MNRE Standard
ALL GLASS (GLASS IN GLASS) EVACUATED SOLAR COLLECTOR TUBES

Ministry of New and Renewable Energy
Block-14, CGO Complex,
Lodhi Road, New Delhi-110 003,

May 2013

MNRE Standard
All Glass (Glass in Glass) Evacuated Solar Collector Tubes

1.0 SCOPE

This standard specifies requirements of all glass evacuated solar collector tubes intended for non concentrating type solar collector.

2.0 REFERENCES

IS/ISO 9488:1999 Solar Energy - Vocabulary
ISO 3585:1998 Borosilicate glass 3.3

3.0 DEFINITIONS

In addition to the terms and definitions given in ISO 9488, the following shall apply for this standard:

3.1 Absorber - Inner glass tube with solar selective absorbing coating on its outer surface that absorbs solar radiation and converts it into thermal energy.

3.2 Angle of incidence - The angle between the direct solar irradiation and the normal to the aperture plane.

3.3 Average heat loss coefficient - Average heat loss through the absorber unit surface area under the condition of no solar irradiance for every 1°C difference between the average temperature of the hot water filling up the all-glass evacuated solar collector tube and the average ambient temperature.

3.4 Bubble (stone) - Solid impurity contained in the glass body.

3.5 Diffuse flat plate reflector- Flat plate mainly with diffuse reflection, which is installed below at a certain distance from the all glass evacuated solar collector tube and used for increasing the solar radiation collected by the all-glass evacuated solar collector tube.

3.6 Knot - Vitreous body in glass that varies from the main component of glass.

3.7 Pyranometer - A radiometer used to measure the total solar radiation (direct, diffuse, and reflected) incident on a surface per unit time per unit area.

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

3.9 Solar Irradiance - Irradiance is the rate of solar radiation received by a unit surface area in unit time in W/m^2.

3.10 Solar selective absorbing coating (surface) - Coating with high solar absorbing ratio and low emitting ratio.

3.11 Stagnation temperature - Maximum temperature of air within the all-glass evacuated solar collector tube under quasi-steady-state at specified solar irradiance when there is only air inside the all-glass evacuated solar collector tube

3.12 Stagnation parameter of an all glass evacuated solar collector tube - Ratio of the difference between stagnation temperature and ambient temperature and the solar irradiance.

3.13 Tube length – The length of the all glass evacuated solar collector tube is the distance from the open end to the point at which the diameter of the outer glass cover measured 15mm.

3.14 Vacuum jacket in all glass evacuated solar collector tube - Jacket between the cover glass tube and inner glass tube of the all-glass evacuated solar collector tube, where air pressure is sufficiently low, thermal conduction and convection of air can be ignored.

3.15 Vacuum quality – Vacuum performance in the evacuated tube which is expressed by disappearance ratio in axial length of the getter mirror after interior of an evacuated tube is heated.

4.0 PRODUCT CATEGORIZATION

4.1 STRUCTURE OF ALL GLASS EVACUATED SOLAR COLLECTOR TUBE

The all glass evacuated solar collector tube shall comprise of the inner glass tube with solar selective absorbing coating on its outer surface and coaxial cover glass tube. The one end of the inner glass tube shall be closed at base and seated in a steel strut. The other end of the inner glass tube shall be thermally sealed with the other end of the cover glass tube. The space between the inner tube and outer cover tube shall be vacuumised (vacuum $\leq$ $5x10^{-3}$ Pa) before thermal sealing of the other end of cover tube.

