

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Household microwave ovens – Methods for measuring performance

Fours à micro-ondes à usage domestique – Méthodes de mesure de l'aptitude à la fonction



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**HOUSEHOLD MICROWAVE OVENS –
METHODS FOR MEASURING PERFORMANCE**

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International Standard IEC 60705 has been prepared by subcommittee 59K: Ovens and microwave ovens, cooking ranges and similar appliances, of IEC technical committee 59: Performance of household and similar electrical appliances.

This fourth edition cancels and replaces the third edition published in 1999, its amendment 1 (2004) and its amendment 2 (2006), and constitutes a technical revision. The main changes from the previous edition are as follows:

- the definition of rounding is given in 3.5;
- the usable volume and the overall volume are respectively determined in 7.2 and 7.3.

The text of this standard is based on the following documents:

FDIS	Report on voting
59K/195/FDIS	59K/198/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In this standard, the following print types are used:

- *test specifications: in italic type*
- notes: in small roman type
- other texts: in roman type.

Words in **bold** in the text are defined in Clause 3.

The following differences exist in some countries:

Clause 7: Metric dimensional measures are not in common use (USA).

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

HOUSEHOLD MICROWAVE OVENS – METHODS FOR MEASURING PERFORMANCE

1 Scope

This International Standard applies to **microwave ovens** for household use. It also applies to **combination microwave ovens**.

This standard defines the main performance characteristics of household microwave ovens which are of interest to the user, and it specifies methods for measuring these characteristics.

NOTE 1 This standard does not deal with

- ovens which cannot accept a load having a diameter of ≥ 200 mm;
- safety requirements (see IEC 60335-2-25 [1]* and IEC 60335-2-90 [2]).

NOTE 2 This standard does not apply to ovens incorporating conventional heating means only (see IEC 60350) [3].

2 Normative references

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

ISO 80000-1:2009, *Quantities and units – Part 1: General*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1

microwave oven

appliance using electromagnetic energy in the ISM frequency band of 2 450 MHz, for heating food and beverages in the cavity

NOTE 1 The microwave oven may incorporate a browning element.

NOTE 2 ISM frequency bands are the electromagnetic frequencies established by the ITU and reproduced in CISPR 11 [4].

3.2

combination microwave oven

microwave oven in which the microwave energy is combined with thermal energy

3.3

microwave transparent

property of a material having negligible absorption and reflection of microwaves

NOTE The relative permittivity of a microwave transparent material is less than 7 and the relative loss factor is less than 0,015.

* Figures in square brackets refer to the bibliography.

3.4

rated voltage

voltage assigned to the appliance by the manufacturer

4 Classification

Appliances are classified according to their type and characteristics.

4.1 According to type

- **Microwave ovens**
- **Combination microwave ovens**

The type of oven shall be stated in the report.

4.2 According to characteristics

- Usable cavity dimensions
- With or without a turntable

The characteristics of the oven shall be stated in the report.

5 List of measurements

Performance is measured by the tests listed in Table 1.

Table 1 – List of measurements

Item of measurement	Clause or subclause	Reproducibility	Microwave ovens ^a	Combination microwave ovens
External dimensions	7.1	Yes	*	*
Usable internal dimensions and usable volume	7.2	Yes	*	*
Overall internal dimensions and overall volume	7.3	Yes	*	*
Microwave power output	8	Yes	*	
Efficiency	9	Yes	*	
Square tank	10.2	Yes	*	
Multiple cup	10.3	Yes	*	
Heating beverages	11.1	Yes	*	
Heating simulated food	11.2	Yes	*	
Egg custard	12.3.1	No	*	
Sponge cake	12.3.2	No	*	
Meatloaf	12.3.3	No	*	
Potato gratin	12.3.4	No		*
Cake	12.3.5	No		*
Chicken	12.3.6	No		*
Meat defrosting	13.3	No	*	
* Test is applicable.				
^a Except for the tests of 10.2, these tests are also applicable to combination microwave ovens when operated in the microwave only mode.				

6 General conditions for measurements

6.1 General

Unless otherwise specified, the measurements are made under the following conditions.

