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BOARD OF RULES AND APPEALS

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To: Members of the Plumbing Technical Advisory Committee.

Mr. James Terry Mr. Cary Bauer Mr. Tim Fallon Mr. Albert Korelishn
Mr. Daniel Rourke Mr. Gregg D'Attile Mr. Gary Kozan Mr. Richard Bong
Mr. Carl Rasmussen Mr. Jason Miller Ms. Lynn Wolfson Mr. Alan Corriveau
Mr. Timothy A. Reger

Staff: Jose Cruz-Vellon, Chief Plumbing Code Compliance Officer
Timothy De Carion, Chief Energy Code Compliance Officer
Maria "Pat" Kong, Administrative Specialist

Date: August 11, 2022

Subject: Water for public hand-washing facilities, and the developed length of hot or tempered water supply piping from the source of hot water.

The Chairman of the Plumbing TAC Committee, Mr. James Terry has called for a meeting on Wednesday August 31, 2022, from 1:30 pm to 3:00 pm. The meeting will be held via zoom.

AGENDA

New Committee Member Introduction, Timothy A. Reger.

Roll Call

Guest Speaker: Chief Energy Code Compliance Officer, Timothy De Carion.

Business Items

Item 1: Water for public hand-washing facilities. Code reference in question FBC 419.5 & 607.1

1a. Mr. Albert Korelishn request for clarification on the Interpretation. Pg.2
1b. FBC 419.5 Water for public hand-washing facilities. Pg.3
1c. FBC 607.1 Where required. Pg.4
1d. FBC 102.1 General. Scope & Administration. Pg.5
1e. BOAF informal interpretation concerning cold or tempered water for public handwashing. Pg.6

Item 2: Developed length of hot or tempered water supply piping from source of hot water.

Residential occupancies.

2a. P2905 Heated water distribution systems. (Residential Code) Pg.7
2b. R403.5 Service hot water systems. (Residential Energy Code) Pg.8
2c. P2905.3 Length of hot water piping to fixture. Illustration Pg.10
2d. SEDAC. Smart Energy Design Assistance Center. Illustration Pg.11

Non-residential occupancies.

2e. FBC.607.2 Hot or tempered water supply to fixture. Pg.13-14
2f. FBC Energy. C404.5, C404.5.1, C404.5.2 Efficient heated water supply piping. Pg.15
2g. FBC Energy. C404 Service Water Heating & Commentary (Mandatory). Pg.17-23

General Discussion

Schedule Next Meeting

Adjournment

Sunshine Law Reminder: *Advisory Board members cannot communicate with each other on a possible committee or Board topic outside of a public meeting, per State statute.*

ITEM 1

Water for public hand-washing facilities. Code reference in question FBC 419.5 & 607.1

From: Albert Korelishn <akorelishn@aol.com>
Sent: Friday, May 6, 2022 6:07 AM
To: Dipietro, James <JDIPIETRO@broward.org>
Subject: clarification & iillustration of

Good morning James,

There is some confusion in the interpretation of the hot water requirements for establishments other than single family residences. Perhaps your new Plumbing Code Compliance Officer can furnish an illustration depicting different methods to meet the Florida Energy Code.

An additional problem is the need for a county wide permit for water heater REPLACEMENTS.
This is an old problem that needs to addressed.

Appreciatively yours,
Albert C. korelishn

417.2 Waste connection. Garbage can washers shall be trapped separately. The receptacle receiving the waste from the washer shall have a removable basket or strainer to prevent the discharge of large particles into the drainage system.

SECTION 418
LAUNDRY TRAYS

418.1 Approval. Laundry trays shall conform to ASME A112.19.1/CSA B45.2, ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124.

418.2 Waste outlet. Each compartment of a laundry tray shall be provided with a waste outlet not less than $1^1/_2$ inches (38 mm) in diameter and a strainer or crossbar to restrict the clear opening of the waste outlet.

SECTION 419
LAVATORIES

419.1 Approval. Lavatories shall conform to ASME A112.19.1/CSA B45.2, ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124. Group wash-up equipment shall conform to the requirements of Section 402. Every 20 inches (508 mm) of rim space shall be considered as one lavatory.

419.2 Cultured marble lavatories. Cultured marble vanity tops with an integral lavatory shall conform to CSA B45.5/IAPMO Z124.

419.3 Lavatory waste outlets. Lavatories shall have waste outlets not less than $1^1/_4$ inches (32 mm) in diameter. A strainer, pop-up stopper, crossbar or other device shall be provided to restrict the clear opening of the waste outlet.

419.4 Moveable lavatory systems. Moveable lavatory systems shall comply with ASME A112.19.12.

419.5 Water for public hand-washing facilities. Cold or *tempered water* shall be delivered from lavatories and group wash fixtures located in public toilet facilities provided for customers, patrons and visitors. *Tempered water* shall be delivered through an *approved* water-temperature limiting device that conforms to ASSE 1070 or CSA B125.3.

SECTION 420
MANUAL FOOD AND BEVERAGE DISPENSING EQUIPMENT

420.1 Approval. Manual food and beverage dispensing equipment shall conform to the requirements of NSF 18.

SECTION 421
SHOWERS

421.1 Approval. Prefabricated showers and shower compartments shall conform to ASME A112.19.2/CSA B45.1 or CSA B45.5/IAPMO Z124. Shower valves for individual showers shall conform to the requirements of Section 412.3.

421.2 Water supply riser. Water supply risers from the shower valve to the shower head outlet, whether exposed or concealed, shall be attached to the structure. The attachment to the structure shall be made by the use of support devices designed for use with the specific piping material or by fittings anchored with screws.

421.3 Shower waste outlet. Waste outlets serving showers shall be not less than $1^1/_2$ inches (38 mm) in diameter and, for other than waste outlets in bathtubs, shall have removable strainers not less than 3 inches (76 mm) in diameter with strainer openings not less than $^1/_4$ inch (6.4 mm) in least dimension. Where each shower space is not provided with an individual waste outlet, the waste outlet shall be located and the floor pitched so that waste from one shower does not flow over the floor area serving another shower. Waste outlets shall be fastened to the waste pipe in an *approved* manner.

421.4 Shower compartments. Shower compartments shall be not less than 900 square inches (0.58 m^2) in interior cross-sectional area. Shower compartments shall be not less than 30 inches (762 mm) in least dimension as measured from the finished interior dimension of the compartment, exclusive of fixture valves, showerheads, soap dishes and safety grab bars or rails. Except as required in Section 404, the minimum required area and dimension shall be measured from the finished interior dimension at a height equal to the top of the threshold and at a point tangent to its centerline and shall be continued to a height not less than 70 inches (1778 mm) above the shower drain outlet.

Exception: Shower compartments having not less than 25 inches (635 mm) in minimum dimension measured from the finished interior dimension of the compartment, provided that the shower compartment has not less than 1,300 square inches (0.838 m^2) of cross-sectional area.

421.4.1 Floor and wall area. Bathtub floors, shower floors, wall areas above built-in tubs that have installed shower heads and walls in shower compartments shall be constructed of smooth, corrosion-resistant and nonabsorbent waterproof materials. Wall materials shall extend to a height of not less than 6 feet (1829 mm) above the room floor level, and not less than 70 inches (1778 mm) above the drain of the tub or shower. Such walls shall form a water-tight joint with each other and with either the tub or shower floor.

421.4.2 Access. The shower compartment access and egress opening shall have a clear and unobstructed finished width of not less than 22 inches (559 mm). Shower compartments required to be designed in conformance to accessibility provisions shall comply with Section 404.1.

421.5 Shower floors or receptors. Floor surfaces shall be constructed of impervious, noncorrosive, nonabsorbent and waterproof materials.

421.5.1 Support. Floors or receptors under shower compartments shall be laid on, and supported by, a smooth and structurally sound base.

421.5.2 Shower lining. Floors under shower compartments, except where prefabricated receptors have been provided, shall be lined and made water tight utilizing material complying with Sections 421.5.2.1 through 421.5.2.6. Such liners shall turn up on all sides not less

1c.

for overflow pipes and shall not be smaller in size than specified in Table 606.5.7.

TABLE 606.5.7
SIZE OF DRAIN PIPES FOR WATER TANKS

TANK CAPACITY (gallons)	DRAIN PIPE (inches)
Up to 750	1
751 to 1,500	$1^1/_2$
1,501 to 3,000	2
3,001 to 5,000	$2^1/_2$
5,000 to 7,500	3
Over 7,500	4

For SI: 1 inch = 25.4 mm, 1 gallon = 3.785 L.

606.5.8 Prohibited location of potable supply tanks. Potable water gravity tanks or manholes of potable water pressure tanks shall not be located directly under any soil or waste piping or any source of contamination.

606.5.9 Pressure tanks, vacuum relief. All water pressure tanks shall be provided with a vacuum relief valve at the top of the tank that will operate up to a maximum water pressure of 200 psi (1380 kPa) and up to a maximum temperature of 200°F (93°C). The size of such vacuum relief valve shall be not less than $^1/_2$ inch (12.7 mm).

Exception: This section shall not apply to pressurized captive air diaphragm/bladder tanks.

606.5.10 Pressure relief for tanks. Every pressure tank in a hydropneumatic pressure booster system shall be protected with a pressure relief valve. The pressure relief valve shall be set at a maximum pressure equal to the rating of the tank. The relief valve shall be installed on the supply pipe to the tank or on the tank. The relief valve shall discharge by gravity to a safe place of disposal.

606.6 Water supply system test. Upon completion of a section of or the entire water supply system, the system, or portion completed, shall be tested in accordance with Section 312.

606.7 Labeling of water distribution pipes in bundles. Where water distribution piping is bundled at installation, each pipe in the bundle shall be indentified using stenciling or commercially available pipe labels. The identification shall indicate the pipe contents and the direction of flow in the pipe. The interval of the identification markings on the pipe shall not exceed 25 feet (7620 mm). There shall be not less than one identification label on each pipe in each room, space or story.