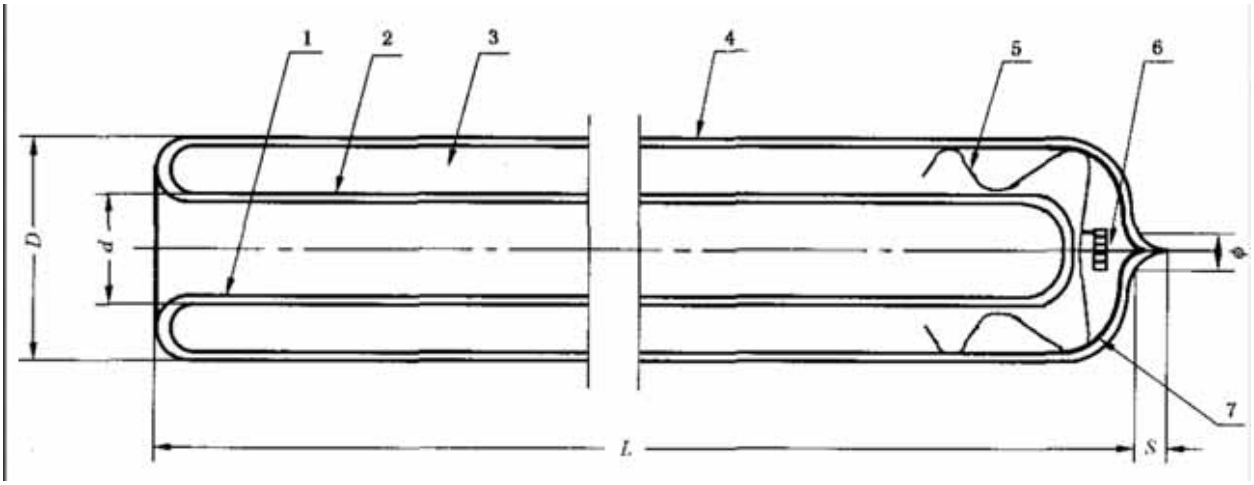

Fig. 1 Structure of all-glass evacuated solar collector tube

1— Inner glass tube;
2— Solar selective absorbing coating;
3— Vacuum jacket;
4— Cover glass tube;
5— Strut member;
6— Getter;
7— Getter mirror surface.
D — Outer Diameter of cover glass tube
d — Outer Diameter of inner glass tube
L — Length of tube
S — Length of sealing section

4.2 Dimensions of All Glass Evacuated Solar Collector Tubes

4.2.1 The dimensions of all glass evacuated solar collector tubes shall be as shown in Table-1.

TABLE 1

All dimensions in mm

Outer Dia of cover glass tube D Tolerance ± 1	Outer Dia of inner glass tube d Tolerance ± 1	Thickness of cover glass tube Tolerance ± 0.1	Thickness of inner glass tube Tolerance ± 0.1	Tube Length L Tolerance ± 0.5%	Length of sealing section S
47	37	1.6	1.6	1500,1800,2000, 2100	**≤ 15**
58	47	1.6	1.6		
70	58	2.0	1.6		

4.2.2 Bending of the all glass evacuated solar collector tube shall not be more than 0.2 %

4.2.3 The cross section of the open end of the all glass evacuated solar collector tube at a distance of 20mm±10 mm) from open end shall be of round shape and the ratio of the maximum outside diameter to the minimum outside diameter shall be not more than 1.02.

4.2.4 All glass evacuated solar collector tubes of other sizes may be supplied with the approval of MNRE provided they meet all other requirements of this standard.

4.3 Solar Selective Absorbing Coating

The Solar selective absorbing coating shall be three target coating having three layer - absorption layer (Aluminium nitride), bonding agent cum absorption layer (Aluminium nitride – stainless steel) and anti reflection layer (copper).

4.4 Designation

Designation of all glass evacuated solar collector tube shall comprise of following 5 parts:

Part-1 All glass evacuated solar collector tube
Part -2 Chemical symbol of selective coating
Part -3 Outer diameter of cover glass and inner glass tube
Part -4 Length of tube
Part -5 Type of coating (Three target)

Example: All glass evacuated solar collector tube having AlN/AlN-SS/Cu multilayer selective coating with 58 mm outer diameter of cover glass tube and 47 mm outer diameter of inner glass tube, 1800 mm length and three target coating shall be designated as:

ET - AlN/AlN-SS/Cu - 58/47 - 1800 - 3T

5.0 GENERAL REQUIREMENTS

5.1 MATERIAL

5.1.1 The material of glass tube shall be of Borosilicate glass 3.3 conforming to ISO 3585. The solar transmittance ratio of outer glass tube shall be $\tau \geq 0.89$ (at air mass 1.5 i.e. AM 1.5).

5.1.2 The absorptivity of solar selective coating shall be minimum 0.92 at AM 1.5.

5.2 VISUAL APPEARANCE

5.2.1 On viewing internal surface of inner tube of all glass evacuated solar collector tube colour of coating shall appear orange or copper like in case of three target copper coated tubes.