When a metal turn table or any metal accessories are provided and used for the measurements, the load position and the corresponding shape of the metal turn table or any metal accessories shall be reported, together with the test results.

NOTE The positioning influences the repeatability of the test results.

If numbers have to be rounded, they shall be rounded to the nearest 50 W according to ISO 80000-1:2009, Annex B.3 Rule B. If the rounding takes place to the right of the comma, the omitted places shall not be filled with Zeros.

6.2 Supply voltage

*The appliance is supplied at **rated voltage** ± 1 %. If the appliance has a rated voltage range, the tests are carried out at the nominal voltage of the country where the appliance is intended to be used. This voltage is stated in the report.*

NOTE The supply voltage should be essentially sinusoidal. Results of the tests may otherwise be affected.

6.3 Test room

The tests are carried out in a substantially draught-free room in which the ambient temperature is maintained at $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

6.4 Water

Potable water is used for the tests.

6.5 Initial condition of the oven

At the beginning of each test,

- *the temperatures of the magnetron and the power supply shall be within 5 K of the ambient temperature, or*
- *the oven has not been operated for a period of at least 6 h. However, this period may be reduced if it can be demonstrated that the microwave power output, as determined in Clause 8, is available earlier.*

NOTE Forced cooling may be used to assist in reducing the oven temperature.

6.6 Control setting

The tests are carried out with the controls set to give the highest power output. Unless otherwise specified the measurements are made with boost function, if available.

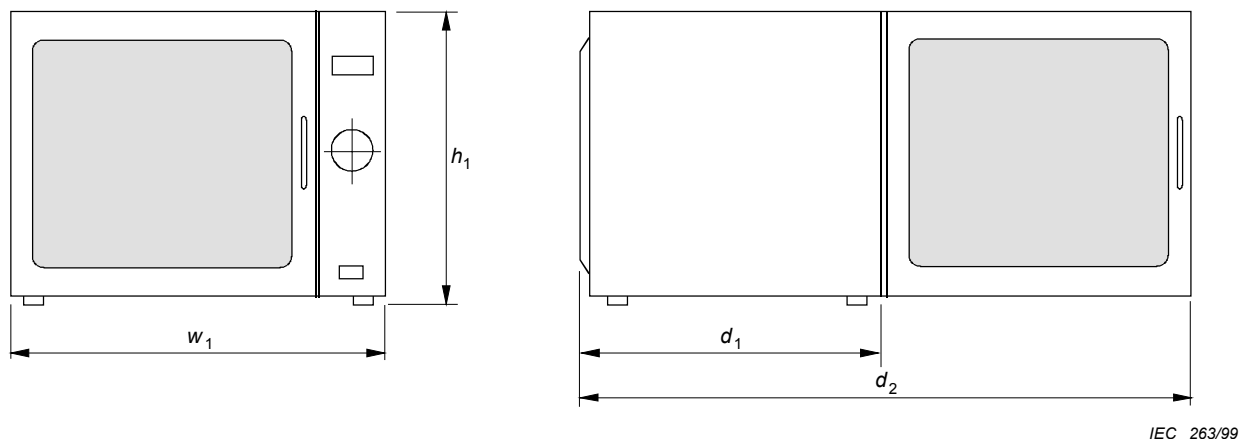
7 Dimensions and volume

7.1 External dimensions

The overall height, width and depth of the appliance, excluding any knobs and handles on the front surface, are measured. The depth is also measured with the door fully open. The

dimensions are shown in Figure 1. If adjustable feet are provided, the height of the appliance is determined with the feet in their minimum and maximum positions.

The dimensions are stated in millimetres.



h_1	height
w_1	width
d_1	depth
d_2	depth with the door open

Figure 1 – External dimensions of the microwave oven

7.2 Usable internal dimensions and usable volume

7.2.1 General

Removable items specified in the user instructions to be not essential for the operation of the appliance in the manner for which it is intended shall be removed before measurement is carried out.

