CSA Unit 18 - Water Heaters and Combination Systems Chapter 1

Installation of new and replacement gas water heaters is a normal part of a gas technician's/fitter's duties. The types of heaters, controls, components, and piping systems vary greatly as do the installation requirements for each type. It is important for the gas technician/fitter to be able to identify and select the proper water heater and related equipment required for an application and perform the work in accordance with applicable Codes and manufacturer's instructions.

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Installation Requirements

CSA B149.1

The Natural Gas and Propane Installation Code specifies requirements for water heaters in Clause 7 (Installation of specific types of appliances) and Clause 8 (Venting systems and air supply for appliances).

National Plumbing Code of Canada

The NPC specifies the requirements for hot water tank installations, particularly regarding shut-off valves, relief valves, and thermal expansion.

Manufacturer's Instructions

Compliance with manufacturer's recommendations and instructions is a code requirement and is necessary for safe and efficient water heater installation and servicing.

Code Requirements for Water Heaters

Location Requirements

A water heater, unless of the direct-vent type, shall not be installed in a bathroom, bedroom, or any enclosure where sleeping accommodation is provided.

Relief Valve Requirements

The temperature and pressure relief device on a tank type water heater shall have a discharge pipe of a size at least equal to the nominal size of the device outlet. The discharge pipe shall terminate not more than 12 in (300 mm) above the floor.

Clearance Requirements

The minimum clearance from combustible material for an underfired storage-type water heater shall be 2 in (50 mm), and the minimum clearance for any other type of water heater shall be 6 in (150 mm).

Air Supply Requirements

Small Water Heaters

An outdoor air supply shall not be required for a single water heater with an input of 50,000 Btuh (15 kW) or less within an enclosure or structure where there are no other appliances that require an air supply.

Enclosed Heaters

When an appliance is located within an enclosure, permanent openings must be provided to allow communication between the enclosure and the rest of the structure.

Opening Size

An opening shall have a free area of not less than 1 in^2 per 1000 Btu/h (2225 mm^2 per kW) of the total input of all appliances within the enclosure.

Opening Location

The opening shall be located not more than 18 in (450 mm) or less than 6 in (150 mm) above floor level.

National Plumbing Code Requirements

Clause 2.6.1.3 (7)	Every pipe that supplies water to a hot water tank shall be provided with a shut-off valve located close to the tank.
Clause 2.6.1.7 (1)	A storage-type service water heater must be equipped with a pressure relief valve designed to open when the water pressure in the tank reaches the rated working pressure.
Clause 2.6.1.7 (2)	Storage-type service water heaters must be equipped with a temperature relief valve with a temperature sensing element located within the top 150 mm of the tank.
Clause 2.6.1.7 (3)	A pressure-relief valve and temperature-relief valve may be combined (commonly referred to as a "T & P" Valve).
Clause 2.6.1.7 (7)	A shut-off valve is not permitted on the pipe between any tank and the relief valves or on the discharge lines from such relief valves.

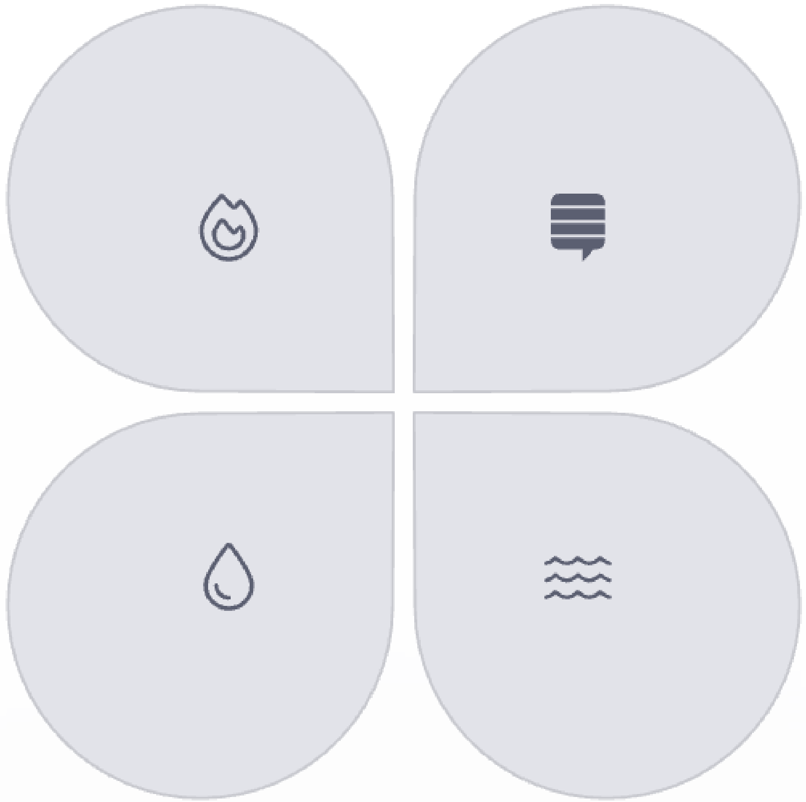
Types of Water Heaters

Direct-Fired Heaters

Heat from the gas flame's hot products of combustion are in direct contact with a tank or pipe containing the water to be heated.

Indirect Water Heating

Heat from the gas flame's hot products of combustion does not heat the water directly. A fluid (heat transfer fluid) heated by a secondary appliance heats the stored water.



Tankless (On-Demand)

These appliances heat water on demand instead of storing heated water in a tank, offering continuous hot water supply within their rated capacity.

Under-Fired Storage

The most common type of gas-fired water heater, where the burner, storage tank, outer jacket, insulation, and controls are combined into one unit.

More Water Heater Types

Direct-Vent

Combustion air is supplied directly from the outdoors by enclosed ductwork connected directly to the heater. The heater's combustion products are also vented directly to the outdoors.

Power-Vented

Used for installations where higher efficiencies are desired or when adequate vertical venting through a chimney or B vent is impractical. An electric motor-driven exhaust fan is typically connected to a certified venting system.

Condensing

Designed to achieve very high levels of thermal efficiency by reclaiming latent heat, allowing these appliances to achieve efficiencies well over 90%.

Combination Units

Designed to provide both domestic water heating and space heating, consisting of a heat source, space heating unit, circulating equipment, and control devices.

Under-Fired Storage Water Heaters

Construction

In a direct-fired storage heater, the gas flame's hot products of combustion heat the water by conduction through the tank bottom and flue surfaces. The flue acts as a heat exchanger and as a vent for the products of combustion.

Features

- Most common type of gas-fired water heater
- Burner, storage tank, outer jacket, insulation, and controls combined into one unit
- Storage tank serves as a heat exchanger
- Typically available in sizes up to 75 US gallons (300 L) for residential use

Tankless (On-Demand) Water Heaters

Operation Sequence

When a hot water tap is opened, water flow through the tankless water heater detects the call for hot water.

Control Response

The water flow sensor sends a signal to the control board, which monitors incoming water temperature, desired water temperature, and the calculated difference between the two.

Heating Process

The gas flow into the burner assembly is modulated, the electronic ignition sequence begins, and water is heated to the desired temperature as it circulates through the heat exchanger.

Shutdown

When the hot water tap is turned off, the tankless water heater sequentially shuts down and is placed in a standby mode pending the next call for hot water.

Tankless Water Heater Benefits

Energy Efficiency

They have the potential to be 25-30% more energy efficient than storage heaters.

Longer Lifespan

Working life has the potential to be longer than a tank-type hot water heater, and they are repairable.

Continuous Hot Water

They provide a continuous supply of hot water within their design capacity.

Space Saving

They take up less space and can be wall mounted.

Tankless Water Heater Considerations

Flow Rate Limitations

On-demand production of hot water directly depends on the temperature rise required for the installation. The colder the inlet water temperature from the source, the lower the rate of production available from tankless water heaters.

For example, a 70°F water temperature rise may be possible at a flow rate of 5 gallons per minute. Higher flow rates or colder groundwater temperatures require higher input capacity water heaters.

Gas Supply Requirements

Tankless water heaters have a very high firing rate (normally 100,000 to 200,000 Btu/h) compared to under-fired storage water heaters (normally 35,000 to 80,000 Btu/h). As a result, the size of gas pipe to a tankless water heater is typically larger.

Proper sizing of gas lines is critical for ensuring adequate performance of tankless units.

Copper-Fin-Tube Water Heaters

Description

Copper-fin-tube water heaters used for direct heating or copper-fin-tube boilers with separate storage tanks can be used in residential, commercial, and industrial applications. They require certification as a water heater as they will be heating potable water.

Construction

This type of heater consists of a copper-fin-tube heat exchanger, enclosed in an insulated sheet-metal outer casing. Cold water enters the heat exchanger coil through an inlet port, is heated, and may be stored for later use.

Direct-Vent Water Heaters

Combustion Air Supply

A direct-vent water heater's combustion air is supplied directly from the outdoors by enclosed ductwork connected directly to the heater. The heater's combustion products are also vented directly to the outdoors.

Venting Configurations

- Concentric (coaxial) venting system with a smaller-diameter duct centrally located in the larger combustion-air intake duct
- Two separate pipes: one for combustion air intake and another for flue gas venting

Ensuring adequate and secure venting is of primary importance for direct-vent installations.

Power-Vented Water Heaters

1

Applications

Used for installations where higher efficiencies are desired, when adequate vertical venting through a chimney or B vent is impractical, or when the heater location makes power venting necessary.

2

Construction

An electric motor-driven exhaust fan, mounted on top of the water heater, is typically connected to a certified ULC S636 plastic venting system, which conveys the products of combustion to the outdoors.

3

Operation

The pressure created by the fan induces a draft that pulls dilution air into the draft control openings at the top of the heater. The gas valve is interlocked to a differential pressure switch that verifies the venter fan's operation before allowing the gas valve to open.

4

Ignition System

Standing pilots are not used on these types of water heaters because it comes with a mechanical venting system. Intermittent pilot systems or electronic direct ignition systems light the main burner.

Power-Vented Installation Requirements

Must Do

- Use ULC S636 plastic gas vent pipe as required by Clause 8.9.6 of CSA B149.1
- Ensure the venting system services the water heater only
- Terminate venting in a horizontal run to the outdoors
- Secure vertical and horizontal piping runs to the building structure
- Ensure horizontal piping has a rise of at least 0.25 inches/ft (21 mm/m) of run

Must Not Do

- Connect the venting system to an existing vent or chimney
- Allow vent piping to operate on a downhill angle
- Use more than three elbow joints in a piping run
- Exceed the total length limits specified by the manufacturer
- Exceed 20 ft (6 m) for vertical piping runs

Condensing Water Heaters

Air and Fuel Delivery

A motor-driven fan blows combustion air through the burner, which is often mounted on top of the storage tank.

Combustion Process

After ignition, the hot combustion gases are forced down through the central, submerged combustion chamber at high velocity into the heat exchanger.

Heat Exchange

The heat exchanger consists of a stainless helical coil of tubing wound around the exterior of the combustion chamber. The swirling motion induced by the heat exchanger coil produces a high rate of heat transfer.

Condensation and Exhaust

The flue gases travel to the base of the vessel where they will condense as they are exposed to the coolest water in the tank. Flue gas condensate is removed through the condensate trap and the products of combustion exit through the venting system.

Combination Systems

Heat Source

Water heater appliance provides hot water for both domestic use and space heating

Space Heating Unit

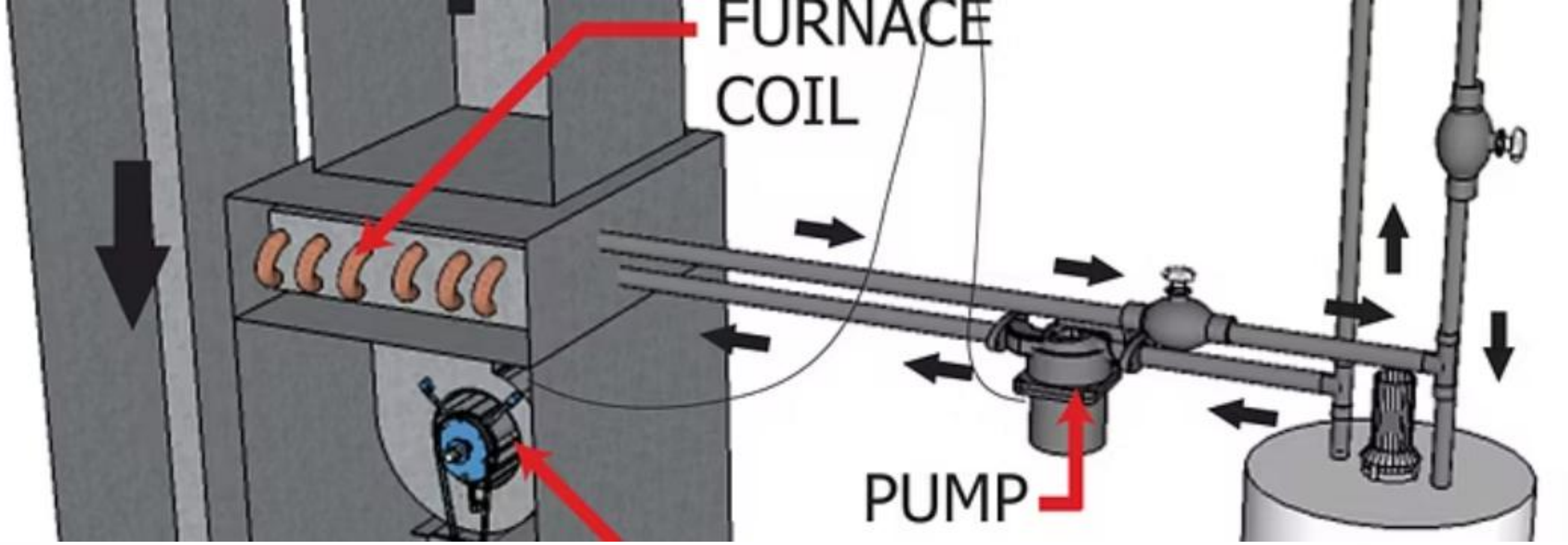
Water-to-air heat exchanger (fan coil) transfers heat to air

Control Devices

Regulate water temperature and system operation

Circulation

Pump circulates hot water through the heat exchanger



Combination System Operation

1

2

3

Hot Water Production

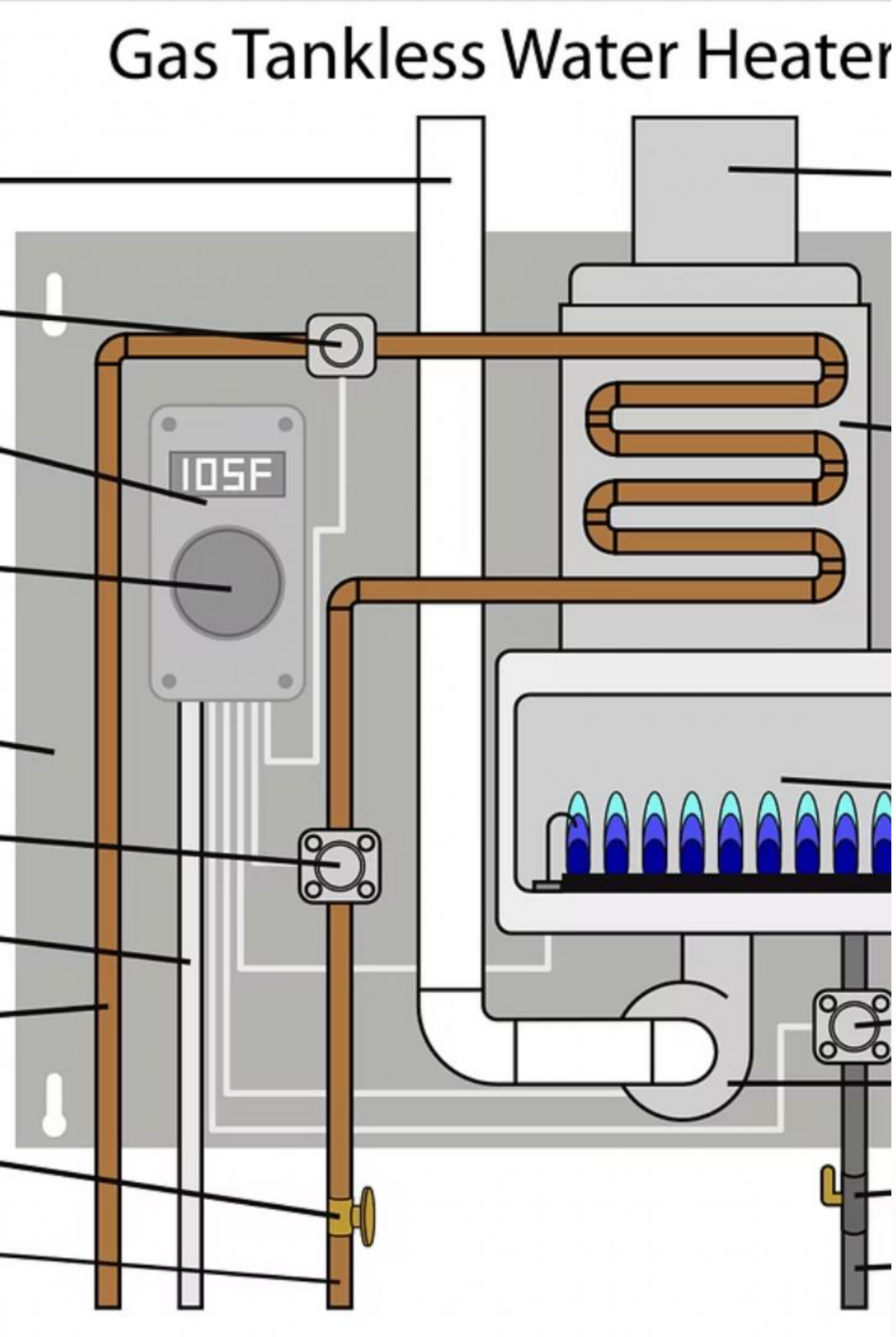
Hot water from a storage-type heater is circulated through a water-to-air heat exchanger (fan coil).

Air Heating

A fan forces air across the heat exchanger and through distribution ducts to heat the building.

Water Recirculation

After passing through the heat exchanger, the water is recirculated back to the water heater for reheating.



Water Heater Controls and Accessories

Thermostatic Mixing Valve

Prevents scalding by mixing cold water with hot water when temperatures exceed safe levels

Thermostatic Gas Control

Controls gas flow to the burner based on water temperature

Safety Devices

Includes thermal cut-off (TCO), energy cut-off (ECO), and flammable vapor sensors

Relief Valves

Temperature and pressure relief valves protect against excessive pressure or temperature

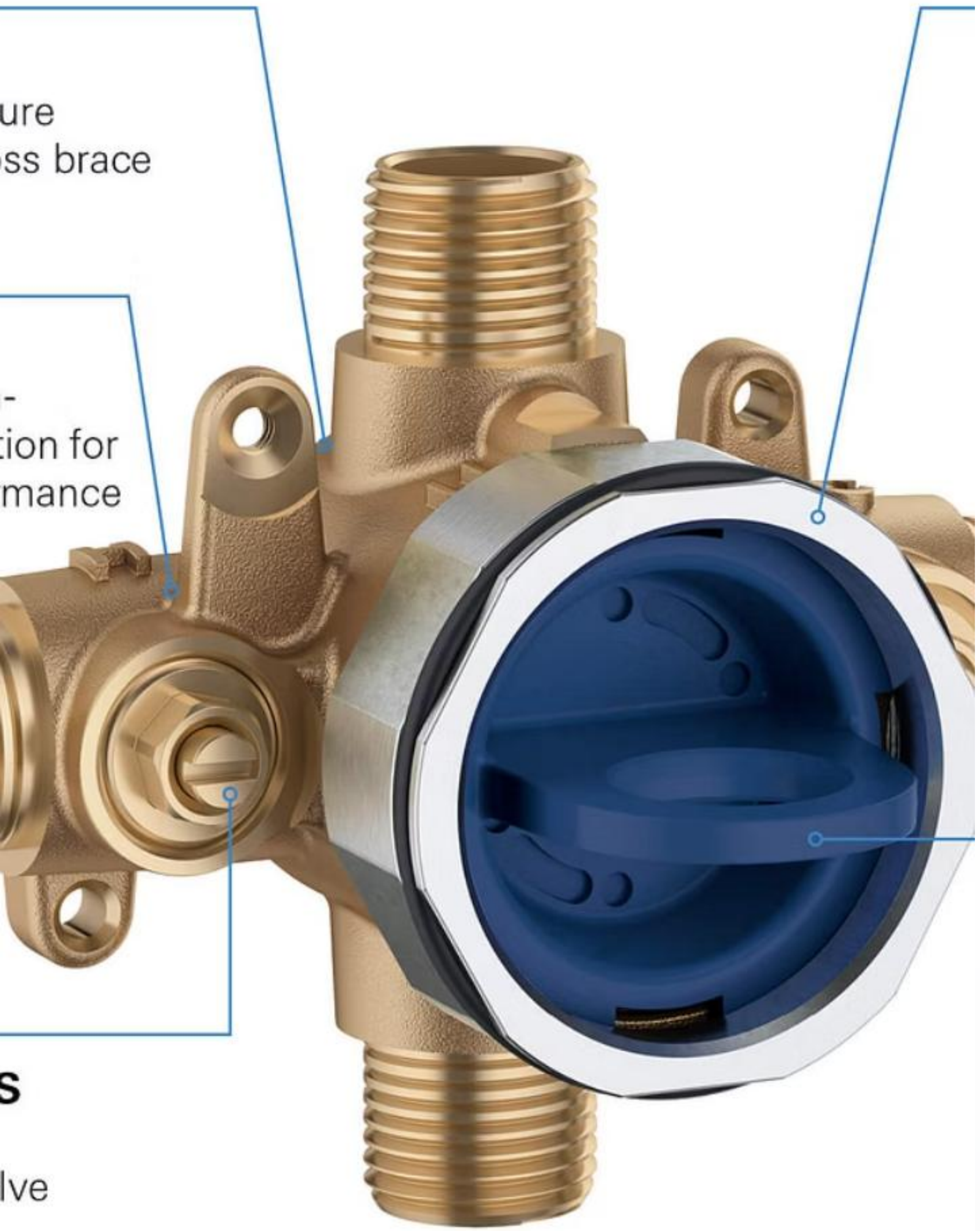
Scalding Prevention

Scalding Risks

More than 90% of scalding incidents occur in the home. Scalding injuries are tremendously painful, and the effects can last for years. Water at temperatures above 106°F (41°C) are painful. At a temperature of 131°F (55°C), a person can be scalded with a third-degree burn in less than 4 seconds.

Legionella Concerns

If water is stored at 120°F (49°C) or lower, there is a danger of the development and growth of Legionella bacteria, which can cause serious health problems. To address both safety concerns, water should be stored at 140°F (60°C) and a thermostatic mixing device should be installed to temper the distribution system to 120°F (49°C) or less.



Thermostatic Mixing Valves

1

Function

Three-port, automatic temperature-compensating valves continuously sense the temperature of the water flowing through their outlet.

2

Design

They have a cold inlet port, a hot inlet port and a mixed outlet port.

3

Operation

When the outlet water temperature increases above set limits, the valve opens to allow cold water to mix with the hot water flow. When the temperature of the hot water is reduced to safe levels, the cold port closes.

Thermostatic Gas Control Valve

Manual Gas Valve

Allows turning gas flow on or off manually

Appliance Regulator

Maintains constant gas pressure at the burner to control flow rate

Safety Shut-Off Valve

Prevents gas flow to the main burner and pilot burner if the pilot goes out

Pilot Adjustment

Manual valve for adjusting gas flow rate to the pilot burner

Energy Cut-Off Device

Shuts off gas flow if water temperature becomes excessively high

Rod and Tube Aquastat

Construction

The aquastat has a copper tube and invar rod assembly that is immersed in the tank. The copper tube has a high expansion and contraction rate, while the invar rod has a very low expansion and contraction rate.

Operation

The rod and tube are connected together at the far end, and expansion and contraction of the tube allow the invar rod to control the movement of the control mechanism. Whenever the temperature of the stored water drops a predetermined amount, typically 15°F (8°C) to 20°F (11°C), the tube contracts to turn on the gas flow to reheat the water to the setpoint temperature.

Safety Devices

Thermal Cut-Off (TCO)

A high-limit switch set to a temperature above normal operating temperature (typically 190°F/88°C). This type of switch may or may not have a manual reset.

Energy Cut-Off Device (ECO)

A safety feature added to many rod and tube gas control valves. If water temperature becomes excessively high, the ECO will cut off gas flow to the burner. It's a fusible link wired in series within the pilot safety circuit.

Flammable Vapour Sensor

Senses the presence of flammable vapours and prevents the blower purge cycle from starting or continuing, thereby preventing the operation of the igniter or the continued operation of the gas valve.

Temperature and Pressure Relief Valve

Opens automatically to release water if the tank pressure or water temperature becomes excessively high.

Flammable Vapour Ignition Resistance (FVIR)

Development Background

In 1995, the Water Heater Industry Joint Research and Development Consortium was formed to determine whether a residential gas water heater could be made more resistant to accidents caused by mishandling or improper storage of gasoline or other flammable materials.

Implementation

By July 2006, all gas water heaters 75,000 Btuh or less produced in the U.S. and Canada were required to comply with the new FVIR standard.

Sensor Technology

The sensor technology is comprised of three primary components: silicone sensor film, moulded base insert, and moulded cover. When the sensor senses flammable vapour, silicone expands, pulling some of the carbon particles apart and increasing the resistance of the sensor.

Safety Response

When these sensors have locked out the ignition sequence, there is usually an error code visible at some point on the water heater gas control. Technicians must typically contact the manufacturer directly to obtain the reactivation code.

FVIR Design Features

Air Intake Design

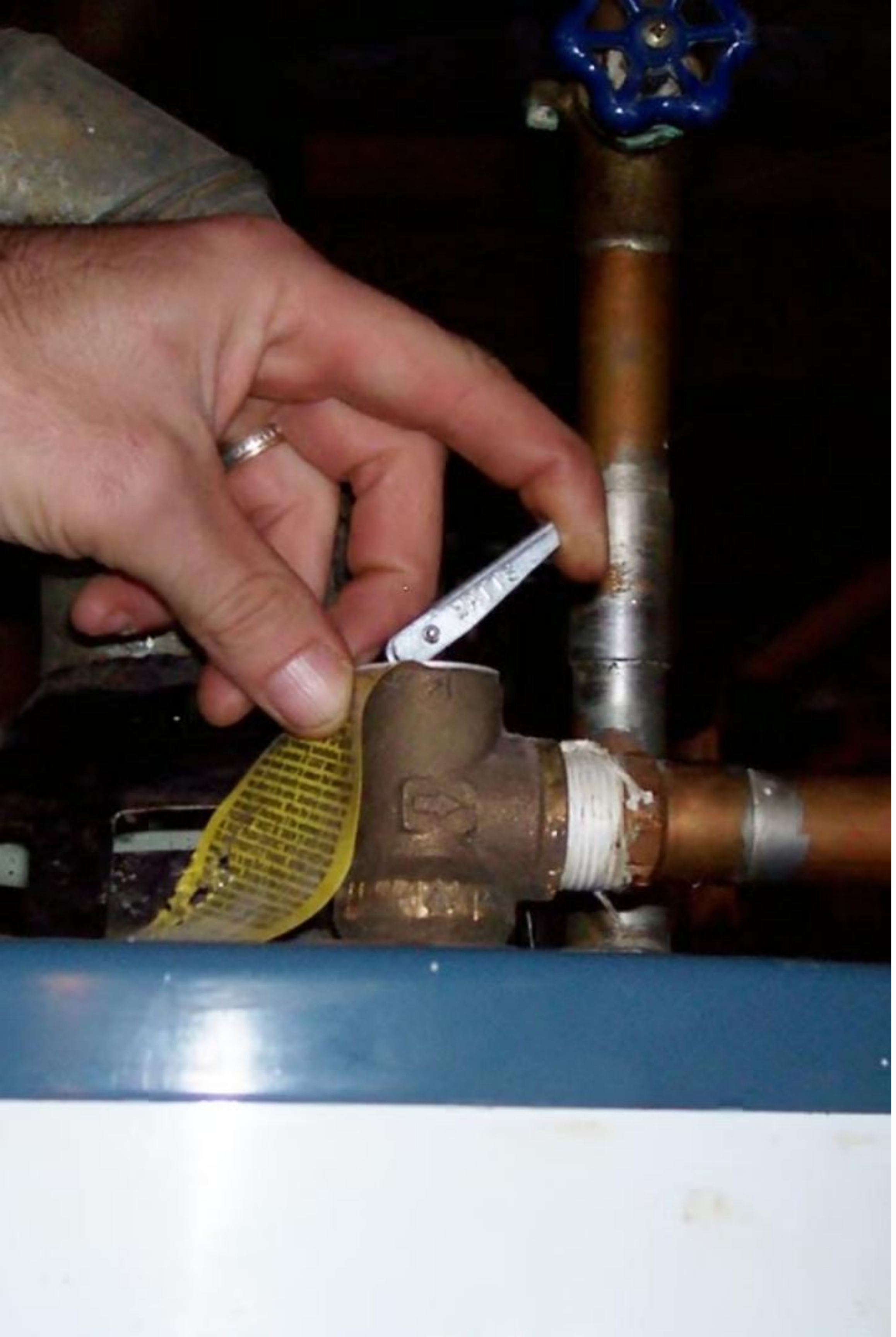
FVIR water heaters are designed to seal off the combustion chamber access doors and draw combustion air for the burner from an 18 inch height instead of floor level.

Flame Arrestor

Combustion air enters through the one-way intake system and passes through the flame arrestor plate (usually stainless steel). If flammable vapours are introduced and ignite, the flames are contained within the combustion chamber and cannot escape back out of the heater.

Thermal Limit

The thermal limit or TCO shuts off gas flow to the main and pilot burners during flammable vapour ignition inside the combustion chamber or if excessive temperatures indicate poor combustion due to a clogged screen or filter.



Temperature and Pressure Relief Valve

Temperature Sensing

The sensing stem of the relief valve extends down into the water within the top 150 mm (6 inches) of the tank.

Pressure Relief

If the tank pressure becomes excessively high, the valve will open automatically to release water.

Safety Warning

Never install any valve, cap, or plug on the outlet of a relief valve.

Replacement

Whenever a water heater is replaced, install a new valve and discard the old one.

Water Heater Components

Dip Tube

The cold-water inlet is usually at the top of the tank. A dip tube, which is usually non-metallic, extends down into the tank from the cold-water inlet. The dip tube directs incoming cold water to the lower part of the tank to ensure that the hot water in the tank rises and leaves the tank first.

Without the dip tube, the incoming cold water would mix with the hot water in the tank, resulting in the heater delivering warm instead of hot water.

Anti-Siphon Hole

A small anti-siphon hole, located near the top of the dip tube, prevents siphoning action that could result from the cold water supply being isolated. If the cold water supply is shut off, the tank will only siphon to the level of the anti-siphon hole.

Anode Rod

Most storage-type water heaters are equipped with an internal anode rod for electrolytic corrosion protection. The anode rod, which is usually made of magnesium, will corrode before the steel tank, thus extending the life of the tank.

Venting Systems

Internal Flue

Most residential water heaters have an internal flue that conducts the products of combustion to the venting system. In a storage water heater, the flue is also part of the heat exchange surface. The flue contains a spiral-shaped sheet-metal baffle, which swirls the hot gases in the flue to improve heat transfer to the water.

Flue Configurations

- Center-flue design (most common)
- Offset flue from the center of the tank
- External flue located adjacent to the outer wall of the tank
- Floating-tank water heater with external flue that completely encircles the tank
- High efficiency water heaters with multiple passes and passages

Circulating Pumps

Domestic System Pumps

Pumps that are used to circulate potable water must be suitable for the application. Bronze body or stainless pumps are the usual choice to maintain quality of the potable water.

In large domestic and commercial systems, a pump may be used to recirculate hot water continuously, so it is immediately available at maximum temperature, even at the most distant points of the system.

Combination System Pumps

Room thermostats control combination system pumps. On a call for heat, the pump would be activated and circulate water from the water heater through the heat transfer unit (like a fan coil).

Flow Sensors

Flow sensors and flow switches detect fluid movement. In a water heating system, a flow switch or flow sensor can be used to ensure that circulating pumps are operating.

Water Heater Piping Layout

General Requirements

Gas supply and water piping installations for hot water heaters must conform to manufacturer's specifications and applicable Code requirements. Hot water piping runs should be kept as short as possible to ensure minimum heat loss and faster delivery of hot water to the point of use.

Residential Connections

Residential-type hot water heaters are generally fitted with 3/4 inch cold-water inlet and hot-water outlet galvanized threaded piping connections. Metallic piping should be connected to these tank nipples for a minimum distance of 450 mm (18 inches) to protect any plastic water distribution piping within the system.

The cold-water inlet supply pipe must come with a shut-off valve to isolate the water heater from the building water supply when the heater requires maintenance, repair, or replacement.

Multiple Water Heater Installations

Parallel Piping

When two water heaters are required, plumb them in a manner that will assist in balancing the flow through each unit. This parallel piping arrangement is sometimes referred to as a cascade design.

Piping Drawings

Mechanical drawings for multiple gas-fired hot water heater installations include component names, types, sizes, part numbers, locations, configurations, and other data necessary for installation purposes.

Piping sizes are specified on drawings to ensure that the installation maintains proper flow rates and meet minimum plumbing Code requirements when completed.

Relief Valve Discharge Line Requirements

Must Do

- Grade and install it to allow complete drainage of itself and the relief valve
- Terminate in an air break at least 25 mm (1") in height, to a maximum of 300 mm (12")
- Locate the end of the pipe so that any discharge is visible
- In the absence of a floor drain, the discharge line must indirectly drain to the exterior of the building
- Weather-seal and mechanically protect all piping that penetrates exterior walls

Must Not Do

- Make it smaller in size than the relief valve outlet
- Include valves or other restrictions
- Locate it in areas subject to freezing
- Thread or cap the end of the line
- Use steel or black iron pipe, as internal corrosion may build up and block the discharge pipe

Hot Water Storage Systems

Large Tank Storage Heaters

Larger water heaters for commercial and industrial applications often have temperature sensed at more than one level in the tank for more accurate control. Temperature control is accomplished by means of a diaphragm valve connected by external bleed lines to the lower and upper level control sensors.

Two-Tank Systems

Often used for applications that require hot water at different temperatures. For example, one tank may supply water at 140°F for kitchen and laundry use and as preheated water for a second tank. The second tank may supply water at 180°F (82°C) for dishwashing.

Circulating Water Heaters

In a circulation-type system, water is heated in a small tank and stored in another larger tank. The water is circulated through the heater by gravity or by a circulating pump.

Tankless Water Heater Types

Indoor Power-Vent

Uses a fan to push flue gases to the outdoors. Air needed for combustion is taken from the inside space where the appliance is located.

Indoor Direct-Vent

Combustion air is supplied to the gas burner directly from the outdoors to the appliance sealed combustion chamber. Two pipes, or one concentric pipe, run from the water heater through the wall or roof of the building.

Outdoor

These water heaters receive combustion air from their immediate environment. Flue gas is exhausted in the same way.

Tankless Water Heater Venting

Venting Categories

Indoor units are typically listed as either Category 3 or Category 4 appliances, with positive vent static pressure, utilizing either stainless steel or plastic venting. These appliance venting systems must be sized and installed according to the manufacturer's literature.

Installation Guidelines

- The venting should be as direct as possible with a minimum number of fittings
- The total developed length and number of fittings used in an installation shall not exceed the requirements as outlined by the appliance manufacturer's installation instructions
- Terminations must be in accordance with the appliance manufacturer's instructions, local building code requirements, and CSA B149.1

Water Heater Removal Procedure

Obtain Permits

Obtain the appropriate permits as required by local gas and plumbing authorities.

Shut Down and Drain

Turn off the gas and cold water supply to the water heater. Open a nearby hot water faucet and the water heater drain valve. If necessary, a hose may be connected to the drain valve to direct the water to a drain.

Allow Cooling

Allow the heater to cool sufficiently for safe handling.

Disconnect and Remove

Disconnect the heater's gas supply piping. Disconnect the plumbing piping when the heater has drained completely. Remove the heater from the premises and prepare it for disposal.

Water Heater Installation Planning

Location Considerations

For a new installation, plan the location carefully to ensure there will be adequate combustion air supply, proper venting action, and effective relief valve drainage. Unless a water heater is of the direct-vent type, it shall not be installed in a bedroom, bathroom, or any area where sleeping accommodation is provided.

