FLORIDA SOLAR ENERGY CENTER®

FSEC STANDARD

Florida Standards for Design and Installation of Solar Thermal Systems

FSEC Standard 104-05

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Introduction

The Solar Energy Standards Act of 1976, Section 377.705, Florida Statutes, directs the Florida Solar Energy Center (FSEC) to develop and promulgate standards for solar energy systems manufactured or sold in the state; to establish criteria for testing performance of solar energy systems; and to maintain the necessary capability for testing or evaluating performance of solar energy systems.

In 1978 the Legislature amended the act to require, effective January 1, 1980, that all solar energy systems manufactured or sold in the state meet the standards established by the Center and display accepted results of approved performance tests in a manner prescribed by the Center.

1.0 Purpose

These standards are intended to apply the best technology available to solar water heating (SWH) system design and installation and to be flexible enough to allow freedom of design and encourage innovation while meeting the requirements and intent of the Solar Energy Standards Act.

An ongoing effort is being made by national and international organizations to refine solar equipment standards. As recognized standards are developed, the Florida standards will be brought into agreement with their provisions to the greatest practicable extent. This should help Florida's solar industry to penetrate the national and international market and maintain leadership in providing solar energy system quality.

This document contains the technical criteria to be met by designers, manufacturers, installers, and evaluators of solar domestic water heating systems in order to ensure product safety, durability, and performance.

Standards are addressed by chapter for design, performance, durability, safety, operation and service, installation, and manuals. In each chapter entries are separated into statements of criterion and commentary.

Criterion is a statement giving the level of performance required to meet the application or expectation for the component or function being addressed. Due to limitations in the state-of-the-art, a quantitative statement is not always contained in each criterion, and in some criteria, quantitative statements have been intentionally omitted where these values should be provided by the designer.

In some cases, commentary will provide background information for the reader and presents the rationale behind the selection of specific data presented in the criterion. The commentary is intended for information purposes and is therefore only advisory.

2.0 Scope

The criteria presented in this document apply to the evaluation and approval of systems manufactured or sold in Florida to heat domestic water with solar thermal energy.

FSEC's solar collector certification program provides a standard test method, minimum quality standards, and a performance rating method for solar collectors. This document addresses requirements for all parts of the systems that use solar energy to heat domestic water.

3.0 Definitions

Words and phrases used in this document have the meanings given below.

Approved (component) - Evaluated on the basis of supplier’s data and application information and considered by FSEC to be suitable for use in solar energy systems. Tests are required for some components and limitations on suitable uses may be stated.

Auxiliary Heating Equipment - Equipment utilizing energy other than solar to supplement the output provided by the solar energy system.

Certification: Designation that specific products are in compliance with FSEC standards.

Collector: A device designed to absorb incident solar radiation, to convert it to thermal energy, and to transfer the thermal energy to a heat transfer material or storage material in contact with the absorbing surface.

Combustible Material - A material that will support combustion.

Controller - Any device which regulates the operation of the solar water heating system.

Controls System - The assembly of devices and their electrical, pneumatic or hydraulic auxiliaries which regulate the flow of energy used to operate the system by responding to sensed environmental conditions, internal conditions of the system, and requirements of the load. This includes devices which protect the system from damage by temperature and pressure extremes.

Design Life - The period of time during which a SWH system is expected to perform its intended function without requiring major maintenance or replacement.

Durability - Capability to withstand wear and tear and decay.

Heat Transfer Fluid - A liquid or gas, including all additives present under operating conditions, used to transport thermal energy.

In-service Conditions - The conditions to which a SWH system and its components will be exposed during their operational lifetimes.

Integral Collector Storage (ICS) - A solar system that has all or most of its water storage co-located with the collector. The system operates as a passive solar device without the use of mechanical equipment.

Manual - The total documentation package to be provided by the supplier to the purchaser which describes the general operation and maintenance procedures of the system. The manual will include a parts list, a system diagram, a description of major components, and other features required by this document.

May - Action indicated is allowed.

Potable Water - Water free from impurities in amounts sufficient to cause disease or harmful physiological effects when taken internally by humans or domesticated animals.

Readily Accessible: Capable of being reached quickly for operation, renewal or inspection without requiring a person to climb over or remove obstacles or resort to portable ladders, chairs, etc.

Shall - The criterion is required to comply with the standard.

Should - Recommended, but not required.

Significant (Corrosion, Deterioration, Loss, etc.) - Sufficient to result either in the creation of a hazard or a decrease in performance greater than that allowed for in design.

Solar Component - A component of a SWH system which is included in the system.

Solar Degradation: The process by which exposure to sunlight deteriorates the properties of materials and components.

Solar Energy: The photon energy originating from the sun's radiation in the wavelength of 0.3 to 3.0 micrometers.

Solar Loop: The collector, pump and associated piping and valves which transfer solar heat to the storage tank.

Subsystem: A major, separable, functional assembly or components.

SWH System: Domestic hot water system obtaining at least part of its thermal energy from incident solar energy.

System: (Also referred to as Solar Water Heating System, SWH System or Solar Water Heater) - A unit or package of components designed to provide solar heated water to residential type loads.

Thermosiphon: A solar system that has the storage tank located above the collector. Movement of fluid is through natural convection without the use of mechanical equipment.

Toxic Fluids: Gases or liquids which are poisonous, irritating or suffocating as classified in the Hazardous Substances Act, Code of Federal Regulations, Title l5.

Water Hammer: The term used to identify the hammering noises and severe shocks that may occur in pressurized water supply systems when flow is halted abruptly.

