FDUS 855-2

FINAL DRAFT UGANDA STANDARD

First Edition
2009-mm-dd

Thermal solar systems and components – Factory made systems – Part 2: Test methods

Reference number
FDUS 855-2: 2009

Compliance with this standard does not, of itself confer immunity from legal obligations

A Uganda Standard does not purport to include all necessary provisions of a contract. Users are responsible for its correct application

The Executive Director
Uganda National Bureau of Standards
P.O. Box 6329
Kampala
Uganda
Tel: 256 414 505995
Fax: 256 414 286 123
E-mail: unbs@infocom.co.ug
Web: www.unbs.go.ug

Contents

Page

Foreword

Uganda National Bureau of Standards (UNBS) is a parastatal under the Ministry of Tourism, Trade and Industry established under Cap 323, of the Laws of Uganda. UNBS is mandated to co-ordinate the elaboration of standards and is

(a) a member of International Organisation for Standardisation (ISO) and

(b) a contact point for the WHO/FAO Codex Alimentarius Commission on Food Standards, and

(c) the National Enquiry Point on TBT/SPS Agreements of the World Trade Organisation (WTO).

The work of preparing Uganda Standards is carried out through Technical Committees. A Technical Committee is established to deliberate on standards in a given field or area and consists of representatives of consumers, traders, academicians, manufacturers, government and other stakeholders.

Draft Uganda Standards adopted by the Technical Committee are widely circulated to stakeholders and the general public for comments. The committee reviews the comments before recommending the draft standards for approval and declaration as Uganda Standards by the National Standards Council.

Committee membership

The following organisations were represented on Subcommittee on Solar Energy, UNBS TC 13/SC 3, in the preparation of this standard:

- Renewable Energy Department, Ministry of Energy and Mineral Development
- Makerere University
- Incafex Solar Systems
- Battery Masters (U) Limited
- Equator-sun (U) Limited
- Ultratec (U) Limited
- Sonnerkraft Solar Systems
- Solar Masters
- Uganda National Plumbers Association
- Uganda Institute of Professional Engineers
- Uganda National Bureau of Standards

Thermal solar systems and components – Factory made systems – Part 2: Test methods

1 Scope

This Uganda Standard specifies test methods for validating the requirements for Factory Made Thermal Solar Heating systems as specified in DUS 855-1. The standard also includes two test methods for thermal performance characterization by means of whole system testing.

2 Normative references

The following referenced documents are indispensable for the application of this Uganda standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DUS 854-2, Thermal solar systems and components – Solar collectors – Part 2: Test methods

IEC 60335-1, Household and similar electrical appliances – Safety – Part 1: General requirements

IEC 60335-2-21, Household and similar electrical appliances – Safety – Part 2-21: Particular requirements for storage water heaters

ISO 9488, Solar energy – Vocabulary

ISO 9459-1, Solar heating – Domestic water heating systems – Part 1: Performance rating procedure using indoor test methods

ISO 9459 -2, Solar heating - Domestic water heating systems – Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems

ISO 9459-5, Solar heating – Domestic water heating systems – Part 5: System performance characterization by means of whole-system tests and computer simulation

EN 1717, Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow

3 Terms and definitions

For the purposes of this Uganda standard, the terms and definitions given in ISO 9488 and DUS 855-1 apply.

4 Symbols and abbreviations

$Q_{aux,net}$ net auxiliary energy demand of a solar heating system delivered by the auxiliary heater to the store or directly to the distribution system (see 5.8.3.2)

Q_d heat demand

Q_L energy delivered at the outlet of the solar heating system

Q_{par} parasitic energy (electricity) for the collector loop pump(s) and control unit

H_c hemispherical solar irradiation in the collector plane

Q_l Store heat loss

Q_{ohp} heat diverted from the store as active overheating protection, if any

Q_{sol} heat delivered by the collector loop to the store

5 Testing

5.1 Freeze resistance

5.1.1 General

The following checks are given to ensure that the protective antifreezing provisions are operating properly. There are many possible forms of protective provisions, and testing authority shall first identify which method has been employed.

The provision shall then be checked in accordance with appropriate section of the following list (see 5.1.2 to 5.1.6) in accordance with the manufacturer's recommendations.

5.1.2 Systems using antifreeze fluid

The system components which are exposed to low ambient temperature are filled with an antifreeze fluid, usually a glycol/water mixture, having a low enough freezing point.

For these systems, no freezing test is performed. However, if no sufficient data is available on the freezing point of the antifreeze fluid, the freezing point shall be measured and checked against the minimum system temperature as given by the manufacturer.

NOTE In general, the minimum allowed temperature of the system is equal to the freezing point of the antifreeze fluid. If the concentration of some antifreeze fluids – like glycols – exceeds a certain limit, they can freeze without damaging the system. In this case the minimum allowed temperature can be lower than the freezing point of the antifreeze fluid.

Check the freezing point by measuring the glycol concentration (e.g. using a portable refractometer). The freezing point should be as recommended by the manufacturer in agreement with local climate (minimum expected air temperature, radiative cooling of the collectors).

The composition of the fluid shall be checked to see whether it is accordance with the manufacturer's specifications.

5.1.3 Drain-back systems

The fluid in the system components, which are exposed to low ambient temperature, is drained into a storage vessel for subsequent reuse when freezing danger occurs.

The collector loop piping should be in accordance with the manufacturer's recommendation in the installer manual and if there is no instruction, according to reference conditions given in Annex B.

Filing may be observed gauge or from water level indicator. Switch the pump on, and observe the pressure gauge or water level indicator. If the system does not include a pressure gauge or level indicator, other means for checking filing provided by the manufacturer shall be used in accordance with the instruction manual.

Drain-back may be observed from the decreasing reading of the pressure gauge or water level indicator. Switch the pump OFF, and observe the pressure gauge or water level indicator. If the system does not include a pressure gauge or level indicator, other means for checking drain-back provided by the manufacturer shall be used in accordance with the instruction manual. It might be necessary to repeat the check at high storage temperature (90 ^{o}C) in order to insure drain-back in all situations (see 5.2).

5.1.4 Drain-down systems

The fluid in the system components, which are exposed to low ambient temperature, is drained and run to waste when freezing danger occurs.

Check the proper opening and closing of the vacuum relief valve.

If there is a solenoid drain valve independent of the control unit, simulate the opening temperature.

If there is a non-electrically operated freeze-protection valve, a check can be made using a freezing spray. The temperature-sensing element shall be sprayed. The measured temperature of the valve opening is to be compared with the nominal value given by the manufacturer. It is important that the sensing part of the freeze-protection valve be properly placed.

The collector loop piping should be in accordance with the manufacturer's recommendations in the installer manual and if there is no instruction, according to reference conditions given in Annex B.

Open drain-down valve manually and measure the drain rate with vessel and a stop-watch.

If the system uses an electrically operated freeze-protection valve, drain down shall be checked while interrupting the power.

5.1.5 Freeze protection and control functions combined

For systems where the freeze-protection and control functions are combined, the control unit shall be checked as follows:

Set the simulated temperature of the freeze-protection sensor to a value deactivating the freeze protection. Decrease the simulated temperature slowly. Measure the temperature $T_{\text{FP (freeze-protection)}}$ of the related actuator. Compare it with the nominal value given by the manufacturer.

5.1.6 Other systems

For all other systems, the pump control system, drain-down valve or any other freeze protection device or system shall be checked to the manufacturer's specification and the minimum allowed temperature specified by the manufacturer. For ICS systems, or other SDHW systems with the tank placed outside, special frost resistance test should be carried out, as described in C.1.

5.2 Over temperature protection

5.2.1 Purpose

The purpose of this test is to determine whether the solar water heating system is protected against damage and the user is protected from scalding hot water delivery after a period of no hot water draw and failure of electrical power.

5.2.2 Apparatus

The following apparatus is required:

a) A pyranometer having the minimum characteristics specified in DUS 854-2, to measure the hemispherical solar irradiance, or the short wave irradiance form a solar simulator lamp if the test is to be conducted inside a solar simulator chamber.

b) Equipment to measure the temperature, flow rate and volume of hot water drawn from the system.

c) An outdoor or an indoor test stand for installing the solar hot water system with the collector array at the manufacturer's specified angle of inclination.

d) A temperature and pressure controlled water supply within the range of 5 ^{o}C to 25 ^{o}C and 200 kPa to 600 kPa or the manufacturer's maximum working pressure whichever is less.

This test may be conducted using a solar simulator or outdoors.

5.2.3 Procedure

The system, both as described in the installation manual and as installed on the test facility, shall be first checked on overheating safety, e.g. if safety valves and other overheating protection devices are present and installed at the right place, if there are no valves between components and relief valves etc. For systems containing antifreeze fluids, it shall be checked whether sufficient precautions have been taken to prevent the antifreeze fluid from deterioration as a result of high temperature conditions (see also 5.6)

Furthermore, if non-metallic materials are used in any circuit, the highest temperature in the circuit shall be measured during the overheating temperature protection test, for use in the pressure resistance test.

The procedure of testing shall be as follows:

a) Assemble the solar water heating system according to the installation instructions with the collector array oriented towards solar noon for the outdoor test, or the simulator lamp may be adjusted to normal incidence for the indoor test.

b) Charge the system from the water supply and, for pressurized storage tanks, maintain the water supply pressure.

c) Energize the system as per installation instructions.

d) (i) For the outdoor test, operate the system for a minimum of 4 consecutive days without any hot water withdrawal and until the collector array has been subjected to 2 consecutive days in which the solar, temperature on the plane of the collector array has exceeded 20MJ/m^2 per day and the ambient temperature has exceeded 20 ^{o}C during solar noon.

(ii) For the indoor test, operate the system without any hit water withdrawal at an ambient temperature of (25 ± 2) ^{o}C and a minimum solar lamp irradiance of 1000 W/m^2 at the plane of the collector array, measured and with uniformity as specified in ISO 9459-1, 6.3.1.2 for a 5 h period or until the collector array drains.

e) (i) For the outdoor test, disconnect all electrical power to the system and continue to operate the system until the solar irradiation on the plane of the collector array has exceeded 20 MJ/m^2 per day or until the collector array drains.

(ii) For the indoor test, disconnect all electrical power to the system and subject the system to a solar lamp irradiance of 1000 W/m2 at the plane of the collector array for an addition 4 h or until the collector array drains.

f) Immediately begin to withdraw a volume of water greater than the total volume of water in the system at a rate of 2 x 10^{-4} ± 3 x 10^{-5} m^3/s (10 ± 1 L/min)

5.2.4 Reporting requirements

The following results shall be reported:

a) The make and model identification of the system including ancillary scald and over temperature protection devices fitted.

b) The inclination of the collector array.

c) A record of temperature of the hot water withdrawn from the system versus time and the total volume of water withdrawn. Note the presence of stem if observed.

d) Details of the condition of the system and individual components following the test or any failure modes during the test with particular regard to any defects which may affect the serviceability of the system such as the swelling of pipes and components or fluid leakages.

5.3 Pressure resistance

5.3.1 Purpose

The purpose of this test is to evaluate hydraulic pressure rating of all components and interconnections of a solar water heating system when installed according to the manufacturer's instructions.

5.3.2 Apparatus

The apparatus shall consist of the following:

a) suitable platform and support structure for installation of the system

b) pressure regulated hydraulic pressure source

c) pressure gauge suitable to determine the test pressure to within 5 %

d) bleed valve

e) isolation valve

5.3.3 Safety precaution

An explosion safe enclosure is recommended when testing systems that have an integral expansion space or tank that contains entrapped air.

5.3.4 Procedure

The system, both as described in the installation manual and as installed on the test facility, shall be first checked on pressure safety, e.g. if safety valves and other overheating protection devices are present and installed at the right place, if there are no valves between components and relief valves etc.