Clearances

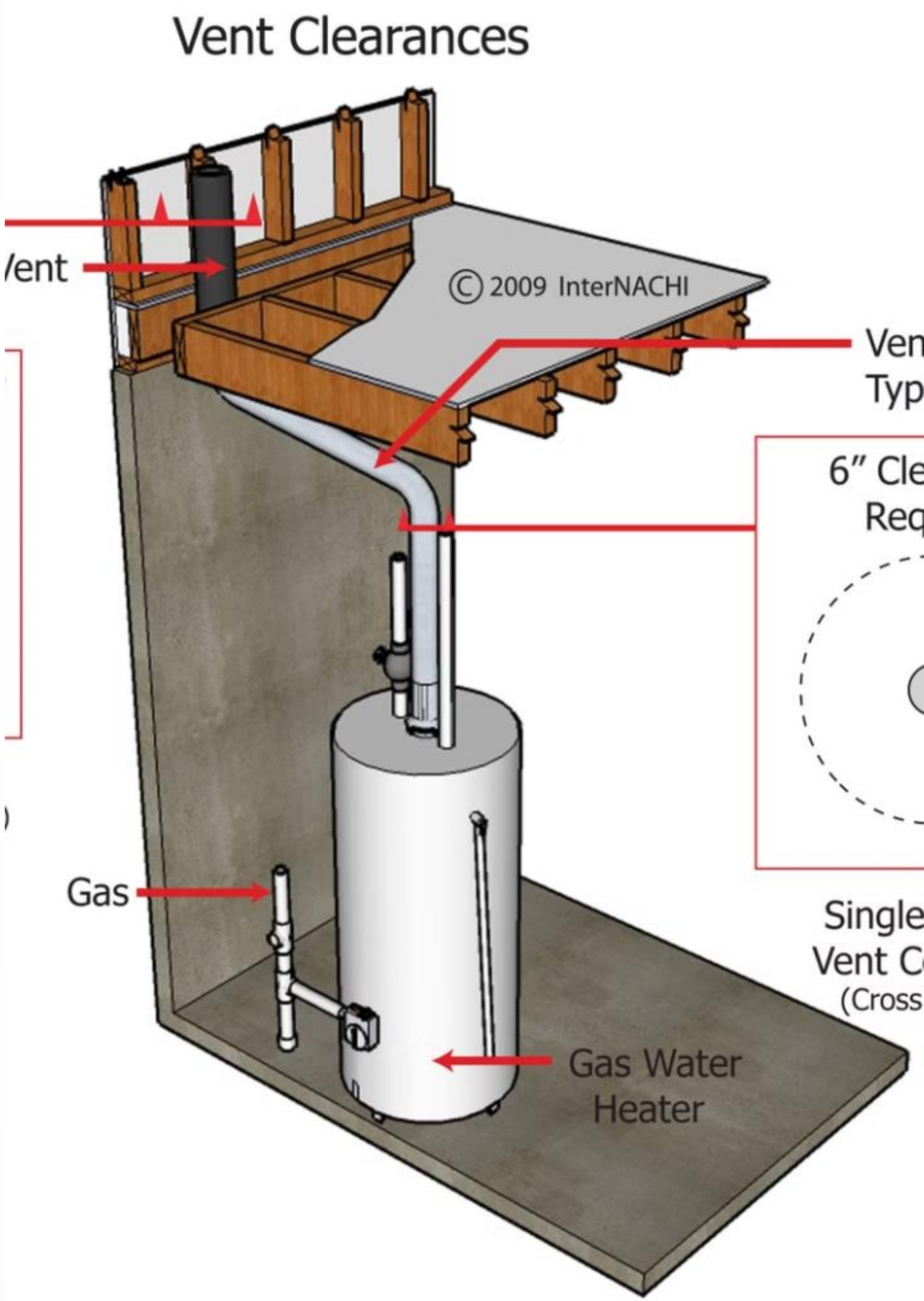
Installation clearances at the rear and sides of an underfired storage-type water heater must be no less than 2 inches (50 mm). Ample clearance must also be provided at the front of the unit for lighting, servicing, cleaning, and adjustment.

Combustion Air

The area selected must have adequate ventilation, as the burner will consume oxygen during water heater operation. If the water heater is installed in an enclosed area, ventilation openings or an air inlet must be provided in accordance with the applicable Code requirements.

Venting Requirements

Single-wall type vent	6 inches (150 mm) clearance from combustible surfaces
Type B vent	1 inch (25 mm) clearance from combustible surfaces
Type BH vent (special venting system)	Consult venting manufacturer
Sides of the water heater	At least 2 inches (50 mm) clearance



Water Heater Installation - Drainage

Drainage Requirements

A water heater should not be installed in a location where water damage can result from water heater leakage (this is particularly important in multi-storey buildings). In such cases, the installation must include a means of directing leakage or overflow to a suitable drain, i.e., a pan installed under the tank and piped to a suitable location.

Drain Pan Specifications

The National Plumbing Code requires that drain pans be installed for all water heaters when they may cause damage to wood construction or are located in a ceiling or roof space. The drain pan must be at least 50 mm larger than the tank's diameter and have walls a minimum of 25 mm high. It must have a drain that is a minimum 2 sizes larger than the relief valve's discharge pipe.

Water Piping Installation

Preparation

Level the water heater before proceeding with the piping installation. Close the main water supply shut-off valve. Release water pressure and drain piping by opening nearby hot and cold water faucets. Close the water faucets after the system is completely drained.

Fitting Installation

Install the necessary fittings to connect the cold and hot water supply to the heater. Markings on the heater identify inlet and outlet connections. Check that the cold-water inlet connection contains the factory furnished dip tube.

Connection Guidelines

Do not solder the cold water supply pipe directly to the cold-water inlet connection. If required, solder the tubing to an appropriate adapter before attaching the adapter to the cold-water inlet. The cold-water inlet line must contain a shut-off valve and a union should be provided.

Vacuum Relief

The National Plumbing Code requires the installation of a vacuum relief valve in the cold water supply line between the shut-off valve and the cold-water inlet to the tank. In the case of depressurization in the supply line, the valve will prevent a vacuum from imploding the tank.

Gas Piping Installation

1

Code Compliance

Consult CSA B149.1 for the type and size of pipe to use. The rating plate on the heater indicates the type of gas and maximum rated input of the unit.

2

Preparation

Turn off the gas supply. Remove burrs, oil, pipe compound, and other contamination from the pipe or tubing. Ensure that the interior of the piping is clean. Foreign material left in gas piping can work its way to the gas control valve and damage the components.

3

Installation

Cut the piping in accordance with good piping practices. Ensure that all connections are gas-tight. Avoid stressing the gas control valve when attaching the supply pipe by supporting the control valve with a wrench.

4

Testing

Slowly open the gas shut-off valve and carefully check all gas piping, including factory piping, for leaks. Use an appropriate liquid solution or a leak-detection device.

Filling the Water Heater

Close Drain Valve

Close the heater drain valve.

Open Water Supply

Open the cold water supply valve.

Purge Air

Open a nearby hot water faucet (remove the faucet aerator to avoid clogging it with debris). This will assist filling by allowing the air in the heater and piping to escape. When a steady stream of water flows from the open faucet, the tank is full.

Check for Leaks

Close the hot water faucet. Replace the aerator. Check all water piping and plumbing fitting connections for leaks, and repair as necessary.

Gas Leak Check

1

Turn On Gas

Turn on the main gas supply. Relight the pilot burners of any other gas appliances with standing pilots. Turn on the gas shut-off valve in the water heater gas supply pipe.

2

Safety Precautions

Do not light the pilot burner (if applicable). Do not use a match or open flame to test for gas leaks.

3

Leak Testing

Use a liquid solution (like soapy water) or a leak detection device to test for leaks. Apply the soap mixture to all gas pipe joints and fittings.

4

Inspection

Observe connection joints for the presence of soap bubbles, which will indicate leaks. Repair leaks as necessary and ensure that the installation is left in a safe condition.

General Installation Check

1. ### Clearance Check

   Check to ensure there is at least 2 inches of clearance between the water heater and combustible materials.

2. ### Leak Inspection

   Ensure that there is no water leakage.

3. ### Ventilation Verification

   Confirm there is adequate ventilation around the heater area.

4. ### Water Fill Confirmation

   Verify the heater is completely filled with water and that all air has been expelled from the system.

5. ### Gas Piping Compliance

   Ensure the gas piping conforms with applicable Codes.

6. ### Venting Installation

   Confirm the draft hood and vent pipe are installed properly.

Lighting the Pilot Burner

Turn Off Pilot

Turn the PILOT ON-OFF dial on the thermostat control valve to the OFF position. Wait five minutes when relighting.

Prepare for Lighting

Turn the PILOT ON-OFF dial on the thermostat control valve to the PILOT position.

Light the Pilot

Apply an open flame to the pilot burner opening and depress the PILOT RESET button for approximately one minute or until the burner flame remains constant upon release of the RESET button.

Complete Setup

Turn the PILOT ON-OFF dial on the thermostat control valve to the ON position. Adjust the thermostat temperature selector dial to the desired temperature.

Tankless Water Heater Applications

4000

Btu/h per Gallon

Minimum input rate per gallon (0.26 kW per litre) of water stored in the unit

75,000

Btu/h

Typical minimum input for residential tankless heaters

200,000

Btu/h

Typical maximum input for residential tankless heaters

400,000

Btu/h

Maximum input for commercial tankless units (120 kW)

Legionella Prevention

What is Legionella?

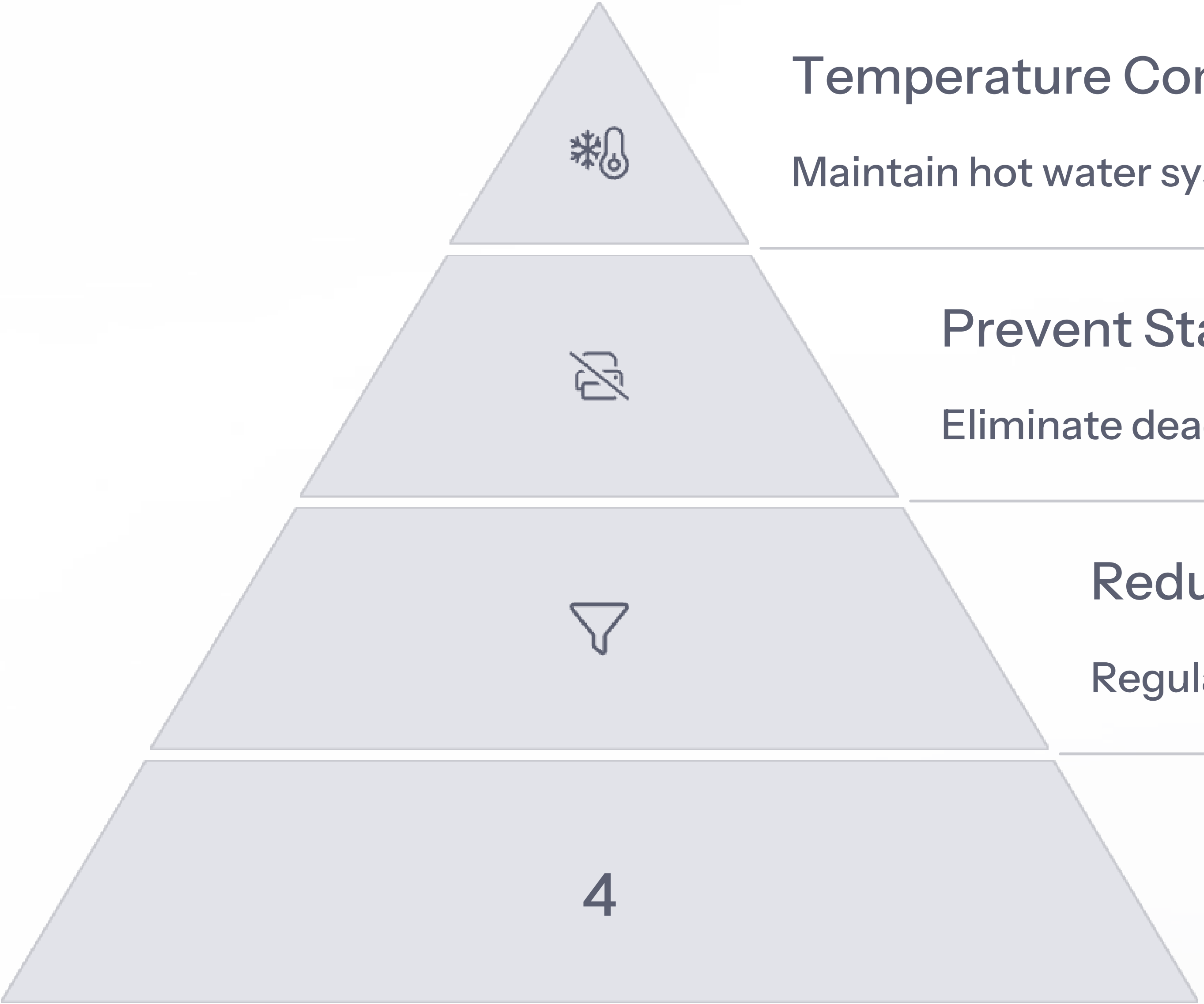
Legionella is a fairly common water bacteria found to exist widely in many surface water sources such as lakes, rivers, streams and ponds. It can also be found in groundwater sources and some soils. At the levels found in these naturally occurring sources, it typically does not pose a threat to public health.

Ideal Growth Conditions

When the bacterium enters a domestic water system, it can find an ideal host environment in the following conditions, where it can rapidly colonize, forming higher concentrations that can pose the public health threat of Legionnaires Disease:

- Warm water temperatures 104-115°F (40-46°C)
- Stagnant water areas (storage tanks and dead-end piping legs)
- Ample food sources (sediment, scale, deposits and biofilm)

Legionella Control Methods



Temperature Control

Maintain hot water system storage temperature at or above 140°F (60°C)

Prevent Stagnation

Eliminate dead legs and ensure proper circulation

Reduce Food Sources

Regular cleaning to remove sediment and biofilm

Anti-Scald Protection

Use thermostatic mixing valves to prevent scalding

Thermal Expansion Protection

Code Requirement

The National Plumbing Code requires protection against thermal expansion for closed water distribution systems to accommodate the increase in pressure from water expansion when heated.

Solutions

- Diaphragm expansion tank (rated for use with potable water)
- Auxiliary thermal expansion relief valve (TER Valve)

These devices prevent excessive pressure buildup in the water heater tank and distribution system, which could potentially damage components or cause the temperature and pressure relief valve to discharge.

Plastic Piping Considerations

Manufacturer Recommendations

If plastic piping is used for the construction of the water distribution system, the manufacturers recommend to not connect to within 18 inches (450 mm) of the water heater with these products.

Best Practice

It is good plumbing practice to use a minimum of 18 inches (450 mm) of metallic piping to connect the heater to the water distribution system. This helps protect plastic piping from the high temperatures that can occur near the water heater connections.

Temperature Stratification

What is Temperature Stratification?

The water at the top of tank-type water heaters reaches a higher temperature than the water at the bottom during those periods when the hot water is not being drawn off. This temperature difference is called "temperature stratification".

Influencing Factors

- The shape of the tank - taller tanks influence stratification
- The length of the dip tube - a shorter dip tube would allow too much mixing to occur

Proper stratification helps ensure that the hottest water is available at the outlet, improving the efficiency and performance of the water heater.

Flue Baffle Function

Purpose

In a storage water heater, the flue is part of the heat exchange surface. The flue contains a spiral-shaped sheet-metal baffle, which swirls the hot gases in the flue to improve heat transfer to the water.

Benefits

- Increases the time hot gases remain in contact with the flue surface
- Creates turbulence in the flue gas flow, enhancing heat transfer
- Improves overall efficiency of the water heater
- Reduces the temperature of the flue gases exiting the water heater

Condensing Water Heater Efficiency

90%

Efficiency

Condensing water heaters can achieve efficiencies well over 90%

970

BTU/ft^3

Latent heat recovered from water vapor in flue gas

140°F

Flue Gas Temperature

Typical maximum exhaust temperature, much lower than conventional heaters

Power-Vented Water Heater Operation

Fan Operation

Exhaust fan creates negative pressure in combustion chamber

Pressure Verification

Differential pressure switch verifies fan operation

Burner Ignition

Gas valve opens allowing burner to ignite

Post-Purge

Fan continues to run after burner shutdown

Direct-Vent Water Heater Advantages

Location Flexibility

Can be installed in bedrooms, bathrooms, or any enclosure where sleeping accommodation is provided, unlike conventional water heaters.

Combustion Air Quality

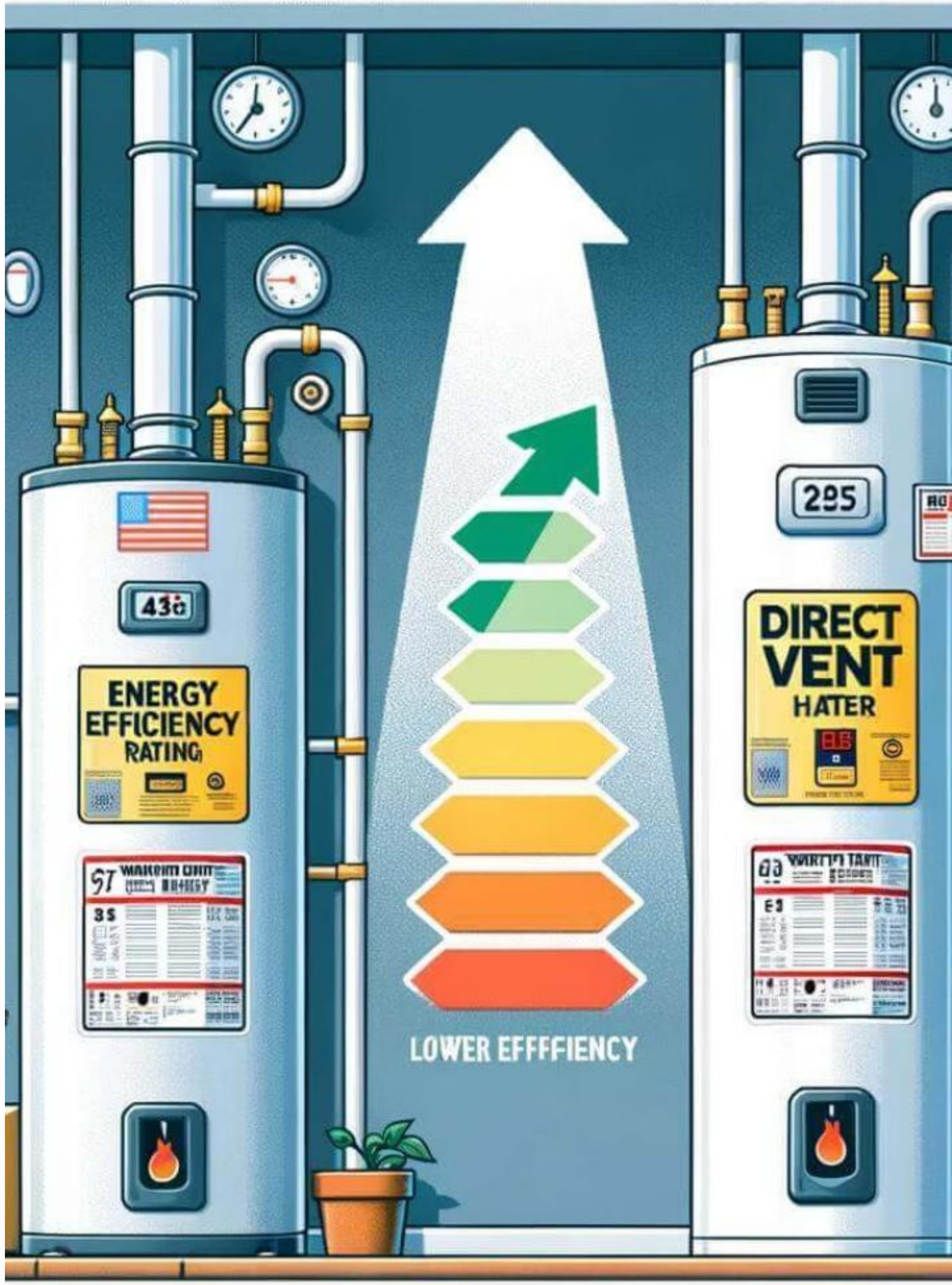
Draws combustion air directly from outside, ensuring clean air for combustion regardless of indoor air quality.

Safety

Sealed combustion system prevents products of combustion from entering the living space and is not affected by negative pressure conditions in the building.

Efficiency

Often more efficient than conventional water heaters because they're not affected by drafts or indoor air temperature fluctuations.



FVIR Sensor Technology

Sensor Components

The sensor technology is comprised of three primary components:

- Silicone sensor film
- Moulded base insert
- Moulded cover

Operation

When the sensor senses flammable vapour, silicone expands, pulling some of the carbon particles apart and increasing the resistance of the sensor. The magnitude of the increase in resistance depends upon the gasoline vapour concentration - higher concentrations cause increased expansion of the silicone film, which results in a higher sensor resistance and vice versa.

Vacuum Relief Valve Importance

Purpose

The National Plumbing Code requires that a vacuum relief valve be installed when any tank may be subject to back-siphonage. Note that most storage tanks can be subject to pressures less than atmospheric when there is a reduction or interruption in service pressure.

Installation

This valve must be installed downstream of the tank shut-off valve and should not have a means to prevent it from supervising the pressure in the tank. The vacuum relief valve protects the tank from implosion due to negative pressure, which may occur within the tank.

Drain Pan Requirements

50

Millimeters

Minimum size larger than the tank's diameter

25

Millimeters

Minimum height of drain pan walls

2

Pipe Sizes

Minimum drain pipe size larger than the relief valve's discharge pipe

The National Plumbing Code requires drain pans for all water heaters when they may cause damage to wood construction or are located in a ceiling or roof space. The drain pan must be properly sized and have an adequate drain to prevent water damage in case of leaks or relief valve discharge.

Water Heater Maintenance Importance

Regular Inspection

Periodic inspection of water heaters helps identify potential issues before they become major problems.

Anode Rod Replacement

The anode rod should be checked regularly and replaced when significantly corroded to extend the life of the tank.

Sediment Removal

Regular flushing of the tank helps remove sediment buildup that can reduce efficiency and cause premature failure.

Temperature Setting

Periodically check and adjust the temperature setting to ensure it meets both safety requirements and household needs.

Relief Valve Testing

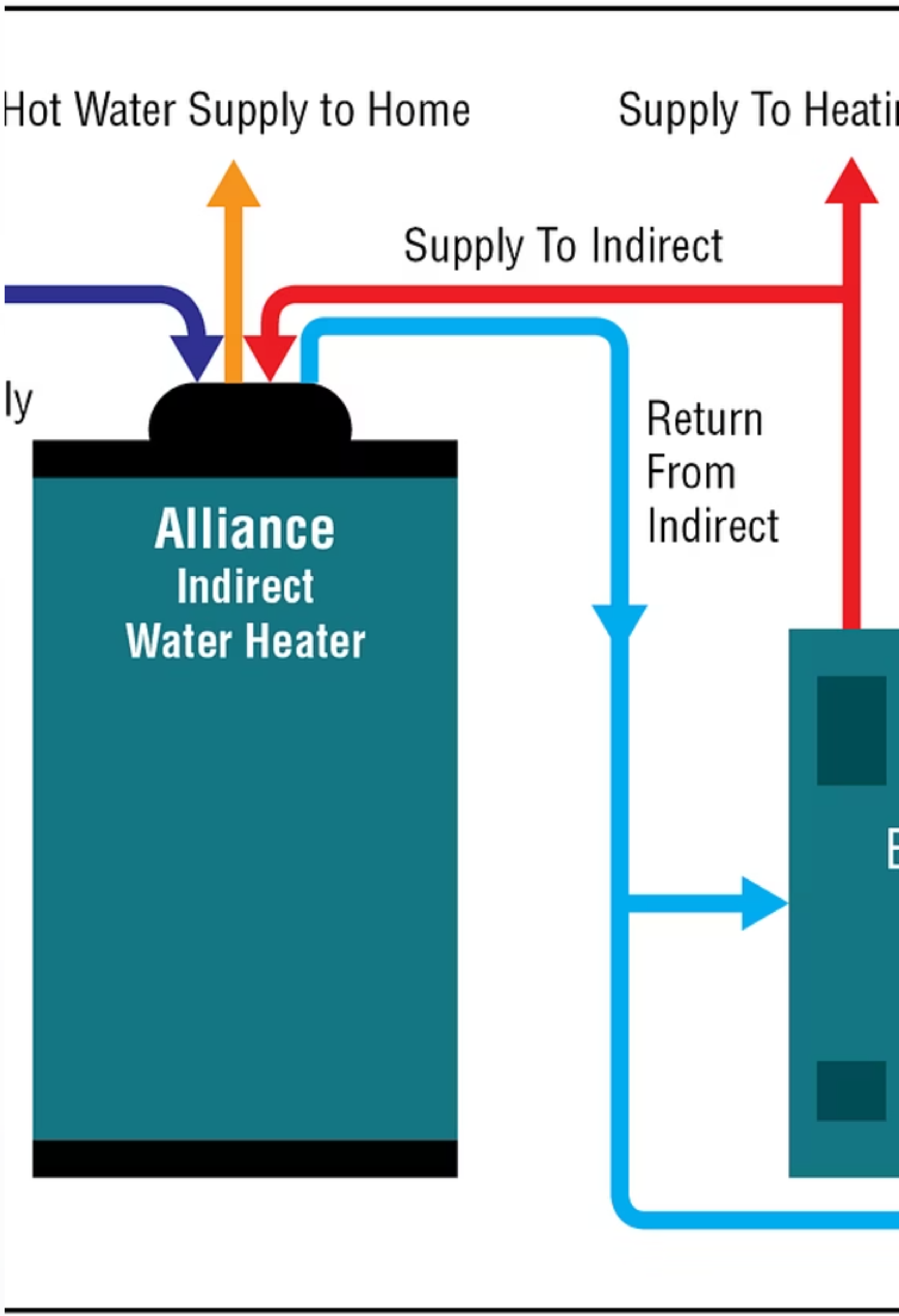
The temperature and pressure relief valve should be tested periodically to ensure it will function properly in an emergency.

CSA Unit 18

Chapter 2

Combination Systems for Heating and Hot Water

Most occupied buildings have a supply of domestic hot water and equipment for central heating. Combining the two systems is sometimes the most economical and efficient way to provide both services. Because the popularity of this type of system is increasing, the gas technician/fitter must be able to identify, select, and install components and controls that will ensure both the domestic hot water and space heating requirements of the system are met.



Objectives of Combination Systems

Installation Requirements

Describe installation requirements for combination systems

System Types

Describe types of combination systems

System Layout

Describe system layout

Wiring Procedures

Describe wiring procedures

Key Terminology

Term	Abbreviation (Symbol)	Definition
Non-potable		Water that is not safe to drink
Potable		Water that is safe to drink

Special Note on Installation Requirements

Plumbing Connections

Connections made to gas appliances that include connections to the potable water system must meet local, provincial, and municipal code requirements and will typically fall outside of the scope of a gas technician/fitter's practice in most provinces.

Compliance Requirements

It is the responsibility of the gas technician/fitter to comply with all codes, as well as their local trade regulations. In most jurisdictions within Canada, the only individual permitted to perform installation, alteration, or repair on any part of a plumbing system is a licensed Red Seal Plumber or Registered Plumbing Apprentice.

Guidance Organizations for Combination Systems

National Resources Canada

Publishes a water heater guide that outlines the pros and cons of using combination systems

Canadian Institute for Plumbing and Heating (CIPH)

Association of manufacturers that promotes the correct use of certified equipment and supports recognized industry standards for water heating

Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)

Developed a resource document of suggested best practice with regards to combination systems

CSA B214

Contains minimum requirements for combination heating systems

HRAI Guidelines for Combination Systems

Certification Requirements

These systems consist of a certified combination storage-type or a certified tankless potable water heater used in conjunction with a fan-coil (ducted) heating system, hydronic baseboard system, and/or a hydronic radiant slab heating system, and is intended for space heating applications of not more than 75,000 Btu/h (22 kW).

Proper Sizing

Combination system components must be selected and sized to meet and maintain the total calculated demands for hot water service and space heating heat loss requirements.

Labeling

Domestic water heaters incorporated in combination heating systems must be certified and labelled as being "Suitable for water (potable) and space heating."

Pressure and Temperature Ratings

All components in the combination heating system or on the potable water side of a heat exchanger shall have a design pressure of not less than 1035 kPa (150 psi) and shall be able to withstand a continuous water temperature of 71°C (160°F) and a short-term exposure of 99°C (210°F).

Additional HRAI Guidelines

Ventilation Requirements

Ventilation air, which must be introduced into the building in accordance with the Building Code, must be heated and this will affect the overall system design.

Plumbing Code Compliance

Piping and components of the combination system that contain potable water must comply with the requirements of the applicable local plumbing code, or in its absence, the NPC.

Component Approval

All appliances, accessories, components, equipment, or materials used in an installation must be of a type and rating approved for the specific application for which they are used.

Certification Labeling

The water heating appliance and the fan coil unit must be certified by an approved agency, such as CSA Group, and labelled "Suitable for water (potable) and space heating."

Material and Chemical Restrictions

Ferrous Materials Prohibited

Ferrous materials (those containing iron) must not be used for potable water applications.

Non-Potable Chemicals Prohibited

The use of non-potable chemicals is prohibited in potable water systems.

Previous System Connections

Combination systems may not be connected to any heating systems or components previously used for non-potable water heating systems.

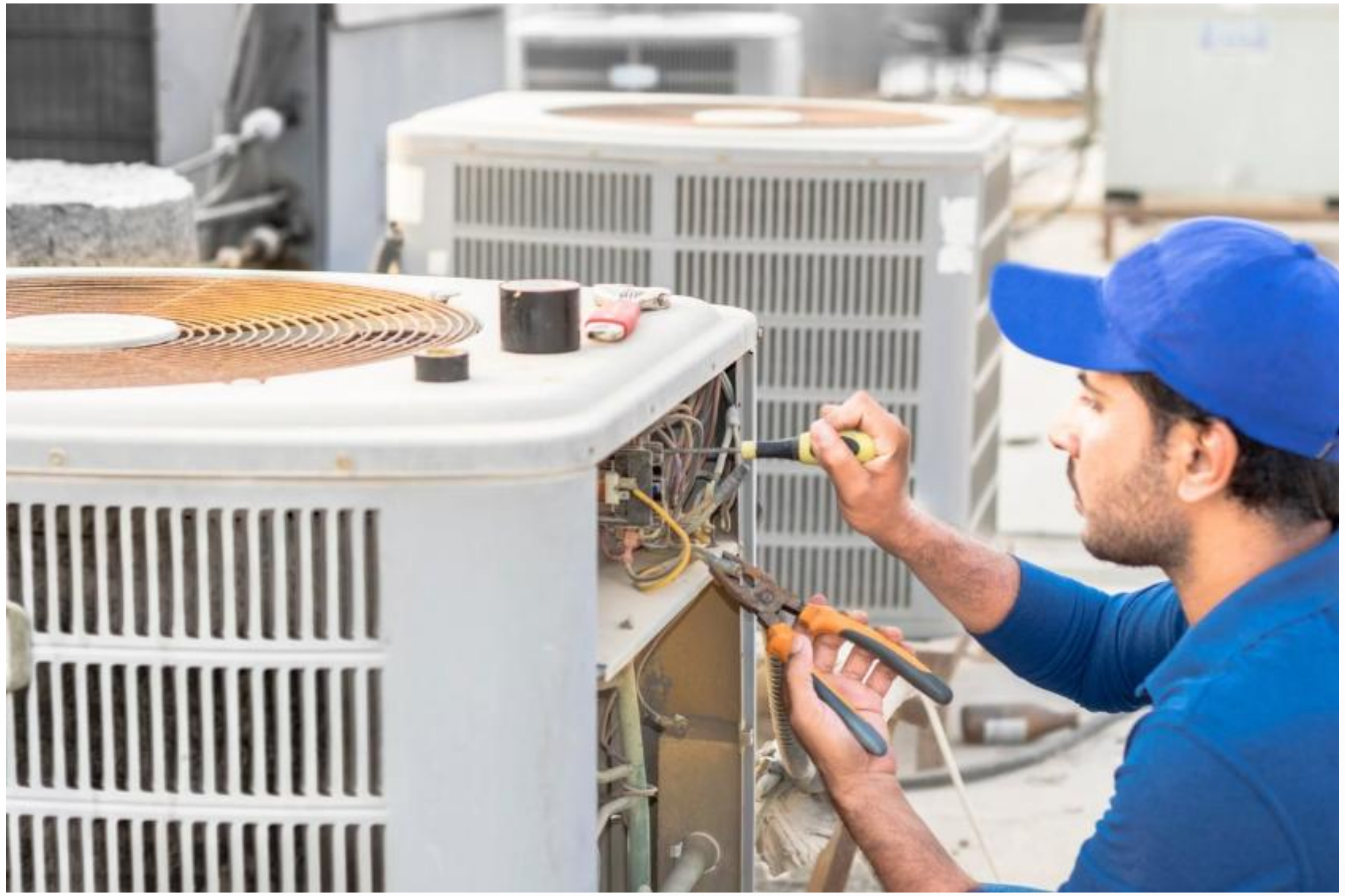
Pump-Cycle Timer Requirement

A pump-cycle timer must be installed to circulate all water contained in the fan coil space heating piping and components at least once every 24 hours. The timer may be factory installed in the air handling unit.

Qualifications and Responsibilities

Skilled Installation

Qualified gas technicians/fitters must complete all installations in a skillful, thorough manner. Pay careful attention to the mechanical aspects of the work, to the layout of the installation, and proper instructions to the end-user.



Training and Qualification

Gas technicians/fitters performing installation, service, and maintenance work on combination systems must be properly trained and qualified to do so. All work must be done in accordance with Trade and Apprenticeship Acts and/or fuel certification licenses applicable to the jurisdiction in which the work is being performed.

For example, in most provinces, any work beyond the immediate piping of the gas-fired appliance connections are the responsibilities of a licensed Red Seal Plumber or registered plumbing apprentice.

Installer Responsibilities

Code Compliance

The installation technician/fitter must ensure that the appliance, accessory, component, or equipment installed complies with all Code requirements. The technician/fitter initially activating the appliance must ensure that it is in safe working order.

User Instruction

The installer must instruct the end-user in the safe and proper operation of all the appliances and equipment installed and supply the end-user with the appropriate manufacturer's operation and maintenance instructions.

Follow Manufacturer Guidelines

All appliances, accessories, components, equipment, or any other item must be installed in accordance with the manufacturer's installation instructions and approved trade practices.

Code Compliance and Conflict Resolution

Manufacturer Instructions

Follow detailed installation guidelines

Code Requirements

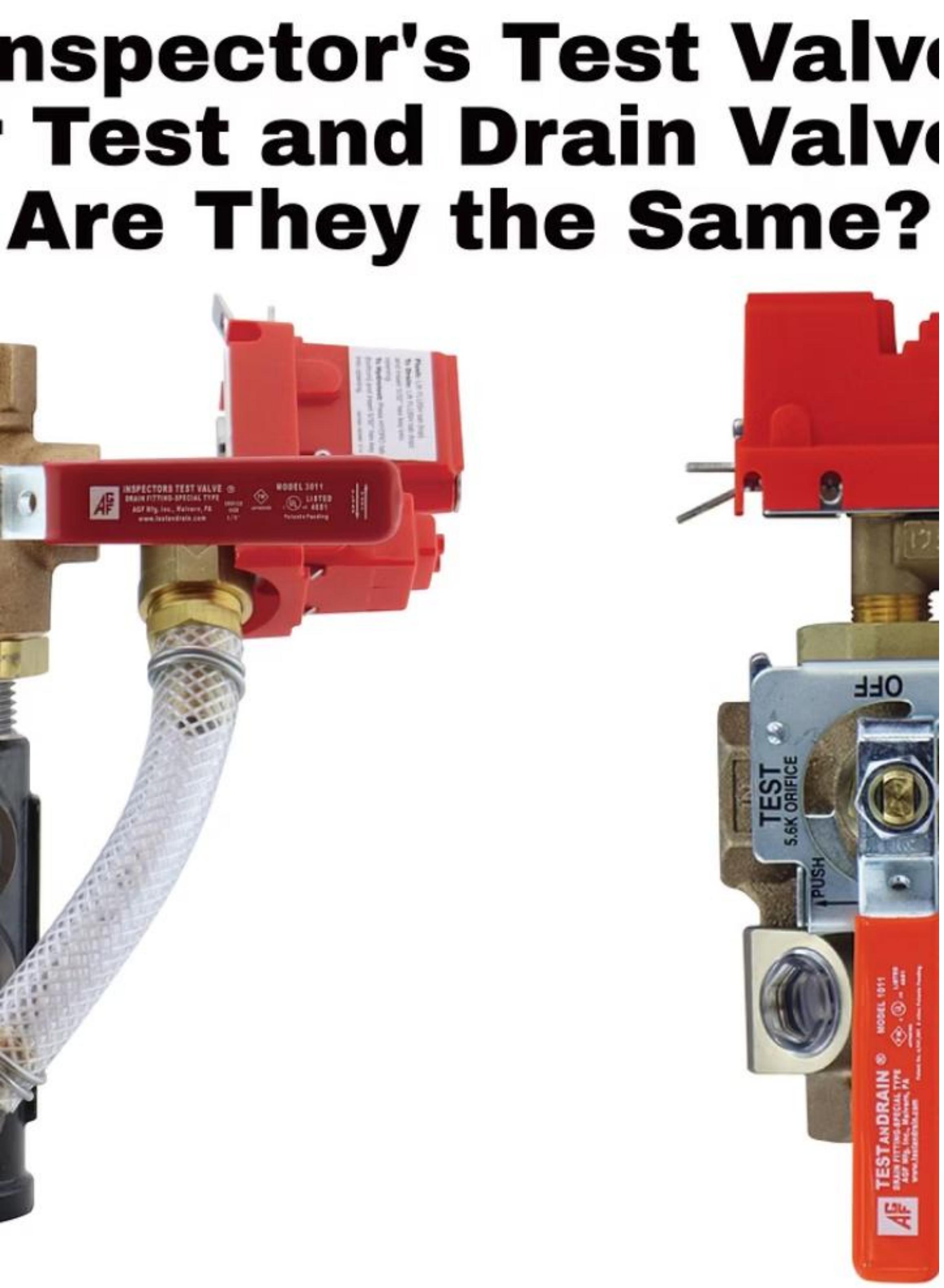
Adhere to all applicable codes

Conflict Resolution

When conflicts exist, code requirements prevail

AHJ Approval

Unless otherwise approved by authority having jurisdiction



Design Requirements for Combination Systems

1. **System Connections**

   Existing non-potable hydronic systems, or parts taken from or connected to these systems, must not be connected to potable water combination systems.