4.0 Referenced Standards and Organizations

Drinking Water System Components – Health Effects, ANSI/NSF 61-1991, NSF International, Ann Arbor, MI 48113 <http://www.nsf.org/>

Federal Hazardous Substances Act, Code of Federal Regulations, Title 15, Chapter 30. < http://www.gpoaccess.gov/cfr/index.html>

Fire Protection Handbook, National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169-7471. <http://www.nfpa.org/catalog/home/index.asp>

Flammable and Combustible Liquids Code, NFPA 30 (1997 Edition), National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169-7471. <http://www.nfpa.org/catalog/home/index.asp>

HUD Minimum Property Standard 4930.2 (1997 Edition), US Department of Housing and Urban Development, Washington D.C. <http://www.hud.gov/>

International Boiler and Pressure Vessel Code (1992 Edition), Section VIII, Division 1, "Rules for Construction of Pressure Vessels," The American Society of Mechanical Engineers, ASME International, Three Park Avenue, New York, NY 10016-5990. <http://www.asme.org/>

International Boiler and Pressure Vessel Code (1992 Edition), Section X, "Fiber-Reinforced Plastic Pressure Vessels," The American Society of Mechanical Engineers, ASME International, Three Park Avenue, New York, NY 10016-5990. <http://www.asme.org/>

National Electrical Code (1993 Edition), Article 240, National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169-7471. http://www.nfpa.org/catalog/home/index.asp>

National Roofing Contractors Association, 10255 W. Higgins Road, Suite 600, Rosemont, IL 60018. <http://www.nrca.net/>

Operation of the Solar Thermal Collector Certification Program, FSEC Standard 101-05, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703. <http://www.fsec.ucf.edu/>

Operation of the Solar Thermal Systems Certification Program, FSEC Standard 103-05, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703. <http://www.fsec.ucf.edu/>

Solar Thermal System and Components Test Protocols, FSEC Protocol 105-04, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL, 32922-5703. <http://www.fsec.ucf.edu/>

Test Methods and Minimum Standards for Certifying Solar Thermal Collectors, FSEC Standard 102-05, Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703. <http://www.fsec.ucf.edu/>

5.0 Implementation and Requirements for Compliance with Florida Standards

5.1 Implementation

There are two aspects to the application of the standards program to solar energy systems. First, is system certification whereby a system is judged for conformance to requirements for:

- a. Design
- b. Durability
- c. Safety
- d. Operation and Service
- e. Installation
- f. Manuals

Second is inspection or verification that the delivered product meets local code requirements.

5.2 Requirements for Compliance with Florida Standards

Solar domestic hot water systems shall comply with all applicable criteria of this document. All components shall be installed in accordance with the manufacturer's instructions unless an alternate method of installation is approved by FSEC.

In order to be awarded certification, the design and analytical evaluation of components which comprise the SWH system, i.e., collectors, controls, sensors, fluids, heat exchangers, pumps, plumbing, piping and tanks, shall meet or exceed the minimum standards established in this document.

This document is provided to supplement local regulations and building codes. Installed certified solar energy systems shall comply with all codes in force at the installation site. Where provisions of this standard conflict with local regulations, the more restrictive of the provisions will apply.

Requirements for system certification and manuals shall be waived for an owner designed and constructed system, but the equipment and its installation must comply with the requirements of applicable local codes.

6.0 Certification

6.1 Design

6.1.1 Overall System Design

6.1.1.1 Fluid Flow Control

The system controls shall maintain the SWH system within the temperature and pressure operating limits as required by the design.

Commentary: A system incapable of withstanding thermal shock created by filling hot collectors with cool fluids may require controls which would accept cool fluids only when the collector is cool. Control provision may also be required for the dumping of heat when temperatures and pressures approach unacceptable levels if under such conditions, deterioration of components may occur or system function may be impaired by such factors as boiling, vapor lock, vacuum formation or pressure drops.

6.1.1.2 Collector Isolation

Means shall be provided to isolate the solar loop in SWH systems for servicing, manual draindown freeze protection, or emergencies. Such isolation shall not interrupt water service. Use of gate valves to meet this requirement on SWH systems is not recommended.

Commentary: Isolating sections of a system is desirable when component removal is required. Isolation valves permit shutdown of system sections in an emergency situation or allow for draining the collector to prevent freezing. Gate valves after extended service have been shown to be unreliable in meeting the above isolation requirement. Ball valves are more suitable for use as isolation valves.

6.1.1.3 Thermal Changes

The system components, assemblies, and piping shall be designed to allow for the thermal contraction and expansion that will occur over the design temperature range.

Commentary: Piping and other components may change their dimensions as a result of temperature variations, producing excessive stresses within the piping, piping supports, pumps, and solar collectors unless the piping system design allows for thermal movement. Damage from thermal expansion is seldom a problem in residential applications, but these stresses may be problems in larger arrays which have long pipe runs with intersecting lines, or small components with tight tolerances. Movement due to thermal changes can also create abrasion on rough surfaces or corrosion problems by bringing dissimilar metals into contract.

6.1.1.4 Auxiliary Water Heating Equipment

A backup system shall be provided such that the combined system will provide the same degree of reliability and performance as a conventional system.

Auxiliary (nonsolar) water heating equipment shall be compatible with the solar system heat output, temperatures, flow rates and fluid types. Auxiliary equipment (including all electrically operated equipment) shall be listed and labeled by a recognized third party listing agency.

6.1.1.5 Thermosiphon Losses

Means shall be provided to prevent undesired escape of thermal energy from storage through thermosiphoning action.

Commentary: When the storage tank is below the height of the collector, nighttime circulation may move the cooler, heavier collector fluid into the tank and return the warmer fluid from the tank to the collector, causing a significant nighttime heat loss for the system. Generally, zone valves or check valves not dependent on back-pressure should be used to prevent such circulation. Properly controlled, this circulation can be an acceptable means of freeze protection.

6.1.1.6 Fluid System Sizing

Pumps, fans, ducts, piping and other components shall be sized to carry the heat transfer fluid at design flow rates without significant erosion or corrosion. Consideration should be given to minimizing pressure drops and vibrations. The FSEC rating will be determined for 4.9 meter (16 ft.) head and 7.6 meter (25 ft.) pipe runs to and from the collector array.

Commentary: To transfer heat through the system/subsystem, a number of different transfer approaches such as gravity circulation, combined forced and gravity circulation, or forced circulation may be used. Standard piping design manuals provide recognized design practices for the determination of limiting velocities for heat transfer liquids.

6.1.1.7 Reserved for Future Criteria

6.1.1.8 Vacuum-Induced Pressure Protection

All components shall be protected against damage from vacuum induced pressure. Such components shall be designed to withstand such pressures or have vacuum relief protection.

6.1.1.9 Thermal Shock Protection

The system shall be able to withstand any thermal shock caused by an electric power failure.

6.1.1.10 Compatibility of Similar Materials

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

Commentary: When considering compatibility of dissimilar materials, attention should be paid to all elements of a solar system including energy transport system, structural support and connections, fabricated parts and roofing materials.

Corrosion inhibitors or dielectric fittings may be used to electrically isolate dissimilar materials, but the presence of even a pinhole in protective coatings can accelerate corrosive action. It is better to minimize the presence of incompatible materials whenever possible.