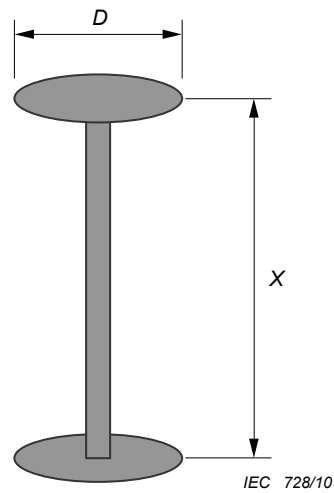
The measurement of the usable oven volume is to be carried out at ambient temperature.

The height, width and depth of the usable volume in the cavity shall be measured according to 7.2.2 – 7.2.4.

For verification purposes a gauge, as shown in Figure 2a, shall be used to determine all of the three dimensions. The gauge shall be used without appreciable force.

Dimensions are stated in millimetres.

Microwave ovens having a usable height of less than 120 mm are disregarded.



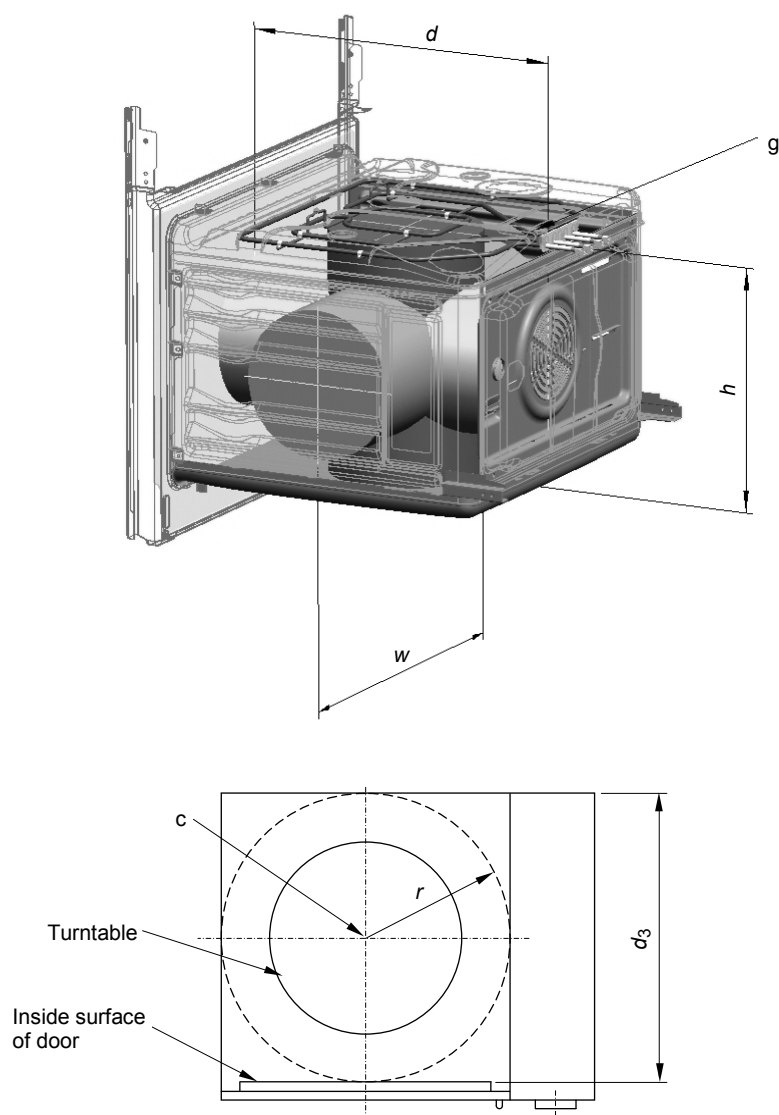
Key

D = 200 mm or 120 mm

X = dimension to be measured

(See Subclauses 7.2.2, 7.2.3 and 7.2.4)

Figure 2a – Gauge for determining the usable volume



IEC 729/10

Key

- d usable depth
- g heating element
- h usable height
- w usable width
- c centre of rotation of the turntable
- r distance from c to the nearest wall

Figure 2b – Example of usable cavity dimensions**Figure 2 – Usable internal dimensions****7.2.2 Usable height**

The usable height is the maximum length of a cylinder with a diameter of 200 mm reaching vertically from the centre of the cooking cavity bottom to the lowest point on the ceiling. The lowest point of the ceiling can be constituted by a lamp, a heating element or similar object in the area of the cylinder.