2. **Chemical Additives**

   No chemicals, such as those used in a typical boiler-heated system, may be added to the combination system.

3. **System Drainage**

   Provision must be made to allow the entire combination system to be drained.

4. **System Testing**

   Only potable water may be used to test the combination system, and the system must be flushed before being put into service.

Installation and Access Requirements

Component Access

All components of the combination system must be installed with provision for ready access for inspection, maintenance, repair, and cleaning, in accordance with the manufacturer's operation and maintenance instructions.

Air Conditioning Considerations

The air conditioning system must be installed in such a manner that any component of the air conditioning system will not obstruct service or removal of the water heater or other components.

Warning Label Requirement

The installer must affix a warning label, in plain view of the consumer, which states that the water temperature controls should not be adjusted or tampered with by the end-user.

representatives will be taken into account during the pre-contract tender period.

As part of this tender process DBY Infrastructure makes no obligations in any way to:

(i) pay any vendor for any ITT response; or

(ii) award the contract with the lowest or any bidder; or

CSA Combo Performance Specification

CSA P.9 Standard

CSA Combo Performance Specification Summary (refer to CAN/CSA P.9) applies to forced-air combo heating systems. This Standard allows mechanical designers to select and specify an efficiently and appropriately sized combination system.

Designer Resources

The standard provides the installer with a table of requirements and selected system ratings and the manufacturer's P.9 performance summary and system schematic.

Efficiency Ratings

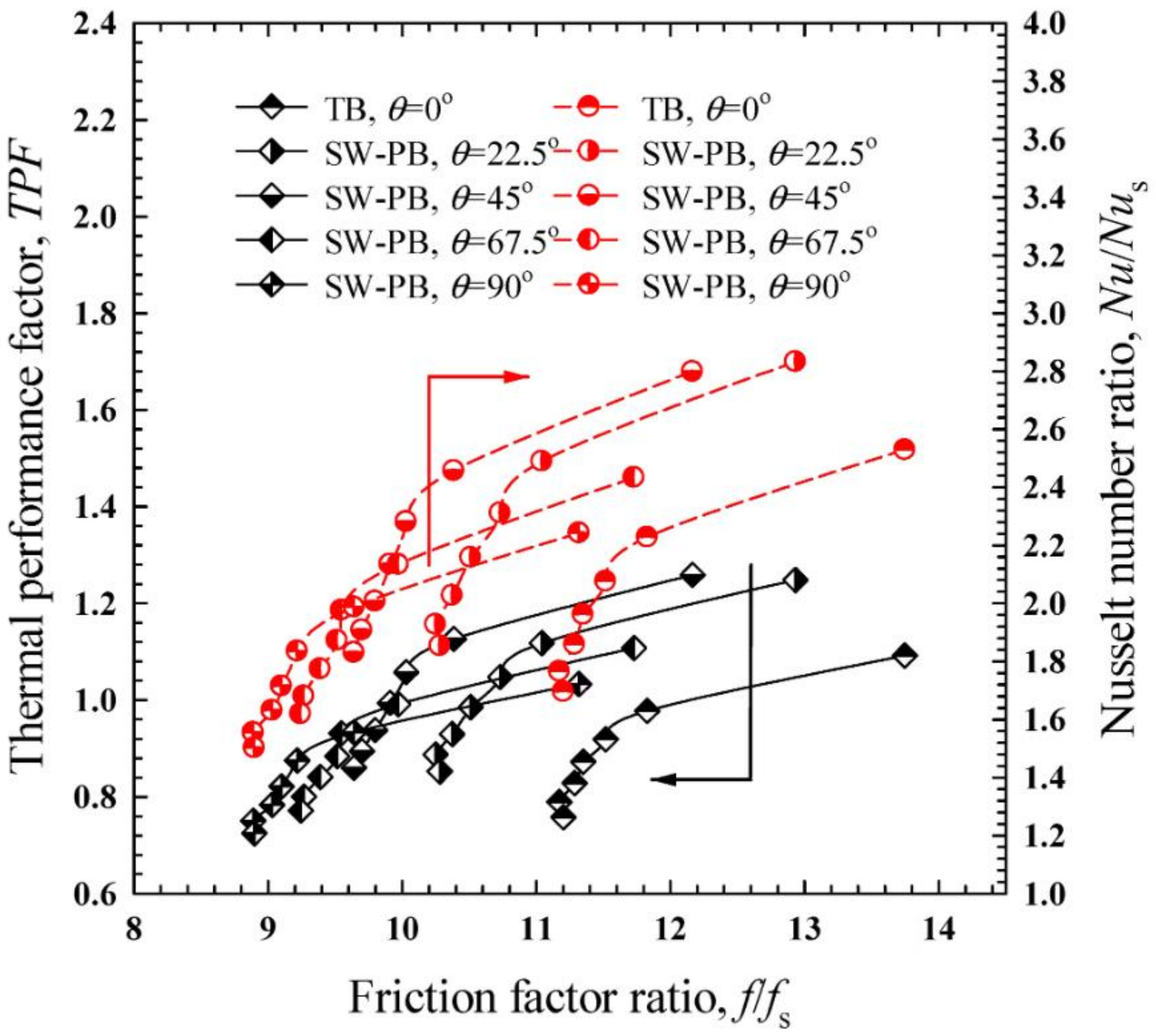
It is important to use the CAN/CSA P.9 efficiency ratings as simply knowing the efficiency of a water heater in water heating mode only does not provide useful information on the efficiency of a combination system in space heating mode.

Thermal Performance Factor (TPF)

Building Code Requirements

The National Building Code of Canada (and some provincial building codes) recently set a minimum requirement for systems using the CAN/CSA P.9 Thermal Performance Factor (TPF).

TPF defines the gas-use efficiency based on both space and water heating test ratings. Higher values equate to higher efficiency and lower energy costs.



(b) TPF and $f/f_s/Nu/Nu_s$

Minimum Requirements

The minimum acceptable TPF may be set by the building code or in relation to any high-performance housing

Functions of Combination Systems

2

Primary Functions

Combination systems perform two functions: space heating and domestic water heating.

4

Component Categories

The components of combination systems are grouped into four main categories: heat sources, space heating units, circulating equipment, and control devices.

System Certification Requirements

Certification Marking

Systems and water heaters should be identified and certified as suitable for combination heating systems.

Proper Labeling

Equipment must be labeled "Suitable for water (potable) and space heating."

Approved Components

All components must be approved for the specific application for which they are used.

Certificate of Registration

This certifies that the Occupational Health and Safety Management System of

, LLC. DBA Tutco-Farnam Custom Pro

30 Legend Drive
Arden, North Carolina, 28704, United States

been assessed by NSF-ISR and found to be in conformance to the following standar

ISO 45001:2018

Scope of Registration:
Design, Development and Manufacture of Electric Heating Elements.

Certificate Number:	C0098523-OH4
Certificate Issue Date:	16-NOV-2021
Registration Date:	17-DEC-2020
Expiration Date *:	16-DEC-2023

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*Company is audited for conformance at regular intervals. To verify registrations call (888) NSF-9000 or visit our web site at www.nsf-isr.org

Principles of Operation

Hot Water Source

Hot water is drawn from a gas-fired storage-type water heater

Circulation

Water is circulated through a water-to-air heat exchanger (fan-coil)

Return Circulation

After passing through the heat exchanger, the hot water is re-circulated back to the water heater

Heat Distribution

A fan forces the warm air from the heat exchanger through distribution ductwork

Water Heater Types for Combination Systems

Storage-Type Water Heaters

A direct-fired combination system may have a standard, storage-type water heater that provides both domestic hot water and water for space heating.

Tankless Water Heaters

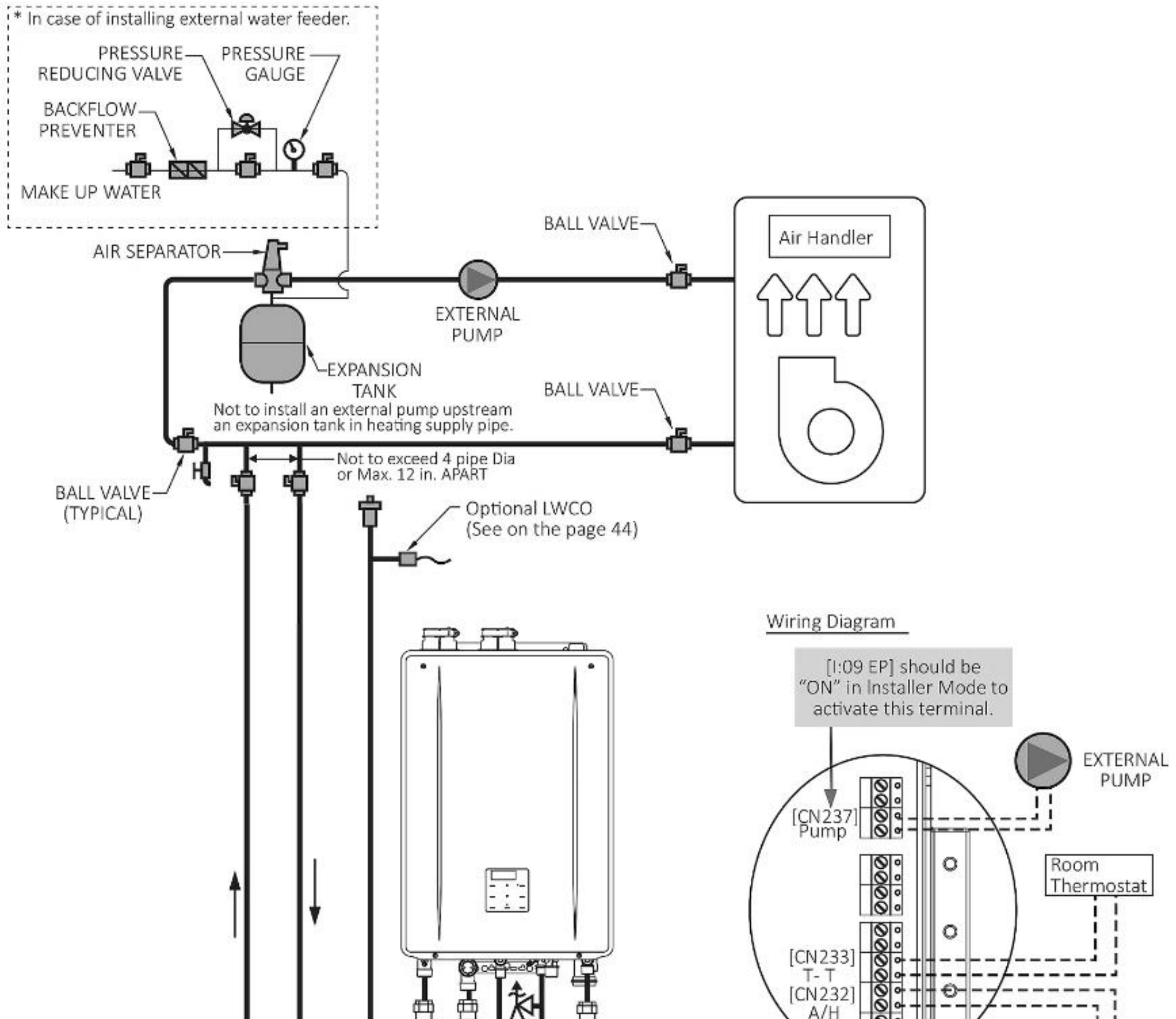
Systems equipped with tankless water heaters may also include an additional hot water storage tank to ensure adequate supply for both domestic use and space heating demands.

Types of Combination Heating Systems

Open System

According to CSA B214, an open system is a piping system conveying potable water or a hydronic solution that is open at any point to atmosphere.

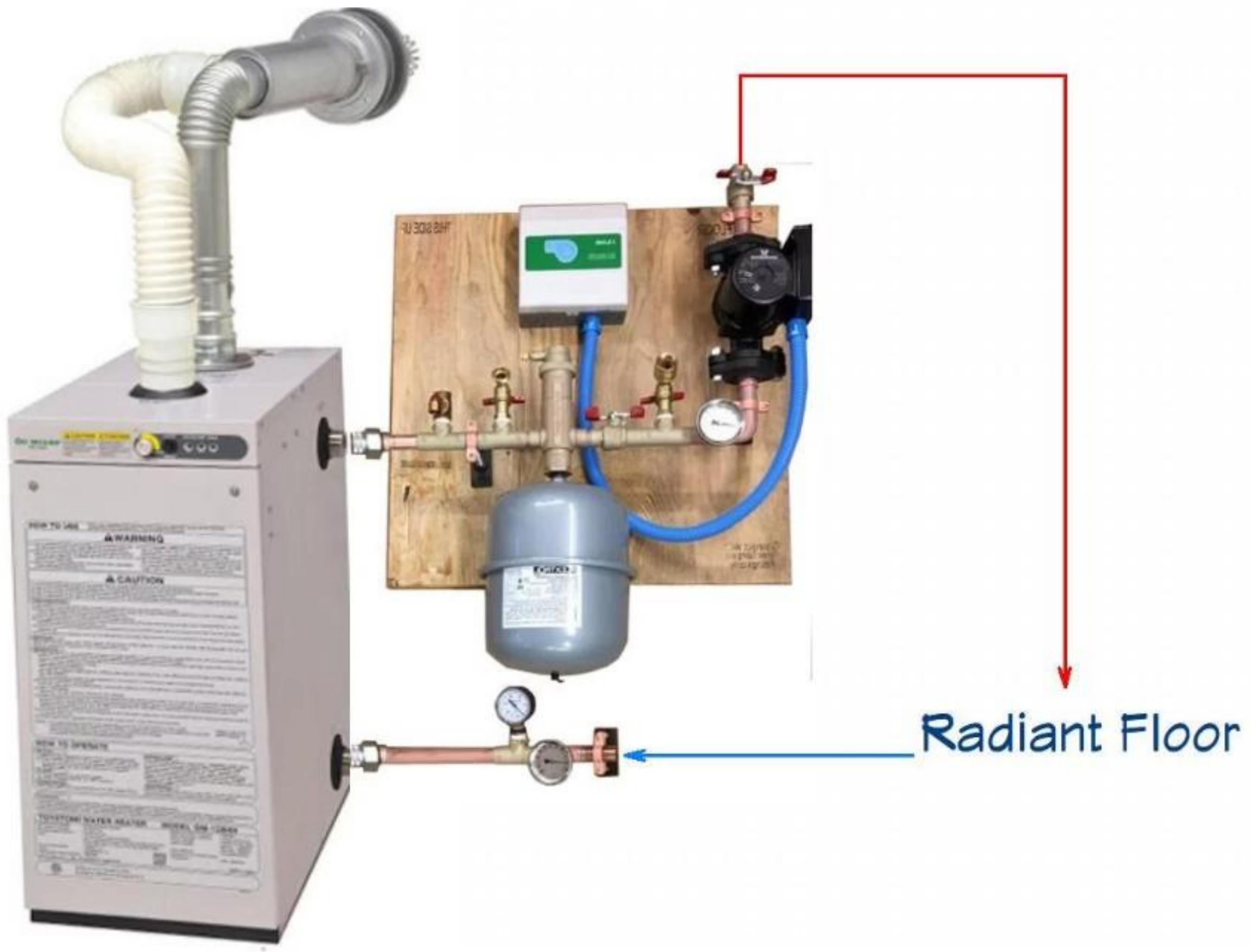
Any properly installed hydronic space heating system that circulates water for the purposes of heat transfer that may exit at some point through a faucet or other potable system outlet, and/or has another opening to atmosphere at some point, is considered an "open system".



Closed-Loop System

A closed system is a piping system that is sealed at all points from the atmosphere and contains a non-potable solution.

For a system to be considered a "closed system", there must be no contact to atmosphere at any point. This includes complete separation of the space heating fluid from the domestic water system using a hydronic (water-to-water) heat exchanger.



Heat Exchanger Requirements for Closed Systems

Double-Walled Heat Exchangers

In some cases, a double-walled heat exchanger (with or without a vented leak path) may be required to reduce the possibility of cross-contamination of the potable supply.

Local Jurisdiction Requirements

Check with local jurisdiction for more information regarding backflow prevention in your area.

System Classification Note

This is not to be confused with an open expansion tank vs. a closed expansion tank. For example, if you have a closed-style expansion device, however, your system heat transfer fluid communicates directly with the potable water system, you have an open-loop system.

Potable Water Status

A closed-loop system does not maintain its heat transfer fluid in a potable state.

Applications for Combination Systems

Single-Family Residential Installations

Combination forced air and hot water heating systems provide design flexibility and can be adapted to many different applications, including single-family homes.

Add-On Unit Installations

These systems can be used to supplement existing heating systems, providing additional heating capacity or efficiency.

Important Considerations

Careful adherence to trade regulations and proper design/installation that maintains the integrity of the potable water system is paramount in part because of the liability associated with an improperly installed and/or maintained system.

Understanding System Fundamentals

Service Knowledge

It is important for a gas fitter/technician to recognize and understand the fundamentals of operation for these systems in order to properly service the associated gas-fired appliance.

System Types

The combination systems discussed in Unit 18 Water heaters and combination systems consists mostly of direct-fired domestic water heaters and packaged air-handling units.

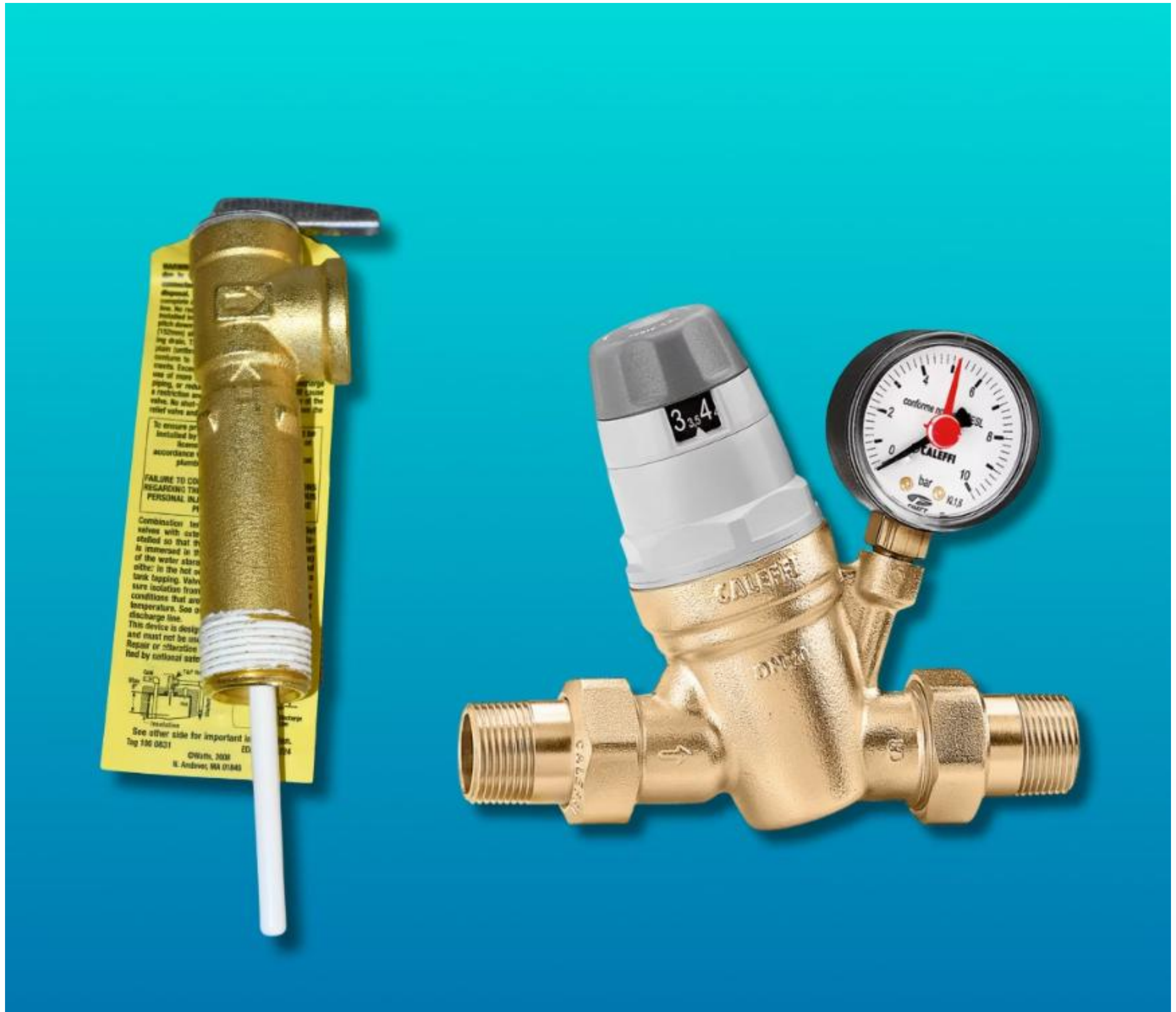
Advanced Systems

Other types of combination systems include indirect-fired water heaters, boilers, radiant heating units, and other components, which are covered in detail in Unit 20 Hydronic heating systems.

Temperature and Pressure Relief Valve

Code Requirement

Installation of a correctly sized water heater temperature and pressure relief valve (T&P) is a Code requirement for all plumbing systems, regardless of whether an additional lower pressure relief valve is installed.



Safety Function

The temperature and pressure relief valve opens to safely discharge fluid from the system before excessive pressures can develop.

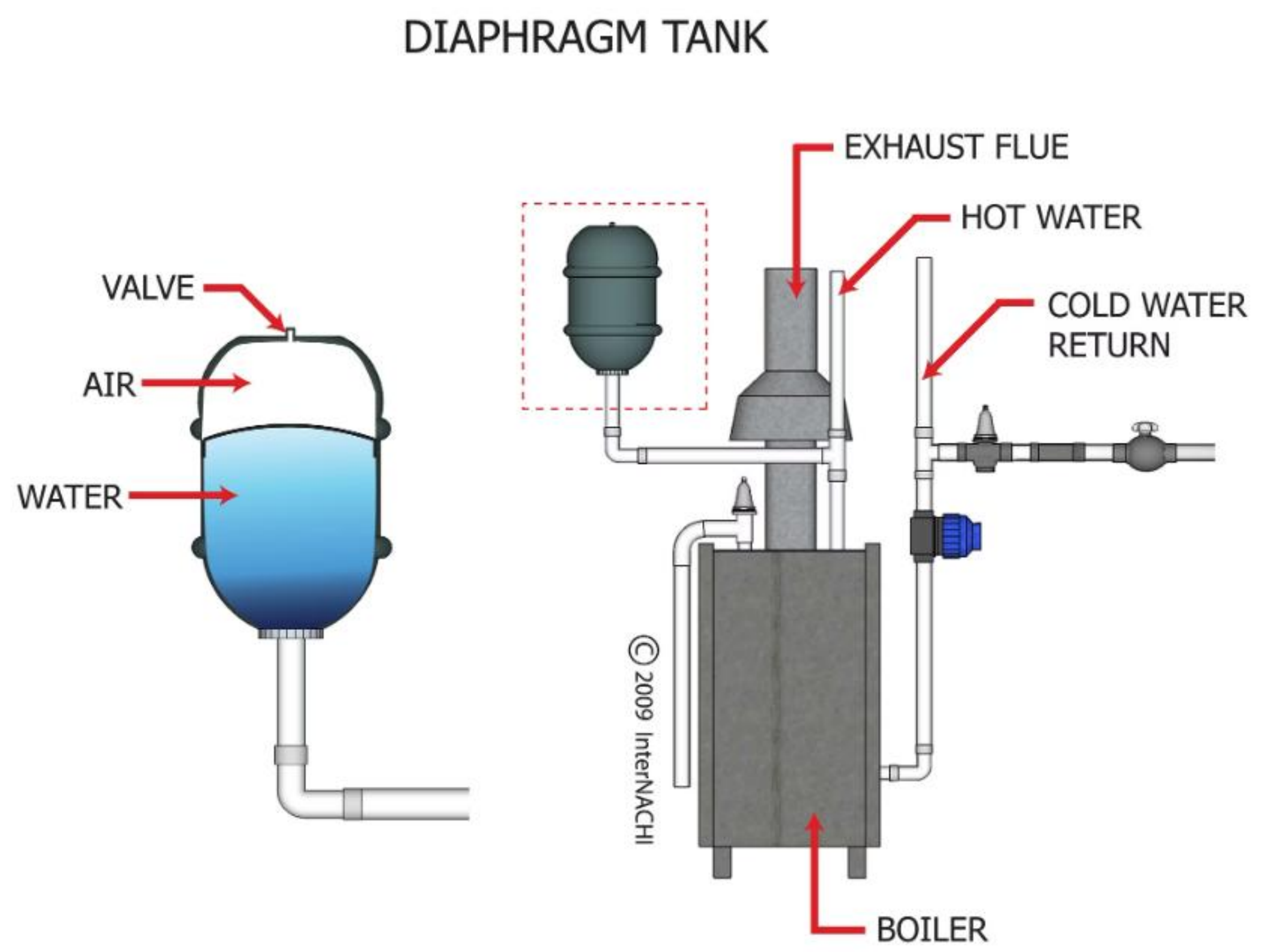
This is a critical safety component that protects against dangerous pressure buildup that could lead to equipment damage or personal injury.

Expansion Tank Purpose and Function

Thermal Expansion Control

The fluid expands when it undergoes heating. The pressure that the expanding fluid creates in a heating system requires control to prevent it from reaching dangerous levels.

A diaphragm-type expansion tank helps contain the increased volume of fluid within the system, as explained below.



How It Works

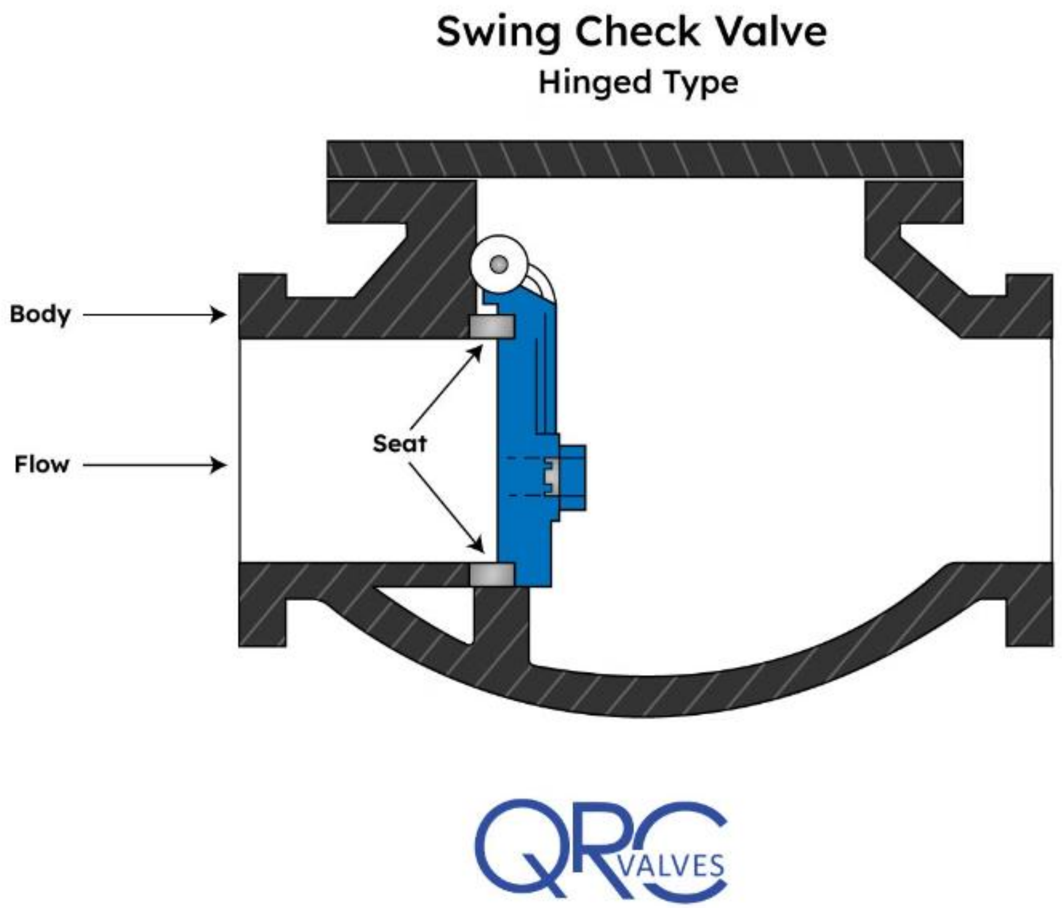
- The internal diaphragm in this type of expansion tank divides the tank into two chambers.
- The chamber below the diaphragm contains a volume of compressed air that has been pre-pressurized by the manufacturer of the tank (this must be adjusted to match the system design pressure).
- The chamber above the diaphragm accommodates the expanded volume of heated system fluid.
- Fluid entering the tank causes the diaphragm to flex, further compressing the air volume in the lower chamber.
- When the total volume of fluid in the system is reduced because of cooling, the fluid in the expansion tank is forced back into the system by the pressure exerted on the diaphragm by the compressed air in the lower chamber.

Check Valves in Combination Systems

Purpose of Check Valves

Check valves prevent reverse flow. They should not be confused with (or substituted for) approved backflow prevention assemblies as they are neither designed nor approved for cross contamination prevention.

Backflow prevention assemblies are more elaborate in their design and often require annual testing and maintenance.



Swing Check Valve

The most common type of check valve in use is the swing check valve. This type of valve has a hinged disc that swings open to allow fluid flow in the desired direction. A swing check valve works best in the upright horizontal position only.

A vertical check valve is commonly called a lift check.

Other types of check valves may incorporate a spring and can be installed in any position. When the fluid flow reverses direction, the disc closes onto the valve seat preventing the fluid from flowing backwards in the system.

Vacuum Relief Valves

Function and Purpose

Vacuum relief valves are normally open valves installed on cold-water inlet lines to storage tanks. They are not a backflow device - their purpose is to allow air to enter the water system to prevent negative pressure from developing in the water heater storage tank.

Any vacuum created in the system opens the vacuum relief valve to draw in outside air to maintain the balance of pressure in the system.

Importance for Water Temperature

At atmospheric pressure water boils at 212°F (100°C). If the pressure is lower than atmospheric pressure (vacuum), it will boil and change state to steam at a lower temperature.

This is why maintaining proper pressure in the system is critical for safe operation and preventing premature water state changes that could damage equipment or create unsafe conditions.

Mixing Valves for Temperature Control

Purpose

Some systems may require hot water for domestic use to be delivered at a lower temperature than when it comes from the water heater.

Function

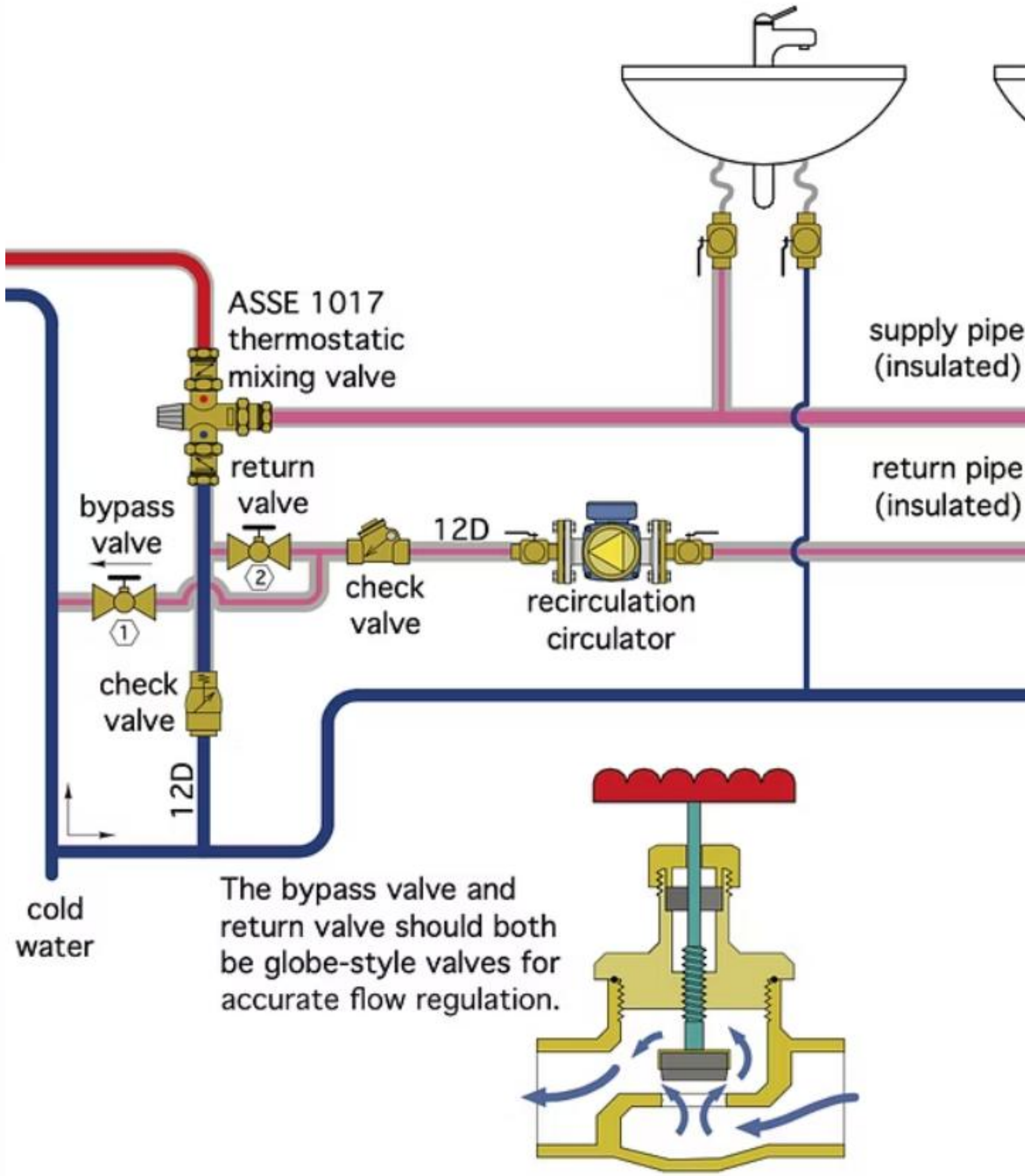
A thermostatic mixing valve is used to blend cold water with the hot water from the tank to achieve the lower temperature.

Safety Benefit

This helps prevent scalding while allowing the water heater to operate at higher temperatures for effective space heating.

Code Compliance

If hot water is produced at higher than 140°F (60°C), a mixing valve conforming to CSA Standard B125.3 is required to supply domestic hot water at 140°F (60°C).



Circulating Pumps in Hydronic Systems

Purpose and Type

A circulating pump (circulator) is used to move the fluid through a hydronic system. A centrifugal-type pump is most commonly used as the circulator in a hydronic system.

Pump Control Options

A circulation pump control may be a simple on-off switch, when required for a domestic hot water recirculating system, or a relay-type device.

The pump control works as follows:

1. On a call for heat, the thermostat contacts close, energizing the coil of the 24 V relay. The normally open contacts of the relay then close to complete the 110 V pump operating circuit.
2. When the desired temperature is reached, the thermostat contacts open, the relay contacts open, and the pump stops operating.

Additional Requirements for Combination Systems

No Chemical Additives

No chemical additives must be used in the system.