SECTION 607
HOT WATER SUPPLY SYSTEM

607.1 Where required. In residential *occupancies*, *hot water* shall be supplied to plumbing fixtures and equipment utilized for bathing, washing, culinary purposes, cleansing, laundry or building maintenance. In nonresidential *occupancies*, *hot water* shall be supplied for culinary purposes, cleansing, laundry or building maintenance purposes. In nonresidential *occupancies*, *hot water* or *tempered water* shall be supplied for bathing and washing purposes.

607.1.1 Temperature limiting means. A thermostat control for a water heater shall not serve as the temperature limiting means for the purposes of complying with the requirements of this code for maximum allowable *hot* or *tempered water* delivery temperature at fixtures.

607.1.2 Tempered water temperature control. *Tempered water* shall be supplied through a water temperature limiting device that conforms to ASSE 1070 and shall limit the *tempered water* to a maximum of 110°F (43°C). This provision shall not supersede the requirement for protective shower valves in accordance with Section 412.3.

607.2 Hot or tempered water supply to fixtures. The *developed length* of *hot* or *tempered water* piping, from the source of hot water to the fixtures that require *hot* or *tempered water*, shall not exceed 50 feet (15 240 mm). Recirculating system piping and heat-traced piping shall be considered to be sources of *hot* or *tempered water*.

607.2.1 Circulation systems and heat trace systems for maintaining heated water temperature in distribution systems. For Group R2, R3 and R4 occupancies that are three stories or less in height above grade plane, the installation of heated water circulation and temperature maintenance systems shall be in accordance with Section R403.5.1 of the *Florida Building Code, Energy Conservation*. For other than Group R2, R3 and R4 occupancies that are three stories or less in height above grade plane, the installation of heated water circulation and heat trace systems shall be in accordance with Section C404.6 of the *Florida Building Code, Energy Conservation*.

607.2.1.1 Pump controls for hot water storage systems. The controls on pumps that circulate water between a water heater and a storage tank for heated water shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

607.2.1.2 Demand recirculation controls for distribution systems. A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe shall be a demand recirculation water system. Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture, or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The control shall limit the temperature of the water entering the cold water piping to 104°F (40°C).

607.2.2 Piping for recirculation systems having master thermostatic valves. Where a thermostatic mixing valve is used in a system with a hot water recirculating pump, the *hot water* or *tempered water* return line shall be routed to the cold water inlet pipe of the water heater and the cold

CHAPTER 1
SCOPE AND ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION 101
GENERAL

[A] 101.1 Title. These regulations shall be known as the *Florida Building Code,* hereinafter referred to as "this code."

[A] 101.2 Scope. The provisions of this code shall apply to the construction, *alteration*, relocation, enlargement, replacement, *repair*, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures.

Exceptions:

1. Detached one- and two-family *dwellings* and multiple single-family *dwellings (townhouses)* not more than three *stories above grade plane* in height with a separate *means of egress*, and their accessory structures not more than three *stories above grade plane* in height, shall comply with the *Florida Building Code, Residential*.
2. Code requirements that address snow loads and earthquake protection are pervasive; they are left in place but shall not be utilized or enforced because Florida has no snow load or earthquake threat.

[A] 101.2.1 Appendices. Provisions in the appendices shall not apply unless specifically adopted.

[A] 101.3 Intent. The purpose of this code is to establish the minimum requirements to provide a reasonable level of safety, public health and general welfare through structural strength, *means of egress* facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment and to provide a reasonable level of safety to fire fighters and emergency responders during emergency operations.

[A] 101.4 Referenced codes. The other codes listed in Sections 101.4.1 through 101.4.9 and referenced elsewhere in this code shall be considered part of the requirements of this code to the prescribed extent of each such reference.

[A] 101.4.1 Gas. The provisions of the *Florida Building Code, Fuel Gas* shall apply to the installation of gas piping from the point of delivery, gas appliances and related accessories as covered in this code. These requirements apply to gas piping systems extending from the point of delivery to the inlet connections of appliances and the installation and operation of residential and commercial gas appliances and related accessories.

[A] 101.4.2 Mechanical. The provisions of the *Florida Building Code, Mechanical* shall apply to the installation, *alterations*, *repairs* and replacement of mechanical systems, including equipment, appliances, fixtures, fittings and/or appurtenances, including ventilating, heating, cooling, air-conditioning and refrigeration systems, incinerators and other energy-related systems.

[A] 101.4.3 Plumbing. The provisions of the *Florida Building Code, Plumbing* shall apply to the installation, *alteration*, *repair* and replacement of plumbing systems, including equipment, appliances, fixtures, fittings and appurtenances, and where connected to a water or sewage system and all aspects of a medical gas system.

[A] 101.4.4 Property maintenance. Reserved.

[A] 101.4.5 Fire prevention. For provisions related to fire prevention, refer to the *Florida Fire Prevention Code*. The *Florida Fire Prevention Code* shall apply to matters affecting or relating to structures, processes and premises from the hazard of fire and explosion arising from the storage, handling or use of structures, materials or devices; from conditions hazardous to life, property or public welfare in the occupancy of structures or premises; and from the construction, extension, *repair, alteration* or removal of fire suppression, and alarm systems or fire hazards in the structure or on the premises from occupancy or operation.

[A] 101.4.6 Energy. The provisions of the *Florida Building Code, Energy Conservation* shall apply to all matters governing the design and construction of buildings for energy efficiency.

[A] 101.4.7 Existing buildings. The provisions of the *Florida Building Code, Existing Building* shall apply to matters governing the *repair*, *alteration*, change of occupancy, *addition* to and relocation of existing buildings.

101.4.8 Accessibility. For provisions related to accessibility, refer to the *Florida Building Code, Accessibility.*

101.4.9 Manufactured buildings. For additional administrative and special code requirements, see Section 458, *Florida Building Code, Building*, and Rule 61-41 F.A.C.

SECTION 102
APPLICABILITY

[A] 102.1 General. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern.

102.1.1 *The Florida Building Code* does not apply to, and no code enforcement action shall be brought with respect to, zoning requirements, land use requirements and owner specifications or programmatic requirements which do not pertain to and govern the design, construction, erection,

Informal Interpretation Report
Number 8500

Date 12/29/2020

Report 2021

Section Sections 607 & 419.5

Question:

Paragraph 607.1 states..... In nonresidential occupancies, hot water shall be supplied for culinary purposes, cleansing, laundry or building maintenance purposes. In nonresidential occupancies, hot water or tempered water shall be supplied for bathing and washing purposes.

Since Paragraph 607.1 indicates that hot or tempered water shall be supplied for "washing purposes", does this section conflict with Section 419.5 Water for public handwashing facilities?

Answer:

No, Section 419.5 allows cold or tempered water for public handwashing facilities only, 607.1 requires hot water or tempered water in non-residential occupancies for bathing and washing purposes.607.1 is a general requirement, 419.5 is a specific requirement for lavatories. Section 102.1 states where a general requirement and a specific requirement are in conflict the specific requirement shall be applicable.

On 01/25/2021 at 4:48 PM

Commentary:

If we are just talking about public handwashing facilities then 419.5 would apply as the most specific, however for any nonresidential occupancies for bathing or washing purposes hot water or tempered water would be required.

ITEM 2

Developed length of hot or tempered water supply piping from source of hot water

P2904.8.1 Preconcealment inspection. The following items shall be verified prior to the concealment of any sprinkler system piping:

1. Sprinklers are installed in all areas as required by Section P2904.1.1.
2. Where sprinkler water spray patterns are obstructed by construction features, luminaires or ceiling fans, additional sprinklers are installed as required by Section P2904.2.4.2.
3. Sprinklers are the correct temperature rating and are installed at or beyond the required separation distances from heat sources as required by Sections P2904.2.1 and P2904.2.2.
4. The pipe size equals or exceeds the size used in applying Tables P2904.6.2(4) through P2904.6.2(9) or, if the piping system was hydraulically calculated in accordance with Section P2904.6.1, the size used in the hydraulic calculation.
5. The pipe length does not exceed the length permitted by Tables P2904.6.2(4) through P2904.6.2(9) or, if the piping system was hydraulically calculated in accordance with Section P2904.6.1, pipe lengths and fittings do not exceed those used in the hydraulic calculation.
6. Nonmetallic piping that conveys water to sprinklers is listed for use with fire sprinklers.
7. Piping is supported in accordance with the pipe manufacturer's and sprinkler manufacturer's installation instructions.
8. The piping system is tested in accordance with Section P2503.7.

P2904.8.2 Final inspection. The following items shall be verified upon completion of the system:

1. Sprinkler are not painted, damaged or otherwise hindered from operation.
2. Where a pump is required to provide water to the system, the pump starts automatically upon system water demand.
3. Pressure-reducing valves, water softeners, water filters or other impairments to water flow that were not part of the original design have not been installed.
4. The sign or valve tag required by Section P2904.7 is installed and the owner's manual for the system is present.

SECTION P2905
HEATED WATER DISTRIBUTION SYSTEMS

P2905.1 Heated water circulation systems and heat trace systems. Circulation systems and heat trace systems that are installed to bring heated water in close proximity to one or more fixtures shall meet the requirements of Section R403.5.1 of the *Florida Building Code, Energy Conservation*.

P2905.2 Demand recirculation systems. Demand recirculation water systems shall be in accordance with Section R403.5.2 of the *Florida Building Code, Energy Conservation*.

P2905.3 Hot water supply to fixtures. The developed length of hot water piping, from the source of hot water to the fixtures that require hot water, shall not exceed 100 feet. Water heaters and recirculating system piping shall be considered to be sources of hot water.

