International Code Council (ICC)

BSR/ICC 903/SRCC 500, Thermal Energy Storage Tank Standard

First Public Comment Draft

April 23, 2025

The first public comment draft of BSR/ICC 903/SRCC 500-202X, Thermal Energy Storage Tank Standard was released on April 23, 2025. Public comments will be accepted through June 23, 2025. Comments must be submitted using the Public Comment Form at the end of the document.

The revisions proposed are made to the published ICC 903/SRCC 500 -2024 edition of the standard, approved by ANSI in May 2024.

BSR/ICC 903/SRCC 500-202X Thermal Energy Storage Tank Standard

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CHAPTER 1

APPLICATION AND ADMINISTRATION

SECTION 101—GENERAL

101.1 Purpose. This standard is intended to establish minimum safety, durability and marking requirements for thermal energy storage tanks used to store heated fluids. It is intended for use in conjunction with applicable local building codes. This standard addresses thermal energy storage tanks used as components within heating systems intended to supply heated fluids, including but not limited to solar tanks used within solar water heating systems. Thermal energy storage tanks are not intended for use as stand-alone water heaters outside of split-system water heaters.

The standard is designed to address topics and features unique to thermal energy storage tanks that are not addressed in existing standards for storage water heaters.

101.2 Scope. This standard sets forth minimum durability, safety and labeling requirements for thermal energy storage tanks used as components in heating systems. This standard applies to:

1. Thermal energy storage tanks designed to store fluids that remain in liquid phase at temperatures between 40°F (4.4°C) and 210°F (99°C) and pressures between 0 psi (0 MPa) and 150 psi (1.03 MPa).
2. Thermal energy storage tanks designed for use with potable water or other food-grade liquid.
3. Thermal energy storage tanks that include integral supplemental electric heating devices that are not more than 600 volts and 12 kilowatts, total.
4. Thermal energy storage tanks with integral supplemental gas heating devices with input ratings less than or equal to 75,000 Btu/hr. (21,980 W).
5. Tanks, constructed entirely of new, unused parts and materials.
6. Thermal energy storage tanks that include integral single or double-wall heat exchanger(s).
7. Pressurized thermal energy storage tanks with a fluid capacity not less than 1 gallon (3.8 L).
8. Unpressurized thermal energy storagetanks with a fluid capacity of not more than 5,000 gallons (18,927 L).
9. Thermal energy storage tanks designed for indoor and/or outdoor installation.

The following tanks are excluded from the scope of this standard.

1. Tanks designed to function as standalone water heaters, without external heat sources.
2. Tanks designed to store or utilize hazardous, flammable, or toxic fluids.
3. Tanks that are inseparable from solar thermal collectors for the purpose of testing under this standard.
4. Tanks designed for use in hazardous locations.
5. Portable tanks.
6. Building-integrated tanks.

SECTION 102—REFERENCED DOCUMENTS

102.1 Referenced documents. The codes and standards referenced in this standard shall be part of the requirements of this standard to the prescribed extent of each such reference. Chapter 7 contains a complete list of all referenced standards.

CHAPTER **2**

DEFINITIONS

SECTION 201—GENERAL

201.1 General. For this standard, the terms listed in Section 202 have the indicated meaning.

201.2 Undefined terms. The meaning of terms not specifically defined in this document or in referenced standards shall have ordinarily accepted meanings as the context implies.

201.3 Interchangeability. Words, terms, and phrases used in the singular include the plural and the plural include the singular.

SECTION 202—DEFINED TERMS

DEGRADATION. Leading to significant permanent loss of performance or leading to elevated risk of danger to life, limb, or product.

DESIGN LIFE. Period for which a component is expected to function at its designated capacity without major repairs.

DISTORTION. A change witnessed or measured during testing that suggests a change to the functional dimensional integrity of a product raising safety, reliability, or performance concerns.

FOOD-GRADE FLUID. Potable water or a fluid containing additives listed in accordance with the Code of Federal Regulations, Title 21, Food and Drugs, Chapter 1, Food and Drug Administration, Parts 174–186.

HEAT EXCHANGER. A device that transfers thermal energy from one medium to another.

Double-wall heat exchanger. A heat exchanger design in which a single failure of any fluid barrier will not cause a cross connection or permit backflow of heat transfer fluid between two separate fluid systems.

Single-wall heat exchanger. A heat exchanger design in which a single failure of any fluid barrier will cause a cross connection or permit backflow of heat transfer fluid between two separate fluid systems.

HEAT TRANSFER FLUID. Air, water, or other fluid that is used to transfer thermal energy between components in an indirect water heating system.

INTEGRATED COLLECTOR STORAGE (ICS). Devices designed to both collect solar thermal energy and store the heated fluid. The collection and storage functions of ICS devices cannot be separated for testing purposes.

LABELED. Equipment, materials, or products that have been affixed with a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and whose labeling indicates either that the equipment, material, or product meets identified standards or has been tested and found suitable for a specified purpose.

LISTED. Equipment, materials, products, or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product, or service meets identified standards or has been tested and found suitable for a specified purpose.

MANUAL. The total documentation package provided by the manufacturer describing the installation, operation, and maintenance of the tank.

MAXIMUM THERMAL ENERGY DELIVERY RATE. The maximum thermal energy delivery rate of a thermal energy storage tank indicates that maximum rate at which energy can be discharged from the tank directly (not through an integral heat exchanger) using a specified fluid. It is determined using the maximum operating temperature, maximum operating pressure and the outlet size.

NONFOOD GRADE. Any fluid that is not designated as a *food-grade fluid*.

NONPOTABLE WATER. Water that is not safe for drinking or for personal or culinary use.

POTABLE WATER. Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming to the bacteriological and chemical quality requirements of the Public Health Service Drinking Water Standards or the regulations of the public health authority having jurisdiction.

RATED THERMAL ENERGY CAPACITY. The rated thermal energy storage capacity of a thermal energy storage tank indicates the maximum thermal energy that can be stored within a tank using a specified fluid and reference condition. It is determinedusing the rated storage volume and maximum temperature rise over a reference incoming fluid temperature.

SPLIT-SYSTEM WATER HEATER. A water heating system comprised of separate components connected by piping where the primary heat source(s) are not integrated into an assembly with thermal energy storage tank(s) as an appliance.

SUPPLEMENTAL HEAT SOURCE. A source of heat such as electric heating elements, heat pump systems, gas burners or oil burners incorporated into thermal energy storage tanks to augment the energy supplied by external heat sources.

THERMAL ENERGY STORAGE TANK. A tank designed to store fluid in liquid form that is heated primarily by an independent external source. The tank may include integral supplemental heaters and/or heat exchangers.

SOLAR TANK. A thermal energy storage tank designed for use as component in a solar heating system to accept and store water or other food-grade fluid heated by means of solar thermal collectors. Solar tanks may incorporate integral heat exchangers and supplemental heat sources and may be pressurized or unpressurized. Solar tanks are not designed or listed to function as stand-alone water heaters (without solar energy input).

VOLUMETRIC CAPACITY. Maximum volume of liquid that can be stored in a thermal energy storage tank.

CHAPTER 3

DESIGN AND CONSTRUCTION

SECTION 301—GENERAL

301.1 General. All types of tanks within the scope of this standard shall be designed and constructed in accordance with the requirements of this chapter.

301.2 Workmanship. Tanks shall be free of sharp edges or projections that could present a hazard under normal use or servicing.

301.3 Mounting. Tanks shall be constructed to constrain the filled weight of the tank when installed in a stable manner that prevents tipping under normal operation. All approved mounting methods and orientations shall be specified by the manufacturer.

301.4 Supplemental electric heaters. Supplemental electric heaters installed within or integral to thermal energy storage tanks shall have a total electrical input of 12 kW or less.

301.5 Protective controls. Any thermal energy storage tank with a supplemental heater shall meet the requirements of the relevant base standard in Table 401.1 for temperature limiting controls.

SECTION 302—MATERIALS

302.1 General. Materials used in the construction of thermal energy storage tanks shall be compatible with fluids approved for use with the tank under design operating conditions. Materials in contact with fluids shall be resistant to moisture absorption and degradation.

302.2 Incompatible materials. Incompatible materials shall be isolated or treated to prevent degradation to the extent that their function could be impaired under in-service conditions.

302.3 Potable water contamination. Materials that come in direct contact with potable water shall not adversely affect the taste, odor or physical quality and appearance of the water and shall comply with NSF 61 and NSF 372 and shall have a weighted average lead content of 0.25 percent or less. Plastic-lined tanks designed for contact with potable water shall comply with ANSI/NSF 14.

302.4 Non-potable tank materials. Non-potable water tanks shall be constructed of materials that are suitable for use with approved fluids as indicated in the product labeling prescribed in Chapter 6.

SECTION 303—CONSTRUCTION

303.1 General. Thermal energy storage tanks shall be designed and constructed in accordance with the requirements of this section.

303.1.1 Listed components. Listed components incorporated into a thermal energy storage tank shall be used and installed in a manner complying with the component manufacturer's instructions and the conditions of listing. Listed components shall not be modified in any way that invalidates the listing of the component.

303.2 Relief valves for excessive pressure and temperature. Each portion of pressurized tanks and integral heat exchangers where excessive pressures can develop shall be protected by temperature and pressure relief valves or combinations thereof. Relief valves shall be listed and labeled to ANSI Z21.22/CSA 4.4, with a pressure setting not exceeding the manufacturer's rated working pressure or 150 psi (1035 kPa), whichever is less, and a temperature setpoint not exceeding 210°F (98.9°C). Means of rendering a relief device ineffective shall not be incorporated or installed.

