

INTERNATIONAL STANDARD

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**Household electric cooking appliances –
Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring
performance**

**Appareils de cuisson électrodomestiques –
Partie 1: Cuisinières, fours, fours à vapeur et grils – Méthodes de mesure de
l'aptitude à la fonction**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HOUSEHOLD ELECTRIC COOKING APPLIANCES –

**Part 1: Ranges, ovens, steam ovens and grills –
Methods for measuring performance**

FOREWORD

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IEC 60350-1 has been prepared by subcommittee 59K: Performance of household and similar electrical cooking appliances, of IEC technical committee 59: Performance of household and similar electrical appliances. It is an International Standard.

This third edition cancels and replaces the second edition published in 2016 and Interpretation Sheet 1:2021. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) new definitions for heating function, eco function and definitions relevant for low power mode considerations are amended in Clause 3;
- b) order of clauses is changed;
- c) revision of 5.3;
- d) update of 6.2 in order to improve the reliability of volume measurement;
- e) removal of 6.7, Level of shelf;

- f) revision of Clause 7 concerning the accuracy of **eco functions** with residual heat use;
- g) revision of Clause 8 in order to improve the reliability of the method for measuring the energy consumption, especially regarding anti-circumvention;
- h) unique energy consumption measurement for all **heating functions** and **eco functions** with an indication of the energy consumption for a temperature increase of 165 K (compared to 155 K currently for forced air circulation function, for example), which results in higher energy consumption values compared to the previous edition;
- i) R_y replaced by L^* in Clause 9 and reference to IEC TS 63350;
- j) cooking time for reference measurement introduced for broccoli in Clause 10;
- k) yellow part replaced by hue angle value in Clause 10;
- l) requirements for digital assessment (see former 7.5.3.6.3) are obsolete as specified in IEC TS 63350;
- m) revision of Clause 14 (Consumption measurement of low power modes, previous Clause 12);
- n) former Annex G (informative) is cancelled due to the fact that this method for measuring an associated activity has been not applied;
- o) former Annexes B and F are obsolete, up-to-date shade charts are specified in IEC TS 63350;
- p) former Annex E will be substituted by a supporting document located on the IEC's website.

The document contains supplementary material highlighted by notes indicating the link.

The text of this International Standard is based on the following documents:

Draft	Report on voting
59K/365/FDIS	59K/370/RVD

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

The language used for the development of this International Standard is English.

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

A list of all parts in the IEC 60350 series, published under the general title *Household electric cooking appliances*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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HOUSEHOLD ELECTRIC COOKING APPLIANCES –

Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance

1 Scope

This part of IEC 60350 specifies methods for measuring the performance of electric **cooking ranges, ovens, steam ovens, and grills** for household use.

NOTE 1 This document is also applicable to portable appliances with similar functionalities that were previously covered by the withdrawn IEC 61817.

The **ovens** covered by this document can be with or without microwave function.

Manufacturers are expected to define the primary cooking function of the appliance – microwave function or thermal heat. The primary cooking function is measured with an existing method according to energy consumption. If the primary cooking function is declared in the instruction manual as a microwave function, IEC 60705 is applied for energy consumption measurement. If the primary cooking function is declared as a thermal heat, then IEC 60350-1 is applied for energy consumption measurement.

If the primary function is not declared by the manufacturer, the performance of the microwave function and thermal heat is measured as far as it is possible.

NOTE 2 For measurement of energy consumption and time for heating a load (see Clause 8), this document is furthermore not applicable to:

- microwave combination function;
- **ovens** with reciprocating trays or turntable;
- **small cavity ovens** (see 3.16);
- **ovens** without adjustable temperature control;
- **heating functions** and **eco functions** other than defined in this document;
- appliances with only solo **steam function**.

NOTE 3 This document does not apply to

- microwave ovens (IEC 60705).

This document defines the main performance characteristics of these appliances that are of interest to the user and specifies methods for measuring these characteristics.

This document does not specify a classification or ranking for performance.

NOTE 4 This document does not deal with safety requirements (IEC 60335-2-6 and IEC 60335-2-9).

NOTE 5 Appliances covered by this document can be built-in or for placing on a working surface or the floor.

NOTE 6 There is no measurement method for the energy consumption for grilling and **steam functions** available.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60584-1, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 62301:2011, *Household electrical appliances – Measurement of standby power*

IEC TS 63350:2022, *Household electrical appliances – Specification of the properties of a digital system for measuring the performance*

IEC 63474¹, *Electrical and electronic household and office equipment – Measurement of networked standby power consumption of edge equipment*

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

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

active mode

mode in which the appliance is connected to a mains power source, has been activated, and is performing any of the intended functions

EXAMPLE Producing heat transfer by thermal heat, electromagnetic energy or condensation

Note 1 to entry: Examples of recognised associated functions include displaying recipes, running an egg timer, software download, running a cooling fan and the like.

3.2

combi steam oven

appliance or compartment of a **cooking range** in which food is cooked by a combination of **oven** and **steam oven**

Note 1 to entry: Appliances with only a steam assist function also exist. For these **ovens**, the **steam function** can only be tested if this function is described in the instruction manual or if the appliance provides a setting for **steam function**.

Note 2 to entry: The term "steam" does not refer to the evaporated water from the food.

3.3

cooking range

appliance having a **hob** and at least one **oven** and which can incorporate a **grill**

3.4

delay start

condition where the user has selected a specified delay to the beginning of any **active mode**

Note 1 to entry: This mode is only applicable if the appliance provides a delay start function for the user.

¹ Under preparation. Stage at the time of publication: IEC CDV 63474:2022.

3.5

eco function

heat transmission by natural air circulation, forced air circulation or radiation for certain applications using efficient technical solutions

EXAMPLE Technical solutions:

- residual heat usage;
- low-power heating;
- or a combination of both.

3.6

grill

appliance or part of an appliance in which food is cooked by radiant heating

3.7

heating function

heat transmission by natural or forced air circulation, or radiation for baking and roasting

EXAMPLE

- Forced air circulation function which heats food mainly by circulating the air with the aid of a fan;
- conventional **heating function** which heats food mainly by natural convection of the air;
- or a combination of both functions.

Note 1 to entry: Heat transmission by steam or by microwave power, also in combination with any **heating function**, is excluded.

3.8

hob

cooktop

appliance or part of an appliance which incorporates one or more **cooking zones** and/or **cooking areas** including a **control** unit

Note 1 to entry: The **control** unit can be included in the **hob** itself or integrated in a **cooking range**.

3.9

hot steam function

heat transmission to the food by generated steam in combination with radiation or convection, or a combination of both, at ambient pressure (approximately 100 kPa) and with a temperature > 100 °C

3.10

multiple cavity appliance

appliance that has more than one separate cavity in which food is cooked and which can be controlled independently, but cannot be installed separately

3.11

network

communication infrastructure with a topology of links, an architecture, including the physical components, organizational principles, communication procedures and formats (protocols)

3.12

off mode

condition in which the appliance is connected to the mains and is not providing any **active mode** or **standby mode** and where the mode can persist for an indefinite time

Note 1 to entry: The following shall also be considered as **off mode**:

- a) conditions providing only an indication of **off mode**;
- b) conditions providing only functionalities intended to ensure electromagnetic compatibility.

3.13

oven

appliance or compartment of a **cooking range** in which food is cooked by radiation, by natural convection, by forced-air circulation or by a combination of these heating methods

3.14

oven thermostat

device or sensor that detects the temperature inside the cavity in order to control the set temperature

3.15

oven with catalytic cleaning

oven in which cooking deposits are removed by breaking them down on a special coating

3.16

small cavity oven

oven with the following dimensions:

- both internal width and internal depth are < 250 mm, or
- either one of internal width and internal depth is < 120 mm. or
- internal height is < 120 mm

Note 1 to entry: The defined maximum size of small cavity **ovens** in this document is adapted to the size of the test load used in Clause 8.

3.17

standby mode

condition where the appliance is connected to the mains and provides only the following functions, which can persist for an indefinite duration:

- (a) reactivation function, or reactivation function and a mere indication of enabled reactivation function;
- (b) information or status display;
- (c) detection function for emergency measures.

3.18

standby mode in condition of networked standby

condition where the appliance is connected to the mains and provides only the reactivation function through a connection to a **network**, which can persist for an indefinite duration

Note 1 to entry: This mode is only applicable to appliances that provide a connection function to a **network**.

3.19

pyrolytic self-cleaning oven

oven in which cooking deposits are removed by heating the **oven** to a sufficiently high temperature

3.20

steam oven

appliance or compartment of a **cooking range** in which food is cooked mainly by steam condensation at ambient pressure

Note 1 to entry: Appliances are fitted with their own steam generator.

Note 2 to entry: The term "steam" does not refer to the evaporated water from the food.