5.2.2 The close end of all glass evacuated solar collector tube shall appear silver/mercury colour to indicate desired vacuum in the tube.

5.2.3 There shall not be any bubble (stone) bigger than 1mm on the glass tube and there shall not be more than 1 bubble (stone) within a area of 10mm x 10mm and not more than 5 bubbles (stones) on the whole of the tube. There shall be no crack around the bubble.

5.2.4 There shall be no dense knots bigger than 1.5mm on glass tube. There shall not be more than 5 knots on the whole tube.

5.2.5 The accumulative length of minor scratches shall not be more than 1/3 tube length and the scratches shall not be visible from a distance of minimum 1200mm.

5.2.6 The selective coating of the all glass evacuated solar collector tube shall have no smear, peel off and fade off.

5.2.7 Distance from the obvious colour fading area of the selective absorber coating at the open end of the all glass evacuated solar collector tube shall be no more than 50mm.

5.2.8 The strut member supporting the free end of the inner glass tube shall be properly placed and shall not be loose.

5.2.9 The inner and cover tube at the open end of the all glass evacuated solar collector tube shall have smooth ends without any glass peel off and shall not have any deformation.

5.2.10 The sealed end of the tube shall not have any sharp end and shall be smooth.

6.0 TESTING

6.1 TEST REQUIREMENTS

The following tests shall be performed on sample of all glass evacuated solar collector tube:

i) Dimensions - Shall conform to the requirements given in clause **4.2**.

ii) Visual Appearance– Shall conform to the requirements given in clause **5.2.**These are visual requirements.

iii) Stagnation performance parameter test - The stagnation performance (Y) shall not be less than190 $m^2.^oC/kW$, when tested as per **Appendix A**.

iv) Stagnation solar irradiance test - The stagnation solar irradiance when tested as per **Appendix B** shall be as under**:**

- **a)** Not more than 3.7 MJ/m^2 for 47 mm outside diameter cover glass tube,
- **b)** Not more than 4.7 MJ/m^2 for 58 mm outside diameter cover glass tube and
- **c)** Not more than 5.7 MJ/m^2 for 70 mm outside diameter cover glass tube

v) **Average thermal loss coefficient test** – Average thermal loss coefficient (U_{LT}) shall be less than 0.85 $W/m^{2o}C$ when tested as per **Appendix C.**

vi) Vacuum performance test – The all glass evacuated solar collector tube shall meet the following requirements when tested as per **Appendix D :**

a) If glass surface showing weak fluorescence, tube meets the requirements**.** If sparks penetrate the glass surface or sparks are divergent and there is no fluorescence on glass surface, tube does not meet the requirement.

b) The disappearance ratio in getter mirror axial length shall be not more than 50%.

vii) Resistance to thermal shock test - There shall be no damage when tested as per **Appendix E.**

viii) Resistance to impact test - There shall be no damage when tested as per **Appendix F.**

ix) Resistance to internal pressure test - There shall be no damage when tested as per **Appendix G**.

x) Absorptivity and emissivity test of the selective coating - Selective coating of the tube shall have absorptivity Min 0.92 and emissivity less than 7% when tested as per **Appendix H**.

7.0 TEST REPORT

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

8.0 MARKING

The following markings shall be marked on all glass evacuated solar collector tubes:
a) Manufacturer's trade mark or logo and
b) Batch no. or date of manufacture.

9.0 PACKING

The all glass evacuated solar collector tubes shall be suitably packed in boxes to avoid any damage during handling, storage and transportation.

APPENDIX A

STAGNATION PERFORMANCE PARAMETER TEST
{ Clause 6.1 iii)}

A-1 Test conditions

A-1.1 This test shall be conducted outdoor.
A-1.2 Pyranometer shall be placed on a mounting stand (Ref Fig 2). The plane on which the Pyranometer is placed shall be parallel with the plane of collector.
A-1.3 Solar irradiance G≥800W/m^2,
A-1.4 The ambient temperature during testing shall be 20ºC ≤t_a≤30ºC. The thermometer shall be located shaded by a Stevenson screen in the vicinity of the test set-up (not more than 10 m from it). The bottom of screen shall be kept atleast 1m above the ground level.
A-1.5 Wind velocity during testing shall be ≤4 m/s. The anemometer shall be kept near to test bench to measure air speed.