6.1.1.11 Airborne Pollutants

Solar components and materials that are exposed to airborne pollutants such as ozone, salt spray, SO_2 or NOx shall not be adversely affected by these factors to the extent that their function will be significantly impaired during their design life.

Commentary: Ozone concentrations of 1 to 5 parts per hundred million by volume have been recorded in normal dry air; however, concentrations of 100 pphm/volume have been reported during very smoggy conditions. Ozone is known to degrade some organic materials, but it has little effect on inorganic materials other than metals. The effect of solar radiation in combination with airborne pollutants also may be an important consideration in the dry condition or in the presence of moisture. Factors of concern include cover plate surface erosion and consequent transmission loss, deterioration of coupling hoses and exposed seals, and corrosion of metallic elements.

6.1.1.12 Effects of Decomposition Products

Chemical decomposition products that are expelled from solar components under in-service conditions shall not cause the degradation of solar components or building elements to the extent that would significantly impair their ability to perform their intended function over their design life.

Commentary: Components and materials, such as gaskets, sealants, coatings, etc., may yield degradation products during their service life without impairing their function or aesthetic properties; however, the degradation products could significantly impair the performance of other components in the system.

Heat transfer fluids, including inhibited water, may decompose and produce scale buildup which may cause deterioration of performance. This is particularly true of water heaters where supply water is heated directly in the collector, and dissolved solids (calcium salts) precipitate.

6.1.2 Collector Design

6.1.2.1 Collectors

Collector component(s) shall be tested in accordance with either FSEC Standard 102-05, “Test Methods and Minimum Standards for Certifying Solar Thermal Collectors,” FSEC Standard 101-05, “Operation of the Solar Thermal Collector Certification Program,” FSEC Protocol 105-05, “Solar Thermal System and Components Test Protocols,”or a similar test procedure approved by FSEC provided that the alternate test procedure includes the durability tests specified in Section 5.0 of FSEC Standard 102-05 and the collector component of the system meets the collector standards specified in Section 6.0 of FSEC Standard 102-05.

Test data on the solar collecting portion of the system shall be no older than 10 years.

6.1.2.2 Protection From Ultraviolet Radiation

Ultraviolet radiation shall not significantly alter the performance of any component or subcomponent of the system.

6.1.2.3 Reserved for Future Criteria

6.1.2.4 Flow Distribution in Collectors

In multiple collector arrays, the instantaneous flow rate variations between collectors shall not exceed 10% of the array average flow.

When an array of collectors is connected by manifolds to form a parallel flow configuration, provision shall be incorporated in the manifold and/or collectors to maintain the proper design flow rate of the heat transfer fluid through each collector.

Commentary: A collector array can be a combination of series and parallel connections sometimes resulting in unequal flow distribution through the collectors. Because of friction and velocity head variation in manifolding, flow rates may be inadequate through collectors remote from the pump. This can result in inefficient collector operation. Flow-regulating devices are one means of preventing this problem; another is the use of reversed supply and return headers for parallel compensating for changes in flow rate. Such reverse return methods may not always be capable of coping with varying field conditions; thus balancing valves or restrictors may be needed.

6.1.2.5 Reserved for Future Criteria

6.1.2.6 Reserved for Future Criteria

6.1.2.7 Circulation Control

The collector subsystem control shall be designed to be compatible with control requirements of the system.

Commentary: It can be wasteful of energy to circulate fluid when no solar energy is available unless the circulation is being used for freeze protection. Various control schemes are available including simple temperature sensitive snap switches and variable differential temperature controllers. Special attention should be given to the installation of the control mechanism, including the location and mounting of the sensor element. Incorrectly installed sensors can degrade system performance or shorten the life of the sensor.

6.1.3 Electrically Operated Components

6.1.3.1 Tank Design Requirements

Both pressurized and non-pressurized tanks shall meet the requirements set by a nationally accepted standard setting organization.

Non-pressurized tanks shall be vented to atmospheric pressure.

Non-Fiberglass hot water storage tanks shall comply with ASME Boiler and Pressure Vessel Code, Division 1, Section VIII, “Rules for Construction of Pressure Vessels” unless they fall into one of the classes of vessels exempted in Part U-1(c).

Fiber-reinforced plastic pressure vessels shall comply with ASME Boiler and Pressure Vessel Code, Section X, “Fiber-Reinforced Plastic Pressure Vessels” unless they fall into one of the classes of vessels exempted in Part RG-121.

6.1.3.2 Tank Insulation

On SWH systems, insulation shall be provided on storage tanks. Tank insulation shall have a minimum of R-2.1^{o} K-m^{2}/W (R-12^{o} F-ft^{2}-hr/Btu). An exterior insulation blanket may be used to satisfy this requirement. Insulation shall be suitable for the particular application and location, and shall include protection from environmental degradation.

Commentary: Care should be taken to assure the continued effectiveness of insulation, particularly in exterior and underground locations where water-soaked insulation may result in thermal losses. Coatings must protect insulation from degradation caused by ultraviolet radiation and weather. The compressive strength of insulation underneath storage tanks must resist crushing, which would reduce its thermal effectiveness. Mechanical strength of insulation is also important in avoiding sagging, pulling away from components, and opening up at seams.

6.1.3.3 Waterproofing

Underground and above ground unsheltered storage tanks shall be waterproofed to prevent water seepage.

6.1.3.4 Thermal Expansion of Fluids

The system design shall include adequate provisions for the thermal expansion of heat transfer fluids and thermal storage fluids. Expansion tanks shall be sized in accordance with ASHRAE recommendations.

Commentary: Water expands about 4 percent in volume when heated from 4.4°C to 93.3 °C (40°F to 200°F). Other heat transfer fluids may have greater coefficients of volume expansion. Means should be provided in the system design to contain this additional fluid volume without exceeding the operating pressure of the system or resulting in spillage.

6.1.3.5 Reserved for Future Criteria

6.1.3.6 Separation of Circulation Loop

There shall be at least two physically separated walls or interfaces, with leak detection, between the potable water supply and any toxic heat transfer or thermal storage fluids carried in circulation loops. Single wall separation may be used between the potable water supply and fluids declared to be suitable for human consumption by a recognized health authority.

