Designation: E 1056 – 85 (Reapproved 2001)

Standard Practice for Installation and Service of Solar Domestic Water Heating Systems for One- and Two-Family Dwellings[1]

This standard is issued under the fixed designation E 1056; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides descriptions of solar domestic water heating systems and sets forth installation and service practices in new and existing one- and two-family dwellings to help ensure adequate operation and safety.[2,3]

1.2 This practice applies regardless of the fraction of heating requirement supplied by solar energy, the type of conventional fuel used in conjunction with solar, or the heat transfer fluid (or fluids) used as the energy transport medium. However, where more stringent requirements are recommended by the manufacturer, these manufacturer requirements shall prevail.

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Sections 6 and 7.

2. Referenced Documents

2.1 *ASTM Standards:*

E 772 Terminology Relating to Solar Energy Conversion[4]

2.2 *SMACNA Standards:*

Medium Pressure Duct Construction Standards[5]

Fibrous Glass Duct Construction Standards[5]

Flexible Duct Performance and Installation Standards[5]

2.3 *NFPA Standard:*

NFPA 321 Basic Classifications of Flammable and Combustible Liquids[6]

2.4 *ANSI Standard:*

Z 21.22 Relief Valves and Automatic Gas Shut Off Devices for Hot Water Supply Systems[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *auxiliary energy subsystem*, *n*—in solar energy application, equipment using nonsolar energy sources to supplement or backup the output provided by a solar energy system. **(E 772)**

3.1.2 *flash point*, *n*—of a liquid, the minimum temperature at which it gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the vessel as specified by appropriate test procedure and apparatus. (See Terminology E 772 and NFPA 321.)

3.1.3 *heat transfer fluid*, *n*—(*1*) in solar energy systems, a liquid or gas that passes through the solar collector and carries the absorbed thermal energy away from the collector. (*2*) any fluid that is used to transfer thermal energy between subsystems in solar energy systems. **(E 772)**

3.1.4 *operating conditions*, *extreme*, *n*—unusual physical conditions to which a component or system may be exposed and for which it is not designed or intended to withstand, nor is it required to withstand by a local regulatory agency. **(E 772)**

3.1.5 *operating conditions, normal*, *n*—the usual range of physical conditions (for example, temperature, pressure, wear and tear, weather) for which the component or system was designed. **(E 772)**

3.1.6 *solar energy system, active*, *n*—a solar energy system that uses mechanical equipment (pumps, fans), that is not an integral part of a structure, to collect and transfer thermal energy, either to the point of use or to be stored for later use. **(E 772)**

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[1] This practice is under the jurisdiction of ASTM Committee E44 on Solar, Geothermal, and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.05 on Solar Heating and Cooling Subsystems and Systems.

Current edition approved Feb. 22, 1985. Published May 1985.

[2] Dikkers, R., "Performance Criteria for Solar Heating and Cooling Systems in Residential Buildings," Department of Housing and Urban Development and National Bureau of Standards, September, 1982.

[3] Hollander, P. E., "Installation Guidelines for Solar DHW Systems in One- and Two-Family Dwellings," Franklin Research Center, U. S. Goverment Printing Office, April 1979.

[4] *Annual Book of ASTM Standards*, Vol 12.02.

[5] Available from Sheet Metal and Air Conditioning Contractors National Assoc. (SMACNA), 8224 Old Courthouse Rd., Tysons Center, VA 22180.

[6] Available from National Fire Protection Assoc., Batterymach Park, Quincy, MA 02269.

[7] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

3.1.7 *solar water heating systems, direct*, *n*—a solar water heating system in which the potable water passes directly from the water supply, through the collectors and storage, to the residential hot water supply. **(E 772)**

3.1.8 *solar energy system, drainback*, *n*—a solar energy system in which the heat transfer fluid is drained out of the collector and exposed piping, and into a storage tank, a holding tank, or expansion tank in order to protect the collector and piping from damage due to freezing. **(E 772)**

3.1.9 *solar energy system, draindown*, *n*—a solar energy system in which the heat transfer fluid is drained out of the collector and exposed piping to an external drain in order to protect the collector and piping from damage due to freezing. **(E 772)**

3.1.10 *solar water heating system, indirect*, *n*—a solar water heating system in which a closed circulation loop isolates one fluid from contact with others in the system. This closed loop may contain a nonpotable fluid. **(E 772)**

3.1.11 *solar energy system, thermosiphon*, *n*—a solar energy system in which the heat transfer fluid circulates by convection as the less dense, warm fluid rises and is displayed by the denser, cooler fluid. **(E 772)**

3.1.12 *solar water heating system, tank absorber*, *n*—Solar Domestic Hot Water (SDHW) system in which solar radiation is absorbed by the surface of the storage tank, which is usually installed in an insulated housing whose sunward side is glazed. Such systems are also referred to as "batch" or "breadbox" heaters.

3.1.13 *weather conditions, extreme*, *n*—environmental conditions that are rare in a local climatic region (which have occurred no more than once during the past 30 years).

3.1.14 *weather conditions, normal*, *n*—the (actual or anticipated) range of environmental conditions (rain, snow, hail, wind, temperature, pollution) that typically occur in a local climatic region over several years. **(E 772)**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *accessible*, *adj*—permitting close approach that may require removal or opening of an access panel, door, or similar obstruction.

3.2.2 *durability*, *n*—the ability (of a system or component) to operate properly as long as intended.

3.2.3 *potable water*, *n*—water that is free of impurities in amounts sufficient to cause disease or harmful physiological effects and conforming in its bacteriological and chemical quality to the regulations of the public health authority having jurisdiction.

3.2.4 *reliability*, *n*—the ability (of a system or component) to operate properly when required.

3.2.5 *SDHW*, *n*—solar domestic hot water.

3.2.6 *shall*, *vi*—a mandatory requirement necessary to provide minimum operation and safety.

3.2.7 *should*, *vi*—a recommended method or component to provide improved performance and effectiveness.

3.2.8 *toxic*, *adj*—any substance (other than a radioactive substance) that has the capacity to produce personal injury or illness to man through ingestion, inhalation, or absorption through any body surface, or any substance producing a lethal dose in half (LD50) of white rats when ingested as a single dose of less than 10 g/kg of body mass.

4. Significance and Use

4.1 This practice is intended to serve as a guide to manufacturers, distributors, installers, contractors, regulatory officials, and owners. It is not intended to specify detailed methods of testing, installation, or servicing for the system or any of its components.