SECTION P2906
MATERIALS, JOINTS AND CONNECTIONS

P2906.1 Soil and groundwater. The installation of water service pipe, water distribution pipe, fittings, valves, appurtenances and gaskets shall be prohibited in soil and groundwater that is contaminated with solvents, fuels, organic compounds or other detrimental materials that cause permeation, corrosion, degradation or structural failure of the water service or water distribution piping material.

P2906.1.1 Investigation required. Where detrimental conditions are suspected by or brought to the attention of the *building official*, a chemical analysis of the soil and groundwater conditions shall be required to ascertain the acceptability of the water service material for the specific installation.

P2906.1.2 Detrimental condition. Where a detrimental condition exists, *approved* alternate materials or alternate routing shall be required.

P2906.2 Lead content. The lead content in pipe and fittings used in the water supply system shall be not greater than 8 percent.

P2906.2.1 Lead content of drinking water pipe and fittings. Pipe, pipe fittings, joints, valves, faucets and fixture fittings utilized to supply water for drinking or cooking purposes shall comply with NSF 372 and shall have a weighted average lead content of 0.25 percent lead or less.

P2906.3 Polyethylene plastic piping installation. Polyethylene pipe shall be cut square using a cutter designed for plastic pipe. Except where joined by heat fusion, pipe ends shall be chamfered to remove sharp edges. Pipe that has been kinked shall not be installed. For bends, the installed radius of pipe curvature shall be greater than 30 pipe diameters or the coil radius where bending with the coil. Coiled pipe shall not be bent beyond straight. Bends within 10 pipe diameters of any fitting or valve shall be prohibited. Joints between polyethylene plastic pipe and fittings shall comply with Section P2906.3.1 or P2906.3.2.

P2906.3.1 Heat-fusion joints. Joint surfaces shall be clean and free from moisture. Joint surfaces shall be heated to melting temperature and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D2657.

P2906.3.2 Mechanical joints. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

P2906.4 Water service pipe. Water service pipe shall conform to NSF 61 and shall conform to one of the standards

min) per 100 square feet (9.29 m^2) of conditioned floor area.

R403.3.5 Building cavities (Mandatory). Building framing cavities shall not be used as ducts or plenums.

R403.3.6 Air-handling units. Air-handling units shall not be installed in the attic when a home is brought into code compliance by Section R402. Air-handling units shall be allowed in attics for compliance by Section R405 only if the following conditions are met:

1. The service panel of the equipment is located within 6 feet (1829 mm) of an attic access.
2. A device is installed to alert the owner or shut down the unit when the condensation drain is not working properly.
3. The attic access opening is of sufficient size to replace the air handler.
4. A notice is posted on the electric service panel indicating to the homeowner that the air handler is located in the attic. Said notice shall be in all capitals, in 16-point type, with the title and first paragraph in bold:

NOTICE TO HOMEOWNER

A PART OF YOUR AIR-CONDITIONING SYSTEM, THE AIR HANDLER, IS LOCATED IN THE ATTIC. FOR PROPER, EFFICIENT AND ECONOMIC OPERATION OF THE AIR-CONDITIONING SYSTEM, YOU MUST ENSURE THAT REGULAR MAINTENANCE IS PERFORMED. YOUR AIR-CONDITIONING SYSTEM IS EQUIPPED WITH ONE OR BOTH OF THE FOLLOWING: (1) A DEVICE THAT WILL ALERT YOU WHEN THE CONDENSATION DRAIN IS NOT WORKING PROPERLY OR (2) A DEVICE THAT WILL SHUT DOWN THE SYSTEM WHEN THE CONDENSATION DRAIN IS NOT WORKING. TO LIMIT POTENTIAL DAMAGE TO YOUR HOME, AND TO AVOID DISRUPTION OF SERVICE, IT IS RECOMMENDED THAT YOU ENSURE PROPER WORKING ORDER OF THESE DEVICES BEFORE EACH SEASON OF PEAK OPERATION.

R403.4 Mechanical system piping insulation (Mandatory). Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3.

R403.4.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

R403.5 Service hot water systems. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.5.1 through R403.5.6.

R403.5.1 Heated water circulation and temperature maintenance systems (Mandatory). If heated water circulation systems are installed, they shall be in accordance with Section R403.5.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R403.5.1.2. Automatic controls, temperature sensors and pumps shall be accessible. Manual controls shall be readily accessible.

R403.5.1.1 Circulation systems. Heated water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermosyphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

R403.5.1.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1 or UL 515. Controls for such systems shall automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

R403.5.2 Demand recirculation systems. A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe shall be a *demand recirculation water system.* Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The control shall limit the temperature of the water entering the cold water piping to 104°F (40°C).

R403.5.3 Hot water pipe insulation (Prescriptive). Insulation for hot water pipe with a minimum thermal resistance (*R*-value) of R-3 shall be applied to the following:

1. Piping $^3/_4$ inch (19.1 mm) and larger in nominal diameter.
2. Piping serving more than one dwelling unit.
3. Piping located outside the conditioned space.
4. Piping from the water heater to a distribution manifold.
5. Piping located under a floor slab.
6. Buried in piping.
7. Supply and return piping in recirculation systems other than demand recirculation systems.

R403.5.4 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Drain water heat recovery units shall be tested in accordance with CSA B55.1. Potable water-side pressure loss of drain water heat recovery units shall be less than 3 psi (20.7 kPa) for individual units connected to one or two showers. Potable water-side pressure loss of drain water heat recovery units shall be less than 2 psi (13.8 kPa) for individual units connected to three or more showers.

R403.5.5 Heat traps (Mandatory). Storage water heaters not equipped with integral heat traps and having vertical pipe risers shall have heat traps installed on both the inlets and outlets. External heat traps shall consist of either a commercially available heat trap or a downward and upward bend of at least $3^1/_2$ inches (89 mm) in the hot water distribution line and cold water line located as close as possible to the storage tank.

R403.5.6 Water heater efficiencies (Mandatory).

R403.5.6.1 Storage water heater temperature controls.

403.5.6.1.1 Automatic controls. Service water-heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use. The minimum temperature setting range shall be from 100°F to 140°F (38°C to 60°C).

R403.5.6.1.2 Shut down. A separate switch or a clearly marked circuit breaker shall be provided to permit the power supplied to electric service systems to be turned off. A separate valve shall be provided to permit the energy supplied to the main burner(s) of combustion types of service water-heating systems to be turned off.

R403.5.6.2 Water-heating equipment. Water-heating equipment installed in residential units shall meet the minimum efficiencies of Table C404.2 in Chapter 4 of the *Florida Building Code, Energy Conservation,* Commercial Provisions, for the type of equipment installed. Equipment used to provide heating functions as part of a combination system shall satisfy all stated requirements for the appropriate water-heating category. Solar water heaters shall meet the criteria of Section R403.5.6.2.1.

R403.5.6.2.1 Solar water-heating systems. Solar systems for domestic hot water production are rated by the annual solar energy factor of the system. The solar energy factor of a system shall be determined from the Florida Solar Energy Center Directory of Certified Solar Systems. Solar collectors shall be tested in accordance with ISO Standard 9806, *Test Methods for Solar Collectors,* and SRCC Standard TM-1, *Solar Domestic Hot Water System and Component Test Protocol.* Collectors in installed solar water-heating systems should meet the following criteria:

1. Be installed with a tilt angle between 10 degrees and 40 degrees of the horizontal; and
2. Be installed at an orientation within 45 degrees of true south.

R403.6 Mechanical ventilation (Mandatory). The building shall be provided with ventilation that meets the requirements of the *Florida Building Code, Residential,* or *Florida Building Code, Mechanical,* as applicable, or with other approved means of ventilation including: Natural, Infiltration or Mechanical means. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

R403.6.1 Whole-house mechanical ventilation system fan efficacy. When installed to function as a whole-house mechanical ventilation system, fans shall meet the efficacy requirements of Table R403.6.1.

Exception: Where an air handler that is integral to tested and listed HVAC equipment is used to provide whole-house mechanical ventilation, the air handler shall be powered by an electronically commutated motor.

TABLE R403.6.1
WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM FAN EFFICACY

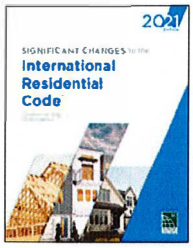
FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY[a] (CFM/WATT)	AIRFLOW RATE MAXIMUM (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

For SI: 1 cfm = 28.3 L/min.

a. When tested in accordance with HVI Standard 916.

P2905.3

Length of Hot Water Piping to Fixtures



This excerpt is taken from ***Significant Changes to the International Residential Code, 2021 Edition***.