In the event that either the width or the depth of the cavity is less than 250 mm, the diameter of the cylinder to be measured shall be reduced to 120 mm.

NOTE The centre of the cavity bottom is defined by the middle of the usable depth and the middle of the usable width.

7.2.3 Usable width

The usable width is the maximum length of a cylinder with a diameter of 200 mm reaching horizontally from the left-hand side wall to the right-hand side wall of the cavity.

In the event that either the height or the depth of the cavity is less than 250 mm, the diameter of the cylinder to be measured shall be reduced to 120 mm.

NOTE The centre of the side wall of the cavity is defined by the middle of the usable depth and the middle of the usable height.

7.2.4 Usable depth

The usable depth is the maximum length of a cylinder with a diameter of 200 mm reaching horizontally from the centre of the rear wall to the inner face of the closed door.

In the event that either the width or the height of the cavity is less than 250 mm, the diameter of the cylinder to be measured shall be reduced to 120 mm.

For measuring the usable depth, the gauge is placed on a support in such a way that the axis lies horizontally in the centre of the cavity, the axis being extended slightly over the expected usable depth. The door is closed carefully so that the gauge is compressed to give the usable depth.

NOTE The centre of the rear wall of the cavity is defined by the middle of the usable height and the middle of the usable width.

7.2.5 Reciprocating tray

If there is a reciprocating tray, the extent of movement of the tray is measured and subtracted from the usable dimension in the direction of reciprocation as measured above.

7.2.6 Usable volume

The usable volume is calculated from these dimensions and is given in litres rounded to the next full litre.

If the appliance has a turntable, the base area for the usable volume is determined by the circular area formed by twice the minimum distance between the axis of rotation of the turntable and the nearest wall or door multiplied with the usable height.

If it is permissible to operate the appliance with the cavity divided into two parts by the use of components supplied with the appliance, the volume of each part shall be determined separately and the two volumes are added together.

NOTE In any case the largest achievable total volume is to be reported.

7.3 Overall internal dimensions and overall volume

7.3.1 General

Where the surfaces forming the boundaries of the cavity incorporate protrusions or depressions, the planes used for measurement shall be those comprising the largest percentages of the total areas of the surfaces. Holes in surfaces shall be disregarded when calculating areas for this determination.

The following volumes or spaces shall be disregarded:

- those occupied by removable items specified by the manufacturer as not essential for the operation of the appliance, such as shelves or temperature probes;
- those occupied by radiant heating elements if provided;
- those occupied by minor irregularities in the cooking compartment walls, including covers over waveguides and lamps;
- those occupied by turntables or reciprocating trays, their drive mechanisms and support arrangements;
- corner radii smaller than 10 mm at the intersections of the interior surfaces of the cooking cavity.

Dimensions are stated in millimetres.

7.3.2 Overall height (H)

The maximum vertical distance in millimetres between the plane of the cooking cavity bottom and the plane of the cavity ceiling.

7.3.3 Overall width (W)

The maximum horizontal distance in millimetres between the planes of the cavity side walls.

7.3.4 Overall depth (D)

The maximum horizontal distance in millimetres from the plane of the inside surface of the door when closed with the interlocks engaged to the plane of the rear cavity wall.

NOTE The overall dimensions of microwave drawers may be measured using the same principles.

7.3.5 Overall volume of rectangular cavities

The overall volume is the total internal volume of the cavity in which cooking takes place and is expressed as the product of H , W and D determined as above, divided by 10^6 and rounded to the nearest litre.

7.3.6 Overall volume of non-rectangular cavities

At a complex shaped cavity, the following measuring method is considered as one alternative measuring method. Seal all openings of the cavity and fill water to the sealed cavity and separately fill water to the concave space of the door cavity side. The volume is expressed to the nearest litre.

8 Determination of microwave power output

The measurement is made with a water load in a glass container. The water temperature is initially below ambient temperature and is raised to approximately ambient temperature by heating in the microwave oven. This procedure ensures that the heat losses and the heat capacity of the container have a minimum effect, but in any case a correction factor is introduced. However, the procedure requires the water temperature to be measured accurately.

