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मानक

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IS 13429-3 (2000): Solar Cooker - Box Type, Part 3: Test Method [MED 4: Mechanical Engineering]



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भाग 3 परीक्षण पद्धति
(पहला पुनरीक्षण)

Indian Standard
SOLAR COOKER — BOX TYPE — SPECIFICATION
PART 3 TEST METHOD
(*First Revision*)

ICS 19.020.27.160. 97.040.20

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

FOREWORD

This Indian Standard (Part 3) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Non-Conventional Energy Sources Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard was first published in 1992 as one of the three parts of Indian Standards on solar cooker, the other two parts being on Requirements and Components. One amendment was issued in January 1993.

This standard has been revised based on the feedback received from various organizations connected with the solar cooking programme in the country. The present revision has been drafted taking into consideration the practical difficulties experienced while conducting the tests. The procedure for mirror reflectivity test and thermal performance test has also been revised based on the experiments conducted by the Institutes connected with the solar cooking programme.

The other parts of solar cooker standards simultaneously revised are as follows:

- | | |
|-------------------|--|
| IS 13429 (Part 1) | Solar cooker — Box type — Specification: Part 1 Requirements (<i>first revision</i>) |
| IS 13429 (Part 2) | Solar cooker — Box type — Specification: Part 2 Components (<i>first revision</i>) |

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960, 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard. Where specific limit ('Maximum' or 'Minimum') has been stipulated in the standard the values obtained shall be rounded off in one direction only in accordance with Amendment No. 1 February 1997 to IS 2 : 1960 (*revised*).

AMENDMENT NO. 2 JUNE 2010
TO
IS 13429 (PART 3) : 2000 SOLAR COOKER — BOX
TYPE — SPECIFICATION

PART 3 TEST METHOD

(First Revision)

[Page 2, clause **4.5.1.2**(d)(3), line 2] — Substitute ' $\pm 1^{\circ}\text{C}$ ' for ' $\pm 0.2^{\circ}\text{C}$ '

(ME 04)

Reprography Unit, BIS, New Delhi, India

**AMENDMENT NO, 1 MAY 2003
TO
IS 13429 (PART 3) : 2000 SOLAR COOKER — BOX
TYPE — SPECIFICATION**

PART 3 TEST METHOD

(First Revision)

(Page 1, clause 4.3.1) — Insert the following Note after the clause:

'NOTE — For routine test, photo-voltaic based solarimeter may be used.'

(Page 2, clause 4.3.2, para 4, line 2) — Substitute ' $R = R_1/R_3$ ' for ' $R = R_3/R_1$ '.

(MED 4)

Reprography Unit, BIS, New Delhi, India

Indian Standard

SOLAR COOKER — BOX TYPE — SPECIFICATION

PART 3 TEST METHOD

(First Revision)

1 SCOPE

This standard (Part 3) specifies the test methods for box type solar cooker.

2 REFERENCE

The Indian Standard listed below contains provisions which through reference in this text, constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

<i>IS No.</i>	<i>Title</i>
12934 : 1990	Solar energy — Thermal applications — Vocabulary

3 DEFINITIONS

For the purpose of this standard, the terminology and definitions given in IS 12934 are generally applicable.

4 TEST METHOD

4.1 Leakage Test

4.1.1 Cooking Tray Leakage Test

Dismantle the cooking tray from the main body and fill with water. After one hour, examine the joints of the tray for any signs of leakage.

4.1.2 Rubber Gasket Leakage Test

Insert a piece of paper in between the gasket and the cover plate in at least four positions along each side of the cooker. The paper used shall be approximately 50 mm wide and maximum 0.05 mm thick. Ensure that the cover plate is properly tightened. The paper shall exhibit a firm resistance to withdrawal by hand at all points tested.

4.1.3 Cover Plate Leakage Test

Leakage from cover plate may occur from upper and lower sides. Therefore, the cooker shall be tested for following two tests:

- a) *Leakage test for upper side of cover plate* — Ensure that the cover plate is properly tightened. Pour a thin film of water on the cover plate. After one hour, examine the

cover plate for any signs of water entry between the two glass sheets. This test shall be done in the shade.

- b) *Leakage test for lower side of cover plate* — Fill the cooking pots with water and keep them in the cooking tray. Tighten the cover plate. Place the cooker in open around 1000 h for exposure to sun rays for 4-5 h. Then place the cooker in shade for 15 min to allow any vapour to condense. Examine the cover plate for any signs of water vapour entry between the gap of inner and outer of cover plate.

4.1.4 Rain Penetration Test

4.1.4.1 Apparatus

The basic apparatus shall be a 5 mm spray nozzle.