3.21

steam function

heat transmission to the food mainly by condensation of steam at ambient pressure (approximately 100 kPa) and with a temperature ≤ 100 °C

3.22

warming compartment

separate compartment in which dishes are placed in order to preheat them prior to serving, or in which food is maintained at serving temperature

4 List of measurements

4.1 Dimensions and mass

The following measurements are carried out:

- overall dimensions (see 6.1);
- internal dimensions (see 6.2);
- dimensions of shelves and steaming accessories (see 6.4);
- dimensions of grill grids (see 6.5);
- dimensions of **warming compartments** (see 6.6);
- mass of the appliance (see 6.7).

4.2 Oven and combi steam oven

The following measurements are carried out:

- preheating the empty **oven** (see 7.3);
- accuracy of the control (see 7.4);
- energy consumption and time for heating a load (see Clause 8);
- heat distribution (see 9.2);
- ability to supply heat (see 9.3).

4.3 Steam oven and combi steam oven

The following measurements are carried out:

- ability to supply steam (see 10.1);
- distribution of steam (see 10.2);
- determination of the capacity (see 10.3).

4.4 Grill

The following measurements are carried out:

- grilling area (see Clause 11);

4.5 Warming compartments

The following measurements are carried out:

- temperature control and energy consumption (see Clause 12).

4.6 Cleaning

The following measurements are carried out:

- cleaning of pyrolytic self-cleaning **ovens** (see 13.1);
- cleaning of **ovens** with catalytic cleaning (see 13.2).

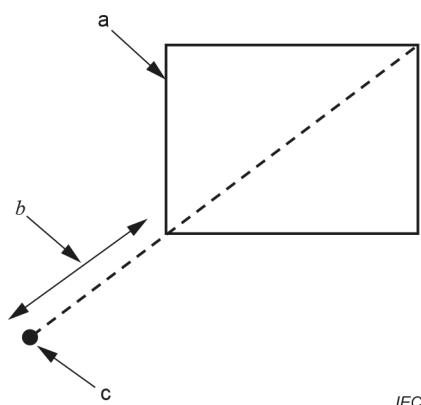
5 General conditions for the measurement

5.1 Test room

The tests are carried out in a substantially draught-free room in which the ambient temperature is maintained at $(23 \pm 2) ^\circ\text{C}$.

For the tests specified in 9.2.1, 9.3.1, 9.3.2, Clause 10 and Clause 11, maintaining the ambient temperature at $(25 \pm 5) ^\circ\text{C}$ is sufficient.

This ambient temperature is measured at a point that is at the same height as the centre of the calculated volume of the **oven** cavity under test and at a distance of 0,5 m diagonally from one of the front edges of the appliance (see Figure 1).



Key

- a **oven** (top view)
- b 0,5 m
- c thermocouple

Figure 1 – Position of the thermocouple for measuring ambient temperature

The measurement of the ambient temperature shall not be influenced by the appliance itself or by any other appliance.

5.2 Electricity supply

The appliance is supplied at rated voltage $\pm 1 \%$.

- the supply voltage shall be maintained at the main terminal at the rated voltage $\pm 1 \%$, while the heating elements are switched on;
- the supply frequency shall be at the rated frequency $\pm 1 \%$ throughout the test. If a frequency range is indicated, then the test frequency shall be the nominal frequency of the country in which the appliance is intended to be used.

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.

NOTE In the case of a fixed cable, the plug (or the end of the cable) is the reference point to maintain the voltage.

5.3 Instrumentation

Instruments used and measurements made for this document shall comply with the specifications in Table 1 and Table 2.

Table 1 – Instruments

Parameter	Unit	Minimum resolution	Maximum permissible error	Details / Additional requirements
Mass	g			
≤ 3 000 g		0,1 g	± 0,1 g	
> 3 000 g		0,5 g	± 3 g	
Temperature (thermocouples)				
• ambient temperature	°C	0,1 °C	± 0,5 K	Thermocouple with welded point
• temperature in the cavity in a range of 0 °C to 100 °C	°C	0,1 °C	± 0,5 K	Thermocouple with welded point (suitable to measurements inside of ovens with wet- steam functions)
• temperature in the cavity in a range of 100 °C to 300 °C	°C	0,1 °C	± 2,5 K	Thermocouple with welded point.
• centre temperature of the brick	°C	0,1 °C	± 1,5 K	1 mm steel tube thermocouple, class 1 in accordance with IEC 60584-1.
Dimensions	mm	1 mm	1 mm	≤ 1 mm or 0,5 % whatever is the greater
Time	s	1 s	± 1 s per hour	

Table 2 – Measurements

Parameter	Unit	Maximum permissible error	Additional requirements
Voltage	V	± 0,5 %	Measured value.
Energy consumption measurement	Wh	± 1,5 % or ± 10 Wh	Whichever is greater
Temperature measurement	°C	± 1,0 K	Excluding the thermocouples Sampling rate ≤ 1 s
For Clause 14, the power measurement requirements shall be in accordance with IEC 62301		-	In accordance with IEC 62301

5.4 Positioning the appliance

Built-in appliances are installed in accordance with the instructions for installation. Other appliances are placed with their back against a wall, unless otherwise specified in the instructions.

Floor-standing appliances are positioned between kitchen cabinets. Table-top appliances are positioned away from side walls.

For installation of the appliance, the surface shall be horizontal.

When the appliance is connected to the mains for the first time, it shall be operated once on any setting for at least 1 h before the energy consumption is measured in order to avoid changes in the appliance's performance or consumption values when tested 'out-of-the-box' compared to some time later at the same settings.

If the appliance is disconnected from the mains, it shall be ensured that required basic settings, like the time, are set and finalized before starting the measurement.

5.5 Preheating

The appliance is initially at room temperature. However, if preheating is specified, the appliance is preheated in accordance with the instructions for use. If no instructions are given, the appliance is considered to be preheated after the thermostat has switched off the first time.

5.6 Setting of controls

The control is set to give the temperature specified for the test. However, if the temperature cannot be attained due to the construction of the control, the nearest setting related to the specified temperature is chosen.

All tests, except the measurements for low-power modes (see Clause 14), shall be carried out:

- with the default factory settings;
- ensuring that no **network** is connected to the appliance for the duration of the measurement.

Using any modes and controls, resulting in measurements that are unrepresentative of the appliance's true characteristics that can occur during baking and roasting under comparable conditions are not allowed.

EXAMPLE A camera used to detect that the appliance is under test is not allowed.

5.7 Rounding

If numbers shall be rounded, they shall be rounded in accordance with ISO 80000-1:2009, Clause B.3, rule B.