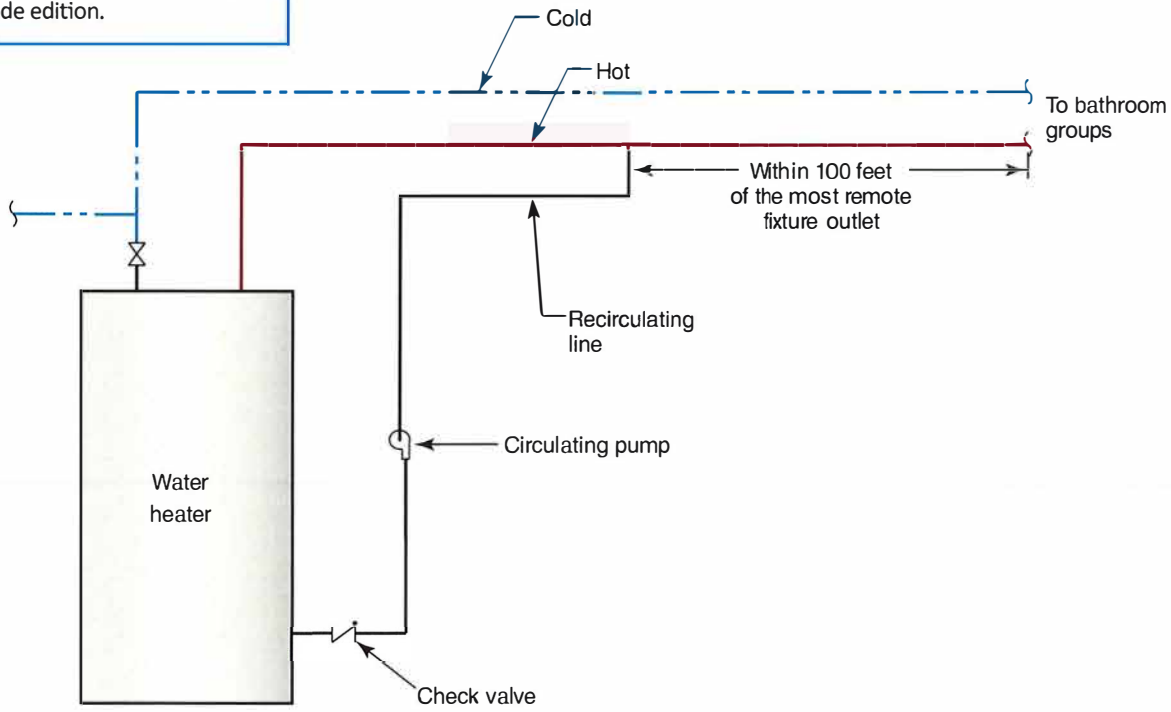
The Significant Changes series takes you directly to the most important changes that impact projects. Key changes are identified then followed by in-depth discussion of how the change affects real-world application. Photos, tables and illustrations are included to further clarify application. Available for the IBC, IRC, IFC, IECC and IPC/IMC/IFGC, the Significant Changes publications are very useful training and review tools for transitioning to a new code edition.

CHANGE TYPE: Addition

CHANGE SUMMARY: The code now limits the length of hot water piping serving fixtures.

2021 CODE: **P2905.3 Hot water supply to fixtures.** The developed length of hot water piping, from the source of hot water to the fixtures that require hot water, shall not exceed 100 feet (30 480 mm). Water heaters and recirculating system piping shall be considered to be sources of hot water.

CHANGE SIGNIFICANCE: A new section limits the hot water supply line length to 100 feet measured from the source of hot water to the fixtures that require hot water. This provision is similar to existing language in IPC Section 607.2, except the IPC limits the length to not greater than 50 feet. Hot water supply lines greater than 100 feet waste water (proportional to pipe size) while occupants wait for hot water to reach fixtures for bathing, washing and culinary purposes. Even when hot water supply lines are insulated, the hot water remaining in the lines between demand periods cools down. Limiting the length and consequent volume of heated water in the supply lines reduces the amount of wasted water and occupant waiting time.



Hot water piping is limited to 100 feet from the source.

SEDAC
SMART ENERGY DESIGN ASSISTANCE CENTER

Energy Code Smart Tips

Domestic Hot Water Recirculation

Can Recirculation Systems Conserve Energy?

The US Department of Energy estimates that more than 400 billion gallons of water are wasted nationally from people waiting for hot water to arrive at the fixture. Hot water recirculation systems solve this problem by bringing hot water closer to the point of use.

There's just one problem: many recirculation systems run all day, every day, which wastes pumping and heating energy. A setback allowing a 10 degree temperature drop in the circulation pipes during unoccupied times can reduce standby losses in the system by as much as 25%.

This Smart Tip describes how the Illinois Energy Code addresses this subject.

Hot Water Recirculation Requirements in the 2018 IECC

Requirements:	Implementation:
Two system types:	**Different controls strategies:**
Demand Recirculation Systems use the cold water line to return water to the heater. The pump must to start upon receiving a signal from the action of a user or sensing flow to a fixture. Also, water entering the cold water line must be no more than 104 ° F. **See C404.7 and R403.5.2**	For **Demand Recirculation Systems** controls include occupancy sensors, user operated low voltage switchs and other user initiated inputs. Commonly for these systems, the pump is located under the sink that is furthest from the water heater.
Circulation systems usually have a dedicated return line and are more common in large buildings. The Code specifies that these system start based on demand for hot water. The controls must automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a draw of hot water in the building. **See C404.6.1 and R403.5.2**	In **Circulation Systems**, a flow sensor is required on the cold water inlet of the water heater. This would signal the pump when to operate based on fixture use. Also, a temperature sensor must be located at the end of the hot water loop to notify the system when the target temperature has been met. A flow sensor on the hot water line cannot be used since recirculation would look the same as demand.

What about Legionella?

There is a risk of legionella bacteria in hot water systems, but the 2018 IECC rules take this into consideration. The return water temperature sensor at the end of the loop also ensures a safe *minimum* temperature is maintained. Further, properly insulated pipes per IECC rules ensure good contact time for effective bacteria kill. **You don't have to sacrifice safety for an energy efficient hot water system!**

WHO WE ARE

SEDAC is the Energy Code Training Provider on behalf of the Illinois EPA Office of Energy. Attend SEDAC's workshops and webinars to learn more. We also offer online courses and technical support.

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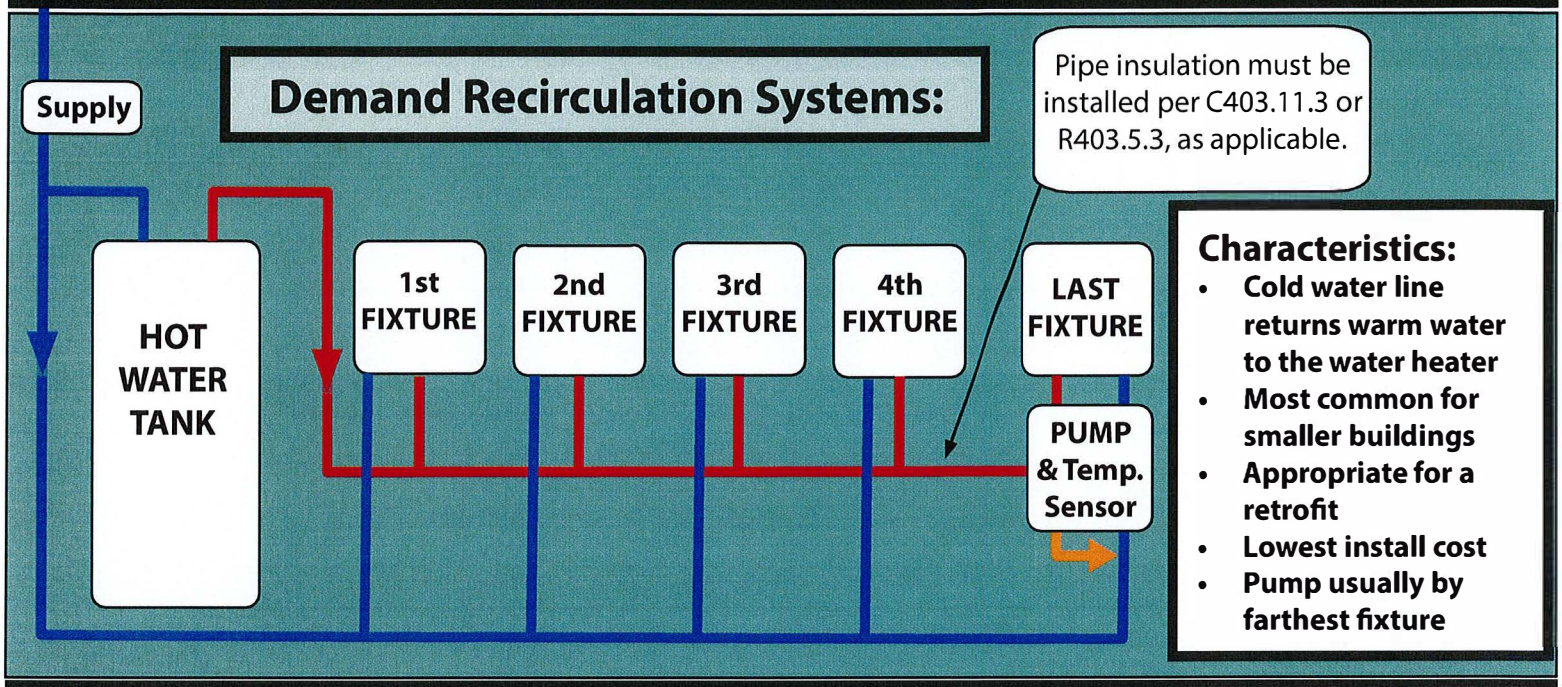
Hot Water Recirculation System Types in the 2018 IECC

