MNRE Standard
ALL GLASS (GLASS IN GLASS) EVACUATED TUBES SOLAR WATER HEATING SYSTEM

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MNRE STANDARD
ALL GLASS (GLASS IN GLASS) EVACUATED TUBES SOLAR WATER HEATING SYSTEM

1.0 SCOPE

1.1 This standard specifies requirements of all glass evacuated tubes solar water heating system. This standard covers only non concentrating, direct, vented solar collector system that convert solar radiation to thermal energy for heating water based on thermo syphonic principle.

1.2 In case solar water heating systems is having an auxiliary heater as an integral part of the system, auxilary heater will be switched off during testing as the operation of the auxiliary input may influence the performance of the system.

2.0 REFERENCES

IS 6392:1971 Steel pipe flanges

IS 6911: 1992 Stainless steel plate, sheet and strip –specification

IS/ ISO 9488:1999 Solar energy – Vocabulary

MNRE STD 01:2013 All glass (glass in glass) evacuated solar collector tubes

MNRE STD 02:2013 Storage water tank for all glass (glass in glass) evacuated tubes solar collector

DOC: MED 04(1050) F Test procedure for thermo syphon type domestic solar hot water heating systems (under print)

3.0 DEFINITIONS

In addition to the terms and definitions given in IS/ISO 9488 and MNRE STD 01:2013 following shall also apply for this standard.

3.1 Ambient Air - Ambient air is the outdoor air in the vicinity of the solar collector system being tested.

3.2 Aperture Area - Maximum projected area through which the un-concentrated solar radiation enters a collector.

3.3 Water Draw-Off Rate - Rate at which water is withdrawn from a water heating System.

3.4 Direct Solar Water Heating System - Heating system in which the water to be heated is circulated through a collector where the solar heat gathered by the collector is transferred to the circulating water itself.

3.5 All glass evacuated tubes solar collector - Solar collector employing transparent glass tubes with an

evacuated space between the tube wall and the absorber.

3.6 Heat Exchanger - Device specifically designed to transfer heat between two physically separated fluids. Heat exchangers can have either Single or double Walls.

3.7 Heat Transfer Fluid - Fluid that is used to transfer thermal energy between components in a System.

3.8 Open System - In which the heat transfer fluid is in extensive contact with the atmosphere.

3.9 Reflector or Reflective Surface: A surface intended for the primary function of reflecting radiant energy.

3.10 Solar Collector - A solar collector is a device designed to absorb incident solar radiation, to convert it to thermal energy, and to transfer the thermal energy to a fluid coming in contact with it.

3.11 Solar Energy -The energy originating from the sun's radiation primarily encountered in the wavelength region from 0.3 to 3.0 micrometers.

3.12 Solar Storage Capacity - Quantity of sensible heat that can be stored per unit volume of store for every degree of temperature change.

3.13 Water Tank Capacity - Measured volume of the water in the tank when full. This capacity shall not include the water in the collector tubes and will be equal to system capacity.

3.14 Thermo-syphon System- The system which utilizes only density changes of the heat transfer fluid to achieve circulation between collector and storage tank.

3.15 Vented System - In which contact between the heat transfer fluid and the atmosphere is restricted either to the free surface of a feed and expansion cistern or to an open vent pipe only.

3.16 Working Pressure / Rated pressure - Maximum system pressure (in kg/cm^2) at which the water heater is designed to operate, or the maximum operating pressure (in kg/cm^2) assigned to the water heater by the manufacturer and marked on the water heater.

4.0 PRODUCT CATEGORIZATION

4.1 All glass evacuated tubes solar water heating system shall comprise of following main components:
a) All glass evacuated tubes for solar water collector,
b) Storage water tank for all glass evacuated tubes solar collector,
c) Diffuse flat plate reflector (if provided),
d) Manifold (applicable for closed type water storage tank in the system),
e) Tube resting caps,
f) Supporting frame/stand, and
g) Integral pipe & pipe fittigs; flanges ,valves etc (for closed type water storage tank in the system) with insulation of suitable thickness

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4.2 All glass evacuated tubes in the solar water heating system shall conform to MNRE STD 01.

4.3 Storage water tank in the solar water heating system shall conform to MNRE STD 02.

4.4 Diffuse flat plate reflector if provided shall be bright aluminium/stainless steel sheet of suitable thickness.

4.5 Manifold when provided shall have header (inner container) of Stainless steel sheet conforming to grade X02Cr19Ni10 or X02Cr17Ni12Mo2 of IS 6911/ ASTM 304,304L/316 and outer cladding shall be as given in 5.2 of MNRE STD 02. The insulation in manifold shall be PUF of minimum 25mm thickness. Alternatively, inner container of manifold may be of mild steel sheet conforming to IS 1079 with anticorrosive coating.