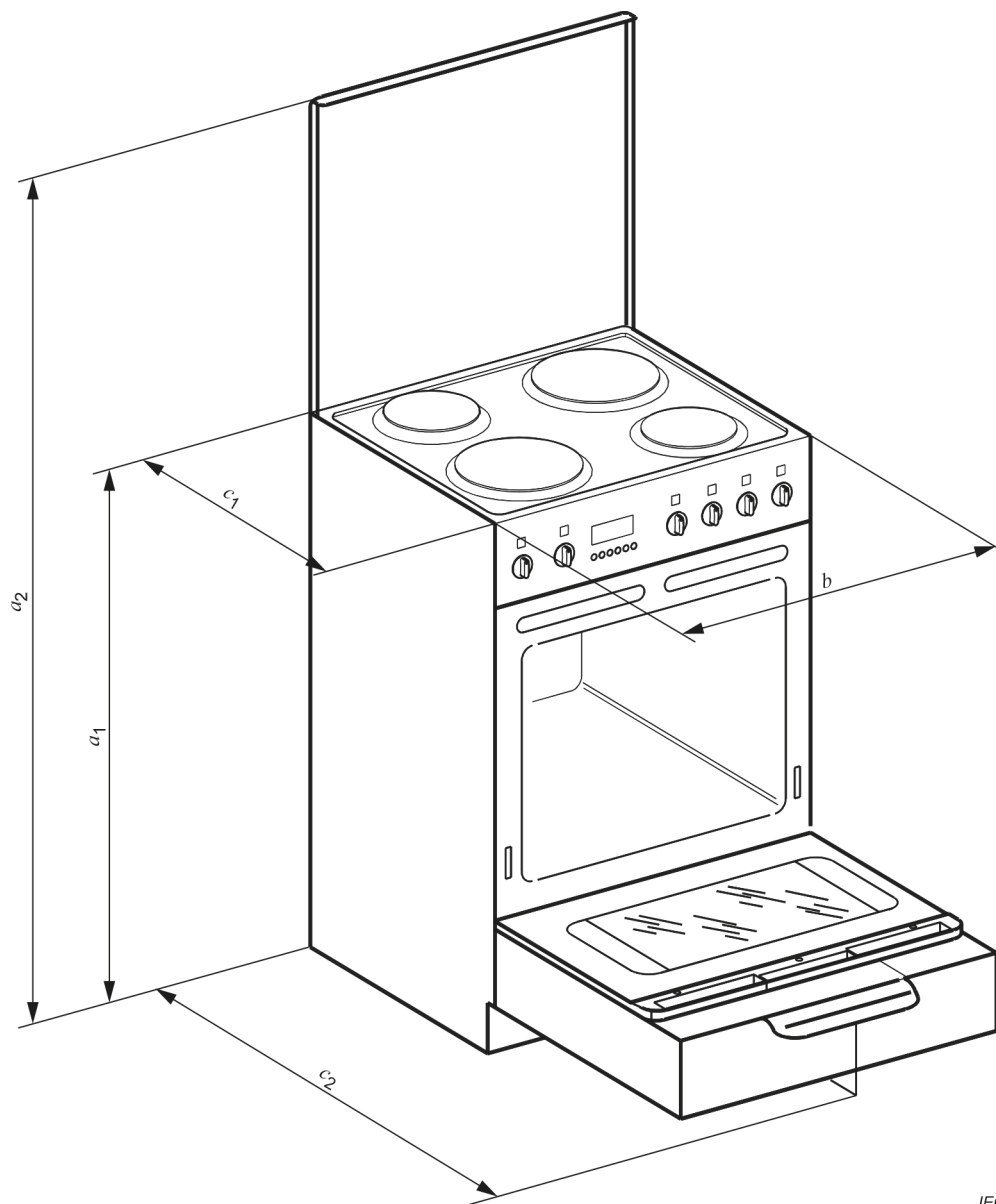
6 Dimensions and mass

6.1 Overall dimensions

The overall dimensions of the appliance are measured and stated in millimetres as follows:

Cooking ranges and other appliances placed on a surface are measured as shown in Figure 2.

Built-in **ovens** are measured as shown in Figure 3.



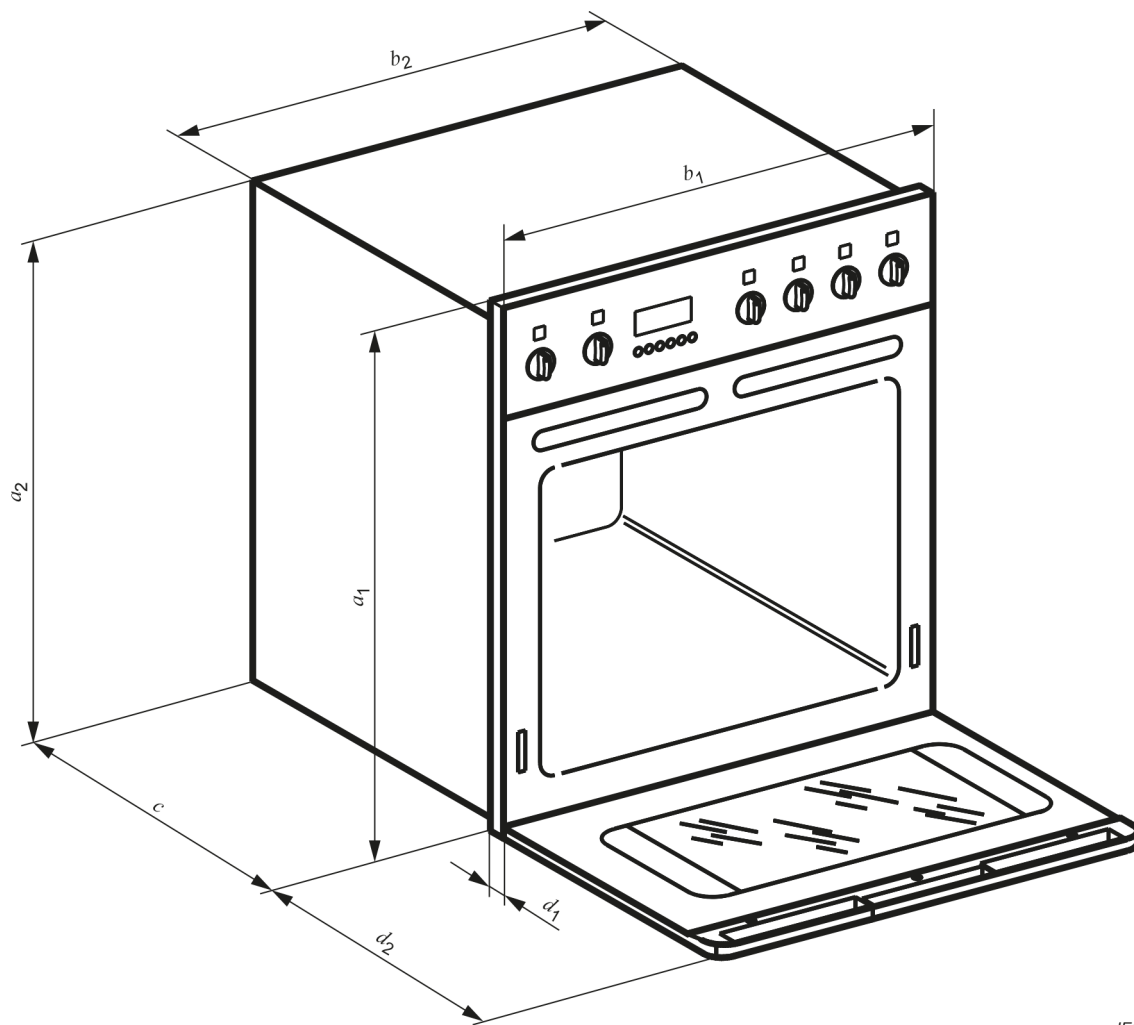
IEC

If adjustable feet are provided, the height is measured with the feet in both extreme positions.

Key

- a_1 height from the supporting surface to the **hob** surface
- b overall width of the appliance
- a_2 maximum height from the supporting surface to the uppermost part of the appliance, with any lid in the open position
- c_1 depth of the appliance, ignoring any knobs, etc.
- c_2 maximum depth of the appliance, with any doors and drawers fully open

Figure 2 – Dimensions of appliances



IEC

Key

- a_1 front height of the appliance
- b_1 front width of the appliance
- c maximum depth of the appliance within the kitchen furniture
- a_2 maximum height of the appliance within the kitchen furniture
- b_2 maximum width of the appliance within the kitchen furniture
- d_1 depth of the appliance outside the kitchen furniture, ignoring any knobs, etc.
- d_2 depth of the appliance outside the kitchen furniture, with any doors and drawers fully open

Figure 3 – Dimensions of built-in appliances

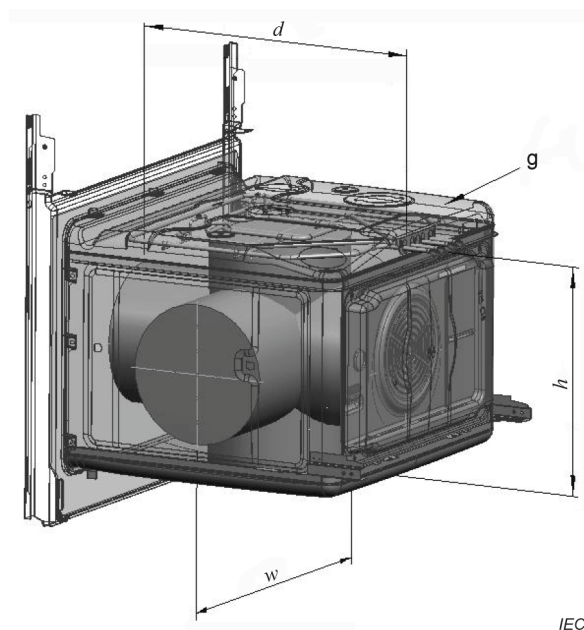
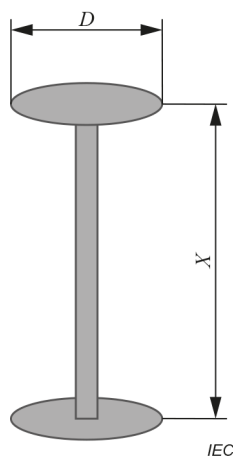
6.2 Internal dimensions and calculated volume

6.2.1 General

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

The height, width and depth of the calculated volume in the cavity shall be measured in accordance with 6.2.2 to 6.2.4. The measurements are shown in Figure 4.

For verification purposes, the gauge shown in Figure 5, shall be used to determine all three dimensions. The gauge shall be used without appreciable force. Dimensions are stated in millimetres.

**Key** d depth g heating element h height w width**Figure 4 – Internal dimensions****Key** $D = 200 \text{ mm or } 120 \text{ mm}$ $X = \text{dimension to be measured}$ **Figure 5 – Gauge for measuring these dimensions****6.2.2 Internal height**

The height is the maximum length of a cylinder with a diameter of 200 mm reaching vertically from the centre of the cavity floor to the lowest point on the ceiling. No accessories, such as a grill grid, are inserted.

A lamp, a heating element or similar object in the area of the cylinder can constitute the lowest point of the ceiling. Protruding parts such as lamp covers, heating elements and fixing hooks shall not be removed or folded away.

If 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 internal depth and the middle of the internal width.

6.2.3 Internal width

The internal 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.

