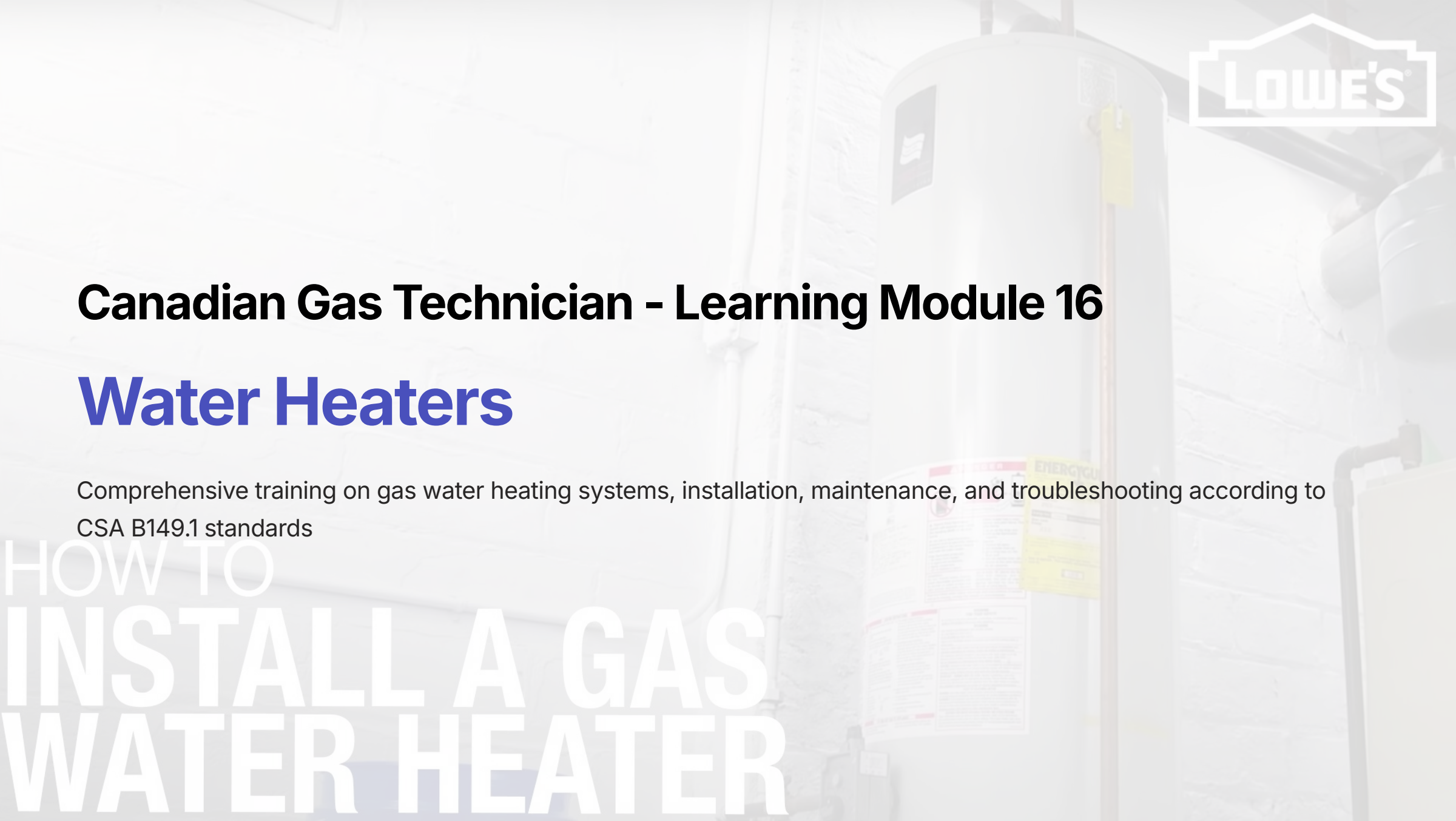
Canadian Gas Technician - Learning Module 16

Water Heaters

Comprehensive training on gas water heating systems, installation, maintenance, and troubleshooting according to CSA B149.1 standards



Chapter 16

Water Heaters

Water heating represents the second-largest energy use in most homes, accounting for 15-25% of total energy consumption. Gas water heaters provide reliable, cost-effective hot water for residential, commercial, and industrial applications. Understanding their design, installation, and maintenance is essential for gas technicians.