Commentary: Double wall heat exchanger designs are one way of meeting the intent of this criterion. When double wall exchanger designs consisting of two single-wall heat exchangers in combination with an intermediary potable heat transfer liquid are used, leakage through one of the walls would result in a single-wall configuration. When two walls are in intimate contact with one another, pitting initiated through one wall can readily continue through the other. There are several other designs that avoid this problem.

Extra thick single walls and singe-wall configurations which rely solely upon potable water pressure to prevent contamination are examples of constructions which do not satisfy this criterion.

6.1.4 Reserved for Future Criteria

6.1.5 Pumps and Control

6.1.5.1 Reserved for Future Criteria

6.1.5.2 Controls Override

The system controls, except for safety controls, shall include such provision for bypass, adjustment or override of manual or automatic controls as required to facilitate installation, startup, operation, shutdown and maintenance.

Commentary: Manual operation of controls may be needed during installation, startup and operation to balance or adjust the system. Manual control may be necessary to ensure the safety and durability of the system and the building. Other controls may be required for tests or maintenance after the system has been in operation or for seasonal shutdown. Override capability may be met by opening or shorting sensor leads at wiring terminals.

6.1.5.3 Wiring identification

Control circuit wiring and terminals shall be identified and marked or color-coded.

Commentary: A hazardous voltage may exist in terminals or wires within the control subsystem; these points should be identified. Wire and terminal identification can save a serviceman considerable time that otherwise would be spent tracing wires and circuitry.

6.1.5.4 Temperature Rating

Wiring under insulation shall be rated for expected increased temperature conditions.

6.1.5.5 Protection of control lines

The wiring, pneumatic lines, hydraulic lines or other means for transmitting sensor outputs to control devices shall be protected from damage or from introducing false signals as a result of environmental or system operating conditions.

Commentary: Thermal or electric insulation used to protect sensors or sensor wiring is often subjected to severe weather conditions, transient emf fields, as well as system temperature extremes.

6.1.5.6 Reserved for Future Criteria

6.1.6 Plumbing and Piping Design

6.1.6.1 Reserved for Future Criteria

6.1.6.2 Reserved for Future Criteria

6.1.6.3 Insulation

On SWH systems, insulation shall be provided on piping that interconnects solar components where heat loss may occur. Insulation shall be suitable for the particular application and location, and include protection from environmental degradation. All interconnecting hot water piping and the final 1.5 meters (5.0 feet) of the cold water supply pipe leading to the system, or the length of piping which is accessible if less than 1.5 meters, shall be insulated with R-0.46 $^{\circ}$K m^2/W (R-2.6 °F-ft^2-hr /Btu) or greater insulation.

All exterior piping insulation shall be protected from ultraviolet radiation and moisture damage.

6.1.6.4 Reserved for Future Criteria

6.1.6.5 Reserved for Future Criteria

6.1.6.6 Service Connections

Suitable connections shall be provided at a readily accessible location for filling, draining and flushing liquid systems.

6.1.6.7 Maintenance and Servicing Considerations

All individual components of the SWH systems which may require periodic examination, adjustment, service and/or maintenance shall be accessible for inspection, service, repair, removal or replacement without dismantling any adjoining major piece of equipment, subsystem or building element. Individual collectors in any array shall be replaceable or repairable without disturbing non-adjacent collectors in the array.

6.1.6.8 Reserved for Future Criteria

6.1.6.9 Reserved for Future Criteria

6.1.6.10 Reserved for Future Criteria

6.1.6.11 Reserved for Future Criteria

6.2 Reliability and Durability

6.2.1 Thermal Degradation, Shock and Cycling Stresses

Solar components and materials shall not physically degrade to the extent that their function will be reduced below design levels during their design life when exposed to maximum and minimum service temperatures and pressures.

Solar components and materials should be capable of withstanding the stresses induced by thermal shock for the respective design lives.

SWH systems and their various subassemblies shall be capable of withstanding the stresses induced by thermal and pressure cycling for their respective design lives.

Commentary: Some organic components which may be used in the system may be particularly susceptible to thermal degradation under prolonged exposure. Organic collector components of particular concern include cover plates, absorbers, absorptive coatings, heat traps, insulation, sealants and enclosure frames. Storage containers, piping, liners and coating composed of organic materials are also susceptible to failure under temperature extremes.

In addition to evaluating thermal degradation, this criterion is intended to identify potential problems that may occur as a result of differential thermal expansion. Thermal compatibility is especially critical in the case of collectors with large amounts of glazing. If thermal expansion is cumulative in system or subsystem design, the design must accommodate this condition. Areas of concern include the attachment of cover plates to frame, collector to support, collector to collector, collector to piping, reflective surface to substrate, and tubes to absorber plate.

6.2.2 Criterion: Solar Degradation

Components of materials shall not be affected by exposure to sunlight to an extent that will significantly impair their function during their design life.

Commentary: Certain organic materials which may be used in the system may be particularly susceptible to solar degradation under prolonged exposure. Components of special concern include cover plates (including films and coatings), absorber surfaces, plastic pipe, collector heat traps, collector insulation, outdoor exposed insulation and its coatings, and reflectors. Care should be taken to properly install coated cover plates that have a weather side. Some glazings are designed to be recoated after a period of time due to weathering of the surface.

Ultraviolet radiation is singularly damaging to exposed materials since it causes paint to peel, crack, blister and fade and causes insulation to dry up, become brittle and lose its insulation qualities.

6.2.3 Operating Conditions

Collectors, tanks, pumps, valves, regulating orifices, pressure regulators, heat exchangers, piping, hoses and other components shall be capable of operating within the design pressure and temperature ranges and withstanding environmental extremes anticipated in actual service without significantly reducing system design life.

Commentary: Components may be exposed to temperatures or pressures outside their normal operating range when a power failure or system malfunction occurs. The component must be able to withstand this temporary condition and return to normal operation without impairment.

6.2.4 Reserved for Future Criteria

6.2.5 Freeze Protection

Components containing liquids shall be protected from freeze damage under the most severe environmental conditions that can be expected in actual use. For solar systems where the collector fluid is water, a minimum of two (2) freeze protection mechanisms shall be provided on each system. Manual draining is suitable as one mechanism. At least one freeze protection mechanism, in addition to manual draindown, must be designed to protect components from freeze damage in the event of power failure. The thermal mass of a system can be considered to be a limited form of freeze protection. Systems installed in a location that has no record of an ambient temperature below 5^0 C (41^0 F) may be exempted from the requirements of this criterion.