303.3 Thermal insulation. Thermal energy storage tanks shall be insulated to an R-value of not less than R-12.5 (h × ft^2 × °F)/Btu [R-2.2 (m^2× K/W)].

303.4 Ports. Thermal energy storage tanks shall have at least two ports for connections to external heat sources in addition to dedicated inlet, outlet, and drainage ports.

303.4.1 Drainage port accessibility. Drainage ports shall be accessible when the tank is installed in all orientations approved by the manufacturer.

303.5 Dip tubes. Non-metallic dip tubes shall comply with ANSI Z21.98/CSA 4.10.

CHAPTER 4

PRESSURIZED TANKS

SECTION 401—GENERAL

401.1 Base Standard. Pressurized thermal energy storage tanks shall comply with applicable requirements in Chapter 3 of this document and at least one appropriate base standard(s) referenced in Table 401.1. Once the base standard is selected, the thermal energy storage tank shall comply with all applicable requirements and tests from the selected base standard as modified and supplemented by this standard.

TABLE 401.1—PRESSURIZED TANK BASE STANDARDS

PRESSURIZED TANK CATEGORY	BASE STANDARD
Pressurized Storage Tanks with Electric Resistive Heating Element(s)	UL 174 or UL 1453
Pressurized Storage Tank with Gas Burner	ANSI Z21.10.1 CSA 4.1
Pressurized Storage Tanks with Oil Burner	UL 732
Pressurized Storage Tanks with Heat Pump	UL 60335-2-40
Pressurized Storage Tank with no Supplemental Heater	UL 174 or ANSI Z21.10.1/CSA 4.1 or UL 1453

SECTION 402—ADDITIONAL DESIGN REQUIREMENTS

402.1 Vacuum resistance. Pressurized thermal energy storage tanks that are bottom-fed and/or designed for installation in elevated locations shall be provided with a vacuum relief valve listed and labeled to ANSI Z21.22/CSA 4.4.

SECTION 403—HEAT EXCHANGERS FOR PRESSURIZED TANKS

403.1 General. Pressurized thermal energy storage tanks with one or more heat exchangers integrated into or installed on the tank shall comply with this section.

403.2 Construction. Heat exchangers integrated into thermal energy storage tanks shall be double walled. Double-wall heat exchangers shall be designed such that any failure of a barrier will allow the discharge of heat transfer fluids to the atmosphere in a way that is readily observable.

Exception: Single-wall heat exchangers shall be permitted when in compliance with both of the following:

1. The tank and any heat exchangers are approved for use only with potable water or fluids containing components that are food grade.
2. The maximum operating pressure of non-potable heat transfer fluids within the heat exchanger is less than the normal operating pressure of the tank vessel.

403.3 Hydrostatic pressure test. Heat exchangers integral to or installed on pressurized thermal energy storage tanks shall be subject to hydrostatic pressure testing in accordance with the following procedures, unless certified and marked according to ASME Boiler & Pressure Vessel Code, Section IV or VIII. The test shall be conducted in accordance with the following procedure:

403.3.1 Test sequence. Hydrostatic heat exchanger pressure testing shall be conducted immediately following the hydrostatic pressure testing specified for the tank in the applicable base standard in Table A.

403.3.2 Test method. The maximum test pressure shall be twice the manufacturers rated maximum pressure for the supply side of the heat exchanger. If a tank incorporates more than one heat exchanger, they shall be tested individually.

1. The supply side of the heat exchanger shall be filled with water, eliminating all air. The potable water side of the tank shall be filled with water to normal operating pressure as per the manufacturer's installation instructions, before commencing this test.

2. The pressure to the supply side of the heat exchanger shall then be increased to the maximum test pressure at a maximum rate of 20 psi (138 kPa) per second.

3. The maximum test pressure shall then be maintained for not less than 10 minutes.

4. The pressure shall then be reduced to atmospheric pressure at a maximum rate of 20 psi (138 kPa) per second. The heat exchanger shall then be drained and inspected.

403.3.3 Test criteria. To pass the test, no leakage or significant distortion of the heat exchanger or tank shall be observed. The tank shall also be inspected to determine whether any leakage occurred from the heat exchanger into the tank. The results shall be documented, noting any distortion of the tank or heat exchanger observed during or after the test. No rupture or permanent deformation shall be permitted.

SECTION 404—PRESSURIZED TANKS FOR OUTDOOR USE

404.1 General. Pressurized thermal energy storage tanks designed for installation outdoors shall comply with the requirements of the base standard selected in Section 401.1 or be rated to a minimum of IPX4 as specified in IEC 60529 or NEMA 3R as specified in NEMA 250. If the selected base standard does not establish requirements for unprotected installation outdoors that include a water spray test, the tank shall be rated to a minimum of IPX4, as specified in IEC 60529 or NEMA 3R as specified in NEMA 250. After water spray testing, there shall be no evidence of water ingress that impacts the safety or performance of the tank.

CHAPTER 5

UNPRESSURIZED TANKS

SECTION 501—UNPRESSURIZED THERMAL ENERGY STORAGE TANKS WITH SUPPLEMENTAL HEATERS

501.1 Base standard. Unpressurized thermal energy storage tanks with one or more supplemental heaters shall comply with the applicable requirements in Chapter 3 of this document and the corresponding base standard referenced in Table 501.1. Where more than one standard is listed, the thermal energy storage device tank shall comply with one as determined by scope of base standard. Once the base standard is selected, the thermal energy storage tank shall comply with all applicable requirements and tests from that standard as modified and supplemented by this standard.

TABLE 501.1—UNPRESSURIZED THERMAL ENERGY STORAGE TANK BASE STANDARDS

CATEGORY	BASE STANDARD
Unpressurized Hot Water Storage Tanks with Supplemental Electric Resistive Heating Element(s)	UL 174 or UL 1453
Unpressurized Hot Water Storage Tank with Supplemental Gas Burner	ANSI Z21.10.1 CSA 4.1
Unpressurized Hot Water Storage Tanks with Oil Burner	UL 732
Unpressurized Hot Water Storage Tanks with Heat Pump	UL 60335-2-40
Unpressurized Hot Water Storage Tank with no Supplemental Heater	UL 174 or ANSI Z21.10.1/CSA 4.1 or UL 1453

SECTION 502—UNPRESSURIZED THERMAL ENERGY STORAGE TANKS WITHOUTSUPPLEMENTAL HEATERS

502.1 General. Unpressurized thermal energy storage tanks withoutsupplemental heatersshall comply with one of the following:

1. One of the base standard as specified in Section 501, or
2. The requirements of Section 502 of this document.

Unpressurized thermal energy storage tanks listed to one of the base standards in Section 501 are not required to be assessed to the requirements of Section 502. All unpressurized tanks shall comply with the requirements of Sections 503 and 504 as applicable.

502.2 Venting. Unpressurized thermal energy storage tanks shall be vented to atmospheric pressure by means of open vents. Open vents shall be sized to ensure that the pressure in the tank does not exceed atmospheric pressure during heat cycling, within design parameters and must be at least ¾”nominal pipe size or equivalent. Tank vents shall not be connected to, or combined with, any other vents. Open vents shall extend vertically not less than 6 inches (152 mm) above the maximum tank fluid level. Open vents shall be protected from contamination by means of an approved cap or U-bend installed with the opening directed downward. Open vents shall be protected against the entrance of vermin and insects. Screen materials shall be compatible with contacting system components and fluids and shall not accelerate corrosion of system components.

502.3 Outer jackets. Unpressurized thermal energy storage tanks shall be provided with an outer jacket to provide protection for the tank, insulation, and stored fluids.

502.3.1 Polymeric materials for outer jacket. Polymeric materials used in the construction of the outer jacket shall have a minimum HB flammability classification when tested per UL 94. Outer jacket materials with surface area greater than 10 square feet shall also have a maximum flame spread index of 200 when tested per UL 723 or ASTM E84. Outer jackets comprised of polymeric materials shall comply with the Resistance to Impact Test described in UL 746C. After impact testing, there shall be no visible cracks or openings, or other evidence of damage that impacts the safety or performance of the tank.

502.4 Polymeric foam insulation. Polymeric foam insulation used within thermal energy storage tanks shall have a maximum flame spread index of 25 when tested per UL 723 or ASTM E84 or be enclosed in a metal outer jacket. Foam shall be tested per UL 746B and be rated for the maximum operating temperature of the tank.

502.5 Leakage test. Unpressurized thermal energy storage tanks shall be tested for leakage in accordance with the following procedure:

502.5.1 Test method. The tank shall be filled with water to capacity, noting the initial water level. The water shall be heated to and maintained at the tank's maximum operating temperature. After maintaining the maximum operating temperature ±5°F (±2.8°C) for a minimum of 24 hours, the water level shall be determined and recorded. The tank shall then be fully drained and inspected.

502.5.2 Test criteria. No leakage or significant distortion in the tank shall be observed. The results shall be documented, noting any changes to the water level, fluid leakage or tank distortions observed during or after the test.

502.6 Maximum temperature test. Unpressurized thermal energy storage tanks assessed per this section shall be tested to verify the ability to withstand the maximum design operating temperature. The tank shall be installed and oriented in a manner consistent with the intended use and manufacturer's instructions. An approved pressure & temperature relief valve shall be installed on any pressurized heat exchangers with a setpoint no more than manufacturer's rated working pressure or 150 psi (1035 kPa), whichever is less. The temperature setpoint of the pressure & temperature relief valve shall not exceed 210°F (98.9°C).