4.2 This practice sets forth those methods and components necessary for minimum operation and safety. It also suggests methods for improved operation and effectiveness.

5. System Components and Control Functions

5.1 This section covers the system components and related control functions that are required to collect, transport, store, and convert the solar energy for typical domestic hot water systems.

5.2 Table 1 shows the recommended system components and related control functions that are required for solar domestic hot water systems. Numbers in Figs. 1-7 refer to components in Table 1.

5.3 Freeze protection is a necessary subsystem for most SDHW systems. Each type of system in Figs. 1-7 provide freeze protection by the use of specific components or the nature of the system operation. One option for providing freeze protection for each system is illustrated in Figs. 1-7 (see 6.2 for other acceptable options). Options may be combined.

6. Installation and Servicing

6.1 This section outlines recommended installation and servicing minimum practices needed to provide an effective SDHW system operation.

6.2 *Freeze Protection*:

6.2.1 SDHW systems installed in climates where freezing can occur shall be protected.

6.2.1.1 *Antifreeze Chemicals*—Freeze protection may be accomplished through the use of chemicals either as or in the heat transfer fluid.

6.2.1.2 *Automatic Draining*—Freeze protection may be accomplished through the use of system controls which automatically allow heat transfer fluids to drain from parts of the system exposed to freezing temperatures, as in the draindown or drainback systems. Electrically operated valves shall drain the system when there is a power outage (that is, fail safe).

6.2.1.3 *Automatic Recirculation*—Freeze protection may be accomplished through the use of system controls which automatically circulates heat transfer fluids through the system when outdoor temperatures reach predetermined levels. This freeze protection does not operate during periods of power outage unless an auxiliary source of power is provided. This freeze protection system is not recommended for use in areas with frequent or severe freeze conditions, and may increase the heat loss of the system during off periods.

6.2.1.4 *Manual Draining*—Freeze protection may be accomplished through the use of system controls which allow an operator to manually drain the system of heat transfer fluids. Caution should be exercised when depending on this method of

TABLE 1 Solar Domestic Water Heating System Components

Schematic I.D. No.	Component	Function	Text Reference
1	Solar Collector	convert radiant energy into thermal energy	6.3, 7.6.1
2	Solar Storage Tank	accumulate thermal energy in the form of solar heated water to supply domestic needs	6.4
3	Insulation	minimize thermal losses from components	6.4.2, 7.6.3, 6.7.3, 6.7.11
4	Piping Fittings	interconnect components and convey heat transfer fluid	6.7
5	Mixing Valve	limit temperature of domestic hot water delivered for personal use	7.2.10
6	Temperature and Pressure Relief Valve	automatically relieves pressure if temperature and/or pressure maxima are exceeded	6.6.3, 7.2.1-7.2.7
7	Auxiliary Heat Source	supplements solar energy to provide adequate hot water	6.7.17
8	Pump	circulate liquid	6.8
9	Controller	controls the collection and distribution of thermal energy within the solar domestic hot water system and may provide limited safety functions	6.6
10	Auxiliary Storage Tank and Heat Source	supplements solar energy to provide hot water and storage	6.7.17
11	Heat Exchanger (internal or external)	transfer thermal energy between physically separated fluids	6.8.4–6.8.46, 6.5.2, 7.3.1
12	Air Duct	interconnect collectors and heat exchanger in system employing air as transfer medium	6.7
13	Blower	circulate air	6.8
14	Expansion Tank	protect system from pressure damage created by expansion of heat transfer liquid	6.6.5
15	Heat Transfer Fluid	Transports thermal energy	6.5, 7.6.2
16	Pressure Relief Valve	automatically relieves pressure if maximum is exceeded	6.6.3, 7.2.1-7.2.7
17	Check Valve	prevent reverse liquid flow	6.6.8
18	Vent Valve	release trapped air	6.7.10, 6.7.18
19	Drain Valve	to drain fluid passages of liquid; manual or automatic	6.7.9, 6.6.2
20	Backflow Preventer	to prevent backflow of nonpotable fluid into potable water supply	7.2.2, 7.3.3
21	Vacuum Breaker	to relieve a vacuum by permitting air into a system	6.7.18
22	Air Damper	control air flow	6.6.4, 6.6.9
23	Shutoff Valves	to isolate components; manual or automatic	6.6.3, 6.6.7
24	Temperature Sensor	senses fluid temperature to operate controller	6.6.9

freeze protection since it requires human attention for proper operation. Failure to operate the system properly may result in considerable damage.

6.2.1.5 *Low Wattage Electric Resistance Heating*—Freeze protection for tank absorber systems may be accomplished through the use of low wattage (less than 300 W) electrical resistance heaters and system controls that supply heat to the tank and adjacent piping/fittings only when temperatures inside the system reach 35 + 2°F (2 + 1°C). This freeze protection system does not operate during periods of power outage unless an auxiliary source power is provided.

6.2.1.6 *Freeze Tolerant Materials*—Freeze protection may be accomplished through the use of materials which are not damaged by repeated cycles of freezing and thawing while filled with potable water, provided evidence that the material can withstand such cycling is supplied. (See proposed Specification for Polybutylene Plastic Hot and Cold Water Distribution Assemblies in Solar Energy Systems.[8])

6.3 *Collector Subsystems*:

6.3.1 Collectors shall be installed in accordance with the instructions provided by the collector manufacturer or system designer, or both, and in compliance with requirements of the applicable building codes and standards.

6.3.2 Structural supports shall be constructed to support the collector under anticipated extremes of environmental conditions and to withstand local conditions and anticipated loads, such as wind, seismic, rain, snow, and ice so that the solar system does not impair the resistance to damage of the building. Neither wind loading nor the additional mass of filled collectors shall exceed the live and dead load ratings of the building, roof, foundation, or soil.

6.3.3 Structural supports shall be constructed to maintain collector tilt and orientation within design conditions throughout the life of the SDHW system.

6.3.4 Joints between support structures and the building shall be caulked or flashed, or both, to prevent water leakage. Access should be provided to permit minor repairs to flashing and caulking without disturbing roof, collector supports, or collector panels.

6.3.5 Collectors shall be installed so as not to contribute to moisture buildup, rotting, or other accelerated deterioration of roofing materials.