A system subject to damage by freezing shall have the proper fittings, pipe slope and collector design to allow for manual gravity draining of the collector and exterior piping. Pipe slope for gravity draining shall have a minimum 7mm (1/4-inch) vertical drop for each 30 cm (1-foot) horizontal length. This also applies to any header pipe or absorber plate riser tubes internal to the collector.

All freeze protection mechanisms utilized by each system shall be clearly stated in the owner's manual and on a permanent label 13 cm x 18 cm (5" x 7" minimum) conspicuously displayed on the equipment. This label shall also include the procedure required for manual draindown freeze protection. All equipment used in the manual draindown procedure shall be identified (color coded, numbered, tagged, etc.) for easy consumer recognition.

Commentary: The intent of this criterion is to ensure that rupture or other damage to solar collectors and associated piping and equipment will not occur from expansion of water or other heat transfer liquid if it freezes. It is not the intent of this criterion to restrict the designer to the use of antifreeze solutions for liquid systems.

If automatic draindown is the freeze protection technique to be used, automatic air vents, vacuum relief valves and draindown valves should be protected from freezing. Rate of draindown should be compared to rate of thermal losses to prevent ice blockages.

Antifreeze heat transfer fluids circulated at freezing temperatures because of thermosiphoning or a malfunctioning control or pump may cause freezing of stored water at the heat exchanger interface.

Fail-safe or passive freeze protection methods are desirable since methods requiring electric power will be ineffective in the event of power failure. Systems employing draindown require controlled venting for draining and refill and may need special protection against contamination or corrosion of the system during these operations.

Thermally operated freeze protection valves, if used, should be designed and installed to protect the collector from freezing recognizing that the collector plate temperature, under certain environmental conditions, may be substantially colder than the ambient air.

6.2.6 Protection From Leaks

All potable water sections of a solar water heating system shall not leak when tested in accordance with the codes in force at the installation site. All non-potable sections of a solar water heating system shall be tested for leaks in accordance with the supplier's instructions.

6.2.7 Materials/Transfer Fluid Compatibility

Materials designed to be used in contact with heat transfer fluids shall not be corroded or otherwise adversely affected by these fluids to the extent that their function will be significantly impaired under in-service conditions during their design life.

Commentary: Corrosion of metals by heat transfer fluids could be a serious problem in solar energy systems. All metals used in the storage system which come into contact with the heat transfer fluid shall be in accordance with Tables S-515-2.3.2 or S-515-2.3.3 of HUD Minimum Property Standard 4930.2. Documentation shall be provided to demonstrate that material usages not covered in these tables meet the intent of S-515-1.4 and S-515-7.4. Experience indicates that tightly sealing closed-loop systems helps to prevent corrosion.

Any use of inhibitors should be keyed to the characteristics of all exposed elements of the energy transport system involved, including collectors, piping, connectors, tanks, pumps, valves, heat exchangers, etc. Inhibitors should be selected to maintain the desired fluid properties.

6.2.8 Deterioration of Fluids

Except when allowed by the system design, fluids shall not freeze, give rise to excessive precipitation or otherwise lose their homogeneity, boil, change absorptivity, or change pH or viscosity beyond the design ranges when exposed to their maximum and minimum service temperatures and pressures during their design life.

Commentary: Although boiling can be prevented by pressurization, excessive temperatures can break down constituents of some heat transfer fluids to form organic acids. Buffers can counter the pH balance but only until they are exhausted. Changes in pH can be accepted, but when the allowable range is exceeded the transfer fluid, or at least the buffers, must be renewed. This can be an acceptable maintenance requirement.

Thermal cycling may cause precipitation, which could lead to malfunction through a buildup of solids in pump seals and valve seats.

If not considered in the design, viscosity changes in heat transfer fluids may cause pumping problems, such as excessive pumping power requirements or overheating due to thickened heat transfer fluid.

When heat transfer fluids are used as absorbers, bleaching of the fluid may significantly reduce system performance.

6.2.9 Reserved for Future Criteria

6.2.10 Soil-Related Degradation

Solar components and materials that are intended to be buried in soils shall not degrade under in-service conditions to an extent that their function will be impaired during their design life. Underground installations shall be given special consideration to prevent deterioration of insulating properties by compression, water penetration, and chemical or bacterial actions.

Commentary: This criterion is primarily intended to protect metallic components from soil corrosion. It may be possible to protect some metallic components with the use of sacrificial anodes. Components made of wood or plastic may also be degraded by contact with soil.

6.2.11 Deterioration of Gaskets, Sealants and Hoses

Gaskets, sealants and coupling hoses, either dry or in direct contact with liquids, shall not be adversely affected by contact with liquids or the environment to an extent that will significantly impair their ability to function during their design life.

Commentary: Gaskets, sealants, coupling hoses and similar organic materials may swell when exposed to certain liquids and thus may lose their ability to function. Since coupling hose connections are a potential source of leakage, the selection of hoses and clamps is quite critical. Many failures have been caused by the clamping of a hose with screw- or spring-type clamps, exposing the hose to high temperatures which tend to harden it beneath the clamp, causing it to lose resiliency and begin to leak. Silicone and synthetic rubber hoses, if properly vulcanized, tend to maintain their resiliency with no inclination to take a thermal set. Due to the pliability of silicone rubber hoses, however, screw-type clamps with perforated bands should not be used, because the hose material may extrude through the perforations.

6.2.12 Water Hammer

When a liquid is used as the transfer fluid and quick-closing valves are employed in the design, the piping system shall be able to control or withstand potential water hammer.

Commentary: Pressure rises resulting from water hammer may damage piping and equipment.

6.2.13 Sound and Vibration Control

Piping and associated fittings shall be designed to carry the heat transfer fluid at design flow rates without excessive noise or vibrations which could be annoying or induce mechanical stress levels high enough to cause damage or annoyance.

Pumps and compressors, or other components involving moving parts, shall be balanced or mounted in such a manner that they do not induce excessive noise or vibration that could be annoying or cause damage.

Commentary: Examples of possible sound and vibration are (1) lengths of piping and connecting equipment that are resonant with pressure pulsation frequency; (2) vibration resulting from improperly mounted motors, pumps, and compressors; (3) water hammer and quick-closing valves; (4) excitation of piping by wind turbulence.