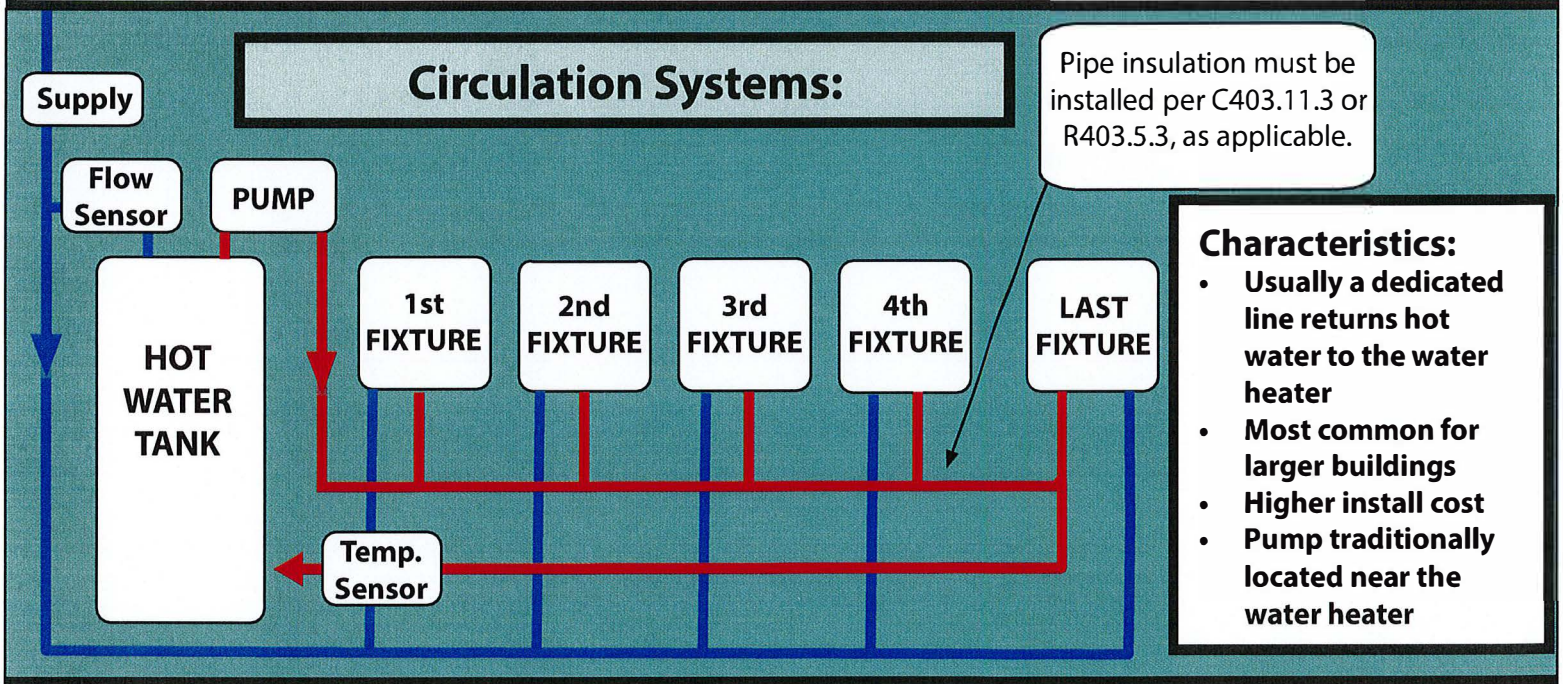


Characteristics:

- **Cold water line returns warm water to the water heater**
- **Most common for smaller buildings**
- **Appropriate for a retrofit**
- **Lowest install cost**
- **Pump usually by farthest fixture**

IECC Requirements for Demand Recirculation Systems (IECC C404.7 and R403.5.2):

- **Return water can't be more than 104 ° F**
- **The pump must be switched on due to one of the following:**
  1. An action by a user 2. Sensing the presence of a user 3. Sensing flow to a fixture or appliance



Characteristics:

- **Usually a dedicated line returns hot water to the water heater**
- **Most common for larger buildings**
- **Higher install cost**
- **Pump traditionally located near the water heater**

IECC Requirements for Circulation Systems (IECC C404.6.1 and R403.5.2):

- **The pump must be switched on based on demand for hot water in the building**
- **The pump must switch off based on the target temperature and no demand for hot water**

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for overflow pipes and shall not be smaller in size than specified in Table 606.5.7.

TABLE 606.5.7
SIZE OF DRAIN PIPES FOR WATER TANKS

TANK CAPACITY (gallons)	DRAIN PIPE (inches)
Up to 750	1
751 to 1,500	$1^1/_2$
1,501 to 3,000	2
3,001 to 5,000	$2^1/_2$
5,000 to 7,500	3
Over 7,500	4

For SI: 1 inch = 25.4 mm, 1 gallon = 3.785 L.

606.5.8 Prohibited location of potable supply tanks. Potable water gravity tanks or manholes of potable water pressure tanks shall not be located directly under any soil or waste piping or any source of contamination.

606.5.9 Pressure tanks, vacuum relief. All water pressure tanks shall be provided with a vacuum relief valve at the top of the tank that will operate up to a maximum water pressure of 200 psi (1380 kPa) and up to a maximum temperature of 200°F (93°C). The size of such vacuum relief valve shall be not less than $^1/_2$ inch (12.7 mm).

Exception: This section shall not apply to pressurized captive air diaphragm/bladder tanks.

606.5.10 Pressure relief for tanks. Every pressure tank in a hydropneumatic pressure booster system shall be protected with a pressure relief valve. The pressure relief valve shall be set at a maximum pressure equal to the rating of the tank. The relief valve shall be installed on the supply pipe to the tank or on the tank. The relief valve shall discharge by gravity to a safe place of disposal.

606.6 Water supply system test. Upon completion of a section of or the entire water supply system, the system, or portion completed, shall be tested in accordance with Section 312.

606.7 Labeling of water distribution pipes in bundles. Where water distribution piping is bundled at installation, each pipe in the bundle shall be indentified using stenciling or commercially available pipe labels. The identification shall indicate the pipe contents and the direction of flow in the pipe. The interval of the identification markings on the pipe shall not exceed 25 feet (7620 mm). There shall be not less than one identification label on each pipe in each room, space or story.

SECTION 607
HOT WATER SUPPLY SYSTEM

607.1 Where required. In residential *occupancies*, *hot water* shall be supplied to plumbing fixtures and equipment utilized for bathing, washing, culinary purposes, cleansing, laundry or building maintenance. In nonresidential *occupancies*, *hot water* shall be supplied for culinary purposes, cleansing, laundry or building maintenance purposes. In nonresidential *occupancies*, *hot water* or *tempered water* shall be supplied for bathing and washing purposes.

607.1.1 Temperature limiting means. A thermostat control for a water heater shall not serve as the temperature limiting means for the purposes of complying with the requirements of this code for maximum allowable *hot* or *tempered water* delivery temperature at fixtures.

607.1.2 Tempered water temperature control. *Tempered water* shall be supplied through a water temperature limiting device that conforms to ASSE 1070 and shall limit the *tempered water* to a maximum of 110°F (43°C). This provision shall not supersede the requirement for protective shower valves in accordance with Section 412.3.

607.2 Hot or tempered water supply to fixtures. The *developed length* of *hot* or *tempered water* piping, from the source of hot water to the fixtures that require *hot* or *tempered water*, shall not exceed 50 feet (15 240 mm). Recirculating system piping and heat-traced piping shall be considered to be sources of *hot* or *tempered water*.

607.2.1 Circulation systems and heat trace systems for maintaining heated water temperature in distribution systems. For Group R2, R3 and R4 occupancies that are three stories or less in height above grade plane, the installation of heated water circulation and temperature maintenance systems shall be in accordance with Section R403.5.1 of the *Florida Building Code, Energy Conservation*. For other than Group R2, R3 and R4 occupancies that are three stories or less in height above grade plane, the installation of heated water circulation and heat trace systems shall be in accordance with Section C404.6 of the *Florida Building Code, Energy Conservation*.

607.2.1.1 Pump controls for hot water storage systems. The controls on pumps that circulate water between a water heater and a storage tank for heated water shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

607.2.1.2 Demand recirculation controls for distribution systems. A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe shall be a demand recirculation water system. Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture, or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The control shall limit the temperature of the water entering the cold water piping to 104°F (40°C).

607.2.2 Piping for recirculation systems having master thermostatic valves. Where a thermostatic mixing valve is used in a system with a hot water recirculating pump, the *hot water* or *tempered water* return line shall be routed to the cold water inlet pipe of the water heater and the cold

water inlet pipe or the hot water return connection of the thermostatic mixing valve.

607.3 Thermal expansion control. Where a storage water heater is supplied with cold water that passes through a check valve, pressure reducing valve or backflow preventer, a thermal expansion control device shall be connected to the water heater cold water supply pipe at a point that is downstream of all check valves, pressure reducing valves and backflow preventers. Thermal expansion control devices shall be sized in accordance with the manufacturer's instructions and shall be sized such that the pressure in the water distribution system shall not exceed that required by Section 604.8.

607.4 Flow of hot water to fixtures. Fixture fittings, faucets and diverters shall be installed and adjusted so that the flow of hot water from the fittings corresponds to the left-hand side of the fixture fitting.

Exception: Shower and tub/shower mixing valves conforming to ASSE 1016/ASME A112.1016/CSA B125.16 or ASME A112.18.1/CSA B125.1, where the flow of hot water corresponds to the markings on the device.

[E] 607.5 Insulation of piping. For other than Group R2, R3 and R4 occupancies that are three stories or less in height above grade plane, piping to the inlet of a water heater and piping conveying water heated by a water heater shall be insulated in accordance with Section C404.4 of the *Florida Building Code, Energy Conservation.* For Group R2, R3 and R4 occupancies that are three stories or less in height above grade plane, piping to the inlet of a water heater and piping conveying water heated by a water heater shall be insulated in accordance with Section R403.5.3 of the *Florida Building Code, Energy Conservation.*

SECTION 608
PROTECTION OF POTABLE WATER SUPPLY

608.1 General. A potable water supply system shall be designed, installed and maintained in such a manner so as to prevent contamination from nonpotable liquids, solids or gases being introduced into the potable water supply through cross connections or any other piping connections to the system. Backflow preventer applications shall conform to Table 608.1, except as specifically stated in Sections 608.2 through 608.17.10.

608.2 Plumbing fixtures. The supply lines and fittings for plumbing fixtures shall be installed so as to prevent backflow. Plumbing fixture fittings shall provide backflow protection in accordance with ASME A112.18.1/CSA B125.1.

608.3 Devices, appurtenances, appliances and apparatus. Devices, appurtenances, appliances and apparatus intended to serve some special function, such as sterilization, distillation, processing, cooling, or storage of ice or foods, and that connect to the water supply system, shall be provided with protection against backflow and contamination of the water supply system.