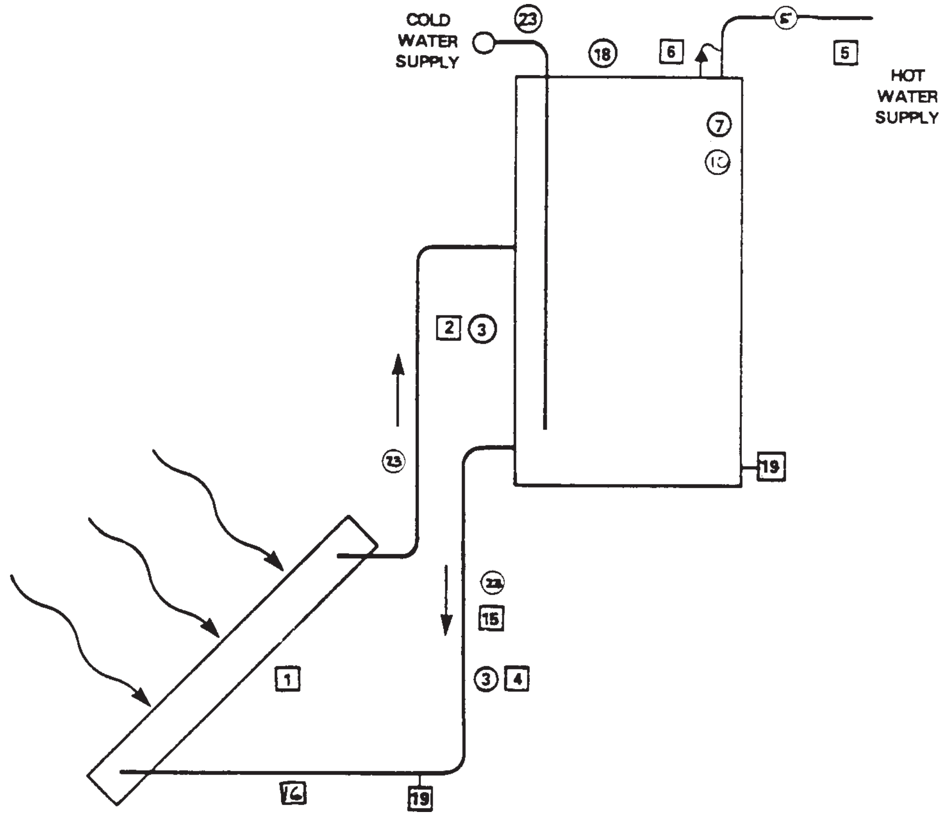
6.3.6 Collectors and supports shall be installed in a manner that water flowing off the collector surface will not increase the potential for ice dams or cause water damage, or both, to the building or premature erosion of the roof.

6.3.7 Provisions should be taken to minimize buildup of snow upon collectors which may reduce their effectiveness.

6.3.8 Structural supports shall be selected and installed in such a manner that thermal expansion of the collector subsystem will not cause damage to the collector, structural frame, or building.

6.3.9 Collectors and supports shall not create a hazard by blocking any means of egress.

[8] This proposed Specification of ASTM Committee E-17 is a draft document under development and is identified by the document number 3338. A copy of the latest edition of this document is available from ASTM Information Center, 1916 Race St., Phila., PA 19103.



1. SOLAR COLLECTOR
2. SOLAR STORAGE TANK
3. INSULATION
4. PIPING/FITTINGS
5. MIXING VALVE
6. TEMPERATURE AND PRESSURE RELIEF VALVE
7. AUXILIARY HEAT SOURCE
10. AUXILIARY STORAGE TANK AND HEAT SOURCE
15. HEAT TRANSFER FLUID
16. PRESSURE RELIEF VALVE
18. VENT VALVE
19. DRAIN VALVE
23. SHUT OFF VALVES

FREEZE PROTECTION-SHUTOFF VALVES (23) AND DRAIN VALVES (19) ALLOW FOR MANUAL DRAINING OF THE SYSTEM

□ REQUIRED FOR SAFETY OR MINIMUM OPERATION

○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING COD

FIG. 1 Typical Single Tank Thermosyphon System

6.3.10 Safe access to components subject to deterioration or failure, such as rubber hoses, joint sealants, and cover plates, shall be provided to allow for maintenance or repair. For roof-mounted collectors, work space adjacent to collectors and provisions for safe placement of ladders should be considered.

6.3.11 Collectors should be installed giving consideration to minimizing objectionable glare.

6.3.12 Protection of collectors and components shall be provided during handling and installation to prevent damage.

6.3.13 Frames, braces, and fasteners used in collector installation shall be made of materials suitable for exterior location.

6.3.14 Collectors shall not reduce the fire rating of the roof as prescribed in applicable building codes.

6.3.15 Roof penetrations necessitated by a collector array should be kept to a minimum.

6.3.16 The collector array should not move with frost heave unless adequate provisions for flexing have been provided.

6.3.17 In thermosiphon systems, the bottom of the storage tank should be above the top of the collector.

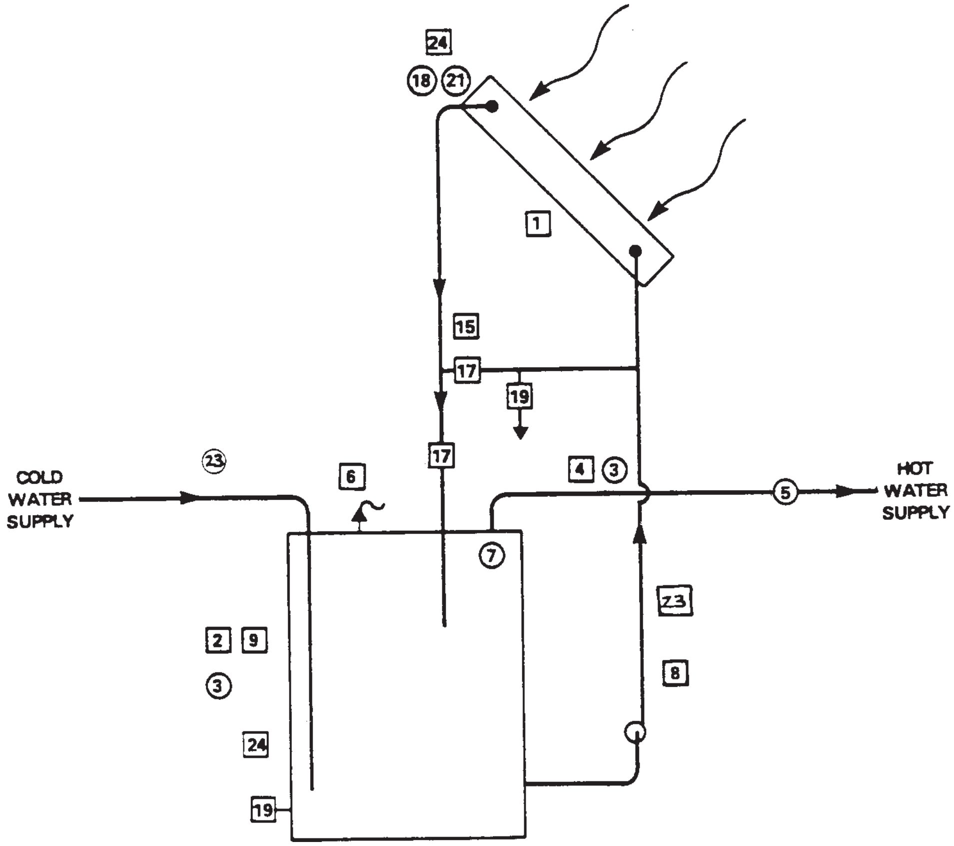
6.4 *Thermal Storage Devices*:

6.4.1 Where heat losses may occur, thermal insulation shall be provided on the storage devices and related piping. Insulation shall be suitable for the application, site, and occupancy conditions.

6.4.2 Care shall be exercised during the installation of the storage device to prevent damage to the device, lining, and insulation material during handling, mounting or other installation procedures.

6.4.3 If liquid storage devices are provided with overflows, the outlets shall be located so that spillage will not damage the premises.

6.4.4 Storage devices installed in an attic shall be provided with a drip pan whose outlet is piped to an adequate drain.



1. SOLAR COLLECTOR
2. SOLAR STORAGE TANK□ REQUIRED FOR SAFETY OR MINIMUM OPERATION
3. INSULATION
4. PIPING/FITTINGS
5. MIXING VALVE
6. TEMPERATURE AND PRESSURE RELIEF VALVE
7. AUXILIARY HEAT SOURCE
8. PUMP
9. CONTROLLER
15. HEAT TRANSFER FLUID
17. CHECK VALVE
18. VENT VALVE
19. DRAIN VALVE
21. VACUUM BREAKER
23. SHUT OFF VALVE
24. TEMPERATURE SENSOR

FREEZE PROTECTION-MANUAL OR AUTOMATICALLY OPERATED SHUTOFF VALVES (23) AND DRAIN VALVE (19) ALLOW SYSTEM TO DRAIN

□ REQUIRED FOR SAFETY OR MINIMUM OPERATION

○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING CODES

FIG. 2 Typical Single Tank Direct System (Draindown)

6.4.5 Fill devices shall be installed with air gaps, backflow preventers, or some method to prevent contamination of potable water supplies as prescribed by applicable codes.

6.5 *Heat Transfer Fluids*:

6.5.1 Heat transfer fluids shall be added and maintained in accordance with the manufacturers' instructions.

6.5.2 Toxic heat transfer fluids shall be separated from the potable water supply by means of a double walled heat exchanger or equivalent protection (see 7.3).

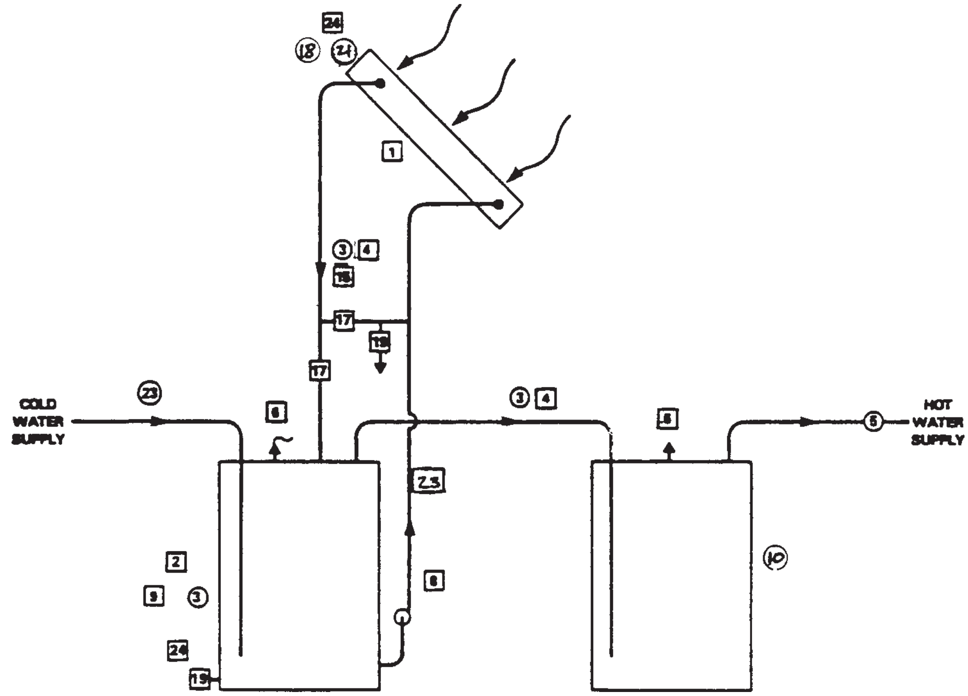
6.5.3 Heat transfer fluids shall be selected for normal operating temperatures, as well as maximum (no-flow) and minimum temperatures.

6.5.4 Heat transfer fluids should not accelerate corrosion. Similar metals, corrosion inhibitors, inert fluids, or sacrificial anodes should be used.

6.5.5 Heat transfer fluids shall be disposed of in a manner acceptable to local health authorities.

6.6 *Controls and Safety Devices*:

6.6.1 Controls and safety devices shall be selected and installed in a manner that, in the event of a failure of any system component, such failure will not result in serious damage to the rest of the system or any part thereof. Installation shall be in accordance with the manufacturers instructions and applicable building code requirements.