6.3 Safety

6.3.1 Reserved for Future Criteria

6.3.2 Protection of Electrical Components

Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the device and with provisions of the National Electric Code.

6.3.3 Reserved for Future Criteria

6.3.4 System Failure Prevention

The system shall be designed that, in the event of a power failure or a failure of any of the system components, the temperatures or pressures resulting from overheat in SWH systems will not endanger the building or its occupants or damage any of the system components.

Commentary: The excessive pressure and temperatures that can build up in collectors under "no flow" conditions demand attention. One point of concern is thermal shock which could occur when cool heat transfer fluids are introduced into collectors which have been exposed to solar radiation under "no-flow" conditions. In systems which cannot withstand the maximum temperatures to which they will be exposed (i.e., under "no-flow" conditions) it is essential that some means of protection, such as energy dumping, be provided.

6.3.5 Reserved for Future Criteria

6.3.6 Protection Against Auto-Ignition of Combustibles

Combustible materials used in solar equipment shall not be exposed to elevated temperature which could cause ignition.

Commentary: When cellulosic and other combustible materials, are exposed to elevated temperatures over an extended period of time, they may reach and surpass their auto-ignition temperature. This may occur, for example, in collectors framed in wood or in attic collectors. The most commonly accepted ignition temperature of wood is 200° C (392° F); however, NFPA's Fire Protection Handbook indicates that prolonged exposure to elevated temperatures may reduce the ignition temperature of wood. The ignition temperature of plastics may be above or below those of cellulosic materials.

6.3.7 Fluid Handling Instructions

Drains and other points in solar systems which may discharge a fluid requiring special handling or fluids at high-temperature or high-pressure shall be labeled with the identification of the fluid, instructions concerning its safe handling, and emergency first-aid procedures.

Commentary: The original fluid containers often will be discarded after the system is charged, which could result in no record of the fluid's properties being retained. Since the system drain is the point at which the owner or service personnel are most likely to contact the heat transfer fluid, permanent labeling should be retained at that point. Identification may be provided by attaching a tag bearing the required information such as may be supplied by the heat transfer fluid manufacturer.

Solar systems which utilize a heat exchanger shall display in a conspicuous place instructions as to the proper fluid to be used along with instructions for filling and disposing of the fluid. This criterion also applies if water is used as the heat transfer fluid.

Commentary: Storage tanks and other components may not be compatible with certain heat transfer fluids. This criterion is intended to prevent the system from being filled with the wrong fluid during servicing.

6.3.8 Contamination of Potable Water

Materials that come in direct contact with potable water shall not affect the taste, odor, or physical quality and appearance of the water and shall meet the standards of NSF International.

6.3.9 Entrapped Air

Systems using liquid heat transfer fluids shall provide suitable means for air or gas removal from points in the piping system where air is most likely to accumulate.

Commentary: Trapped air in piping can impede the flow of liquids, reduce heat transfer potential and otherwise reduce overall system efficiency. The freezing of exposed air vent fittings has been known to trap air in solar piping systems. The potential buildup of vapor, which could create voids and thus block or restrict the flow of heat transfer fluids, should be avoided.

6.3.10 Reserved for Future Criteria

6.3.11 Reserved for Future Criteria

6.3.12 Toxic Fluids

The use of toxic fluids shall comply with the Federal Hazardous Substances Act Title 15 and the requirements of the health authority having jurisdiction.

Commentary: Characteristics of the complete fluid mixture must be considered in determining toxicity. For example, addition of inhibitors or buffers to water or antifreeze/water mixtures may affect toxicity characteristics.

6.3.13 Combustible Liquids

The storage, piping and handling of combustible liquids shall conform to the requirements of the Flammable and Combustible Liquids Code NFPA 30.

6.3.14 Liquid Flash Point

The flash point of a liquid heat transfer fluid shall exceed by 28° C (50° F) or more the design maximum no-flow temperature to be reached by the fluid in the collector. The flash point shall be determined by the methods described in NFPA 30: Flammable and Combustible Liquids Code.

Commentary: The design maximum no-flow temperature of the fluid is defined as the maximum fluid temperature that will be reached when the heat transfer fluid is not flowing through the system. Generally, this temperature will occur in the collector when it is receiving its maximum level of solar radiation at maximum ambient temperature.

Flash point values listed in manufacturers' literature are frequently typical values determined by an open-cup flash point test. Flash point values must be based on actual measurement of certified minimum values determined by the required closed-cup flash point test method.

The flash point of aqueous solutions or organic materials depends on the percentage of water in the mixture. A flash point does not exist for certain mixtures of propylene glycol and water. When these mixtures are boiled and the vapors allowed to escape, the flash point will usually be reduced, ultimately approaching that of the pure propylene glycol. Care should be taken that the mixture's flash point is based on the anticipated percentage of water during the actual use of the liquid in the system and not necessarily on the percentage as installed.

6.3.15 Reserved for Future Criteria

6.3.16 Pressure Relief

Each portion of the system where excessive pressures can develop shall have a pressure relief device to ensure that no section can be valved off or otherwise isolated from a relief device. Automatic pressure relief devices shall be set to open at not more than maximum design pressure.

Commentary: Care should be taken in the design and layout of the fluid transport system to prevent development of excessive pressures or temperatures by flow restrictions or air locks. Large pressure drops due to flow of vapors or boiling fluids should be considered in the selection and location of pressure relief devices. A pressure relief valve may be located at any suitable point between the isolation valves.

Relief devices must be protected to remain workable in time of need. Precautions must be taken to prevent discharge of heat transfer liquids which could damage or blemish roofing, paint or vegetation, or compromise the safety of anyone in the vicinity. It may be desirable to provide a means of detecting when venting has occurred (i.e., when recharging is necessary for continued proper operation).

6.3.17 Heated Components

SWH system subassemblies which are exposed to public traffic and are maintained at elevated temperatures shall either be insulated sufficiently to keep exposed surface temperatures below 60° C (140° F) during operation, or they shall be suitably isolated. Any other exposed areas that are maintained at hazardous temperatures shall be identified with appropriate warnings.

6.4 Operation and Servicing

6.4.1 Operation Indicators

A pumped SWH system shall include means for an observer to determine readily when the collector loop pump is operating.

Commentary: A minimum level of information is essential to help the user know whether the solar system is functioning. This may be accomplished by an indicator light or some other inexpensive device.