The duration of the test is 15 min for metallic material. If a non-metallic material is used in any circuit, this circuit shall be pressure tested for 1 h at the highest temperature measured during the over temperature protection test +10 ^{o}C.

a) Install the solar water heating system on the test platform in accordance with the manufacturer's instructions.

b) Disable the pressure relief valves, if applicable, to prevent their opening during testing.

c) Connect the pressure gauge and bleed valve at the hot water outlet of the system.

d) Connect the isolation valve and hydraulic pressure source, using water as the test fluid, to the cold water inlet of the system.

e) Fill the potable water side of the system using the hydraulic pressure source and bleed all air, as possible, out of the system through the bleed valve at the hot water outlet of the system.

f) Apply a hydraulic pressure equal to 1.5 times the manufacturer's stated maximum working pressure.

g) Isolate the pressure source by closing the isolation valve and record the readings of the pressure gauge at the beginning and end of the next 15 min interval.

h) Release the system pressure through the bleed valve and record any visible permanent deformation and water leakage from system components and inter connections.

i) Disconnect the bleed valve, pressure gauge, isolation valve and hydraulic pressure source from the system.

For those systems not constructed with a heat exchanger and a separate pressurized heat transfer loop, the following procedural steps are to be omitted.

j) Connect the bleed valve and pressure gauge to the drain port of the system's heat transfer loop and connect the isolation valve and hydraulic pressure source, using the manufacturer's stated heat transfer fluid, to the fill port of the heat transfer loop.

k) Fill the heat transfer loop of the system using the hydraulic pressure source and bleed all air, as possible, out of the loop through the bleed valve at the drain part of the top of the collector array.

l) Apply a hydraulic pressure equal to 1.5 times the manufacturer's stated maximum individual working pressures.

m) Isolate the pressure source by closing the isolation valve and record the readings of the pressure gauge at the beginning and end of the next 15 min interval.

n) Release the system pressure through the bleed valve and record any visible permanent deformation and heat transferor fluid leakage from system components and interconnections.

5.3.5 Reporting requirements

Report the maximum test pressures applied, the pressure readings at the beginning and end of the 15 min

Test intervals and any visible permanent deformation or leakage from system components and interconnections. Note if the applied test pressures are lower than 1.5 times the manufacturer's stated maximum working pressure.

5.4 Water contamination

See EN 1717.

5.5 Lightning protection

Annexes E and F give information to assist manufacturers in meeting the requirements given in IEC 61024-1.

5.6 Safety equipment

5.6.1 Safety valves

Check the system documentation to verify that each collector circuit or group of collector circuits is fitted with at least one safety valve.

Check the specification of the safety valves, whether the materials conform to requirements given in 4.4.1 of DUS 855-1.

Check whether the size of the safety valve is correct in conformity with requirements given in 4.4.1 of DUS 855-1.

Check whether the temperature of the heat transfer medium at the release pressure of the safety valve exceeds the maximum allowed temperature of the heat transfer medium.

To check the applicability of the specified maintenance frequency of a thermostatic valve, the ageing test for thermostatic valves should be carried out, as described in Annex D.

5.6.2 Safety lines and expansion lines

Check the hydraulic scheme and system documentation to verify that safety and expansion lines, if any, cannot be shut-off.

Check the internal diameter of the expansion line, if any, with respect to the requirements given in 4.4.2 of DUS 855-1

Check the system documentation to verify that the expansion line and the safety line, if any, are connected and laid in such a way that any accumulation of dirt, scale or similar impurities are avoided.

5.6.3 Blow-off lines

Check the hydraulic scheme and system documentation to verify that the blow-off lines, if any, conform to requirements given in 4.4.3 of DUS 855-1

5.7 Labelling

Check the marking plate or Label of the solar heating system and examine if all items of the labelling list are completed (as specified in 4.7 of DUS 855-1)

5.8 Thermal performance characterization

5.8.1 Introduction

In this clause the methods for performance testing are described. The thermal performance of the system shall be characterized as described in 5.8.2 and presented as specified in 5.8.3.

NOTE The performance of a solar heating system depends on the individual installation and actual boundary conditions. With regard to the heat losses of the store besides deficits in the thermal insulation, badly designed connections can increase the heat loss capacity rate of the store due to natural convection that occurs internally in the pipe. In order to avoid this effect the connections of the pipes should be designed in such a way that no natural convention inside the pipe occurs. This can e.g. be achieved if the pipe is directly going downwards after leaving the store or by using a siphon.

5.8.2 Test procedure

One of the following test methods shall be used, as described in Table 2.

a) Test method in accordance with ISO 9459-2. This test method maybe applied on “solar only” or “preheat systems”.

b) Test method in accordance with ISO 9459-5. this test method may be applied on all types of systems

Table 2 – Selection of the performance test method

Test method	Solar-plus-supplementary systems *)	Solar-only and preheat systems
ISO 9459-2 (CSTG)	No	Yes
ISO 9459-5 (DST)	Yes	Yes

NOTE1. Some systems have allowances for variations in the installation instructions that may affect the performance of the systems. In cases where the circumstances are not uniquely defined by the Reference Conditions given in Annex B, the most unfavourable conditions should be chosen for testing and reporting of the system performance. For example, systems without forced circulation should be tested with the lowest position of the storage above the collector and the longest pipe length between collector and storage specified by the manufacturer.

NOTE2. In October 1999, the EU-SMT project team "Bridging the Gap" reported on the comparability between CSTG (ISO 9459-2) and DST (ISO 9459-5) and conversion factors were successfully established. The relation between the performance predictions of both test methods is given by:

$$Q_{DST} = (a \pm \sigma_a) Q_{CSTG}$$

The 'a-values' are represented in Table 3:

Table 3 – Parameter a values for different load volumes

Type of system	Condition	α	σ_a
Forced circulation	$V_{load} \geq V_{store}$ [a]	1.004	0.004
Thermosyphon system	All V^{load}	1.056	0.004
ICS system	All V_{load}	1.037	0.003
[a] In case $V_{load} < V_{store}$ (forced circulation systems), the determined 'a-values' are higher. This indicates a stronger tendency for overestimation of the DST test method.			

5.8.3 Prediction of yearly performance indicators

5.8.3.1 General

NOTE In the following, performance indicators for solar heating systems for hot water preparation only are specified. The text of these paragraphs is identical for this standard and for Custom Built Systems (DUS…-2). Performance Indicators for space heating systems are presently excluded, since there is not yet enough experience available. This is a preliminary step for the standardisation of this procedure. After enough experience has been gained, also the performance indicators for space heating systems will be elaborated.

Uniform reference conditions for the calculation of the performance are specified in the identical Annex B of this standard derived from the performance test results:

For "solar-plus-supplementary systems"

a) the net auxiliary energy demand $Q_{aux,net}$

b) parasitic energy Q_{par}

For "solar-only" and "preheat systems"

c) the heat delivered by the solar heating system Q_L

d) the solar fraction f_{sol}

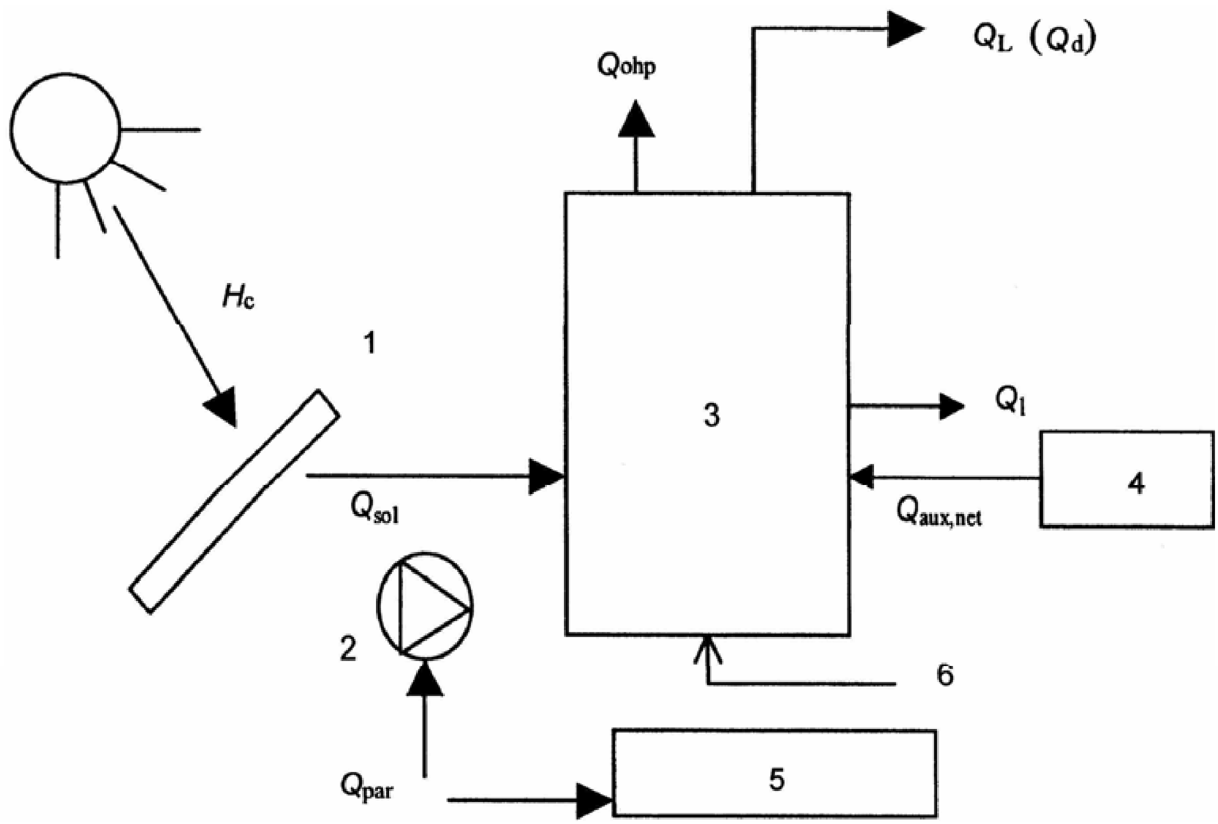
e) the parasitic energy, Q_{par} if any

5.8.3.2 Calculation of the net auxiliary energy demand for solar-plus-supplementary systems

Calculate the yearly net auxiliary energy demand $Q_{aux,net}$ directly by computer simulation (long term performance prediction) as specified in 5.8.2 of this standard (for Factory Made systems) or 7.5.1 of DUS 857-2 (for Custom Built Systems). Additional indication on the quantities entering the energy balance of a one-store solar-plus-supplementary heating system may be found in Figure 1.

If a solar-plus-supplementary system cannot meet the heat demand to such a degree that the energy delivered to the user is less than 90% of the yearly heat demand, this shall be in the test report.

NOTE The energy delivered to the user can be less than the heat demand for example when the power of the auxiliary heater is not sufficient or when strong mixing occurs in the store during draw-offs.



Key
1 Collector
2 Pump
3 Store
4 Auxiliary heater
5 Control unit
6 Cold water

Figure 1 – Energy balance for one-store solar-plus-supplementary systems (example)

5.8.3.3 Calculation of the solar fraction for solar-only and preheat systems

Compute the system energy balance on a yearly basis. This includes the following energy quantities (see Figure 2 and Figure 3), calculated using the reference data and conditions given in Annex B of this standard or Annex A of DUS 857-2.

