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Thermal solar systems and components - Solar collectors – Part 1: General requirements

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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

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(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

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Thermal solar systems and components – Solar collectors – Part 1: General requirements

1 Scope

This Uganda Standard specifies requirements on durability (including mechanical strength), reliability and safety for liquid heating solar collectors. It also includes provisions for evaluation of conformity to these requirements.

It is not applicable to those collectors in which the thermal storage unit is an integral part of the collector to such an extent that the collection process cannot be separated from the storage process for the purpose of making measurements of these two processes. It is not applicable to tracking concentrating solar collectors.

Collectors that are custom-built (built-in, roof integrated collectors that do not comprise factory made modules and are assembled directly on the place of installation) cannot be tested in their actual form for durability, reliability and thermal performance according to this standard. Instead, a module with the same structure as the ready collector is tested. The module gross area in the case of custom built collectors should be at least 2 m^2. The test is valid only for larger collectors, than the tested module.

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 requirements) applies.

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

ISO 9488, Solar energy – Vocabulary

3 Terms and definitions

For the purposes of this Uganda Standard, the terms and definitions given in ISO 9488 apply.

4 Symbols and units

For the purposes of this Uganda Standard, the symbols and units given in ISO 9488 and DUS 854 -2 apply.

5 Durability and reliability

5.1 Materials and design

Information about the materials and manufacture of solar collectors, including the materials they are manufactured of and their resistance to all influences which they might meet in service, retaining their operational ability are given in Annex A.

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5.2 Required tests

The collector shall be subjected to the following series of tests:

a) Internal pressure for absorber (see 5.2 of DUS 854 -2);

b) High temperature resistance (see 5.3 of DUS 854-2);

c) Exposure (se 5.4 of DUS 854-2);

d) External thermal shock. May be combined with the high temperature resistance or exposure test (see 5.5 of DUS 854-2);

e) Internal thermal shock. May be combined with the high temperature resistance or exposure test (see 5.6 of DUS 854-2);

f) Rain penetration, only for glazed collectors (see 5.7 of DUS 854-2);

g) Mechanical load (see 5.9 of DUS 854-2);

h) Thermal performance (see Clause 6 of DUS 854-2);

i) Freeze resistance, only in the cases specified in 5.8 of DUS 854-2;

j) Stagnation temperature (see Annex C of DUS 854-2). May be combined with the high temperature resistance or exposure test.

k) Final inspection (see 5.11 of DUS 854-2).

The optional test for impact resistance (see 5.10 of DUS 854-2) shall be carried out if requested. The result shall be recorded.

NOTE Regarding the durability and reliability of elastic materials it is recommended to refer to ISO 9808 and ISO 9553.

5.3 Pass criteria

5.3.1 General

The pass criteria for the reliability tests are given for each test in 5.3.2 to 5.3.10. The term “no major failure”, denotes that none of the following occurs:

- Absorber leakage or such deformation that permanent contact between absorber and cover is established;

- Breaking or permanent deformation of cover or cover fixing;

- Breaking or permanent deformation of collector fixing points or collector box;

- Vacuum loss, such that vacuum or sub-atmospheric collectors shall be classified according to the definition in ISO 9488 (only applicable for vacuum and sub-atmospheric collectors);

- Accumulation of humidity in form of condensate on the inside of the transparent cover of the collector exceeding 10 % of the aperture area.

NOTE The evaluation of accumulation of humidity for application of the pass criteria should be applied only on the following tests:

- external Thermal shock

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- rain penetration test

5.3.2 Internal pressure for absorber

The test pressure shall be as specified in 5.2 of DUS 854-2. In the case of absorbers made of organic materials, climate conditions according to Table 2 of DUS 854-2 shall be applied. After the internal pressure test, the collector shall not show any major failure as defined in 5.3.1.

5.3.3 High temperature resistance

When tested in accordance with 5.3 of DUS 854-2, the collector shall not show any major failure as defined in 5.3.1.