Where the tank is intended solely for indoor use, testing shall be conducted at an ambient temperature maintained between 65.0 and 70.0°F (18.3 – 21.1°C). For tanks designed for use outdoors, testing shall be conducted at the maximum ambient design temperature specified by the manufacturer.

502.6.1 Test procedure. The tank shall be filled with water raised to the maximum design operating temperature. Where the tank includes an integral heat exchanger, it shall not be filled and shall be vented to the atmosphere. Water shall be circulated into the tank through an inlet port and out through an outlet port and heated as required to maintain the maximum design operating temperature within ±5°F (±2.8°C). Water shall be circulated at a flowrate not less than 0.02 kg/s at the design operating pressure for a minimum of 24 hours.

Throughout the test, surface temperatures shall be measured a minimum of every 5 minutes on all surfaces subject to contact during normal operation and maintenance.

502.6.2 Post-test inspection. Upon completion of the test, the tank shall be emptied of water and inspected to assess the condition. All defects, abnormalities, deformation, damage, and changes to the function of the tank shall be documented. Proper operation of any electrical features shall be confirmed and documented following the test.

502.6.3 Test criteria. The test shall be considered passed where the following criteria are met:

- No surface temperature shall exceed 150°F.
- No signs of leakage from any part of the tank.
- No significant deterioration, warpage, discoloration, or damage to any materials.
- No electrical short circuits, ground faults or damage to wiring or electrical components.

SECTION 503—HEAT EXCHANGERS FOR UNPRESSURIZED THERMAL ENERGY STORAGETANKS

503.1 General. Unpressurized thermal energy storage tanks assessed under Section 501 or 502 containing one or more integral heat exchangers shall comply with the following requirements.

503.2 Hydrostatic heat exchanger pressure test. Heat exchangers integrated into unpressurized thermal energy storage tanks shall be subject to hydrostatic pressure testing in accordance with the following procedures. The test shall be conducted in accordance with the following procedure.

503.2.1 Test method. The maximum test pressure shall be twice the manufacturers rated maximum pressure for the supply side of the heat exchanger. If a tank incorporates more than one separate heat exchanger, they shall be tested individually.

1. The supply side of the heat exchanger shall be filled with water, eliminating all air. The tank shall be empty and open to the atmosphere.
2. The pressure to the supply side of the heat exchanger shall then be increased to the maximum test pressure at a maximum rate of 20 psi (138 kPa) per second.
3. The maximum test pressure shall then be maintained for not less than 10 minutes.

4. The pressure shall then be reduced to atmospheric pressure at a maximum rate of 20 psi (138 kPa) per second. The heat exchanger shall then be drained and inspected.

503.2.2 Test criteria. No leakage or significant distortion shall be observed. The tank shall also be inspected to determine whether any leakage occurred from the heat exchanger into the tank. The results shall be documented, noting any distortion of the tank or heat exchanger observed during or after the test. No rupture or permanent deformation shall be permitted.

SECTION 504—UNPRESSURIZED THERMAL ENERGY STORAGE TANKS FOR OUTDOOR USE

504.1 Outdoor use. Unpressurized thermal energy storage tanks assessed under Section 501 or 502 and designed for installation outdoors shall be tested per the Rain Test method in UL 174 or have a minimum rating of IPX4 as specified in IEC 60529 or NEMA 3R as specified in NEMA 250. After water spray testing, there shall be no evidence of water ingress that impacts the safety or performance of the tank.

504.1.1 Gaskets. Rubber or neoprene gaskets necessary for compliance with the Rain Test in 504.1 shall be tested per and comply with the Accelerated Aging Tests for Gaskets of UL 174, or with the requirements of UL 157 for the application.

504.1.2 Polymeric materials. Exposed polymeric materials shall be tested and be suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 746C.

CHAPTER 6

LABELING AND MANUALS

SECTION 601—MARKING & LABELS

601.1 General. Thermal energy storage tanks shall be marked and/or labeled with the information listed in this section. The information shall be provided in a clearly readable size and format. Markings shall be stamped, molded, etched, or engraved on the exterior of the product, or using labels affixed to the product. Marks and labels shall comply with permanence requirements set forth in UL 969. Marks and labels shall be in a location visible after the tank is installed.

601.1.1 Site-built tanks. Where thermal energy storage tanks are assembled or built at the location of installation, a permanent label shall be affixed to a location visible after installation.

601.2 Mark and label content. The marks and/or labels shall include the following minimum information:

1. Model name and/or number.
2. Year of manufacture and/or serial number.
3. Certification number and third-party certification agency.
4. Maximum working pressure for the tank and any integral heat exchangers in kilopascals (kPa) and pounds per square inch (psi).
5. Dry weight in kilograms (kg) and pounds (lbs).
6. Volumetric capacity in liters (L) and gallons (gal), determined in accordance with Section 603.
7. Compatible fluids. Tanks shall be specifically labeled to indicate whether or not they are approved for potable water use within the tank and any integral heat exchangers.
8. Integral heat exchanger type (single-wall, double-wall), as applicable.
9. Electrical rating in volts and amperes or watts, indicating alternating current (AC) or direct current (DC), frequency and number of phases (where applicable) of any integrated supplemental electric heaters.
10. Rated thermal energy storage capacity in kilowatt-hours (kWh), determined in accordance with Section 604.
11. Maximum thermal energy delivery rating in watts (W), determined in accordance with Section 605.
12. Usage statement: "THIS TANK IS DESIGNED AND TESTED FOR USE AS PART OF A THERMAL ENERGY SYSTEM. IT IS NOT INTENDED FOR USE AS A STAND-ALONE WATER HEATER."
13. All other content prescribed by the base standard used in accordance with Section 401 or 501.

SECTION 602—MANUALS

602.1 General. At least one manual shall be provided with each thermal energy storage tank in hard copy or digital copy via download link. The manual(s) shall describe procedures for installation, operation and maintenance in accordance with this section. The following general information must be provided:

1. Manufacturer's name and address.
2. Model.
3. Certification number and third-party certification agency.
4. Usage statement: "THIS TANK IS DESIGNED AND TESTED FOR USE AS PART OF A THERMAL ENERGY SYSTEM. IT IS NOT INTENDED FOR USE AS A STAND-ALONE WATER HEATER."
5. Maximum working pressure in kilopascals (kPa) and pounds per square inch (psi).
6. Maximum and minimum recommended operating temperature in degrees Celsius (°C) and Fahrenheit (°F).
7. Dry weight in kilograms (kg) and pounds (lbs).
8. Volumetric capacity in liters (L) and gallons (gal), determined in accordance with Section 603.

9. Rated thermal energy storage capacity in kilowatt-hours (kWh), determined in accordance with Section 604.

10. Maximum thermal energy delivery rating in watts (W), determined in accordance with Section 605.

11. Compatible heat transfer fluids with specific indication whether tanks and integral heat exchangers are approved for potable water use.

12. Heat exchanger type (single-wall, double-wall), as applicable.

13. Approved installation locations: indoors, outdoors – protected, outdoors – unprotected.

14. Outer dimensions in millimeters (mm) and inches (in).

15. Locations, types and sizes of all ports.

16. Warning against health and safety hazards that could arise in the operation and maintenance of the tank and full description of the precautions that must be taken to avoid these hazards.

17. Description of any warranty for the tank and the method for obtaining warranty coverage.

18. Directions for transport, storage, and handling.

19. Manufacturer's approved mounting hardware and instructions for mounting of the tank in each approved orientation.

20. Requirements for any field-installed components supplied with the tank.

21. Methods for filling the tank with fluids, including safe handling of approved fluids.

22. All other content prescribed by the base standard(s) used in accordance with Section 401 or 501.

602.2 Installation. The manual shall prescribe installation in accordance with the building code, plumbing code, mechanical code, fuel gas code, fire code and electrical code adopted by the authorities having jurisdiction at the installation site. In the absence of such codes, the manual shall prescribe installation in accordance with the International Building Code® (IBC), International Plumbing Code® (IPC), International Mechanical Code® (IMC), International Fire Code® (IFC), and National Electrical Code (NFPA 70, NEC).

602.3 Operation instructions. The manual shall include instructions for the operation of the thermal energy storage tank along with maintenance practices. Any parts that may be subject to periodic inspection, maintenance, repair or replacement shall be identified.

SECTION 603—VOLUMETRIC CAPACITY

603.1 General. The volumetric capacity of thermal energy storage tanks shall be determined by means of direct measurement per the Measured Volume Method or Calculated Volume Method below. The result shall be reported to the nearest gallon. The manufacturer's rated volume shall be within ± 5.0 percent of the measured or calculated volumetric capacity.

603.2 Measured volume method. The empty (tare) weight of the tank shall first be measured. The tank volume shall be measured by filling it with an approved liquid and pressurizing to the design operating pressure, after which the filled weight is determined. If the tank includes an integral heat exchanger, the heat exchanger shall not be filled. The net weight is determined by subtracting the dry weight from the filled weight. The net weight is then divided by the density of the liquid to determine the volumetric capacity.

$$V_{st} = \frac{(W_f - W_t)}{\rho}$$

Where:

V_{st} = the measured volumetric capacity of the tank, gal (L)

W_f = the weight of the tank when filled with liquid, lb (kg)

W_t = the (tare) weight of the tank when completely empty, lb (kg)

ρ = density of liquid used to fill the tank measured at the temperature of the liquid, lb/gal (kg/L)

603.3 Calculated volume method. The calculated volumetric capacity shall be determined by means of mathematical calculations of the enclosed volume. The volume enclosed by the heat exchanger shall not be included in the calculated volumetric capacity.