Q_d heat demand;

Q_L heat delivered by the solar heating system (load)

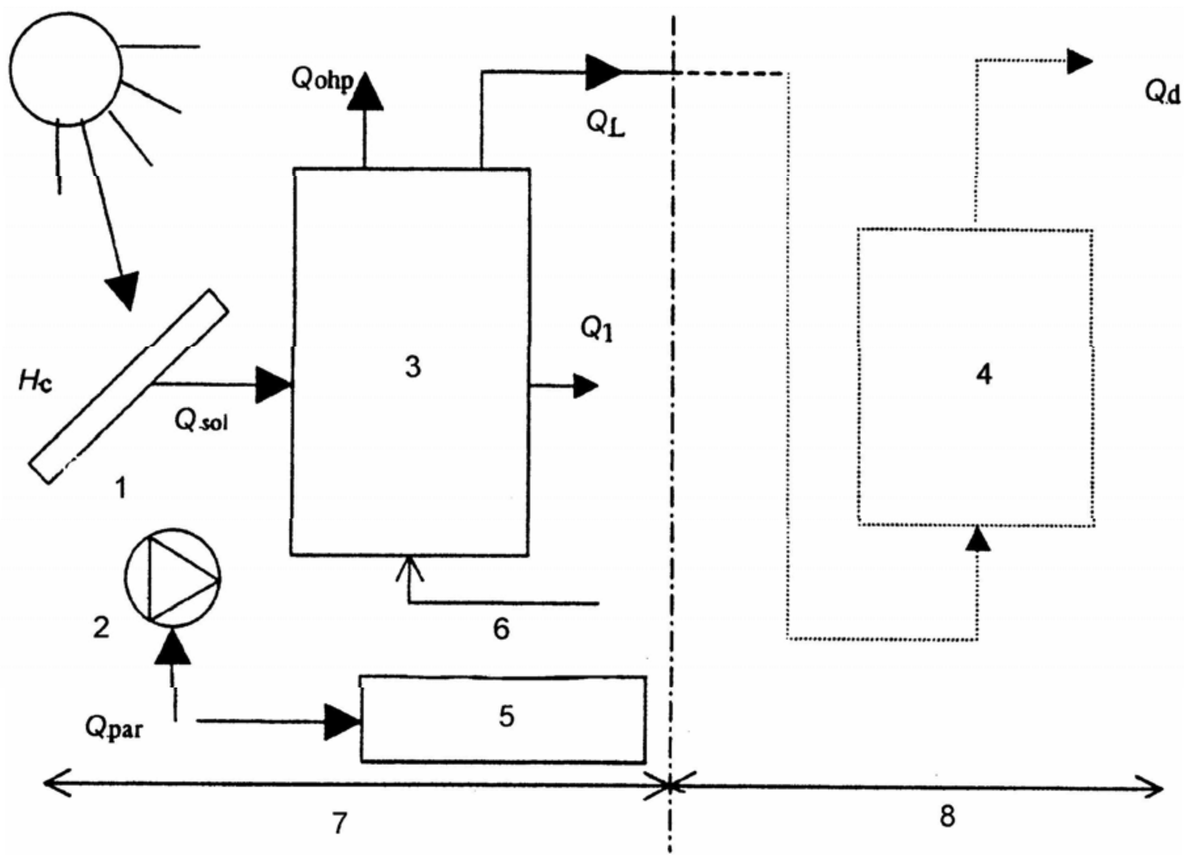
Q_{par} parasitic energy (electricity) for pump and controls

The parasitic energy Q_{par} shall be calculated according to 5.8.3.4.

NOTE 1 The reference locations for calculating the load Q_L are the store ports or the load-side heat exchanger ports, if provided. The reference temperature for calculating the loads is the cold water temperature. Heat losses of the circulation line are not included in the loads.

NOTE 2 According to ISO 9488, a solar preheat system is a solar system to preheat water or air prior to its entry into any other type of water or air heater. This water or air heater is not part of the solar preheat system itself. Hence, for this type of the system the energy delivered by the solar heating system Q_L is calculated at the outlet of the solar heating system and the store heat loss Q_l is the heat loss of the solar store itself (see Figure 3)

NOTE 3 The yearly heat demand is calculated using the load volume, cold water temperature and the desired temperature as specified in Annex B.



Key
1 Collector
2 Pump
3 Solar store
4 Auxiliary heater
5 Control unit
6 Cold water
7 Solar preheat system
8 Series connected auxiliary heating system

Figure 3 - Energy balance for solar preheat systems

Calculate the solar fraction, f_{sol} by using the definition of ISO 9488.

Solar fraction f_{sol}: The energy supplied by the solar part of a system divided by the total system load (Q_d = heat demand).

$$f_{sol} = Q_L / Q_d$$

5.8.3.4 Calculation of the parasitic energy

Calculate the yearly parasitic energy needed by pumps, controllers etc, in conformity with 4.6.3 h) 3) of DUS 855-1-general

5.8.3.5 Presentation of performance indicators

The results from 5.8.3.2 to 5.8.3.4 shall be presented for the load volume(s) as specified in Annex B or Annex A of DUS 857-2. For Factory Made Systems, the reporting form given in Annex A shall be used, for Custom Built systems the table given in 7.6 of DUS 857-2 shall be used.

5.9 Ability of solar-plus-supplementary systems to cover the load

5.9.1 General

The test described in this clause shall be carried out in order to ensure that the solar-plus-supplementary system is able to cover the maximum daily load without solar contribution. If recommended by the manufacturer, this test can be performed for a daily load higher than the maximum daily load related to the reported performance prediction (5.9.3). if the system fails to cover the maximum daily load, this shall be stated in the test report together with the results of the performance prediction related to this maximum daily load. The test shall be repeated for a lower maximum daily load.

The ability of the system to cover the maximum daily load shall be determined for the boundary conditions given in 5.9.2 and 5.9.3.

For systems with auxiliary heater, which are tested in accordance with the test method given in ISO 9459-5 (see 5.9.2), the ability of the system to cover the maximum daily load without solar contribution shall be determined either by the test described in 5.9.4 or by means of numerical simulations as described in 5.9.5.

5.9.2 Boundary conditions for auxiliary heating

The auxiliary heater shall be mounted and operated during the test in accordance with the settings in Annex B for the yearly performance prediction.

In the case of an emergency heater the apparatus shall be made fully operational in accordance with the manufacturers specifications.

When several types of heating devices can be installed, the heating device with a heating power fitted for the maximum “daily load volume” shall be used. The manufacturer shall in this case select the appropriate type of heating device.

For systems with auxiliary heating by means of heated water (e.g. directly or with an immersed heat exchanger inside the store) the “flowrate through auxiliary heat exchanger’ shall be stated in Table B.1.

The following specifications shall be reported:

- the control setting for the temperature of the integrated auxiliary heater;
- the type of control, if available the serial number of the device and if applicable the setting of the hysteresis;
- the power of the electrical auxiliary heating element or thermal power delivered to the store as applicable;
- if applicable the flowrate through the heating device.

5.9.3 Boundary conditions for daily load

The “maximum daily load conditions” are characterized by:

- volume, as being the highest daily load volume for which the yearly performance is reported (Table B.1);

- flowrate, in accordance with Table B.1;

- cold water temperature, in accordance with the lowest value in table B.4.

if the cold water inlet temperature during the test in accordance with 5.9.4 differs from the minimum cold water inlet temperature in accordance with Table B.4, the draw-off flow rate shall be adjusted in order to perform a discharge with the same power as calculated with the defined settings.

One “daily load cycle” consists of the following draw-offs based on the cold water temperature (the cycle starts at t_o):

- at $t = (t_o + 12)$h withdraw of 40% of the daily load volume;

- at $t = (t_o + 17)$h withdraw of 40% of the daily load volume;

- at $t = (t_o + 22)$h withdraw of 40% of the daily load volume;

If repeated tests are necessary the cycle starts again at 24 h after the last t_o

NOTE Some kinds of stores with an integrated domestic hot water heat exchanger where the flow inside the store depends on certain thermosiphonic effects sometimes require a certain temperature in the lower part of the store in order to reach their full performance with respect to hot water preparation. In this case it is recommended to repeat the daily load several times.

5.9.4 Determination of the ability to cover the maximum daily load by means of testing the system

The system shall be mounted, fully operational, but with:

- the collector circuit disabled or the collector covered in such a way that there is no contribution from the solar collector to the store;
- the mixing valve installed, and set as described in the product specifications, only if it is an integral part of the system. At the beginning of the test at least three store volumes shall be withdrawn while the auxiliary is disabled.

After this initial conditioning ($t = t_0$) the auxiliary heating is set into operation. Discharges in accordance with the daily load cycle as described in 5.9.3 shall be performed.

During each draw off the temperature of the hot water drawn from the store and the thermal power discharged form the store shall be measured and recorded.

The test with duration of one daily load cycle is considered as valid, if during 95% of the draw-off time the hot water temperature does not drop below 45 ^{o}C.

5.9.5 Determination of the ability to cover the maximum daily load by means of numerical simulations

For the determination of the ability to cover the maximum daily load by means of numerical simulations the model given in ISO 9495-5, with the boundary conditions described in 5.9.2 and 5.9.3 shall be used.

The calculation procedure for the determination of the ability to cover the maximum daily load (without solar contribution) by means of numerical simulations is in principle similar to the test procedure described in 5.9.4.

During the calculation process the solar irradiation shall be set to zero.

The power for the heating element used in the DST-model shall be determined as the mean value of the measured power delivered to the store during the first heating up of the auxiliary part within the test sequence S_{aux}. The test with duration of one daily load cycle is considered as valid, if during 95 % of the draw-off time the hot water temperature does not drop below 45 ^{o}C.

5.10 Reverse flow protection

Visual inspection shall be performed on the existence of a check valve or other provisions.

5.11 Electrical safety

If the system contains any electrical device, these shall be tested in accordance with IEC 60335-1 and IEC 60335-2-21.

Annex A
(normative)

Thermal performance presentation sheet

Name and type	:…………………….Factory Made/Custom Built System[a]
Derived from test report	:
By test institute	:
This table filled in by	:
Date	:
Test method used	: Factory made systems ISO 9449–5[a]
	: Custom Built System: DUS …..-2[a]
Integrated auxiliary heater	: Electric / Indirect /Direct Gas / None / Other.

NOTE. In case of solar heating systems with emergency heaters, instructions should be issued that this emergency heater shall only be used for emergency heater purposes.

[a] Select appropriate option

Figure A.1 – Thermal performance presentation sheet

Table A.1 – Presentation of the system performance indicators for solar-plus-supplementary systems

Performance indicators for solar-plus-supplementary systems on annual base for a demand volume of …..Ld^{-1}			
Location (latitude)	Q_d MJ	$Q_{aux,net}$ MJ	Q_{par} MJ
Stockholm (59.6 ^{o}N)	-		
Wurzburg (49.5 ^{o}N)	-		
Davos (46.8 ^{o}N)	-		
Athens (38.0 ^{o}N)	-		
a -			

[a] For a location free to choose

Table A.1 – Presentation of the system performance indicators for solar-only and solar preheat systems

Performance indicators for solar-only and solar preheat systems on annual base for a demand volume of …..Ld^{-1}				
Location (latitude)	Q_d MJ	Q_L MJ	f_{sol} %	Q_{par} MJ
Stockholm (59.6 ^{o}N)	-			
Wurzburg (49.5 ^{o}N)	-			
Davos (46.8 ^{o}N)	-			
Athens (38.0 ^{o}N)	-			
a -				
[a] For a location free to choose				

Annex B
(normative)

Reference conditions for performance prediction

B.1 General

The conditions given in Table B.1 shall be used when calculating, reporting or comparing the performance of a system, either from a test or from a computer simulation. These conditions should also be applied to the system during any system performance test, if not specified otherwise.

NOTE Except the specification in respect of the status of the auxiliary heater for solar-plus-supplementary systems (see Table A.1 in DUS 857-2), the following reference conditions are identical for testing and simulating of Factory Made Systems in this standard and Custom Built Systems in DUS 857-2.

For systems tested according to ISO 9459-2, the Long Term Performance Prediction, will be in agreement with the reference conditions of this annex provided that the following changes in the calculation procedure are implemented:

Changes in Clause 9 of ISO 9459-2:1995 (pages 21, 22, 23 and 24), step 3 (Energy drawn off):

Calculations for Day 1:

Q_c (1) is calculated according to:

$$Q_c(1) = Q(1)\int_0^{v'} f(V)dV$$

where V' is determined by two conditions:

$Q_c(1) \leq V_{load}\rho_w C_{pw}(t_{load} - t_{main})$ and $V' \geq V_{load}$

Calculations for Day 2 and subsequent days:

Q_c (2:part 1) is calculated according to:

$$Qc(2 : part1) = Q(2 : part1)\int_0^{v} f(V)dV$$

And Q_c(2 :part 2) is calculated according to :

$$Qc(2 : part2) = Q(2 : part1)\int_0^{v'} g(V)dV$$

The value V' is determined when the total energy extracted is calculated according to:

$Q_c(2) = Q_c(2\text{:part1}) + Q_c(2\text{:part 2}) \leq V_{load}\rho_w C_{pw}(t_{load} - t_{main})$ and $V' \leq V_{load}$

The calculations done according to this procedure give lower values than with one load volume extracted everyday, but will give higher values than will the consideration of a minimum load temperature.