Side racks shall be removed if they can be removed without a tool. If parts are fixed to or by the side racks, they shall be removed as well.

NOTE 1 A coin or a spoon is not considered as a tool.

If 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 2 The centre of the side wall of the cavity is defined by the middle of the depth and the middle of the height.

6.2.4 Internal depth

The 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.

Protruding parts such as the baffle or components of the door shall not be removed.

If 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 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 depth. The door is closed carefully so that the gauge is compressed to give the internal depth.

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

6.2.5 Calculated volume

The calculated volume is determined from these three dimensions and is stated in litres, rounded to the nearest litre.

6.3 Overall internal dimensions and overall volume

6.3.1 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, racks or temperature probes;
- those occupied by heating elements;
- those occupied by minor irregularities in the cooking compartment walls, including covers over temperature sensors and lamps;
- those occupied by the convection baffle;

- corner radii smaller than 50 mm at the intersections of the interior surfaces of the cooking cavity.

Dimensions are stated in millimetres.

6.3.2 Overall height (H)

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

6.3.3 Overall width (W)

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

6.3.4 Overall depth (D)

The maximum horizontal distance, in mm, from the plane of the inside surface of the door when closed to the plane of the rear cavity wall.

6.3.5 Overall volume of rectangular cavities

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

6.3.6 Overall volume of non-rectangular cavities

Non-rectangular cavities shall have the volume of any non-conforming section such as a curved door or cavity wall determined by direct measurement and the application of conventional geometrical calculations. The remainder of the cavity shall be treated as a rectangular cavity and the individual volumes added together. The volume is expressed to the nearest litre.

6.4 Dimensions of shelves and steaming accessories

The usable width and usable depth of the shelf are measured. The dimensions are determined 5 mm above the surface of the shelf.

The surface area is calculated and stated in square centimetres, rounded to the nearest 10 cm².

NOTE The shelf can be a baking tray or a steaming accessory.

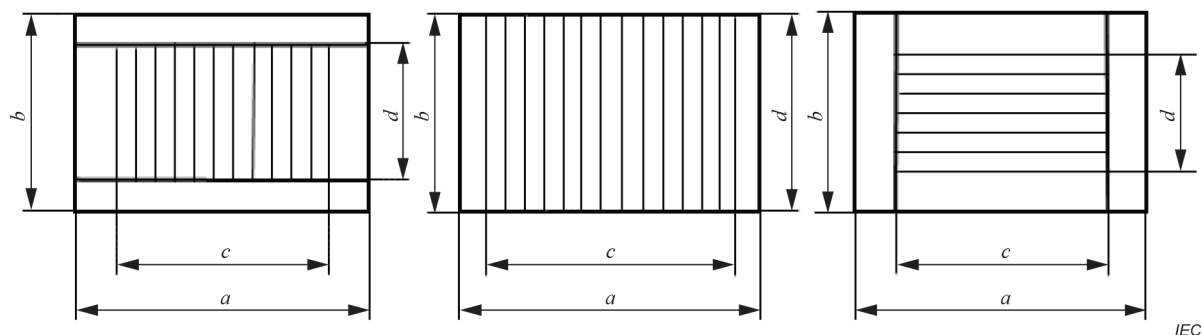
6.5 Dimensions of grill grids

6.5.1 Entire area

The entire area of the grill grid is determined by measuring the maximum width and the maximum depth of the outer rods. This entire area of the grill grid is calculated and stated in square centimetres, rounded to 10 cm².

6.5.2 Usable area

The usable width and usable depth of the grill grid are measured, by considering only the inner grid, which is suitable for placing food. The usable area of the grill grid is calculated and stated in square centimetres, rounded to 10 cm². See Figure 6.



Key

- a is the maximum width of the grill grid
- b is the maximum depth of the grill grid
- c is the usable width of the grill grid
- d is the usable depth of the grill grid

Figure 6 – Examples for determining the entire area and usable area of a grill grid

6.6 Dimensions of warming compartments

The height, width and depth of the calculated volume within the **warming compartment** are measured and indicated in millimetres.

NOTE When a heating element is located inside the **warming compartment**, the dimensions are measured up to its most protruding part.

6.7 Mass of the appliance

The mass of the appliance is determined and expressed in kilogrammes, rounded to the nearest kilogramme. To determine the mass, only the accessory described in the test in Clause 8 shall be considered.

7 Preheating and accuracy

7.1 Purpose

The purpose of the tests in Clause 7 is to assess the performance of the **oven** and **combi steam oven** in relation to preheating and functioning of the control.

7.2 Test setup

The air temperature in the empty **oven** and **combi steam oven** is measured with a thermocouple that conforms to the criteria specified in 5.3 fixed to the grid that is delivered with the appliance. It is placed in the **oven** and **combi steam oven** in a way that the welding point of the thermocouple is located at the centre of the calculated volume of the **oven** and **combi steam oven** with a distance of at least 30 mm from the grid.

If no grid can be purchased from the manufacturer of the appliance, the thermocouple shall be positioned in the centre in a suitable way.

Thermocouples are led through the door gap in a way that the door is completely closed without applying additional force.

The door shall be completely closed.

7.3 Preheating the empty oven

The purpose of this test is to measure the energy consumption and time it takes to preheat an empty **oven** or **combi steam oven** from room temperature by a given temperature rise.

Prior to the measurement, the whole appliance (this includes the material and the insulation) shall be at ambient temperature of $(23 \pm 2) ^\circ\text{C}$. In **multiple cavity appliances**, each **oven** cavity shall be measured separately. Only the cavity measured shall be switched on.

A **heating function**, **eco function** or **hot steam function** shall be selected. The temperature control is set to the maximum position. The appliance is heated until the rise reaches 165 K.

The temperature rise is the difference of the **oven** temperatures measured at the beginning and at the end of the test.

The time t_{ph} (t_{ph} means preheating) in minutes and seconds and the energy consumption E_{ph} in kWh shall be measured.

The time for preheating of the empty **oven**, t_{ph} , shall be reported and rounded to the nearest half minute.

The energy consumption for preheating the empty **oven**, E_{ph} , shall be reported in kWh and rounded to two decimal spaces.

If the **oven** has an additional preheating setting, the test shall be repeated with this setting.

NOTE The energy consumption of components, such as lamps and fans that are automatically switched on with the appliance, is included in the measurement.

7.4 Accuracy of the control

7.4.1 Purpose

The purpose of this test is to determine the accuracy of the temperature control and to calculate the corrected temperature setting used for tests for Clause 9.

7.4.2 Measurements

Prior to the measurements, the whole appliance shall be at ambient temperature of $(23 \pm 2) ^\circ\text{C}$.

The temperature control element is set to the position marked 150 °C and the appliance is heated for $t_{\text{check}, 150} = 60$ min. Then the temperature control element is set to the position marked 200 °C and the appliance is heated for further $t_{\text{check}, 200} = 60$ min. Then the temperature control element is set to the position marked 250 °C and the appliance is heated for a further $t_{\text{check}, 250} = 60$ min.

Markings of the control element for grilling are ignored. If 250 °C is not marked, the next higher marked setting is taken into account. If the highest marked setting is below 250 °C, the highest possible marked setting shall be chosen. If the control element is not marked in degrees Celsius, the control element is set at appropriate markings taking into account the instructions for use.

Measurements shall be performed without fast preheating function.

The **oven** temperature is recorded continuously in line with 7.2.

7.4.3 Assessment

For assessing the accuracy of control, the deviations from each set temperature (V_{150} , V_{200} , V_{250}) to the **oven** temperatures are determined where the **oven** temperature is the arithmetic mean during the last 20 min of t_{check} .

Regarding the corrected temperature setting used for the tests in Clause 9, the level of the deviations V_{150} , V_{200} and V_{250} are decisive. The temperature setting used for tests in Clause 9 shall only be corrected if all deviations V_{150} , V_{200} and V_{250} are < 20 K.

NOTE Deviations equal to or more than 20 K are not corrected because the device is assumed to have an **eco function** that uses residual heat.

To calculate the corrected temperature setting for the tests in Clause 9, the **oven** temperatures T_{150} and T_{200} are used and linear regression is applied.

8 Energy consumption and time for heating a load

8.1 Purpose

The purpose of this test is to measure the energy consumption and the time for heating a load for a given **heating function** or an **eco function** in an **oven**, **combi steam oven** and **combi microwave oven**. The load is a water-saturated brick that is representative of any food, e.g. a roast dinner.

8.2 Symbols and abbreviations

Table 3 shows the main symbols used in Clause 8.