Learning Objectives

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

01

Identify different types of water heaters and their applications

02

Understand the components and operation of various water heater systems

03

Install water heaters according to CSA B149.1 and manufacturer specifications

04

Calculate proper water heater sizing based on demand and usage patterns

05

Configure tankless water heaters for optimal performance

Learning Objectives (continued)

01

Install and test temperature and pressure relief valves properly

02

Perform routine maintenance on water heating systems

03

Troubleshoot common water heater problems systematically

04

Apply code requirements for safe water heater installation

05

Educate customers on water heater operation and maintenance

Introduction to Water Heating Technology

This chapter covers the full spectrum of gas water heating technology, from traditional atmospheric tank heaters to modern condensing tankless units. We'll explore:

Various water heater types and their applications

Understanding the differences between atmospheric, power vent, direct vent, tankless, and condensing systems

Critical components and their functions

Detailed examination of tanks, anodes, valves, controls, and safety devices

Code-compliant installation procedures

Following CSA B149.1 requirements for safe and proper installation

Introduction (continued)

Proper sizing methodologies

Calculating capacity based on demand, recovery rates, and usage patterns

Maintenance requirements

Regular inspection, testing, and service procedures to ensure longevity

Systematic troubleshooting approaches

Diagnosing and resolving common problems efficiently and safely

Water heater technology continues evolving with efficiency improvements, smart controls, and hybrid designs. However, fundamental principles of safe gas combustion, proper venting, and temperature/pressure safety remain constant.

16.1 Water Heater Types

Atmospheric Storage Tank

Operating Principle: Atmospheric water heaters use natural draft for venting, relying on the buoyancy of hot combustion gases to create draft through the vent system.

Atmospheric Storage Tank

Construction Features

- Glass-lined steel tank (30-80 gallons residential)
- Central flue tube through tank
- Natural draft hood
- Standing pilot or electronic ignition
- Bottom-fired burner
- Efficiency: 60-80% AFUE

Components

1. Tank Assembly

- Welded steel construction
- Glass lining (porcelain enamel)
- Foam insulation (R-8 to R-16)
- Outer jacket

Atmospheric Storage Tank Components

Combustion System

- Atmospheric burner
- Pilot assembly (thermocouple)
- Main burner orifice
- Burner chamber

Venting System

- Draft hood
- B-vent connector
- Natural draft operation

Typical Specifications

Capacity: 30, 40, 50, 60, 75 gallons
Input: 30,000-75,000 BTU/h
Recovery: 30-41 gallons/hour
First Hour Rating: 60-90 gallons
Efficiency: 60-62% (standard), 76-80% (ENERGY STAR)

Atmospheric Storage Tank

Advantages

- Lower initial cost
- Simple operation
- No electricity required (pilot models)
- Reliable and proven technology
- Easy to service

Disadvantages

- Lower efficiency
- Requires vertical venting
- Susceptible to backdrafting
- Higher standby losses
- Limited installation locations

Power Vent Storage Tank

Operating Principle: Power vent water heaters use an electric blower to exhaust combustion products, allowing horizontal venting and longer vent runs.

Construction Features

- Similar tank construction to atmospheric
- Blower assembly on top
- Pressure switch safety
- Horizontal venting capability
- Electronic ignition typical
- Efficiency: 62-82% AFUE

