you find a furnace installed with 1" side clearance. The rating plate specifies 6" minimum clearance to combustibles on sides. The wall is wood-framed with drywall. The homeowner says it's been like this for 5 years with no problems.

Questions:

1. Is this a code violation?
2. What is the safety risk?
3. Can the furnace remain in service?
4. What are the correction options?
5. Can clearances be reduced with protection?
6. How much would approved protection reduce clearances?
7. What if relocation is impossible?
8. What happens if homeowner refuses correction?

Case Study 4: Altitude Installation

Scenario: You're installing a furnace in a mountain town at 6,000 feet elevation. The rating plate states: "Suitable for use up to 2,000 ft without de-rating. De-rate 4% per 1,000 ft above 2,000 ft." The furnace is rated 80,000 BTU/hr input with natural gas orifice #43.

Questions:

1. Calculate the required de-rating
2. What should the de-rated input be?
3. How is de-rating accomplished?
4. What orifice size should be used?
5. What happens if not de-rated?
6. How do you verify proper de-rating?
7. What combustion testing would you perform?
8. What documentation is required?

Case Study 5: High Efficiency vs. Standard Efficiency

Scenario: A customer is replacing their furnace. Current furnace: 100,000 BTU, 80% AFUE, costing approximately $1,200/year in gas. Options:

- Option A: Standard efficiency 95,000 BTU, 80% AFUE, installed $3,500
- Option B: High efficiency 95,000 BTU, 96% AFUE, condensing, installed $5,800

Natural gas costs $0.80/therm (100,000 BTU). Heat load analysis shows 95,000 BTU output adequate.

Questions:

1. Calculate annual fuel cost for each option
2. Calculate annual savings with high efficiency
3. Calculate simple payback period
4. What other factors should customer consider?
5. What maintenance differences exist?
6. What installation differences?
7. What would you recommend and why?

8. How would propane prices change the analysis?

Case Study 6: Commissioning Failure

Scenario: You've installed a new high-efficiency furnace (Category IV, 96% AFUE, 100,000 BTU input). During commissioning, your combustion analyzer shows:

- O_2: 12%
- CO: 450 ppm air-free
- CO_2: 6%
- Stack temperature: 210°F The flame appears yellow with some soot.

Questions:

1. Are these readings acceptable?
2. What problem(s) do the readings indicate?
3. What is causing high CO?
4. What is causing low CO_2?
5. What should the readings be?
6. What would you check and adjust?
7. Can the furnace be left in service?
8. What if you can't correct the problem?

Key Terms

AFUE (Annual Fuel Utilization Efficiency): Seasonal average efficiency including all losses; expressed as percentage.

Category I Appliance: Draft hood equipped, natural draft, non-condensing, uses Type B vent.

Category IV Appliance: Positive vent pressure, condensing, high efficiency, uses PVC or other special vent.

Certification Mark: Symbol (CSA, AGA/CGA, ULC) indicating appliance meets safety standards.

Clearance: Minimum distance from appliance to combustible materials.

Combustion Air: Air provided for fuel combustion; oxygen source for burner.

Combustion Efficiency: Percentage of fuel energy extracted during combustion; field measurement.

Confined Space: Space with less than 50 ft^3 per 1,000 BTU/hr of appliance input.

De-rating: Reducing appliance input for altitude or fuel type change.

Direct Vent: Sealed combustion appliance using outdoor air; concentric vent common.

Input Rating: Rate at which appliance consumes fuel energy; measured in BTU/hr.

Output Rating: Useful heat delivered by appliance; always less than input due to losses.

Rating Plate: Metal tag on appliance showing specifications, certifications, and requirements.

Thermal Efficiency: Steady-state efficiency during continuous operation; used for water heaters.

Unconfined Space: Space with 50 ft^3 or more per 1,000 BTU/hr of appliance input.

End of Chapter 9