No Boiler Replacement

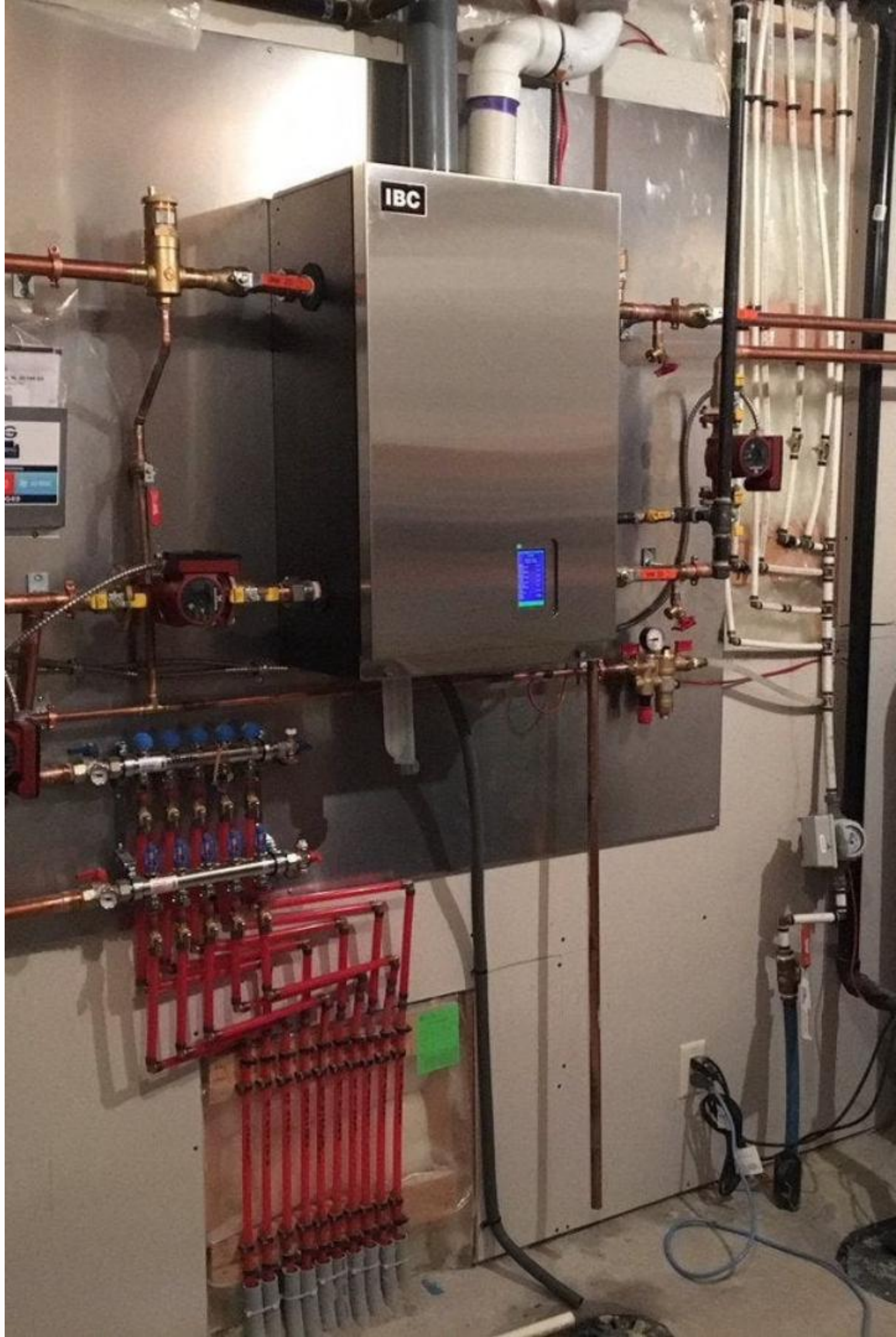
No water heater must be used to replace an existing boiler.

Water Conditioning

Water conditioning may be required in hard water areas.

Backflow Prevention

A backflow preventer is required wherever the potential for cross-contamination of potable and non-potable systems exists.



Vacuum Relief Valve Installation Note

Qualified Installation

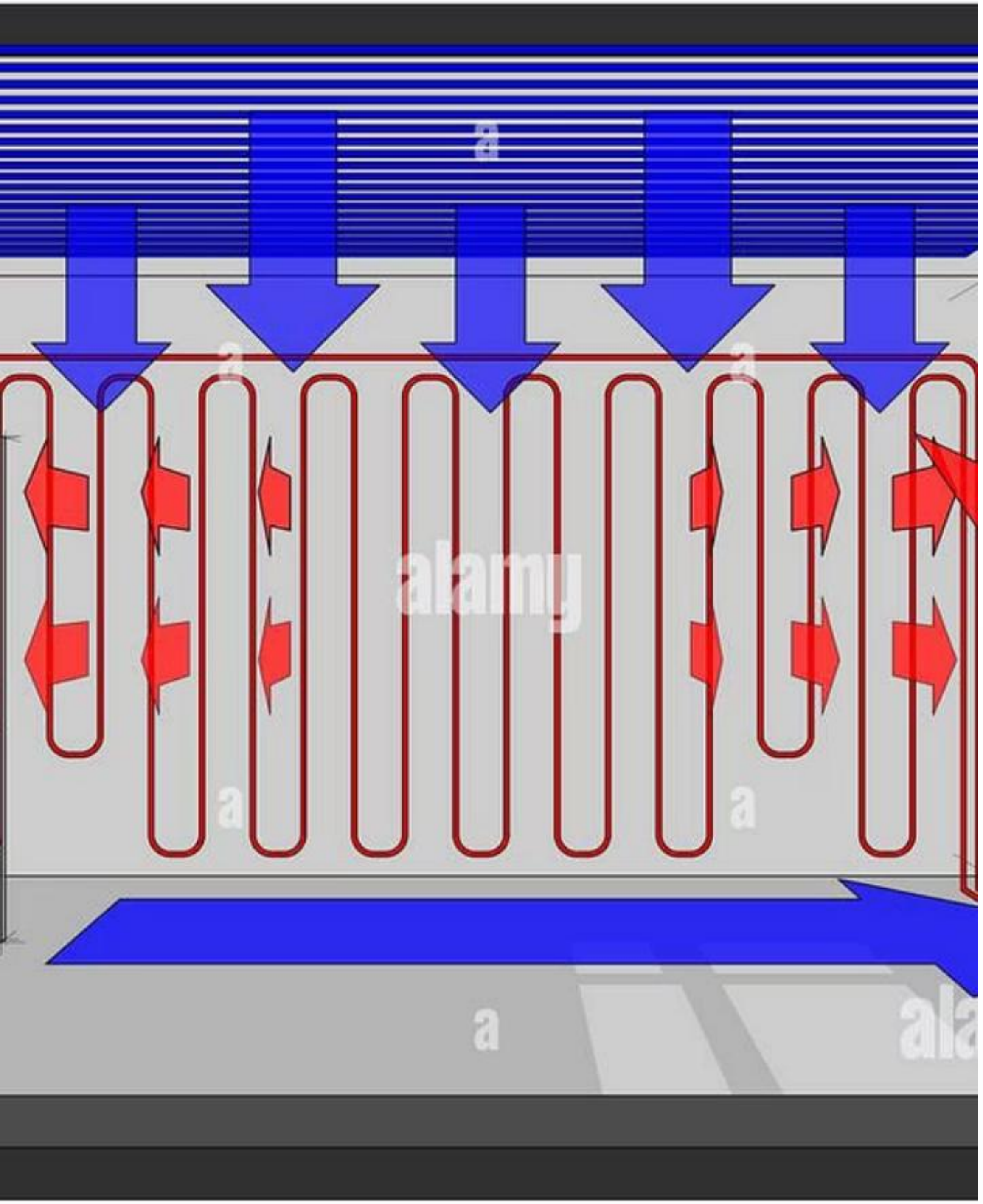
A qualified installer/tester must install a typical vacuum relief valve and ensure that provisions to alleviate the potential for bacterial growth within a potable water system.

Proper Placement

Vacuum relief valves must be installed in the correct location to function properly and provide system protection.

Regular Maintenance

Like all safety devices, vacuum relief valves should be inspected regularly to ensure proper operation.



System Layout: Open System with Fan Coil

This diagram shows a typical combination system layout for domestic water and fan coil space heating in an open system configuration. The system includes hot water supply and return lines, a fan coil unit, hot water pump with cycle timer, check valve, and return air duct.

Key Components

Hot water coil, hot water pump with cycle timer, check valve, and return air duct are all visible in this layout.

Material Requirements

All piping and components must be approved for potable use. All copper tubing must be type "K" or "L". All plastic piping must be approved for potable use.

System Layout: Important Notes

1
Potable Water Requirements

All piping and components to be approved for potable use.

2
Copper Tubing Specifications

All copper tubing to be type "K" or "L".

3
Plastic Piping Approval

All plastic piping must be approved for potable use.

4
Temperature Control

If hot water is produced at higher than 140°F (60°C), a mixing valve conforming to CSA Standard B125.3 is required to supply domestic hot water at 140°F (60°C).

5
Cycle Timer Requirement

For single or multiple space heating units, zones, or loops, a cycle timer must be used to circulate all the water in the space heating system once every 24 hours.

System Layout: Additional Components

Local Code Compliance

Other accessories or components may be used for different types of controls and/or required in accordance with local codes.

Municipal Restrictions

Many municipalities do not allow the optional piping method described as "for space heating for water heaters without side tappings".

Consultation Requirement

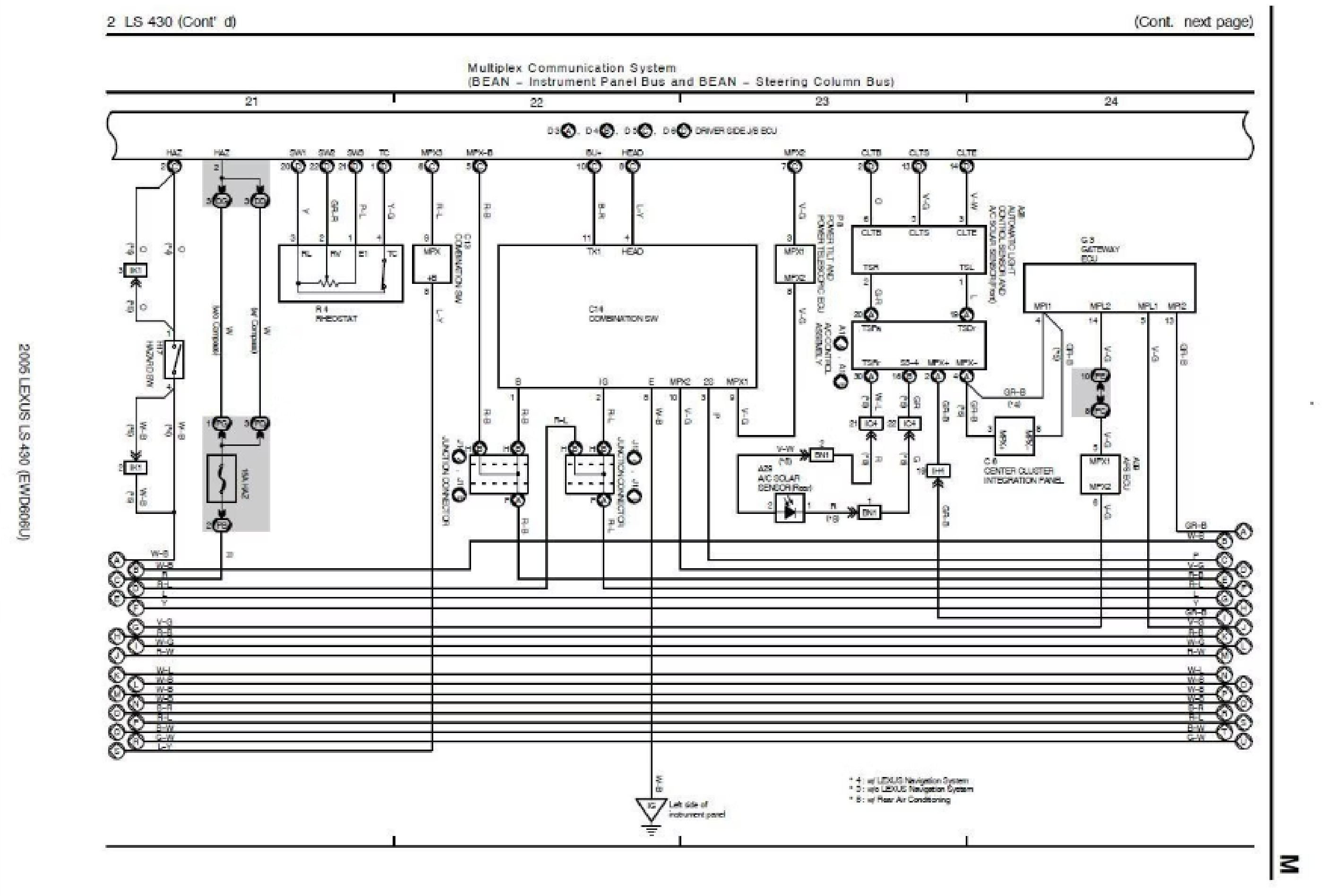
Always consult with local authorities having jurisdiction before finalizing system design and installation.

Wiring Procedures for Combination Systems

Manufacturer's Instructions

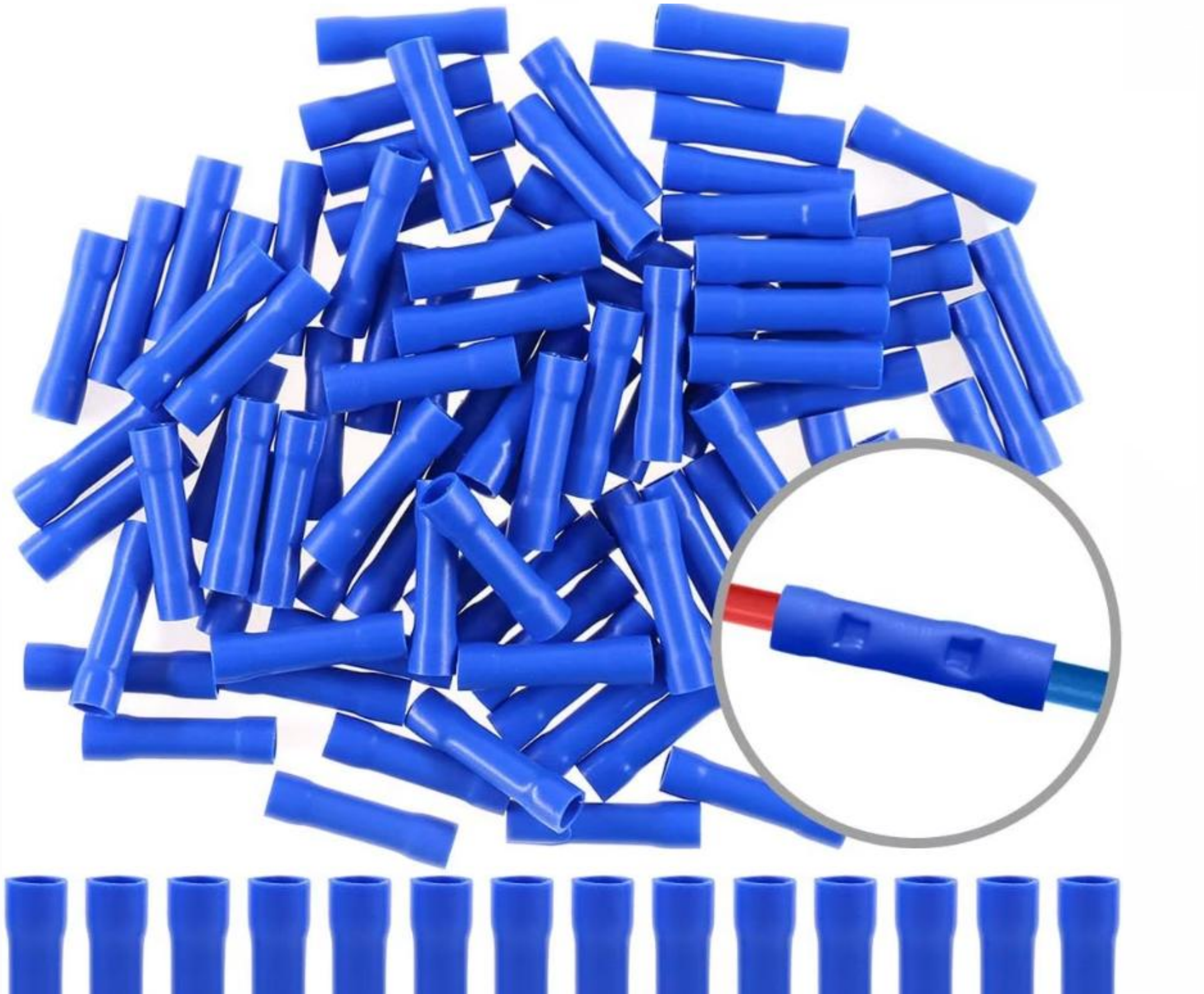
The manufacturer's instructions and wiring diagrams supplied with combination system components specify the correct wiring procedures to follow when installing the equipment.

Unit 20 Hydronic heating systems covers wiring procedures for combination systems in detail.

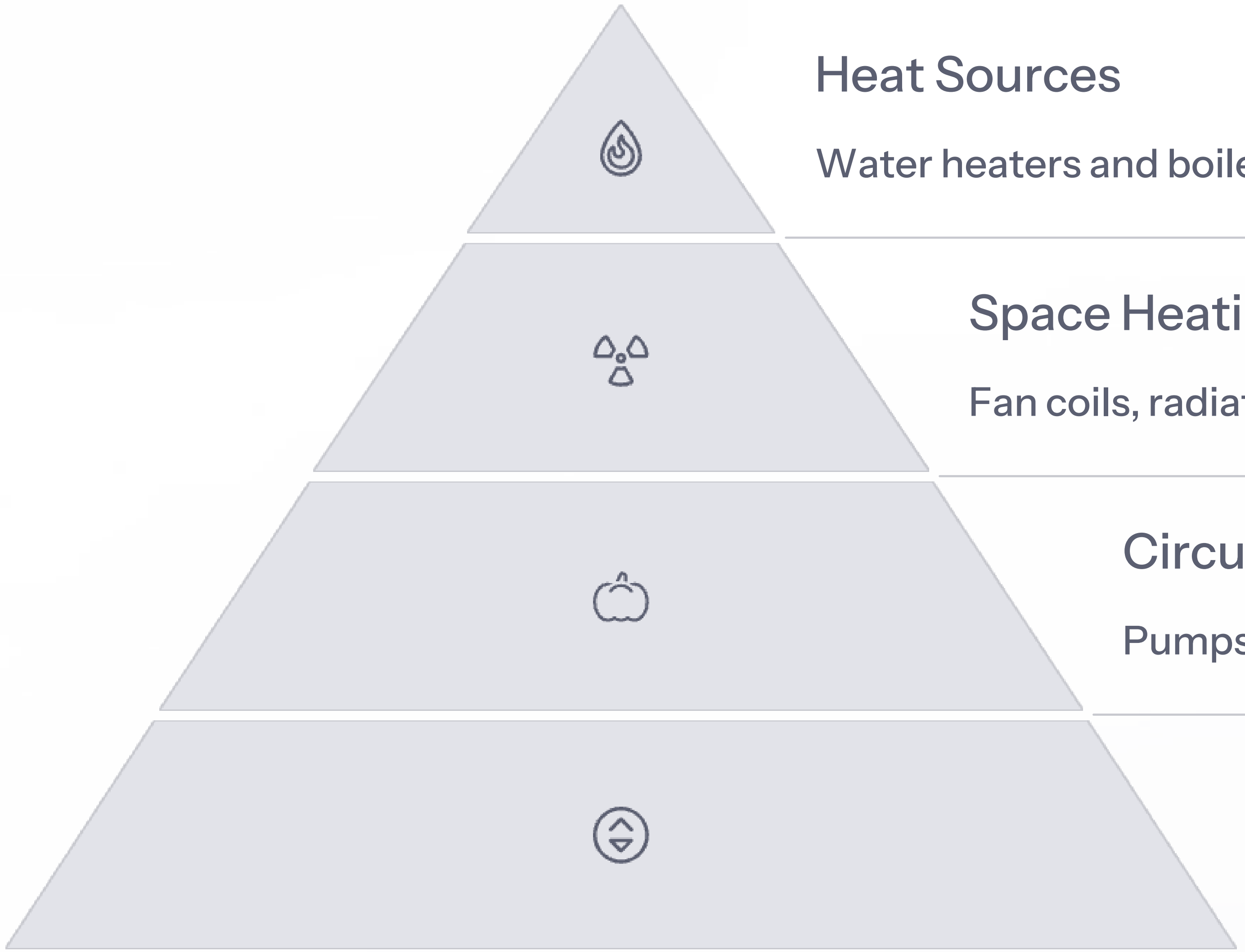


Low-Voltage Connections

Low-voltage connections should be made to the low-voltage wiring harness. Use insulated butt splices instead of wire nuts to make the connections for low-voltage devices such as thermostats to provide for neater, more reliable connections.



Combination System Component Categories



Heat Sources

Water heaters and boilers that provide thermal energy

Space Heating Units

Fan coils, radiators, and other heat distribution devices

Circulating Equipment

Pumps and related components that move water through the system

Control Devices

Thermostats, valves, and other regulation equipment

Combination System Benefits

2

Functions

Provides both space heating and domestic hot water from a single appliance

30%

Space Savings

Reduces mechanical room footprint compared to separate systems

15%

Energy Savings

Can reduce energy consumption compared to separate systems

1

Maintenance Point

Single heat source to maintain instead of multiple appliances

Combination System Design Considerations

Combination System Installation Checklist

Verify Certification

Ensure all components are certified for combination system use and properly labeled for potable water and space heating applications.

Check Material Compatibility

Verify all materials are approved for potable water use and no ferrous materials are used in potable water sections.

Install Safety Devices

Properly install temperature and pressure relief valves, expansion tanks, check valves, and mixing valves according to code requirements.

Set Up Controls

Install and configure pump cycle timers, thermostats, and other control devices according to manufacturer specifications.

Test System

Flush the system with potable water, test for leaks, and verify proper operation of all components before commissioning.

Combination System Maintenance Requirements

Regular Inspection

Check all components for signs of wear or damage

System Cleaning

Flush system periodically to remove sediment

Performance Adjustment

Optimize settings for efficiency and comfort

Safety Testing

Test relief valves and other safety devices

Combination System Troubleshooting Guide

Insufficient Hot Water

- Check water heater temperature setting
- Verify proper sizing of water heater
- Inspect for scale buildup in heat exchanger
- Check for air in system

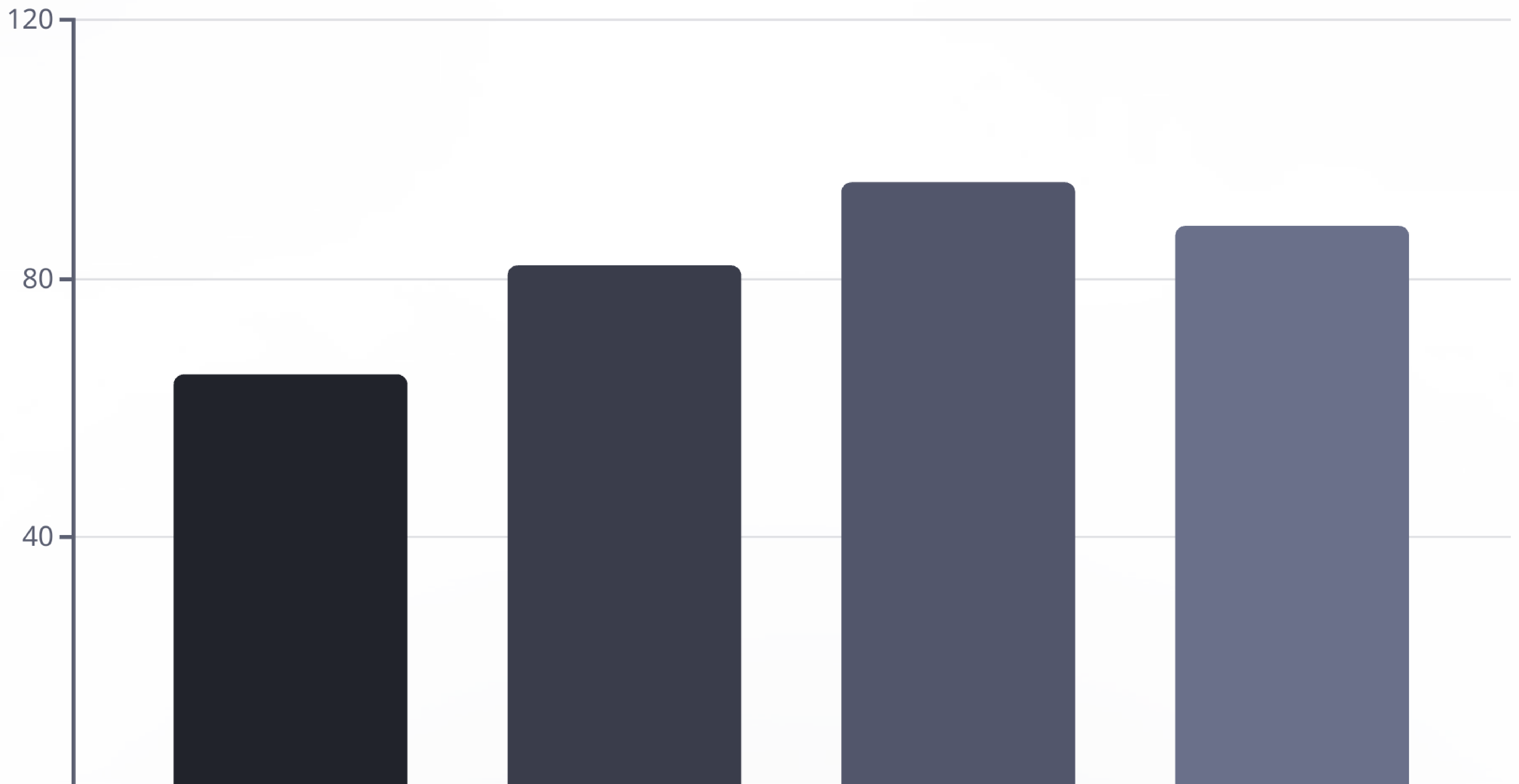
Inadequate Space Heating

- Verify pump operation
- Check for closed or blocked valves
- Inspect fan coil for dirt or blockage
- Confirm thermostat operation

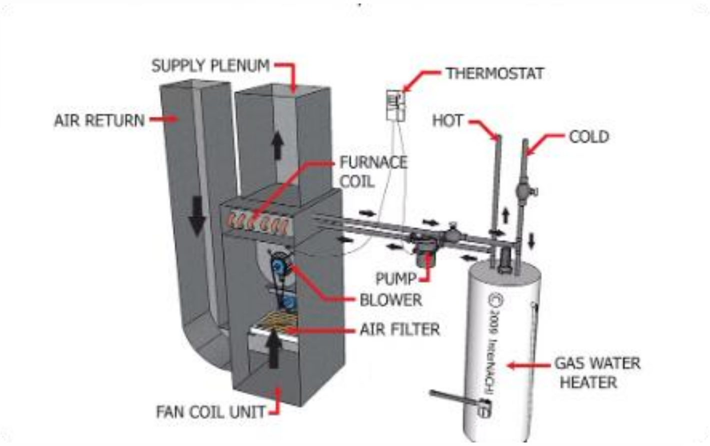
System Noise

- Bleed air from system
- Check pump mounting
- Verify proper pipe sizing
- Inspect for water hammer

Combination System Energy Efficiency



Combination System Applications



Residential Applications

Combination systems are ideal for single-family homes and small multi-family buildings where space is limited and efficiency is desired. They provide both domestic hot water and space heating from a single appliance, reducing mechanical room footprint.

Light Commercial Applications

Small offices, retail spaces, and other light commercial buildings can benefit from combination systems, especially when hot water demands are moderate and space heating is required. These systems can be more cost-effective than separate appliances for each function.

Renovation Projects

When upgrading existing buildings, combination systems can provide an efficient solution that requires less space than separate systems. They're particularly valuable in retrofit situations where mechanical room space is limited.

Future Trends in Combination Systems

Higher Efficiency

Continued improvements in thermal efficiency and heat transfer

Smart Controls

Integration with home automation and predictive algorithms

Renewable Integration

Compatibility with solar thermal and other renewable sources

Compact Design

Smaller footprints with greater capacity and performance

Summary of Combination Systems

System Understanding

Recognize different types and components

Proper Installation

Follow codes and manufacturer guidelines

Regular Maintenance

Ensure safe and efficient operation

User Education

Provide clear instructions to end-users

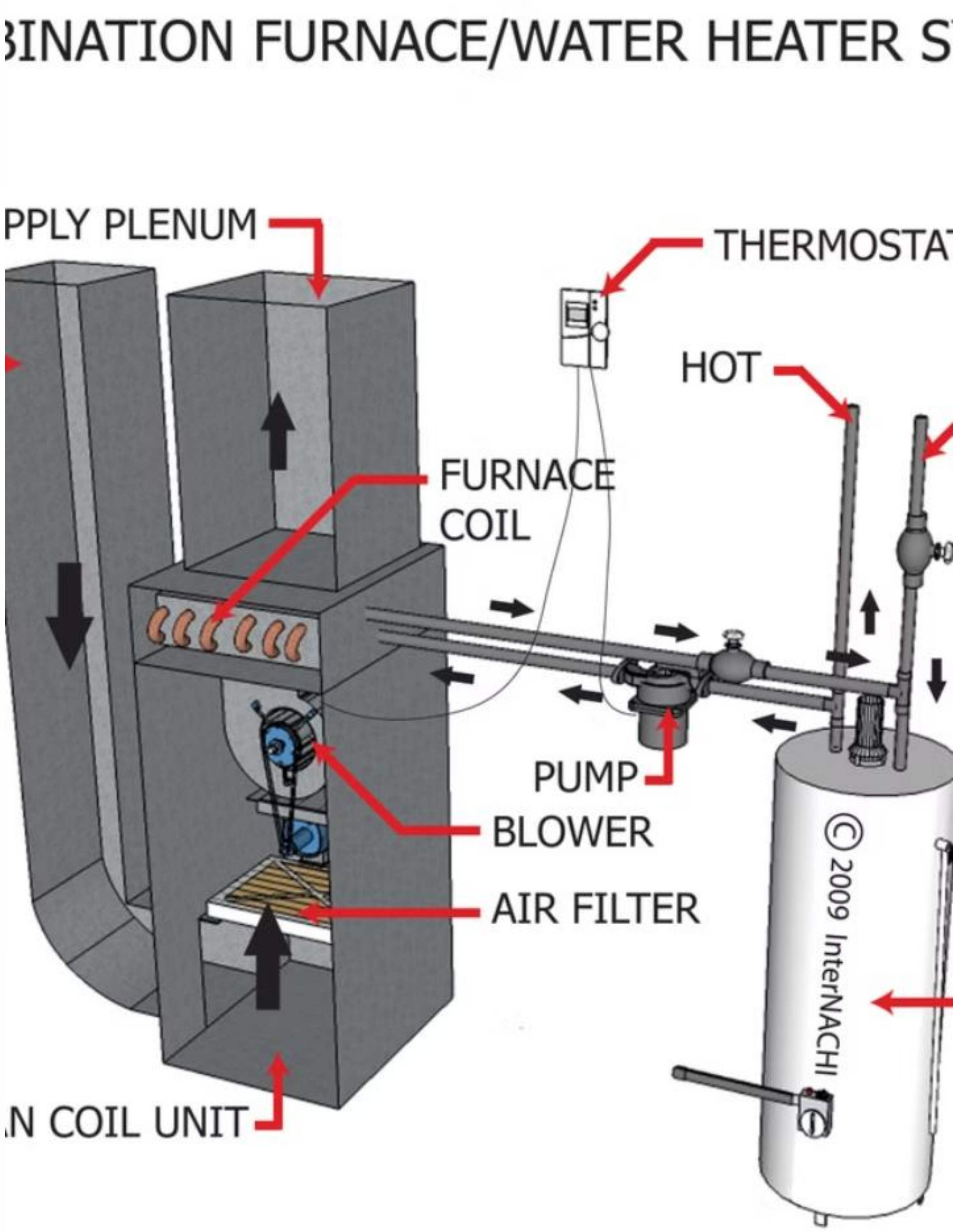
Combination systems provide an economical and efficient way to deliver both domestic hot water and space heating from a single appliance. Gas technicians/fitters must understand the installation requirements, system types, layout considerations, and wiring procedures to ensure these systems are installed correctly and operate safely. By following proper codes and manufacturer guidelines, these systems can provide years of reliable service while maintaining the integrity of the potable water system.

CSA Unit 18

Chapter 3

Systems Sizing for Water Heaters and Combination Systems

Gas technicians do not design potable water systems as this work is typically done by plumbers. However, when sizing domestic hot water heaters and allowing for combination system requirements, the gas technician/fitter must consider several factors to ensure that the needs of the application are met. Important design considerations include accurate calculation of space heating heat loss requirements and proper sizing of water heaters and pumps.



Objectives of System Sizing

Determine Water Heater Size

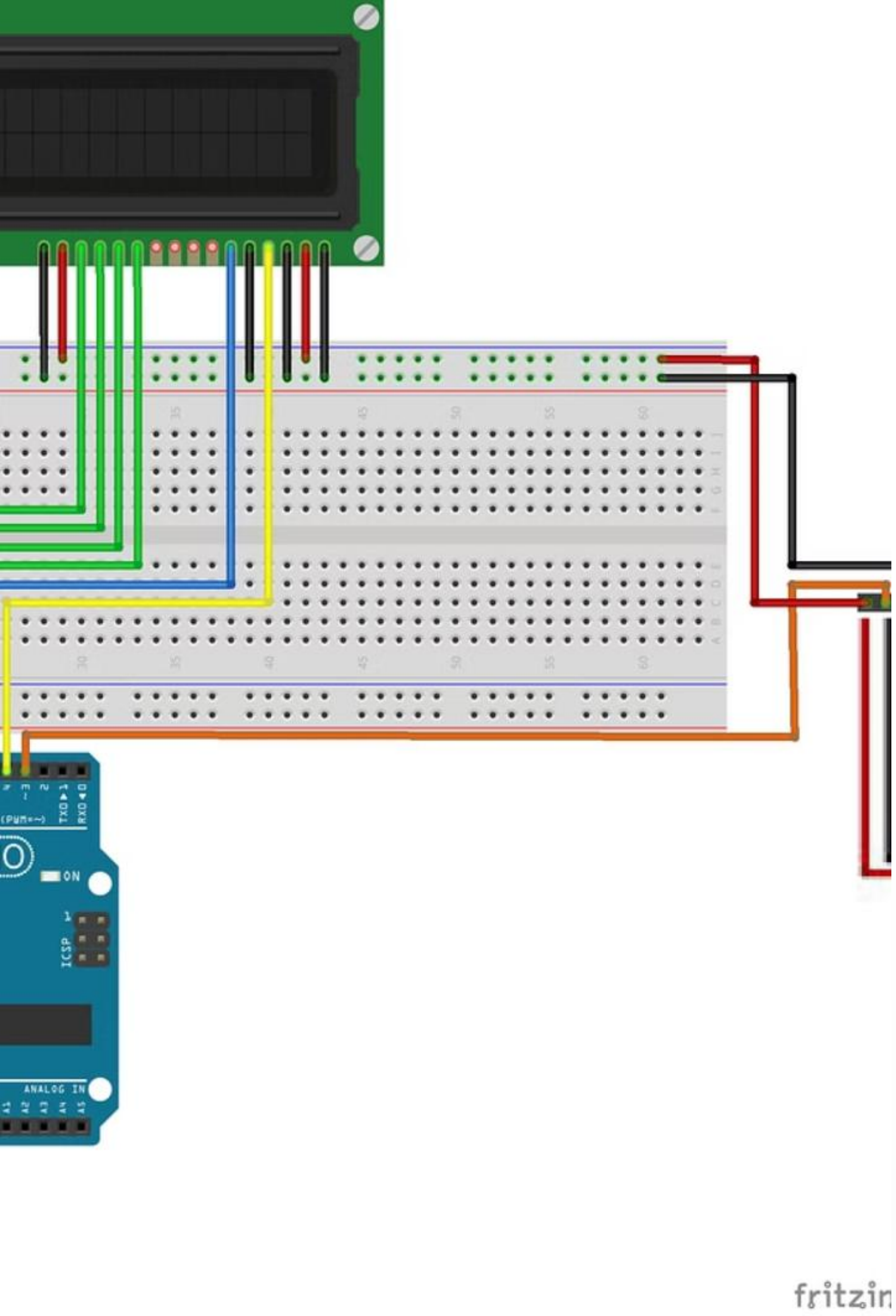
Learn how to determine the appropriate size of water heater required for specific applications

Calculate Space Heating Requirements

Understand how to determine space heating requirements for combination systems

Describe Pump Sizing Requirements

Learn how to properly size pumps for water heating and combination systems



Key Terminology

Term	Abbreviation (Symbol)	Definition
Feet of head water column	ft. hd. w.c.	Measurement of pressure loss in a piping system
Flow rate		The amount of water to be circulated through the system, traditionally measured in US gallons per minute
Gallon per minute	gpm	Unit of measurement for flow rate

Water Heater Sizing Basics

Basic Guide

The sizing information provided is a basic guide to water heater sizing for combination potable water heating and space heating applications.

Be aware that each building's domestic hot water requirements vary. Proper water heater sizing must consider two factors:

- The capacity of the water heater in gallons
- The Btu input of the water heater

RESIDENTIAL WATER HEATER SIZING CHART

FAMILY SIZE	DEMAND	LITRE CAPACITY REQUIRED	
		ELECTRIC USEAGE/LITRES	GAS USEAGE/LITRES
5+ PEOPLE			
	HIGH	120/450	60-75/227-28
	REGULAR/LOW	80/284	50/189
3-4 PEOPLE			
	HIGH	80/284	50-60/189-227
	REGULAR/LOW	50/182	40/151
2-3 PEOPLE			
	HIGH	50/182	50/189
	REGULAR/LOW	50/182	40/151
1-2 PEOPLE			
	HIGH	50/182	40/151

Water heater sizing is critical to ensure adequate hot water supply for both

Determining Water Heater Capacity

The following water heater sizing criteria are taken from a manufacturer's installation guide. The use of a minimum 40 imperial gallon/48 USG (180 L), high-recovery and/or high-efficiency gas-fired water heater is recommended.