608.3.1 Special equipment, water supply protection. The water supply for hospital fixtures shall be protected against backflow with a reduced pressure principle backflow prevention assembly, an atmospheric or spill-resistant vacuum breaker assembly, or an *air gap.* Vacuum breakers for bedpan washer hoses shall not be located less than 5 feet (1524 mm) above the floor. Vacuum breakers for hose connections in health care or laboratory areas shall not be less than 6 feet (1829 mm) above the floor.

608.4 Potable water handling and treatment equipment. Water pumps, filters, softeners, tanks and other appliances and devices that handle or treat potable water to be supplied to the potable water distribution system shall be located to prevent contamination from entering the appliances and devices. Overflow, relief valve and waste discharge pipes from such appliances and devices shall terminate through an air gap.

608.5 Water service piping. Water service piping shall be protected in accordance with Sections 603.2 and 603.2.1.

608.6 Chemicals and other substances. Chemicals and other substances that produce either toxic conditions, taste, odor or discoloration in a potable water system shall not be introduced into, or utilized in, such systems.

608.7 Cross connection control. Cross connections shall be prohibited, except where *approved* backflow prevention assemblies, backflow prevention devices or other means or methods are installed to protect the potable water supply.

608.7.1 Private water supplies. Cross connections between a private water supply and a potable public supply shall be prohibited.

608.8 Valves and outlets prohibited below grade. Potable water outlets and combination stop-and-waste valves shall not be installed underground or below grade. A freezeproof yard hydrant that drains the riser into the ground shall be considered as having a stop-and-waste valve below grade.

Exception: Freezeproof yard hydrants that drain the riser into the ground shall be permitted to be installed provided that the potable water supply to such hydrants is protected in accordance with Section 608.14.2 or 608.14.5 and the hydrants and the piping from the backflow preventer to the hydrant are identified in accordance with Section 608.9.

shall be provided with heat traps on the supply and discharge piping associated with the equipment.

C404.4 Insulation of piping. The following piping shall be insulated to levels shown in Table C403.2.10:

a. Recirculating system piping, including the supply and return piping of a circulating tank type water heater.

b. The first 8 feet of outlet piping for a constant-temperature nonrecirculating storage system.

c. The first 8 feet of branch piping connecting to recirculated, heat-traced, or impedance heated piping.

d. The inlet piping between the storage tank and a *heat trap* in a nonrecirculating storage system.

e. Piping that is externally heated (such as heat trace or impedance heating).

C404.5 Efficient heated water supply piping. Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through $^1/_4$-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through $^5/_{16}$-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through $^3/_8$-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

C404.5.1 Maximum allowable pipe length method. The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1.

1. For a public lavatory faucet, use the "Public lavatory faucets" column in Table C404.5.1.
2. For all other plumbing fixtures and plumbing appliances, use the "Other fixtures and appliances" column in Table C404.5.1.

C404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

C404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

C404.6 Heated-water circulating and temperature maintenance systems. Heated-water circulation systems shall be in accordance with Section C404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section C404.6.2. Controls for hot water storage shall be in accordance with Section C404.6.3. Automatic controls, temperature sensors and pumps shall be *accessible*. Manual controls shall be *readily accessible*.

C404.6.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermo-syphon circu-

TABLE C404.5.1
PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public lavatory faucets	Other fixtures and appliances
$^1/_4$	0.33	6	50
$^5/_{16}$	0.5	4	50
$^3/_8$	0.75	3	50
$^1/_2$	1.5	2	43
$^5/_8$	2	1	32
$^3/_4$	3	0.5	21
$^7/_8$	4	0.5	16
1	5	0.5	13
$1^1/_4$	8	0.5	8
$1^1/_2$	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

lation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

C404.6.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy. Heat trace shall be arranged to be turned off automatically when there is no hot water demand.

C404.6.3 Controls for hot water storage. The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

C404.7 Demand recirculation controls. A water distribution system having one or more recirculation pumps that pump water from a heated-water supply pipe back to the heated-water source through a cold-water supply pipe shall be a *demand recirculation water system.* Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The control shall limit the temperature of the water entering the cold-water piping to 104°F (40°C).

C404.8 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Potable water-side pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. For Group R occupancies, the efficiency of drain water heat recovery unit efficiency shall be in accordance with CSA B55.1.

C404.9 Energy consumption of pools and permanent spas (Mandatory). The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections C404.9.1 through C404.9.3.

C404.9.1 Heaters. The electric power to all heaters shall be controlled by a readily accessible on-off switch that is an integral part of the heater, mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Gas-fired heaters shall not be equipped with continuously burning ignition pilots.

C404.9.2 Time switches. Time switches or other control methods that can automatically turn off and on heaters and pump motors according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Pumps that operate solar- and waste-heat-recovery pool heating systems.

C404.9.3 Covers. Outdoor heated swimming pools and outdoor permanent spas shall be equipped with a vapor-retardant cover on or at the water surface or a liquid cover or other means proven to reduce heat loss.

Exception: Where more than 70 percent of the energy for heating, computed over an operating season, is from site-recovered energy such as from a heat pump or solar energy source, covers or other vapor-retardant means shall not be required.

C404.10 Energy consumption of portable spas (Mandatory). The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

C404.11 Water flow rate controls.

C404.11.1 Showers. Showers used for other than safety reasons shall be equipped with flow control devices to limit the water discharge to a maximum of 2.5 gpm (.16 L/S) per showerhead at a distribution pressure of 80 psig (552 kPa) when tested in accordance with the procedures of ANSI A112.18.1M. Flow restricting inserts used as a component part of a showerhead shall be mechanically retained at the point of manufacture.

C404.11.2 Lavatories or restrooms of public facilities. Lavatories or restrooms of public facilities shall:

1. Be equipped with outlet devices that limit the flow of hot water to a maximum of 0.5 gpm (.03 L/S) or be equipped with self-closing valves that limit delivery to a per cycle maximum of 0.25 gallons (.95 L) of hot water for recirculating systems and to a maximum of 0.50 gallons (1.9 L) for nonrecirculating systems.

   Exception: Separate lavatories for physically handicapped persons shall not be equipped with self-closing valves.
2. Be equipped with devices that limit the outlet temperature to a maximum of 110°F (43°C).
3. Meet the provisions of 42 CFR 6295 (k), Standards for Water Closets and Urinals.

SECTION C405
ELECTRICAL POWER AND LIGHTING SYSTEMS

C405.1 General (Mandatory). This section covers lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption.

Dwelling units within multifamily buildings shall comply with Section R404.1. All other dwelling units shall comply with Section R404.1, or with Sections C405.2.4 and C405.3. Sleeping units shall comply with Section C405.2.4, and with Section R404.1 or C405.3. Lighting installed in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and

C403.5.2 Compressor systems. Refrigeration compressor systems shall comply with the following:

1. Compressors and multiple-compressor system suction groups shall include control systems that use floating suction pressure control logic to reset the target suction pressure temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

   Exception: Controls are not required for the following:

   1. Single-compressor systems that do not have variable capacity capability.
   2. Suction groups that have a design saturated suction temperature of 30°F (-1.1°C) or higher, suction groups that comprise the high stage of a two-stage or cascade system, or suction groups that primarily serve chillers for secondary cooling fluids.

2. Liquid subcooling shall be provided for all low-temperature compressor systems with a design cooling capacity equal to or greater than 100,000 Btu/hr (29.3 kW) with a design-saturated suction temperature of -10°F (-23°C) or lower. The sub-cooled liquid temperature shall be controlled at a maximum temperature setpoint of 50°F (10°C) at the exit of the subcooler using either compressor economizer (interstage) ports or a separate compressor suction group operating at a saturated suction temperature of 18°F (-7.8°C) or higher.

   2.1. Insulation for liquid lines with a fluid operating temperature less than 60°F (15.6°C) shall comply with Table C403.2.10.

3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

C403.5.3 Condensing coils installed in cool air stream of another air-conditioning unit. The condensing coil of one air-conditioning unit shall not be installed in the cool air stream of another air-conditioning unit.

Exceptions:

1. Where condenser heat reclaim is used in a properly designed system including enthalpy control devices to achieve requisite humidity control for process, special storage or equipment spaces and occupant comfort within the criteria of ASHRAE Standard 55. Such systems shall result in less energy use than other appropriate options.
2. For computer or clean rooms whose location precludes the use of systems that would not reject heat into conditioned spaces.

SECTION C404
SERVICE WATER HEATING (MANDATORY)

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

C404.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment also intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

C404.2.1 High input-rated service water-heating systems. Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, E_t, of not less than 90 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input-capacity-weighted-average thermal efficiency, E_t, shall be not less than 90 percent.

Exceptions:

1. Where 25 percent of the annual *service water-heating* requirement is provided by site-solar or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.
2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of *service water-heating* equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of *service water-heating* equipment for a building.

C404.3 Heat traps. Water-heating equipment not supplied with integral heat traps and serving noncirculating systems

automatic or manual control that is configured to shut off when the outdoor temperature is above 40°F (4°C).

❖ Snow- and ice-melting systems, regardless of the source of the energy for the system, are required to include automatic controls capable of shutting off the system when the pavement temperature is greater than 50°F (10°C), no precipitation is falling and the outside temperature is greater than 40°F (4°C). The automatic shutoff prevents loss of energy often occurring when building occupants simply forget to turn the system off.

C403.12.3 Freeze protection system controls. Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls configured to shut off the systems when outdoor air temperatures are above 40°F (4°C) or when the conditions of the protected fluid will prevent freezing.

❖ Where piping and equipment are located outdoors or in unconditioned spaces, freeze protection heating systems are often installed to prevent freezing in the winter. A common type of such systems is electric-resistance heat tracing wound around piping through which a current is run. This action heats the piping in order to keep it about above 32°F (0°C). Clearly, when outside temperatures reach a level where the liquid in the system will no longer freeze, putting any energy into such a freeze protection system is wasteful. The code simply requires automatic controls be provided to shut off the system as prescribed.