4.1.4.2 Procedure

The closed cooker shall be sprayed water on all sides using a spray nozzle at a pressure of 0.1 MPa. Spray from the nozzle shall be directed downwards from the cooker top and also towards the four comers of the cooker. The water shall be sprayed on the cooker top and comer for 10 min.

After the test external surface of the cooker shall be wiped dry and the cooker shall be inspected visually for any entry of water vapour.

4.2 Slam Tests

This test is to ensure that the mirror or cover plate shall not be damaged when allowed to fall from the fully opened position as given below:

- a) *Cover Plate Slam Test* — With the lid open, lift the cover plate as high as possible and then let it fall to a closed position. This shall be repeated five times. There shall be no damage to the glass sheets.
- b) *Mirror Slam Test* — Hold the mirror at near vertical and let it fall to a closed position. This shall be repeated five times. There shall be no damage to the mirror, the cover plate, or any other part of the cooker.

4.3 Mirror Reflectivity Test

4.3.1 Apparatus

Two pyranometers and a stand with two axis tracking

arrangement for holding the mirror and a pyranometer parallel to the mirror at a distance of about 30 cm. The stand will have a pointer (10-15 cm long pin) fixed normal to its plane.

4.3.2 Procedure

Place the stand in an open space free from shadow and reflected radiations from the surroundings. Fix the mirror on the stand parallel to its plane. Also fix one of the pyranometer (P_1) in such a way that its sensor faces towards the mirror. Place the other pyranometer (P_2) horizontally near the stand for using it as a reference pyranometer.

Adjust the stand for normal incidence in such a way that shadow of the pointer is not there. Tilt the stand about 10° from the normal position and adjust the position of pyranometer (P_1) on it in such a way that radiation reflected from the mirror falls on the pyranometer sensor. Record the readings R_1 and R_2 of the pyranometers P_1 and P_2 respectively.

Without changing the tilt of the stand, reverse the pyranometer P_1 so that its sensor faces the Sun and is parallel to the mirror. Record the readings R_3 and R_4 of both the pyranometers P_1 and P_2 respectively. The two readings of the reference pyranometer P_2 (R_2 and R_4) should not have changed by more than 5 percent. The experiments should be performed in clear weather and the global radiation recorded should be more than 600 W/m^2 .

Calculate the reflectivity of the mirror from the relation $R = R_3/R_1$. Repeat the test six times. The average of the six values of the R will give the reflectivity of the mirror.

4.4 Exposure Test

4.4.1 Apparatus

The basic apparatus shall consist of solar pyranometer, along with recording device.

4.4.2 Procedure

The solar cooker shall be left to stagnate which may lead to the following possible degradation:

- Breakdown of rubber or plastic material;
- Outgassing from the insulating material;
- Discoloration or peeling of black paint on the cooking pots and cooking tray;
- Depositions of water vapour, dust or any other material inside the double glass lid; and
- Cracking of glazings and/or mirror and/or body.

The solar cooker shall be left open in an unshaded area for at least 30 days having daily irradiation level

of at least 4 kWh/m^2 on horizontal surface. These days need not to be consecutive. The cooking pots inside the cooker shall be empty. The mirror shall be placed vertically and the cooker shall be oriented to face south. The cooker may be kept inside during rains.

4.5 Thermal Performance Test

The thermal performance test shall be conducted under the following conditions and values of F_1 and F_2 shall be calculated. The values of F_1 and F_2 shall be reported based on arithmetic average of at least 3 test values which shall not have variation more than 0.002.

4.5.1 Stagnation Temperature Test

4.5.1.1 Apparatus

Pyranometer and temperature sensor along with measuring/recording device.

4.5.1.2 Procedure

The hot junction of the thermocouple (with radiation seal) should be fixed at the mid-point of tray with proper thermal contact and without protruding out. The no load test shall be carried out on a clear day in following steps starting before 1000 h so that the stagnation temperature is achieved near solar noon or just after noon:

- Place the solar cooker without pot in open sun condition;
- Cover the reflector of the solar cooker with a black cloth;
- Monitor the cooker tray temperature at an interval of 5 min continuously. Also measure intensity of total solar radiation, ambient temperature and wind speed at the level of glazings of solar cooker; and
- When the cooker tray temperature has reached a quasi steady state note down the final steady cooker tray temperature (T_{px}) and the corresponding outside ambient air temperature (T_{az}) alongwith the solar radiation (G_s) at that time. The steady state conditions shall be defined as 10 min period when:
 - variation in cooker tray temperature is $\pm 1^\circ\text{C}$.
 - variation in solar radiation is $\pm 20 \text{ W/m}^2$.
 - variation in ambient temperature is $\pm 0.2^\circ\text{C}$.
 - Solar radiation is greater than 600 W/m^2

Calculate F_1 , which is defined as the ratio of optical efficiency to the heat loss coefficient at/U_L as follows:

$$F_1 = \frac{T_{pz} - T_{az}}{G_s}$$

where

- τ = transmittance of glass,
- α = absorptance of cooking tray,
- U_L = heat loss coefficient of the cooker, and
- G_L = solar radiation during steady state.