Air handler	Minimum water heater capacity
600 cfm (280 L/s) to 800 cfm (380 L/s)	40 imp. gallon/48 USG (180 L)
1000 cfm (470 L/s) to 1200 cfm (570 L/s)	50 imp. gallon/60 USG (225 L)
1400 cfm (660 L/s) to 1600 cfm (755 L/s)	Two 40 imp. gallon (180 L), twinned, or One high-input 50 imp. gallon (225 L), or One 72 (327 L) to 75 imp. gallon/90 USG (341 L)
2000 cfm (940 L/s)	Any combination of water heaters having at least 105,000 Btu/h (30.8 kW) output

Determining Water Heater Input

Required Calculation Factors

The required water heater input calculation is based on the:

- Calculated heat loss of the building in which the system is to be installed
- Water heater recovery efficiency rating

Perform the heat loss calculation in accordance with approved industry engineering practices. The importance of this step cannot be understated.

Climate Considerations

Local climate and temperature variations have an effect on building heat loss and will therefore also influence input calculations.

For example, a water heater installed in an area that has long, cold winters would require more energy to produce a given amount of heat than one installed in a milder climate. For this reason, a multiplication factor reflecting local climatic conditions must be factored into the calculation.

Always consult local information sources to ensure that your calculations include the proper climate multiplication factors. The two examples shown below are for reference only.

- For mild climates, Input = calculated heat loss x 1.51
- For colder climates, Input = calculated heat loss x 1.58

Space Heating Requirements

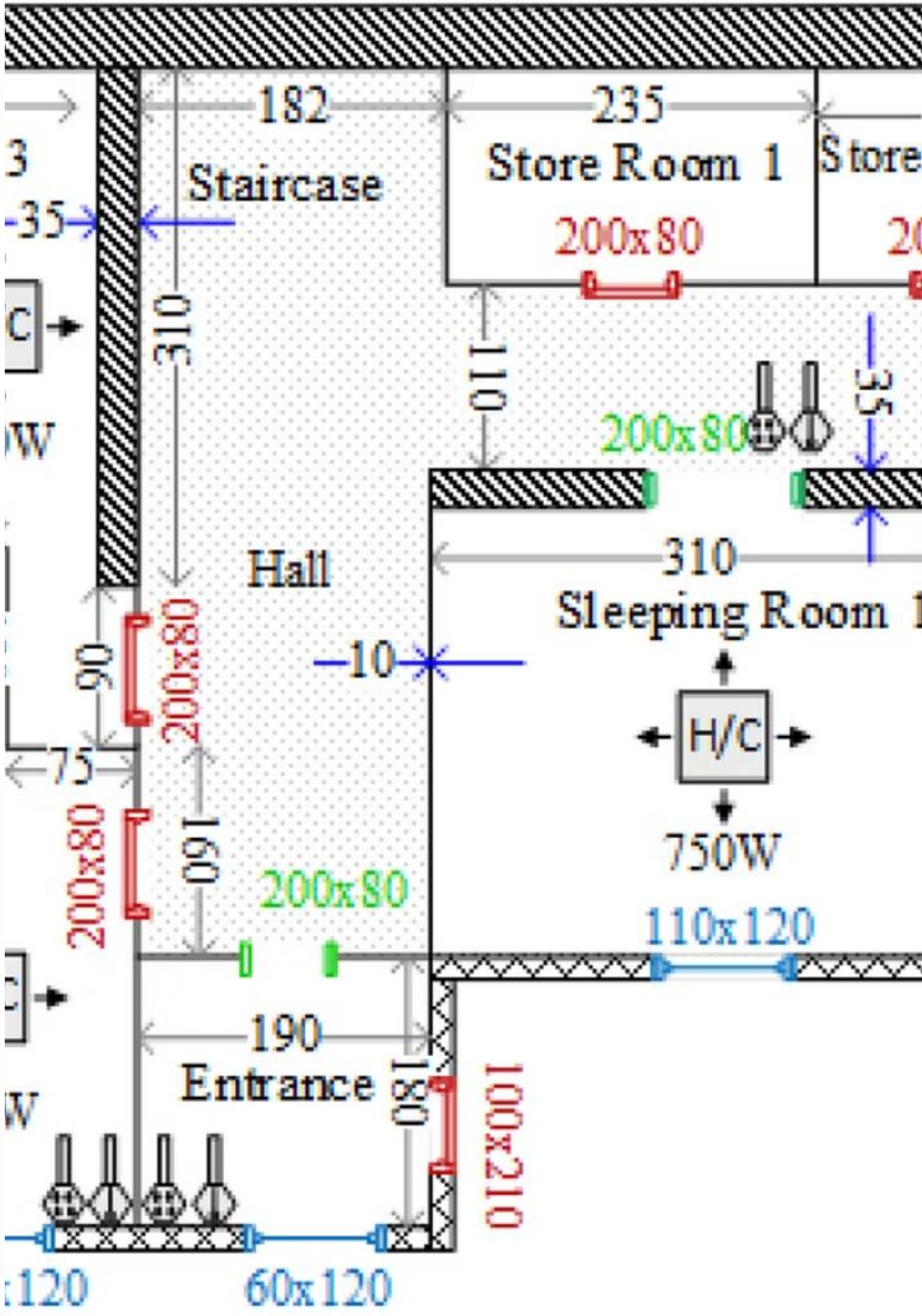
Minimum Capacity Requirements

The minimum capacity of an appliance or the portion of its total capacity used for space heating must be based on the calculated heat loss of the building. Where an air handler is used as the only source of heat, it should be sized accordingly.

Design and Installation Standards

The design and installation of the system must be in accordance with approved industry engineering practices or manuals published by one of the following organizations or an equivalent:

- Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)
- American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE)
- Air Conditioning Contractors of America (ACCA)



Air Handler Selection

Calculate Heat Loss

Determine the calculated space heating loss of the building

Select Air Handler

Choose an air handler with heating output that exceeds the calculated space heating loss

Match Cooling Coil

Ensure cooling coil is sized to match the outdoor condensing unit

Consider Water Heater Size

Remember that if the water heater is undersized, the heating capacity of the air handler will be less than its rated output

Domestic Hot Water Heating Standards

ASHRAE

American Society of Heating Refrigeration and Air Conditioning Engineers

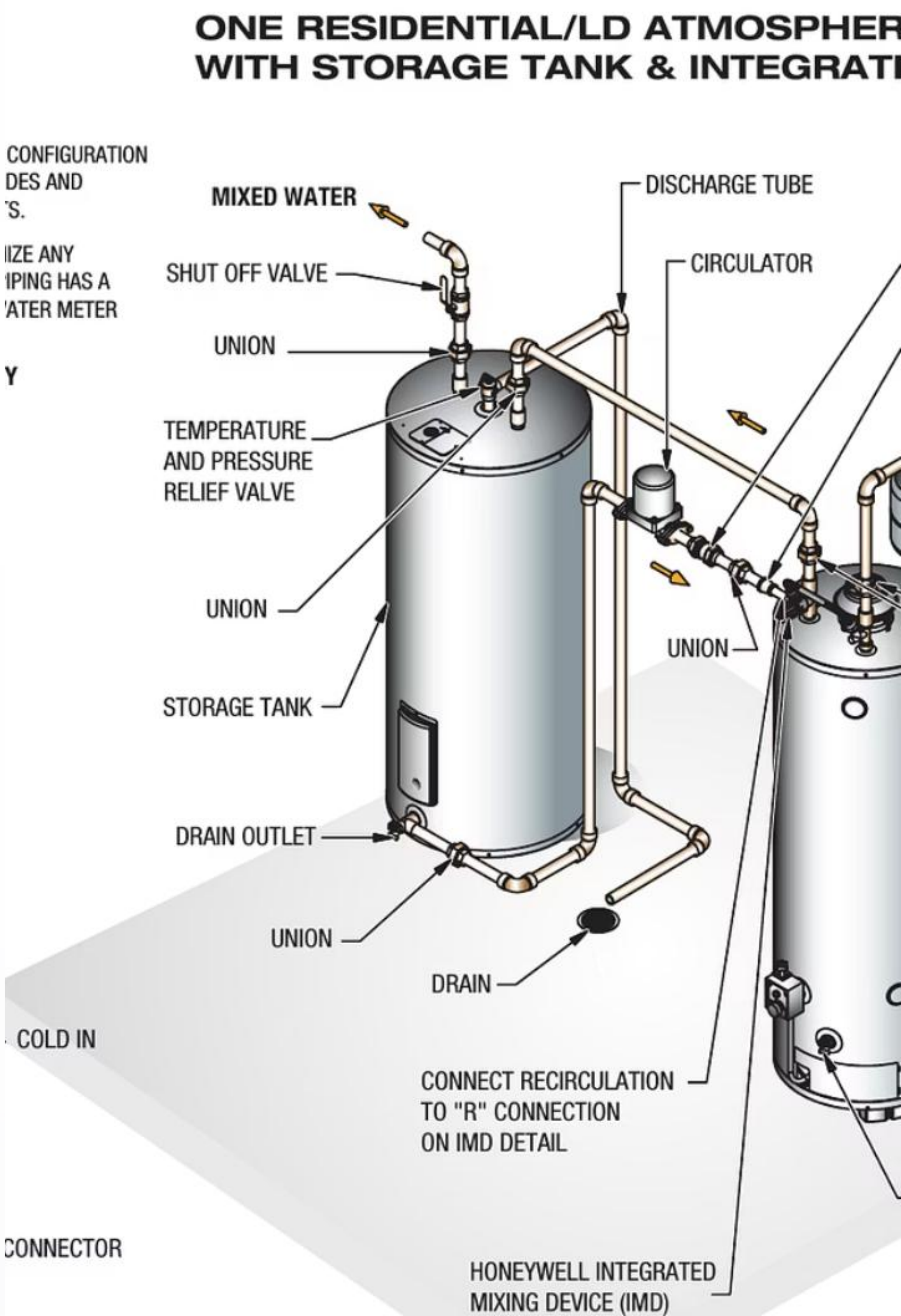
HRAI

Heating, Refrigeration and Air Conditioning Institute of Canada

ASPE

American Society of Plumbing Engineers

The minimum capacity of an appliance, or the portion of its total capacity used for supplying domestic hot water, must be based on approved industry engineering practices or publication from one of these organizations or an equivalent.

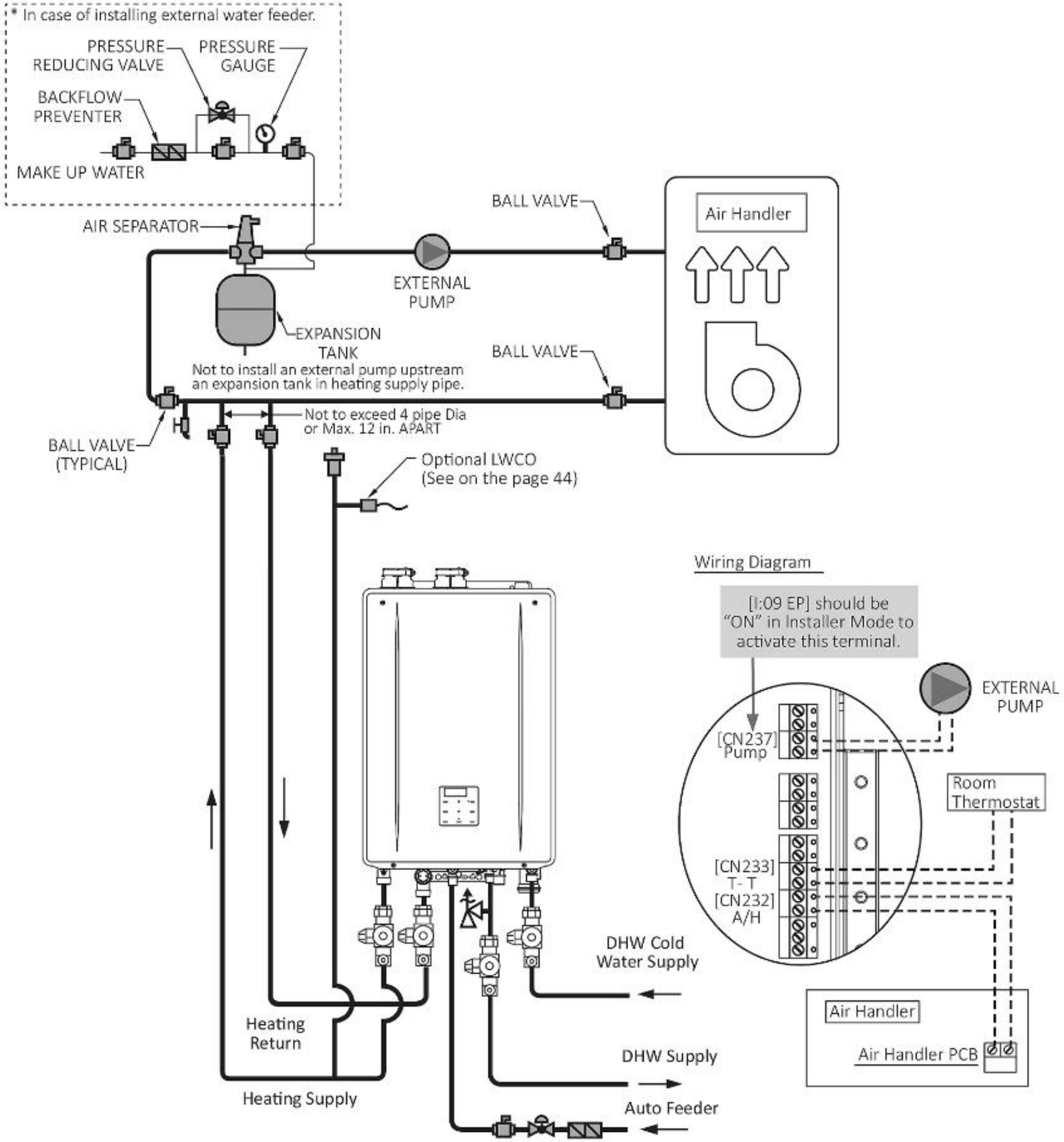


Combination Space and Domestic Hot Water Heating

Capacity Calculation

The capacities of combination hot water tank (HWT) and fan coil heating units can be calculated in accordance with the Combo System HWT/Fan Coil Sizing design worksheet. The design and installation of the system must be according to approved industry engineering practices.

The design worksheet provides a convenient way to size the system. The designer may use the basic drawings provided in approved publications to show the basic principles of the proposed combination system. Other accessories or components may be required in accordance with local codes.



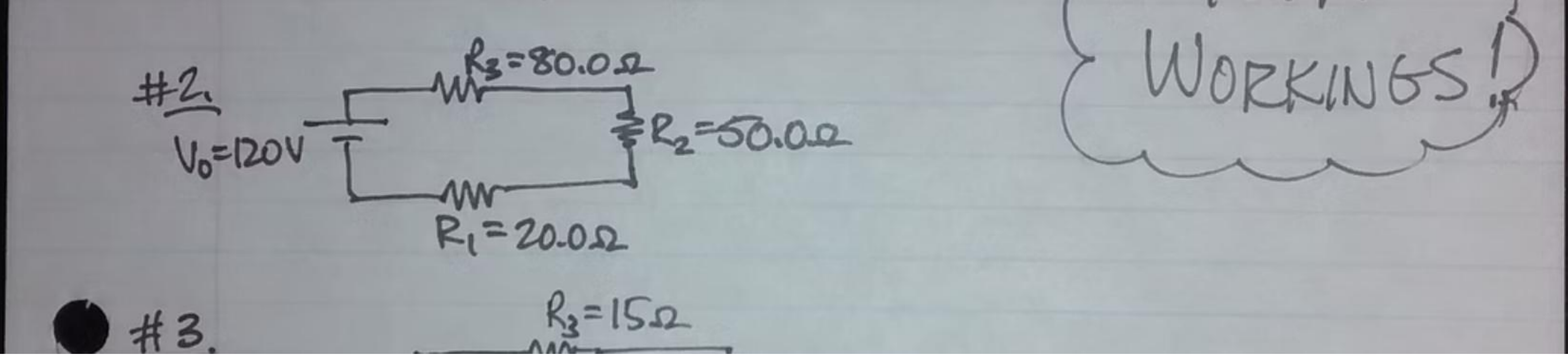
CSA B149.1 Stipulations for Combo Heating Systems

Section 7.27.6

Except for direct-vent water heaters, when the water heater is used in a combo heating system, return-air inlets shall not be installed in the same enclosure that contains both an air-handling unit and the water heater. Adequate combustion air shall be provided for the water heater.

Section 7.27.7

When the return air duct(s) of an air handling unit in a combo heating system is installed in an enclosure in which any spillage-susceptible appliances are located, it shall be sealed to the air handling unit casing, and joints in the ducting shall be sealed to prevent infiltration of air from the enclosure into the return-air ducting.



Combo System HWT/Fan-Coil Sizing Design Worksheet

The Combo System HWT/Fan-Coil Sizing design worksheet provides a structured approach to calculating the requirements for combination systems. It includes sections for fan coil specifications, domestic demand calculations, combo water heater sizing, and available BTU for fan coil use.

This worksheet helps ensure that all critical factors are considered when sizing a combination system, including heated area, heating demand, domestic hot water requirements, and water heater specifications.

Fan-Coil Water Heater Types

Storage-Type Water Heater

A conventional water heater with a tank that stores hot water for both domestic use and space heating. These systems maintain a reserve of hot water that can be used for both purposes.

- Provides consistent hot water supply
- Can handle simultaneous demands
- Takes up more space

Tankless Water Heater

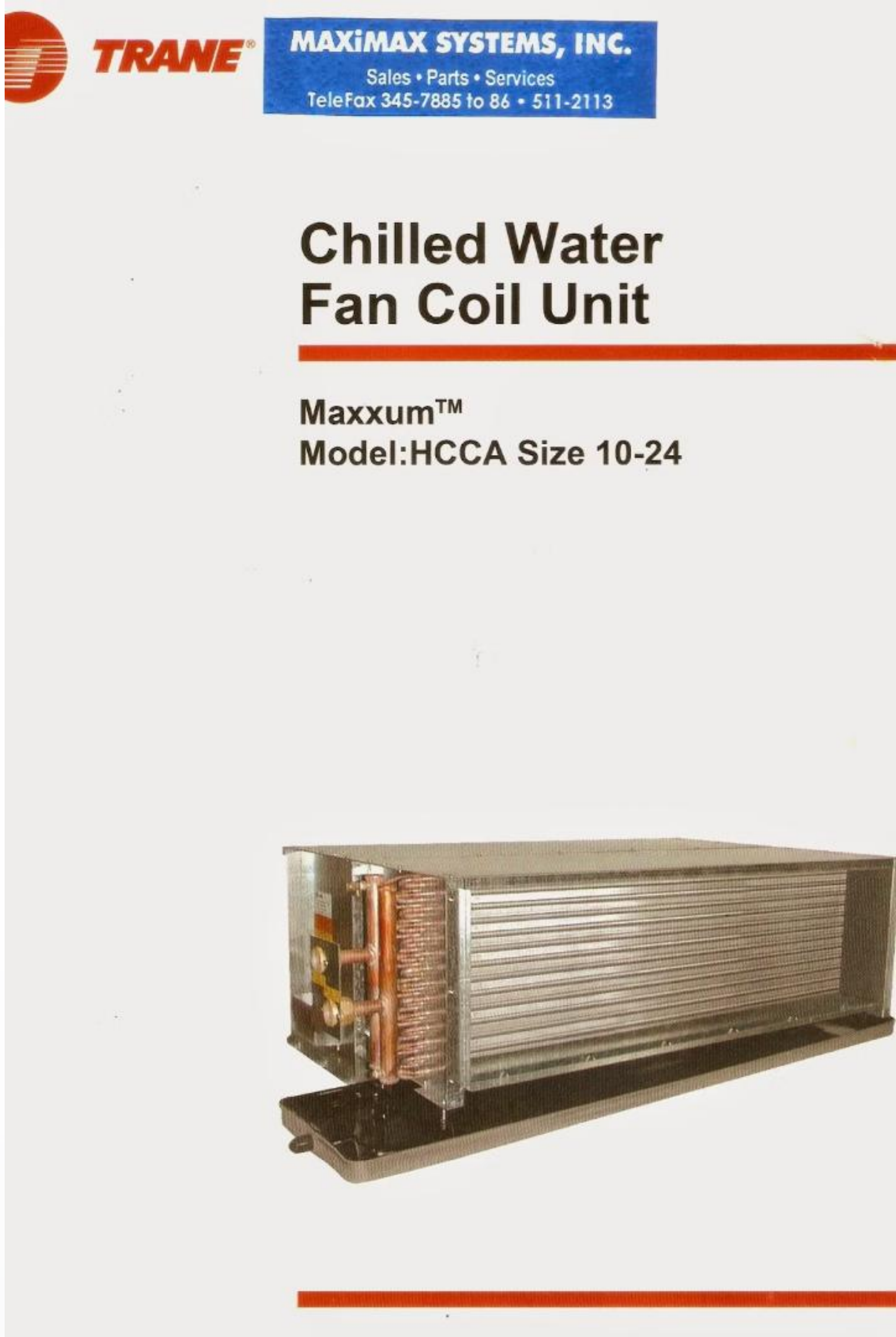
A system that heats water on demand without storing it in a tank. These systems can provide hot water for both domestic use and space heating as needed.

- More energy efficient
- Takes up less space
- May have limitations during peak demand

Combination System with Storage-Type Water Heater

The diagram shows a typical configuration for a combination fan-coil unit with a storage-type water heater. This system uses a conventional water heater to provide hot water for both domestic use and space heating through a fan-coil unit.

The storage-type water heater maintains a reserve of hot water that can be used for both domestic purposes and space heating, providing a reliable source of heat for the fan-coil unit.



Combination System Sample Calculation

Dwelling Specifications

The following combination system sample calculation is based on a dwelling with:

- Two bedrooms
- Two bathrooms
- 21,000 Btu/h heat loss

The example is based on typical domestic hot water usage rates. If the dwelling has additional hot water requirements (such as a hot tub), the system must be designed to meet those additional requirements.

Water Heater Specifications

Specification	Requirement
Storage capacity	50 gallons (225 L)
Input	50,000 Btu/h (15 kW)
Recovery efficiency	76%
Output	38,000 Btu/h (11 kW)

Sample Calculation Results

Using the Combo System Sizing Worksheet, the designed domestic draw of 60 gal (273 L) is satisfied by the selected conventional combination hot water heater with 29,700 Btu/h (8.7 kW) available for the fan coil to satisfy the 24,150 Btu/h (7.1 kW) space heat loss requirement.

This calculation demonstrates how to properly size a combination system to meet both domestic hot water needs and space heating requirements. The worksheet helps ensure that the selected water heater has sufficient capacity for both purposes.

d Weights of Fixtures in Fixture

ıp	Occupancy	Type of Supply Control	ASPE Da Chapter 3: Systems (N (Weight in Fi
	Public	Flush valve	10
	Public	Flush tank	5
	Public	Flush valve	10
al	Public	Flush valve	5
al	Public	Flush tank	3
	Public	Faucet	2
	Public	Faucet	4
	Public	Mixing Valve	4
	Office, etc	Faucet	3
	Hotel/restaurant	Faucet	4
	Private	Flush valve	6
	Private	Flush tank	3
	Private	Faucet	1
	Private	Faucet	2
	Private	Mixing valve	2
	Private	Flush valve for closet	8
ıp	**Private**	**Flush tank for closet**	**6**
	Private	Mixing valve	2
	Private	**Faucet**	**2**
chine	Private	Automatic	-
-3)	Private	Faucet	3
ure	Private	Faucet	3

Pump Sizing Overview

Circulation Pump Requirements

Most combination systems require a circulation pump to move water through the system. The installation of circulation pumps must be in accordance with the applicable Codes and the air handler manufacturer's installation instructions.

Circulation pumps used in combination systems should be stainless or bronze body centrifugal-type pumps designed for use in hydronic heating systems and sized to meet the requirements of the system.

Proper pump sizing is essential for ensuring efficient operation of combination water heating and space heating systems.

Key Factors in Pump Selection

Flow Rate

The amount of water to be circulated through the system

Pressure Loss

Resistance due to friction that the pump must overcome

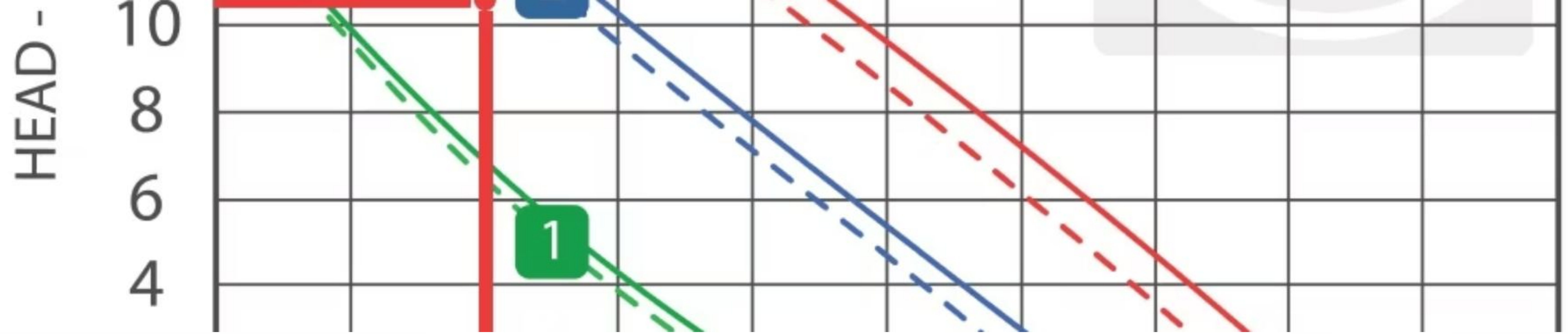
Performance Curve

Manufacturer's data showing relationship between flow rate and pressure loss

Selection

Choose pump based on system requirements and performance data

After determining the system flow rate and pressure loss, you can use the manufacturer's pump performance curve data to select the proper circulator for the application. A pump performance curve shows the relationship between flow rate and pressure loss.



Circulation Pump Sizing Rule-of-Thumb

Flow Rate Calculation

Flow rate of the pump should be 1 US gallon per minute (USGPM) per 10,000 Btu/h heat output required

Friction Pressure Loss

Allow 1 ft of friction pressure loss per 40 ft of pipe run

This rule-of-thumb provides a quick method for estimating the required pump size for a hydronic heating system. More detailed calculations may be necessary for complex systems or those with special requirements.

Understanding Flow Rate

Definition

The flow rate is the amount of water to be circulated through the system. It is traditionally measured in US gallons per minute (USGPM).

Determining Factors

Flow rate is determined by:

- The amount of heat to be supplied
- The difference in temperature between the water leaving the heater
- The temperature of the water that returns to the heater after giving up its heat

The amount of heat to be supplied is the Btu/h output determined by a heat loss calculation for the building.

Understanding Pressure Loss

Friction Resistance

Water flowing through pipes encounters resistance due to friction

Pump Requirements

Pump must overcome this resistance to maintain flow

Calculation

Based on flow rate, pipe size, and run length

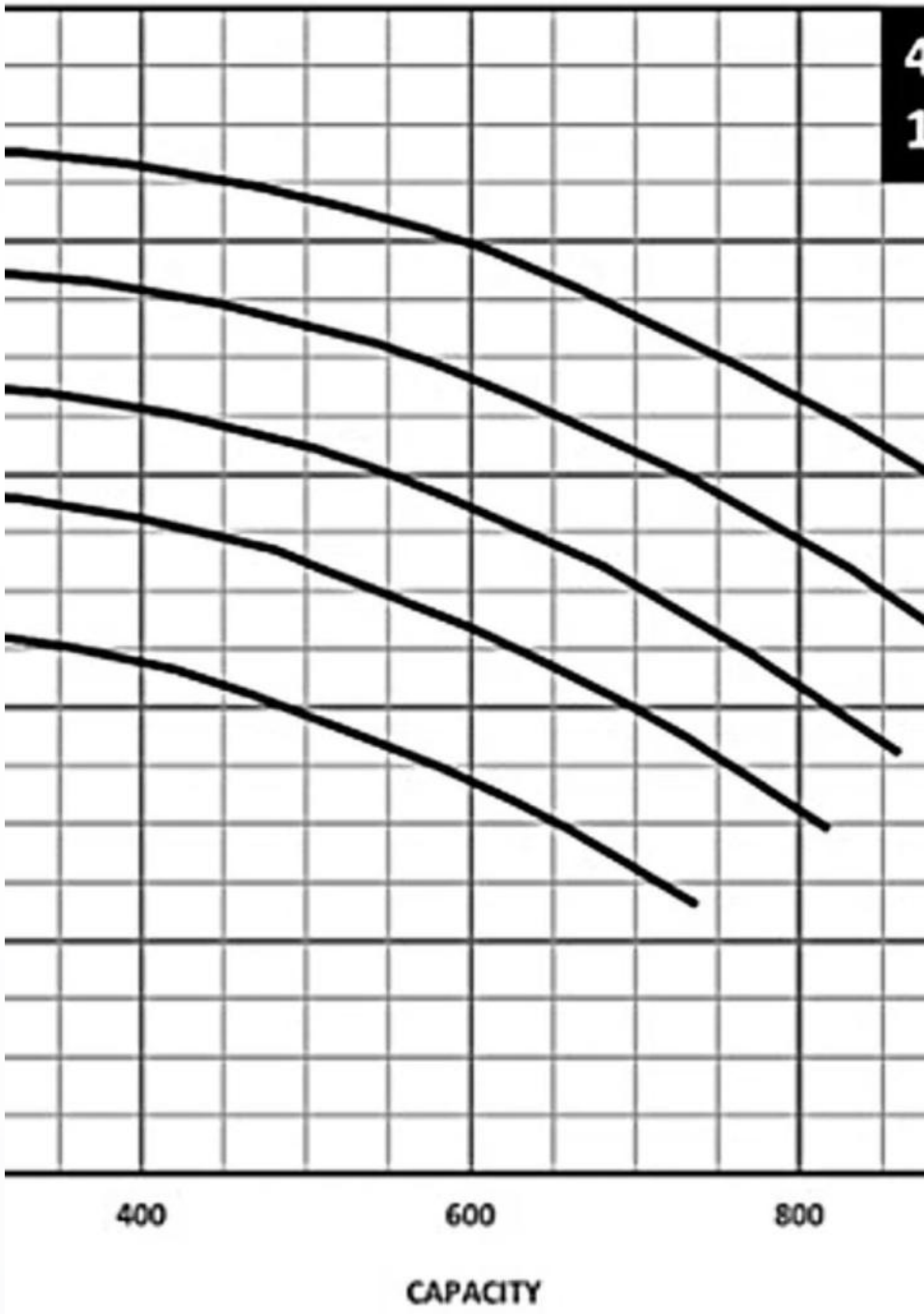
Measurement

Typically measured in feet of head water column (ft. hd. w.c.)

Pump Curve Charts

In order to select the appropriate pump for a given installation, you must know how much pressure a pump will develop for a given gallon per minute (gpm) flow rate. This information can be found on manufacturers' pump curve charts.

Each pump will have its own pump curve, although more than one pump model may appear on a single chart. Pump models A through H shown in the example are from one pump manufacturer.



Reading Pump Curve Charts

Vertical Axis (Head)

The vertical axis of a pump curve chart typically shows the head in feet of water column. This represents the pressure that the pump can develop at different flow rates.

Horizontal Axis (Flow Rate)

The horizontal axis shows the flow rate in gallons per minute (gpm). This represents how much water the pump can move at different pressure levels.

Curve Interpretation

Each curve on the chart represents a specific pump model or speed setting. The point where your system's required flow rate and pressure loss intersect on the chart helps identify the appropriate pump for your application.

Multiple Speed Pump Options

Speed Selection

Most manufacturers offer circulators capable of operating at three different speeds

Speed Control

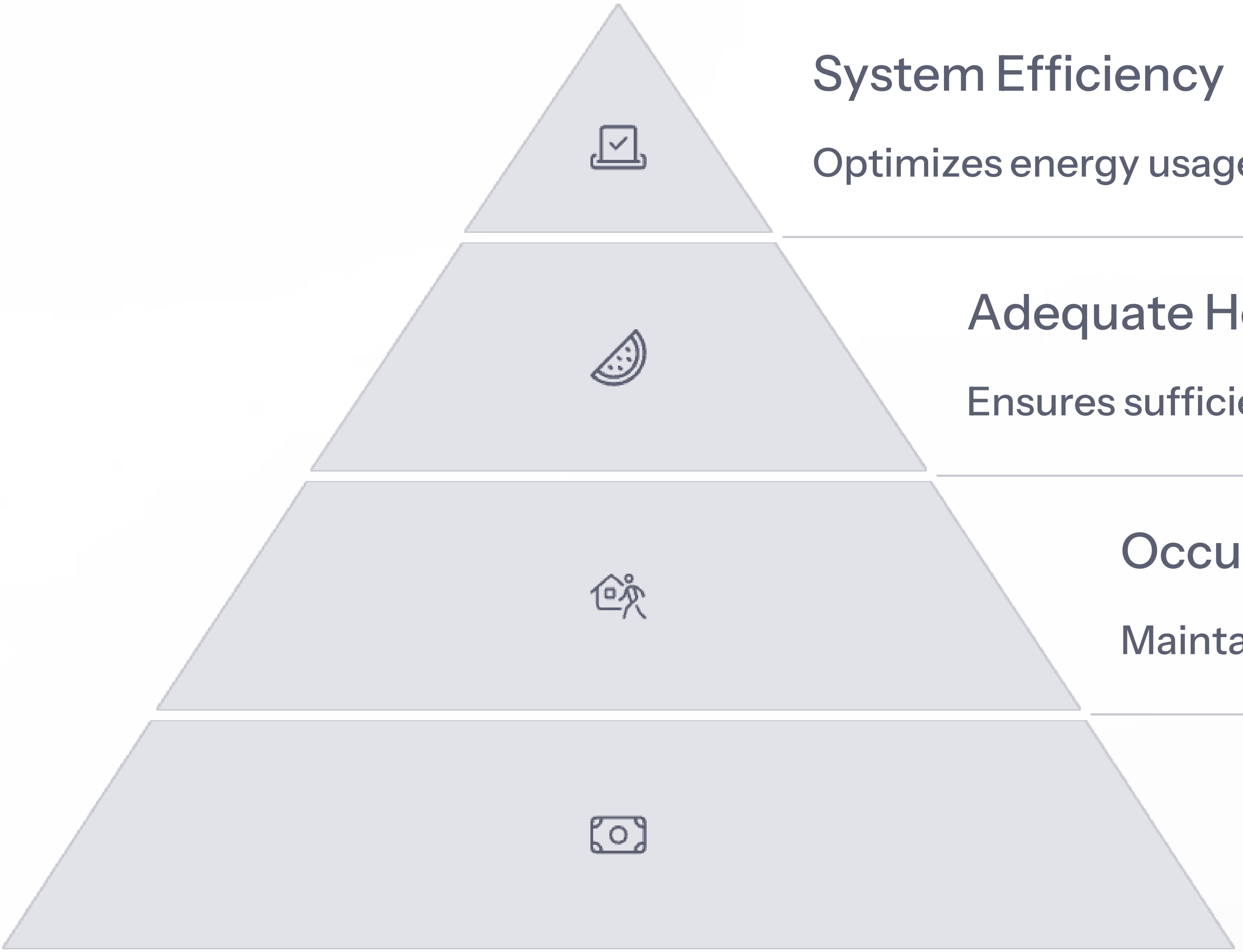
The desired speed is selected using an external switch on the circulator's junction box

Performance Curves

Each operating speed has a corresponding pump curve

To reduce the number of circulator models needed and still cover a wide range of performance requirements, manufacturers typically offer multi-speed options. This allows for flexibility in matching the pump to the specific system requirements.