5.3.4 Exposure

When tested in accordance with 5.4 of DUS 854-2, the collector shall not show any major failure according to 5.3.1 and none of each potential problems of their components shall be graded 2 on the scale given in B.5.5 of DUS 854-2.

5.3.5 External thermal shock

When tested in accordance with 5.5 of DUS 854-2, the collector shall not show any major failure as defined in 5.3.1

5.3.6 Internal thermal shock

When tested in accordance with 5.6 of DUS 854-2, the collector shall not show any major failure as defined in 5.3.1.

5.3.7 Rain penetration

NOTE This test is applicable only for glazed collectors

A visual check shall not show water trace. Moreover, at least one of the following shall be fulfilled:

a) by weighing the collector the determined water quantity shall be less than 30 g/m^2 or

b) by measuring the humidity inside the collector, any visible droplets inside the collector or humidity that exceeds 20 g/kg at any time during the test or humidity that doubles from the value measured after stabilization shall yields to “major failure” or

c) measured condensation level shall be less than 10 % of the transparent cover and the quantity of the water that comes out of the collector when tipping it shall be less than 30 g/m^2.

5.3.8 Mechanical load test

When tested in accordance with 5.9 of DUS 854-2 the cover, the collector box and the fixings between collector box and mounting system shall not show any major failure as defined in 5.3.1 and 5.9.1.3 of DUS 854-2. The permissible and the maximum positive and negative pressure shall be recorded in the installer manual.

5.3.9 Thermal performance

When tested in accordance with Clause 6 of DUS 854-2, the collector shall not show any major failure as defined in 5.3.1. Thermal performance shall be reported.

5.3.10 Freeze resistance test

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This test shall be carried out only in the cases specified in 5.8.1 of DUS 854-2. The pass criterion is no major failure as defined in 5.3.1 after three freeze-thaw cycles.

5.4 Procedure

The required number of collectors shall be available for testing. The collectors shall be tested in accordance with 5.2. The collectors conform to this standard, only if all pass criteria are fulfilled. Freeze resistance shall be tested, for collectors which the manufacturer claims can withstand freezing and freeze/thaw cycling and which are not intended to be filled with antifreeze fluids.

6 Safety

The maximum fluid temperature to be considered in the design of a solar collector or solar plant is the collector stagnation temperature. Materials to be used in the manufacture of collectors or installations incorporating the collector (expansion tanks, safety valves, etc.) shall be chosen taking into account this temperature.

The stagnation temperature shall be calculated in accordance with Equation C.1 of DUS 854-2 under the following climate parameters:

- Hemispherical irradiance on collector plane 1000 W/m^2;

- Surrounding air temperature 30 °C.

Stagnation temperature (see Annex C of DUS 854-2) may be combined with the high temperature resistance or exposure test.

The collector shall provide for safe installation and mounting. Sharp edges, loose connections and other potentially dangerous features shall be avoided. If the weight of the empty collector exceeds 60 kg, an anchorage for a lifting device shall be included, except for the collectors that are assembled on the roof. Collectors filled with a heat transfer fluid irritant to human skin or eyes, or toxic, shall carry a warning label.

7 Collector identification

7.1 Drawings and data sheet

The collector submitted for test shall be accompanied by a set of drawings describing the collector's dimensions and structure along with a list of materials used in the collector and important physical and optical properties as well as by the solar collector description in D.2 or E.2 of DUS 854-2. Drawings shall have a number, date of issue and possible revision date. These documents shall be filled by the test institute for at least the period of time that the collector type is traded by the manufacturer.

NOTE The manufacturer is usually obliged to keep these drawings for at least the period of time that the warranty of the collector type is valid.

7.2 Labelling

Collectors shall carry a visible and durable label with the following data:

- Name of manufacturer;
- Type;
- Serial number;
- Year of production;
- Gross area of collector;

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- Dimensions of collector;
- Maximum operation pressure;
- Stagnation temperature at 1000 W/m^2 and 30 ^{o}C;
- Volume of heat transfer fluid;
- Weight of empty collector……. Made in: ……..