4.5.2 Load Test: Sensible Heating of Water

Sensible heating test should be conducted and figure of merit F_2 shall be calculated as given in 4.5.2.1 and 4.5.2.2.

4.5.2.1 Apparatus

Pyranometer and temperature sensor along with measuring/recording device.

4.5.2.2 Procedure

Weigh the empty cooking pots and then fill with 8 litres of water per square metre of aperture area. Water at ambient temperature is equally distributed in all the cooking pots if they are of the same size. If sizes are different, then water quantity in each cooking pot shall be in proportion to their bottom area. Reweigh and calculate the exact mass of water. Place the pots in the cooker from which the mirror has either been removed or covered with cloth.

Place temperature probe of thermocouple in the largest of the cooking pots with the measuring tip submerged in the water. The temperature probe lead shall be sealed where it leaves the cooking pots and the cooker.

The ambient temperature and wind speed at the level of glazings of solar cooker are measured throughout the test.

The test shall start in the morning between 1000 h and 1030 h of local solar time. If radiation and temperature are measured by spot checks, these shall be no more than 5 min apart.

Constant monitoring at 30 s intervals or less is desirable with averages of radiation recorded over 2 min intervals. Following measurements shall be taken:

- a) Water temperature measured along with the exact time of that measurement shall be recorded;
- b) Continue the data recording until the water temperature exceeds 95°C;
- c) Local initial and final temperature/time data pairs. The initial temperature shall be 60°C and the final temperature shall be 90°C. These will be noted as T_{w1} and T_{w2} respectively and the corresponding times t_1 and t_2 respectively;
- d) Calculate the average ambient air temperature (T_a) between the times t_1 and t_2

- e) The experiment should be conducted in clear weather. Check that the radiation recorded between the two points always exceeds 600 W/m²;
- f) Calculate the average radiation (G) over the time t_1 to t_2 ; and
- g) Calculate the second Figure of merit F_2 as follows:

$$F_2 = \frac{F_1 (MC)_w}{A(t_2 - t_1)} \ln \left[\frac{1 - \left(\frac{T_{w1} - T_a}{F_1 G} \right)}{1 - \left(\frac{T_{w2} - T_a}{F_1 G} \right)} \right]$$

where

- F_1 = First figure of merit from stagnation test,
- $(MC)_w$ = Product of the mass of water and specific heat in J/°C,
- A = Aperture area of the cooker of cover plate in m²
- $(t_2 - t_1)$ = Time taken for heating from T_{w1} and T_{w2} in seconds,
- T_a = Average air temperature over time period $(t_2 - t_1)$ in °C, and
- G = Average radiation over time period $(t_2 - t_1)$ in W/m²

4.5.3 Standard Boiling Time

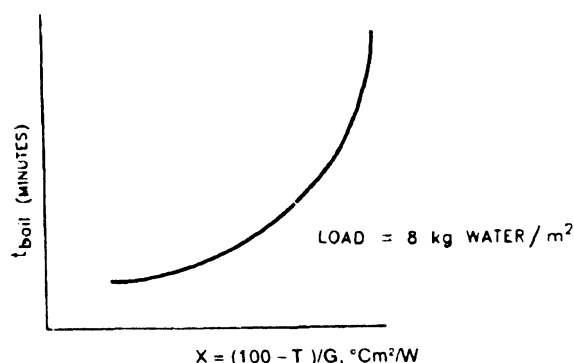
Knowing F_1 and F_2 standard boiling time in minutes shall be calculated as follows:

$$t_{\text{boil}} = \frac{-F_1 (MC)_w}{60 F_2 A} \ln \left(1 - \frac{X}{F_1} \right)$$

where

$$X = (100 - T_a)/G$$

The standard boiling time shall be calculated for different values of X . A plot of t_{boil} versus X shall be provided as follows:



It should be mentioned that the actual boiling time with mirror in position could be expected to be less than the time indicated.

Bureau of Indian Standards

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc : No. ME 04 (0486).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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