Table B.1 – Reference conditions for performance presentation

Reference condition	**Value**	**Remarks**
SYSTEM		
Collector orientation	South	
Collector Tilt Angle	45 ^{o}	For testing, $(45 \pm 5)^{o}$ if not fixed for the system or specified by the manufacturer.
Total length of collector circuit	20m (10m + 10m)	If piping is not delivered with the system or specified by the manufacturer.
Pipe diameter and insulation thickness of collector circuit	See B.2	If piping is not delivered with the system or specified by the manufacturer.
Location of collector circuit pipes	Indoor, for systems with store situated indoors; outdoors, for systems with store situated outdoors	As far as possible at the test rig
Store ambient temperature	15 ^{o}C	For systems where the store is located outside, the ambient temperature from the climate data shall be used.
For systems with indirect (hydraulic) auxiliary heating: Power to be applied on auxiliary heat exchanger	(100 ± 30)W per litre of store volume above the lowest end of heat exchanger	If the auxiliary heater is not delivered with the system and no restrictions have been given in the documentation. The auxiliary heater shall be modeled as an ideal heat source with no heat capacity and constant heating power.
Flowrate through auxiliary heat exchanger	The flowrate through the heat exchanger shall be chosen such that the temperature difference between the inlet and outlet of the auxiliary heat exchanger is (10 ± 2) K under steady state conditions, unless specifies otherwise by the manufacturer.	
For systems with electrical auxiliary heating: Power of electrical element	If an electrical element is normally delivered with system or specified by the manufacturer, this element shall be used. Otherwise, (25 ± 8) W per litre of store volume above the electrical element.	
Temperature of integrated auxiliary heating	52.5 ^{o}C (minimum temperature of hysteresis)	Or a higher temperature, if recommended by the manufacturer
CLIMATE		
Reference locations	Stockholm, Wirzburg, Davos, Athens	
Climate Data	For Stockholm: CEC Test Reference Year, for Davos, Wirzburg and Athens: Test Reference specified in the test procedure.	
HEAT LOAD		
Daily load pattern	For all systems: 100 % at 6h after solar noon For testing, the load patterns shall be as specified in the test procedure.	
Cold water supply temperature	See B.3	For testing, the temperature shall be specified in the test procedure
Desired (mixing valve) temperature	45 ^{o}C	If the daily or yearly loads are calculated I terms of energy, this energy shall be calculated using the cold water supply temperature and the desired temperature.
Daily load volume	The load volumes in litres per day shall be chosen from the following series: 50 l/d, 80 l/d, 110 l/d, 140 l/d, 170 l/d, 200 l/d, 250 l/d, 300 l/d, 400 l/d, 600 l/d. if larger loads are required, the series may be extended by repeatedly multiplying by V2 and rounding to the nearest multiple of 10. the manufacturer shall give a design load for the system. The nearest value given in the above series shall be used, as well as the next lower and higher values. It is recommended to use all lower and higher values from the series, which lie between 0.5 times and 1.5 times the design load. NOTE Fixed load volumes have been chosen to facilitate comparison of the performance of different systems. For testing, the load volumes as specified in the test procedures shall be used.	

Draw – off flow rate	101/min	If the maximal design draw-off flow rate of the system is less than 10 l/min, the maximum design draw-off rate of the system shall be used.

B.2 Pipe diameter and insulation thickness

If the pipe and insulation for the collector circuit are delivered with the system, or the pipe diameter and the insulation thickness to be used for the collector circuit are clearly specified in the insulation manual for the system, the delivered hardware or the specified values shall be used.

When piping and insulation are not delivered with the system or clearly specified, the pipe diameter, thickness and insulation thickness given in table B.1 shall be used for thermosiphon systems.

The material for the collector circuit piping shall be copper, unless specified otherwise in the installation manual.

B.3 Calculation of cold water temperature at reference location

The cold water temperature shall be calculated in accordance with:

$$\vartheta_{cw} = \vartheta_{average} + \Delta\vartheta_{amplit} \, \mathrm{Sin}\,(2\pi([\mathrm{Day}] - D_s) / 365)$$

where

ϑ_{cw} is the cold water temperature to be used for performance presentation

$\vartheta_{average}$ is the yearly average cold water temperature on reference location

$\Delta\vartheta_{amplit}$ is the average amplitude of seasonal variations on reference location

[Day] is the day number of the year

D_s is Shift term

The yearly average cod water temperature, average amplitude of seasonal cold water temperature variations and shift term given in Table B.4 shall be used for reference locations.

Table B.2 – Pipe diameter and insulation thickness for forced- circulation systems

Flow rate in collector circuit l/h	External pipe diameter mm	Pipe thickness mm	Thickness of one layer insulation [1] mm
<90	10 ±1	1	20 ± 2
≥90 and ≤140	12±1	1	20 ± 2
≥140and ≤ 235	15±1	1	20 ± 2
≥235 and ≤ 405	18 ±1	1	20 ± 2
≥405 and ≤ 565	22 ±1	1	20 ± 2
≥565 and ≤880	28±1	1.5	30 ± 2
≥ 880 and ≤ 1445	35 ±1	1.5	30 ± 2
≥1445 and ≤ 1500	42 ± 1	1.5	39 ± 2
>1500	Such that the flow velocity is approximately 0.5 m/s	1.5	Same as internal pipe diameter
[1] based on a thermal conductivity of 0.04 W/mK ± 0.01 for temperature of 10 °C			

Table B.3 – Pipe diameter and insulation thickness for thermosiphon systems

Collector array aperture area m^2	External pipe diameter mm	Pipe thickness mm	Thickness of one layer insulation mm
≥1 and < 2	15 ± 1	1	20 ± 2
≥2and < 6	18± 1	1.5	30 ± 2
≥6and < 10	22 ± 1	1.5	39 ± 2
[1] Based on a thermal conductivity of 0.04 W/mK ± 0.01 for temperature of 10 ^{o}C			

Table B.4 – Data for calculation of the cold water temperature at the reference locations

Reference location	$\vartheta_{average}$ oC	$\Delta\vartheta_{amplit}$ oC	D_s d
Stockholm	8.5	6.4	137
Wurzburg	10.0	3.0	137
Davos	5.4	0.8	137
Athens	17.8	7.4	137

Annex C
(informative)

Extreme climate test procedure for the assessment of the frost resistance of solar DHW systems with outdoor tank

C.1 Indoor test procedure for assessment of the frost resistance of solar DWH systems with outdoor tank

C.1.1 Objective and applicability

The purpose of this test is to determine whether extreme frost conditions for a certain climate region will damage a solar domestic hot water (DHW) system or influence the proper functioning of such a system.

The test is applicable to ICS systems and other solar DHW systems with the storage tank place outdoors, and takes into account the connecting piping and freeze protection device(s). it is suited for systems with or without active freeze protection devices (like a small internal heater).

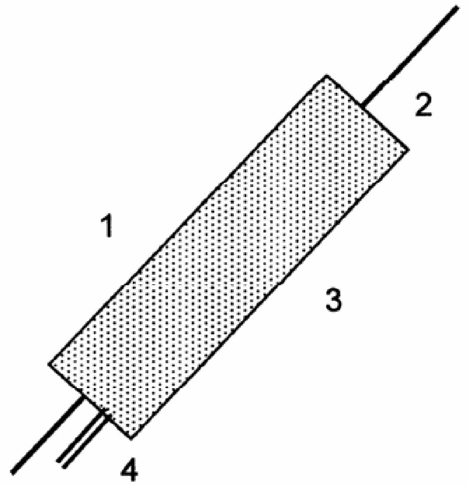
C.1.2 Apparatus and mounting of the system

The solar DHW system is mounted in a climate chamber which is large enough to contain the complex system and the necessary mounting construction, and which is capable of generating the necessary test conditions with regard to temperature, wind speed and irradiation. The lamps to provide irradiation do not need to have a spectrum similar to the solar spectrum, however appropriate measures should be taken to avoid excessive infrared radiation to the solar DHW system (for instance, a transparent screen between the lamps and the solar DHW system which absorbs infrared radiation and which is cooled by a fan). Installation should be similar to realistic conditions, taking into account the most severe conditions that are allowed in the installation manual.

The system should be mounted in accordance with the installation instruction. Special attention should be given to the following points:

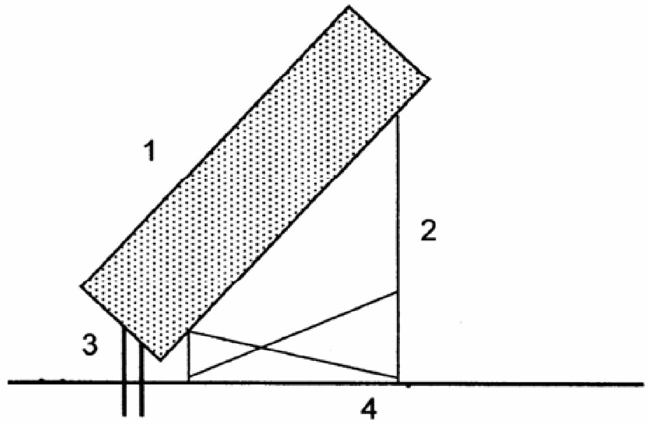
- the mounting and installation of the piping into and from solar DHW system, including check valve and any freeze protection measures.
- Any freeze protection measures required in the installation manual
- The way the solar DHW system is mounted on the roof.

If installation instruction allow the system to be mounted on a flat roof, or otherwise in such a way that no thermal contact with the indoor climate is established, the system should be mounted in such a way that all components are exposed to the cold air temperature in the climate chamber as much as allowed. If however, in accordance with the installation instruction, the system may only be integrated into the roof or otherwise being in contact with the indoor ambient air temperature, the system should accordingly be mounted on a test roof. The test roof should be placed at the lowest tilt angle allowed in the installation instruction. Figures C.1 to C.4 give some examples of mounting, while Figure C.5 gives an overview of the test chamber.



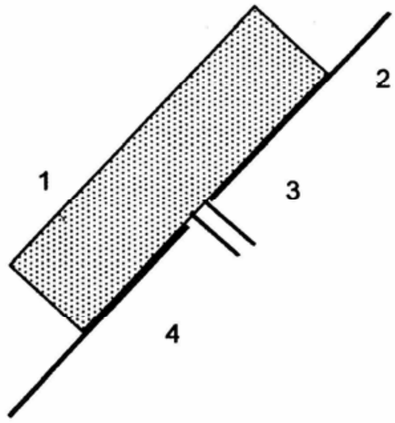
Key
1 SDHW system
2 Titled roof
3 Indoor (Attic) temperature ϑ_1
4 DHW pipes

Figure C.1 — Solar DHW system mounted in a tilted roof



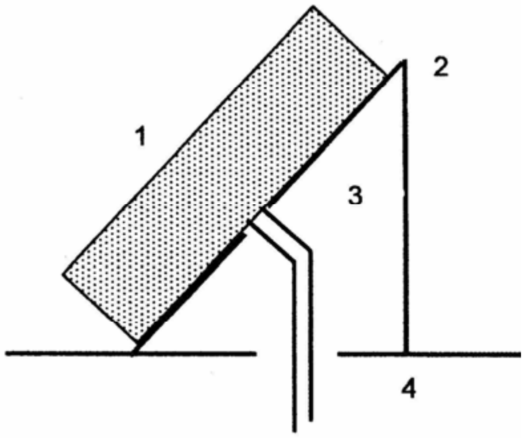
Key
1 SDHW system
2 Flat roof support
3 DHW pipes
4 Flat roof