A cylindrical container of borosilicate glass is used for the test. It has a maximum thickness of 3 mm, an external diameter of approximately 190 mm and a height of approximately 90 mm. The mass of the container is determined.

At the start of the test, the oven and the empty container are at ambient temperature. Water having an initial temperature of $10\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ is used for the test. The water temperature is measured immediately before it is poured into the container.

A quantity of $1\,000\text{ g} \pm 5\text{ g}$ of water is added to the container and its actual mass obtained. The container is then immediately placed in the centre of the oven shelf, which is in its lowest normal position. The oven is operated and the time for the water temperature to attain $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ is measured. The oven is then switched off and the final water temperature is measured within 60 s.

NOTE 1 The water is stirred before its temperature is measured.

NOTE 2 Stirring and measuring devices are to have a low heat capacity.

The microwave power output is calculated from the formula

$$P = \frac{4,187 \cdot m_w(T_2 - T_1) + 0,55 \cdot m_c(T_2 - T_0)}{t}$$

where

- P is the microwave power output, in watts;
- m_w is the mass of the water, in grams;
- m_c is the mass of the container, in grams;
- T_0 is the ambient temperature, in degrees Celsius;
- T_1 is the initial temperature of the water, in degrees Celsius;
- T_2 is the final temperature of the water, in degrees Celsius;
- t is the heating time, in seconds, excluding the magnetron filament heating-up time.

The microwave power output is stated in watts, rounded to the nearest 50 W.

9 Efficiency

The energy consumed during the test of Clause 8 is measured.

The efficiency of the oven is calculated from the formula

$$\eta = 100 \frac{Pt}{W_{in}}$$

where

- P is the calculated microwave power output in watts;
- t is the heating time, in seconds, excluding the magnetron filament heating-up time;
- η is the efficiency;
- W_{in} is including the magnetron filament heating-up energy consumption.

NOTE The energy input includes the energy consumed during the magnetron filament heat-up time.

The efficiency is stated in per cent, rounded to the nearest whole number.

10 Technical tests for performance

10.1 General

The purpose of these tests is to evaluate uniformity of heating by using water. They offer the advantage of expressing the results numerically. Since heating, cooking and defrosting of food involves the geometry and other characteristics of the load affecting the microwave field distribution, the results of these tests should be used with caution. These water tests are complementary to the performance tests of Clauses 11 to 13 and provide additional evaluation of heating uniformity.

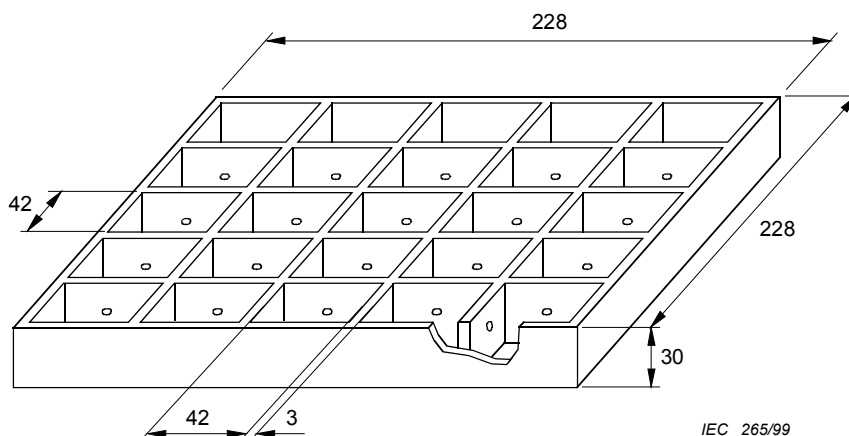
Water having a temperature of $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ is used.

The microwave power output measured according to Clause 8 is used to calculate the heating times corresponding to the energy values given for the various loads.

10.2 Square tank test

10.2.1 Procedure

The tank specified in Figure 3 is filled with $1\,000\text{ g} \pm 10\text{ g}$ of water.



Dimensions in millimetres

NOTE 1 There is a small hole approximately in the centre of each separator.