7.3 Installer instruction manual

Solar collectors shall be accompanied by an installer instruction manual, if traded as stand-alone components. When they are part of a complete system, the system installation manual can cover the complete system. In that case no separate manual for the collector shall be required. The instruction manual shall at least contain the following information:

- dimensions and weight of the collector, instructions about the transport and handling of the collector;
- description of the mounting procedure;
- recommendations about lightning protection;
- instructions about the coupling of the collectors to one another and the connection of the collector field to the heat transfer circuit, including dimensions of pipe connections for collector arrays up to 20 m^2;
- recommendations about the heat transfer media which may be used (also with respect to corrosion) and precautions to be taken during filling, operation and service;
- maximum operation pressure, the pressure drop and the maximum and minimum tilt angle;
- permissible wind and snow load;
- maintenance requirements.

If the collector is traded as a component and sold directly to customers, all relevant documentation concerning personal safety, maintenance and handling of the product shall be made available to the customer in the national language of the country where it is sold.

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Annex A
(informative)

Description of solar collectors materials and manufacture

A.1 General

The operational ability and long lifetime of solar collectors depend on the correct choice of appropriate materials. Testing of the materials, including accelerated life testing, is very important for the development of new collectors and the prediction of service life. Respective literature is referred to in the Bibliography.

Solar collectors may be affected by airborne fire or radiant heat. The use of non-combustible materials should be preferred. Collectors should comply with the regulations to fire-classification.

The collector box should be water-tight to prevent penetration of rain water. The collector box should be constructed in such a way that condensed water does not accumulate in the collector, as this might impair its functional capability and durability. For that purpose the collector should be properly designed to enable ventilation of air through the collector box.

The construction of the collector should ensure that no undue stress is built up in the cover, even at the maximum stagnation temperature of the collector. The materials of collector components should be selected and constructed so that they can withstand the maximum temperature which may occur at stagnation conditions and the thermal shocks they may be exposed to during the summer period. The materials of the collector should preferably be resistant to exposure to UV-radiation and in cases where materials selected are not so, they should be protected against incident and reflected UV-radiation.

Bushings and ducts, leading through the box, should be constructed so that no leakage can occur caused by thermal expansion. The collector box bushings should withstand any damage, if they have to be soldered for assembly. The design of collector should be such that heat bridges between the collector box and the absorber are avoided.

The components and the materials of the collector should be able to withstand the mechanical loads resulting from the heating up and cooling down of the collector. They should also be resistant to environmental stress from outdoor climate caused by factors such as rain, snow, hail, wind, high humidity and air pollutants.

A.2 Absorbers

Absorbers should be made from suitable materials to cope with mechanical, thermal and chemical requirements of the application. The effect of the manufacturing processes like cutting, brazing, soldering etc., on the properties of the absorber, should be considered.

The absorber ducts which guide the flow of the heat transfer fluid, including the connection lines, should be designed and constructed in such a way that venting can be effected in the installed condition, thus ensuring the functional capability of the collector.

Absorbers should be dimensioned on the basis of a calculation pressure corresponding to the permissible working overpressure specified by the manufacturer taking into consideration a safety factor of 1.5. The properties of the heat transfer medium should be considered as well.

The effect of the maximum temperature (stagnation temperature) of the absorber should be considered in the selection of material.

In the case of materials with strength characteristics, which vary appreciably with the temperature and/or UV-exposure, the evaluation criteria should be determined individually in each case.

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The wetted side of the absorber should withstand corrosion under normal operating conditions and taking into account the admixture of possible additives to the heat transfer fluid. The walls of swimming pool collectors which are wetted by the swimming pool water should be resistant to the additives used for the treatment of the swimming pool water.

Absorber coatings should retain their optical properties under high temperature, high humidity and condensation, and sulfur dioxide at high humidity.