SECTION 604—RATED THERMAL ENERGY STORAGE CAPACITY

604.1 General. The rated thermal energy storage capacity of a pressurized or unpressurized thermal energy storage tank shall be calculated by the following method.

604.1.1 Reference inlet fluid temperature. The inlet reference temperature of the fluid shall be assumed to be 58°F (14.4°C), as specified in *10 CFR 430, Subpart B, Appendix E, Uniform Test Method for Measuring the Energy Consumption of Water Heaters.*

604.1.2 Average fluid temperature. The average fluid temperature to be used as the basis for the density and specific heat properties of the fluid, shall be determined by averaging the reference inlet fluid temperature (T_{ref}) and the maximum design operating temperature of the tank (T_{max}).

604.1.3 Fluids. Fluids used for the calculation of the rated thermal energy storage capacity shall be water or other similar Newtonian fluid that is in liquid form over the operating temperature range of the tank.

604.2 Thermal capacity calculation. The rated thermal energy storage capacity of a thermal energy storage tank is determined from the sum of the thermal capacity of a specified fluidin a filled and fully mixed tank and the vessel of the tank. The $3.6x10^6$ kWh/J factor converts the results from J to kWh units.

$Q_t = Q_f + Q_v$

Where:

Q_t = rated thermal energy capacity of the tank filled with a specified fluid (kWh)

Q_f = rated thermal energy capacity of the water stored in the tank (kWh)

Q_v = rated thermal energy capacity of the tank vessel (kWh)

Each component is calculated as follows:

$$Q_w = \frac{\rho_w C_{p,w} V_{st}}{3.6 \times 10^6}(T_{max} - T_{ref})$$

Where:

V_t = rated volumetric storage of the tank (L)

ρ_f = density of the specified fluid at the average fluid temperature (kg/L)

$C_{p,f}$ = specific heat of the specified fluid at the average fluid temperature (J/kgK)

T_{max} = maximum design operating temperature of the tank (°C)

T_{ref} = reference inlet fluid temperature (°C) (assumed to be 14.4°C)

The rated thermal energy capacity shall be reported in units of kWh along with the rated volumetric storage capacity and maximum operating temperature for the specified fluid.

$$Q_v = S \times \frac{C_{p,v} m_v}{3.6 \times 10^6}(T_{max} - T_{ref})$$

Where:

S = scaling factor (0.75)

m_v = mass of the tank vessel (kg)

$C_{p,v}$ = specific heat of the vessel material at the average fluid temperature (J/kgK)

T_{max} = maximum design operating temperature of the tank (°C)

T_{ref} = reference inlet fluid water temperature (°C) (assumed to be 14.4°C)

604.3 Thermal Capacity Reporting. The rated thermal energy storage capacity of a tank calculated in accordance with Section 604.2 shall be reported in units of kilowatt-hours (kWh) along with the selected fluid.

SECTION 605
MAXIMUM THERMAL ENERGY DELIVERY RATING

605.1 General. The maximum thermal energy direct delivery rating of the thermal energy storage tank shall be calculated by one of the methods established in Section 605.2 or 605.3. This methodology is provided for tanks where fluid is directly extracted from the tank for discharge and does not apply to tanks with integral load-side heat exchangers.

605.1.1 Discharge coefficient. The discharge coefficient, Cd, is the product of the velocity coefficient, Cv, and the contraction coefficient Cc. For water, the velocity coefficient shall be assumed to be 0.97. For discharge outlets with sharp edges, the contraction coefficient shall be assumed to be 0.62, and for well-rounded outlets it shall be assumed to be 0.97, unless determined experimentally for the specified fluid.

605.1.2 Reference inlet fluid temperature. The inlet reference temperature of the fluid shall be assumed to be 58°F (14.4°C), as specified in *10 CFR 430, Subpart B, Appendix E, Uniform Test Method for Measuring the Energy Consumption of Water Heaters.*

605.1.3 Fluids. Fluids used for the calculation of maximum thermal energy delivery rating shall be water or other similar Newtonian fluid that is in liquid form over the operating temperature range of the tank.

605.2 Maximum Thermal Energy Delivery Rating Calculation for Pressurized Tanks. The maximum thermal energy delivery rating of a pressurized thermal energy storage tank shall be calculated for a fluid based on the maximum operating pressure, maximum operating temperature, head and dimensional size of the outlet and is calculated as follows:

$$\dot{Q}_{max} = AC_{p,f}C_d(T_{max} - T_{ref})\sqrt{2\rho_f(P + \rho_f gh)}$$

Where:

$\dot{Q}_{max}$ = maximum thermal energy discharge rate for the fluid (W)

A = outlet cross-sectional area (m^2)

$C_{p,f}$ = specific heat of a fluid at the maximum design operating temperature (J/kgK)

C_d = discharge coefficient of the outlet

T_{max} = maximum design operating temperature of the tank (°C)

T_{ref} = reference inlet fluid temperature (°C)

P = maximum design operating pressure of the tank (Pa)

ρ_f = density of the fluid at the maximum design operating temperature of the tank (kg/m^3)

h = vertical distance between the top of the tank and the discharge port (head) (m)

g = gravitational constant (9.81 m/s^2)

605.3 Maximum Thermal Energy Delivery Rating Calculation for Unpressurized Tanks. The maximum thermal energy delivery rating of an unpressurized thermal energy storage tank shall be calculated for a fluid based on gravity or pump-driven flow.

605.3.1 Gravity-driven flow. The maximum thermal energy delivery rating for an unpressurized tank based solely on gravity-driven flow shall be calculated for a fluid based on the maximum operating temperature, head and dimensional size of the outlet as follows:

$$\dot{Q}_{max} = A\rho_f C_{p,f} C_d (T_{max} - T_{ref})\sqrt{2gh}$$

Where:

$\dot{Q}_{max}$ = maximum thermal energy discharge rate (W) for the fluid

A = outlet cross-sectional area (m^2)

$C_{p,f}$ = specific heat of a fluid at the maximum design operating temperature (J/kgK)

C_d = discharge coefficient of the outlet

T_{max} = maximum design operating temperature of the tank (°C)

T_{ref} = reference inlet fluid temperature (°C)

ρ_f = density of the fluid at the maximum design operating temperature of the tank (kg/m^3)

h = vertical distance between the maximum fill level of the tank and the discharge port (head) (m)

g = gravitational constant (9.81 m/s^2)

605.3.2 Pumped flow. The maximum thermal energy delivery rating for an unpressurized tank utilizing a pumped discharge shall be calculated for a fluid based on the maximum operating temperature, and pumped volumetric flowrate as follows:

$$\dot{Q}_{max} = \dot{V}\rho_f C_{p,f} C_d (T_{max} - T_{ref})$$

Where:

$\dot{Q}_{max}$ = maximum thermal energy discharge rate (W) for the fluid

$\dot{V}$ = pumped volumetric flowrate from the discharge port for the fluid (m^3/s)

$C_{p,f}$ = specific heat of a fluid at the maximum design operating temperature (J/kgK)

C_d = discharge coefficient of the outlet

T_{max} = maximum design operating temperature of the tank (°C)

T_{ref} = reference inlet fluid temperature (°C)

ρ_f = density of the fluid at the maximum design operating temperature of the tank (kg/m^3)

The pumped volumetric flowrate from the discharge port of the tank shall be determined by means of the published pump curve together with the system curve or direct measurement. In either case, the discharge from the tank shall be at atmospheric pressure.

605.4 Thermal Capacity Reporting. The maximum thermal energy discharge rate of a pressurized tank calculated in accordance with Section 605.2 shall be reported in units of watts (W) along with the selected fluid. For unpressurized tanks, the discharge rate shall indicate whether the value corresponds to gravity or pump-driven flow. For pump-driven flow, the pump shall be identified. For variable speed pumps, the speed utilized for rating shall be identified.