4.6 Tube resting caps shall be from UV stabilized ABS/Nylon/PP plastic material.

4.7 Supporting frame/stand for the solar heating system shall be manufactured from any of the following material:

i) Mild steel conforming to IS 2062 with hot dip galvanized or powder coated
ii) Galvanized steel sheet conforming to IS 277 with/without powder coating
iii) Stainless steel
iv) Aluminium with anodized coating

The frame/stand shall be strong enough to support the system during its lifetime.

4.8 Pipes used in the system shall be conforming to IS 1239 (Part 1). Flanges used in the system shall be conforming to IS 6392.

5.0 REQUIREMENTS

5.1 General

5.1.1 The system shall fulfill general safety requirements, e.g. care shall be taken to avoid protruding sharp edges on the outside of the system.

5.1.2 All parts of the system to be mounted outdoors shall be resistant to UV radiation and other weather conditions over the prescribed maintenance interval. Any maintenance or replacement of system parts required in order to maintain the system's normal working over a period of 10 years shall be clearly stated in the instruction manual.

5.1.3 The quality of all the work carried out on solar water heating system, including the pipe connections, brazing, welding, insulation of electrical conductors and attachment of accessories, shall be of such nature that the water heating system will perform its intended function without any failure.

5.2 Over temperature protection

5.2.1General

5.2.1.1 The system shall be designed in such a way that prolonged high solar irradiation without heat

extraction does not cause any situation in which special action by the user is required to bring the system back to normal operation. This may be taken care by providing vent as per manufacturer's instructions. In case system run dry without water, the procedure given in instructions manual to be followed for refilling of the system.

5.2.1.2 When the system has a provision to drain an amount of water as a protection against overheating, the hot water drain shall be constructed in such a way that no damage is done to the system, piping or any other materials in the house by the drained hot water. The construction shall be such that there is no danger to inhabitants from steam or hot water from the drain.

5.2.1.3 When the overheating protection of the system is dependent on electric supply and/or cold water supply, this shall be stated clearly in the instructions and on the system.

5.3 Over temperature protection for materials

The system shall be designed in such a way that the maximum allowed temperature of any material in the system is never exceeded.

6.0 TESTING

6.1 Pre-conditioning Test

6.1.1 Idle heating test – There shall be no deformation, crack or other damage in the system when tested as per **Appendix A.**

6.2 Test Requirements

Following tests shall be conducted on sample of all glass evacuated tube solar heating system:

i) **Leakage Test** – There shall be no leakage or damage in the system when tested as per **Appendix B.**

ii) **Integral Test** – There shall be no leakage or damage in the system when tested as per **Appendix C.**

iii) **External Thermal Shock Test** – There shall be no damage or deformation in the system when tested as per **Appendix D**.

iv) **Internal Thermal Shock Test** – There shall be no damage or deformation in the system when tested as per **Appendix E**.

v) **Frost Resistance Test** – This test is applicable only to those systems which manufacturer claims to be frost resistant. There shall be no leakage, damage or twisting in the system when tested as per **Appendix F.**

vi) **Thermal Performance Test** – The system efficiency corresponding to standard test conditions shall be **minimum 40 %.** The thermal performance of the system shall be tested according to the test procedure specified in **BIS Doc MED 04(1050) F**.

vii) **Resistance to Impact Test** – This test shall be carried out as per **Appendix F** of **MNRE STD 01** on each collector tube after dismounting from the system and kept horizontally. There shall be no damage on any collector tube.

7.0 TEST REPORT

A test report shall be generated in the format given at **Appendix G.**

8.0 INSTRUCTION MANUAL

8.1 The manufacturer shall supply an instruction manual with each system containing at least following information in easily understandable language:

a) Brief description of system and its components
b) Technical specification of the system
c) Schematic diagram of all glass evacuated tubes solar water collector system;
d) Instructions for assembly and installation of the system (including mounting details, piping/plumbing diagram) and safety precautions;
e) Instructions for operation and maintenance of the system;
f) Troubleshooting mentioning common problems, their possible causes and solutions;
g) List of service outlets;
h) Warranty clause clearly indicating limitations.