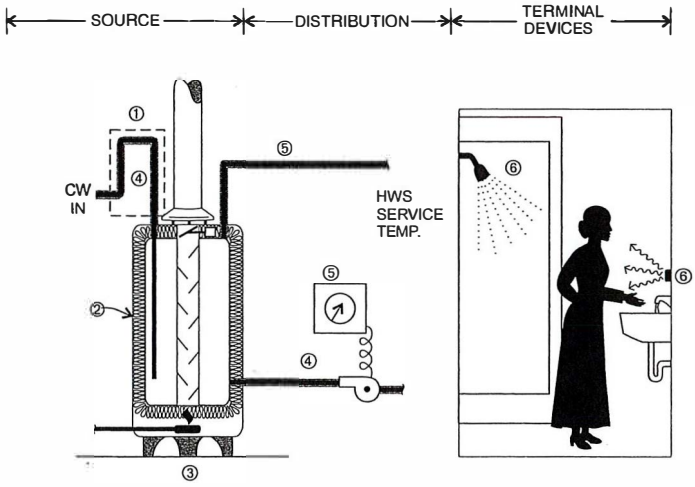
SECTION C404
SERVICE WATER HEATING (MANDATORY)

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

❖ This section restates the general purpose of the requirements for service water-heating equipment (see Commentary Figure C404.1). "Service water heating" is defined as the supply of hot water for purposes other than comfort heating; therefore, this section applies to equipment and piping used to produce and distribute hot water for the following:

- Restrooms.
- Showers.
- Laundries.
- Kitchens.
- Pools and spas.

The requirements of this section are for service water-heating equipment and systems only; however, the principles presented could apply to energy-



①HEAT TRAPS TO REDUCE STANDBY LOSSES
②INSULATED TANKS TO REDUCE STANDBY LOSSES
③HIGH-EFFICIENCY SOURCES
④PIPE INSULATION TO REDUCE DISTRIBUTION AND STANDBY LOSSES
⑤CIRCULATION LOOP TEMPERATURE CONTROLS TO REDUCE DISTRIBUTION LOSSES
⑥FLOW LIMITING DEVICES SUCH AS LOW FLOW SHOWER HEADS AND OCCUPANT SENSORS TO REDUCE WASTE ARE ENCOURAGED BUT NOT REQUIRED BY THE IECC (FOR FURTHER DISCUSSION OF WATER CONSERVATION MEASURED, SEE COMMENTARY TO SECTION 604.4 OF THE *INTERNATIONAL PLUMBING CODE*)

Commentary Figure C404.1
ELEMENTS COVERED BY SECTION C404
(Courtesy of U.S. Department of Energy, Office of Building Technology State and Community Programs, www.energycodes.gov)

efficient process water-heating systems and equipment as well. Space-conditioning boilers and distribution systems for human comfort are covered under the requirements of Section C403. The service water-heating portion of combined space-conditioning and water-heating systems must meet the requirements of this section as well.

Compliance with this section is based on the application of basic, cost-effective design practices:

- Minimize standby losses with heat traps, thermal insulation and temperature controls.
- Reduce distribution losses with thermal insulation and system temperature controls or eliminate through point-of-use heaters.
- Increase overall system performance by utilizing high-efficiency sources.
- Increase efficiency of supply piping by limiting flow rate and pipe length or volume.

C404.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

❖ Table C404.2 presents the minimum required efficiencies for water-heating equipment used for hot water supply and space heating. Equipment must meet the requirement for a minimum heater efficiency [energy factor (EF)], thermal efficiency (E_t) or a maximum standby loss (SL). Smaller equipment, which falls under NAECA, must satisfy the federal energy factor requirements before it can be sold. This minimum energy factor is a combined measure of thermal efficiency and standby loss. NAECA-covered water-heating equipment includes:

- Electric heaters of all types with input ratings less than 12 kW.
- Fuel-fired storage heaters at or below 75,000 Btu/h (21 983 W) input for gas or 105,000 Btu/h (30 776 W) input for oil.
- Fuel-fired instantaneous heaters at or below 200,000 Btu/h (58 620 W) input for gas or 210,000 Btu/h (61 551 W) for oil.
- All fuel-fired pool and spa heaters.

The efficiency requirements for equipment not covered by NAECA are summarized throughout the remaining rows of Table C404.2. Equipment in the table is classified by type (such as instantaneous gas and storage electric) capacity (input rating) and subcategory or rating condition. Data from nationally recognized testing and certification programs using standard DOE/ANSI test procedures often are preferred or used to demonstrate compliance with these requirements.

Pool heaters must meet the efficiency requirements for service water heating in Table C404.2. Electric pool heaters and pumps must be installed with time switches so that they can be shut down during periods of limited use or inactivity (see Section C404.9.2).

TABLE C404.2. See page C4-91.

❖ This table provides the water heater efficiency requirements in Chapter 4 [CE]. The efficiency equation for electric-resistance water heaters in the code is intended to meet the existing federal minimum manufacturing standard and, therefore, differs from the ASHRAE level.

C404.2.1 High input service water-heating systems. Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, E_t, of not less than 90 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input-capacity-weighted-average thermal efficiency, E_t, shall be not less than 90 percent.

Exceptions:

1. Where not less than 25 percent of the annual *service water-heating* requirement is provided by *on-site renewable energy* or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.
2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of *service water-heating* equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of *service water-heating* equipment for a building.

❖ Where the total input rating of water-heating equipment installed in a new building is 1,000,000 Btu/h (293 kW) or greater, the thermal efficiency of the equipment (E_t) must be not less than 90 percent. Where multiple pieces of equipment are used, this can be a combined input capacity weighted average. The requirement only applies to gas-fired water-heating equipment. In determining the total input rating of the service water-heating equipment, the code exempts water heaters installed for individual dwelling units and water heaters with an individual rating less than 100,000 Btu/h (29.3 kW). Where not less than 25 percent of the annual service water heating requirements of the building are supplied by on-site renewable energy systems, the minimum thermal efficiency for the remaining gas-fired equipment is waived.

EQUIPMENT TYPE
Water heaters, electric
Storage water heaters, gas
Instantaneous water heate gas
Storage water heaters, oil
Instantaneous water heate oil
Hot water supply boilers, gas and oil
Hot water supply boilers
Hot water supply boilers
Pool heaters, gas and oil

C404.5.1 Maximum allowable pipe length method. The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1.

1. For a public lavatory faucet, use the "Public lavatory faucets" column in Table C404.5.1.
2. For all other plumbing fixtures and plumbing appliances, use the "Other fixtures and appliances" column in Table C404.5.1.

❖ This section provides one of the two methods called out in Section 404.5 to limit the volume of water in the portion of the hot water supply pipe from the source of the hot water to the outlet, or faucet. Quite simply, this limits the volume by limiting the length of pipe, based on the size of the pipe. A smaller pipe diameter, therefore, has less volume per foot and is allowed to have more length. Although not stated in this section, the source of hot water supply can be a water heater, a circulating water system or a heat-trace maintenance system, as stated in Section C404.5.2. The maximum allowable lengths of pipe from a source to a public lavatory system are restrictive. In most designs, this will certainly require use of a circulating water system or a heat-trace system.

C404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered to be sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

❖ This section provides one of the two methods called out in Section 404.5 to limit the volume of water in the portion of the hot water supply pipe from the source of the hot water to the outlet, or faucet. For calculation of a system where there is merely a run of pipe involved, the method in Section C404.5.1 is easier, and, for larger pipe diameters, somewhat less restrictive. For instance, where a $^1/_2$-inch (12.7 mm) supply pipe is used, Section C404.5.1 would allow 2 feet (610 mm) of pipe from the hot water source to a public faucet. Using this method, only $1^1/_3$ feet (406 mm) of pipe would be allowed. Where the piping system contains a number of valves, fittings, meters or manifolds, this method is needed (see Section 404.5.2.1). This section contains a provision that also applies to Section 404.5.1: the source of hot water can be the water heater, a circulating water system or a heat-trace system. Given the very small volume of water allowed for the supply from the source to a public lavatory faucet, this section would, in most cases, require the use of a circulating water system or a heat-trace system.

C404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

❖ This section provides information regarding what needs to be included in calculating the volume of

TABLE C404.5.1
PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public lavatory faucets	Other fixtures and appliances
$^1/_4$	0.33	6	50
$^5/_{16}$	0.5	4	50
$^3/_8$	0.75	3	50
$^1/_2$	1.5	2	43
$^5/_8$	2	1	32
$^3/_4$	3	0.5	21
$^7/_8$	4	0.5	16
1	5	0.5	13
$1^1/_4$	8	0.5	8
$1^1/_2$	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

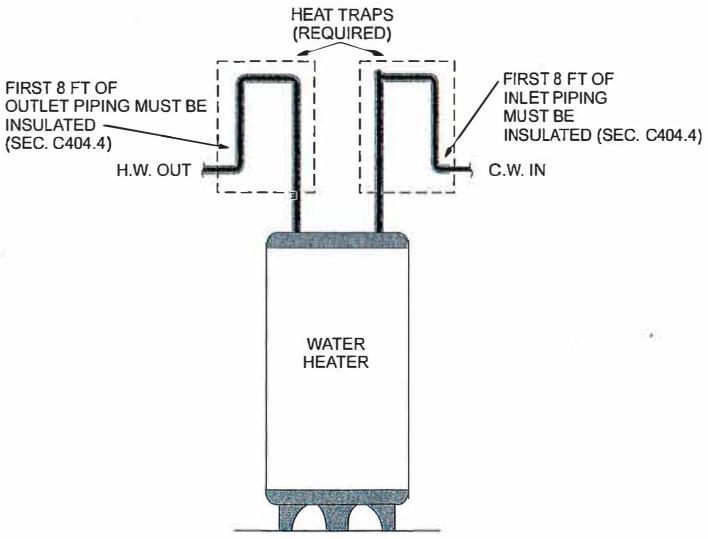
3. Piping from user-controlled shower and bath mixing valves to the water outlets.
4. Cold-water piping of a demand recirculation water system.
5. Tubing from a hot drinking-water heating unit to the water outlet.
6. Piping at locations where a vertical support of the piping is installed.
7. Piping surrounded by building insulation with a thermal resistance (*R*-value) of not less than R-3.