Table 3 – Symbols

$T_{s,k}$	temperature setting displayed by a knob or by the control display, s is the setting and $k = 1, 2, 3$ (summing index)
$T_{o1,k} / T_{o2,k}$	measured observer temperature in phase 1 or phase 2
$T_{a1,k} / T_{a2,k}$	measured ambient temperature in phase 1 or phase 2
$T_{c2,k}$	measured temperature in the cavity centre in phase 2
$\Delta \bar{T}_{c2,1}$	average temperature rise as difference between the average ambient temperature and the cavity temperature measured in phase 2
$\tilde{T}_{c2,k}$	measured temperature in the cavity centre in phase 2, smoothed
$\bar{T}_{c2,k}$	average temperature in the cavity centre in phase 2
E_k	measured energy consumption in phase 1, when the last of the two thermocouples in the brick reaches a temperature rise of 55 K
t_k	measured time in phase 1, when the last of the two thermocouples in the brick reaches a temperature rise of 55 K, also applied for phase 2
t_0	start time of phase 1 or phase 2
i_s	start index determined to calculate $\Delta \bar{T}_{c2,1}$ and $\tilde{T}_{c2,k}$; i_s depends on the oven function and the temperature profile
c_k	ratio between the observer temperatures measured in phase 1 and in phase 2 in the whole phase (t_0 to t_k)
s_k	ratio between the observer temperatures measured in phase 1 and in phase 2 in the last 20 min of the whole phase (t_0 to t_k)

$\Delta T_{s,k}$	difference between temperature setting T_s and average temperature $\overline{T}_{c2,k}$ in the cavity centre in phase 2
$E_{\Delta T_0}$	calculated nominal energy consumption in kWh for heating a load at ΔT_0
ΔT_0	nominal temperature rise; 165 K for all heating functions and eco functions
$t_{\Delta T_0}$	calculated nominal time in s for heating a load at $\Delta T_0 = 165$ K for all heating functions or eco functions

8.3 Test load

8.3.1 General

The test load shall be a brick with two holes for temperature measurements, as shown in Annex C.

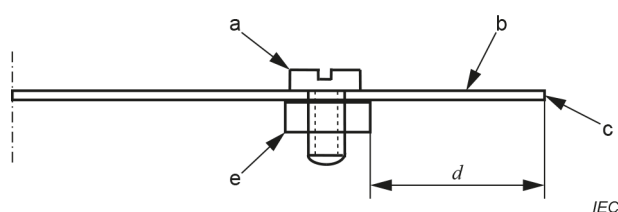
8.3.2 Pre-treatment

A new brick shall be dried before using it for the first time in an **oven** with a forced air circulation function at ≥ 175 °C for 3 h. No more than two bricks shall be dried at the same time in the same **oven**.

NOTE 1 A brick that is still damp due to a previous test needs at least 8 h to be dried as described above. However, see Note 1 in 8.3.3.

The weight m_d ($_d$ means dry) of the completely dry brick without thermocouples shall be measured within 5 min after removal from the **oven** and shall be noted in grams. The dry weight m_d shall be in accordance with the dry weight specified in Clause C.1. The brick shall be identified for accurate calculation of the water absorption in accordance with 8.3.3.

Place markings 32 mm from the measuring point of the two thermocouples in accordance with 5.3, and insert the thermocouples into the holes until the marking matches with the surface of the brick. The thermocouples shall be fixed to ensure that the measuring points remain at a depth of 32 mm during the whole test procedure. See the example in Figure 7.



Key

- a screw with a hole of 1 mm
- b steel tube
- c measuring point
- d 32 mm
- e nut

Figure 7 – Example of a thermocouple

The thermocouples may be fixed by means of a droplet of silicon glue at the surface of the brick or by other suitable means.

Owing to the porosity of the brick, ensure that the holes of the brick are not enlarged if the thermocouples are removed and reinserted.

NOTE 2 A brick can be used for about twenty tests when handled with normal care.

8.3.3 Preparation

The brick, pre-treated in accordance with 8.3.2, shall be prepared for energy measurement as follows.

NOTE 1 It is not necessary to pre-treat the brick between uses. It gets approximately the same water content each time it is soaked in water.

The brick shall be put into a water container so that it is completely covered with water at less than 20 °C. The water container with the brick is placed for at least 8 h into a refrigerator and cooled down to a centre temperature (both thermocouples) of (5 ± 2) °C.

A hot brick shall be cooled down in air to a centre temperature below 25 °C before putting it into the cold water.

NOTE 2 A hot brick put directly into cold water would absorb substantially more water due to the capillary effect and different water viscosity at different temperatures.

Between test series, the brick should be stored in a refrigerator and preferably not soaked with water. The water used for soaking the brick should be kept (to reduce dissolving processes), i.e. the brick's storage water can be reused.

After the brick has been taken out of the water container, excessive water is allowed to drip off for 1 min. Then the weight of the wet brick m_w shall be measured and the absorbed amount of water is determined in g taking into account the weight of the thermocouples, if appropriate, by calculating $\Delta m = m_w - m_d$ (m_w means wet or water; m_d is measured according to 8.3.2). The amount of absorbed water shall be as specified in Clause D.1.

The temperature of the brick is measured. Both thermocouples shall read (5 ± 2) °C.

8.4 Measurement

8.4.1 Test Procedure

Prior to all measurements, the whole appliance (this includes the material and the insulation) shall be at an ambient temperature of (23 ± 2) °C. In **multiple cavity appliances**, measure each **oven** cavity separately and switch on only the cavity measured.

Remove all accessories delivered with the appliance, such as baking trays, side racks that are not used for placing the load.

Measure the cavity temperature $T_{c,k}$ in the empty appliance with a thermocouple that conforms to 5.3 fixed to the grid delivered with the appliance. Place this grid in the appliance in a way that the welding point of the thermocouple is located at the centre of the calculated volume of the **oven** and **combi steam oven** with a distance of at least 30 mm from the grid. If no grid can be purchased from the manufacturer of the appliance, the thermocouple should be positioned in the centre in a suitable way.

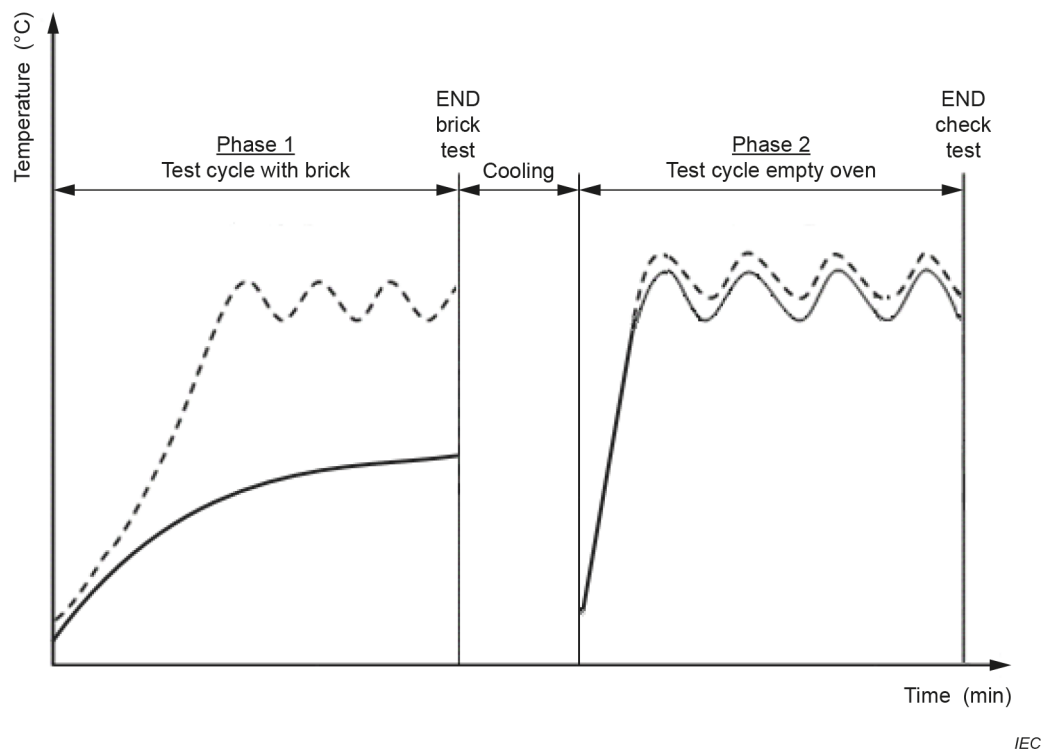
Additionally record the temperature $T_{o,k}$ close to the **oven thermostat** continuously. For this, fix a second thermocouple close to the **oven thermostat** inside the cavity as described in Figure 9, Figure 10 and Figure 11. This thermocouple is the "observer thermocouple".

Lead the thermocouples through the door gap in a way that the door is completely closed without applying additional force.

To determine the energy consumption of a **heating function** or an **eco function**, three measurements with different temperature settings are necessary. Each measurement consists of two phases:

- phase 1: energy measurement while the brick is in the **oven**;
- phase 2: determination of the reference temperature and the c -factor (empty **oven**).

The diagram in Figure 8 shows the entire process of measurement.