9.0 MARKING

Each system shall have the following information clearly marked on a plate or label attached to the system at visible place:

a) Name of manufacturer or recognized trade mark;

b) Collector area in m^2 ;

c) Water capacity of tank in litres per day (lpd);

d) No. of evacuated tubes;

e) Outer diameter and length of evacuated tubes;

f) Serial No.; and

g) Month and Year of manufacture.

APPENDIX A

IDLE HEATING TEST
(Clause 6.1.1)

D–1 Test conditions – This test shall be conducted outdoor as per operating conditions.

D –2 Test instruments/test setup –Anemometer, pyranometer, data logger

D–3 Test Procedure – Install the system under test outdoor according to operating conditions. There shall be no presence of water inside the system. Measure the daily cumulative solar irradiance on the plane of the collector which shall be more than 16 MJ/m^2 . The average wind velocity shall be 4m/s or less. This test to be conducted for three consecutive days.

D –4 Test Result - At the end of the test there shall be no deformation, crack or other damage to the system.

APPENDIX B

LEAKAGE TEST
{Clause 6.2 i)}

B-1 Test Conditions - This test is conducted at normal temperature outdoor.

B– 2 Test instruments/test setup – Hydraulic pressure source, Pressure gauge, Filter, Regulator, Stop watch, soap solution

B- 3 Test Procedure - Fill the evacuated tube solar collector system with water at normal temperature. Release all the residual air inside the system through the exhaust valve and shut off the exhaust valve. Then slowly increase the pressure to the test pressure 0.06 MPa through the hydraulic source. Maintain the test pressure for 10 min. Check leakage by applying soap solution on all joints.

B-4 Test Result - Check any deformation or leakage in the system during and at the end of the test.

APPENDIX C

INTEGRAL TEST
{Clause 6.2 ii)}

E–1 Test conditions – This test shall be conducted outdoor as per operating conditions.

E –2 Test instruments/test setup –Anemometer, pyranometer, data logger

E–3 Test Procedure – Install the system outdoor according to operating conditions. The system is filled with water. Measure the daily cumulative solar irradiance on the plane of the collector which shall be more than 16 MJ/m^2 . The average wind velocity shall be 4m/s or less. This test to be conducted for three consecutive days.

E–4 Result –Check for any deformation or leakage in the system during and at the end of the test.

APPENDIX D

EXTERNAL THERMAL SHOCK TEST
{Clause 6.2 iii)}

D - 1 Test Conditions – This test to be conducted outdoor when the solar irradiation reaches over $700W/m^2$. Spraying water temperature at 15°C±10°C and flow of spray water more than 200 $l/(m^2 \cdot h)$.

D – 2 Test instruments/test setup – Spray water tank with temperature gauge, stop watch, water flow meter

D – 3 Test Procedure - Start the test after solar irradiation reaches over $700W/m^2$. After stagnation period of 30 minutes, **s**pray water that meets the test conditions evenly on the evacuated tube solar collector, the inclination angle between the spraying direction and the collector shall be no less than 20^0. Keep spraying water for 5 min.

D - 4 Test Result - Check for damage and deformation with any part of the evacuated tube solar collector and record observation.

APPENDIX E

INTERNAL THERMAL SHOCK TEST
{Clause 6.2 iv)}

E -1 Test Conditions - This test to be conducted outdoor when the solar irradiation reaches over 700W/m^2. Water tank temperature at 15°C±10°C and water flow more than 60 l/(m^2.h).

E – 2 Test instruments/test setup – Water tank with temperature gauge, stop watch, water flow meter

E – 3 Test Procedure - - Start the test after solar irradiation reaches over 700W/m^2 . After stagnation period of 30 minutes, supply water that meets the test conditions to the absorber of the evacuated tube solar collector for 5 minutes.

E - 4 Test Result - Check for damage and deformation with any part of the evacuated tube solar collector and record observation.

APPENDIX F

FROST RESISTANCE TEST
(Clause 6.2 v)}

F-1 Test Conditions - This test applies to the systems which the manufacturer claims to be frost resistant including systems that work under frost resisting circulation. This test is not applicable to those systems that use frost resisting liquid medium. This test is divided into two tests: i) frost resistance test conducted when the collector is filled with water and ii) frost resistance test conducted when the collector is empty.

F – 2 Test Procedure - Install the collector for the frost resistance test in a cold storage. The installation inclination angle is the minimum included angle to the horizontal plane recommended by the manufacturer. If this angle is not recommended, the installation inclination angle shall be 30^0.

Fill the collector with cold water with temperature t_1 range:

8 ^{0}C$\leq t_1 \leq$25 ^{0}C. Keep the collector at (-20±2) ^{0}C for at least 30min, then increase the temperature to +10^0 C, keep it for 30min. Such freezing and warming circulation shall be conducted 3 times.