1. SOLAR COLLECTOR
2. SOLAR STORAGE TANK
3. INSULATION
4. PIPING/FITTINGS
5. MIXING VALVE
6. TEMPERATURE AND PRESSURE RELIEF VALVE
8. PUMP
9. CONTROLLER
10. AUXILIARY STORAGE TANK AND HEAT SOURCE
15. HEAT TRANSFER FLUID
17. CHECK VALVE
18. VENT VALVE
19. DRAIN VALVE
21. VACUUM BREAKER
23. SHUT OFF VALVE
24. TEMPERATURE SENSOR

FREEZE PROTECTION-MANUAL OR AUTOMATICALLY OPERATED SHUTOFF VALVES (23) AND DRAIN VALVE (19) TO ALLOW SYSTEM TO DRAIN

□ REQUIRED FOR SAFETY OR MINIMUM OPERATION

○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING CODES

FIG. 3 Typical Two Tank Direct System (Draindown)

6.6.2 Where systems are designed to drain out automatically, the automatic drain valves shall be piped to a suitable drain.

6.6.3 Adequately sized pressure relief or temperature and pressure relief devices shall be provided in those parts of the solar system that can be isolated and contain a heat source (see 7.2).

6.6.4 Devices (for example, dampers) shall be installed to prevent cold air from freezing any air to water heat exchanger. Care should be taken during installation to ensure a positive air seal.

6.6.5 Expansion tanks shall be provided as part of the SDHW system to provide for thermal expansion of heat transfer liquids in closed loops. Expansion tanks shall be sized for the expected operating and stagnation temperature and pressure ranges and the type of heat transfer fluid.

6.6.6 Control circuit wiring and terminals should be identified so that wires are readily traceable.

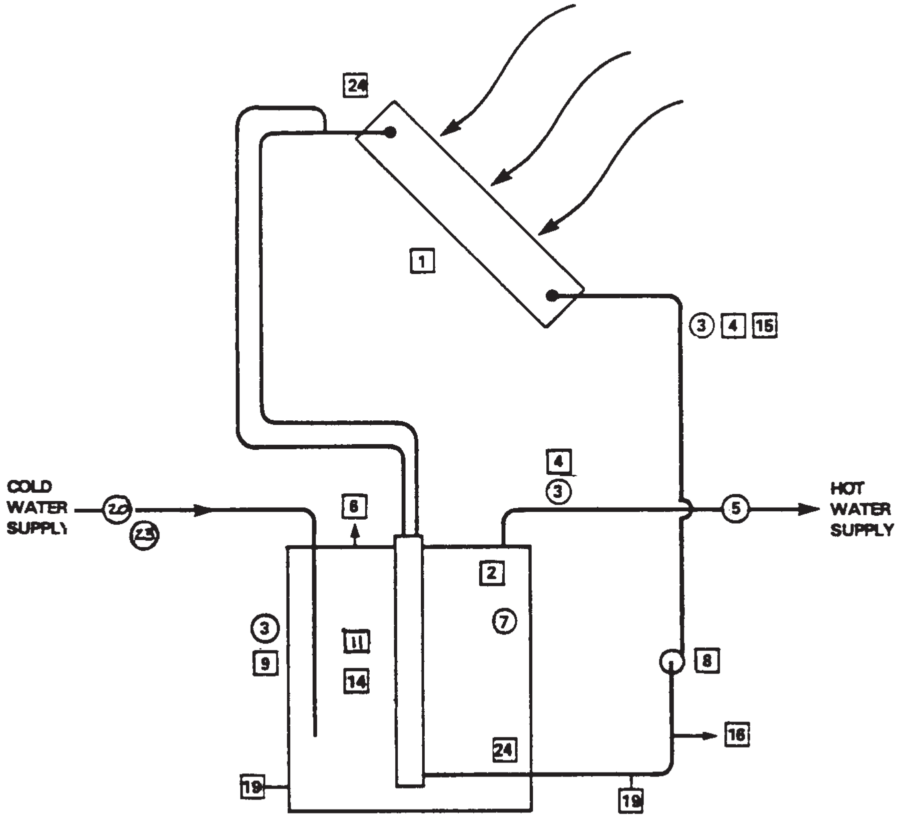
6.6.7 Isolation valves should be provided so that the major components of SDHW systems can be maintained or serviced. If collectors can be isolated, they shall be protected by a pressure relief valve.

6.6.8 Check valves may be used to prevent flow in the opposite direction within the solar energy system. They shall be installed according to manufacturer's directions and never in place of backflow preventers.

6.6.9 Controls, sensors, dampers, and valves should be marked to identify their function. Any control that serves as an emergency shutdown device shall be so indicated by conspicuous and permanent labels.

6.6.10 Systems should include means by which the owner can be alerted that a portion of the system or the entire system has ceased to function and that repairs are necessary (for example, pump pilot lights, thermometers, flow indicators, etc.).

6.7 *Piping, Ducting, and Ancillary Equipment*:



1. SOLAR COLLECTOR
2. SOLAR STORAGE TANK
3. INSULATION
4. PIPING/FITTINGS
5. MIXING VALVE
6. TEMPERATURE AND PRESSURE RELIEF VALVE
7. AUXILIARY HEAT SOURCE
8. PUMP
9. CONTROLLER
11. HEAT EXCHANGER
14. EXPANSION TANK
15. HEAT TRANSFER FLUID
16. PRESSURE RELIEF DEVICE
19. DRAIN VALVE
20. BACKFLOW PREVENTER
23. SHUT OFF VALVE
24. TEMPERATURE SENSOR

FREEZE PROTECTION-FLUID ALLOWED TO DRAIN BACK INTO RESERVOIR TANK ASSOCIATED WITH HEAT EXCHANGER (11)

□ REQUIRED FOR SAFETY OR MINIMUM OPERATION

○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING CODES

FIG. 4 Typical One Tank Indirect System (Drainback)

6.7.1 Piping, ducting, and equipment shall be located so as not to interfere with normal operation of windows, doors, or other exit openings. Piping, ducting, and equipment shall be installed in a manner to prevent damage to such piping, ducting, and equipment; prevent injury to persons; and in accordance with the manufacturer's instructions and the applicable building codes.