NOTE 2 The tank is made from microwave transparent material.

Figure 3 – Square tank

The water temperature is measured. The tank is placed centrally on the shelf, one side being parallel to the front of the oven. The oven is operated for a time corresponding to an output energy of $100\text{ kW}\cdot\text{s}$.

The tank is removed from the oven. The water temperature is measured within 30 s after the end of the heating period.

NOTE The temperature measurement is facilitated by using equipment having 25 thermocouples.

If the oven has more than one shelf position, the test is carried out with the tank on each position in turn.

10.2.2 Evaluation

The minimum and maximum values of the temperature rises of the nine inner compartments are calculated as percentages of the average temperature rise of all 25 compartments.

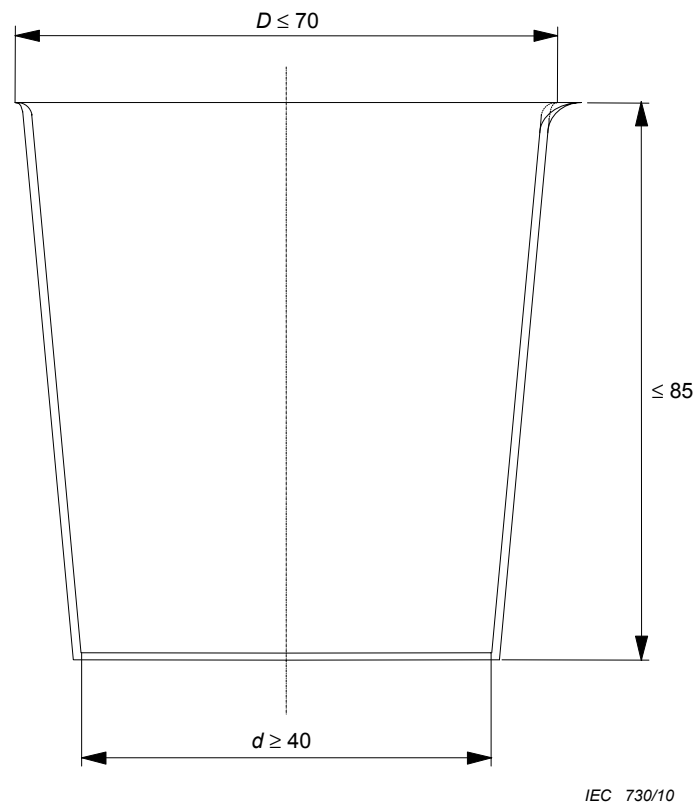
The minimum and maximum values of the temperature rises of the 16 outer compartments are calculated as percentages of the average temperature rise of all 25 compartments.

The calculated values are stated, rounded to the nearest whole number.

10.3 Multiple cup test

10.3.1 Procedure

The five cups as specified in Figure 4 are immersed in water to equalise the temperature.