CHAPTER 7

REFERENCED STANDARDS

About this chapter: *This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 103.1.*

ANSI

American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036

Z21.10.1/CSA 4.1—2019:

Gas Water Heaters, Volume I, Storage Water Heaters with Input Ratings of 75,000 per Hour or Less

Table 401.1, Table 501.1

Z21.22/CSA 4.4—2015(R2020):

Relief Valves for Hot Water Supply Systems

303.2, 402.1

Z21.98/CSA 4.10—2020:

Non-Metallic Dip Tubes for Use in Water Heaters

303.5

ASHRAE

American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle NE, Atlanta, GA 30329

ASHRAE 41.1-2020:

Standard Methods for Temperature Measurement

4.3.2

ASHRAE 41.3-2022:

Standard Methods for Pressure Measurements

4.3.6

ASME

American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990

BPVC-2023:

ASME Boiler & Pressure Vessel Code

403.3

ASTM

ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

E84—21a:

Standard Test Method for Surface Burning Characteristics of Building Materials

502.3.1, 504.1

DOE

U.S. Department of Energy, c/o Superintendent of Documents, 1000 Independence Avenue SW, Washington, DC 20585

10 CFR 430, Subpart B—2023:

Appendix E, Uniform Test Method for Measuring the Energy Consumption of Water Heaters

604.1, A5.3.1

EN

European Committee for Standardization, Rue de la Science 23 B, Brussels, Belgium 1040 Belgium

EN 12897-2020

Water Supply—Specification for Indirectly Heated Unvented (Closed) Storage Water Heaters

A5.3.1

EN 60379-2023

Methods for Measuring the Performance of Electric Storage Water Heaters for Household Purposes

A5.3.1

EN 15332-2020

Heating Boilers—Energy Assessment of Hot Water Storage Tanks

A5.3.1

FDA

US Food and Drug Administration, 10903 New Hampshire Ave, Silver Spring, MD 20993-0002

21 CFR, Parts 174–186

202

ICC

International Code Council, Inc., 200 Massachusetts Avenue, NW, Suite 250, Washington, DC 20001

IBC—24:

International Building Code®

602.2

ICC 900/SRCC 300—2020:

Solar Thermal System Standard

101.1

ICC 901/SRCC 100—2020:

Solar Thermal Collector Standard

101.1

ICC 902/PHTA 902/SRCC 400—2020:

Solar Pool and Spa Heating System Standard

101.1

IFC—24:

International Fire Code®

602.2

IFGC—24:

International Fuel Gas Code®

602.2

IMC—24:

International Mechanical Code®

602.2

IPC—24

International Plumbing Code®

602.2

IEC-ReCNA

International Electrotechnical Commission, IEC Regional Centre for North America (IEC-ReCNA), 446 Main Street, 16th Floor, Worcester, MA 01608

IEC 60529-2020:

Degrees of Protection Provided by Enclosures

404.1, 504.1

ISO

International Organization for Standardization, Chemin de Blandonnet 8, Geneva, Switzerland CP 401 – 1214

ISO 9806—2017:

Solar Energy—Solar Thermal Collectors—Test Methods

A4.2.3, A4.4.3

NEMA

National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 900, Rosslyn, VA 22209

NEMA 250—2018:

Enclosures for Electrical Equipment (1000 Volts Maximum)

NFPA

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471

NFPA 70—2023:

National Electrical Code

602.2

NSF

NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105

NSF/ANSI 14—2021:

Plastic Piping System Components

302.3

NSF/ANSI 372—2020:

Drinking Water System Components—Lead Content

302.3

NSF/ANSI/CAN 61—2020:

Drinking Water System Components—Health Effects

302.3

UL

UL LLC 3, 33 Pfingsten Road, Northbrook, IL 60062

UL 94-2023:

Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

502.3.1

UL 157—2015:

Standard for Gaskets and Seals

504.1.1

UL 174—2004:

Household Electric Storage Tank Water Heaters

Table 401.1, Table 501.1, 504.1, 504.1.1

UL 723—2018:

Test for Surface Burning Characteristics of Building Materials

502.3.1,502.4

UL 732—2023:

Oil-Fired Storage Tank Water Heaters

Table 401.1, Table 501.1

UL 746B—2018:

Polymeric Materials—Long Term Property Evaluation

502.4

UL 746C—2018:

Polymeric Materials—Use in Electrical Equipment Evaluations

502.3.1, 504.1.2

UL 969—2017:

Marking and Labeling Systems

601.1

UL 1453—2016:

Electric Booster and Commercial Storage Tank Water Heaters

Table 401.1, Table 501.1

UL/CSA 60335-2-40—2022:

Household and Similar Electrical Appliances—Safety, Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers

Table 401.1, Table 501.1

APPENDIX

A

ICC-SRCC TM-1B: PERFORMANCE TEST METHODS FOR THERMAL ENERGY STORAGE TANKS

This appendix is informative and is not part of the standard.

1.0 PURPOSE

The tests established in this document are used to produce performance data for thermal energy storage tanksIt is intended for use in conjunction with the ICC 903/SRCC 500-202X: Thermal Energy Storage Tank Standard which includes qualification tests for safety and durability of these tanks.

2.0 SCOPE

This test method applies to thermal energy storage tanks designed for use as a component in heating systems to store heated liquids with a capacity of at least 5 gallons (18.7 l), as specified by the ICC 903/SRCC 500 standard. Thermal energy storage tanks may be pressurized or unpressurized, may or may not include integral supplemental heating devices, and may or may not include integral heat exchangers for a separate heat exchange fluid. The specification does not apply to stand-alone water heaters or devices where a solar thermal collector is integrated and inseparable from the storage, such as Integrated Collector Storage (ICS) or Non-separable Thermosiphon Systems (NSTS) types. This specification does not apply to thermal expansion tanks.

2.1 SOLAR TANK CATEGORIES

Thermal energy storage tanks are produced in many different variations to meet the needs of a wide range of applications. Annex A categorizes and describes each type addressed by this test specification. Each type listed may be pressurized or unpressurized. The categories included are as follows:

- Direct Tank (DT)
- Indirect Tank with one or more Integral Supply-Side Heat Exchanger (IT-SS)
- Indirect Tank with one or more Integral Load-Side Heat Exchanger (IT-LS)
-

3.0 NOMENCLATURE

C: Tank thermal capacitance (J/K).

M_{drawn}: Mass of test fluid withdrawn from the tank during a purge process (kg).

$\dot{m}$: Mass flowrate through the test article (kg/s).

Q_{final}: Energy contained in the fluid in the tank at the end of a test (kJ).

Q_{intial}: Energy contained in the fluid in the tank at the start of a test (kJ).

Q_{loss}: Energy lost from the tank during a test (kJ).

T_a: Ambient air temperature in the vicinity of the tank (°C).

T_{ave}: Average temperature of the fluid contained within the tank at a given point in time (°C). See also $T_{initial}$ and T_{final}.

$T_{initial}$: Average temperature of the fluid in the tank at the beginning of a test (°C).

T_{final} : Average temperature of the fluid in the tank at the end of a test (°C).

T_i: Inlet temperature of the fluid entering the test article (°C).

T_{max}: Maximum temperature of the fluid in the tank as specified by the manufacturer (°C).

T_o: Outlet temperature of the fluid exiting the test article (°C).

UA: Standby heat loss coefficient of a tank (kJ/h°C).

$\dot{V}$: Volumetric flowrate through the test article (l/s).

4.0 TESTING REQUIREMENTS

4.1 Tests Required

Thermal energy storage tanks shall be tested for thermal performance using the procedures proscribed below for each category of tank. Tests must be completed in the order given in Table 4.1. Thermal energy storage tank categories are defined and described in Annex A. Where an "X" is indicated, the test is required in all cases. Where an "O" is indicated, the test may be required under certain conditions.

TABLE 4.1 TEST REQUIREMENTS FOR THERMAL ENERGY STORAGE TANKS

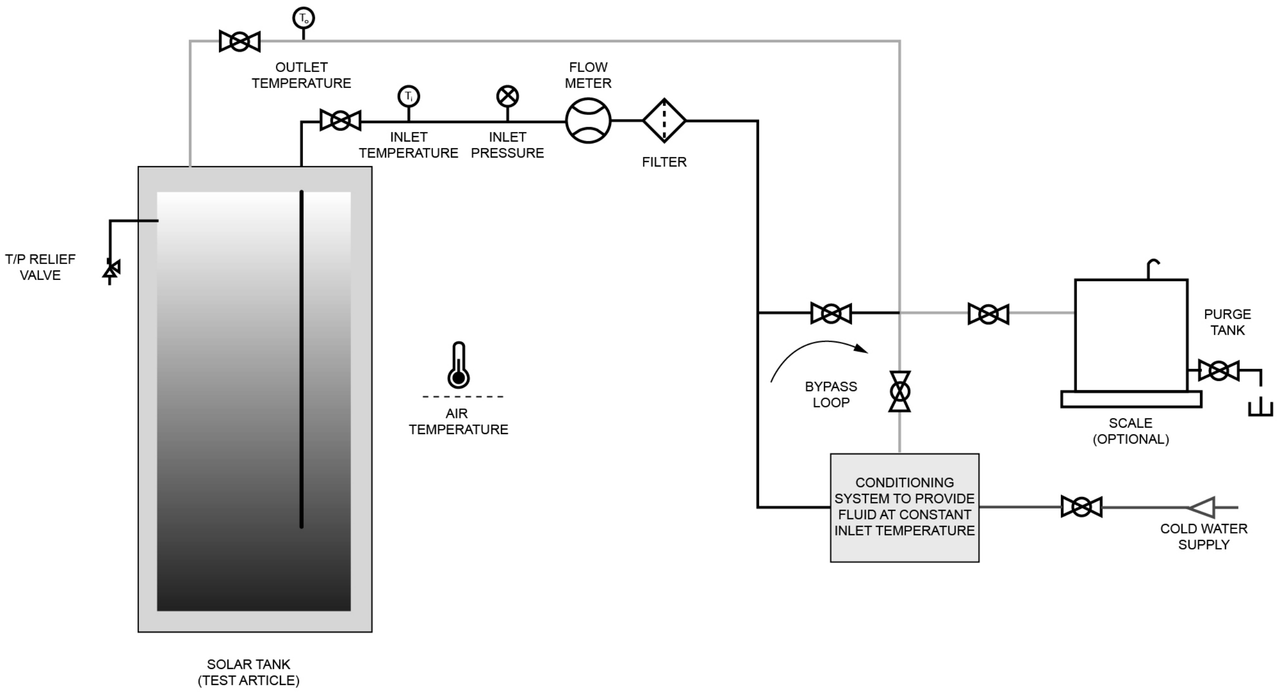
TEST NAME	TEST METHOD SECTION	DT	IT-SS IT-LS
Initial Inspection	5.1	X	X
Capacitance	5.2	O	O
Heat Loss Test	5.3	X	X
Integral Heat Exchanger Pressure Drop Test	5.4		X
Integral Heat Exchanger Performance Test	5.5		X
Final Inspection	5.6	X	X

* Optional test. Alternately, capacitance may be determined by analytical means.