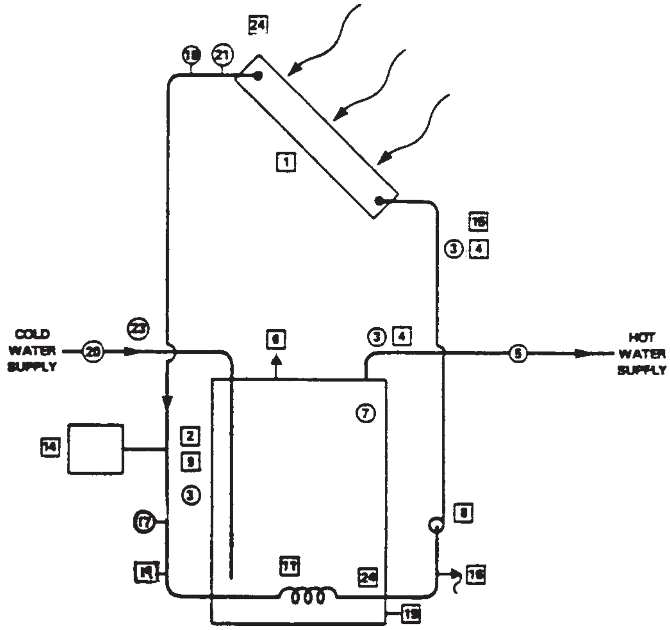
6.7.2 Piping and ductwork shall be selected and installed to withstand the expected operating and stagnation temperatures and pressures without excessive air leaking, sagging, or corrosion. Piping shall not leak.

6.7.3 Pipe hangers, supports, and expansion devices shall be provided to compensate for thermal expansion effects and to provide adequate support. Care shall be exercised during their installation to prevent damage to connections on the collector or the collector casing. Pipe hangers shall not short circuit insulation by creating a thermal bridge. Expansion devices shall not prevent draining. Pipe supports should not compress the insulation.

6.7.4 Standard pipe fittings should be used wherever possible.

6.7.5 Pipe and duct runs should be as short as practical with as few ells and bends as possible.

6.7.6 Joints shall be made with materials selected for durability within the expected operating temperatures and pressures for the fluid selected. Soft solder may not be



1. SOLAR COLLECTOR
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4. PIPING/FITTINGS
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8. PUMP
9. CONTROLLER
11. HEAT EXCHANGER
14. EXPANSION TANK
15. HEAT TRANSFER FLUID
16. PRESSURE RELIEF DEVICE
17. CHECK VALVE
18. VENT VALVE
19. DRAIN VALVE
20. BACKFLOW PREVENTER
21. VACUUM BREAKER
23. SHUT OFF VALVE
24. TEMPERATURE SENSOR

FREEZE PROTECTION-ANTIFREEZE CHEMICALS IN HEAT TRANSFER FLUID (15) PREVENT FREEZING
□ REQUIRED FOR SAFETY OR MINIMUM OPERATION
○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING CODES

FIG. 5 Typical Single Tank Indirect System

adequate for joints near collectors under stagnation conditions. Soldering fluxes shall be water soluble.

6.7.7 Underground piping shall be installed below the frost line. Underground piping subject to vehicular traffic shall be installed to withstand the anticipated static and dynamic loads. The trench shall be free of sharp objects surrounding the pipe.

6.7.8 Piping shall be installed to facilitate drainage of liquid systems. Piping shall be pitched at the minimum rate of ⅛ in./ft (1 cm/m) towards the drain.

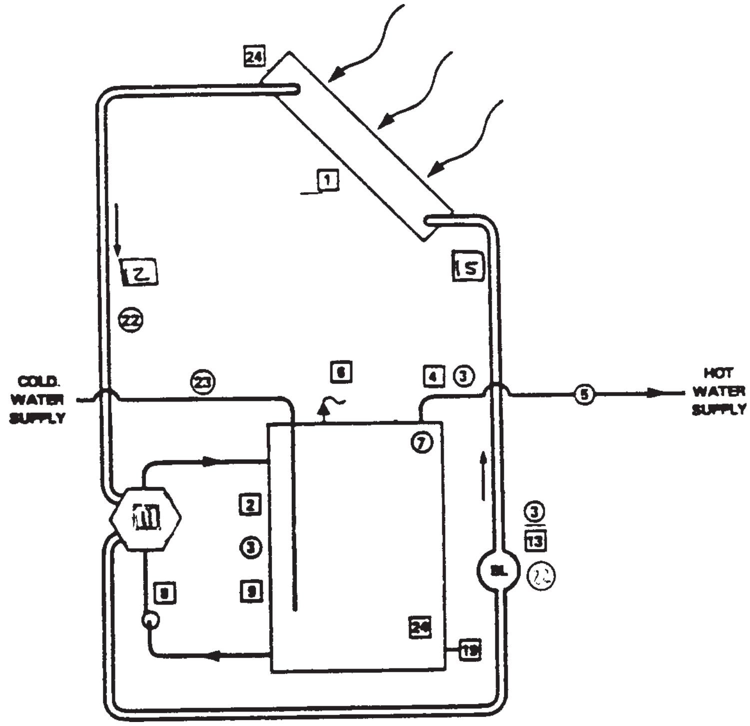
6.7.9 Suitable connections shall be provided for filling, draining, and flushing liquid systems. Interconnecting piping or ducting shall be installed to minimize flow restrictions, prevent air blocks, and to provide a balanced flow.

6.7.10 Where trapped air could impair the performance of a system or prevent drainage, air bleed provisions shall be provided at those high points so that air can be purged from the system.

6.7.11 Where heat losses may occur, insulation shall be provided on piping and ductwork. Insulation shall be suitable for the application and location. Insulation shall be protected against degradation due to weather or environmental conditions. Underground installations shall be protected to prevent deterioration of insulating properties by compression, water penetration, or bacterial action.

6.7.12 Piping shall be leak tested before enclosing, backfilling, or insulating. Caution shall be exercised so that excessive pressure is not applied to the system.

6.7.13 In air SDHW systems the air tightness of the ductwork is critical to system efficiency. All joints in rigid ductwork shall be sealed in accordance with the latest edition of SMACNA Medium Pressure Duct Construction Standards or Fibrous Glass Duct Construction Standards as is appropriate. Joints in flexible ductwork shall be sealed in accordance with the SMACNA Flexible Duct Installation Standards. Brackets



1. SOLAR COLLECTOR
2. SOLAR STORAGE TANK
3. INSULATION
4. PIPING/FITTINGS
5. MIXING VALVE
6. TEMPERATURE AND PRESSURE RELIEF VALVE
7. AUXILIARY HEAT SOURCE
8. PUMP
9. CONTROLLER
11. HEAT EXCHANGER (INTERNAL) OR (EXTERNAL)
12. AIR DUCT
13. BLOWER
15. HEAT TRANSFER FLUID
19. DRAIN VALVE
22. AIR DAMPER
23. SHUTOFF VALVES
24. TEMPERATURE SENSOR

FREEZE PROTECTION-NON-FREEZING FLUID (15) AND DAMPER (22) PREVENT FREEZING

□ REQUIRED FOR SAFETY OR MINIMUM OPERATION

○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING CODES

FIG. 6 Typical Air System

or hangers shall be used to securely support, suspend, or hang ducts. At no time shall duct supports penetrate the duct itself.