Power Vent Venting System

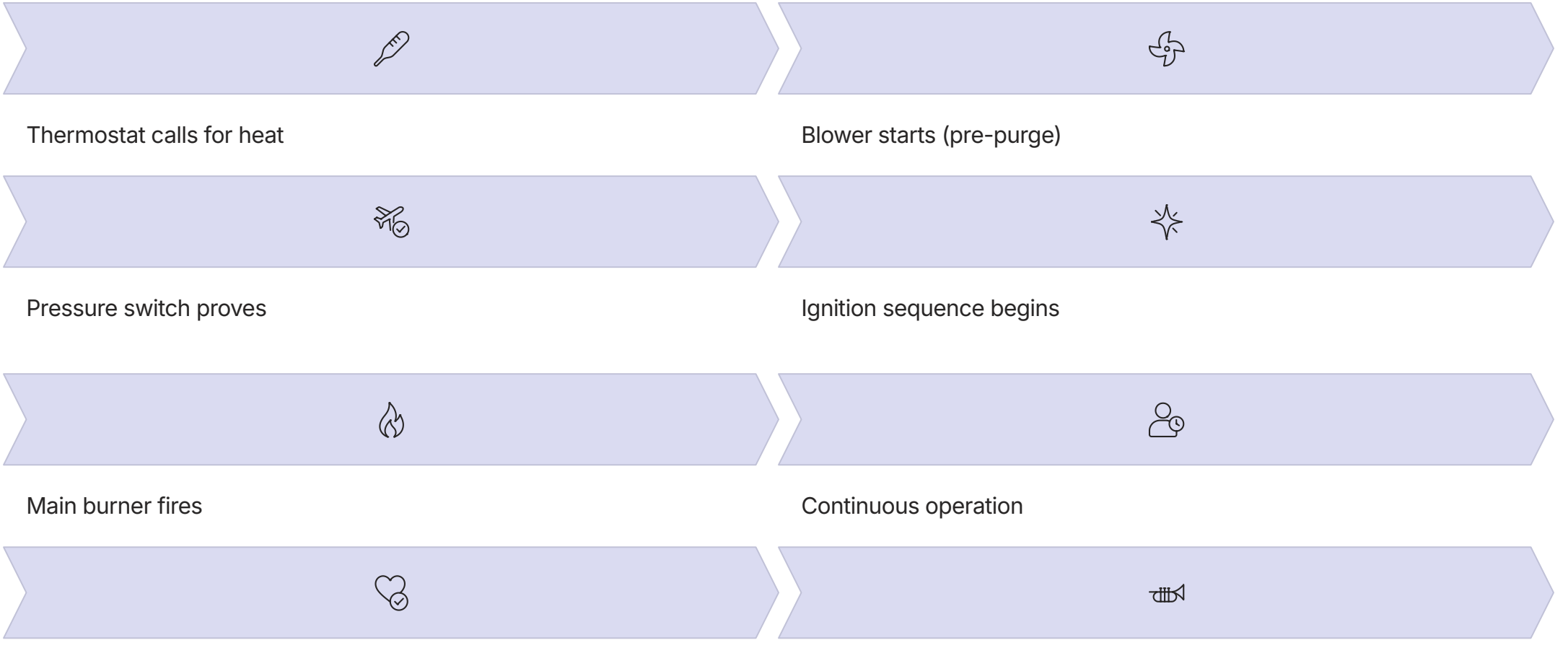
1. Blower Assembly

- Centrifugal fan
- 30-150 CFM typical
- Pre-purge and post-purge
- Sealed combustion chamber

2. Vent Materials

- PVC/CPVC approved
- ABS in some applications
- Maximum temperatures considered

Power Vent Control Sequence



Final Steps: Post-purge (30-60 seconds), then blower stops

Power Vent Storage Tank

Advantages

- Flexible venting options
- Longer vent runs possible
- Reduced backdraft risk
- Can vent through sidewall
- Better for tight homes

Disadvantages

- Requires electricity
- More complex controls
- Blower noise
- Higher initial cost
- No operation during power outage

Direct Vent Storage Tank

Operating Principle: Direct vent water heaters draw combustion air from outside through a sealed system, eliminating indoor air consumption.

Construction Features

- Sealed combustion chamber
- Concentric or dual-pipe venting
- No indoor air required
- Power vented or natural draft
- Higher efficiency potential

Direct Vent Venting Configurations

Concentric Venting

- Pipe within pipe design
- Exhaust in center
- Intake in outer annulus
- Single wall penetration
- Preheats combustion air

Dual-Pipe System

- Separate intake and exhaust
- More flexible routing
- Two wall penetrations
- Various termination options

Direct Vent Installation Benefits

- **No impact on indoor air quality**
- **Ideal for tight construction**
- **Reduced clearances possible**
- **Consistent combustion air temperature**
- **Zone 3 (bedroom) installation allowed**

Typical Applications

Mobile homes, tight/efficient homes, confined space installations, cold climate applications, where indoor air quality critical

Tankless (Instantaneous)

Operating Principle: Tankless water heaters heat water on-demand as it flows through the unit, eliminating standby losses.

Types

Non-Condensing Tankless:

- Efficiency: 80-85%
- Stainless steel heat exchanger
- Higher exhaust temperatures
- Category III venting

Tankless Water Heaters

Condensing Tankless

- Efficiency: 90-98%
- Secondary heat exchanger
- Recovers latent heat
- PVC venting possible
- Condensate management required

Key Components

1. Heat Exchanger

- Copper or stainless steel
- Finned tube design
- High surface area
- Corrosion resistant

2. Modulating System

- Variable gas valve
- Modulating burner
- 5:1 to 15:1 turndown
- Precise temperature control

3. Flow Sensors

- Turbine or paddle wheel
- 0.5-0.75 GPM activation
- Digital flow measurement
- Leak detection capability

4. Control Board

- Microprocessor controlled
- Multiple safety circuits
- Diagnostic capabilities
- Remote control options