4.2 Setup

4.2.1 Test Fixture. Tests are to be performed on a tank test article installed as described in the test fixture described in this section. Instrumentation and bypass loops for preconditioning shall be installed as shown in Figure 4.2. Bypass loops, plumbed in parallel to the test article shall be utilized to precondition the test loops before tests to ensure inlet temperature stability. All piping be-tween the test article and inlet and outlet sensors shall be insulated, having the same diameter as the tank connections. Unions may be used to facilitate the installation and removal of components. An appropriately rated pressure and temperature relief valve on the test article shall be installed in the location specified by the manufacturer. A properly sized expansion tank shall be installed on the supply water piping. Pipes and fittings must be covered with thermal insulation having an R value of $m^2 \times °C/W$ and $h \times ft^2 \times °F/Btu$.

FIGURE 4.2—TEST SETUP



4.2.2 Mounting. The tank shall be mounted in accordance with the manufacturer's installation instructions and as necessary to connect to the text fixture. Wall-mounted tanks shall be supported on a simulated wall as specified by the manufacturer. Tanks shall be oriented as specified in the manufacturer's instructions. If a tank can be installed in more than one orientation (i.e. horizontal or vertical), the same orientation shall be used for all tests and recorded in the test report.

4.2.3 Test Fluid. Testing shall be conducted using water or other fluid approved for use with the tank and heat exchanger as specified in ICC 903/SRCC 500. Where testing with a fluid other than water, tests shall be performed to measure the fluid density (ρ) and specific heat (C_p) of the fluid using a hygrometer or its equivalent.

The fluid density and specific heat of test fluids shall be calculated as a function of in-tank average fluid temperature in accordance with ISO 9806, Annex C for each time step in the datasets.

4.2.4 Operating Conditions. Performance testing shall not be performed in excess of the manufacturer's maximum operating conditions.

4.2.5 Water supply. When designed to be connected directly to a domestic water supply, the test article shall be connected to a water supply capable of delivering water at a pressure maintained between 275 kPa (40 psi) and the maximum allowable pressure specified by the manufacturer If the test article is not designed for direct connection to a domestic water supply, a supply pressure shall be selected within the design range specified by the manufacturer. The water supply temperature(s) shall be as specified in the test method.

4.3 Instrumentation and Measurements

4.3.1 Instrumentation Accuracy

Instrumentation used when conducting tank thermal performance testing of tanks shall comply with the accuracy requirements in the table below.

TABLE 4.3.1 INSTRUMENTATION ACCURACIES		
VALUE TO BE MEASURED	**ACCURACY (+/-)**	
	SI Units	**IP Units**
Temperature, Absolute	0.06°C	0.1°F

Temperature, Differential	0.01K	0.02R
Pressure, Absolute	2%	
Pressure, Differential	2%	
Mass	0.5%	
Mass Flow Rate	1%	
Volume	2%	
Volumetric Flow Rate	1%	

4.3.2 Pipe Fluid Temperature Measurement. Temperature measurements of fluids within pipes shall be made in accordance with ASHRAE 41.1.

4.3.3 Differential Temperature Measurement. If a thermopile is used for differential temperature measurement, it shall be made from calibrated thermocouple wire taken from a single spool. Extension wires to the recording device shall also be made from the same spool.

4.3.4 Ambient Air Temperature Measurement. Ambient air temperature measurements to be conducted for indoor or outdoor testing shall be made using a temperature sensor approximately 610 mm (24 in.) from the surface. The sensor shall be shielded against radiation.

4.3.5 Drawn Fluid Mass Measurement. Where required, measurements of the fluid mass drawn from the test article shall be made by one of the following two methods:

- Collecting the drawn fluid in a vessel situated on a scale, or
- Measure the real-time mass or volumetric fluid flowrate during the draw process

Regardless of the method selected, the total mass and mass flowrate measurements shall comply with the accuracy requirements specified in Section 4.3.1. If a vessel is used, it shall be insulated to minimize the heat loss to the environment during the energy purge process.

4.3.6 Pressure Measurement. Pressure measurements shall be in accordance with ANSI/ASHRAE Standard 41.3. An inlet pressure sensor shall be installed between 3 and 5 nominal pipe diameters from the point of connection to the inlet of the test article. If an outlet pressure sensor is used to determine differential pressure, it shall be installed between 9 and 11 nominal pipe diameters from the point of connection to the outlet. If a differential pressure sensor is used, the upstream and downstream connection points shall comply with the inlet and outlet pressure sensor location requirements given above. Where a pressure sensor is installed on a tank to measure static pressure, the sensor shall be installed through one of the following openings:

- Anodic device opening
- Relief valve opening
- Hot water outlet

4.3.7 Heater Energy Measurement. Measurements of supplemental heater energy consumption should use the nominal input voltage (electric) and/or supply flow and pressure (gas) specified by the manufacturer. Where this is not practical, the lab should note the deviation.

4.4 Tank Energy Measurement Process.

4.4.1 General. Several tests require that the change in the energy within the tank be quantified at the end of the test period. The initial condition within the tank, after the charging processes prescribed in each test, assumes a fully mixed, isothermal tank with an average initial fluid temperature ($T_{initial}$). To determine the energy change, the energy in the tank and the final average temperature of the fluid in the tank must be determined. This is accomplished through the Energy Purge Process, conducted in accordance with Section 4.4.2 with analysis of the resulting data per Section 4.4.3.

4.4.2 Energy Purge Process Measurement Method.

Where an energy purge process is specified in a test method, it shall be conducted in accordance with the requirements of this section and the requirements for setup prescribed in Section 4.2 and instrumentation in Section 4.3.

a. Pre-condition the inlet water to the specified purge temperature using the bypass loop before introducing water to the test article. Unless otherwise specified, the purge temperature to be used is the same temperature as the initial temperature ($T_{initial}$) specified for the test.

b. Purge the energy in the test article by circulating water at the purge temperature (specified in the test) through it at a flow rate of 0.125 to 0.189 l/s (2-3 GPM) and collecting the water displaced from the outlet. Conduct real time measurement of the following parameters. Note that measurements of the parameters should be taken at the highest possible frequency to maximize accuracy.

a. Total mass of the fluid displaced from the test article from the start to the end of the purge process (M_{drawn}).

b. Temperature of the fluid introduced into the test article (T_i) to purge the fluid from the test article.

c. Temperature of the fluid displaced/purged from the test article (T_o) through the outlet during the purge process.

d. Ambient air temperature in the vicinity of the test article (T_a).

e. Volumetric flowrate of the fluid (�$\dot{V}$).

f. Time (t) from the start of the purge process.

c. The purge flow and measurements shall continue until one of the following two conditions is met for a minimum of 10 minutes:

$$\overline{T_i - T_o} \leq 0.2K(0.4R)$$

or

$$\frac{\partial \overline{T_i - T_o}}{\partial t} \leq 0.05K(0.09R)$$

4.4.3 Purge Process Data Analysis and Reporting.

Upon completion of the energy purge measurements, the final energy in the tank (Q_{final}) shall be calculated from the time-dependent dataset using the following equation. Values for density and specific heat of the fluid as a function of temperature shall be determined in accordance with ISO 9806, Annex C.

$$Q_{final} = \int \dot{m}(t)C_p(T)(T_o(t) - T_i(t))dt$$

The average final temperature of the fluid ($\bar{T}_{final}$) for the entire purged fluid dataset shall also be calculated.

5.0 TEST METHODS

5.1 Initial Inspection and Volume Measurement.

The test article shall be inspected prior to installation and testing and any evidence of damage shall be recorded. A detailed initial inspection of the test article shall document the following:

1. Outer dimensions
2. Location and vertical height of each port when installed in the orientation to be used for testing
3. Type, location and vertical height of each supplemental heater when installed in the orientation used for testing
4. Measured volumetric tank storage capacity and heat exchanger capacity
5. Empty weight
6. Materials of construction

7. Photographic record of all test articles

8. Test article serial number and/or date of manufacture

The enclosed fluid mass shall be calculated by subtracting the tare (empty) weight of the tank from the gross weight when completely filled with water. The volumetric storage capacity shall be determined by dividing the result by the density of water at the fluid temperature. If the tank includes integral heat exchangers, they shall be empty during these measurements.

If the tank includes one or more integral heat exchangers, the volumetric test shall be repeated with the storage tank empty, filling each heat exchanger individually and completely with water. The gross weight of the tank shall then be measured with each heat exchanger filled individually. The volumetric capacity of each integral heat exchanger shall be calculated and reported by dividing the result by the density of water at the fluid temperature.

5.2 Capacitance Test.

5.2.1 Test Setup. The test article shall be installed in a test fixture as specified in Section 4.2. Testing shall be performed indoors, where the ambient temperature shall not vary by more than ±1.4°C (2.5°F) during the test. It is recommended that the ambient temperature be maintained between 18.3 and 21.1°C (65.0 and 70.0°F). Any source of heating, including supplemental heaters, must be shut off for the duration of the test. All applicable parameters listed in Section 5.2.2 shall be measured during the entire test.