6.7.14 The direct joining of dissimilar metals in liquid systems that may result in accelerated corrosion should be avoided. Where it is necessary to joint dissimilar metals in the same system, they should be separated by electrically insulated joints or suitable intermediate metals.

6.7.15 When a liquid is used as the heat transfer fluid in a SDHW system and quick-closing valves are employed in the design, the piping system shall be able to control or withstand potential "water hammer." Water hammer arresters shall be in compliance with local codes.

6.7.16 Grounding electrical systems to SDHW system piping shall not be employed.

6.7.17 Auxiliary (nonsolar) heating equipment shall be sized and located to provide the residence with the required water temperature and flow whenever solar energy is inadequate. It shall be compatible with the solar system with regard to such items as output, temperatures, flow volume, and fluid types.

6.7.18 Where air needs to enter the system to allow drainage, a vacuum breaker should be located at the high point of the system.

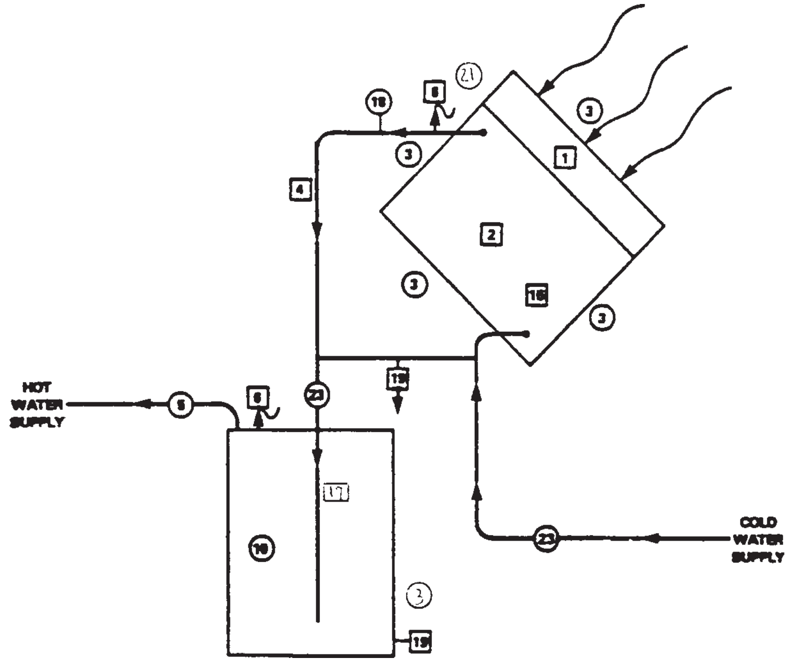
6.8 *Pumps, Blowers and Heat Exchangers*:

6.8.1 Pumps and blowers shall be installed in accordance with the manufacturer's instructions and so that the flow is in the proper direction.

6.8.2 Pumps and blowers should be installed with consideration to access for maintenance.

6.8.3 Pumps and blowers shall be installed to allow sufficient air circulation to prevent motor overheating.

6.8.4 Pumps and heat exchangers shall be adequately supported for their mass and to minimize vibration.



1. SOLAR COLLECTOR
2. SOLAR STORAGE TANK
3. INSULATION
4. PIPING/FITTINGS
5. MIXING VALVE
6. TEMPERATURE AND PRESSURE RELIEF VALVE
10. AUXILIARY STORAGE TANK AND HEAT SOURCE
15. HEAT TRANSFER FLUID
17. CHECK VALVE
18. VENT VALVE
19. DRAIN VALVE
20. BACKFLOW PREVENTER
21. VACUUM BREAKER
23. SHUTOFF VALVE

FREEZE PROTECTION-SHUTOFF VALVES (23) AND DRAIN VALVES (19) ALLOW FOR MANUAL DRAINING

□ REQUIRED FOR SAFETY OR MINIMUM OPERATION

○ FOR INCREASED EFFICIENCY OR AS REQUIRED BY APPLICABLE BUILDING CODES

FIG. 7 Typical Tank-Absorber Heater System

6.8.5 Heat exchangers shall be installed in accordance with the manufacturer's instructions.

6.8.6 Materials of construction used in pumps and heat exchangers should be compatible with other SDHW system components and the heat transfer fluid.

6.9 *System Start Up and Check Out Procedures*:

6.9.1 All liquid loops of a SDHW system shall be flushed and leak tested. If hydrostatically tested, pressurized systems shall be isolated and tested at the maximum working pressure of its lowest rated component as specified by the manufacturer. If air tested, the maximum test pressure shall not exceed 40 psig (275 kPa). Care should be exercised to purge completely fluids used in flushing. During flushing of the system, the collectors may be disconnected or by-passed to prevent the passage of debris through the collector.

6.9.2 All air loops of a SDHW system should be examined to confirm compliance with 6.7.13.

6.9.3 After the system has been installed, it shall be tested in all modes of operation to the extent practical to ensure that it is functioning properly.

6.10 *Owners Manual and Maintenance*:

6.10.1 Written operating instructions for the SDHW system shall be given to the owner for retention.

6.10.2 Complete operating instructions, including sequence of operation, wiring diagrams, and flow diagrams, shall be provided with the SDHW system. Installers shall provide written instructions to the building occupant for proper operating, safety, and emergency shutdown procedures of the devices.

6.10.3 Where hazardous fluids are used in the system, suitable warning labels shall be permanently mounted in a conspicuous place, with instructions for emergency treatment.

6.10.4 The owner shall be provided with written instructions for routine required maintenance, including operations that should be performed by service personnel. Instructions shall include collector glazing cleaning (see 6.10.7), draining and refilling, air venting of liquid systems, cleaning of components, corrosion control, and other maintenance procedures, in the systems's operating instructions.