A-2 Test instruments: Pyranometer ; Platinum Resistance Thermometer, Mercury Thermometer with Stevenson screen, Anemometer, Data Logger.

A-3 Test bench set up - Place 3 all-glass evacuated solar collector tubes in parallel in south-north direction. The all glass evacuated solar collector tube to be tested shall be in the middle and the other two tubes are accompanying test tubes. The center to center spacing is twice the inner tube diameter. The center to the flat plate reflector spacing is 70 mm. The flat plate reflector has a diffuse reflectance no less than 0.60. Air is used as the thermal conducting medium inside the all glass evacuated solar collector tube, the temperature shall be measured at the center of the tube and the sensor shall not contact the wall of the glass tube. A 50mm thick rigid polyurethane foam is used as thermal insulation cap at the open end of the all glass evacuated solar collector tube. The cap shall not cover the selective surface. The angle of inclination between the horizontal plane and the all glass evacuated solar collector tube is ±5° of latitude of the location but not less than 30^0. The measuring device is to be set up as shown in the Fig 2.

A-4 Test Procedure: When the solar irradiance is G≥800W/m^2 ± 30W/m^2 record the solar irradiance, temperature inside the collector tube and ambient temperature every 5 minutes. Take 4 set of readings. Take the average value of the 4 readings of solar irradiance as solar irradiance G. Similarly, take the average value of 4 readings of temperature inside the collector tube and ambient temperature as temperatures t_s and t_a respectively. Air speed shall be measured at the start of the test and end of the test & recorded in the test report.

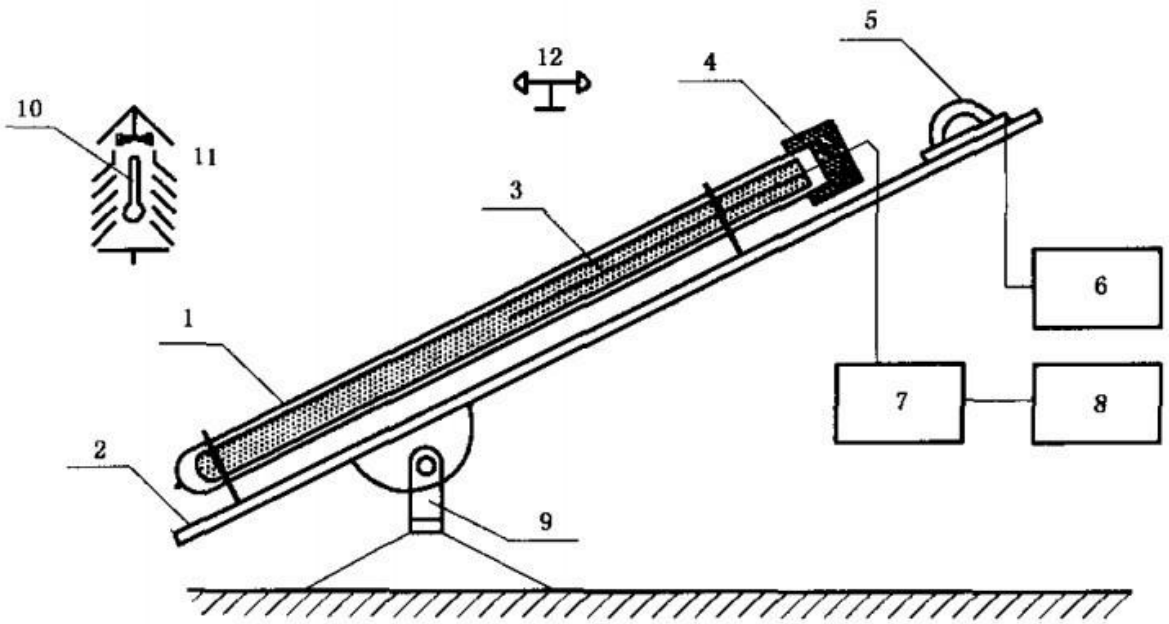

Fig. 2 Schematic diagram of thermal performance testing device of all glass evacuated solar collector tube