6.4.2 Reserved for Future Criteria

6.4.3 Reserved for Future Criteria

6.4.4 Waste Disposal

Systems utilizing a toxic heat transfer fluid or thermal storage fluid shall provide for the catchment and harmless removal of these fluids from vents where fluid may be automatically discharged.

Commentary: The discharge of toxic, corrosive, combustible or explosive fluids into sewers can create serious health and safety hazards both within the immediate community and at a considerable distance along watercourses into which the sewers discharge. Safe disposal of such a fluid requires, among other things, consideration of its composition, its concentration and frequency of discharge, and the nature of the sewage treatment and disposal system available to the site. In some instances catchment of this discharge and removal to specialized treatment facilities may be the only acceptable disposal method. Under such conditions, adequately sized and protected catch basins should be provided.

The leakage of toxic fluids into the ground could contaminate ground water. In addition, leakage of some heat transfer fluids could damage roofing, sealants and other building materials. Leakage of combustible fluids could pose a fire hazard when exposed to an external heat source.

6.4.5 Dirt Retention and Staining

Solar systems and collectors shall be accessible for periodic cleaning if conditions are such that self-cleaning by rain is not sufficient to keep the collectors operating efficiently.

Commentary: Dirt and stains on the cover plate may significantly affect collector performance. Retention of dirt may be affected by the collector's tilt angle. Although rainfall is generally sufficient to keep the cover plate clean on the outside, in areas of low rainfall or because of the nature of the cover plate surface, periodic washing may be required. Accumulations of sap, leaves, branches, etc., can also degrade collector performance. Abrasive wear may occur in areas subject to wind-driven dirt and sand. Also, abrasive wear of cover plates resulting from cleaning or scrubbing may significantly affect their ability to transmit sunlight.

6.4.6 Maintenance and Servicing Considerations

The SWH systems shall be designed to provide sufficient access and appurtenances for general maintenance and convenient servicing.

6.4.7 Permanent Maintenance Accessories

Permanent maintenance accessories such as hose bibs, drains and ladder supports necessary for maintenance of the SWH systems shall be provided.

6.4.8 Reserved for Future Criteria

6.5 Installation

6.5.1 Firestopping

SWH system components that are integral parts of assemblies which normally require firestopping shall be firestopped consistent with local codes and ordinances.

Commentary: It is the intent of this criterion to prevent SWH system components from reducing the effectiveness of firestopping. For example, in the case where a solar collector is an integral part of a wood-framed wall which would normally be firestopped between studs, firestopping may be required in the wall above and below the collector.

6.5.2 Reserved for Future Criteria

6.5.3 Space Use

Solar components should not reduce or increase humidity, temperature or thermal radiation beyond acceptable levels or interfere with required headroom or air circulation space.

6.5.4 Accessibility

The location of the solar components should not impair accessibility needed to maintain the building or site.

Commentary: Roof maintenance may be difficult if collector installations are not designed for this need. The location of underground elements should be examined both to ensure that they can be maintained without trespassing on adjoining property and to ensure that they do not prevent digging, truck access, etc., necessary to maintain the facility or site.

6.5.5 Building Penetrations

Penetrations of the building through which piping or wiring is passed shall not reduce or impair the function of the enclosure.

Penetrations through walls or other surfaces shall not allow intrusion by vermin. Required roof penetrations shall be made in accordance with applicable codes and also by practices recommended by the National Roofing Contractors Associations.

Commentary: Particularly relative to collector supports, the penetrations should either be accessible for maintenance or the assembly should be fastened securely to the roof and flashed and caulked as necessary for water tightness.

The primary sources of roof leakage problems are wind induced motion of mounting bolts which penetrate waterproof membranes as well as thermal expansion and contraction of piping, mounting hardware or collector housings.

Penetrations should be constructed in such a way as to accommodate motion of the penetrating members, resulting from either cause, without reducing either the durability or the weatherproofing effectiveness of the membrane.

6.5.6 Water Damage

Collectors and supports shall be installed in such a manner that water flowing off the collector surface will not damage the building or cause premature erosion of the roof.

6.5.7 Reserved for Future Criteria

6.5.8 Structural Supports

Neither wind loading nor the additional weight of filled collectors shall exceed the live or dead load ratings of the building, roof, foundation or soil. Collector supports shall not impose undue stresses on the collectors.

Commentary: Damaging stresses may be imposed by thermal expansion or contraction, wind movement, seismic loads, vibratory loads, or foundation settlement. Solar components vary in their ability to withstand the effect of differential settlement on their performance.

6.5.9 Expansion and Contraction of Supports

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

6.5.10 Penetration of Structural Members

When penetrations are required in structural members to accompany passage of solar components, those modified structural members shall comply with local building codes.

Commentary: This criterion is intended to prevent penetrations made for the installation of pipes, ducts, conduit wires and other mechanical equipment from weakening structural members beyond their required strength.

6.5.11 Protection from Thermal Deterioration

Building materials adjacent to solar equipment shall not be exposed to elevated temperatures which could accelerate their deterioration.

Commentary: Certain building materials exposed to elevated temperatures may be subject to hardening, softening, melting, blistering, buckling and other adverse changes which could reduce their structural or fire resistance ratings.

6.5.12 Tilt and Azimuth

The collector shall be installed on a mount capable of maintaining tilt and azimuth to design conditions

Commentary: Collectors can either be fixed, require seasonal adjustment, or be continuously movable. It is not the intent of this criterion that the collector necessarily be reoriented or tilted after initial installation.

The commonly used value for collector tilt for hot water systems is equal to the geographical latitude. This orientation maximizes the amount of energy collected on an annual basis. Collectors are often mounted at a different orientation for aesthetic reasons or to favor performance during certain seasons. Deviations $\pm 15^{\circ}$ from latitude tilt when using conventional flat-plate collectors will usually have little effect on an annual basis, but the seasonal effect may be as much as 15 percent.

Conventional flat-plate collector orientation should be such that it generally faces south. Deviations to the east or west up to 30° may increase the seasonal variation but cause no major decrease in captured radiation on an annual basis.

6.5.13 Shading of Collector

The location and orientation of the collector shall be such that it is not shaded by external obstructions or mutual shadowing more than the specified period allowed in the design.

Commentary: Data are available for calculating shading angles as a function of the time of day and year.

6.5.14 Pipe and Component Supports

Hangers shall provide adequate support and correct pitch of pipes. Hangers or supports for insulated pipes or components shall be designed to avoid compressing or damaging the insulation material.