6.10.5 A periodic maintenance program is recommended.

6.10.6 Service check lists and logs should be provided with system operating instructions.

6.10.7 Periodic cleaning of the collector glazing may be needed to maintain optimum efficiency. Operating instructions should recommend the proper cleaning agents and methods of cleaning that are compatible with collectors.

6.10.8 Valves should be checked periodically for proper operation.

6.10.9 Periodic inspection of the storage tank pan drains should be made to ensure their ability to drain adequately when needed.

6.10.10 Devices such as pumps, valves, and controls should be accessible for repair and maintenance.

7. Safety Precautions

7.1 This section covers the safety aspects of the SDHW system. It describes the use of accepted practices that are common in many existing building and plumbing codes. Its purpose is to ensure the safe operation of the system with regard for human safety.

7.2 *Release of Hot or Hazardous Fluids*:

7.2.1 All parts of the SDHW system that are isolated, or are capable of being isolated by valves or other means, shall have a pressure relief valve set to open at the maximum recommended working pressure of that part of the system. The rating of the relief valve shall exceed the heat input of the collector(s) or other heat source.

7.2.2 Relief valve discharges shall not damage structural members, contaminate potable water sources, or create risk of fire, and shall not pose a hazard to health or safety, and shall drain to locations acceptable to local codes and ordinances.

7.2.3 All liquid containment components shall be capable of withstanding a minimum pressure 1 and ½ times the rated maximum working pressure of the system without rupture.

7.2.4 All systems shall be provided with an approved self-closing (levered) pressure relief valve and temperature relief valve or combination thereof. Such valve shall be installed in the shell of the water heater tank or in the hot water outlet, provided that the thermo-element of the valve shall be installed within the top 6 in. (150 mm) of the tank. For installations with separate storage tanks, the valves shall be installed on both tanks. Pressure relief valves may be located adjacent to the equipment they serve. There shall be no check valve or shut-off valve between a relief valve and the heater(s) or tank(s) that it serves.

7.2.5 All automatically controlled systems shall be equipped with an energy cut-off device that will interrupt the supply of energy to the water tank before the temperature of the potable water in the tank exceeds 190°F (88°C) or 20°F (12°C) less than the temperature setting of the temperature relief valve. This energy cut-off device shall be in addition to the temperature and pressure relief valve.

7.2.6 Temperature and pressure relief valves, or combinations thereof, shall comply with the requirements of ANSI Z21.22 with a temperature setting of not more than 210°F (99°C) and a pressure setting not to exceed the tank or heater manufacturer's rated working pressure. The relieving capacity of these devices shall equal or exceed the heat input to the water heater or storage tank.

7.2.7 To avoid fluid damage or scalding due to relief valve discharge, drain pipe shall be connected to the valve outlet and run to a safe place of disposal. Drain pipe shall be as short as possible and be the same size as the valve discharge connection throughout its entire length. Drain line shall pitch downward from the valve and terminate at least 6 in. (150 mm) above the floor drain where any discharge will be clearly visible. The drain line shall terminate plain, not threaded, of material serviceable for 250°F (120°C), or greater. Excessive length (over 15 in. (4m)) or use of more than two elbows can cause a restriction of flows and reduce the discharge capacity of the valve. Shut-off valves shall not be installed between the relief valve and tank, or in the drain line.

7.2.8 All pressurized storage tanks shall be capable of withstanding a hydrostatic test pressure in accordance with accepted criteria applicable to the usage and maximum working pressures recommended by the manufacturer.

7.2.9 All piping materials used in interconnections shall be capable of withstanding the temperatures and pressures anticipated in the system.

7.2.10 In the event that temperature of the stored potable water is not limited to 140°F (60°C), a mixing valve shall be provided to limit the water for personal use to not more than 140°F (60°C). Maximum water temperature shall be in conformance with local codes.

7.3 *Contamination of Potable Water Supplies*:

7.3.1 Double wall heat exchangers should be provided with means to detect leakage through one of the walls (see 6.5.2).

7.3.2 Materials that come into direct physical contact with the potable water shall be acceptable for that use under the applicable codes.

7.3.3 No direct connection between the potable water supply and a non-potable piping system shall be allowed, unless separated by an approved backflow preventer.

7.3.4 Each system shall be clearly and permanently marked near the filling port(s) with a label specifying the fluids approved by the designer or manufacturer for use in the system.[9]

7.4 *Falling or Flying Objects*:

7.4.1 Collectors employing glass in their construction should be located so that in the event of glass breakage by any cause, glass fragments will not create an undue safety hazard.

7.4.2 Collectors should be located in such a way to minimize melting snow from sliding onto walkways or driveways.

7.5 *Electrical Hazards*—Electrical equipment shall conform to the requirements of the applicable electrical code. Electrical equipment and wiring shall not be located in spaces having temperatures higher than the thermal rating of the wire or equipment.

7.6 *Fire Hazards*:

7.6.1 Solar Collector System:

[9] Parts, L., and Conine, D., "Superior Heat Transfer Fluids for Solar Heating and Cooling Applications—Results of Acute Oral Toxicity Determinations," U. S. Department of Energy, Los Alamos National Laboratory, November 1981.

7.6.1.1 Assemblies and materials used in the SDHW system shall comply with the requirements of the applicable codes for fire safety under all anticipated operating and no-flow conditions.

7.6.1.2 Solar collectors shall be constructed and installed in such a way that any nearby or adjacent combustible material shall not be heated to temperatures in excess of 194°F (90°C) during periods of maximum temperature under no-flow conditions. Wood structural components should be protected from prolonged exposure to temperatures over 150°F (65°C).

7.6.2 Heat Transfer Fluids—Liquid Flash Point—The flash point of a liquid heat transfer fluid shall equal or exceed the higher temperature determined from: *(A)* a temperature of 50°F (28°C) above the design maximum flow temperature of the heat transfer fluid in the solar system, and *(B)* the design maximum no-flow temperature of the fluid.

7.6.2.1 *Exception:* When the collector manifold assembly is located outside of the building and exposed to the weather, and provided that the relief valves located adjacent to the collector or collector manifold do not discharge directly or indirectly into the building, and such discharge is directed away from flames and ignition sources, only *A* applies.

7.6.3 Insulating Materials—Materials used for insulating piping and storage tanks shall be of a fire resistance as specified in the local codes and appropriate to the location and use.

8. Keywords

8.1 active solar energy system; solar domestic hot water (SDHW); solar domestic water heating; solar energy; water heating