Figure C.2 – Solar DHW system mounted on a flat



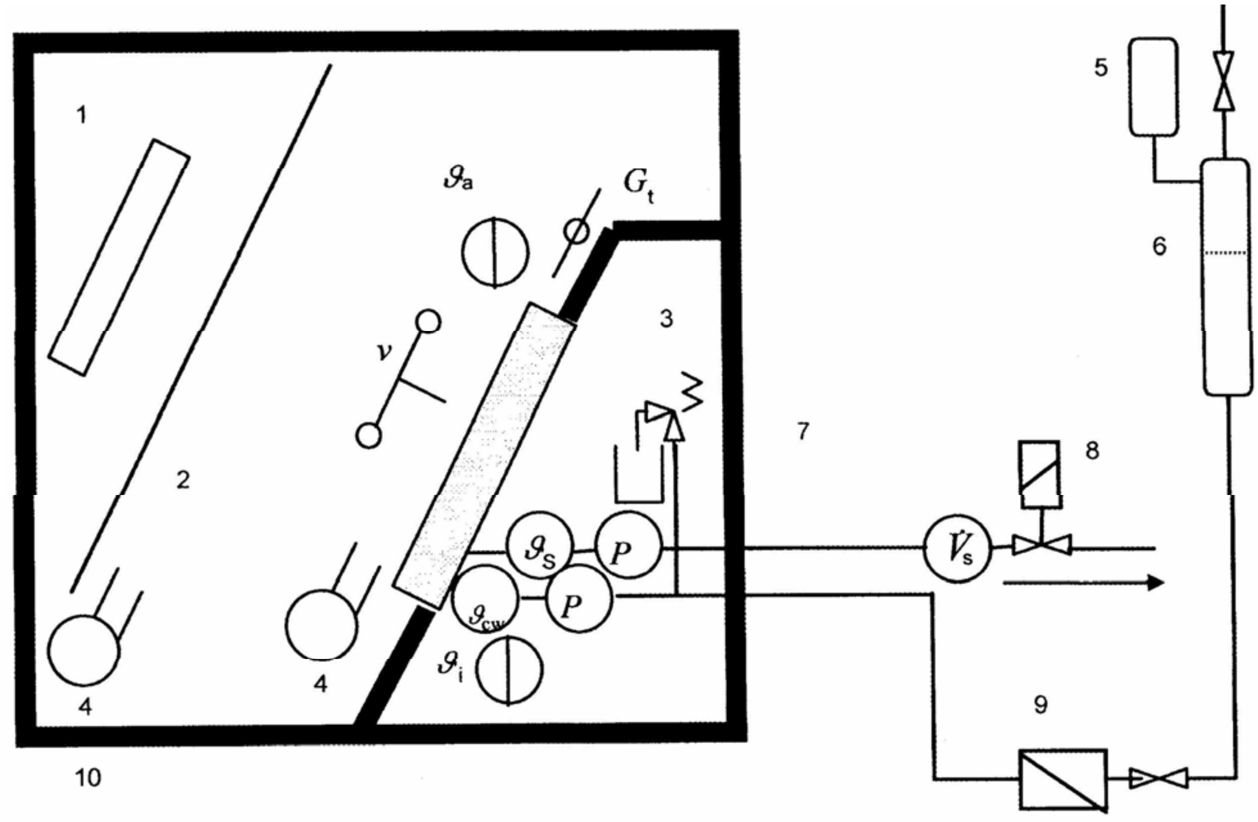
Key
1 SDHW system
2 Titled roof
3 DHW pipes through roof opening
4 Indoor (Attic) temperature ϑi

Figure C.3 — Solar DHW system mounted on a tilted roof with thermal contact to indoor ambient air



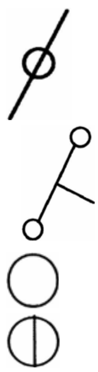
Key
1 SDHW system
2 Closed extension to flat roof
3 Indoor (Attic) temperature ϑi
4 DHW pipes through roof opening

Figure C.4 – Solar DHW system mounted on a tilted extension of a flat roof with thermal contact to indoor ambient air



Key

1 Light source
2 Infrared absorption screen
3 SDHW system
4 Fan
5 Expansion tank
6 Transparent mains water tank enables detection of small flows
7 Safety valve (installed ace. to installers instructions)
8 Draw-off valve
9 Check valve
10 Insulated, climatised test chamber with test roof



Pyranometer

Anemometer

Fluid thermometer (ϑ), flow meter (*V*) or pressure sensor (*P*)

Air thermometer

Figure C.5—Schematic of test set-up

The water flow rate and volume to the solar DHW system should be measured in the mains water pipe and monitored throughout the test. Also the volume of water discharged through the hot water pipe as well as though freeze protection devices or safety valves should be measured and monitored. The measurement equipment should be able to detect water volumes at very low flow rates, with an accuracy of 5 ml. for outlets, like the domestic hot water outlet and safety device outlets; this may be done by capturing the water in an open vessel and weighing it. For the mains water pipe, a transparent vessel with expansion vessel is recommended; the water fed to the system can then be measured by reading the water level. In that case, the expansion vessel should allow for pressure of the mains water which does not differ more than 10000 Pa from usual mains pressure. When necessary, the vessel can be kept at the mains water temperature by refilling.

Water pressure sensors should be placed in the mains water and outlet pipes, in order to obtain extra pressure information during the test, if any freeze protection requires electricity or any other external energy source, the consumption of energy should be measured throughout the test. It is recommended to include a means of detecting or handling excessive leakage during the test in order to protect the climate chamber.

The system is filled with mains water in accordance with the installation instruction and checked for any leakage. The hot water outlet pipe is then shut off, and the cold water pipe is kept at mains pressure. The system is energized as specified by the manufacturer, including any freeze protection equipment. If the system contains an auxiliary heating which plays a role in freeze protection (as specified by the manufacturer), the auxiliary heater is switched on, otherwise kept switched off. The temperature of the mains cold water at the inlet to the climate chamber is kept at 5 ^{o}C.

C.1.3 Test procedure

The test procedure consists of three periods, which are described below in the order they have to be carried out. The values of the parameters mentioned in this description are given in C.1.4.

C.1.3.1 Test period I

C.1.3.1.1 General

Test period I consists of n days with low solar irradiation and ambient air temperature to induce ice growth and/or low solar DHW system temperatures, simulating average values of extreme climate conditions for the climate region considered; see C.1.4.1.

The test starts after the system has been filled as described above, the domestic hot water draw-off flow rate has been measured and the hot water valve has been shut off.

C.1.3.1.2 Procedure

Conduct the test as follows.

a) Reduce the air temperature of the test cell to $\vartheta_{a,1}$ the indoor ambient air temperature to $\vartheta_{i,1}$ (if applicable) and apply a wind speed level of $V_{w,1}$

b) Condition the system by drawing off at least three times the system volume while keeping the mains water temperature at (5 ± 1) ^{o}C. Keep the system under these temperature and wind conditions for a period of *n* days ± 1 h, starting from the above draw-off.

c) During these *n* days, periodically apply an irradiance level of $G_{sol,1}$ during a time interval $f_{sol,1}$. The start of the first irradiation period may be chosen within the first 18 h of the test period. The start of the second irradiation period should be (24 ± 1) h after the start of the first irradiation period. The third irradiation period should start (48 ± 1) h after the start of the first irradiation period, and so on in a daily cycle.

d) During the test

- Visually inspect the solar DHW system for leakage or frost damage at least every four days. No water should be withdrawn from the system;

- especially record the consumption of water which is not equalled by corresponding discharge through the outlet pipe or any safety device.

e) At the end of the period I, visually inspect the solar DHW system for any leakage or frost damage.

C.1.3.2 Test period II

C.1.3.2.1 General

Test period II consists of a number of hours with no solar irradiation as well as absolute minimum air temperature and maximum wind speed for the climate region considered.

C.1.3.2.2 Procedure

Conduct the procedure as follows:

a) Immediately after test period I, reduce the air temperature to $\vartheta_{a, 2x}$ and set the wind speed to $V_{w, 2x}$ and maintain this condition during t_2 h (starting from the moment when the air temperature reaches $\vartheta_{a, 2x}$ without any irradiation. No water shall be withdrawn from the system

b) Record the pressure read out of the pressure sensors at least every two hours

c) Record the moment and quantity of any water consumption or use of electricity or other external sources.

d) Record especially the consumption of water, which is not equalled by corresponding discharge through the outlet pipe or any safety device.

e) At the end of the period II, open the draw-off valve for (10 ± 1) s and measure the quantity of water drawn off. This may be done by accumulating the drawn off water and weighing it.

When this tapping shows the domestic hot water line of the system is not blocked by ice, the test period III is not necessary.

NOTE indications for possible pressure build-up in the system are the following:

- ice formation blocking the domestic hot water line (as indicated by no or very low water flow rate during the final draw-off;
- the pressure relief valve was frozen during the test. In many systems, the pressure valve will start leaking during the test periods I or II, to release the volume increase caused by ice formation in the systems. When at later stage, i.e. after several daily cycles, the pressure valve stops leaking. This is an indication of the valve being blocked by ice. A further indication is pressure build-up beyond the release pressure of the pressure relief valve, registered by one of the pressure sensors. However, it is also possible that an ice block is located between the system and the sensor.

If ice is blocking the domestic hot water line or the pressure relief valve is blocked, there is a possibility of pressure build-up in the solar DHW system, and the test period III is recommended to investigate whether repeated pressure build-up could damage the system

f) If period III is carried out, visually inspect the solar DHW system for any leakage or frost damage immediately after period II. During this inspection, the temperature in the test chamber should not rise more than 5 K above the temperature $\vartheta_{a, 2x}$, for a period of no longer than 1 h. Then immediately (see C.1.3.3.2a)) continue with test period III.

g) If period III is not carried out, withdraw at least three times the system volume while keeping the mains water temperature at (5 ± 1) ^{o}C. Record the flow rate and the temperature of the drawn off water during this draw-off. Again visually inspect the solar DHW system for any leakage, frost damage or permanent deformation.

C.1.3.3 Test period III

C.1.3.3.1 General

Test period III consists of 7-day period that simulates daily cycles of frost and defrost. The goal of this test is to establish a cumulative effect of cycles of water freezing, expanding and thereby possibly deforming the system, then thawing (during which some extra water could be consumed by the system to compensate the decrease in volume of the melted water), and then freezing again.

C.1.3.3.2 Procedure

Conduct the procedure as follows:

a) Start test period III within 2 h after the end of test period II, during which time the temperature in the test chamber should not rise more than 5 K above the temperature $\vartheta_{a, 2x}$.

b) Set the wind speed to $V_{w,3}$ and start applying the following daily cycle to the system.

c) In the first period with length $f_{sol,3}$, raise the temperature to $\vartheta_{a, 3x}$ within the first hour and apply a solar irradiance level of $G_{sol,3}$ in the plane of the solar DHW system cover.

d) In the second period with length (24 – $t_{sol,3}$) h, lower the temperature to $\vartheta_{a, 3x}$ within the first hour and without applying irradiance.

e) Repeat the steps a) to d) 7 times and continue with f)

f) At the end of period III,

- visually inspect the solar DHW system for any leakage or frost damage
- withdraw at least three times the system volume while keeping the mains water temperature at (5 ± 1) oC.
- record the flow rate and the temperature of the drawn off water during this draw-off.
- Again visually inspect the solar DHW system for any leakage, frost damage or permanent deformation.

C.1.4 Test conditions

C.1.4.1 General

C.1.4.2 to C.1.4.4 describe procedures to obtain the test conditions from local weather data. In C.1.4.5, the test conditions are given for the climate region of the Netherlands.

All test conditions are determined from a series of weather data, which includes extreme weather conditions for a representative location. The series should consist of weather data, which contain the five most severe cold waves ever; 10 days before and 10 days after each cold wave period should be included. If these data are not available, a representative weather data file of at least 10 consecutive years should be taken. In this case, the specified penalties as given apply.

C.1.4.2 Determination of the test conditions for period II

The conditions for test period I are represented by:

$H_{sol,1}$ total daily diffuse solar irradiation, in MJ/m2;

$G_{sol,1}$ corresponding solar irradiance during a specific time interval fv in W/m2;

$\vartheta_{a,1}$ ambient air temperature applied to the parts of the solar DHW system that would normally be located outdoors, in oC;

$V_{w,1}$ wind speed, in m/s;

$\vartheta_{I,1}$ indoor ambient air temperature applied to the parts of the solar DHW system that would normally be located indoors, in oC;

n length of the period, in d;

$t_{sol,1}$ irradiation period, in h.

The quantities *n*, $H_{sol,1}$, $G_{sol,1}$, $\vartheta_{a,1}$, $V_{w,1}$, $\vartheta_{I,1}$ and $t_{sol,1}$ are determined from the climate data described in C.1.4.1 in accordance with the following consecutive steps. In consultation with the manufacturer, more severe conditions may be chosen, which should then be reported with the test result.

a) Search all possible periods of n consecutive days in the climate data set, with the average ambient air temperature below zero for each day in the period and period length n = 7d, 8d, 9d,…..,19d, 20d and 21d. For each period, determine hourly values of the quantity – $H_{sol,1}$ t $\vartheta_{I,1}$ and the average value of that quantity.

b) Detect the absolute minimum of all averaged - $H_{sol,1}$ t $\vartheta_{I,1}$ values found under a) and the date and length *n* of the corresponding period.

c) For this period, calculate the average values of the irradiation, temperature, duration of the daylight period and wind speed to obtain, $H_{sol,1}$, $\vartheta_{I,1}$, $t_{sol,1}$ and $V_{w,1}$ respectively.

d) If weather data from an arbitrary decade is used, penalty $\vartheta_{p,1}$ should be applied to correct $\vartheta_{a,1}$ for more extreme temperatures than found in the decade investigated. The penalty is a summation of the following temperature differences:

- Temperature difference between the minimum n-days average temperature value of the decade considered and the average temperature value of the most severe cold wave in the region considered.