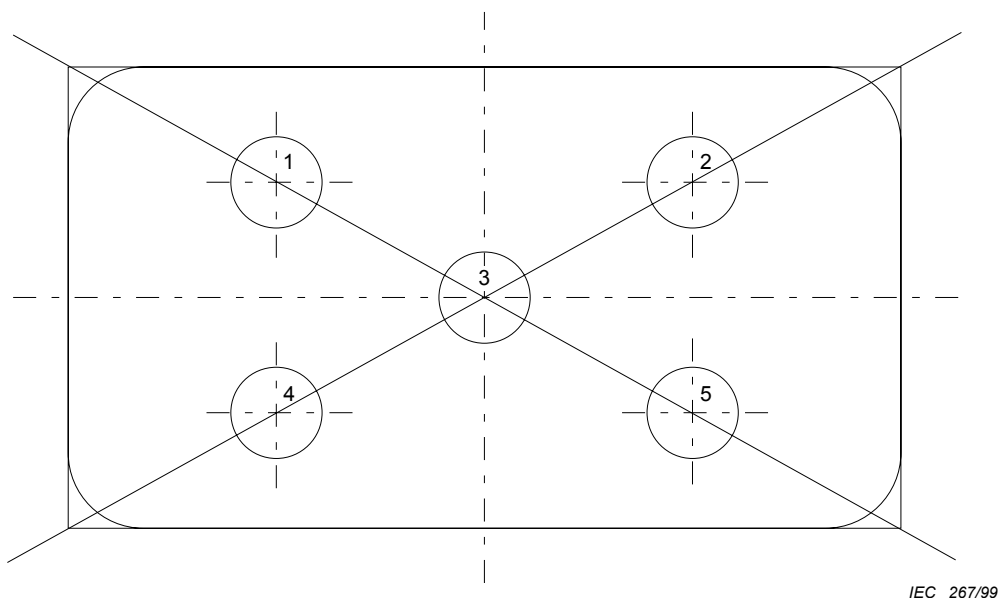


Dimensions in millimetres

NOTE The cup is made from thin wall microwave transparent material and has a circular cross-section

Figure 4 – Cup

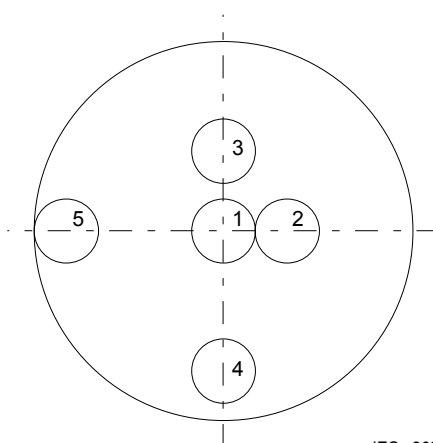
The cups are then removed from the water and dried on the outside. Each cup is filled with $100 \text{ g} \pm 1 \text{ g}$ of water and placed on a pad of thermal insulation. The water temperature is measured and the cups are placed on the oven shelf as shown in Figure 5. They are then heated for a time corresponding to an output energy of $50 \text{ kW}\cdot\text{s}$.



IEC 267/99

Cup 3 is placed at the centre. The other cups are placed on the diagonal midway between the centre and each corner.

Figure 5a – Position of cups on rectangular shelves



IEC 268/99

Cup 1 is at the centre of the turntable.

Cup 2 is contiguous with cup 1.

Cup 3 is centred at distance $r/3 + d/2$ from the centre of the turntable.

Cup 4 is centred at distance $2r/3$ from the centre of the turntable.

Cup 5 is contiguous with the edge of the turntable.

r is the radius of the turntable.

d is the maximum diameter of the cup.

Figure 5b – Position of cups on the turntable

Figure 5 – Cup positions for the test of 10.3

The cups are removed from the oven and replaced on the pad. The water is stirred and its temperature is measured. The measurements are carried out in numerical order of the cups and within 30 s after the end of the heating period.

The test is repeated, the final temperatures being measured in the reverse order.

10.3.2 Evaluation

The average temperature rise of the water is calculated for each cup position. The difference between the maximum and minimum of the five values is then calculated and divided by the total average temperature rise.

The result is stated as a percentage, rounded to the nearest whole number.

11 Heating performance

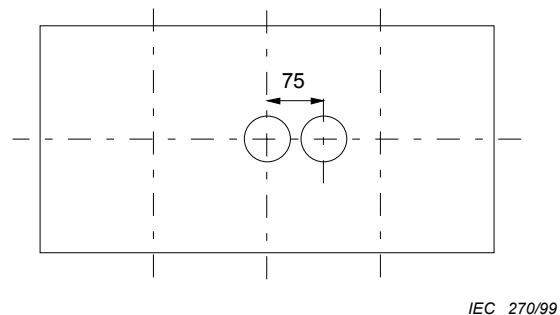
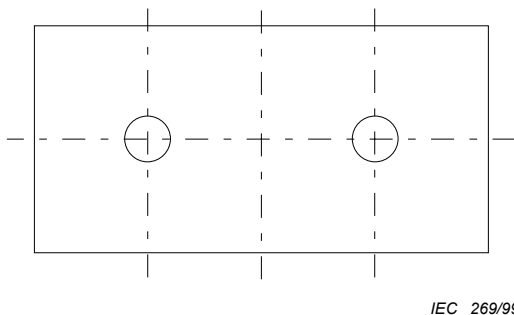
11.1 Heating beverages

11.1.1 General

The purpose of the test is to evaluate the evenness of temperatures and the heating time when the oven is used for heating beverages.