Tankless Performance Specifications

Flow Rate: 3-11 GPM
Input: 120,000-199,900 BTU/h
Temperature Rise:
- 35°F at 7 GPM
- 45°F at 5 GPM
- 70°F at 3 GPM

Minimum Flow: 0.5 GPM
Maximum Pressure: 150 PSI

Advantages

- Endless hot water
- Space saving
- No standby losses
- Longer equipment life (20+ years)
- Precise temperature control

Disadvantages

- Higher initial cost
- Complex installation
- Minimum flow requirements
- Cold water sandwich effect
- Higher gas demand

Condensing Storage

Operating Principle: Condensing storage water heaters achieve high efficiency by extracting latent heat from combustion gases, similar to condensing furnaces.

Design Features

- 90-98% thermal efficiency
- Secondary heat exchanger
- PVC venting capability
- Modulating burner (some models)
- Advanced controls

Condensing Storage Construction

1. Primary Heat Exchanger

- Submerged in tank
- Spiral or helical design
- Maximum surface area

2. Secondary Heat Exchanger

- Captures latent heat
- Condensate production
- Corrosion-resistant materials

3. Condensate Management

- Collection tray
- Neutralization (if required)
- Proper drainage

Efficiency Features

Low stack temperatures (100-140°F), reduced cycling losses, better stratification, smart controls, heat pump hybrid options

Applications

High-use residential, light commercial, energy-conscious installations, where gas savings justify cost

Commercial Water Heaters

Types and Features

Power Burner Storage

- 75-100 gallon capacity
- 75,000-500,000 BTU/h input
- Forced combustion air
- Higher recovery rates
- Modulating options available

Copper-Fin Tube Heaters

- Fast recovery
- 100-500,000 BTU/h
- Multiple pass design
- 80-88% efficiency
- Compact footprint

Condensing Commercial

- 95-98% efficiency
- 100,000-2,000,000 BTU/h
- Stainless steel construction
- Modulating operation
- Advanced controls

Commercial Water Heaters

Installation Requirements

- Dedicated combustion air
- Larger gas connections (1"-2")
- Multiple unit manifolds
- Building automation interface
- Seismic bracing (zones)

Control Features

- Lead-lag operation
- Outdoor reset capability
- Building management interface
- Remote monitoring
- Predictive maintenance