- Temperature difference correction for nightly radiation as the infrared radiation in the test facility is less than for real outdoor conditions.

e) The solar irradiance Gsol,1 to be used is calculated from the following equation:

$$G_{sol,1} = (10^6 / 3600) \text{ x } \tau_{snow} \times \tau_{iam} \times H_{sol,1} / t_{sol,1}$$

Where:

τ_{snow} = 0.2 the transmission factor of snow layer on the system;

τ_{iam} = 0.7, the average incidence angle modifier of the system. The value given here is an approximation; when a measure value is known this may also be used. This shall be reported with the test results.

f) If the system is mounted in thermal connection to a test roof as described in C.1.2, the air temperature to be maintained under the test roof $\vartheta_{I,1}$ should be equal to the minimum air temperature specified in the instruction manual. If no minimum air temperature is specified, the air temperature under the roof $\vartheta_{I,1}$ should be equal to ($\vartheta_{a,1}$ + 5) K.

These values are used for period I of the freeze protection test.

C.1.4.3 Determination of the test conditions for period III

The conditions for this period are represented by:

$\vartheta_{i,2}$ indoor ambient air temperature, in °C;

$\vartheta_{a,2}$ daily average outdoor ambient air temperature, in °C;

$\vartheta_{a,2x}$ minimum hourly ambient air temperature, in °C;

$V_{w,2}$ wind speed, in m/s;

t_2 test period, in h.

From the climate data set as specified in C.1.4.1, find the day with the minimum hourly temperature $\vartheta_{a,2x}$. For the same day, determine the daily average temperature $\vartheta_{a,2}$.

If weather data from an arbitrary decade is used, penalty $\vartheta_{p,2}$ should be applied to correct $\vartheta_{a,2x}$ for more extreme temperatures than found in the decade (see C.1.4.1) investigated. The penalty is a summation of the following temperature differences:

- Temperature difference between the minimum hourly temperature $\vartheta_{a,2x}$ and the absolute minimum hourly value in the region considered.
- Temperature difference correction for nightly radiation as the infrared radiation in the test facility is less than for real outdoor conditions.

Select the absolute maximum hourly average wind speed $V_{w,2}$ during a period of frost. Calculate the test duration from:

$$t_2 = 24 \times \vartheta_{a,2} / \vartheta_{a,2x}$$

where

$\vartheta_{a,2x}$ is the value without the penalty $\vartheta_{p,2}$ described above.

There is no solar irradiation during period II.

If the system is mounted in thermal connection to a test roof as described in C.1.2, the air temperature to be maintained under the test roof $\$_{p2}$ should be equal to the minimum air temperature specified in the instruction manual. If no minimum air temperature is specified, the air temperature under the roof $\vartheta_{i,2}$ should be equal to ($\vartheta_{a,2}$ + 5) K. Again, more severe conditions, e.g., longer test duration, may be chosen in consultation with the manufacturer.

C.1.4.4 Determination of the test conditions for period III

The conditions for this period are represented by:

$\vartheta_{1,3a}$ indoor ambient air temperature during the irradiation period, in °C;

$\vartheta_{1,3b}$ indoor ambient air temperature during the cold period, in °C;

$\vartheta_{a,3a}$ outdoor ambient air temperature during the irradiation period, in °C;

$\vartheta_{a,3b}$ outdoor ambient air temperature during the cold period, in °C;

$H_{sol,3}$ solar irradiation in the plane of the solar DHW system cover, in MJ/(m^2.d);

$G_{sol,3}$ solar irradiance in the plane of the solar DHW system cover, in W/m^2;

$V_{w,3}$ wind speed, in m/s;

$f_{sol,3}$ duration of the irradiation period, in h.

Apart from the conditions for period III obtained by the following steps, different conditions in consultation with the manufacturer may be chosen. The conditions used should be reported with the test results.

From the climate data set as specified in C.1.4.1, select a consecutive 21-days period around the day with the absolute minimum daily average temperature already found in C.1.3.2. The 21-days period should comprise the 10 days before this day, the day itself and the ten consecutive days.

Find in that period the day with the maximum daily average solar irradiation *H*sol,3. From that day, also obtain the maximum solar irradiance $G_{sol,3.}$

Calculate $f_{sol,3}$ from the following equation:

$$t_{sol,3} = (10^6 /3600)\times H_{sol,3} /G_{sol,3}$$

and find, in the 21-days period, the period with length $t_{sol,3}$ which has the highest average temperature $\vartheta_{a,3a.}$ Also find, in the 21-days period, the period with length (24 – $t_{sol,3}$) h that has the lowest average temperature $\vartheta_{a,3b}$.

The value of $V_{w,3}$ should be taken equal to *v*w,1.

If the system is mounted in thermal connection to a test roof as described in C.1.2, the ambient air temperature to be maintained under the test roof $\vartheta_{i,3}$ should be equal to the minimum air temperature specified in the instruction manual. If no minimum air temperature is specified, the ambient air temperature under the roof ($\vartheta_{a,3a}$ or $\vartheta_{a,3b}$) should be equal to the ambient air temperature ($\vartheta_{a,3a}$ or $\vartheta_{a,3b}$) + 5K.

C.1.4.5 Test conditions elaborated for specific locations

The procedures given in C.1.4.2 to C.1.4.4 have been elaborated for the climate of the Netherlands. The results are:

For test period I: $H_{sol,1}$ = 0.3 MJ/(m^2.d); $G_{sol,1}$ = 10 W/m^2; $\vartheta_{a,1}$ = -9 °C; $V_{w,1}$ = 5 m/s; *n* = 14d; t_1 = 8.3 h.

For test period II: $\vartheta_{a,2x}$ = -30 °C; $V_{w,2}$ = 10 m/s; t_2 = 10 h.

For test period III, no values are available yet.

Climate data used involve the years 1961 to 1980.

C.1.5 Results

The following results should be reported:

a) make and model identification of the system including auxiliary freeze protection devices fitted.

b) details of installation of the solar DHW system: mounting on or in the test roof, inclination, connections, lay-out, insulation of piping, etc. A sketch or photo of the installation should be included.

c) location and time span of the climate data considered for determination of the test conditions.

d) all test conditions as determined from the climate data.

e) record of draw-off flow rate and water temperature during initial conditioning of the solar DHW system at the start of period I.

f) volume of water discharged through freeze protection devices.

g) record of the time of activation of auxiliary freeze protection devices.

h) record of the water flow rate to the solar DHW system. If the system consumed more water than the amount obtained by draw-offs or discharged through freeze protection or other safety devices, this could be an indication of internal deformation of the system and it shall be reported.

i) record of consumption of electricity or other external sources by freeze protection devices.

j) results of all visual inspections, including any evidence of ice formation or leakage.

k) record of water pressure as measured by the pressure sensors.

l) volume of water drawn off at the end of period II (only when period III is carried out).

m) record of the draw-off flow rate and water temperature during the draw-off at the end of period II (if possible; only when period III is not carried out).

C.2 Indoor test procedure for assessment of the reliability of solar DWH systems in respect of overheating protection

C.2.1 Objective and applicability

The purpose of this test is to assess if a solar DHW system is able to withstand extreme overheating conditions without being damaged.

The test is applicable to solar DHW systems, including connecting piping and overheating protection device(s). It is especially suited for systems that do not have an active overheating protection device; however, for systems that do have such a device, the capability of that device to protect the system is tested.

C.2.2 Apparatus and mounting of the system

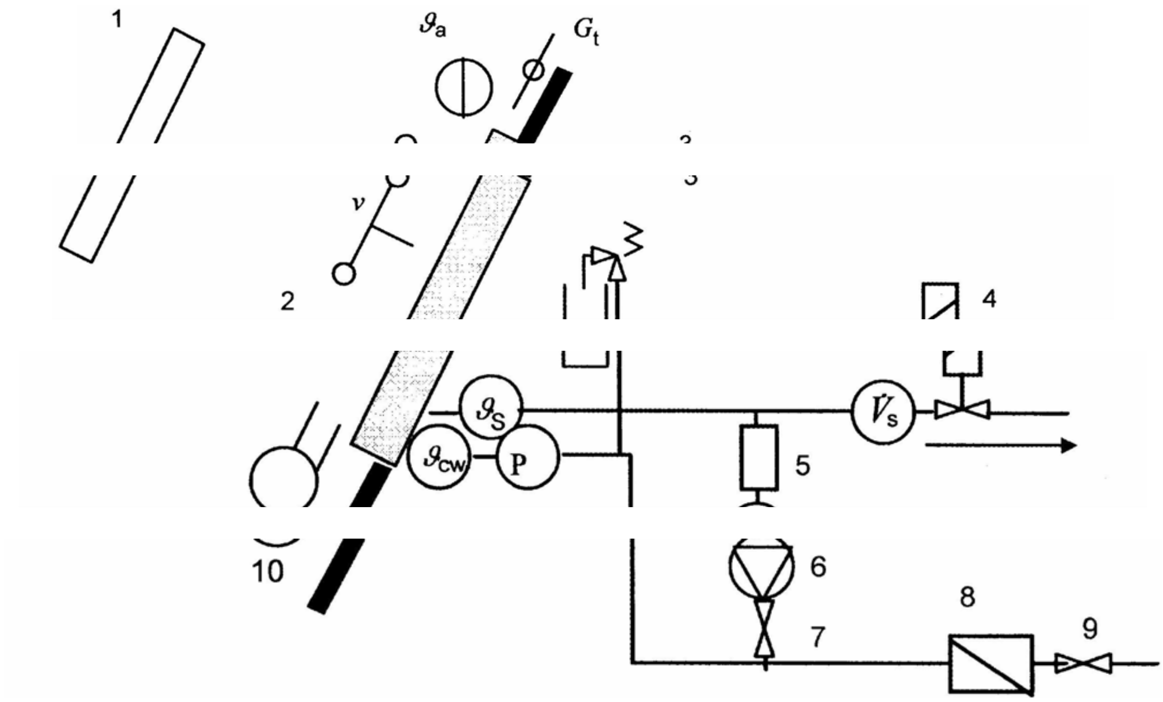
The solar DHW system is mounted in a solar simulator (similar to the solar simulators used for efficiency determination of solar collectors), capable of generating the necessary test conditions with regard to temperature, wind speed and irradiation (see Figure C.6). The installation should be similar to realistic conditions, taking into account the most severe conditions that are allowed in the installation manual. The system slope should be 45°, unless specified otherwise in the installation manual.

The system should be mounted in accordance with the installation instructions. Special attention should be given to the following points:

- The mounting and installation of the piping to and from the solar DHW system, including check valve and any overheating protection measures.

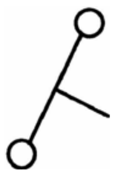
- Any overheating protection measures required in the installation manual.

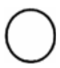
- The way the solar DHW system is connected to the roof.



Key
1 Solar simulator
2 SDHW system
3 Safety valve (installed according to installers instructions)
4 Draw-off valve A
5 Heater
6 Pump
7 Valve C
8 Non-return
9 Valve B
10 Fan


Pyranometer


Anemometer


Fluid thermometer (ϑ), flow meter (V) or pressure sensor (P)

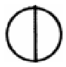

Air thermometer

Figure C.6 — Scheme of the test set-up

The water flow rate into the solar DHW system should be measured in the mains water pipe and monitored throughout the test. Also the volume of water discharged through overheating protection devices or safety valves should be measured and monitored.

If any overheating protection requires electricity or any other external energy source, the consumption of energy should be measured throughout the test. A water pressure sensor should be placed in the mains water line.

The cold water inlet and the hot water outlet of the solar DHW system are also connected to a circuit including a water heater and a pump, which has the purpose of heating up the solar DHW system water content at the start of the test period. This extra circuit is fitted with two valves to make it possible to separate the circuit from the normal mains water connection and outlet pipe. Furthermore, a connection is present to enable a pressure test to be made on the solar DHW system.