Phase 1		Cooling	Phase 2	
---	observer temperature $T_{o1,k}$		----	observer temperature $T_{o2,k}$
—	centre temperature brick		—	cavity temperature $T_{c2,k}$

Figure 8 – Entire process of measurement

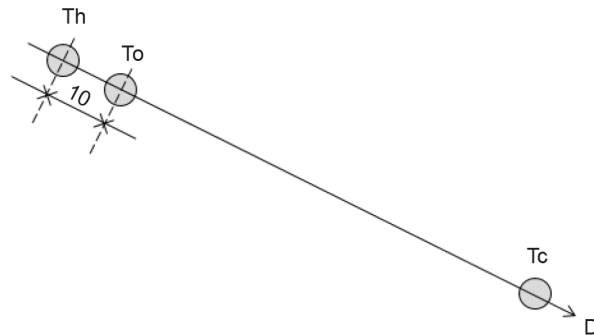
For both phases, the temperature $T_{o,k}$ is recorded continuously with a thermocouple fixed with a distance ≤ 10 mm to the **oven thermostat** inside the cavity without contact. This thermocouple is the observer thermocouple; it is fixed symmetrically in both x and y axes, on the direction of the z axis (see Figure 10 and Figure 11). The D axis is oriented toward the centre of the cavity (see Figure 9). Mount the observer thermocouple on the closest wall of the cavity with a heat resistant tape.

If the **oven thermostat** is not accessible, take into account the manufacturer's instructions regarding the position of the thermocouple.

If more than one **oven thermostat** is available, the information about the **oven thermostat** relevant for the temperature control of the considered cavity can be obtained from the manufacturer's instructions.

Keep the position of the observer thermocouple unchanged during phase 1 and phase 2.

Dimensions in millimetres



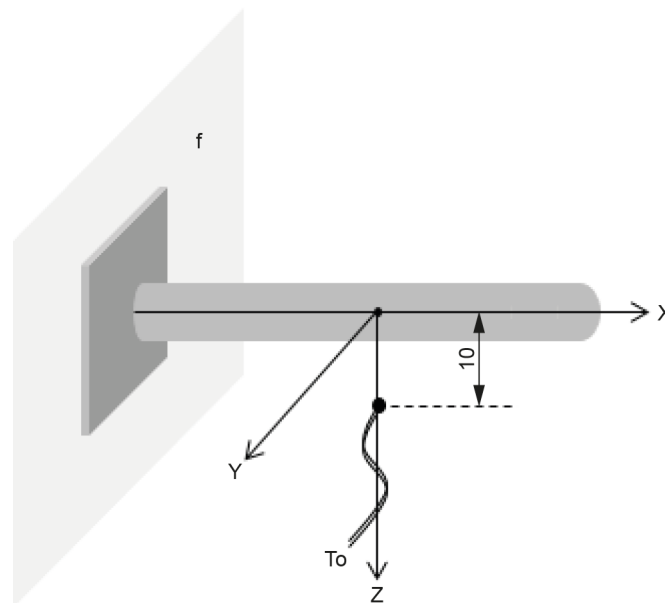
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Key

- Th **oven thermostat**
- To **observer thermocouple**
- Tc **oven centre thermocouple**
- D **direction toward the oven centre**

Figure 9 – Installation observer thermocouple

Dimensions in millimetres



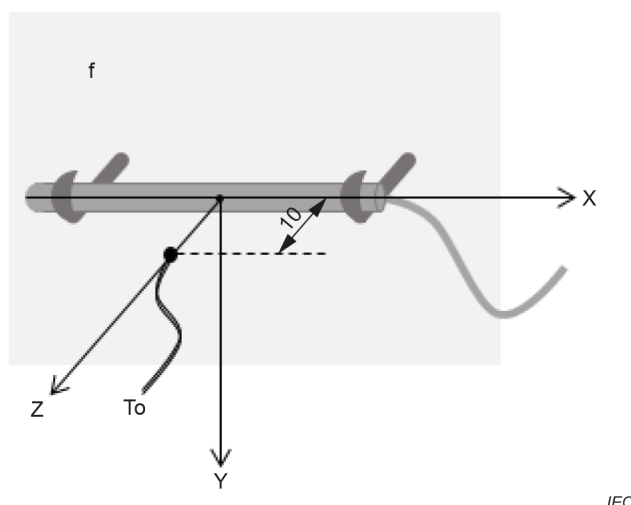
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Key

- f **fixation wall - position of the thermostat to the fixation wall (the thermostat body shows a perpendicular position to the surface of the fixation wall)**
- To **observer thermocouple**
- Z **direction – under thermostat**

Figure 10 – Vertical installation of the observer thermocouple

Dimensions in millimetres

**Key**

f fixation wall - position of the thermostat to the fixation wall where the thermostat body shows a parallel position to the surface of the fixation wall

To observer thermocouple

Z direction – in front of thermostat

Figure 11 – Horizontal installation of the observer thermocouple

8.4.2 Oven settings

For measuring the energy consumption, a **heating function** or **eco function** shall be used. If more than one **heating function** or **eco function** is available, the recommendation in the manufacturer's instructions is taken into account.

The temperature control is set to a position where the average temperature rises $\Delta \bar{T}_{c2,k}$ as defined in Table 4 can be expected. $\Delta \bar{T}_{c2,k}$ is the difference between the average ambient temperature and the average cavity temperature measured in phase 2; $k = 1, 2, 3$ (k is the summing index).

The temperature setting T_s , which is the displayed setting of the knob or the control display (s is the setting), shall be noted. If the temperature steps are not clearly marked, the temperature setting should be determined by the angle according to the visible marks on the knob using polar coordinate paper (see Annex E).

If the temperature is set by a knob, the knob shall always be turned from zero to the required setting.

Table 4 – Temperature rise for three settings

Temperature rise	
$\Delta \bar{T}_{c2,1}$	(135 ± 15) K
$\Delta \bar{T}_{c2,2}$	(165 ± 15) K
$\Delta \bar{T}_{c2,3}$	(195 ± 15) K ^a
^a Or the maximum temperature rise if this value cannot be reached.	

Report the used **heating function** or **eco function** and the temperature setting $T_{s,k}$ for each measurement.

8.4.3 Phase 1

- Remove all accessories delivered with the appliance, such as baking trays and side racks, which are not used for placing the brick.
- Place the brick, prepared in accordance with 8.3.3, in the geometric centre of the calculated cavity with its largest surface centrally on the grid delivered with the appliance, with the thermocouples on the upper side. If no grid can be purchased from the manufacturer of the appliance, any suitable grid should be used, however not a baking tray, tin or similar.
- Insert the grid into a shelf support level of the appliance so that the centre of the brick comes as close as possible to the centre, but not higher than the centre, of the calculated cavity. The longest axis of the brick shall be parallel with the appliance front. Where the grid can be inserted in two different positions (e.g. upside down gives a different height), the position should be taken that brings the brick's centre closest to the cavity's centre, but not higher. Only if the grid is already placed on the lowest level may the centre of the brick be higher than the centre of the cavity.
- If the appliance is prepared with the thermocouples, do not operate it with a function combined with microwave energy. Out-coupled microwave power through the thermocouples can damage instruments.

NOTE 1 See Annex D.

- Start the measurement within 3 min from the removal of the brick from the refrigerator by switching on the appliance following the requirements for setting.

The following data are measured:

- the measured energy consumption(s) E_k in kWh and the time(s) t_k in min and s, when the last of the two thermocouples in the brick reaches a temperature rise of 55 K, $k = 1, 2$ and 3;
- centre temperatures of the brick in °C;
- $T_{o1,k}$ continuously measured by the observer thermocouple in °C;
- ambient temperature $T_{a1,k}$ from the beginning of the test (when the appliance is switched on) to the end of the test (i.e. when the last of the two thermocouples in the brick has reached 55 K temperature rise) in °C.

NOTE 2 The energy consumption of components such as lamps and fans that are automatically switched on with the appliance, is included in the measurement.

8.4.4 Phase 2

In phase 2, the measurement of phase 1 is repeated in an empty **oven**.

For this, remove the brick and cool the appliance as long as it is ensured that the whole appliance (this includes the material and the insulation) is at ambient temperature of $(23 \pm 2) ^\circ\text{C}$. Forced cooling by a fan can be applied.

After cooling, verify that the setting is strictly identical to that used in phase 1 (see 8.4.3). This includes:

- unchanged position of the observer thermocouple;
- same temperature setting $T_{s,k}$;
- same **heating function**.

Switch on the appliance and operate for the same duration of t_k (measured in 8.4.3).

Measure the following data continuously:

- $T_{o2,k}$ from t_0 to t_k by the observer thermocouple during phase 2 in $^\circ\text{C}$;
- $T_{c2,k}$ from t_0 to t_k by the centre thermocouple during phase 2 in $^\circ\text{C}$;
- $T_{a2,k}$ from t_0 to t_k by the thermocouple positioned in accordance with 5.1 for measuring the ambient temperature in $^\circ\text{C}$.