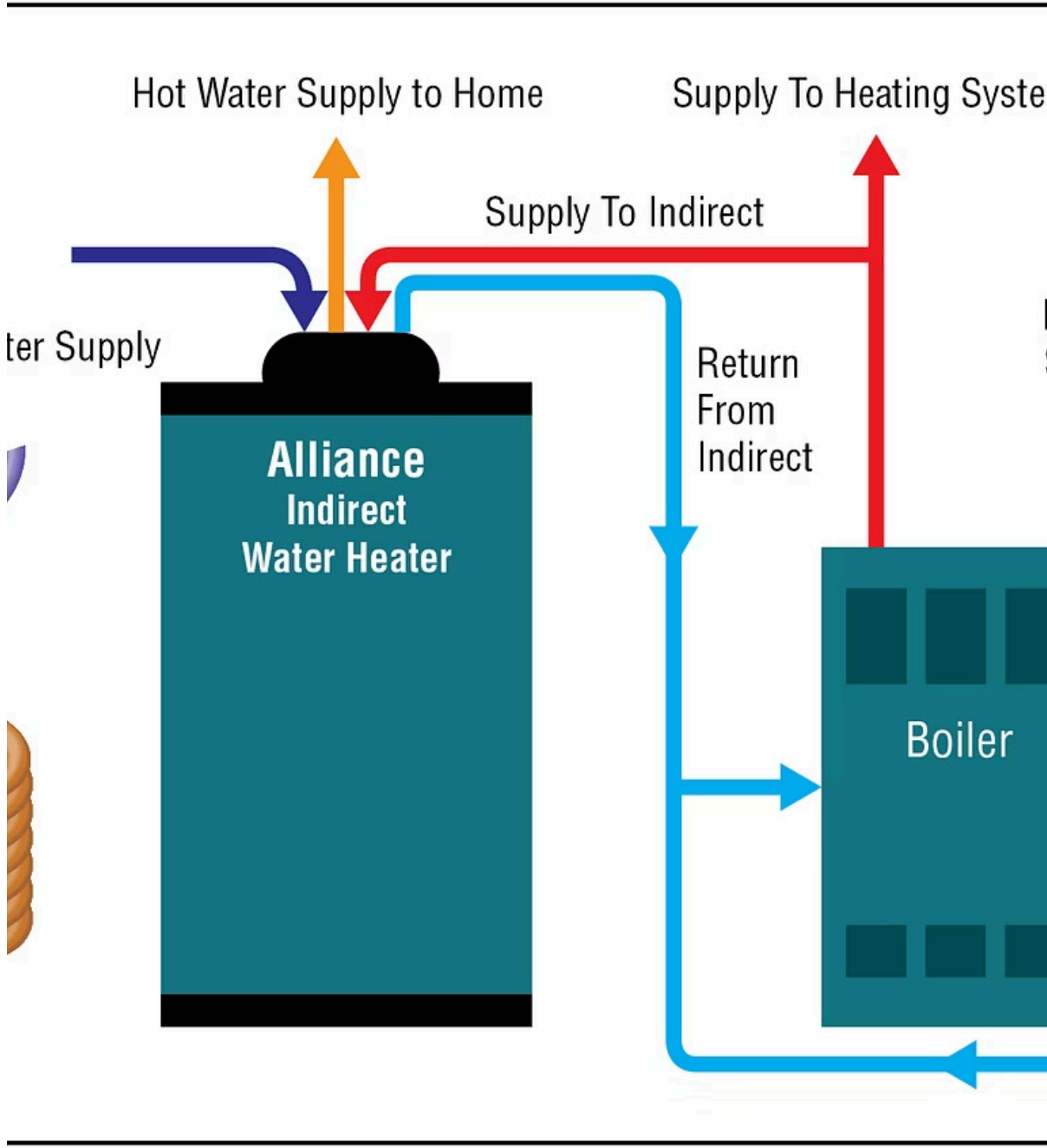
Indirect Water Heaters

Operating Principle: Indirect water heaters use boiler water to heat domestic water through a heat exchanger, eliminating direct flame contact.

Types

Tank-in-Tank Design: Inner domestic water tank, outer boiler water jacket, large heat transfer area, natural convection

Internal Coil Design: Coiled heat exchanger, immersed in domestic water, forced circulation typical, compact design



Indirect Water Heaters

External Heat Exchanger

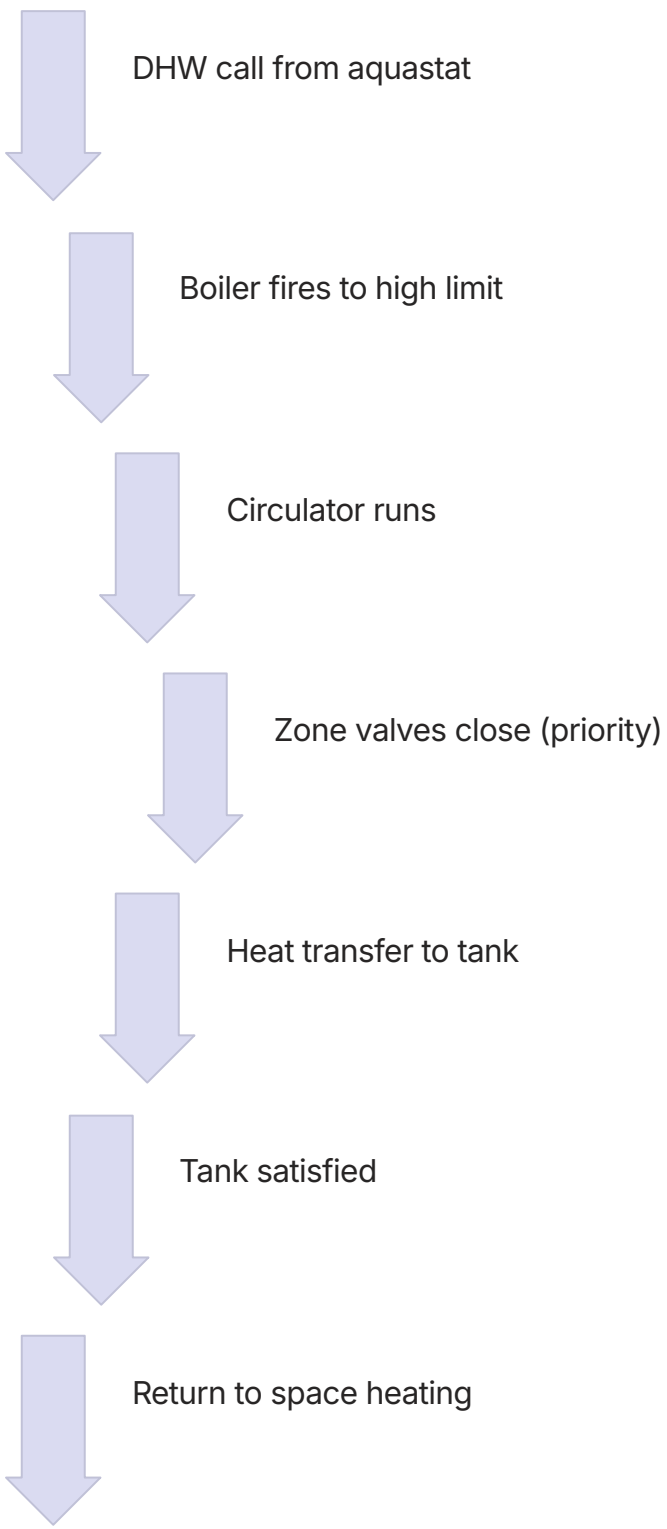
Plate or shell-tube, separate from storage tank, high heat transfer rates, complex piping