The system and test circuit are filled with mains water in accordance with the installation instruction. The hot water outlet pipe is then shut off.

C.2.3 Test procedure

Ensure that the solar simulator is switched off.

Carry out a pressure safety valve test by gradually raising the water pressure in the solar DHW system to the opening pressure of the safety valve. Read the pressure at which the valve opens, and check the system for any leakage or damage.

Restore the system to normal mains water pressure. Energize the system according to the manufacturer instruction, including any overheating protection equipment and auxiliary thermal sources.

Connect the water heater circuit to the solar DHW system. Switch on the pump and heat the water in the solar DHW system using the water heater until the water in the solar DHW system reaches (75 ± 2) °C.

NOTE1 If the solar DHW system is not designed ever to reach a temperature of 75 °C or if it will never reach that temperature during normal operation, a lower temperature may be chosen. This should be reported with the test results.

Disconnect the water heater circuit and switch the solar DHW system back to mains water supply. Set the ambient air temperature in the chamber to $\vartheta_{i,4}$ and the wind speed to vw,4.

NOTE 2 $\vartheta_{i,4}$ and $V_{w,4}$ are defined in C.2.

Keep the system under these temperature and wind conditions for a period of 5 days +1 h. During these 5 days, periodically apply an irradiation of $G_{sol,4}$ during a time $t_{sol,4}$. The daily irradiation should be equal to $H_{sol,4.}$ The start of the first irradiation period may be chosen within the first 6 h of the test period. The start of the second irradiation period should be (24 ± 1) h after the start of the first irradiation period. The third irradiation period should start (48 + 1) h after the start of the first irradiation period, and so on in a daily cycle.

Record the temperature and amount of the water discharged to prevent overheating.

At the end of the 5-days period, withdraw at least three times the system volume while keeping the mains water temperature constant to 1 °C around a value between 10 °C and 20 °C. Record the temperature of the drawn off water during this draw-off. Visually inspect the solar DHW system for any damage or permanent deformation.

C.2.4 Test conditions

C.2.4.1 General

In C.2.4.2 a procedure is described to obtain the test conditions from local weather data. In C.2.4.3 the test conditions are given for the climate region of the Netherlands.

All test conditions are determined from a series of weather data, which includes extreme weather conditions for a representative location. The series should consist of weather data, which contain the five most severe heat waves ever. If these data are not available, a representative weather data file of at least 10 consecutive years should be taken. In this case, the specified penalty as given below should be applied.

C.2.4.2 Determination of test conditions

The conditions for the test are represented by:

$\vartheta_{i,4}$ indoor ambient air temperature, in °C;

$\vartheta_{a,4}$ outdoor ambient air temperature, in °C;

$H_{sol,4}$ 5-days average solar irradiation in the plane of the solar DHW system cover, in MJ/(m^{2}day);

$G_{sol,4}$ peak hourly average solar irradiance in the plane of the solar DHW system cover within the 5-days period, in W/m^2;

$V_{w,4}$ lowest hourly average wind speed within the 5-days period, in m/s;

$t_{sol,4}$ duration of the irradiation period, in h.

The quantities $H_{sol,4}$, $G_{sol,4}$, $t_{sol,4}$, $\vartheta_{a,4}$, $\vartheta_{i,4}$ and $V_{w,4}$ are determined from the climate data described in C.2.4.1 as follows:

a) Select a 5-days period with an average daily irradiation in the plane of the solar DHW system cover $H_{sol,4}$ and an average daily temperature $\vartheta_{a,4}$, which holds the absolute maximum product of Hsol,4 × ϑa,4 .

b) For the selected period, determine ϑ_a , $\vartheta_{a,x}$, $\vartheta_{a,max}$, $H_{sol,4}$, $G_{sol,4}$ and $V_{w,4}$ where:

- ϑ_a is the 5-days average outdoor ambient air temperature, in °C;

- $\vartheta_{a,x}$ is the peak hourly average outdoor ambient air temperature within the 5-days period, in °C

- $\vartheta_{a,max}$ is the peak hourly average outdoor ambient air temperature ever registered, in °C;

Investigate the local weather for $\vartheta_{a,max}$ as well.

c) Calculate the outdoor ambient air temperature for the test from the following equation:

$$\vartheta_{a,4} = \vartheta_a + \vartheta_{p,4} \text{ with}$$

$$\vartheta_{p,4} = 0.5 \times (\vartheta_{a,max} - \vartheta_{a,x})$$

where $\vartheta_{p,4}$ is the penalty for correction of ϑ_a for more severe temperatures than those found in the decade (see C.2.4.1) investigated:

d) Next, the duration of the irradiation period will be determined. If the solar DHW system to be tested is equipped with a TIM (Translucent Insulation Material) one should account for an incidence angle dependent transmittance. In that case, the H_{sol} (not the G_{sol}) should be corrected with a factor cor_{sol} in accordance with the integrated incidence angle modifier (IAM) function of the TI material:

$$cor_{sol} = 0.5 \text{ I } [IAM](\varphi) \times \cos\varphi$$

where φ is the incidence angle, taken from 0 to 90°.

For a number of TIM's, IAM functions are already known. Typical range of cor_{sol} based on the IAM function for realistic TI materials is from 0.90 to 0.75. For a cover having an incidence angle independent transmittance, the *cor*sol is 1.0. Apart from the cover material, the construction of the solar DHW system (deep-seated box structures, parabolic mirrors, etc.) may influence the value of the IAM function and cor_{sol}. Therefore, it is recommended to use a measured IAM function of the solar DHW system.

Taking into account the incidence angle correction, the duration of the daily insolation period is calculated by:

$$t_{sol,4} = 277.8 \times cor_{sol} \times H_{sol,4}/G_{sol,4x}.$$

In order to take into account properties of common solar simulators, a solar irradiance lower than $G_{sol,4x}$ by at most 20 % can be used to calculate the corresponding $t_{sol,4}$.

e) If the system is mounted in thermal connection to a test roof as described in C.1.2, the ambient air temperature to be maintained under the test roof $\vartheta_{i,4}$ should be equal to the maximum ambient air temperature specified in the instruction manual. If no maximum ambient air temperature is specified, the ambient air temperature under the roof $\vartheta_{i,4}$ should be equal to ($\vartheta_{a,4}$ + 5) K.

C.2.4.3 Test conditions elaborated for specific locations

The procedure given in C.2.4.2 has been elaborated for the climate region of the Netherlands. The results are:

$$\vartheta_{a,4} = 27\ °C;\ \ H_{sol,4} = 30\ MJ/(m^2.day);\ \ G_{a,4} = 1000\ W/m^2;\ \ V_{w,4} = 0\ m/s;\ \ t_{sol,4} = 8.3\ h.$$

C.2.5 Results

The following results should be reported:

a) make and model identification of the system including auxiliary overheating protection devices

b) details of installation of the solar DHW system: mounting on or in the test roof, inclination, connections, lay-out, insulation of piping, etc. A sketch or photo of the installation should be included;

c) location and time span of the climate data considered for determination of the test conditions;

d) all test conditions as determined from the climate data;

e) volume of water discharged through overheating protection devices and/or safety valves;

f) record of the time of activation of auxiliary overheating protection devices;

g) record of consumption of electricity or other external sources by overheating protection devices;

h) results of all visual inspections, including any evidence of damage or leakage;

i) record of water pressure as measured by the pressure sensor. If during the pressure test the pressure valve did not open, or if it opened at a pressure higher than its rated pressure, this should be reported. If the pressure at any time exceeded the pressure rating of the pressure valve, this should also be reported;

j) record of the draw-off water temperature during the draw-off at the end of the test. If at any time the water temperature exceeded 100 °C, this should be reported.

Annex D
(informative)

Ageing test for thermostatic valves

D.1 General

This accelerated ageing test has the goal to assess the applicability of the specified maintenance frequency of a thermostatic valve, which is used as overheating protection valve in a solar heating system. Water of specified hardness is used in a cycle of operation and cooling down (closing). The correct functioning is regularly checked. When too large sediments of chalk are observed, the test duration is recalculated to an expected period in normal use. Therefore, the assumption is made that the valve will operate 250 times per year (This number has been estimated based on model simulations for Dutch climate with ICS and thermosiphon systems).

D.2 Test arrangement

The test arrangement (see Figure D.1) consists of a mixing vessel V1 with sufficient volume. The vessel can be filled with drinking water through valve 1. Via the open lid, substances can be added. The water in the vessel is stirred using a stirring device R. In the vessel V1, the water is conditioned to the required hardness by adding a mixture of calcium and magnesium salts. Using a pump H, the conditioned water can be pumped into test vessel V2 where it can be heated electrically. On top of V2 there is a connection where the valve being tested (labelled T&P) is mounted. A flow meter F is used to register the amount of water drained by T&P.

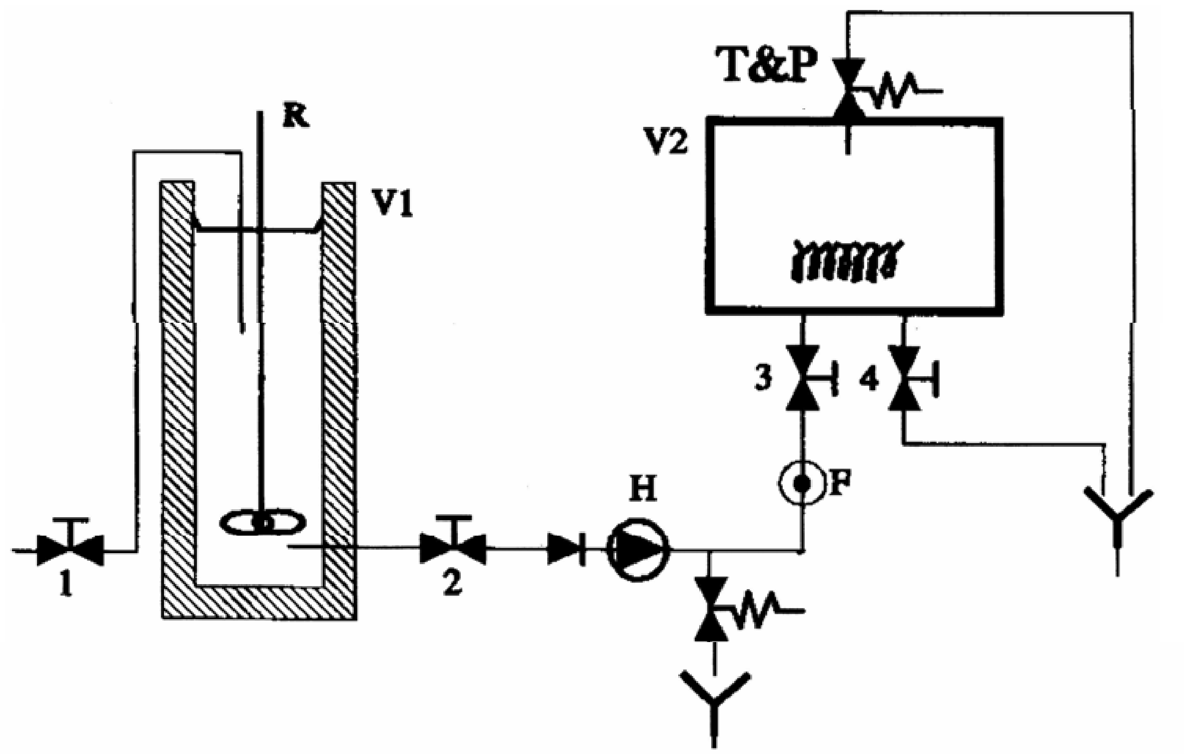


Figure D.1 – Test arrangement for thermostatic valve test

D.3 Test Procedure

D.3.1 Find out the specified maintenance frequency f_m [year-1] of the thermostatic valve. If the maintenance frequency is not specified, assume a system lifetime of 15 years: f_m = 1/15 [year-1].

D.3.2 Determine the number of cycles necessary for the test as $n = 250 / f_m$

D.3.3 Start up the test rig:

a) Rinse V1 with domestic hot water and subsequently fill it.

b) Add magnesium carbonate and calcium sulphate until the desired hardness is reached. Measure the hardness in accordance with ISO 6059. Start the stirring device and the pump. When refilling the store during the test, the amounts of salts to be added may be calculated from the amount of water refilled and the amounts of salts used to condition the first store volume.