1 - All glass evacuated tube collector
2 - Diffuse flat plate reflector
3 - Platinum resistance thermometer
4 - Thermal insulation cap
5 - Pyranometer
6 - Radiation recording device
7 - Temperature recording device
8 - Data Logger
9- Mounting frame
10 - Mercury thermometer
11 - Stevenson screen for thermometer
12 - Anemometer

A-5 Calculate the stagnation performance parameter Y of all-glass evacuated solar collector tube according to formula (1)

$$Y = \frac{t_s - t_a}{G} \qquad \text{---------- (1)}$$

Where as
Y— stagnation performance parameter, $m^{2\cdot\circ}C/kW$
t_s— stagnation temperature, ^oC
t_a— average ambient temperature, ^oC
G— solar irradiance, kW/m^2

A-6 Result – Report the calculated stagnation performance parameter.

APPENDIX B

STAGNATION SOLAR IRRADIANCE TEST
{ Clause 6.1 iv)}

B-1 Test conditions - Same as in **A-1.**

B-2 Test instruments - Same as **in A-2**

B.-3 Test Bench - Same as in **A-3**. Water is used as the thermal conducting medium in all glass evacuated solar collector tube.

B-4 Test Procedure – Cover the all glass evacuated solar collector tube with opaque cover. Fill the water. Initially the water temperature should be lower than ambient. As soon as the water temperature is equal to ambient temperature, record the initial solar irradiance. Expose the all glass evacuated solar collector tube to the sun by removing the opaque cover. When water temperature inside the tube rises by $35^{o}C$ record the final solar irradiance.

B-5 The difference between final solar irradiance and initial solar irradiance is stagnation solar irradiance.

B-6 Result – Report calculated stagnation solar irradiance.

APPENDIX C

AVERAGE HEAT LOSS COEFFICIENT TEST
{ Clause 6.1 v}

C-1 Test Conditions

C-1.1 This test shall be conducted indoor.
C-1.2 The average ambient temperature during the testing period shall be $20^{o}C \leq t_a \leq 30^{o}C$.
C–1.3 There shall be no wind directly blowing onto the all glass evacuated solar collector tube.

C-2 Test Instruments - Platinum Resistance Thermometer, Mercury Thermometer, steel measuring tape

C-3 Test Bench.

C-3.1 All glass evacuated solar collector tube is placed vertical to the horizontal plane. The open end is covered by the same thermal insulation cap as in **A -2.**

C-3.2 There shall be three temperature measuring points from top to bottom in the all-glass evacuated solar collector tube. The measurement points shall be as under :

Tube Length (mm) L	Distance from Open end to the Measurement points in mm
1500	250, 750, 1250
1800	300, 900, 1500
2000	335,1000,1665
2100	350,1050,1750

C-4 Test Procedure - Fill up the all glass evacuated solar collector tube with hot water of minimum temperature 90°C and drain it out after two minutes. Immediately after this preheating, fill up the all glass evacuated solar collector tube with hot water of minimum temperature 90°C. The water level must be up to a height of 40mm from the top of the tube (open end) for tube length up to 1500mm and up to a height of 50mm from top of the tube (open end) for a tube length of 1800mm to 2100mm. Record the first average temperature (t_1) of the 3 measuring points when the water temperature naturally drops to an average of 80°C±0.2°C. Record the second and third average temperature (t_2 and t_3) of three measuring points at an interval of 30 minutes each. Simultaneously, record the corresponding three ambient temperatures (t_{a1}, t_{a2} and t_{a3}) at the same time.