System Components

1. Storage tank (30-119 gallons)
2. Heat exchanger
3. Circulator pump
4. Aquastat control
5. Check valve
6. Mixing valve (optional)

Indirect Water Heater Control Strategy

Priority Control



Indirect Water Heaters

Advantages

- High recovery rates
- Long tank life (no flame)
- Reduced maintenance
- Combined system efficiency
- No separate venting

Disadvantages

- Requires boiler operation
- Summer boiler cycling
- Complex controls
- Higher initial cost
- Space requirements

Section 16.2

Water Heater Components

Understanding the critical components that make up a water heater system is essential for proper installation, maintenance, and troubleshooting.

Tank Construction

Materials and Design

Steel Tank

- Carbon steel construction
- 0.25-0.375" thickness
- Welded seams
- Pressure tested to 300 PSI
- Working pressure: 150 PSI

Glass Lining

- Porcelain enamel coating
- Applied at 1500°F
- Multiple coats
- Prevents corrosion
- Thermal shock resistant

Tank Construction (continued)

Insulation

- Polyurethane foam
- R-8 to R-24 values
- 2-3" thickness typical
- CFC-free formulation
- Reduces standby losses

Outer Jacket

- Baked enamel finish
- Corrosion protection
- Aesthetic appearance
- Access panels

Tank Connections

Standard Residential Tank:
- Cold inlet: 3/4" NPT (top)
- Hot outlet: 3/4" NPT (top)
- Drain valve: 3/4" garden hose
- T&P valve: 3/4" NPT
- Gas connection: 1/2" NPT

Anode Rods

Purpose: Sacrificial anode rods protect the tank from corrosion through galvanic action.

Types

Magnesium Anode

- Most common
- Standard protection
- 3-5 year life typical
- Best for soft water

Aluminum Anode

- Lighter weight
- Reduces odor issues
- Longer life
- Better for hard water

Zinc/Aluminum Alloy

- Reduces sulfur odors
- Antibacterial properties
- Premium option
- 5-7 year life

Powered Anode

- Impressed current system
- Non-sacrificial
- Permanent installation
- Requires power supply

Anode Rod Inspection and Replacement

Inspection Frequency

- Year 1: Initial check
- Years 2-5: Annual inspection
- Years 5+: Every 6 months

Replacement Indicators

- 75% consumed
- Heavy calcium deposits
- Exposed steel core wire
- Tank age over 5 years

Installation Tips

1. Use Teflon tape on threads
2. Don't overtighten
3. May need to bend for clearance
4. Check headroom before removal
5. Consider flexible anode

Dip Tubes

Function: Delivers cold water to tank bottom, promoting stratification and preventing mixing.

Construction

- Polypropylene typical
- Heat-resistant plastic
- 3/4" diameter
- Anti-siphon hole at top

Types

Standard Dip Tube

Straight pipe, 6" from tank bottom, basic design

Curved Dip Tube

Creates swirl action, self-cleaning effect, reduces sediment

Diffuser Dip Tube

Perforated bottom, spreads incoming water, reduces turbulence

Dip Tubes (continued)

Common Problems

- Deterioration (1993-1997 issue)
- Breakage from thermal shock
- Sediment blockage
- Incorrect length

Replacement Procedure

01

Turn off water and gas

02

Drain several gallons

03

Remove cold inlet nipple

04

Extract old dip tube

05

Insert new tube

06

Verify proper length

07

Reinstall nipple

Temperature and Pressure Relief Valves

Purpose: Safety device preventing tank rupture from excess temperature or pressure.