NOTE 1 The EN 60734 standard specifies procedures to obtain 'hard water to be used for testing the performance of some household electrical appliances'. This standard is however very labour intensive and expensive. Therefore a simplified method is given here to achieve the same result.

NOTE 2 At TNO, with drinking water in Delft (hardness 8.5 °D[1]) and a volume of V1 of 600 l, 180 gram of magnesium carbonate and 290.4 gram of calcium sulphate is needed to obtain the desired hardness of about 23 °D.

c) Open valve 2, 3 and 4 to fill V2 with hard water. Close valve 4.

d) Start heating V2 using the electrical heater. At a certain point the valve will open and water will flow from V2 to the drain. Cold water is supplied from V1. After a certain time the temperature has dropped sufficiently for the valve T&P to close again.

e) When V1 is almost empty, close all valves and shut off the stirring device and the pump, refill V1 with water and restart at b).

D.3.4 After every 30th to 35th cycle, check visually if the valve is still functioning. When the valve does not function any more after less than *n* cycles, the number of cycles completed *is* reported.

D.3.5 After *n* cycles, report whether the valve is still functioning. Remove the valve and visually inspect the amount of sediments on the valve.

D.3.6 If *n* cycles have been completed with the valve functioning, the specified maintenance frequency is sufficient for the valve. Else, convert the number of test cycles to an expected operation period:

expected operating period = number of cycles / 250 [year].

D.4 Results

Report *n,* the number of cycles completed and, if applicable, the expected operating period.

[1] German index of hardness of water. The SI unit is mmol/l; 1 mmol/l = 5.6 °D

Annex E
(informative)

Lightning protection test for solar heating systems

E.1 Field of application

This test for lightning protection should be applied only to those parts of Factory Made solar heating systems that are normally exposed to outdoor weather/environment conditions.

Systems that contain few or no metallic parts may be excluded from this test.

Test methods for special devices, components and other items that may be applied to Factory Made solar heating systems or connected to solar heating systems on the roof with LPS installation are not covered by this standard.

The outdoor parts of the system may be considered as "natural components" on roof constructions and should be treated as "natural air termination components" in accordance with the relevant lightning protection standards.

NOTE This test is based on IEC 61024-1, modified for the needs of thermal solar heating systems. It is included in this standard to assist the manufacturers in meeting these requirements.

E.2 Purpose

The purpose of this test is to assess the relative resistance of the Factory Made solar heating systems and to evaluate whether the solar heating system is adequately manufactured to ensure sufficient connections and protection against lightning in case of connecting with a Lightning Protection System (LPS) in the building.

The solar heating systems and components mounted on the roof surface should only be used as a part of the existing LPS with the agreement of the structure engineer or the owner.

The connection with LPS cannot guarantee absolute protection to structures, solar heating systems and components or persons, but will significantly reduce risk of damage caused by lightning.

E.3 Requirements

The system should conform to the requirements given in IEC 61024-1.

When the water tank is mounted outdoors, the separation distance St (see E.5.4) should either fulfill

$S_t > D_t$

or there should be at least one connection (bonding cable or strip) between the tank and the outer cover sheet(i.e. in front and rear bottom). This bonding cable or strip should have at least the sizes as given in Table F.1, when measured in accordance with E.5.5.

where

D_t is the minimum separation distance $(K \times K_c / K_m) \times L_t = 0.044L_t$

Lt is the overall length of the tank, in millimetres;

K_i =0.05

$K_c = 0.44$

$K_m = 0.50$

When the tank is mounted outdoors, the bridging between the tank and the supports should have a total contact (connection) area of at least 100 cm^2 (overlapping surface bolted or spot welded), when measured in accordance with E.5.6.

The bridging between the collectors and supports (as determined in E.5.7) should have a contact (connection) surface of at least 100 cm^2 (overlapping surface bolted or welded).

E.4 Apparatus

No special apparatus is required except:

- a platform on which the complete solar heating system can be installed in accordance with the manufacturer's instructions and

- measuring instruments for distances, etc. (see test procedures below).

E.5 Test procedure

E.5.1 Test conditions

The test is normally carried out on solar heating systems, which are installed in a testing structure in accordance with the manufacturer's instructions.

E.5.2 Solar heating system installation

Install the Factory Made solar water heating system in accordance with the manufacturer's instructions, using his material for connections on the testing base stand and between components. Fill up the solar heating system and the close loop, for indirect systems, with water and take care for removing air from all parts through the air vents.

E.5.3 Separation distance S_t

Measure the overall length L_t of the tank, in millimetres.

Measure the existing separation distance S_t between the tank and the outer metal cover in the front and rear bottom.

Calculate the minimum permitted separation distance D_t.

E.5.4 Size of the bonding cable or strip

Check the existence of the above mentioned bonding connections.

Measure the size of bonding and calculate the cross section surface (or determine the size from electric cable tables).

E.5.5 Bridging between tank and supports

Check if there are bolts or rivets etc. between tank and supports.

Measure and calculate the overlapping surface between these parts. Compare the results with the lower limit of 100 cm^2, overlapping surface.

E.5.6 Bridging between collectors and supports

Check if there are bolts or rivets etc. between collectors and supports. Measure and calculate the overlapping surface between these parts. Compare the results with the lower limit of 100 cm^2, overlapping surface.

E.5.7 Bridging between collectors and tank

No special inspections. There is sufficient electrical continuity via metal supports.

E.5.8 Connecting terminal with Lightning Protection System (LPS)

Check the existence of the holes and measure the sizes *d*, *l* and *h*.

E.5.9 Metal sheets covering parts of the solar heating system

The electrical continuity check is not covered by this standard, but the relevant standards should be applied. Check the thickness of metal sheet.

E.5.10 Heating effects due to lightning currents

The heating effects are considered as negligible.

E.5.11 Mechanical durability due to lightning mechanical loads

The mechanical loads in considered as negligible

The mechanical loads in the solar components are too low and the influence on durability and stability is considered as negligible.

E.6 Report

Report the results of the tests, measurements and calculations in a formal Lightning Protection Testing Sheet given in Annex F.

E.7 Conclusions

The conclusions include the final evaluation that the Factory Made solar heating system is adequately manufactured and capable of connecting with an existing Lightning Protection System (LPS) on the roof of a building. In this way it should be protected against damage due to lighting effects.

Final conclusions are reported and included in the Lighting Protection Testing Sheet.

Annex F
(informative)

Lightning Protection testing sheet

Table F.1 – Size of bonding cable

Protection level	Cable Material	Cable cross-section F_c mm^2	
		Large load of lightning	Non large load lighting
I-II-III-IV	Copper (Cu)	16	6
	Aluminium (Al)	25	10
	Steel (Fe)	50	16

Table F.2 – Size of metal cover sheets

Metal cover sheet	Minimum thickness mm
Galvanized steel	0.50
Stainless steel	0.40
Copper	0.30
Aluminium	0.70
Zinc	0.70
Lead	2.00

Lightning protection testing sheet (Continued)

Laboratory :………………………………………………………………………………..
No of Test :………………..……………………………………………………………..
Date :………………………………………………………………………………..
Standard :……………………………………………..……………………………………
Solar heating system No :……………………………..…………………………………………………….

Manufacturer :……………………………………………………………………………….
(From manufacturer specifications and by laboratory examination of the sample)

Open system : Yes ☐ No ☐

Closed system: Yes ☐ No ☐

Tank Capacity: ……. Collector area : m_2

Construction Materials

<u>Solar Tank</u>
Tank walls :…………………………………………………………………………….
Internal coating :……………………………………………………………………………….
Flange and sealings :……………………………………………………………………………….
Heating element :……………………………………………………………………………….
Pipes :……………………………………………………………………………….
Heat exchanger :……………………………………………………………………………..
Safety devices :……………………………………………………………………………..
Welding / soldering :……………………………………………………………………………..
Other materials :……………………………………………………………………………..

<u>Solar Collector</u>
Absorber pipes :……………………………………………………………………………..
Connecting pipes :…………………………………………………………………………….
Sealing :…………………………………………………………………………….
Welding / soldering materials :…………………………………………………………………………….
Other materials :…………………………………………………………………………….

<u>Supports</u>
Materials :…………………………………………………………………………….
Bolts/rivets/welding :…………………………………………………………………………….
Coating :……………………………………………………………………………….
Other materials :……………………………………………………………………………….

<u>Connecting pipes</u>
Pipes :……………………………………………………………………………….
Welding/soldering materials :……………………………………………………………………………….
Other materials :……………………………………………………………………………….

1. Special components for connection with IPS :		☐ Yes	☐ No
2. Test in accordance with other standards	:	☐ Yes	☐ No
3. Installation on testing platform	:	☐ Yes	☐ No
4. Length of tank L_t	:……..mm		
Separation distance S_t	:……..mm		
Calculation for D_t	:………mm		
Comparison	: $S_t > D_t$	☐ Yes	☐ No
	:………..$S_t < D_t$	☐ Yes	☐ No
Need for bonding	:	☐ Yes	☐ No
Number of bonding cable	:………..Items		
5. Existence of bonding cable	:	☐ Yes	☐ No
Number of cables or strips	:………..items		
Dimensions of cable	:………mm		
Cross section surface F_c	:……… mm^2		
Comparison	: F_c >……mm^2 (from Table F.1)		
	: F_c < …….mm^2 (from Table F.1)		
6. Tank support bridging			
Existence of bolts etc	:	☐ Yes	☐ No
Dimensions of overlapping	:……..cm. Surface of overlapping F_{ov} :…..cm^2		
Comparison	: $F_{ov} > 100\ cm^2$	☐ Yes	☐ No
	: $F_{ov} < 100\ cm^2$	☐ Yes	☐ No
7. Collector supporting bridging			
Existence of bolts etc	:	☐ Yes	☐ No
Dimensions of overlapping	:……cm. Surface of overlapping F_{ov} : ……cm^2		
Comparison	: $F_{ov} > 100\ cm^2$	☐ Yes	☐ No
	: $F_{ov} < 100\ cm^2$	☐ Yes	☐ No
8. Existence of 2 Holes Ö10	:		
Dimensions *d* = 12mm:	*d* = ……..mm	☐ Yes	☐ No
l = 22mm:	*l* = …….mm	☐ Yes	☐ No
h = 200mm	*h* = …….mm	☐ Yes	☐ No
9. Cover sheet thickness *t*	:…………mm		
Comparison (Table F.2)	: t > …….mm	☐ Yes	☐ No
	: t < …….mm	☐ Yes	☐ No

Lightning protection testing sheet (concluded)

Laboratory :………………………………………………………………………………
No of Test :………………………………………………………………………………
Date :………………………………………………………………………………
Standard :………………………………………………………………………………
Solar heating system No :………………………………………………………………………………..

Final Conclusions

Needs for special labelling –identification:

Remarks:

Tested by:

Issued by:

Bibliography

[1] IEC 60734, Household electrical appliances — Performance — Hard water testing

[2] ISO 6059, Water quality — Determination of the sum of calcium and magnesium — EDTA titrimetric method

[3] EN 1717, Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow

[4] US 857-1, Thermal solar systems and components — Custom built systems — Part 1: General requirements

[5] US 857-3, Thermal solar systems and components — Custom built systems — Part 3: Performance characterization of stores for solar heating systems

[6] IEC 60343, Recommended test methods for determining the relative resistance of insulating materials to breakdown by surface discharges

[7] IEC 61024-1, Protection of structures against lighting — Part 1: General principles

Certification marking

Products that conform to Uganda standards may be marked with Uganda National Bureau of Standards (UNBS) Certification Mark shown in the figure below.

The use of the UNBS Certification Mark is governed by the Standards Act, and the Regulations made thereunder. This mark can be used only by those licensed under the certification mark scheme operated by the Uganda National Bureau of Standards and in conjunction with the relevant Uganda Standard. The presence of this mark on a product or in relation to a product is an assurance that the goods comply with the requirements of that standard under a system of supervision, control and testing in accordance with the certification mark scheme of the Uganda National Bureau of Standards. UNBS marked products are continually checked by UNBS for conformity to that standard.

Further particulars of the terms and conditions of licensing may be obtained from the Director, Uganda National Bureau of Standards.

ICS 27.160

Price based on nn pages