Importance of Proper Water Heater Sizing



System Efficiency

Optimizes energy usage and reduces operating costs

Adequate Hot Water Supply

Ensures sufficient hot water for both domestic use and space heating

Occupant Comfort

Maintains consistent temperatures and hot water availability

Cost-Effective Installation

Prevents over-sizing and unnecessary equipment expenses

Heat Loss Calculation Importance

Foundation of System Sizing

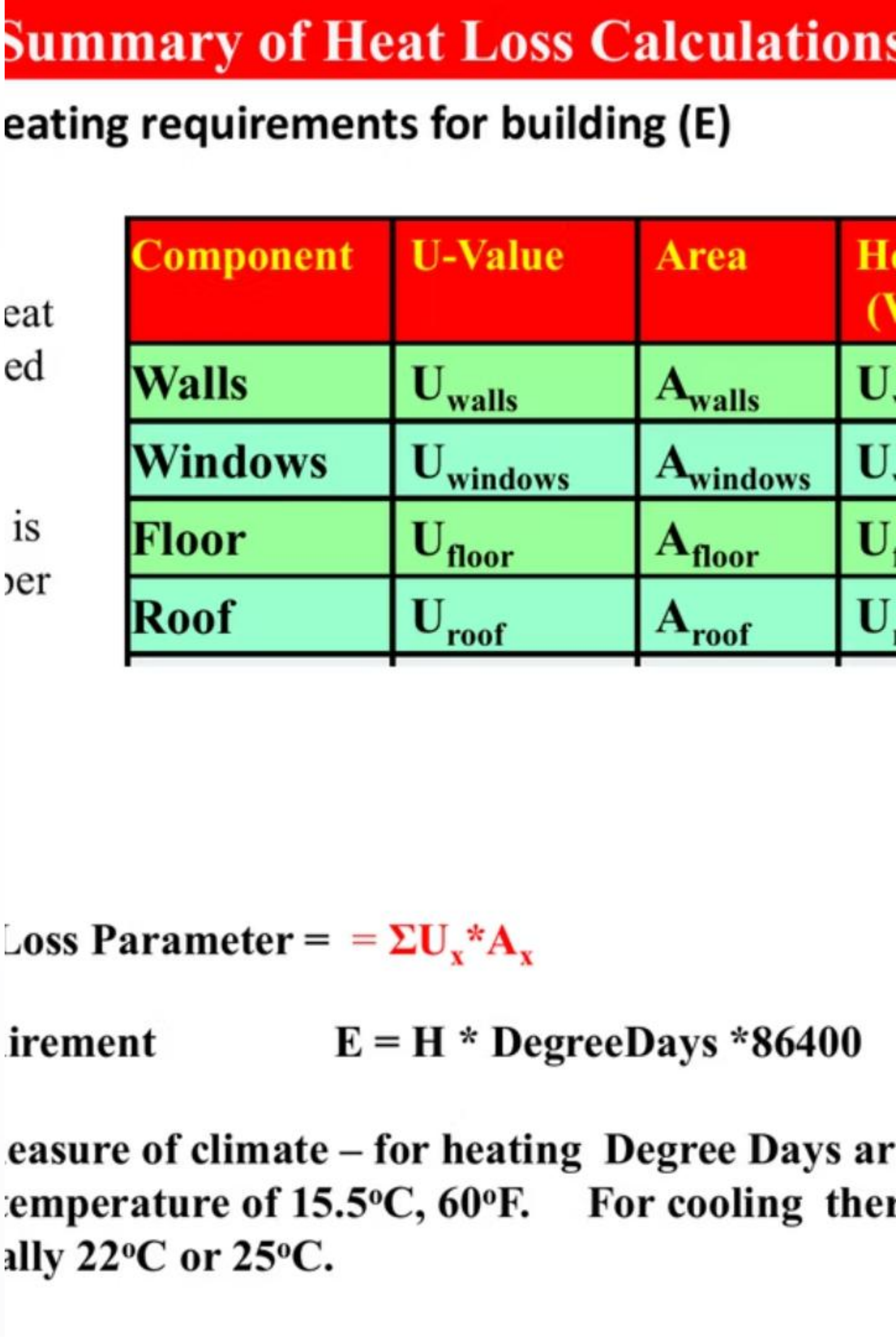
The heat loss calculation forms the basis for determining the required capacity of both the water heater and the space heating components. Perform the heat loss calculation in accordance with approved industry engineering practices.

Accuracy is Critical

An accurate heat loss calculation ensures that the system is neither undersized (leading to inadequate heating) nor oversized (resulting in inefficient operation and unnecessary costs). The importance of this step cannot be understated.

Climate Considerations

Local climate and temperature variations have a significant effect on building heat loss and will therefore influence input calculations. Always consult local information sources to ensure that your calculations include the proper climate multiplication factors.



Climate Multiplication Factors

Purpose

Climate multiplication factors adjust the heat loss calculations to account for local weather conditions. These factors ensure that the water heater and space heating system have sufficient capacity to meet demands during peak cold periods.

Example Factors

The following examples are provided for reference only:

- For mild climates: Input = calculated heat loss x 1.51
- For colder climates: Input = calculated heat loss x 1.58

Always consult local information sources to ensure that your calculations include the proper climate multiplication factors for your specific region.

Air Handler Selection Criteria

Calculate Building Heat Loss

Determine the total heat loss for the building using approved calculation methods from organizations like HRAI, ASHRAE, or ACCA.

Select Air Handler with Adequate Heating Output

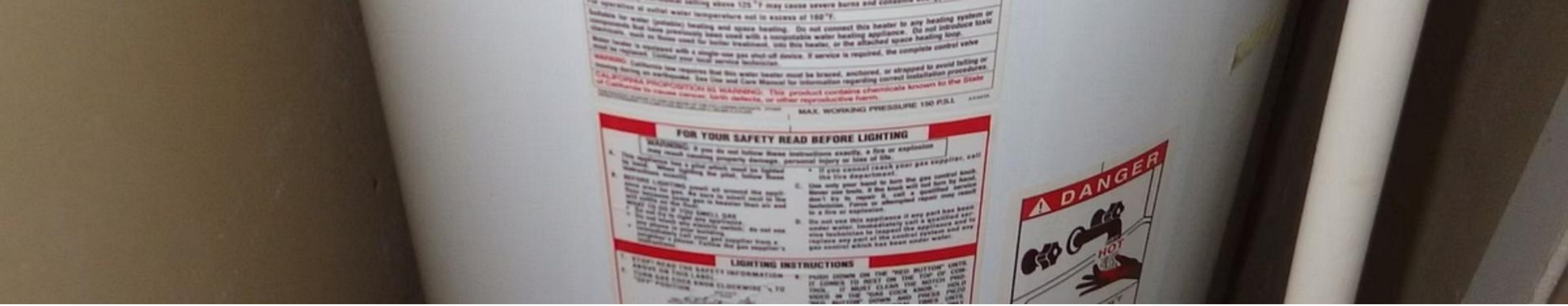
Choose an air handler with a heating output that exceeds the calculated space heating loss of the building to ensure sufficient heating capacity.

Match Cooling Coil to Outdoor Unit

Ensure that the cooling coil in the air handler is sized to match the outdoor condensing unit for proper cooling operation.

Consider Water Heater Capacity

Remember that the heating output of the air handler will be limited by the water heater capacity. If the water heater is undersized, the heating capacity of the air handler will be less than its rated output.



Minimum Water Heater Capacities Table

Table 5 HUD-FHA Minimum Water Heater Capacities for One- and Two-family Living Units provides guidance on the minimum required water heater specifications based on the number of bathrooms and bedrooms in a dwelling.

This table helps ensure that the water heater has sufficient capacity to meet the domestic hot water needs of the household, with specifications for storage capacity, BTU/h input, 1-hour draw capacity, and recovery rate.

Sample Calculation Breakdown

2

Bedrooms

Number of bedrooms in sample dwelling

2

Bathrooms

Number of bathrooms in sample dwelling

21,000

Btu/h

Heat loss calculation result

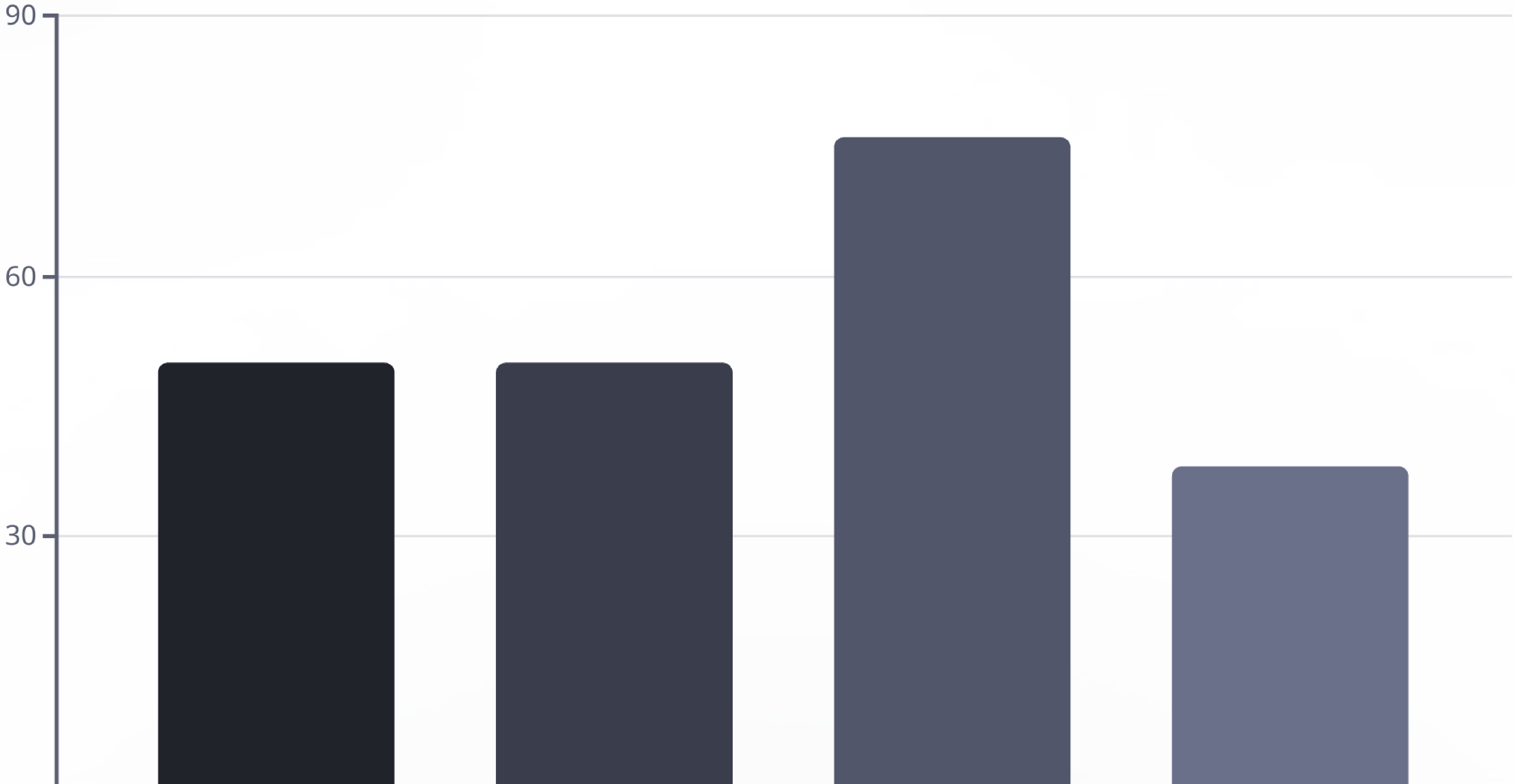
24,150

Btu/h

Minimum fan coil requirement (heat loss x 1.15)

The sample calculation demonstrates how to determine the appropriate water heater and fan coil specifications for a typical residential application with standard domestic hot water usage patterns.

Water Heater Specifications for Sample Calculation



Calculation Results for Sample System

Domestic Hot Water Requirements

The designed domestic draw of 60 gallons (273 L) is satisfied by the selected conventional combination hot water heater. This ensures that the system can meet the household's hot water needs for bathing, washing, and other domestic purposes.

Space Heating Requirements

The selected water heater provides 29,700 Btu/h (8.7 kW) available for the fan coil, which is sufficient to satisfy the 24,150 Btu/h (7.1 kW) space heat loss requirement. This ensures that the system can maintain comfortable indoor temperatures during cold weather.

Pump Flow Rate Determination

Heat Output

Determine required Btu/h from heat loss calculation

Temperature Difference

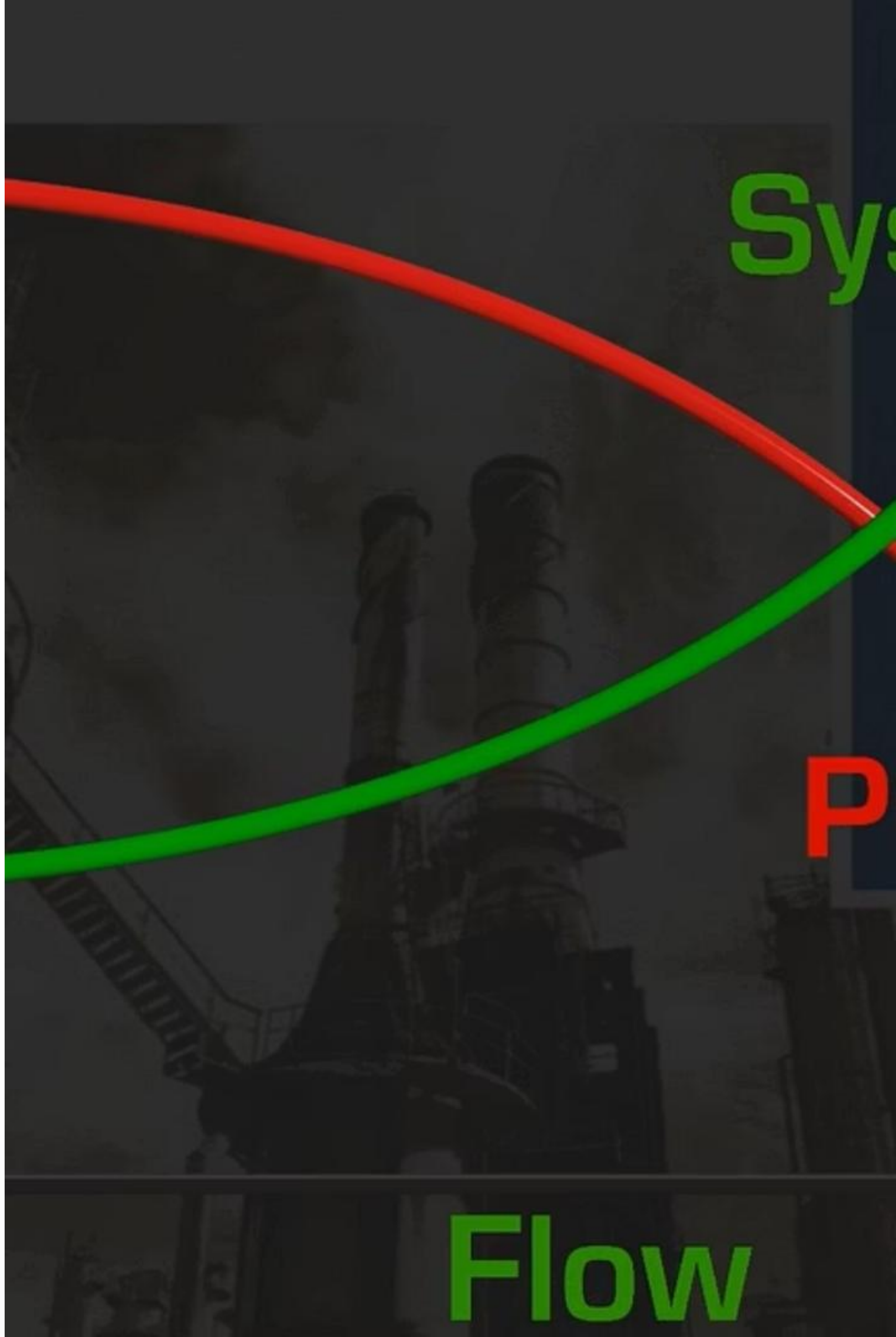
Calculate difference between supply and return water temperatures

Flow Calculation

Apply rule-of-thumb: 1 USGPM per 10,000 Btu/h heat output

Flow Rate Result

Determine required flow rate in gallons per minute



Pressure Loss Calculation

Determine Flow Rate

Calculate the required flow rate in gallons per minute based on the heat output requirements.

Identify Piping Specifications

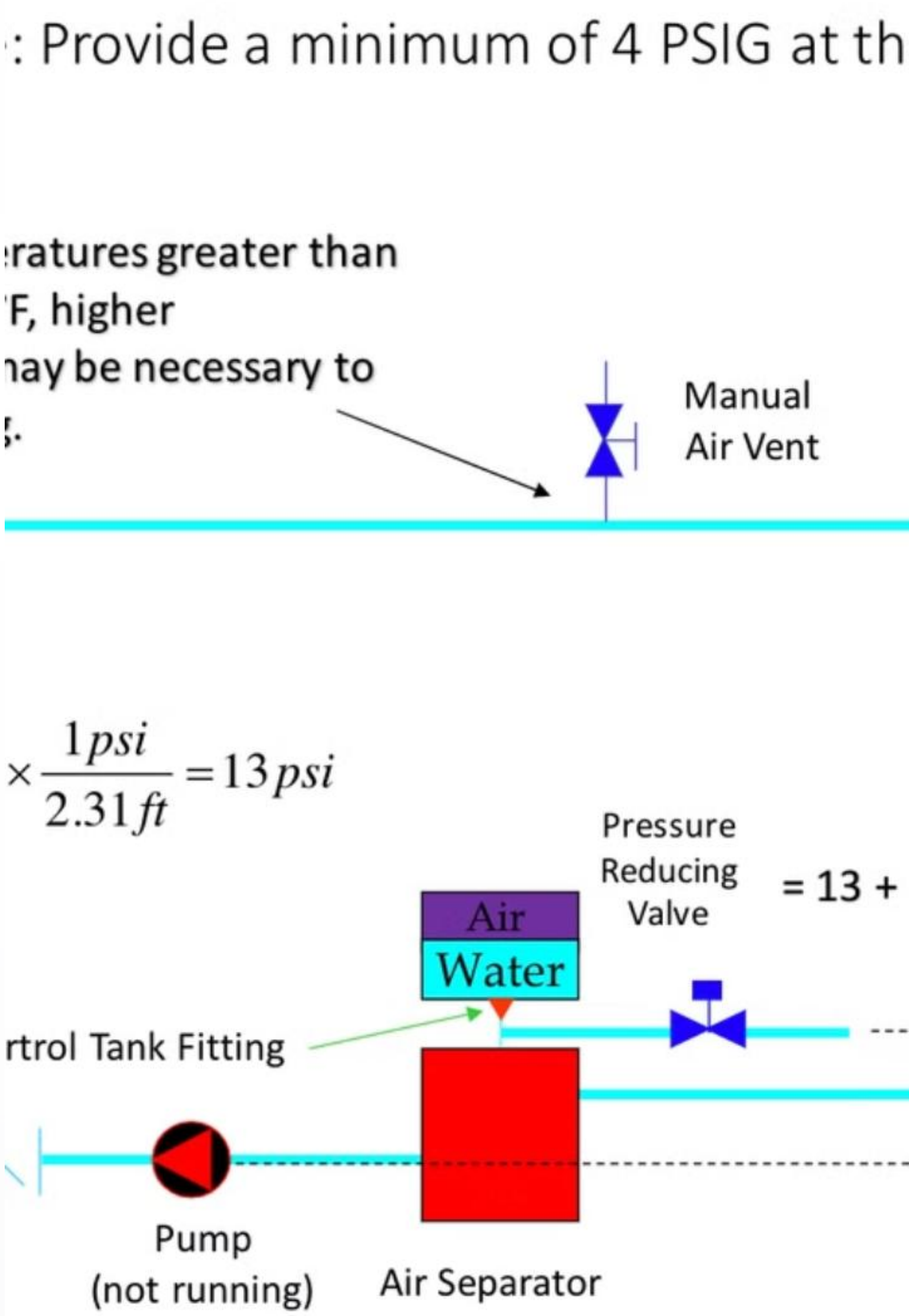
Determine the pipe size and total run length for the system, including all straight runs and fittings.

Calculate Friction Loss

Use the rule-of-thumb of 1 ft of friction pressure loss per 40 ft of pipe run, or consult friction loss tables for more precise calculations.

Determine Total Pressure Loss

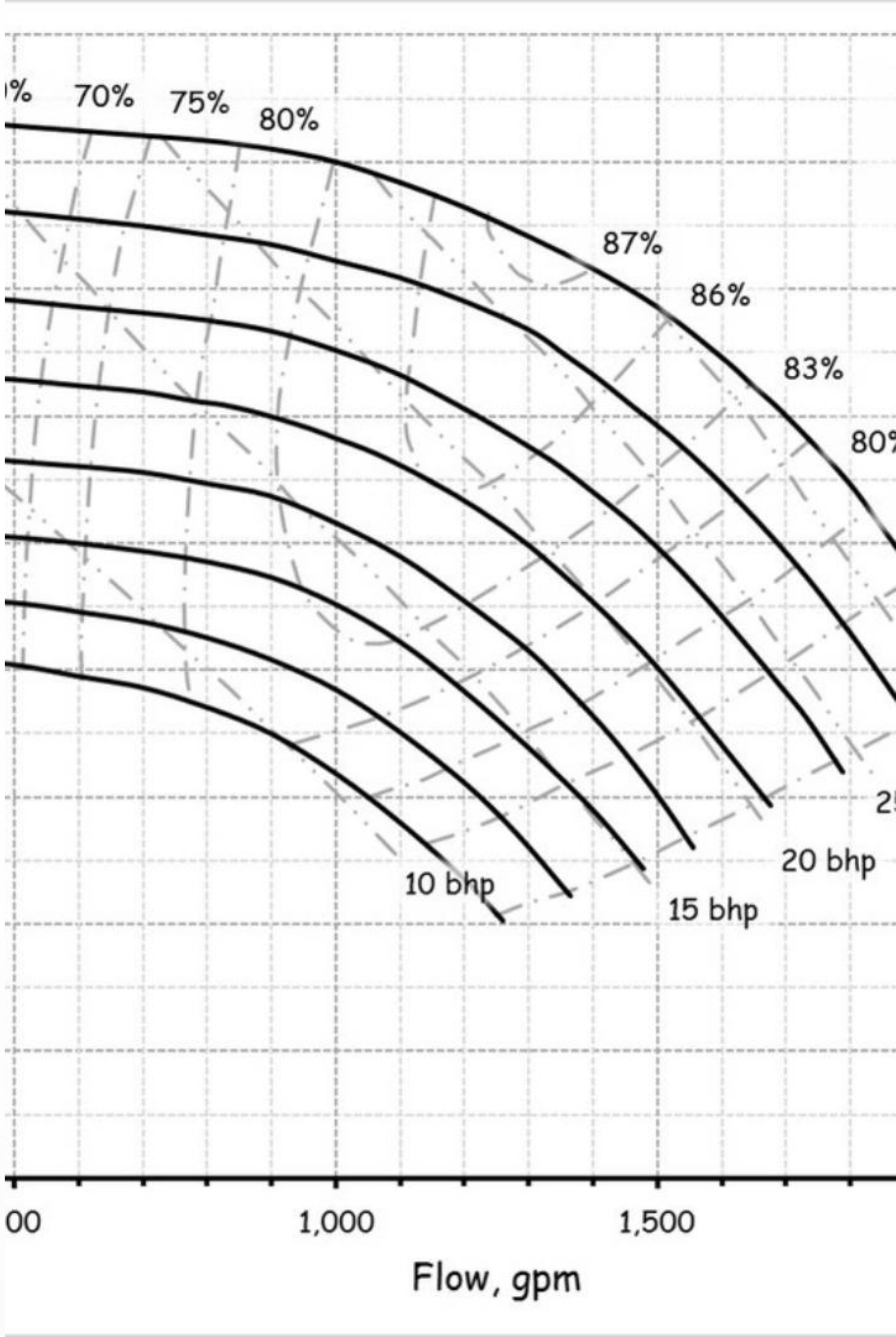
Add up all sources of pressure loss in the system, including pipe friction, fittings, valves, and heat exchange equipment.



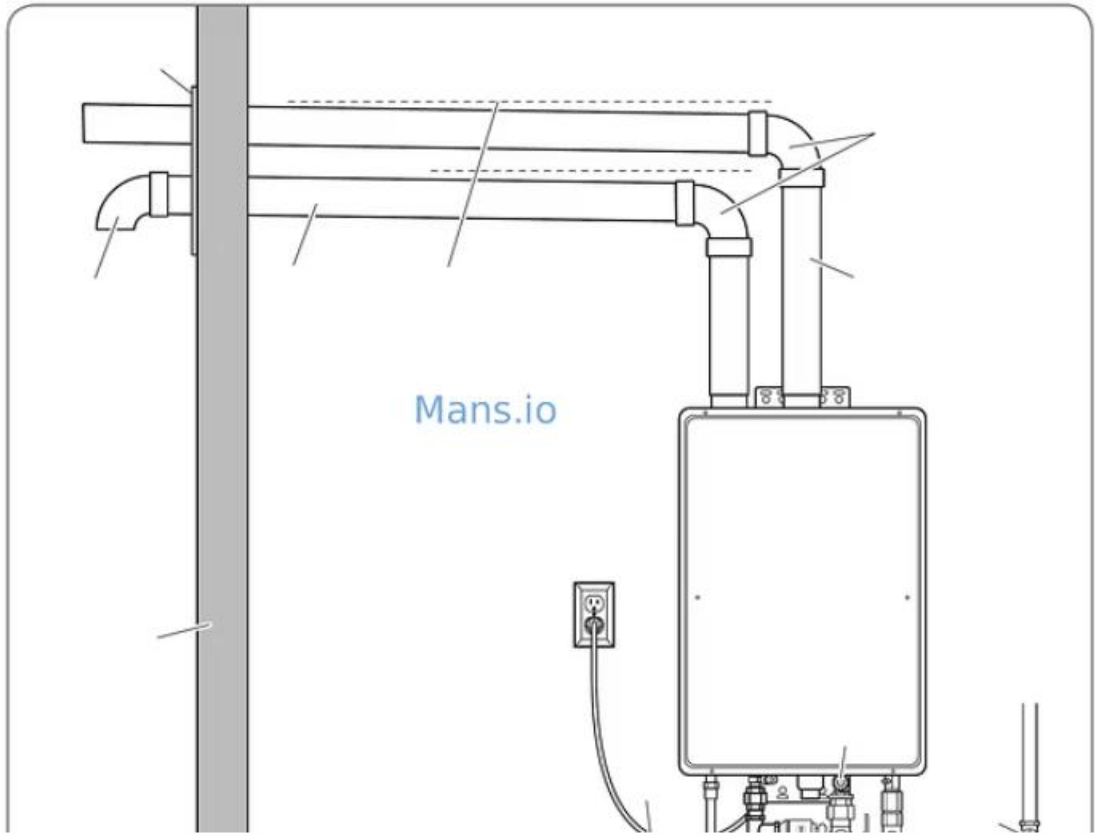
Sample Pump Curve Chart Analysis

The sample pump curve chart shows multiple pump models (labeled A through H) from a single manufacturer. Each curve represents the performance characteristics of a specific pump model, showing the relationship between flow rate (horizontal axis, measured in gallons per minute) and head pressure (vertical axis, measured in feet of head water column).

To select the appropriate pump, identify the point where your system's required flow rate and pressure loss intersect on the chart, then choose the pump model whose curve passes through or just above that point.



CSA B149.1 Requirements for Combo Systems



Section 7.27.6 Requirement

Except for direct-vent water heaters, when the water heater is used in a combo heating system, return-air inlets shall not be installed in the same enclosure that contains both an air-handling unit and the water heater. Adequate combustion air shall be provided for the water heater.

Section 7.27.7 Requirement

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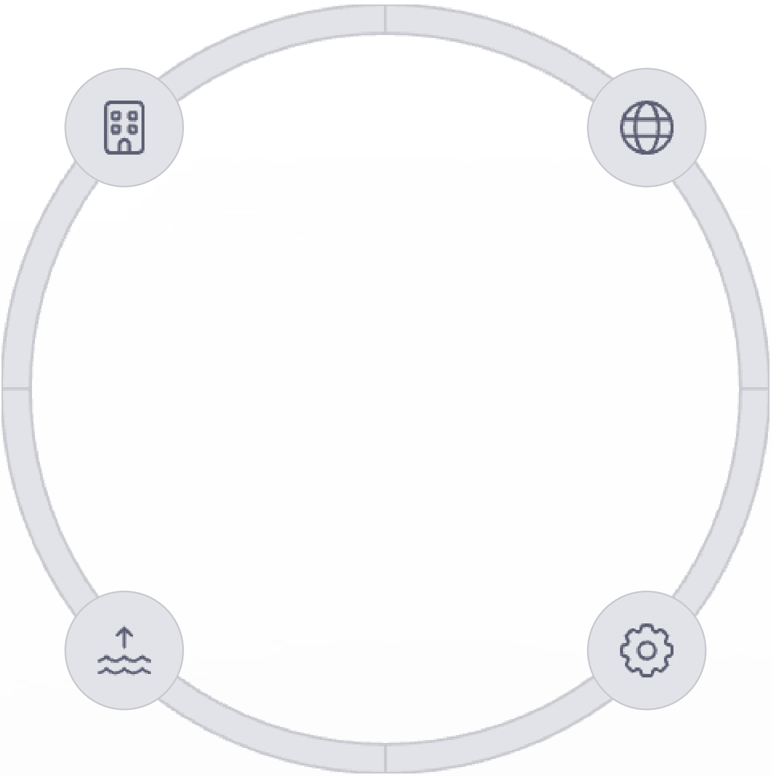
Approved Organizations for System Design

HRAI

Heating, Refrigeration and Air Conditioning Institute of Canada

- Canadian industry association
- Provides technical standards and guidelines
- Offers certification programs



ASHRAE

American Society of Heating Refrigeration and Air Conditioning Engineers

- International technical society
- Develops industry standards
- Publishes technical handbooks

ASPE

American Society of Plumbing Engineers

- Professional organization for plumbing design
- Develops technical standards
- Provides design resources

ACCA

Air Conditioning Contractors of America

- Trade association for HVAC professionals
- Develops technical manuals
- Provides industry resources

Multi-Speed Pump Selection Benefits

Flexibility

Multi-speed pumps allow for adjustment to match specific system requirements, providing flexibility to adapt to different operating conditions or changes in system design.

Energy Efficiency

The ability to select lower speeds when full capacity is not needed can result in significant energy savings, as pump power consumption increases exponentially with speed.

Reduced Inventory

Manufacturers offer multi-speed options to reduce the number of circulator models needed while still covering a wide range of performance requirements, simplifying inventory management for contractors.

System Optimization

Speed selection allows for fine-tuning of the system to achieve optimal performance, balancing flow rate and pressure to meet the specific needs of the installation.

Pump Selection Process Summary

Calculate Heat Loss

Determine the building's heat loss using approved calculation methods

Determine Flow Rate

Calculate required flow rate (typically 1 USGPM per 10,000 Btu/h)

Calculate Pressure Loss

Determine total system pressure loss based on piping layout

Consult Pump Curves

Use manufacturer's pump curve charts to find appropriate model

Select Pump

Choose pump that meets or exceeds flow and pressure requirements

Key Takeaways for System Sizing

Water Heater Sizing

Proper water heater sizing must consider both the capacity in gallons and the Btu input, based on domestic hot water needs and space heating requirements.

Heat Loss Calculation

Accurate heat loss calculation is critical for determining space heating requirements and must be performed according to approved industry practices.

Pump Selection

Pump selection depends on flow rate and pressure loss calculations, with manufacturer's pump curves used to identify the appropriate model for the application.

Industry Standards

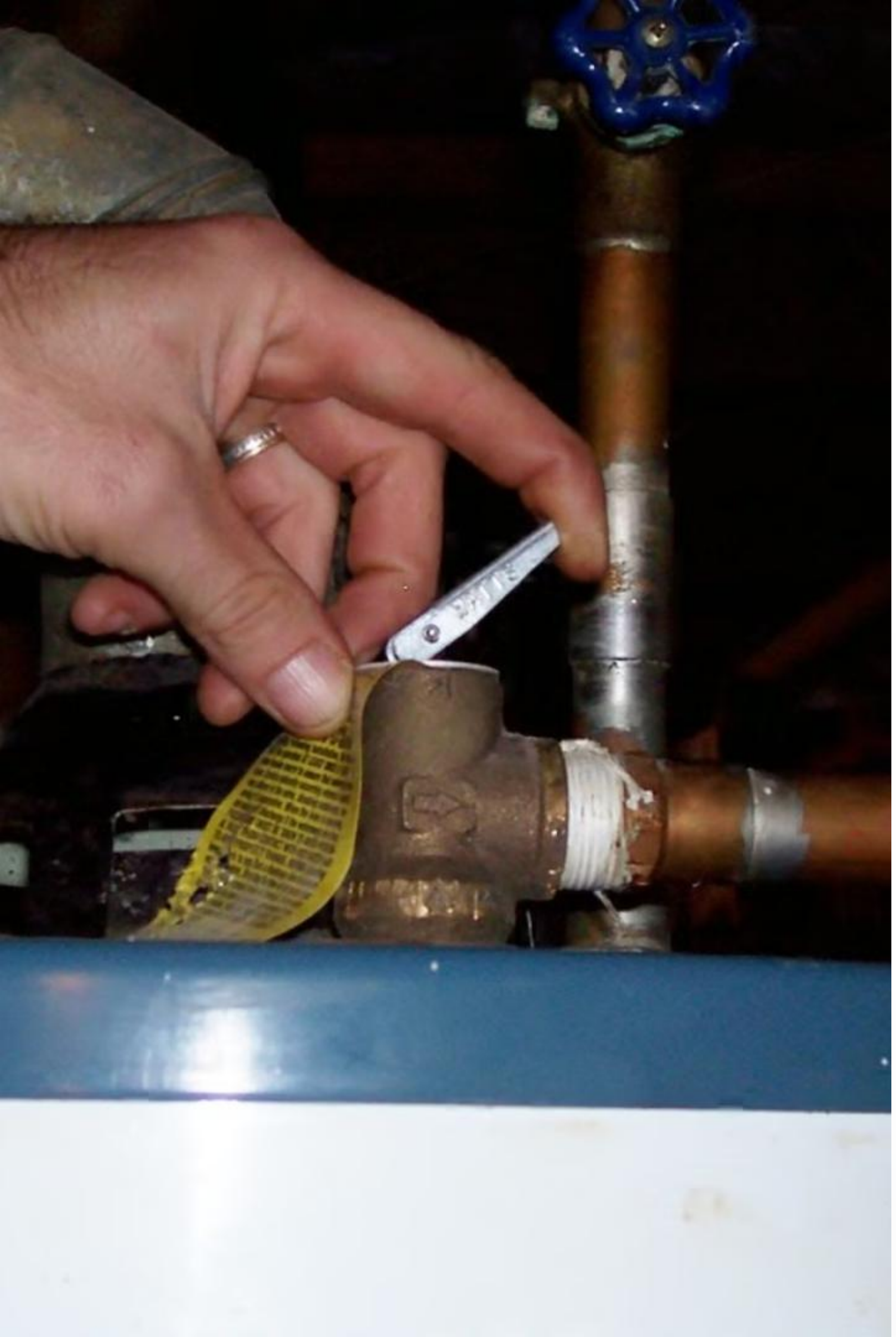
System design and installation must comply with standards from approved organizations like HRAI, ASHRAE, ACCA, and ASPE, as well as local code requirements.

CSA Unit 18

Chapter 4

Servicing Systems for Water Heaters and Combination Systems

An important part of a gas technician's/fitter's duties is to solve safely, accurately, and efficiently the technical problems associated with hot water heating and combination systems. The gas technician/fitter must know how to troubleshoot and service electrical and non-electrical systems and components and analyze and correct problems that result from water conditions and improper combustion.



Temperature and Pressure Relief Valve

Definition

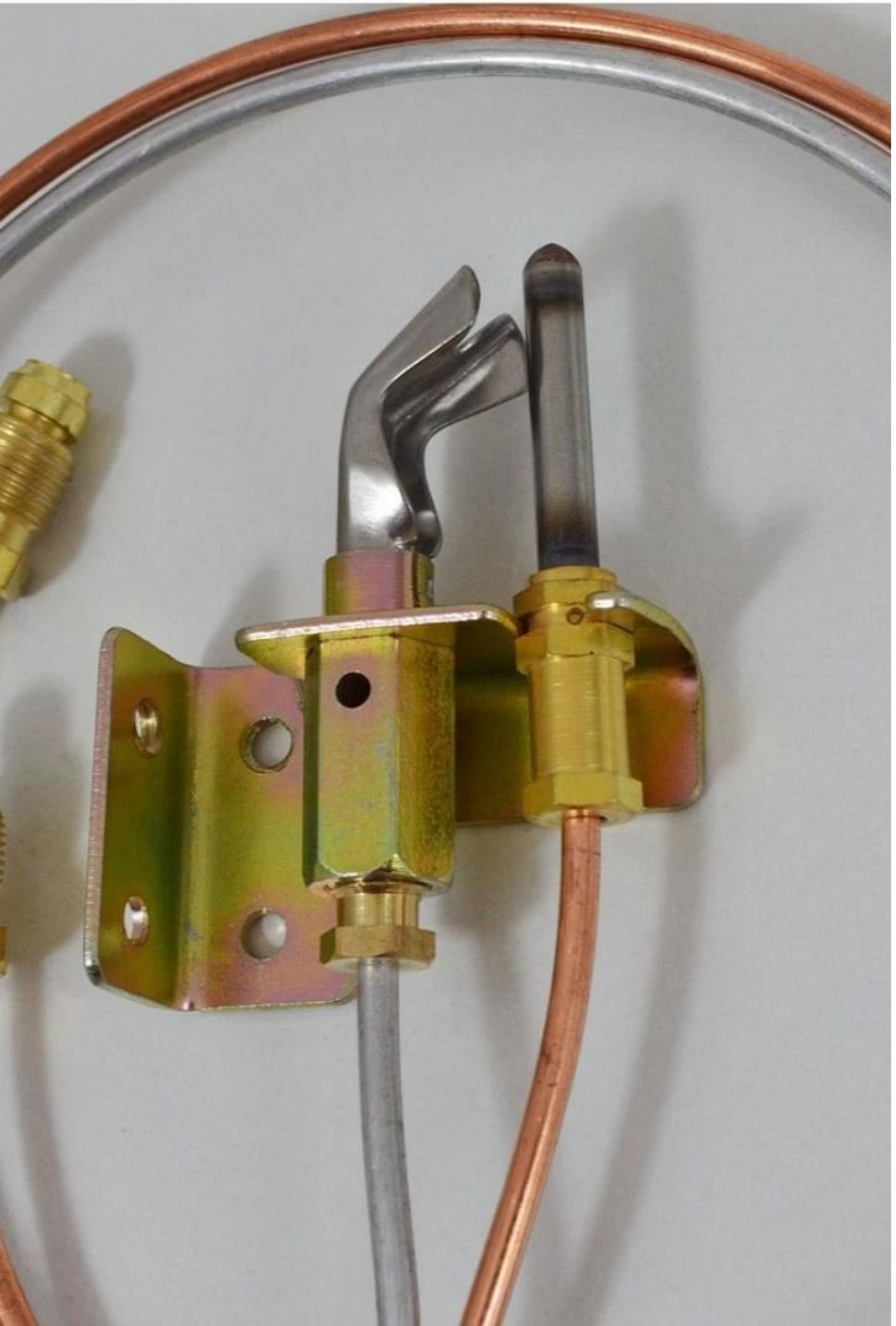
A valve that automatically opens a relief vent when either the pressure or temperature reaches a predetermined value and reseats again when the pressure or temperature returns to normal.