11.1.2 Procedure

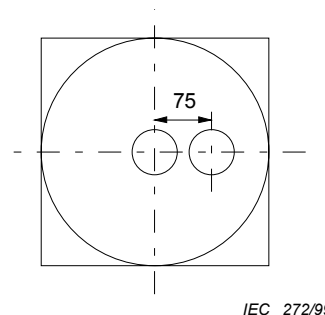
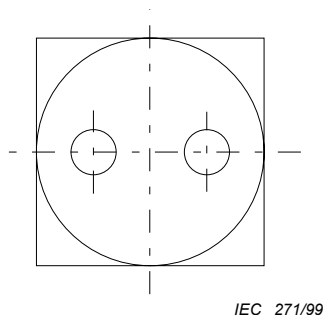
Two cups, as specified in Figure 4, are each filled with $100\text{ g} \pm 2\text{ g}$ of water having a temperature of $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. The actual water temperature is measured. The cups are placed on the shelf in the position shown in Figures 6a or 6c.



Dimensions in millimetres

Figure 6a – First position for rectangular shelves

Figure 6b – Second position for rectangular shelves



Dimensions in millimetres

Figure 6c – First position for circular shelves

Figure 6d – Second position for circular shelves

Figure 6 – Cup position for the test of 11.1

The oven is operated until the average temperature of the two cups is $80\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, the heating time being measured. After heating, the cups are removed from the oven and placed on a pad of thermal insulation. The water is stirred and the temperatures measured within 10 s of the end of the heating period.

NOTE The heating time includes the magnetron filament heat-up time.

The test is repeated but with the cups placed in the position shown in Figures 6b or 6d, the heating time being the same.

If the average water temperature of the four cups is not within the range $80\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, the test is repeated to achieve this condition by adjusting the heating time.

11.1.3 Evaluation

The heating time is calculated for a 60 K temperature rise. The result is stated, rounded to the nearest second.

The average water temperature rise of the four cups is calculated. The maximum deviation from the average is divided by the average temperature rise. The result is stated as a percentage variation, rounded to the nearest whole number.

11.2 Heating simulated food

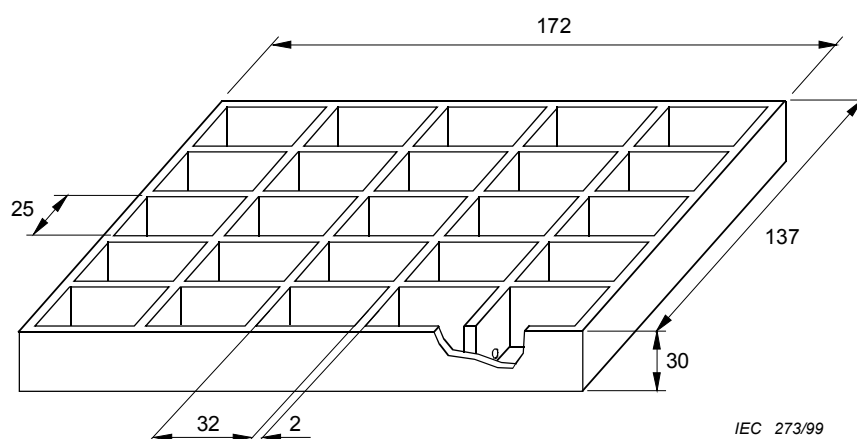
11.2.1 Test purpose

The purpose of the test is to evaluate the ability of the oven to heat uniformly by using a simulated food load.

NOTE The results are intended to be used to assess the evenness of heating a single portion of food.

11.2.2 Procedure

The tank specified in Figure 7 is cooled to approximately $10\text{ }^{\circ}\text{C}$. It is filled with $400\text{ g} \pm 4\text{ g}$ of water having a temperature of $10\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.



Dimensions in millimetres

NOTE 1 There is a small hole in each separator at the bottom of the compartment.

NOTE 2 The tank is made from microwave transparent material.

Figure 7 – Rectangular tank