8.5 Calculation

8.5.1 Smoothing the measured values

For further calculation, the measured data $T_{c2,k}$ are smoothed by a moving average applying Formula (1) in order to exclude possible measurement noise.

$$\tilde{T}_{c2,k,i} = \frac{1}{2n+1} \sum_{j=-n}^n T_{c2,k,i+j} \quad (1)$$

Where:

$\tilde{T}_{c2,k,i}$ is the smoothed temperature in the cavity centre in phase 2 in $^\circ\text{C}$;

$T_{c2,k,i+j}$ is the measured temperature in the cavity centre in phase 2 in $^\circ\text{C}$;

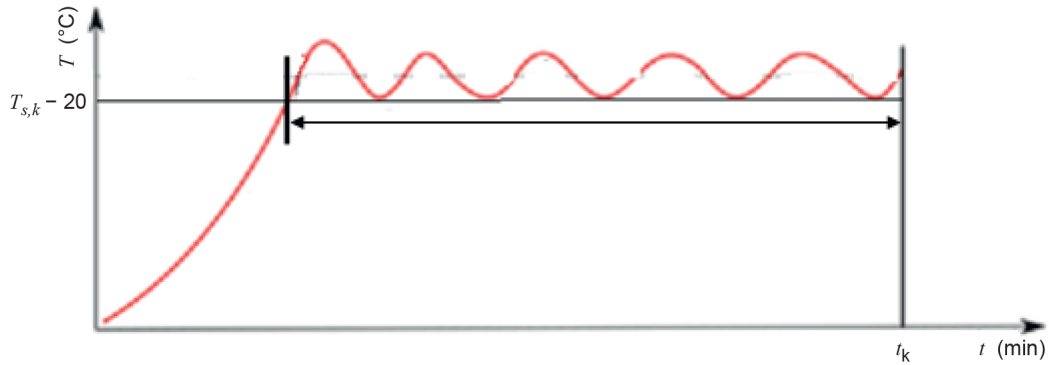
i is the sample index;

n is defined by $n = \left\lfloor \frac{f_s \times t_{\text{mov}} - 1}{2} \right\rfloor$ and where $t_{\text{mov}} = 30 \text{ s}$;

f_s is the sampling rate in 1/s.

8.5.2 Determining the average temperature rise for a heating function (phase 2)

If the manufacturer classifies the function under test as a **heating function**, this clause shall be applied to determine the average temperature rise.



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Figure 12 – Example – average temperature rise for a heating function

The average temperature rise for a **heating function** shall be calculated in the following period:

The start of this period shall be the point where $\tilde{T}_{c2,k}$ reaches $T_s - 20$ K. Hence, the start index i_s shall be defined as:

$$\tilde{T}_{c2,k}(i_s) = T_s - 20 \quad (2)$$

If the time period between $T_{s,k} - 20$ and end of measurement is less than 60 % of whole time t_k , the time period is prolonged to 60 % of t_k . In this case, the start index i_s shall be defined as:

$$i_s = i_k - 0,6i_k \quad (3)$$

The average temperature rise $\Delta\bar{T}_{c2,k}$ shall be calculated by averaging the difference of $T_{c2,k,i}$ and $T_{a2,k,i}$ for i_s until the end of the measurement (see Figure 12) by applying Formula (4):

$$\Delta\bar{T}_{c2,k} = \frac{\sum_{j=i_s}^{i_k} (\tilde{T}_{c2,k,j} - T_{a2,k,j})}{i_k - i_s + 1} \quad (4)$$

Where:

$\Delta\bar{T}_{c2,k}$ is the average temperature rise in phase 2 in K;

$\tilde{T}_{c2,k,j}$ is the measured temperature in the cavity centre in phase 2, smoothed, in °C;

$T_{a2,k,j}$ is the measured ambient temperature in phase 2 in °C;

i_s is the sample index representing the starting point;

i_k is determined by $i_k = \lfloor t_k \times f_s \rfloor$.

The average temperature $\bar{T}_{c2,k}$ shall be calculated accordingly to Formula (5).

$$\bar{T}_{c2,k} = \frac{\sum_{j=i_s}^{i_k} \tilde{T}_{c2,k,j}}{i_k - i_s + 1} \quad (5)$$

Where:

$\bar{T}_{c2,k}$ is the average temperature in the cavity centre in phase 2 in °C.

8.5.3 Determining the average temperature rise for an eco function (phase 2)

If the manufacturer classifies the function under test as an **eco function**, this clause shall be applied to determine the average temperature rise. For an **eco function**, the temperature shall be averaged within a 20 min period depending on the technical solution used for saving energy. See examples in Figure 13 and Figure 14.

– Technical solution A (See Figure 13)

The average temperature rise $\Delta\bar{T}_{c2,k}$ is calculated by averaging the difference of $T_{c2,k,i}$ and $T_{c2,k,i}$ for 1 200 s starting when the temperature setting is reached. Formulae (6) and (7) shall be applied.

$$\tilde{T}_{c2,k}(i_s) \equiv T_{ks} \quad (6)$$

$$\Delta\bar{T}_{c2,k} = \frac{\sum_{j=i_s}^{i_{1200+i_s}-1} (\tilde{T}_{c2,k,j} - T_{a2,k,j})}{i_{1200}} \quad (7)$$

Where:

$\Delta\bar{T}_{c2,k}$ is the average temperature rise in phase 2 in K;

$\tilde{T}_{c2,k,j}$ is the measured temperature in the cavity centre in phase 2, smoothened in °C;

$T_{a2,k,j}$ is the measured ambient temperature in phase 2 in °C;

i_s the sample index representing the starting point;

i_{1200} is defined by $\lfloor 1\,200 \times f_s \rfloor$.

The average temperature $\bar{T}_{c2,k}$ shall be calculated with Formula (8).

$$\bar{T}_{c2,k} = \frac{\sum_{j=i_s}^{i_{1200+i_s}-1} \tilde{T}_{c2,k,j}}{i_{1200}} \quad (8)$$

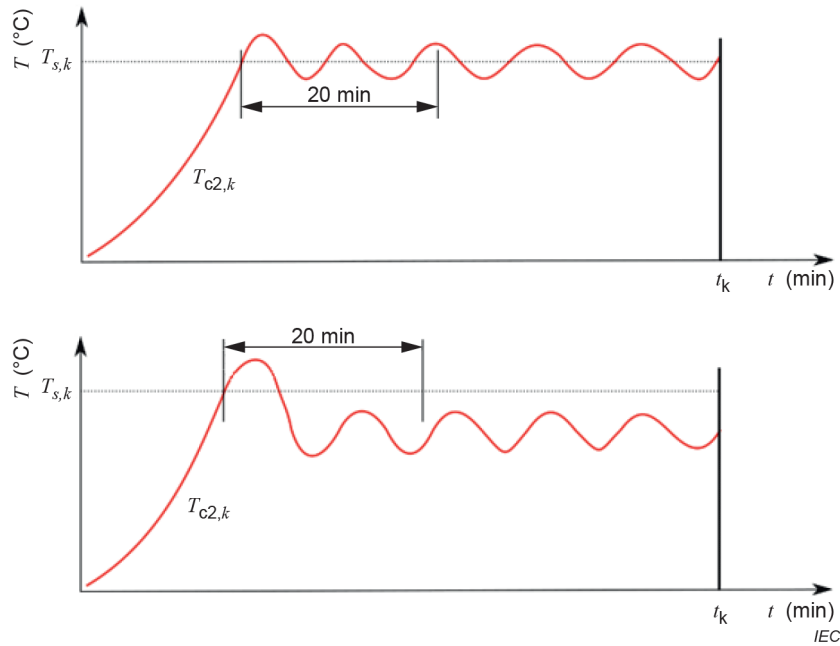


Figure 13 – Examples – set temperature reached

– Technical solution B (See Figure 14)

If the temperature setting is not reached before the last 20 min of phase 2 start, the average temperature rise $\Delta \bar{T}_{c2,k}$ is calculated by averaging the difference of $T_{c2,k,i}$ and $T_{a2,k,i}$ for the last 20 min of phase 2; see Formula (9).

$$\Delta \bar{T}_{c2,k} = \frac{\sum_{j=i_k+1-i_{1200}}^{i_k} (\tilde{T}_{c2,k,j} - T_{a2,k,j})}{i_{1200}} \quad (9)$$

Where:

- $\Delta \bar{T}_{c2,k}$ is the average temperature rise in phase 2 in K;
- $\tilde{T}_{c2,k,j}$ is the measured temperature in the cavity centre in phase 2, smoothed in °C;
- $T_{a2,k,j}$ is the measured ambient temperature in phase 2 in °C;
- i_{1200} is defined by $\lfloor 1200 \times f_s \rfloor$;
- i_k is the index determined by $i_k = \lfloor t_k \times f_s \rfloor$.