5.2.2 Data Collection. The numerical and physical data specified below shall be collected during the Capacitance Test. Instrumentation shall meet the requirements of Section 4.3.

The following measurements shall be collected at a sampling frequency of no less than 10 seconds:

1. T_i: Fluid temperature at the inlet to the test article (°C).
2. T_o: Fluid temperature at the outlet from the test article (°C).
3. T_a: Ambient air temperature (°C).
4. $\dot{m}$: Fluid flow rate through the test article (kg/s).

5.2.3 Capacitance Test Method.

The Capacitance Test shall be conducted as described below:

1. Connect the inlet and outlet ports of the tank vessel to the test fixture. Completely fill the tank vessel with fluid, purging all air.

2. Begin data collection as specified in Section 5.2.2.

3. Heat and fully mix the fluid in the tank to an initial temperature ($T_{initial}$) of 55-60°C by introducing fluid at an inlet temperature (T_i) of 57.5°C ±2.5°C through the inlet port. Continue until one of the following conditions is met for 10 minutes:

$$\overline{T_i - T_o} \leq 0.2K(0.4R)$$

or

$$\frac{\partial \overline{T_i - T_o}}{\partial t} \leq 0.05K(0.09R)$$

4. After one of the conditions in Step 3 is satisfied, immediately determine the energy in the tank by purging the energy in the tank using water with an inlet temperature (T_i) equal to the ambient air temperature in the vicinity of the tank (T_a) as specified in Section 4.4.2.

5.2.4 Capacitance Data Analysis and Reporting

Calculate the thermal capacitance of the test article using the Q_{final} and $\bar{T}_{final}$ values derived from the purge process at the end of the Capacitance Test.

$$C = \frac{Q_{final}}{\bar{T}_{initial} - \bar{T}_{final}}$$

5.3 Heat Loss Test.

5.3.1 General. The standby heat loss coefficient (UA) of the tank shall be determined using the data derived from the Heat Loss Test specified in this section or one of the following methods:

- *Uniform Test Method for Measuring the Energy Consumption of Water Heaters* (*10 CFR 430, Subpart B, Appendix E)*
- *EN 12897, Annex B*
- *EN 60379*
- *EN 15332*

5.3.2 Test Setup. The test article shall be installed in a test fixture as specified in Section 4.2. Testing shall be performed indoors, where the ambient temperature shall not vary by more than ±1.4°C (2.5°F) during the test. It is recommended that the ambient temperature be maintained between 18.3 and 21.1°C (65.0 and 70.0°F). Any source of heating, including supplemental heaters, must be shut off for the duration of the test. All applicable parameters listed in Section 5.3.3 shall be measured during the entire test.

5.3.3 Data Collection. The numerical and physical data specified below shall be collected during the Heat Loss Test. Instrumentation shall meet the requirements of Section 4.3.

The following measurements shall be collected at a sampling frequency of no less than 10 seconds:

1. T_i: Fluid temperature at the inlet to the tank (°C).
2. T_o: Fluid temperature at the outlet from the tank (°C).
3. T_a: Ambient air temperature (°C).
4. $\dot{m}_{tank}$: Fluid flow rate through the tank (kg/s).

5.3.4 Heat Loss Test Method. The Heat Loss Test shall be conducted as described below:

1. Connect the inlet and outlet ports of the tank vessel to the test fixture. Completely fill the tank vessel with fluid, purging all air.
2. Begin data collection as specified in Section 5.3.3.
3. Heat and fully mix the fluid in the tank to an initial temperature ($T_{initial}$) of 55-60°C (131-140°F) by introducing fluid at an inlet temperature (T_i) of 57.5°C ±2.5°C (135°F +/- 4.5°F) through the inlet port. Continue until one of the following conditions is met for 10 minutes:

$$\overline{T_i - T_o} \le 0.2K(0.4R)$$

or

$$\frac{\partial \overline{T_i - T_o}}{\partial t} \le 0.05K(0.09R)$$

4. Close off flow to and from the piping connected to the tank. Monitor and measure the average fluid temperature within the tank and the ambient air temperature in the vicinity of the test article (T_a) until:

$$\frac{1}{3}(T_{initial} - \bar{T}_a) \leq (T_{final} - \bar{T}_a) \leq \frac{2}{3}(T_{initial} - \bar{T}_a)$$

5. After the condition in Step 4 is determined to be satisfied, the energy contained in the tank at the end of the test shall be determined immediately by purging the energy in the tank using water with an inlet temperature (T_i) equal to the ambient air temperature in the vicinity of the tank (T_a) as specified in Section 4.4.2.

6. Confirm that the average fluid temperature at the conclusion of the test met the criteria specified in Step 4 above. If not, the test shall be repeated until the criteria is satisfied.

5.3.5 Heat Loss Data Analysis and Reporting

If the variation in the ambient temperature (T_a) measured during the test <10% of the difference between the average initial fluid and ambient air temperature $\bar{T}_{initial} - \bar{T}_a$ during the test, the ideal exponential temperature decay calculation method can be used to determine *UA*.

$$UA = \frac{C}{t} ln\left[\frac{(\bar{T}_{initial} - \bar{T}_a)}{(\bar{T}_{final} - \bar{T}_a)}\right]$$

5.4 Heat Exchanger Pressure Drop Test

5.4.1 General. The purpose of the pressure drop test is to measure the differential pressure across each integral heat exchanger over a range of fluid flow rates representative of the normal operating conditions.

5.4.2 Test Setup. The test article shall be installed in a test fixture as specified in Section 4.2. Testing shall be performed indoors, where the ambient temperature is maintained between 18.3 and 21.1°C (65.0 and 70.0°F). Any source of heating, including supplemental heaters, must be shut off for the duration of the test. The test shall be conducted for each separate integral heat exchanger with individual inlet and outlet connections installed on the tank. The pressure of the heat transfer fluid shall be within the design operating range as specified by the manufacturer and shall be the same for each test flow rate. Any heat transfer fluid approved for use with the heat exchanger may be used.

5.4.3 Data Collection. The numerical and physical data specified below shall be collected during the heat exchanger test. Instrumentation shall meet the requirements of Section 4.3. The following measurements shall be collected at a sampling frequency of no less than 15 seconds:

1. P_i: Fluid pressure at the inlet to the heat exchanger (kPa).

2. P_o: Fluid pressure at the outlet from the heat exchanger (kPa) orDP: Differential pressure across the heat exchanger (kPa)

3. T_i: Fluid temperature at the inlet to the heat exchanger (°C).

4. T_a: Ambient air temperature (°C).

5. $\dot{m}_{hx}$: Fluid flow rate through the heat exchanger (kg/s).

Testing shall be conducted at a minimum of six measurement conditions. Five measurement conditions shall be conducted at fluid flow rates spaced evenly over the operating flow range of the heat exchanger. The sixth measurement condition shall be conducted at a flow rate of 0.25 l/s. The same ambient air temperature, heat transfer fluid, and inlet pressure and temperature to the heat exchanger shall be used for all measurement conditions.

5.4.4 Heat Exchanger Pressure Drop Test Method. The following method shall be used to measure the pressure drop across the inlet and outlet of heat exchangers integrated into thermal energy storage tanks.

1. Fill the tank vessel with water at a temperature of 18.3-21.1°C (65.0-70.0°F). If a pressurized tank is intended for direct connection to a domestic plumbing system, it shall be pressurized to 275 kPa (40 psi).

2. Connect and fill the heat exchanger with heat transfer fluid. Start flow through the heat exchanger at the first fluid flowrate, maintaining the inlet temperature at 37.8°C ±5°C (100°F ±9°F).

3. Continue flow through the heat exchanger until steady state conditions are established.

4. Begin a 10-minute test period, maintaining the flow rate within ±1% and the inlet temperature within ±5°C (+/-9°F). During the test period, record differential pressure across the heat exchanger and other parameters listed in Section 5.4.3 at the prescribed sampling frequency.

5. Repeat steps 1 - 4 for each of the six measurement conditions.

5.4.5 Heat Exchanger Pressure Drop Data Analysis and Reporting

The average differential pressure across the heat exchanger, inlet and outlet pressure, inlet temperature, ambient temperature and fluid flow rate for each measurement condition shall be calculated and reported individually.

5.5 Integral Heat Exchanger Performance Tests

5.5.1 General. The performance tests measure the data necessary to determine the efficiency of thermal energy transfer between the fluid within the heat exchanger and the fluid contained within the tank vessel over the span of normal operating conditions. Any heat transfer fluid approved for use with the heat exchanger may be used.

5.5.2 Test Setup. The tank shall be installed in a test fixture and instrumented in accordance with Section 4.3. Testing shall be performed indoors, where the ambient temperature shall not vary by more than ±1.4°C (2.5°F) during the test. It is recommended that the ambient temperature be maintained between 18.3 and 21.1°C (65.0 and 70.0°F). Any source of heating (e.g. resistance heaters and/or solar radiation), must be shut off or blocked for the duration of the test.

5.5.2 Data Collection. The numerical and physical data specified below shall be collected during testing of heat exchangers. The timing of each test process and step shall be recorded. Measurements shall be collected at a sampling frequency of no less than 10 seconds. The sampling frequency shall be increased to one sample per second for any flows at or below 0.0315 kg/s.