❖ Distribution losses impact building energy use both in the energy required to make up for the lost heat and in the additional load that can be placed on the space-cooling system if the heat is released to air-conditioned space. These losses can be limited by insulating the hot water storage vessel and pipes. The required amount of insulation is given in Table C403.11.3, which specifies different thicknesses of insulation depending on the size of the pipe or tube, the operating temperature range of the fluid, in this case water, and the conductivity of the insulation. For typical hot water supply, the operating temperature range in the table to consult is 140°F to 200°F (60°C to 93°C).

The locations where pipe insulation is not required are almost common sense but these locations need to be stated to avoid confusion and possible misinterpretations by the code officials. Insulating valves is time-consuming and, where the right type of valve is not used, nearly impossible. A few uninsulated valves in the system are not going to lose a lot of heat. Pumps are also difficult to insulate and, in some cases, insulation might cause overheating of the pump motor. Threaded unions usually only occur in smaller diameter piping systems and are time-consuming to insulate. Such unions represent a small amount of heat loss compared to the entire system. Piping or tubing from a small tankless water heater serving one sink is too small to easily insulate. The heat loss is negligible (see Commentary Figure C404.4).

C404.5 Heated water supply piping. Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through $^{1}/_{4}$-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through $^{5}/_{16}$-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through $^{3}/_{8}$-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

❖ The provisions are simply to limit the volume of water in a hot water supply pipe and therefore reduce the amount of time it takes to get hot water to the faucet. The volume is limited by the method in either Section C404.5.1, which simply limits the length of pipe between the source and the outlet, or Section C404.5.2, which requires a calculation of the volume of water in the specific piping system. The flow rate limitations reflect federal limitations on flow rate based on water conservation measures. Higher flow rates will obviously reduce the time-to-tap performance; however, the maximum volumes in Sections C404.5.1 and C404.5.2 are based on the maximum flow rates listed.



For SI: 1 foot = 304.8 mm.

Commentary Figure C404.3(1)
HEAT TRAP AND INSULATION REQUIREMENTS FOR NONCIRCULATING SYSTEMS
(Courtesy of U.S. Department of Energy, Office of Building Technology State and Community Programs, www.energycodes.gov)

water where using Section 404.5.2 as the design option for limiting the volume of water for the piping and system connecting the hot water source to the faucet or other outlet.

C404.6 Heated-water circulating and temperature maintenance systems. Heated-water circulation systems shall be in accordance with Section C404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section C404.6.2. Controls for hot water storage shall be in accordance with Section C404.6.3. Automatic controls, temperature sensors and pumps shall be in a location with *access*. Manual controls shall be in a location with *ready access*.

❖ Where the distribution piping is heated to maintain usage temperatures, such as in circulating hot water systems, the system pump or heat-trace cable must have conveniently located manual or automatic switches, or other controls, that can be set to optimize system operation or turn off the system during periods of reduced demand.

Most automatic time clocks allow the operator or building engineer to enter different operating schedules for each of the seven days of the week; thus, pipes are not heated during hours of inactivity. More sophisticated devices, such as a combination time and temperature and demand controls, also comply with the requirements of this section.

C404.6.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermo-syphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water.

❖ Circulation systems for heated water must be demand activated. Demand-activated systems provide significantly more energy efficiency than any other type of circulation system. Given that the piping is required to be insulated, the water in the recirculation loop will stay hot for a long time, thus making continuous circulation of the water unnecessary.

C404.6.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy. Heat trace shall be arranged to be turned off automatically when there is not a demand for hot water.

❖ Automatic controls are necessary to adjust water temperature based on use of hot water and to turn off the heat trace system when there is no demand. These automatic controls are intended to make the heat trace system as energy efficient as possible where it is used.

C404.6.3 Controls for hot water storage. The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

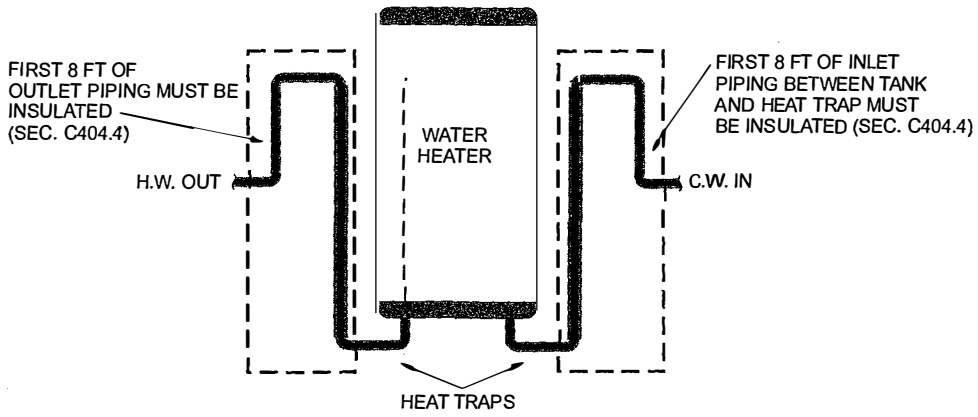
❖ This provision is the same as in the *International Plumbing Code*® (IPC®). This section addresses water-heating systems that utilize a separate water-heating unit to generate hot water for storage in tanks. These systems have a circulating pump to move hot water into the storage tank (and cooler water back to the heating unit). This section requires that the circulation pump not continue to operate after the hot water storage tank is at the desired temperature. The run time of up to 5 minutes after the end of the heating cycle is to allow for the heating unit's heat exchanger to cool down and equalize temperature with the stored hot water.

C404.7 Demand recirculation controls. Demand recirculation water systems shall have controls that comply with both of the following:

1. The controls shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The controls shall limit the temperature of the water entering the cold-water piping to not greater than 104°F (40°C).

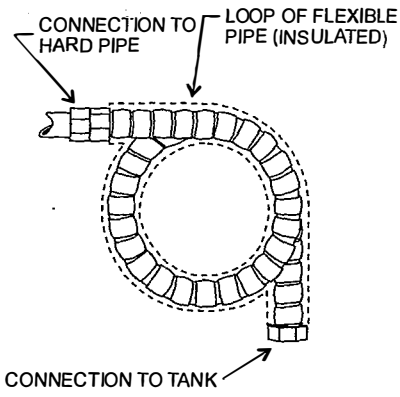
❖ This section applies only to heated water (hot or tempered water) recirculation systems that pump water back to the heated water source through a cold-water supply pipe. Specialized equipment for recirculating hot water to remote fixture systems and back to the heated water source through a cold-water supply pipe has been used for several decades. They are most often used as a retrofit for buildings where routing of dedicated return piping is too costly or impossible. See the commentary to Section 604.2 of the IPC for additional information on "no dedicated return line" recirculation systems.

Research by many organizations, including the Oak Ridge National Laboratory and the California Energy Commission, has determined that having hot water "ready and waiting" at fixtures is a significant energy waste. On the other hand, where a hot (or tempered) water circulation system is not provided, there is a significant waste of energy of heating water that never arrives at the intended point of use except where a large volume of cooler water is flushed down the drain in order to have the heated water arrive at the point of use. Certainly, such water waste is of concern (because of rising water and sewer charges), but the waste of "embedded energy" (utility treatment and pumping energy) in that water is of equal or greater concern. The focus of the research was to determine how to best install and operate hot-water (or tempered-water) recirculation systems for the lowest possible cost.

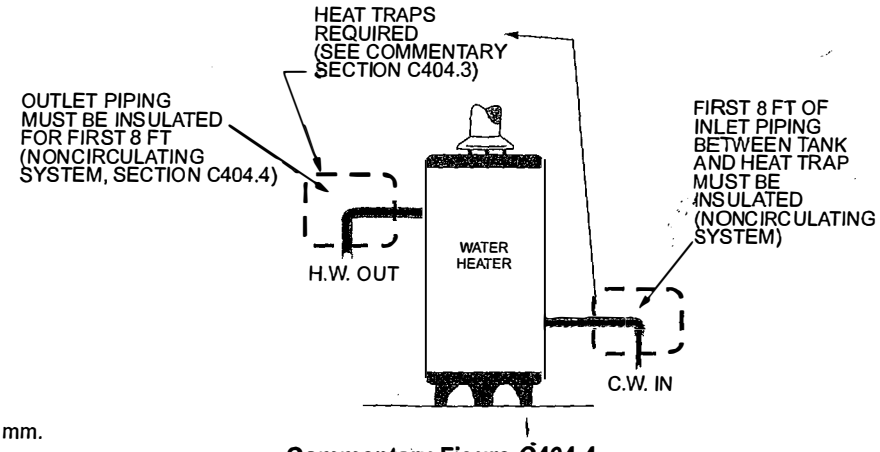


For SI: 1 foot = 304.8 mm.

Commentary Figure C404.3(2)
HEAT TRAPS ON A TANK WITH CONNECTIONS ON THE BOTTOM
(Courtesy of U.S. Department of Energy, Office of Building Technology State and Community Programs, www.energycodes.gov)



Commentary Figure C404.3(3)
HEAT TRAP THROUGH A FLEXIBLE PIPE LOOP
(Courtesy of U.S. Department of Energy, Office of Building Technology State and Community Programs, www.energycodes.gov)



For SI: 1 foot = 304.8 mm.

Commentary Figure C404.4
HEAT TRAPS ON A TANK WITH CONNECTIONS ON SIDES
(Courtesy of U.S. Department of Energy, Office of Building Technology State and Community Programs, www.energycodes.gov)