Operating Parameters

150	210
PSI	**°F**
Pressure relief setting	Temperature relief setting

Combined T&P most common

Construction

- Bronze body typical
- Stainless steel spring
- Thermostat probe
- Test lever
- Discharge connection

Note: Detailed coverage in Section 16.6

Temperature and Pressure Relief Valve Operation

1. Pressure Relief

- Spring-loaded disc
- Opens at 150 PSI
- Full flow capacity

2. Temperature Relief

- Thermal element
- Expands at 210°F
- Opens valve mechanically

Gas Control Valves

Types

Mechanical (Millivolt)

- Thermocouple powered
- No external power needed
- Simple operation
- Standing pilot

Electronic (Thermopile)

- Self-powered
- Electronic ignition
- Status indicators
- Diagnostic capability

Gas Control Valve Components

1

Main Valve

- Redundant solenoids
- Slow-opening design
- Safety shutoff

2

Pilot Valve

- Thermocouple operated
- Safety function
- Manual control

3

Thermostat

- Immersion sensing
- Adjustable 90-160°F
- Differential 10-15°F

4

Regulator

- Maintains outlet pressure
- Compensates for inlet variation
- 3.5" W.C. typical

Control Settings

Typical Residential Settings: Pilot: Continuous or intermittent, Temperature: 120°F recommended, Vacation: Pilot only, Off: Complete shutdown

Thermostats

Mechanical Thermostats

Rod and Tube Type

- Copper tube sensing
- Invar rod inside
- Differential expansion
- Operates gas valve

Bi-Metal Type

- Two metals bonded
- Bends with temperature
- Snap-action contacts
- Simple and reliable

Electronic Thermostats

Thermistor Sensing

- 10K ohm typical
- Precise measurement
- Digital control
- ±1°F accuracy

Microprocessor Control

- Multiple sensors
- Learning algorithms
- Diagnostic features
- Communication capability

Smart Features

WiFi connectivity, usage tracking, leak detection, vacation modes, energy monitoring

Burner Assemblies

Atmospheric Burner

Components

- Cast iron or steel
- Multiple ports
- Venturi mixing
- Primary air adjustment

Operation

1. Gas flows through orifice
2. Venturi creates vacuum
3. Primary air entrained
4. Mixture burns at ports
5. Secondary air from room

Power Burner

Components

- Forced draft blower
- Premix design
- Stainless steel mesh
- Modulation capability

Advantages

Complete combustion

Higher efficiency

Quieter operation

Lower emissions

Venting Components

Draft Hoods (Atmospheric)

- Prevents backdraft
- Dilution air inlet
- Built-in or separate
- Must remain unobstructed

Power Vent Components

- Blower assembly
- Pressure switch
- Vent connector
- Termination fitting

Direct Vent Components

- Concentric termination
- Intake/exhaust pipes
- Wall thimble
- Termination kit

Section 16.3

Water Heater Installation

Proper installation according to CSA B149.1 and manufacturer specifications is critical for safe, efficient, and reliable water heater operation.

Location Requirements per Code

CSA B149.1 Requirements

General Location Rules

Accessibility

- Minimum 24" front clearance
- Service access required
- Removal path planned

Floor Protection

- Non-combustible base (concrete)
- Or listed protective material
- Garage: 18" elevation required

Prohibited Locations

- Bedrooms (except direct vent)
- Bathrooms (except direct vent)
- Clothes closets
- Under stairs (restricted)

Zone Classifications

Zone 1 - General Space

- Living rooms
- Kitchens
- Hallways
- Open basements

Zone 2 - Restricted

- Storage rooms
- Furnace rooms
- Garages (with elevation)

Zone 3 - Special Requirements

- Bedrooms (direct vent only)
- Bathrooms (direct vent only)
- Must have sealed combustion

Seismic Requirements

Zones 4 and higher: Two straps required, Upper: 1/3 from top, Lower: 1/3 from bottom, Lag bolts to studs

Clearances to Combustibles

Atmospheric Water Heaters

Standard Clearances:
- Sides: 1" minimum
- Back: 1" minimum
- Front: 6" service clearance
- Top: 12" to combustibles
- Draft hood: 6" all directions
- Vent connector: 6" (B-vent)

Power Vent Units

Typical Clearances:
- Sides: 2" minimum
- Back: 0" (some models)
- Front: 4" minimum
- Top: 12" to ceiling
- Vent: Per manufacturer

Clearances to Combustibles (continued)

Direct Vent Units

Reduced Clearances:
- Sides: 0" (some models)
- Back: 0" (some models)
- Front: 4" service
- Vent: Per certification

Clearance Reduction

- Use approved shields
- Maintain 1" air gap
- Sheet metal acceptable
- Follow tables in code

Combustion Air Provisions

Natural Draft Requirements

Two-Opening Method

Upper Opening (within 12" of ceiling):
- 1 sq.in. per 4,000 BTU/h
Lower Opening (within 12" of floor):
- 1 sq.in. per 4,000 BTU/h

Example: 40,000 BTU/h heater
Upper: 40,000 ÷ 4,000 = 10 sq.in.
Lower: 40,000 ÷ 4,000 = 10 sq.in.