Purpose

Provides critical safety protection by preventing excessive pressure or temperature buildup in the water heater tank.

Operation

Opens automatically when pressure exceeds rating or temperature exceeds 210°F, then reseats when conditions normalize.



Electrical Components Troubleshooting

Standing Pilot Issues

If the water heater comes with a standing pilot and there is no hot water, check if the pilot burner is out.

Loose Thermocouple Connection

Tighten the thermocouple connection to the control unit a 1/4 turn past hand tight.

Defective Thermocouple

Check for broken or cracked terminals and ensure threads are in good order.

Defective Pilot Magnet

Test the pilotstat coil for proper operation.

Testing for a Loose Thermocouple Connection

Inspect Connection

Check if the thermocouple connection to the control unit is loose.

Tighten Connection

If loose, tighten it a 1/4 turn past hand tight.

Examine Terminal

Remove the thermocouple and check the terminal to make sure it is not broken or cracked.

Verify Threads

Ensure the threads are in good order.

Testing for a Defective Thermocouple

Select Testing Equipment

Use a millivolt-meter or a multi-meter to test for a defective thermocouple.

Perform Open-Circuit Test

Shows the potential millivolts that a thermocouple can produce when not under load.

Perform Closed-Circuit Test

Shows the millivolts that can be maintained when the thermocouple is powering the magnetic coil of a pilotstat device.

Evaluate Results

Replace thermocouple if readings are below specified thresholds.

Open-Circuit Thermocouple Test

Disconnect Thermocouple

Disconnect the thermocouple from the pilotstat.

Set Up Meter

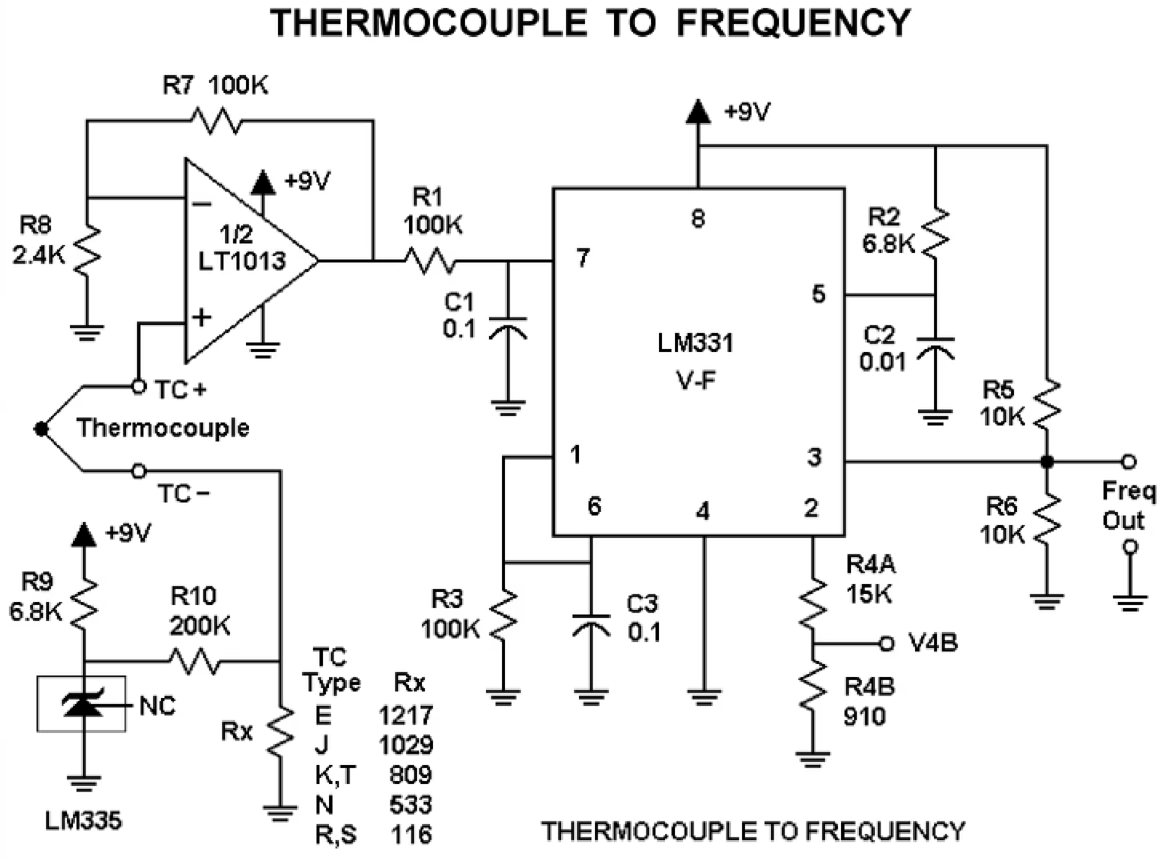
Select a scale on the millivolt-meter suitable for reading a maximum of 30 mV.

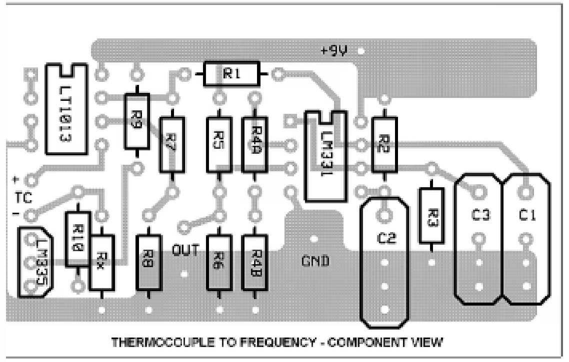
Connect Meter

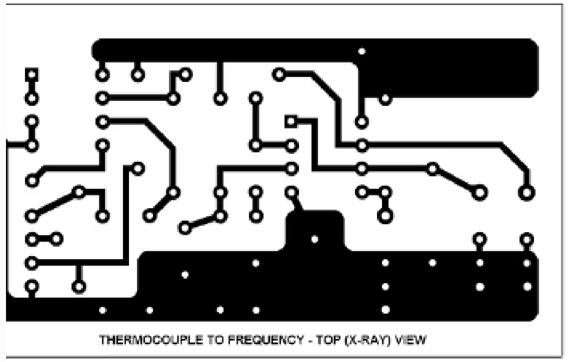
Connect one lead of the meter to the outer copper conductor of the thermocouple and the other lead to the end of the inner conductor.

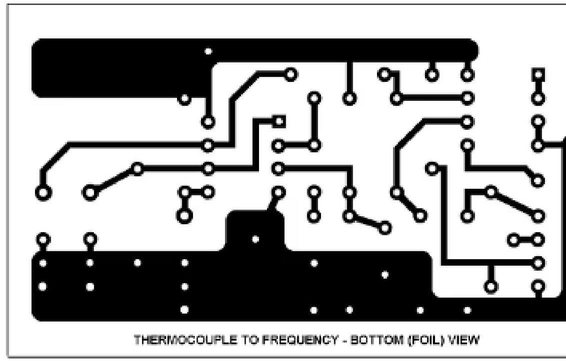
Check Reading

With a pilot flame heating the hot junction of the thermocouple, the meter should read approximately 30 mV. If the meter reading is less than 20 mV, the thermocouple needs replacement.









Closed-Circuit Thermocouple Test

Install Test Block

Disconnect the thermocouple from the pilotstat and install the test block.

Reconnect Components

Reconnect the thermocouple to the top of the test block and relight the pilot burner.

Connect Test Leads

Connect one test lead to the outer conductor of the thermocouple and the other test lead to the side terminal of the test adapter.

Evaluate Reading

The meter should read about 15 mV. If the meter reads less than 8 mV, the thermocouple needs to be replaced.

Testing for a Defective Pilotstat Coil (Drop-Out Test)

Connect Meter

Connect one lead of the millivoltmeter to the copper conductor and the other to the terminal on the side of the test adapter.

Extinguish Pilot

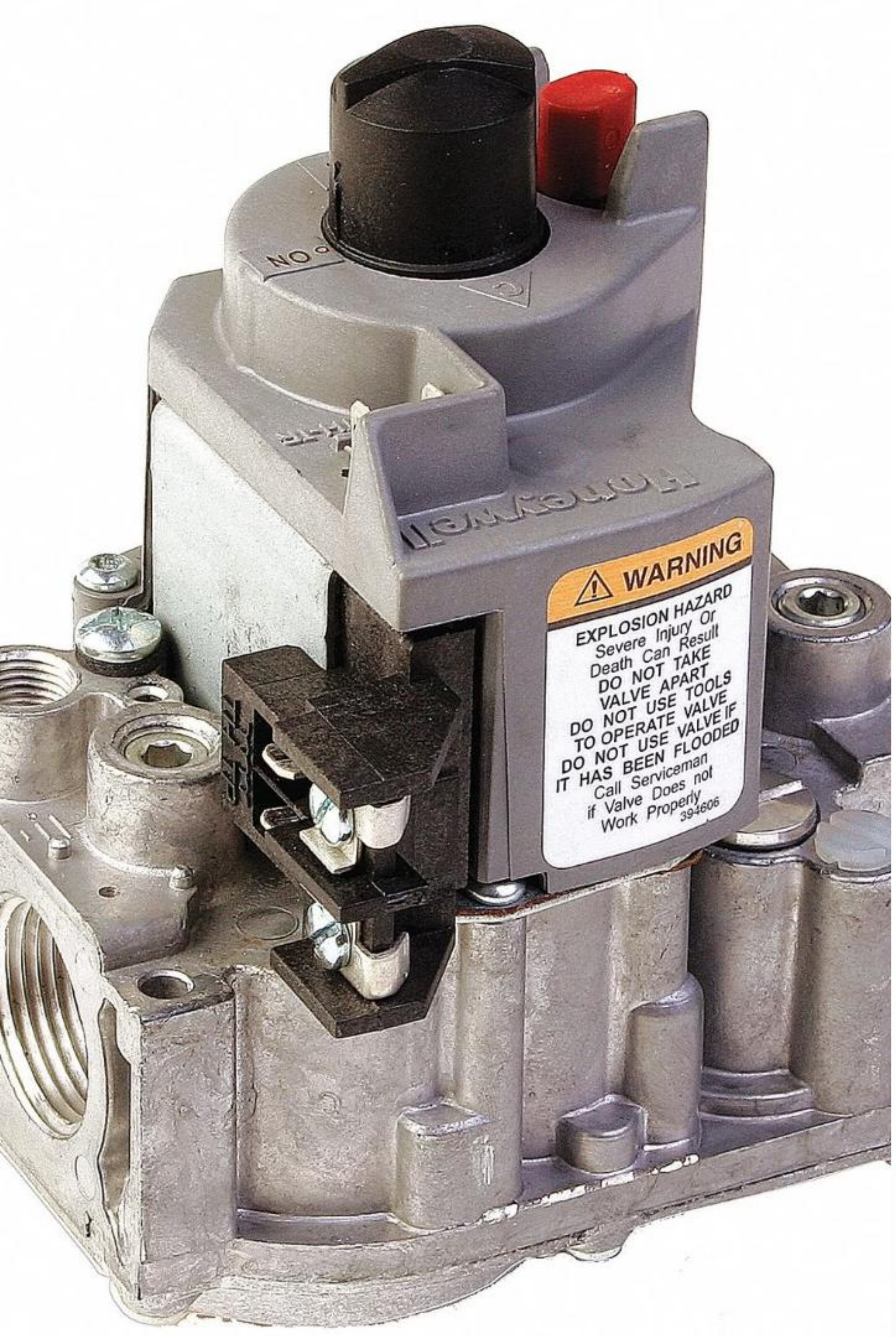
Blow out the pilot flame and allow the thermocouple to cool.

Observe Reading

As the thermocouple cools, observe that the reading on the millivoltmeter slowly decreases.

Evaluate Results

The coil should create enough magnetic field to hold the valve open until the millivoltage drops to between 5 and 2 mV.



Pilotstat Coil Test Results Interpretation

Normal Operation

The coil should create enough magnetic field to hold the valve open until the millivoltage drops to between 5 and 2 mV.

Defective Coil

If the coil drops out with a reading greater than 5 mV, it needs replacement.

Sticking Valve

If the coil holds the valve open with a reading less than 2 mV, the valve is sticking and should be replaced.

Time Requirement

This dropout of the coil must take place within 90 seconds of the flame going out.

Testing Resistances in Millivolt Control Systems

Common Problems

Increases in resistance that reduce the current to a point where the gas valve coils do not operate cause many problems in millivolt control systems.

Causes of Resistance

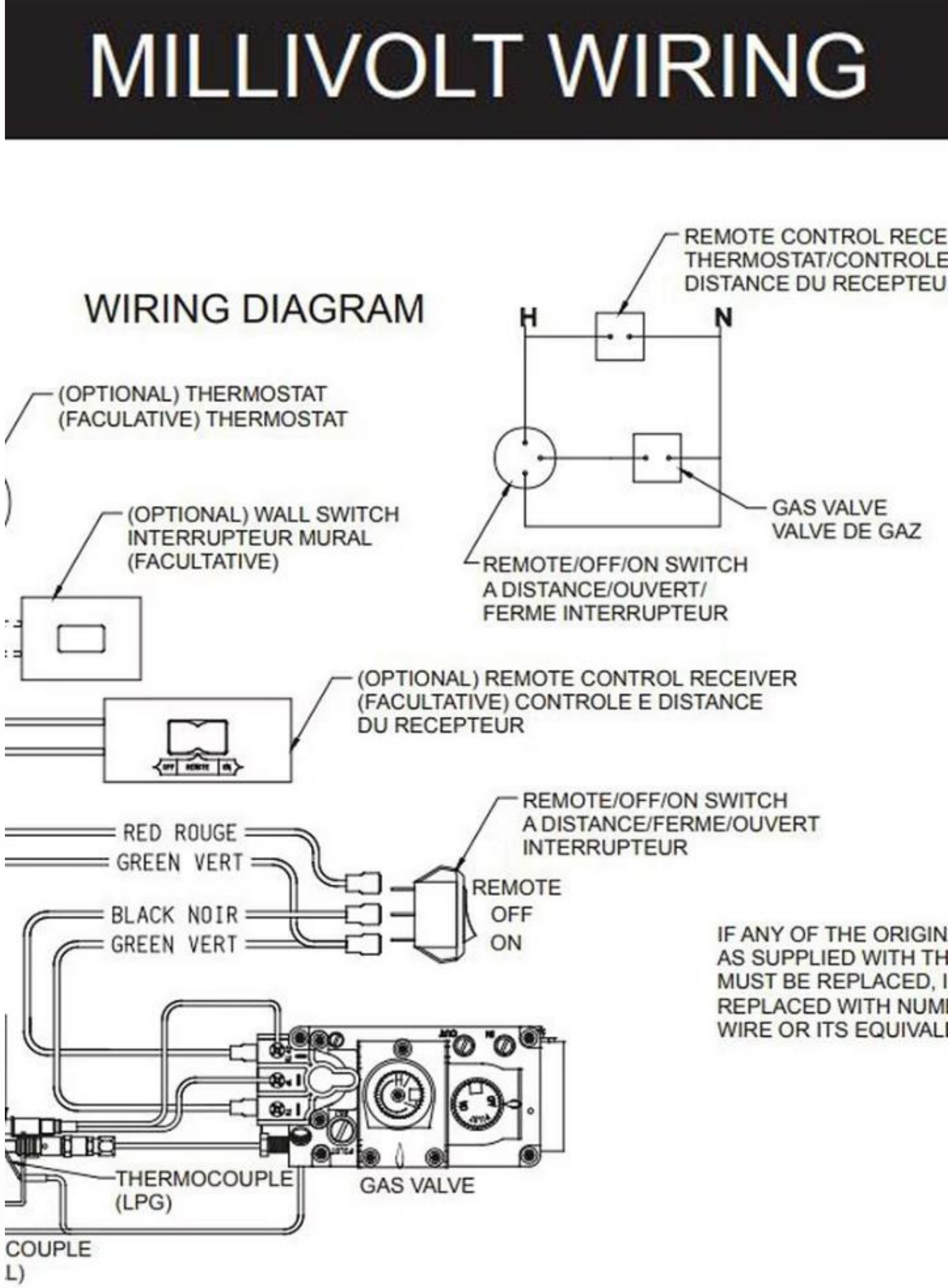
Loose wiring connections, corrosion to terminals and connectors, poor wire splices, and excessive wire lengths.

Testing Method

The easiest way to identify where increases in resistance have developed is to measure the millivolt drop across each component in the electrical circuit.

Diagnosis

Excessive millivolt drop indicates excessive resistances.



Energy Cut-Off (ECO) Device

Purpose

An energy cut-off (ECO) device is a safety feature added to many thermostatic gas controls. It monitors the temperature of the water in the tank.

Operation

The ECO is a fusible link wired in series between the thermocouple and the safety shut-off valve inside the control valve. If the temperature of the water exceeds the preset limit (usually 200°F or 94°C), the fuse melts and the circuit is broken between the thermocouple and the safety shutoff valve, and the gas flow to the burner is terminated.

Replacement

An ECO is a single-use fuse. Once the device is activated, the gas valve must be replaced. If the pilot burner does not remain lit when the reset button is released, check for continuity through the ECO wires; the ECO may have been activated.

Thermal Cut-Off Device (TCO)

Flammable Vapor Protection

In the event of flammable vapour ignition inside the combustion chamber, it senses the corresponding increase in temperature and shuts off gas flow to the main and pilot burners.

Combustion Monitoring

If excessive temperatures inside the combustion chamber indicate poor combustion because of a clogged screen or filter or inadequate air for combustion, the TCO will shut off gas flow to the main and pilot burners.

Mounting Location

The TCO can be mounted just inside the outer door, or it can be part of the pilot assembly.

4

Connection Method

If the water heater is equipped with a rod-and-tube type thermostatic gas control the TCO is usually wired in series with the ECO and safety shut-off valve.

Testing a Thermal Cut-Off Switch (TCO)

Access the Component

Remove the outer jacket door.

Disconnect Wires

Disconnect the wire leads from the thermal switch.

Check Reset Button

If the TCO has a manual reset, ensure that the button is pushed in.

Test Resistance

Using a multimeter capable of measuring resistance or an ohmmeter, place one probe of the meter on each of the wire connection tabs. There should be no resistance through the switch.

Integral Thermocouple TCO

Design

If the water heater is equipped with a TCO that is integral with the thermocouple, the temperature cutoff point will range depending on the make and model.

Operation

This style of TCO is typically an automatic reset thermal switch. When activated it will open the thermocouple circuit and shut off the main and pilot burner gas flow.

Troubleshooting

Light the pilot after the TCO has had sufficient time to cool down. There is no routine service associated with the TCO. The standard thermocouple millivolt output checks would apply. An adequate millivolt reading would indicate that the TCO is closed.

Replacement

If the TCO is an integral part of the thermocouple it will not be replaceable as a separate item. A new pilot burner assembly must be installed.

Flammable Vapour Ignition Resistance Sensor

Locate the Sensor

Flammable vapour sensors are usually located near the air intake of the water heater and are designed to shut off the gas supply to the burner if flammable vapours are present.

Prepare for Testing

Turn the gas valve to the "OFF" position. If the water heater is supplied with 120 volts, de-energize the appliance.

Disconnect Wires

Remove the wires from the sensor.

Test Resistance

Using a multimeter set to Ohms, test the resistance through the sensor. The manufacturer's literature will list an acceptable range of resistance.

Evaluate Results

If the resistance is not within the range as specified by the manufacturer, replace the sensor.

Testing High-Limit Switches

Identify Switch Location

Most water heaters that come with either a vent damper and those that are power vented will have a high-limit switch located next to these devices to ensure that sufficient draft is being created through the appliance and into the venting.

De-energize Appliance

Ensure that the appliance is de-energized.

Disconnect Wires

Disconnect the wire leads from the high-limit switch. On some power-vented models, the high limit may be located inside a protective casing.

Check Reset Button

If the high limit has a manual reset, ensure that the button is pushed in.

Test Resistance

Using a multimeter that can measure resistance or an ohmmeter, place one probe of the meter on each of the wire connection tabs. There should be no resistance through the switch.

Tankless Water Heaters

Diagnostic Features

Most tankless water heaters can monitor their operation continuously. Typically, if a fault occurs, an error code will flash on a display screen to assist in diagnosing the fault and help overcome the problem.

Error Code Access

To display and interpret the error codes, consult the manufacturer's literature. Most manufacturers list a procedure to enable the display of previous error codes.

Performance Monitoring

Many of these units can also display water flow rates and outlet water temperature. Consult the manufacturer's literature.

Thermistors in Tankless Water Heaters

Function

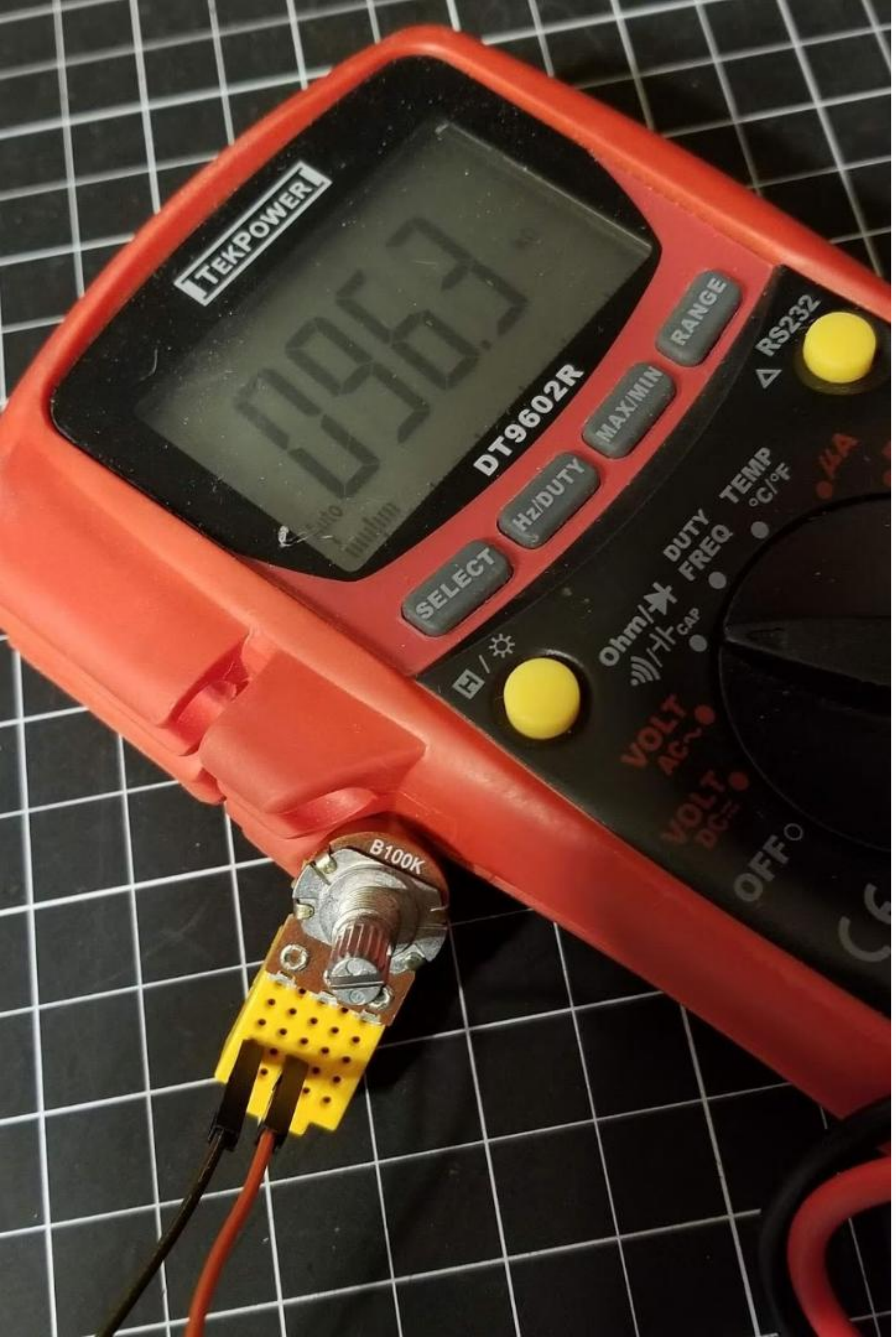
Thermistors are temperature sensitive resistors used to supply information to the circuit board regarding temperature. All resistors vary with temperature, but thermistors are made of semiconductor material with a resistivity that is especially sensitive to temperature.

Operation

The resistance of a Negative Temperature Coefficient (NTC) thermistor decreases with an increase in temperature. If the circuit resistance decreases as the voltage remains constant, the current will increase. The amount of current being supplied to the circuit board through the thermistor indicates the temperature at its location.

Control Function

Based on this information, the circuit board controls the operation of the modulating gas control and/or the water flow control valve.



Testing a Thermistor

Disconnect Wires

Disconnect the wire leads from the thermistor and insert the meter leads into each end of the thermistor plug.

Set Meter

Set the meter to the appropriate Ohm scale (according to the manufacturer's literature) and read the resistance.

Test Temperature Response

Applying heat to the thermistor bulb should decrease the resistance, and applying ice to the thermistor bulb should increase the resistance.

Verify Readings

The manufacturer lists acceptable resistance ranges depending on the temperature.

Testing Heating Elements in Tankless Water Heaters

Consult Documentation

Refer to the manufacturer's literature to determine the acceptable resistance range.

Disconnect Wires

Disconnect the wire leads from the heating element and connect the meter leads to each terminal of the heating element.

Set Meter

Ensure that the meter is set to the appropriate ohm range.

Test Resistance

Measure and compare the resistance to manufacturer specifications.

Flow Switches in Tankless Water Heaters

Purpose

All tankless water heaters come with a flow switch or flow sensor located in the cold water supply. The purpose of the flow sensor is to ensure that there is sufficient water flow to the appliance to prevent it from damage.

Activation Threshold

Depending on the make and model of the water heater, the flow rate required to activate the flow switch could be as low as 0.4 USGPM (1.5 L/min) or as high as 0.9 USGPM (3.4 L/min).

Testing Methods

To test the flow switch, check that the flow switch closes its contacts at minimum flow rate as determined by the manufacturer's literature by either viewing the display screen if the model displays flow rates or performing a flow test and slowly opening a hot water faucet.

Performing a Flow Test

Measure Flow Rate

Use a graduated container and time the fill rate.

Establish Minimum Flow

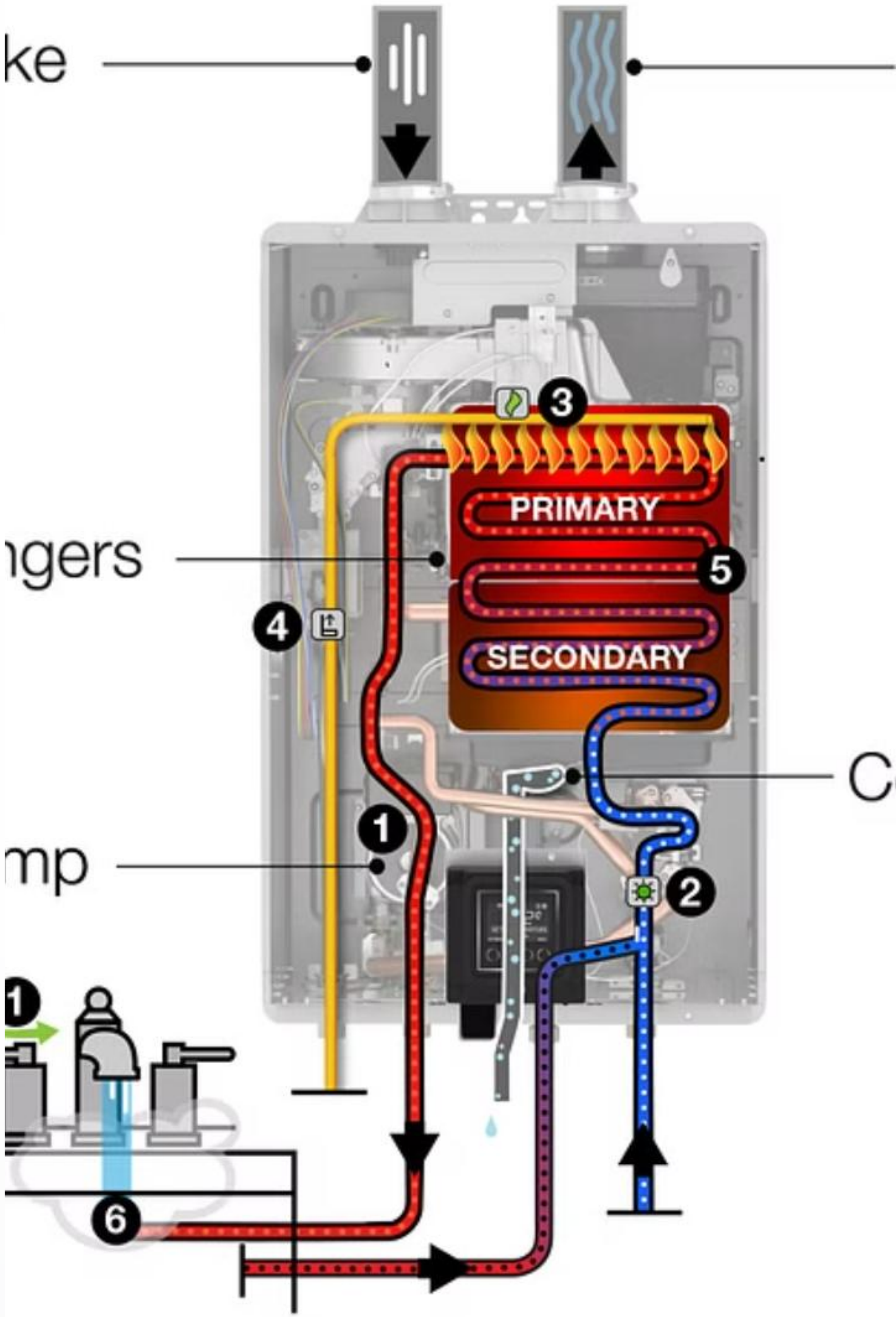
Once the minimum flow rate is established, ensure that there is sufficient voltage at both terminals of the flow switch.

Check Voltage Type

Consult the manufacturer's literature as the voltage could be either AC or DC depending on the make and model.

Test Switch Resistance

If the voltage is correct, de-energize the appliance and test the resistance through the flow switch by disconnecting the wires from the flow switch and connecting an ohmmeter. There should be no resistance through the switch when water is flowing through the heater.



Non-Electrical Problems: Gas Manifold Pressure

Importance

A number of problems that arise are a result of faults with the gas manifold pressure.

Potential Issues

If the gas manifold pressure is incorrect, it can lead to stacking, poor burner flame, and condensation.

Testing Equipment

You should use a manometer to check the manifold pressure. U-tube type and digital manometers are the most accurate.

Reference Information

You can find a list of the correct manifold pressure on the rating plate attached to the heater.

Performing a Manifold Pressure Test

Locate Test Port

Identify the manifold pressure test port on the gas control valve.

Remove Test Plug

Carefully remove the test plug from the manifold pressure port.

Connect Manometer

Insert adapter and connect manometer to the test port.

Measure Pressure

With the water heater operating, read the manifold pressure on the manometer and compare to specifications.

Adjusting the Gas Pressure Regulator

Access Adjustment Screw

Remove the regulator adjustment screw cap by inserting a screwdriver into the screw slot and rotating it counterclockwise.

Remove Sealant

Using a small screwdriver, remove the sealant from the adjustment screw top.

Connect Manometer

Connect your manometer to the test outlet of the control unit.

Adjust Pressure

With the burner operating, adjust the gas pressure as necessary. Turn the adjustment screw clockwise to increase the gas pressure or counterclockwise to decrease the pressure.

Replace Cap

Replace the adjustment screw cap when you are finished.

Checking for Stacking

Shut Off Water

Turn off the cold water supply.

Draw Sample

Draw a small amount of water from the drain valve. Check and note its temperature.

Restore Water Supply

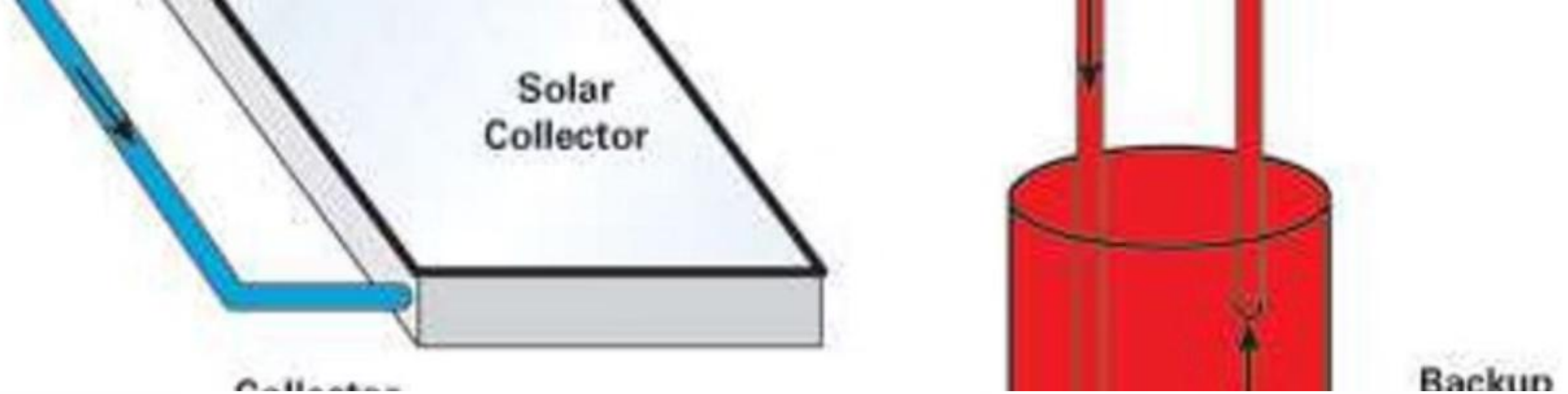
Turn on the cold water supply.

Test Hot Water

Draw water from any hot water faucet. Let the water run for a minute or two, then check and note the temperature.

Evaluate Results

If the temperature difference is greater than 25°F (14°C), there is a stacking condition.



Causes and Solutions for Stacking

Cause	Solution
Too long a dip tube	Remove the dip tube and check its length according to the manufacturer's specifications. Either correct the length or replace the tube.
Excessive liming of the tank	This is covered later, in the section on liming.
Leaky faucets from the water tank	Repair the faucet. These leaks may not always be visible, such as in the case of the drain line. Remove the drain line to check it for leaks.
Frequent draws of hot water	Limit the number of times hot water is drawn.
Repeated short cycling of the control unit	Replace the control unit.

Removing the Dip Tube

Prepare System

Turn off the cold water supply. Do not use any water until the repair job is finished.

Set Controls

Turn the control unit to the pilot position. Open a hot water faucet and wait for the water to stop flowing.

Drain Water

Draw four or five buckets of water off the system through the drain cock.

Access Dip Tube

Cut the copper tubing between the shut-off valve and cold-water inlet to the tank. Remove the dip tube.

Replace Tube

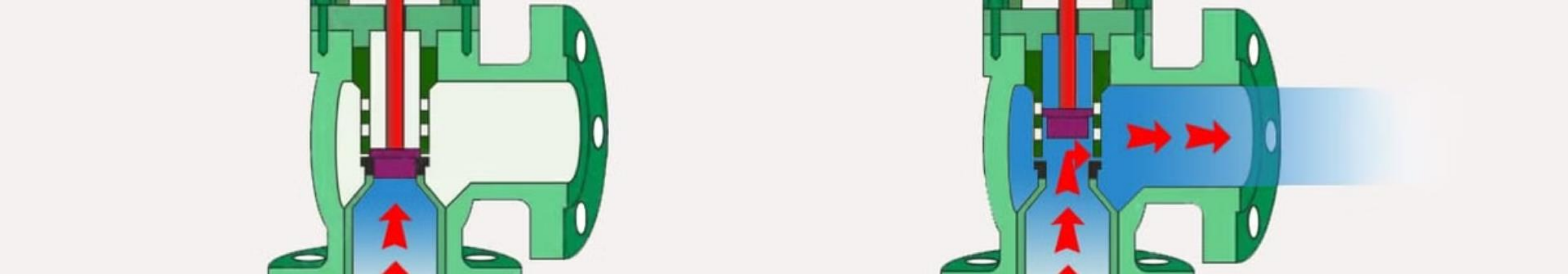
Cut the dip tube to the manufacturer's recommended length or replace it with a longer one. Apply Teflon tape or non-metallic pipe dope to dip tube threads, and install the dip tube in the tank.