Commentary: If pipe or component hangers are installed over the insulation material, sleeves or plates should be used to avoid damaging the insulation.

6.5.15 Pitch or Angle of Piping Installation

Piping should be sloped toward drain ports to facilitate system drainage. Pipes containing water or hazardous heat transfer fluids shall be installed with a drainage slope of no less than 7mm per 30 cm run (1/4 inch per foot run).

Commentary: When a freeze protection system malfunctions, or during a power failure, it may be necessary to drain the system. All the fluid must be removed because frozen pockets of fluid can rupture piping. It is also necessary to remove all fluid when changing or renewing the heat transfer fluid.

6.5.16 Reserved for Future Criteria

6.5.17 Underground Piping

Underground piping subject to vehicular traffic shall be installed to withstand the additional loading applied by this traffic. The trenches and backfill shall be free of sharp objects in contact with the pipe.

6.5.18 Control Sensor Installation

Control sensors shall be protected from environmental influence such as wind, moisture, temperature or other factors which may alter their intended sensing function.

Commentary: Nearby extraneous heat flows sometimes cause sensors to give erroneous readings of system operating conditions, resulting in degraded performance or even freeze-up. Extraneous heat flows may result from solar radiation, wind, ambient temperature and thermal gradients, including thermosiphoning They may also be associated with storage tanks or hot or cold pipes. Proper placement and insulation of sensors will protect them from external heat flows.

Proper thermal contact between the sensor and the sensed medium is essential.

6.5.19 Penetrations Through Fire-Rated Assemblies

Penetrations through fire-rated assemblies etc. shall not reduce the building's fire resistance required by local codes, ordinances and applicable standards.

Commentary: It is the intent of the criterion to (1) ensure that the passage of system components through a fire-rated assembly will not adversely affect the assembly's fire endurance rating in terms of premature collapse of the structural elements and (2) ensure that these components are constructed to provide adequate safety. Because of the potential fire hazard, placement of hot pipes in areas such as walls, attics and crawl spaces may be subject to restrictions in local building codes.

6.5.20 Emergency Egress and Access

The design and installation of SWH systems shall not impair emergency movement of the building occupants.

6.5.21 Reserved for Future Criteria

6.6 Manuals

6.6.1 System Manuals

A manual or manuals shall be provided with each SWH system. The manual shall contain the name and address of the seller and the system model name or number and shall describe the operation of the system and its components and the procedures for installation, operation, and maintenance.

Manuals shall be approved by FSEC for content as described in Section 6.6 and this approval shall be indicated on the manuals as follows:

"The solar energy system described by this manual, when properly installed and maintained, meets the minimum standards established by the Florida Solar Energy Center, in accordance with Section 377.705, Florida Statutes. This certification does not imply endorsement or warranty of this product by the Florida Solar Energy Center or the state of Florida."

Commentary: This manual may consist in part of a series of instruction sheets provided by the various subsystem and component manufacturers. It may be a single manual, or installation instructions may be separate from operation and maintenance. Its size and complexity should be consistent with the need for descriptive information.

6.6.2 Installation Instructions

The manual(s) shall include an explanation of physical and functional requirements of the system and its components and the general procedures for their proper installation.

The instructions shall describe the interconnection requirement of the various subsystems and components and their interface requirements with the building and the site.

The instructions shall be available at the installation site or from normally accessible sources.

Commentary: It is not the intent of this criterion to require the provision of complete, detailed system installation specifications where those specifications would be project-specific.

6.6.3 Operation Instructions

The manual shall describe clearly the operation of the SWH system, explaining the function of each subsystem and component. The manual shall include a system diagram showing the components and their relationships in the typical installed system. Major components shall be described in a separate section or by enclosed descriptive material furnished by the manufacturer of the components.

The manual shall describe procedures for system startup, shutdown, routine maintenance, leaving the system unused for long periods, and special conditional operations such as draindown. The manual should specify temperature, pressure and flow condition expected at various access points to allow simple operational check and troubleshooting.

Commentary: One of the most common sources of malfunction is the control subsystem. These malfunctions are often a matter of adjustment rather than complete failure. Control subsystem malfunctions are not usually obvious, but system operation may be verified by feeling pipes or the pump to sense vibration and temperature differences.

6.6.4 Maintenance Plan

The manual shall include a comprehensive plan for maintaining the specified performance of the SWH system.

The plan shall include a schedule and description of procedures for ordinary and preventive maintenance.

6.6.5 Liquid Quality

Procedures shall be described for maintaining the heat transfer liquid's chemical composition at levels adequate to prevent unacceptable deposits on the heat transfer surfaces, corrosion of the surfaces with which the heat transfer liquid comes in contact, or loss of freeze resistance.

Commentary: When makeup water is of such a quality that the potential for excessive scaling or corrosion is known to exist, a suitable water treatment system is recommended.

The piping in some solar collectors and heat exchangers may have small cross sections in which blockage by dirt, scale, pieces of gasket material, packing or other foreign matter in the heat transfer fluid could occur. To aid in preventing sludge (especially in the heat exchanger when antifreeze solutions are used), the system piping should be thoroughly cleaned and flushed prior to introduction of the heat transfer liquid. Antifreeze solutions may lose their freeze protection capability due to deterioration or the addition of makeup water.

6.6.6 Service and Replacements Parts

The manual shall include a parts list giving a sufficient description of each part for ordering a replacement. Parts, components and equipment required for service, repair or replacement shall be commercially available or available from the system or subsystem manufacturer or supplier. The manual shall include the name and address of at least one company that offers service on the system.

Commentary: This criterion is intended to preclude long periods of system downtime for repair or replacement of parts.

6.6.7 Hazards

The manual shall provide warning against hazards that could arise in the operation or maintenance of the system and shall fully describe the precautions that shall be taken to avoid these hazards. The manual shall contain a clear warning if exceptionally hot water may be delivered by the system.

Commentary: Some systems contain toxic or combustible materials that could poison maintenance personnel or cause fires or explosions when repairs involving soldering or welding are involved.

Indications of hot valves and discharge points should be given. In SWH systems which have no controls to limit water temperatures, there is the potential for scalding water to be delivered to the faucets.

6.6.8 Warranty Coverage

The manual shall provide a full description of the warranty coverage on the system. In addition, the manual shall describe what actions the purchaser shall undertake to obtain warranty coverage.