C-5 Calculate the average heat loss coefficient U_{LT} of the all-glass evacuated solar collector tube according to formula (2), (3) and (4).

$$U_{LT} = \frac{C_{pw} . M (t_1 - t_3)}{A_A (t_m - t_a) \Delta_T} \qquad \ldots\ldots (2)$$

$$t_m = \frac{(t_1 + t_2 + t_3)}{3} \qquad \ldots\ldots\ldots (3)$$

$$t_a = \frac{(t_{a1} + t_{a2} + t_{a3})}{3} \qquad \ldots\ldots\ldots\ldots (4)$$

Where as :

U_{LT}	Average heat loss coefficient, W/($m^2 \cdot$ °C)
t_m	Average water temperature inside the all-glass evacuated solar collector tube during the test, °C
t_a	Average ambient temperature, °C
Δ_T	Total testing time from water temperature t_1 to t_3, s
M	Mass of water inside the all-glass evacuated solar collector tube, kg
C_{pw}	Specific heat of water, J/kg· °C)
A_A	Absorber surface area, m^2.(Refer to ANNEX 1)
t_{a1}, t_{a2}, t_{a3}	Corresponding ambient temperature recorded at the same time, °C
t_1, t_2,t_3	Three average water temperature inside the all glass evacuated solar collector tube at three measuring points each, °C.

C-6 Result – Report calculated average heat loss coefficient.

APPENDIX D

VACUUM PERFORMANCE TEST
{ Clause 6.1 vi)}

D-1 Test Conditions - This test shall be performed indoor.

D-2 Test instruments - Spark leak detector, Electric heating rod (single-end outlet, diameter of 20mm and rated power of 1500 W) of length not less than 90% length of the collector tube under test , Thermocouple, temperature gauge, steel measuring scale, hour meter

D-3 Air pressure test inside the vacuum jacket

D-3.1 Test Procedure – Air pressure of vacuum jacket is checked using a spark leak detector in dark condition. Aim the spark leak detector at open end where no selective coating is on the inner glass tube. The intensity of spark and colour shall be used to check the vacuum standard.

D-3.2 Result - If glass surface showing weak fluorescence sample meets the requirements**.** If sparks penetrate the glass surface or sparks are divergent and there is no fluorescence on glass surface, sample does not meet the requirement.

D-4 Vacuum quality test

D-4.1 **Test Procedure** – Place the electric heating rod inside the all glass evacuated solar collector tube. The electric heating rod is fixed with a aluminum fin type arrangement before being put into the collector tube. Both ends of the aluminum fins are covered with asbestos cloth to prevent direct contact of the aluminum wing with the collector tube wall. The opening of collector tube is covered with fiber glass. A thermocouple is placed at the middle of the collector tube to measure the inner glass tube temperature. The temperature of the inner glass tube is maintained at 340°C(±10°C) for 48 h. The change in mirror surface of the getter is measured. The measurement will be made from the point of diameter of 15mm of the sealed-off end of the collector tube to the getter mirror surface edge. There shall be measurement at six equal portions before heating and after heating. The average value of the 6 points before heating and after heating represents the getter mirror surface axial length L_1 and L_2 respectively.

D-4.2 Calculate the disappearance ratio in getter mirror axial length from the formula (5):

$$R = \frac{L_1 - L_2}{L_1} \times 100\% \qquad \text{..... (5)}$$

Where

R — disappearance ratio in axial length of the getter mirror, %
L_1 — axial length of the getter mirror before heating, mm
L_2 — axial length of the getter mirror after heating, mm

D-4.3 Result – Report calculated disappearance ratio in getter mirror axial length**.**

APPENDIX E

RESISTANCE TO THERMAL SHOCK TEST
{Clause 6.1 vii)}

E--1 Test Conditions - This test shall be performed indoor.

E-2 Test instruments/ test setup – Ice water bath with mercury thermometer, Hot water bath with mercury thermometer, stop watch, steel measuring scale

E–3 Test Procedure – Insert the open side of the all glass evacuated solar collector tube into ice water (≤ 1°C) for a depth not less than 100mm and keep it for one minute. Take it out and immediately immerse it into a hot water bath of temperature not less than 90°C for a depth not less than 100mm and keep it for one minute. Take it out and immediately immerse in the ice water (≤ 1°C). Repeat this test three times.

E– 4 Result – The all glass evacuated solar collector tube shall not have any damage after the test.

APPENDIX F

RESISTANCE TO IMPACT TEST
{Clause 6.1 viii)}

F-1 Test Conditions - This test shall be performed indoor.

F-2 Test instruments/test set up – Test bench having 2 V shaped groove support with 5mm thick polyurethane liner with 500mm space in between to put all glass evacuated solar collector tube in horizontal position, a stand to drop steel ball from a height of 450 mm at the middle of the two supporting points on the tube, a steel ball of 30mm diameter, a steel scale/ steel measuring tape

F-3 Test Procedure – Fix the all glass evacuated solar collector tube on the test bench. Drop the steel ball freely from the stand for vertical impact on the middle of the collector tube.