Reconnect Plumbing

Re-solder the copper. When soldering the last joint, wrap a wet rag around the pipe to prevent the heat from reaching the dip tube.

Restore System

Turn on the cold water supply. Turn on a hot water faucet until water flows continuously. Check for water leaks. Turn the control unit to the on position.



Relief Valve Discharge Problems

Problem	Solution
Stacking	Refer to the Stacking section.
Too high temperature setting for the off position on the control unit	Recalibrate the control unit. If this does not work, replace the control unit.
Control unit sticking in the on position	Check the control unit by rotating the dial on and off a few times. If it is sticking in the on position, you will need to replace it.
A buildup of lime on the T&P relief valve	Replace the relief valve.

Relief Valve Replacement Procedure

Shut Off Gas

Turn the main gas valve off.

Cool System

Draw off enough hot water to ensure that the water at the control unit location is cold.

Shut Off Water

Turn the cold-water inlet valve off. Open a hot water faucet until no water flows. This is very important. Close the hot water faucet.

Prepare New Valve

Apply non-metallic pipe dope to the thread of the valve that you will be using to replace it with.

Remove Old Valve

Place a bucket under the point you will be working at to prevent water damage. Remove the faulty valve.

Install New Valve

Insert the new valve into the tapping and tighten.

Restore System

Turn on the cold water supply. Turn on a hot water faucet until the water starts to flow. Turn on the gas and check for leaks. Relight the pilot and check the manifold pressure.

Low Water Temperature Problems

Problem	Solution
The burner may be clogged.	Clean the burner.
The orifice may be too small.	Check the recommended size of the orifice on the rating plate and resize it.
The gas pressure may be too low.	Increase the gas pressure.
The temperature setting on the control unit is set too low.	This should have been checked first. Increase the temperature setting.
Too many people are making use of the water tank.	In this case, the water is not getting enough time to reach the desired temperature. Recommend that the tank be replaced with a bigger tank if this is possible in the space provided.
The control unit may be out of calibration.	Check to see if it is out of calibration, and if so, recalibrate it.

Checking Control Unit Calibration

Initiate Heating Cycle

Draw off enough hot water to ensure that the burner is operating.

Allow Cycling

Allow the thermostat to cycle the burner off.

Set Temperature

Manually turn the thermostat dial to the 130°F (54°C) mark.

Shut Off Water

Turn off the cold water supply.

Check Temperature

Check the hot water temperature at the drain valve.

Evaluate Results

If you find that the thermostat is more than 20°F (8°C) out of calibration, you will need to recalibrate it.

Calibrating a Control Unit

Set Initial Temperature

Turn the temperature dial to the 130°F (54°C) mark. If the temperature of the water is so high that the burner will not come on, run enough hot water from a faucet to cause the thermostat to turn the burner on. Then, allow the burner to operate until the thermostat shuts it off.

Prepare for Testing

Close off the cold water supply. Open the nearest hot water faucet to break the air lock.

Measure Temperature

Slowly open the drain valve until a flow of water just sufficient to cover the thermometer bulb is obtained. Wait for the temperature on the thermometer to stabilize and make a note of it.

Adjust Dial

Turn the temperature dial to correspond to the temperature that you measured. Remove the temperature dial, mark the location of the stop, and replace the dial.

Test Operation

Turn the dial clockwise until the control snaps on. Turn the dial counterclockwise slowly until the control just snaps off.

Finalize Calibration

Remove the temperature dial while holding the stop to prevent rotation. Carefully loosen the stop adjustment nut. Taking care not to move the temperature adjusting screw, turn the stop until it corresponds with the reference mark you made.

Verify Calibration

Replace the temperature dial. The actual water temperature should now be indicated. It is a good procedure to check the water temperature again.

Insufficient Hot Water Problems

Temperature Settings

- Temperature dial is set below the required temperature
- Control unit is out of calibration

Gas Supply Issues

- Manifold pressure is lower than the rating shown on the plate
- Main burner flame is dirty or carboned

Tank and Component Problems

- Tank is excessively limed
- Dip tube is broken or cracked
- Dip tube is installed incorrectly
- Dip tube has the incorrect length
- Second dip tube installed on hot water outlet
- Hot and cold water lines are crossed

Capacity and Efficiency Issues

- Heater capacity is insufficient for the number of people
- Heat loss results from long runs of uninsulated pipe
- Differential on control unit is out of range

Venting System Checks

Draft Hood

Check to see if a draft hood is required and in place. If not, it needs to be added to the system. Ensure the draft hood has not been damaged or in any way altered.

Draft Test

Check that the vent is working. Ensure that the burner has been on for at least 10 minutes. Light a smoke generator and hold it at the draft hood opening. The smoke should be drawn into the draft hood.

Vent Pipe Inspection

Check the venting pipes which may be broken or have too many bends. This will need fixing. Consult manufacturer's literature for correct venting layout.

Termination Check

The venting system might not be terminated properly, leading to a positive pressure being formed in the vent. This may happen only occasionally, such as on windy days.

Temperature Evaluation

The water heater may not be hot enough. The resulting warm air is then unable to rise naturally through the system.

Common Water Heater Leakage Points

Draft Hood and Flue

Water here could be a result of rainwater leaking in. You should also check for condensation, which may cause further problems.

Piping Connections

If there is a leak here, turn off the water and gas supplies and drain the tank in a proper manner. Disconnect the piping, apply pipe joint compound, and replace.

Drain Valve

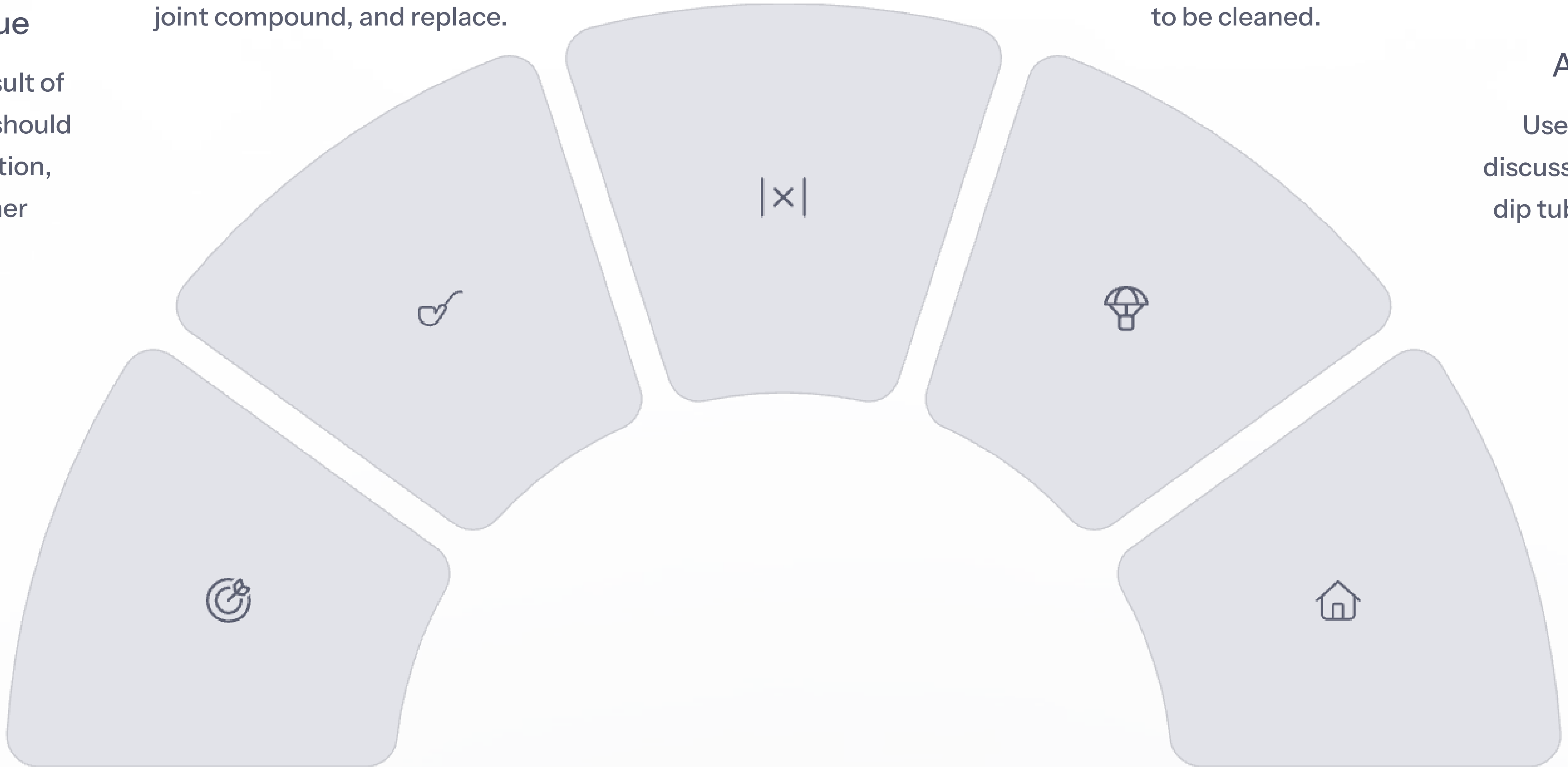
A leak here could be a result of a bad gasket, a loose packing nut, or a valve that is slightly open. Tighten the handle first. If the leak persists, the valve is faulty and needs replacement.

T&P Relief Valve

This often results from a T&P relief valve that is operating properly. There may also be some dirt on the valve seat that needs to be cleaned.

Anode Rod Fitting

Use the procedure that was discussed earlier for removing the dip tube to remove, replace, and reseal the anode.



Condensation Problems

Low Manifold Pressure

The manifold pressure could be too low. Check the manifold pressure. If the measured pressure is lower than stated on the rating plate, you will need to adjust the manifold pressure.

Burner Orifice Issues

The main burner orifice could be blocked or smaller than the recommended size. If it is blocked, you must clean it. If the orifice is smaller than the recommended size, you should install the correct size orifice.

Flue Obstruction

The flue could have an obstruction. If you find one, remove it.

Inadequate Draft

Ensure that the draft is adequate, and perform a flue gas analysis.

Note: When a storage-type water heater is initially activated and the water in the tank is cold, condensation may form. However, once most of the water is heated, the condensation should cease.

Liming in Water Heaters

What is Liming?

Water contains a number of impurities. As there is more heat applied to the water, more of these minerals (calcium and magnesium) are removed from the water. These minerals build up as calcium carbonate (limescale) on the bottom of the tank.

Effects of Liming

This buildup acts as an insulator and reduces the efficiency of the tank, causing higher stack (vent) temperatures. One sign of liming is a rumbling and crackling noise coming from the tank, which is caused when water penetrates the layer of limescale and meets the hot surface of the water heater.

Prevention

You can use a water softener to prevent limescale formation. This reduces the number of hardness minerals in the water.

Resolution

If there is a lime buildup in the tank, and it is not excessive, you can clean it. If the tank is excessively limed, you will have to replace it.

De-Liming a Water Heater Tank

Prepare Tank

Shut off the power, gas, and water supply to the tank. Completely drain the tank of water.

Create Access Points

Remove the drain valve and install a 6 inch nipple in its place. Remove the anode. If there is no other apparent opening on the tank, remove either the hot or cold water nipple.

Initial Cleaning

Use a small pressure washer to flush out as much scale and lime as possible. You can do this by inserting the pressure washer through one of the holes and then shining a light through the other hole to see what you are doing.

Chemical Treatment

Once you have removed as much lime and scale as possible, plug the nipple installed at the drain valve and add either muriatic acid or pickling vinegar to the tank. Allow it to stand.

Final Cleaning

After this de-liming solution has stood for a while, unplug the nipple and allow the tank to drain. Once again, use the pressure washer to flush out the tank.

Reassembly

Replace the drain valve, anode, and any other parts that you removed. Turn on the water. Fill the tank with water. Turn on the power and gas. Start the water heater.

System Flush

Remove the faucet aerators. Flush out the hot water lines. Replace the faucet aerators.

Corrosion in Water Heaters

Prevention

Use the anode to prevent corrosion in the tank. If you notice that the tank is corroding, then it is possible that water softener with an incorrect pH has been added to the tank or the anode is no longer working.

Water Softener Issues

If water softener with the wrong pH is being used and is removing too many of the impurities, you must replace it with water softener with the correct pH.

Anode Rod Function

If the anode is not working, you will need to replace it.

Flue and Vent System Corrosion

Cause of Corrosion

If the air for combustion contains certain chemical vapours that break down into acids during the combustion process and bond with the water vapour of the fuel gas, these acids will corrode the flue and vent systems.

Common Corrosive Chemicals

- Spray-can repellents
- Cleaning solvents
- Bleaches
- Refrigerants
- Swimming pool chemicals
- Calcium
- Sodium chloride (salt)
- Waxes
- Process chemicals

Prevention

You should make every effort to prevent these substances from coming into contact with the flue and vent system or the air for combustion.

Carbon Monoxide Hazards

What is Carbon Monoxide?

Carbon monoxide is a colourless toxic gas. If enough of it is inhaled, it can cause death. One of the problems with carbon monoxide gas is that it is invisible and has no taste or odour, so it is extremely hard to detect.

Primary Cause

The most common reason for the formation of carbon monoxide is when there is not enough oxygen to burn the fuel gas completely, leaving some of the fuel in the flue gas.

Temperature Factors

Another factor that leads to the formation of carbon monoxide is if the temperature of combustion of the fuel gas is too low. For natural gas, the combustion process must maintain a temperature of approximately 1200°F (649°C).

Venting Issues

If the venting is blocked in any way, or the gases are not properly vented, the flue gases will not be able to reach the outdoors and will remain in the room.

Incomplete Combustion and Carbon Monoxide

Insufficient Oxygen

When there is not enough oxygen to burn the fuel gas completely, carbon monoxide forms instead of carbon dioxide.

Gas Recirculation

Flue gas spillage can re-circulate through the combustion chamber, resulting in a lack of combustion air and further carbon monoxide production.

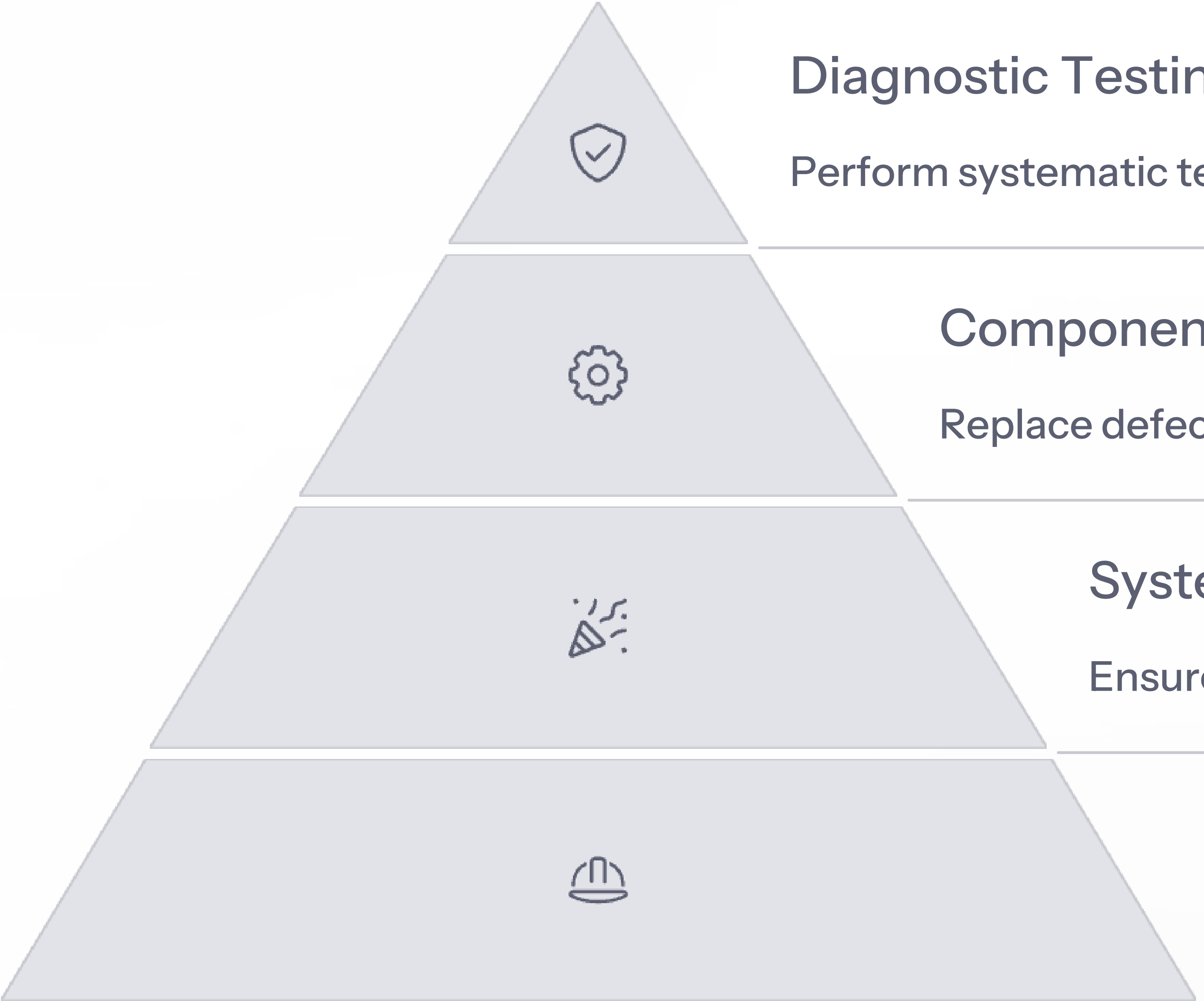
Low Combustion Temperature

If the flame is quenched (cooled due to too much excess air or flame contact with a cooler surface) below 1200°F (649°C), combustion is incomplete.

Venting Problems

Blocked or improper venting prevents flue gases from escaping, causing them to recirculate through the combustion chamber.

Servicing Electrical Components Overview



Diagnostic Testing

Perform systematic testing of electrical components

Component Replacement

Replace defective thermocouples, sensors, and switches

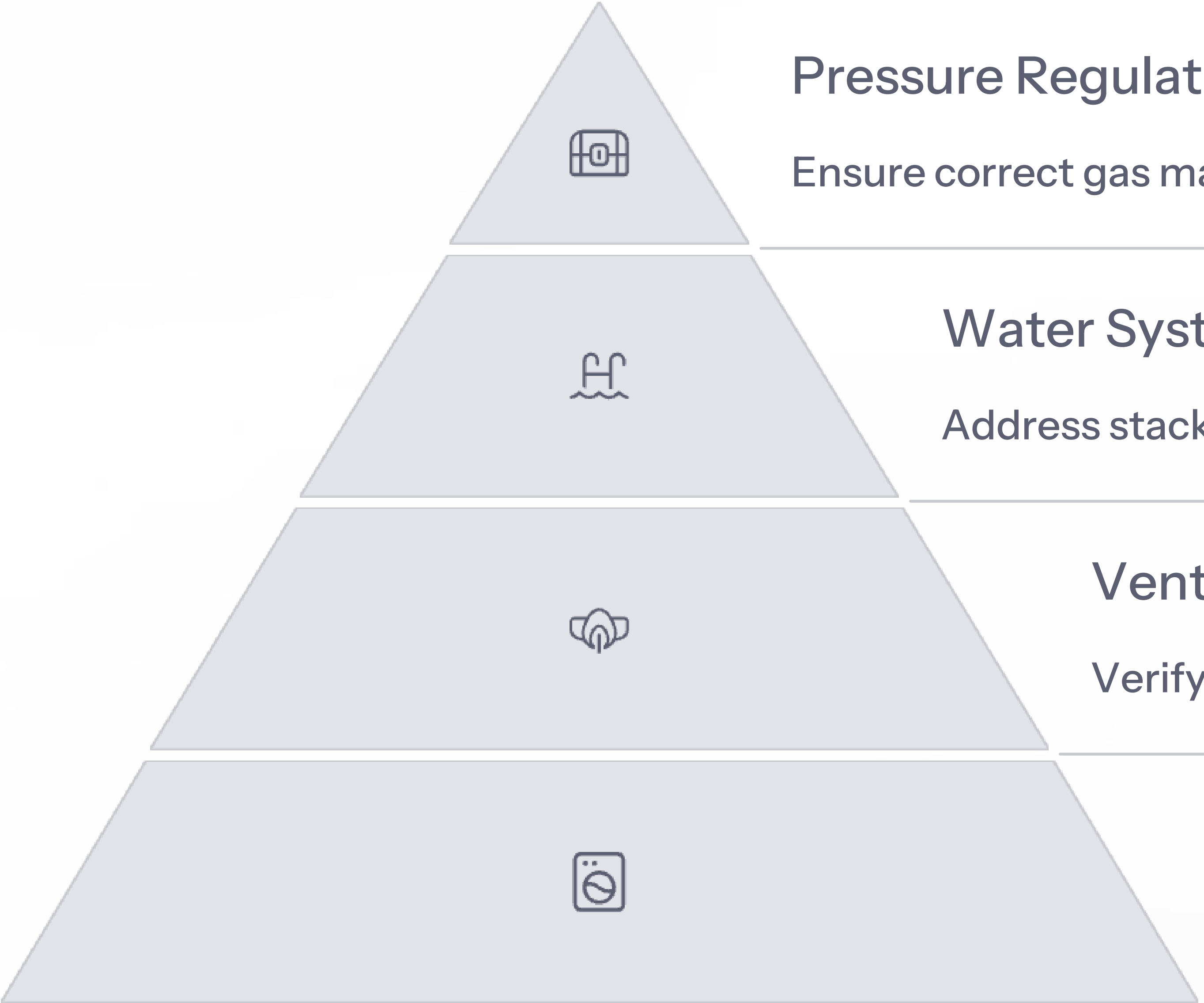
System Calibration

Ensure accurate temperature and pressure settings

Safety Verification

Confirm proper operation of all safety devices

Non-Electrical Servicing Overview



Pressure Regulation

Ensure correct gas manifold pressure

Water System Maintenance

Address stacking, leaks, and valve issues

Venting System Inspection

Verify proper draft and vent configuration

Tank Maintenance

Remove limescale and prevent corrosion

Tankless Water Heater Servicing

Error Code Diagnosis

Interpret error codes displayed on the unit to identify specific faults.

Thermistor Testing

Verify temperature sensor resistance values at different temperatures.

Flow Sensor Verification

Ensure proper activation at minimum flow rates.

Heating Element Inspection

Test freeze protection heating elements for correct resistance.

Water Heater Safety Devices

Temperature and Pressure Relief Valve

Automatically opens a relief vent when either pressure or temperature reaches a predetermined value.

Energy Cut-Off (ECO)

A fusible link that breaks the circuit if water temperature exceeds the preset limit (usually 200°F or 94°C).

Thermal Cut-Off (TCO)

Shuts down the unit if excessive temperatures are detected in the combustion chamber.

Flammable Vapor Sensor

Detects flammable vapors near the air intake and shuts off gas supply to prevent ignition.

High-Limit Switch

Ensures sufficient draft is being created through the appliance and into the venting.

Common Water Heater Problems and Solutions

Water Heater Maintenance Schedule

Maintenance Task	Frequency
Test T&P relief valve	Annually
Inspect anode rod	Every 2 years
Flush tank to remove sediment	Every 6 months
Check gas pressure	Annually
Inspect venting system	Annually
Test safety devices	Annually
Check for water leaks	Monthly
Calibrate temperature controls	As needed

Water Heater Preventive Maintenance Checklist

Company Name

Location of Water Heater

Water Heater Model and Serial Number

Contact Information for Service

Emergency Contact Number

Next Scheduled Review

Task	Description	Frequency	(✓/X)
Visual and General Inspections			
General Visual Inspection	Examine the heater for any signs of leaks, corrosion, or external damage.	Bi-annual	☐
Area Inspection	Ensure the area around the heater is clear of any flammable materials.	Bi-annual	☐
Insulation Inspection	Check and improve insulation around pipes and the heater if necessary.	Bi-annual	☐
Noise Check	Listen for any unusual noises which might indicate a problem.	Bi-annual	☐
			☐
			☐
			☐
Safety and Performance Checks			
Pressure Relief Valve Test	Ensure the valve operates correctly to prevent overpressure.	Bi-annual	☐
Thermostat Setting Verification	Confirm optimal temperature settings for efficiency.	Bi-annual	☐
T&P Pipe Inspection	Examine the temperature and pressure pipe for blockages or leaks.	Bi-annual	☐
Emergency Shut-Off Procedure Check	Confirm that all household members know how to shut off the heater.	Annually	☐
			☐
			☐

Water Heater Efficiency Factors

30%

Energy Savings

Potential reduction in energy use with proper maintenance

15%

Efficiency Loss

Typical efficiency reduction due to limescale buildup

8-12

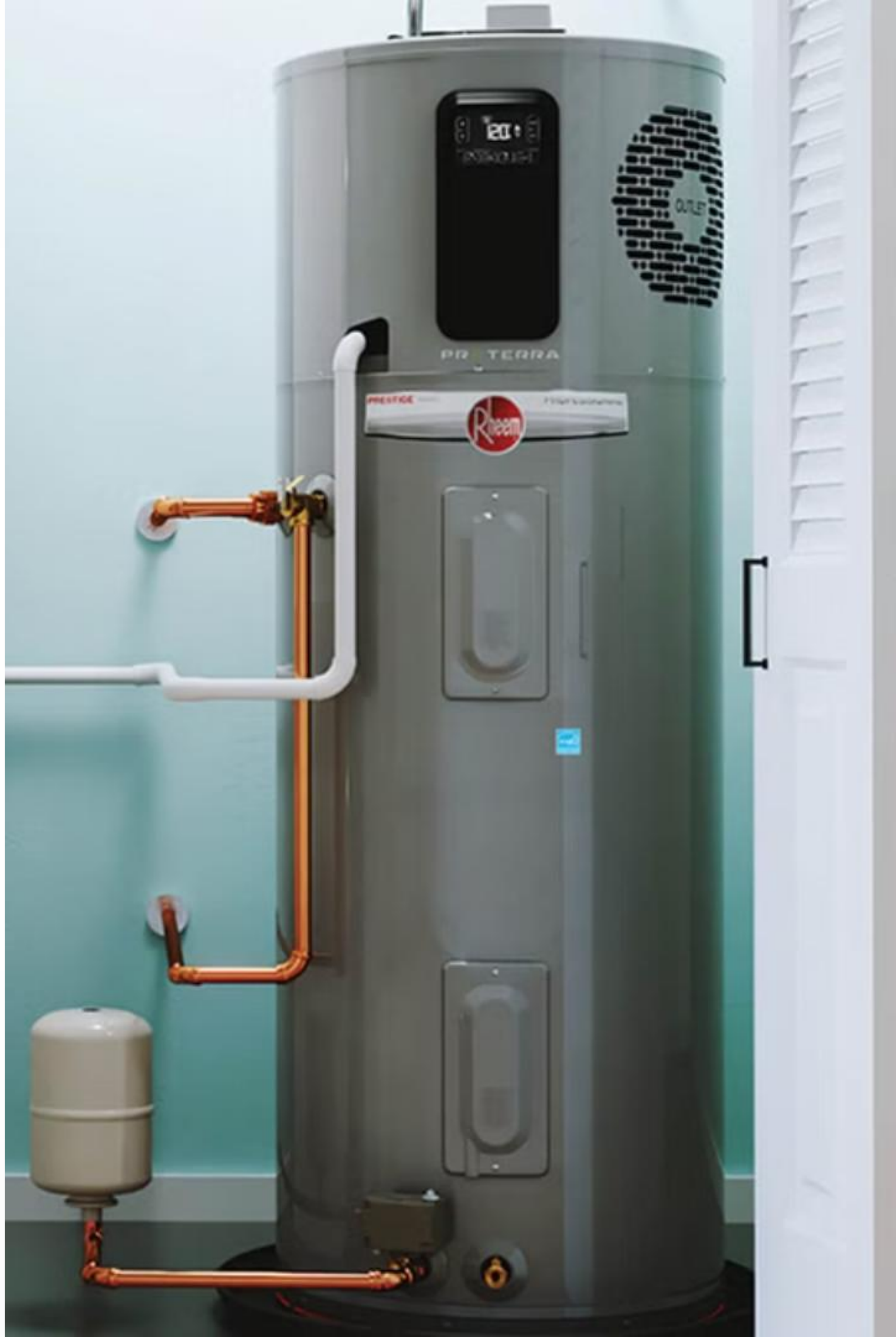
Years

Average lifespan of a well-maintained water heater

140°F

Maximum Safe Temperature

Recommended maximum setting to prevent scalding



Water Heater Troubleshooting Decision Tree

Identify the Problem

Determine if the issue is related to no hot water, insufficient hot water, water temperature, leaks, or unusual noises.

Check Electrical Components

Test thermocouple, ECO, TCO, and other electrical components if there is no hot water.

Verify Gas Supply

Check gas pressure, orifice size, and burner condition if water is not hot enough.

Inspect Water System

Look for leaks, stacking, dip tube issues, or limescale if there is insufficient hot water.

Examine Venting

Ensure proper draft, check for blockages, and verify correct termination if there are combustion issues.

Water Heater Component Replacement Guide






When replacing water heater components, always follow manufacturer guidelines and local codes. Ensure the appliance is de-energized and gas supply is shut off before beginning work. Use appropriate tools and replacement parts designed specifically for the model being serviced.

Water Heater Venting Systems

Natural Draft (Category I)

Uses the natural buoyancy of hot flue gases to create draft. Requires a properly sized and installed draft hood. Most common in residential applications.

Power Vented (Category III)

Uses a fan to force combustion products through the vent system. Can be vented horizontally through a sidewall. Requires electrical connection for the fan motor.

Direct Vent (Category IV)

Draws combustion air directly from outside and vents products of combustion to the outside through a sealed system. Ideal for installations where indoor air quality is a concern.

Water Quality Effects on Water Heaters

Hard Water

Contains high levels of dissolved minerals, primarily calcium and magnesium. Causes limescale buildup on heating elements and tank bottom, reducing efficiency and potentially causing premature failure.

- Reduces heat transfer efficiency
- Creates rumbling noises
- Shortens equipment lifespan

Acidic Water

Water with pH below 7.0 can be corrosive to metal components. Accelerates corrosion of tank lining, anode rod, and fittings.

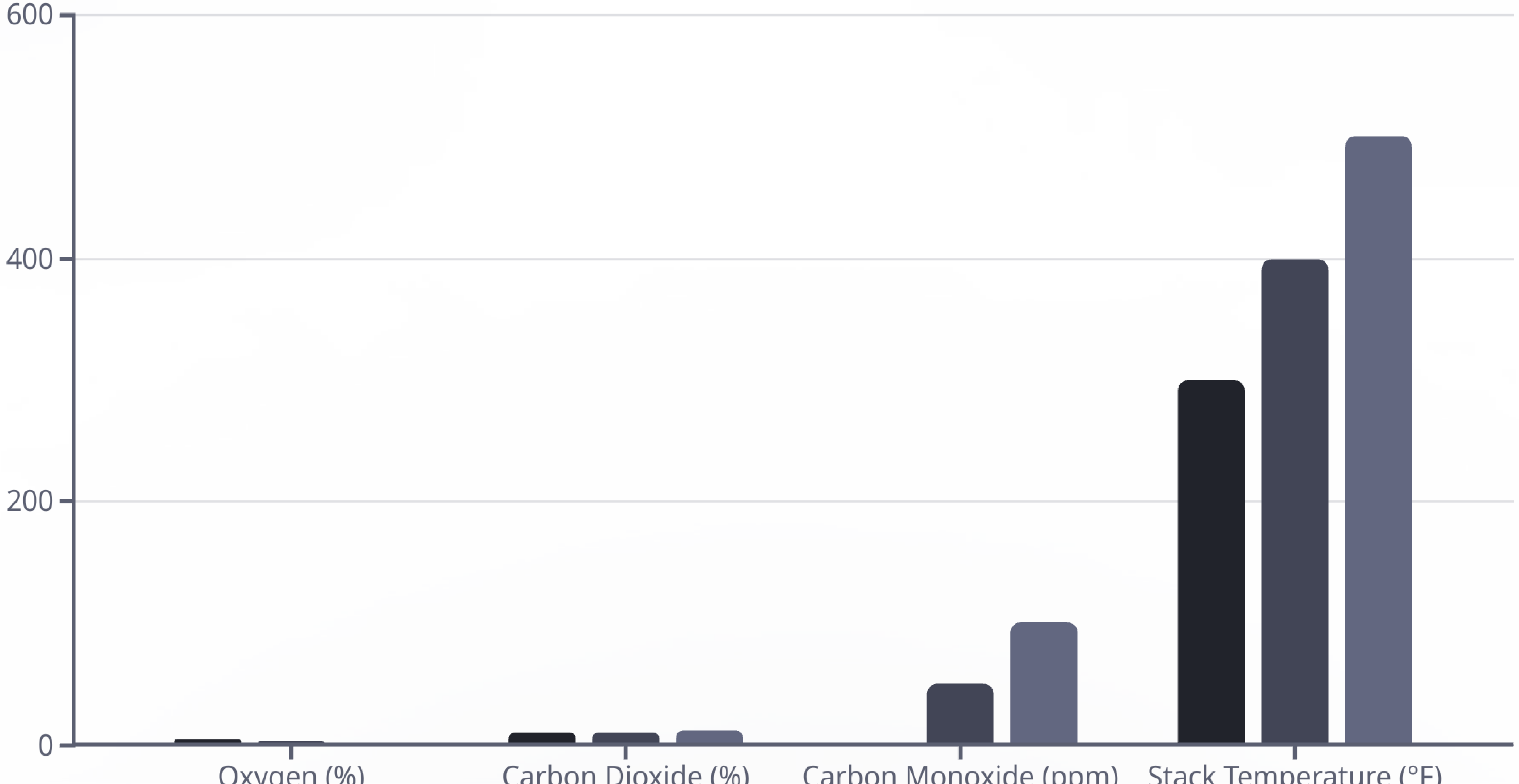
- Accelerates anode rod depletion
- Damages tank lining
- Creates pinhole leaks

High Mineral Content

Water with high levels of iron, manganese, or sulfur can cause discoloration, odors, and deposits. May affect water quality and heater performance.

- Creates sediment buildup
- Produces odors
- Discolors water

Combustion Analysis for Water Heaters



Water Heater Safety Precautions

Electrical Safety

Always de-energize the appliance before servicing electrical components. Use appropriate testing equipment to verify power is off. Never bypass safety devices or controls.

Gas Safety

Shut off gas supply before servicing. Test for gas leaks after service using approved methods. Never use open flames to check for leaks. Ensure proper combustion air supply.

Scalding Prevention

Set water temperature no higher than 120°F (49°C) to prevent scalding. Install anti-scald devices at points of use if higher tank temperatures are needed.

Carbon Monoxide

Verify proper venting to prevent carbon monoxide hazards. Install carbon monoxide detectors near appliance. Address any venting or combustion issues immediately.

Advanced Diagnostic Techniques

Visual Inspection

Examine components for visible damage, corrosion, or improper installation

Electrical Testing

Measure resistance, voltage, and current at key components

Combustion Analysis

Measure O_2, CO_2, CO, and stack temperature

Pressure Testing

Verify gas pressure and water pressure are within specifications

Flow Analysis

Measure water flow rates and patterns through the system

Water Heater Installation Requirements

Proper Location

Install in a clean, dry location with adequate clearances from combustible materials. Provide access for service and maintenance.

Venting System

Install according to manufacturer's instructions and local codes. Ensure proper sizing, support, and termination.

Gas Supply

Provide properly sized gas line with appropriate shutoff valve. Verify correct gas type and pressure.

Water Connections

Install shutoff valves on both hot and cold connections. Include unions for service access. Install T&P relief valve and proper discharge piping.

Electrical Requirements

Provide dedicated circuit if required. Ensure proper grounding. Follow all electrical codes.

Safety Devices

Install all required safety devices including T&P relief valve, vacuum relief if needed, and expansion tank if required by local code.

Water Heater Technology Evolution

1

Traditional Storage

Conventional tank-type water heaters with standing pilot ignition and basic controls.

2

High-Efficiency Storage

Improved insulation, electronic ignition, and better heat transfer for higher efficiency ratings.

3

Tankless On-Demand

Eliminates standby heat loss by heating water only when needed. Modulating controls for precise temperature.

4

Condensing Technology

Captures heat from exhaust gases to improve efficiency above 90%. Requires special venting and condensate management.

5

Smart Connected

Wi-Fi enabled controls, remote monitoring, predictive maintenance, and integration with home automation systems.

Professional Development for Water Heater Technicians

Basic Certification

Obtain fundamental gas technician/fitter certification and licensing required by local authorities. Learn basic principles of combustion, venting, and water heating.

Manufacturer Training

Complete product-specific training from major water heater manufacturers. Learn installation, troubleshooting, and repair procedures for specific models and technologies.

Advanced Diagnostics

Master the use of advanced diagnostic tools including combustion analyzers, digital manometers, and electronic testing equipment. Develop systematic troubleshooting methodologies.

Continuing Education

Stay current with evolving technologies, code changes, and industry best practices through ongoing professional development and certification renewal courses.