The following measurements shall be collected:

1. $T_{i,tank}$: Fluid temperature at the inlet to the tank (°C).
2. $T_{o,tank}$: Fluid temperature at the outlet from the tank (°C).
3. $\dot{m}_{\tan k}$: Fluid flow rate through the tank (kg/s).
4. $T_{i,hx}$ Fluid temperature at the inlet to the heat exchanger (°C).
5. $T_{dp,hx}$ Differential temperature of the fluid between the inlet and outlet of the heat exchanger (°C).
6. $\dot{m}_{hx}$: Fluid flow rate through the heat exchanger (kg/s).
7. $P_{i,hx}$: Fluid pressure at the inlet to the heat exchanger (kPa).
8. T_a: Ambient air temperature (°C).

5.5.3 Measurement Conditions.

Testing must be conducted at several sets of conditions in order to characterize the heat exchanger efficiency over the range of operation. Measurements must be made at a minimum of two initial tank fluid temperatures and two heat exchanger fluid inlet temperatures at a minimum of three heat exchanger flow rates. The flow rates used for testing must be evenly spaced over the operating range of the heat exchanger. The resulting combination of conditions are shown in the table below.

Exception: Where the heat exchanger is designed to be connected to the domestic hot water system (e.g. load side heat exchangers), the following heat exchanger flow rates shall be used for water: 0.032, 0.095, 0.189 kg/s.

MEASUREMENT NUMBER	Hx FLOWRATE ($\dot{m}_{hx}$)	Hx INLET FLUID TEMP. ($T_{i,hx}$)	TANK INITIAL FLUID TEMP ($T_{initial}$)
1	Hx Flow 1	Hx Temp 1	Tank Temp 1
2	Hx Flow 2	Hx Temp 1	Tank Temp 1
3	Hx Flow 3	Hx Temp 1	Tank Temp 1
4	Hx Flow 1	Hx Temp 2	Tank Temp 1

5	Hx Flow 2	Hx Temp 2	Tank Temp 1
6	Hx Flow 3	Hx Temp 2	Tank Temp 1
7	Hx Flow 1	Hx Temp 1	Tank Temp 2
8	Hx Flow 2	Hx Temp 1	Tank Temp 2
9	Hx Flow 3	Hx Temp 1	Tank Temp 2
10	Hx Flow 1	Hx Temp 2	Tank Temp 2
11	Hx Flow 2	Hx Temp 2	Tank Temp 2
12	Hx Flow 3	Hx Temp 2	Tank Temp 2

5.5.4 Performance Test Method for Integral Tank Heat Exchangers. The performance of heat exchangers integrated into thermal energy storage tanks shall be measured as described in this test method.

1. Connect inlet and outlet ports of the tank vessel to the test fixture. Completely fill the tank vessel with fluid, purging all air.
2. Begin data collection for the tank inlet and outlet fluid temperatures as specified in Section 5.5.2.
3. Heat and fully mix the fluid in the tank to the specified tank temperature ($T_{initial}$) by introducing fluid at the specified tank temperature (T_i) through the inlet port. Continue until one of the following conditions is met for 10 minutes:

$$\overline{T_i - T_o} \leq 0.2K(0.4R)$$

or

$$\frac{\partial \overline{T_i - T_o}}{\partial t} \leq 0.05K(0.09R)$$

4. Connect and fill the heat exchanger with heat transfer fluid. Start flow through the heat exchanger, maintaining the inlet temperature at the temperature setpoint for the test within +/- 0.1 K (0.2 R) and the flow at the flowrate setpoint within +/- 0.006 kg/s.
5. When steady state conditions are established for flow through the heat exchanger, stop flow through the tank and start data collection for all parameters listed in Section 5.5.2. Steady state conditions for flow through the heat exchanger shall be when the average flowrate is within +/- 0.003 kg/s and the temperature of the fluid at the inlet is within +/- 0.1 K (0.2 R).
6. Run the test with stable inlet flow rate and temperature through the heat exchanger until the average temperature in the tank has changed by at least 5 K (9 R)). When the prescribed energy transfer has occurred, immediately purge and measure the energy in the tank per the process specified in Section 4.4.2, using fluid at a purge temperature equal to the initial tank temperature ($T_{initial}$) specified for the test.
7. Repeat steps 1-6 for each measurement condition.

5.5.5 Heat Exchanger Performance Data Analysis and Reporting. All measured data points for each measurement condition shall be reported without averaging for post-processing and heat exchanger modeling.

5.6 Final Inspection. The tank shall be inspected after the completion of all testing. Any damage, or degradation of the tank shall be documented. The tank may be disassembled to facilitate the inspection if necessary. Any condensation or water retained within the tank's enclosure or leakage shall be photographed and documented. For non-water fluids, the fluid density and specific heat shall be re-measured.

6.0 ANALYSIS AND REPORTING. Test data acquired through the test methods described in Section 6 shall be analyzed and reported as described in this section.

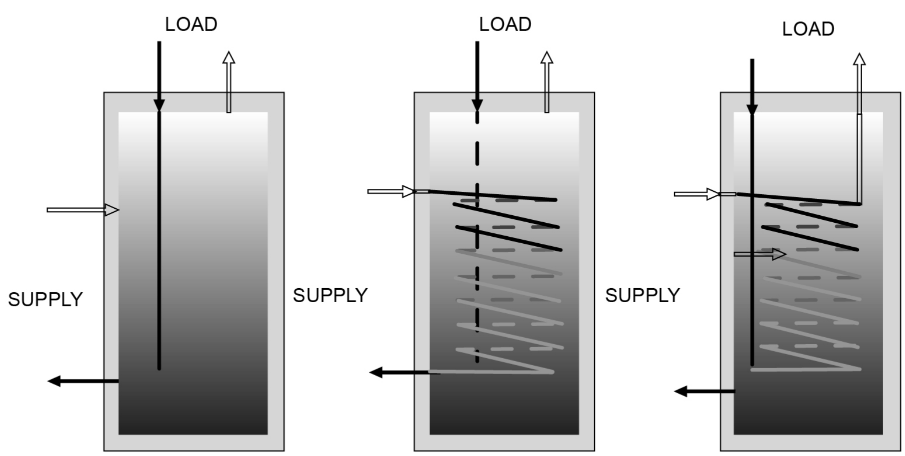
6.1 Test Report. A table of test results shall be provided in the test report as prescribed for each specific test. The following additional documentation for shall be provided in the test report:

1. Instrumentation model numbers
2. Photographs of test equipment and fixtures
3. Diagram of test fixture showing the relative location of all components and instrumentation
4. Photograph of the test article as installed in the test fixture
5. Approved fluids, maximum temperature, maximum pressure and operating flow rate range through heat exchangers prescribed by the manufacturer prior to the test and used to establish the range of the testing conducted
6. Date(s) of each test

ANNEX A

A.0 THERMAL ENERGY STORAGE TANK CATEGORIES

Thermal energy storage tanks are produced in many variations to meet the needs of a wide range of applications. This section categorizes and describes each type addressed by this test specification. Each type may be pressurized or unpressurized and may or may not include an integrated supplemental heater. Example diagrams for each type are shown below. They are not inclusive of all possible configurations within each category. For example, "wrap-around" heat exchanger configurations can be found in each category except direct.



DIRECT SOLAR TANK

INDIRECT SOLAR TANK WITH SUPPLY-SIDE HEAT EXCHANGER

INDIRECT SOLAR TANK WITH LOAD-SIDE HEAT EXCHANGER

A.1 Direct Tank (DT). Direct tanks utilize dedicated ports to connect potable water directly external heat sources. Potable water from the tank flows through a loop to one or more external heat sources and returns to the tank vessel. Direct tanks may be mounted vertically at ground level and use a pump to initiate flow through the loop or horizontally adjacent to and slightly above the external heat sources using thermosiphon action to establish flow.

A.2 Indirect Tank with Supply-Side Heat Exchanger (IT-SS). Indirect tanks with integral supply-side heat exchangers store potable water in the tank, which is isolated from the heat exchange fluid. The heat exchange fluid flows in a circuit from the tank to one or more external heat sources and back through the heat exchanger on the tank. Common heat exchangers integrated into this type of tank include:

- Immersed coil, installed within the vessel, and
- Wrap-around, wound around the outside of the vessel, but in close contact.

The heat exchange fluid flows around the loop, which connects the external heat source and heat exchanger. Flow in the loop is generally driven by an external pump attached to a controller.

A.3 Indirect Tank with Load-Side Heat Exchanger (IT-LS). Indirect tanks with integral load-side heat exchangers store heat exchange fluid in the tank, which is isolated from potable water flowing through the heat exchanger. The loop connects the heat exchange fluid in the tank to external heat sources. Flow through the loop is driven by an external pump or through thermosiphon action. Potable water flows through the heat exchanger and often to a backup water heater before being supplied to the hot water load. Common heat exchangers integrated into this type of tank include:

- Immersed coil, installed within the vessel, and
- Wrap-around, wound around the outside of the vessel, but in close contact.

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CLOSING DATE: All Comments Must Be Received by June 23, 2025

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6) **Revision to:** ☐ **Section** ________ ☐ **Table** ________ ☐ **Figure** ________

7) **COMMENT** **Revise as follows (check BOX and state proposed change):**

☐ **Revise as follows:** ☐ **Add new text as follows** ☐ **Delete and substitute as follows:** ☐ **Delete without Substitution:**

Show the proposed NEW or REVISED or DELETED TEXT in legislative format: ~~Line through text to be deleted.~~ Underline text to be added.

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