Single-Opening Method

Opening Size:
- 1 sq.in. per 3,000 BTU/h
- Within 12" of ceiling

Example: 40,000 BTU/h
40,000 ÷ 3,000 = 13.3 sq.in.

Combustion Air - Mechanical Ventilation

- Engineered system
- Interlocked with appliance
- Proven before operation
- Calculation required

Gas Piping Connections

Sizing Requirements

Typical Connections

Water Heater Size	Inlet Size
30-40 gallon	1/2" NPT
50-75 gallon	1/2" NPT
Tankless <199k	3/4" NPT
Tankless >199k	1" NPT
Commercial	1"-2" NPT

Gas Piping Installation Requirements

Shutoff Valve

- Within 6 feet
- Accessible location
- Approved type

Union

- Downstream of valve
- Allows removal
- Ground joint type

Drip Leg

- 3" minimum length
- Before controls
- Capped nipple

Flexible Connector

- Listed for gas
- 36" maximum length
- No concealed locations

Pressure Requirements

Supply Pressure: Minimum: 5" W.C., Maximum: 10.5" W.C. (NG), Maximum: 13" W.C. (LP)

Venting Requirements per Category

Category I (Atmospheric)

- B-vent required
- Vertical termination
- Natural draft
- Minimum height: 5 feet

Category II (Not common)

- Condensing with positive pressure
- Special materials required

Category III (Power Vent)

- Non-condensing positive pressure
- Stainless steel or approved plastic
- Horizontal venting allowed

Category IV (Condensing)

- Positive pressure condensing
- PVC/CPVC approved
- Slope for drainage
- Condensate management

Common Venting - Connector Rules

- Rise: 1/4" per foot minimum
- Length: Not >75% of height
- Size: Not smaller than outlet
- Support: Every 4 feet

Temperature and Pressure Relief Valve Discharge

Discharge Piping Requirements

Material

- Copper
- CPVC (rated for temperature)
- Galvanized steel
- PEX (if rated)

Installation Requirements

- 3/4" minimum diameter
- No reducers
- No threads on outlet
- Maximum 6" above floor
- Visible termination
- No caps or plugs
- Slope to drain
- Support required

T&P Discharge Piping (continued)

Prohibited

- Direct connection to drain
- Discharge outdoors (freeze risk)
- Threading of discharge end
- Concealed termination

Earthquake Strapping

Requirements by Zone

Seismic Zone 4+

- Two straps mandatory
- 22-gauge minimum
- 1-1/2" wide minimum
- Lag bolts to studs

Installation

Upper Strap

- Within upper 1/3 of tank
- 360° wrap or two 180° straps
- Secured to wall studs

Lower Strap

- Within lower 1/3 of tank
- Above controls
- Same requirements as upper

Additional Bracing

Rigid gas piping, flexible connector limits, platform mounting, wall brackets available

Drain Pan Requirements

When Required

- Above living space
- Where damage possible
- Finished spaces
- Local code requirements

Pan Specifications

- 2" larger than heater diameter
- 1-1/2" to 2-1/2" depth
- Corrosion-resistant material
- 3/4" drain connection

Drain Piping

- To approved location
- Visible termination
- Indirect waste preferred
- Same as T&P discharge

Section 16.4

Water Heater Sizing

Proper sizing ensures adequate hot water supply while avoiding oversizing that wastes energy and increases costs.

First Hour Rating (FHR)

Definition: Amount of hot water delivered in first hour of use, starting with full tank of hot water.

Calculation

FHR = Tank Capacity + (Recovery Rate × 0.7)

Example:
50-gallon tank
40 GPH recovery
FHR = 50 + (40 × 0.7) = 78 gallons

Factors Affecting FHR

- Tank size
- Input BTU/h
- Temperature rise
- Draw pattern
- Thermostat setting

Using FHR for Sizing

1. Determine peak hour demand
2. Select heater with FHR ≥ demand
3. Consider 10-20% safety factor