A.3 Transparent covers

Solar collectors are generally covered with glass or transparent plastic glazing. The durability of glass and tempered glass under the service conditions found in solar collectors is good, but the resistance of plastics and glass treated with a special coating to the combined effects of UV radiation and temperature may be poor. There may be significant degradation with time, and in the case of a reduced transmission in the solar wavelengths, this will lead to degradation in collector performance. A reduction in the tensile strength or impact strength of a cover material may lead to a failure of the collector cover.

The transparency of the covers should not deteriorate appreciably during the service life of the collector, the covers should be resistant to ultraviolet (UV) radiation, air pollution, high humidity and condensate as well as high temperatures depending on the collector design.

A.4 Insulation materials

Insulation materials should withstand the local temperature arising during stagnation temperature conditions of the collector. At this temperature no melting, shrinkage or outgasing of the insulation with consequent condensation inside the collector cover, or absorber performance reduction or corrosion of metallic surfaces should occur to the extent of seriously reducing the collector performance.

Water or humidity absorption by the insulation material may shortly or permanently reduce the insulation performance of the material.

Thermal expansion of the material used in the collector due to the wide range of temperatures should be taken into consideration because of different thermal expansion coefficients. Furthermore transparent insulation materials or Teflon layers used should not deteriorate appreciably, both mechanically and optically, during the service life of the collector due to ultraviolet (UV) radiation, high temperature and humidity.

A.5 Reflectors

Reflectors, diffuse or specular, are reflecting surfaces used to increase the radiation, incident on the absorber. The reflecting surface should be resistant to environmental influences such as air pollution and to corrosion through humidity or rain. Outside the collector box reflectors should also resist mechanical loads through wind, snow and hail, whereas inside reflectors should withstand high temperatures.

A.6 Diffusion barriers

Diffusion barriers are materials used between absorbers and insulation material to prevent diffusion into or out of the insulation material. They should be able to withstand the absorber high temperatures and the incident UV radiation without shrinking and the high humidity or condensate accumulated remaining tight.

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Annex B
(informative)

Environmental protection

B.1 Heat transfer fluid

The heat transfer fluid used should not be toxic, seriously irritant to the human skin or eyes, or water polluting and it should be fully biodegradable.

B.2 Insulation materials

For the collector insulation no materials should be used, which have been manufactured using or containing CFCs. Furthermore, the insulation materials should not contain components, which outgas at the stagnation temperature, specified in Clause 6, which are toxic and seriously irritant to the human skin or eyes.

B.3 Recycling of the collector materials

Solar collectors are mainly used to save energy and reduce pollution. Therefore the design of the collectors should take into consideration the possibility to recycle the materials used. Materials which are not to be recycled should be avoided or used to the lowest possible extent.

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Annex C
(informative)

Tests to be repeated in collector design modifications

If the collector design is changed, Table C.1 may be used as guideline to assess whether one or more test should be repeated.

Table C.1 – Test that should be repeated for the respective modification in the collector design

	Absorbers	**Covers**	**Insulation materials**	**Boxes**	**Reflectors**	**Diffusion barriers**
Thermal performamce	+	+	+	+	+	+
Internal pressure	+	-	-	-	_	-
High temp, resistance	+	+	+	+	+	+
Exposure	+	+	+	+	+	+
External thermal shock	-	+	_	+	+	_
Internal thermal shock	+	-	-	-	-	_
Train penetration	-	+	-	+	-	_
Mechanical tests	-	+	-	+	_	-
Final inspection	+	+	+	+	+	+
+ Test should be repeated - Test need not be repeated						

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[3] ISO 9806-3, *Test methods for solar collectors - Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop*

[4] ISO 9808, *Solar water heaters - Elastomeric materials for absorbers, connecting pipes and fittings - Method of assessment*

[5] ISO/TR 10217, Solar energy - Water heating systems - Guide to material selection with regard to internal corrosion

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