Discharge all the water from the collector. Keep the collector at (-20±2)^{0}C for at least 30min, then increase the temperature to +10 ^{0}C, keep it for 30min. Such freezing and warming circulation shall be conducted 3 times.

F – 3 Test Result - At the end of the test, check whether there is leakage, damage, deformation or twisting in the collector.

APPENDIX G

TEST REPORT
(Clause 7.0)

Official Stationary of the Test Laboratory/ Institution Address and Contact Details

	TEST REPORT	
A.	**GENERAL**	
1.	Name and Address of manufacturer/supplier	
2.	Contact details of manufacturer /supplier	
3.	Details of sample submitted/model	All Glass Evacuated Tubes Solar water Heating System
4.	Latitude & longitude of test laboratory	Latitude – Longitude –
5.	Duration of the Test	Date of start - Date of completion -
B.	**SPECIFICATIONS OF THE TEST SAMPLE** (All dimensions are in mm, unless specified otherwise)	
a)	**All glass evacuated tube**	
1	Make/Model	
2	Complete address of the manufacturer including e-mail/web site etc.	
3	Type	
4	No. of tubes	
5	Tube length , L in mm	
5	Outer diameter of inner tube, d in mm	

6	Outer diameter of cover tube, D in mm			
7	Details of selective coating			
b)	Storage water tank			
1	Storage Water Tank Capacity, litres			
2	Inner tank material & thickness			
3	Outer cladding material & thickness			
4	Insulation material & thickness			
c)	Manifold if applicable			
1	Manifold inner tank material & thickness			
2	Manifold outer cladding material & thickness			
3	Manifold insulation material & thickness			
d)	Collector area in m^2			
C	**TEST RESULTS**	**Specified**	**Observed**	**Remarks**
1	**All glass evacuated tube**	**Conformance to MNRE STD 01**	**See test report as per MNRE STD 01 enclosed**	**pp**
2	**Storage water tank**	**Conformance to MNRE STD 02**	**See test report as per MNRE STD 02 enclosed**	
3	**Collector area**	**As per declaration**	**Actual calculated area**	
4	**Idle heating test**	No damage after test		
5	**Leakage Test**	No leakage or damage during and at the end of test		
6	**Integral Test**	No leakage or damage during and at end of test		
7	**External Thermal Shock Test**	**No damage at the end of test**		
8	**Internal Thermal Shock Test**	No damage at the end of test		

9	**Frost Resistance test**	No damage at the end of test		
10	**Thermal Performance Test**	Minimum 40% system efficiency corresponding to standard test conditions		
11	**Resistance to Impact Test**	No damage after the test		
12	**Any other details**			
13	Remarks			

Date:
Place:

(Testing Officer) **(Head of the Test laboratory)**

APPENDIX H
(Informative)

Capacity wise number of Evacuated tubes and corresponding collector area in solar water heating system with evacuated tubes

The evacuated tubes for manufacturers of solar water heater systems are available in various sizes. The minimum collector area for any capacity of solar water heating system will be as per following Table.

Sr. No.	System Capacity (lpd)	Collector Area (m^2)
1	50	0.75
2	75	1.18
3	100	1.50
4	150	2.25
5	200	3.0
6	250	3.75
7	300	4.50
8	400	6.0
9	500	7.5
10	Above 500	$1.3m^2$ per 100 lpd

The no. of tubes for any capacity can be calculated as under.

No. of tubes = Minimum collector area as per above table / Area of single tube

The area of single tube can be calculated as follows.

Area of tube = π x Radius of cover glass tube (O.D. /2) x length of tube

Minimum no of tubes required for the system can be calculated as per following example:

For a system of 200 lpd, cover glass tube diameter 47 mm & length 1.5 m

Area of tube = π x 0.0235 x 1.5

=0.111 m^2

No. of tubes = 3.0/0.111

=27.09

Rounding of calculated no. of tubes should be done on higher side. Therefore, minimum no. of tubes required in the system is 28.

The area for some of the tubes generally used currently in the system as calculated according to above formula is given below for reference:

Type of tube			
Sr.no.	Cover Tube outside diameter (mm)	Length of tube (mm)	Area of single tube (mm^2)
1	47	1500	0.111
2	47	1800	0.133
3	58	1800	0.163

Area of other size of tubes may be calculated if required as per formula given above

Note 1 –The above collector area calculation is only applicable for subsidy purpose and not for testing of other thermal performance parameter of system.