F-4 Result – The all glass evacuated solar collector tube shall not have any damage after the test.

APPENDIX G

RESISTANCE TO INTERNAL PRESSURE TEST
{Clause 6.1 ix)}

G-1 Test Condition - This test shall be performed indoor.

G-2 Test instruments/ test setup – Arrangement to develop 0.6MPa pressure, pressure gauge, stop watch

G-3 Test Procedure – Fill the all glass evacuated solar collector tube with water. Increase the water pressure evenly to 0.6MPa and keep it for one minute.

G-4 Result – The all glass evacuated solar collector tube shall not have any damage after the test.

APPENDIX H

ABSORPTIVITY AND EMISSIVITY TEST OF THE SELECTIVE COATING {Clause 6.1 x)}

H-1 Test Conditions - This test shall be performed indoor.

H–2 Test instruments/test setup – Spectrophotometer, hemisphere emissometer, temperature gauge

H-3 Test Procedure for Absorptivity - Use a spectrophotometer with integral ball to measure the transmission ratio of the solar selective absorbing coating respectively at 150mm from the open end of the all-glass evacuated collector tube and at middle of the collector tube (length wise) within a wavelength of 0.3 μm~2.5 μm. Then calculate the solar absorbing ratio at AM1.5 and use the average value of the two to express the solar absorbing ratio of the solar selective absorbing coating inside the all-glass evacuated solar collector tube.

H-4 Test Procedure for Emissivity- Place all glass evacuated solar collector tube inside sealed water-cooled jacket. Place a electric heater inside the inner tube and on two sides of the equipment to make a hemisphere emissivity measurement device. Under quasi-steady-state, directly measure the hemisphere emissivity of the selective absorbing coating of the absorber of the all glass evacuated solar collector tube at $80^{o}C \pm 5^{o}C$.

APPENDIX - J

(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			
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)			
	Evacuated Tube (ET)			
1	Make/Model			
2	Complete address of the manufacturer including e-mail/web site etc.			
3	Type	All Glass Evacuated Solar Collector Tube		
4	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			
8	Aperture (exposed) area of a single tube			
C.	**TEST RESULTS**	**Specified**	**Observed**	**Remarks**
1	Dimensions of tube	As per clause 4.2		
2	Visual appearance checks	As per clause 5.2		
3	Stagnation Performance Parameter Test, Y	Not less than190 $m^2.^oC/kW$		
4	Stagnation Solar Irradiance Test	**a)** Not more than 3.7 MJ/m^2 for 47 mm outside diameter cover glass tube, **b)** Not more than 4.7 MJ/m^2 for 58 mm outside diameter cover glass tube and **c)** Not more than 5.7 MJ/m^2 for 70 mm outside diameter cover glass tube		
5	Average Heat Loss Coefficient Test, U_{LT}	less than 0.85 $W/m^{2o}C$		

6	Vacuum performance test i) Air Pressure Test ii) Vacuum Quality Test	i) If glass surface showing weak fluorescence sample meets the requirements ii) The disappearance ratio in getter mirror axial length shall be not more than 50%.		
7	Resistance to thermal shock test	No damage after test		
8	Resistance to Impact Test	No damage after test		
9	Resistance to internal Pressure Test	No damage after test		
10	Selective Coating i) Absorptivity test ii) Emissivity test	i) Absorptivity Min 0.92 ii) Emmisivity less than 7%		
11	Any Other Details			
12	Remarks			

Date:
Place:

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

ANNEX 1
(APPENDIX C)

Outer Dia of cover glass Tube in mm D	Outer Dia of inner glass Tube (absorber tube) in mm d	Length of the All Glass Evacuated Solar Collector Tube in mm	Absorber Area in m^2 A_A
47	37	1500	0.174
		1800	0.209
		2000	0.232
		2100	0.244
58	47	1500	0.221
		1800	0.266
		2000	0.295
		2100	0.310
70	58	1500	0.273
		1800	0.328
		2000	0.364
		2100	0.383