The average temperature $\bar{T}_{c2,k}$ in °C is calculated with Formula (10).

$$\bar{T}_{c2,k} = \frac{\sum_{j=i_k+1-i_{1200}}^{i_k} \tilde{T}_{c2,k,j}}{i_{1200}} \quad (10)$$

Where:

$\bar{T}_{c2,k}$ is the average temperature in phase 2 in °C;

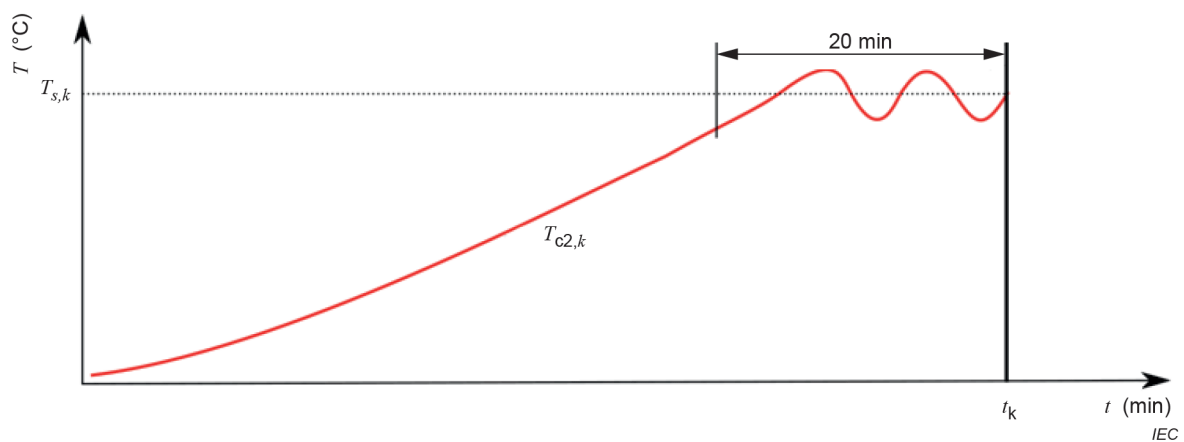


Figure 14 – Example – set temperature not reached

Calculate and note the average temperature rise $\Delta \bar{T}_{c2,k}$ in K for each measurement (each measured heating mode and temperature setting, see Table 4).

Calculate and note the average temperature $\bar{T}_{c2,k}$ in °C for each measurement (each measured heating mode and temperature setting, see Table 4).

8.5.4 Calculation of average ambient temperature

The average ambient temperature in phase 1 and phase 2 is calculated with Formulae (11) and (12):

$$\bar{T}_{a1,k} = \frac{\sum_{j=1}^{i_k} T_{a1,k,j}}{i_k} \quad (11)$$

$$\bar{T}_{a2,k} = \frac{\sum_{j=1}^{i_k} T_{a2,k,j}}{i_k} \quad (12)$$

The average ambient temperature in phase 1 and phase 2 is rounded to one decimal space and reported.

8.5.5 Determining the c -factor

Determine the c_k -factor for each measurement. The c_k -factor is the ratio between the observer temperatures measured in phase 1 and in phase 2 in the whole phase, t_o until t_k , calculated as shown in Formula (13):

$$c_k = \frac{\bar{T}_{o1,k}}{\bar{T}_{o2,k}} \quad (13)$$

Where:

$$\bar{T}_{o1,k} = \frac{\sum_{j=1}^{i_k} T_{o1,k,j}}{i_k} \quad (14)$$

$$\bar{T}_{o2,k} = \frac{\sum_{j=1}^{i_k} T_{o2,k,j}}{i_k} \quad (15)$$

j runs from 1 to i_k , where i_k is determined by $i_k = \lfloor t_k \times f_s \rfloor$.

The c_1 , c_2 and c_3 per **heating function** or **eco function** is rounded to two decimal places and reported.

8.5.6 Determining the s -factor

In the case that the heating mode is designated as a **heating function**, the s -factor shall be determined in addition to the c -factor.

Determine the s_k -factor for each measurement. The s_k -factor is the ratio between the observer temperatures measured in phase 1 and in phase 2 in the last 20 min of the whole phase, $t_k - 20$, calculated as shown in Formulae (16), (17) and (18):

$$s_k = \frac{\bar{T}_{o1,k,20}}{\bar{T}_{o2,k,20}} \quad (16)$$

Where:

$$\bar{T}_{o1,k,20} = \frac{\sum_{j=i_k+1-i_{1200}}^{i_k} T_{o1,k,j}}{i_k} \quad (17)$$

$$\bar{T}_{o2,k,20} = \frac{\sum_{j=i_k+1-i_{1200}}^{i_k} T_{o2,k,j}}{i_k} \quad (18)$$

i_{1200} is defined by $\lfloor 1200 \times f_s \rfloor$

j runs from 1 to i_{1200} , where i_k is determined by $i_k = \lfloor t_k \times f_s \rfloor$.

The s_1 , s_2 and s_3 for the **heating function** is rounded to two decimal places and reported.

8.6 Acceptance verification of the test results

8.6.1 Average temperature rise and standard deviation

Results of the tests in accordance with 8.5 shall only be accepted if

- a) the average temperature rises $\Delta \bar{T}_{c2,k}$ are within the temperatures specified in Table 4, and
- b) the standard deviation σ as defined in Formula (11) is below 0,050 kWh.

Otherwise, for the appropriate function, all measurements shall be repeated in accordance with 8.4.

The standard deviation σ is calculated, from the data pairs $\Delta \bar{T}_{c2,k}$ and E_k measured in accordance with 8.4, according to Formula (19) for each **heating function** or **eco function**, $k = 1, 2, 3$ (see Sachs²).

$$\sigma = f \sqrt{\frac{Q_y - \frac{Q_{xy}^2}{Q_x}}{n-2}} \quad (19)$$

where

n is the number of measuring points (for the purposes of this standard, $n = 3$);

f is an approximation factor, $f = 1,2$.

For calculating the standard deviation, the f -factor of 1,2 shall be used.

NOTE 1 For the purpose of this standard, $\Delta \bar{T}_{c2,k}$ can only vary between 120 K and 210 K resulting in an f -factor of between 1,15 and 1,21. The approach to calculate the f -factor is given in Annex F for information only.

² Applied statistics, formulas 5.29a and 5.69, modified. See the Bibliography.

NOTE 2 The terms Q are described in Annex F.

8.6.2 Temperature setting and average temperature rise

The difference $\Delta T_{s,k}$ between $T_{s,k}$ and $\bar{T}_{c2,k}$ shall be calculated with Formula (20):

$$\Delta T_{s,k} = T_s - \bar{T}_{c2,k} \quad (20)$$

Where

$\Delta T_{s,k}$ is the difference between the set temperature and the average temperature;

$T_{s,k}$ is the set temperature;

$\bar{T}_{c2,k}$ is the average temperature in the cavity centre in phase 2.

The difference $\Delta T_{s,k}$ shall be ≤ 20 K.

If any of the difference $\Delta T_{s,k}$ is > 20 K, the measurement shall be repeated in accordance with 8.4 with an appropriate function.

NOTE The tolerance of 20 K is needed due to the long chain of tolerances (e.g. thermostat, connection, power of heating elements, control element and printing) and the fact that the temperature scale covers different **heating functions** and **eco functions**.

8.6.3 c -factor

The c -factor is used to show that the thermal behaviour of the **oven** in phase 1 and phase 2 is similar.

NOTE The c -factor is less than one, since each load, i.e. the brick in the case of energy measurement, influences the thermal behaviour.

The c_k -factors calculated in 8.5.5 for a function designated as a **heating function** shall be $c_k \geq 0,92$.

The c_k -factors calculated in 8.5.5 for a function designated as an **eco function** shall be $c_k \geq 0,82$.

8.6.4 s -factor

The s_k -factors are used to show that a function designated as a **heating function** does not use residual heat.

The s_k -factors calculated in 8.5.6 for a function designated as a **heating function** shall be $s_k \geq 0,92$.

8.7 Final electric energy consumption

If the acceptance criteria requested in 8.6 are fulfilled, the final energy consumption is calculated for the nominal temperature rise using the linear regression based on the calculated data point ΔT_k (see 8.5) and the measured data point E_k (see 8.4.3); see Formula (21):

$$E_{\Delta T_0} = S \cdot \Delta T_0 + B \quad (21)$$

Where:

- $E_{\Delta T_0}$ is the calculated nominal energy consumption in kWh for heating a load at the setting of the appliance with a temperature rise of ΔT_0 ;
- ΔT_0 is 165 K for all **heating functions** and **eco functions**;
- S is the slope calculated according to Formula (22);
- B is the intercept calculated according to Formula (23).

$$S = \frac{n \sum_{k=1}^n (\Delta \bar{T}_{c2,k} \cdot E_k) - \left(\sum_{k=1}^n \Delta \bar{T}_{c2,k} \right) \left(\sum_{k=1}^n E_k \right)}{n \sum_{k=1}^n (\Delta \bar{T}_{c2,k})^2 - \left(\sum_{k=1}^n \Delta \bar{T}_{c2,k} \right)^2} \quad (22)$$

$$B = \frac{\sum_{k=1}^n E_k - S \cdot \sum_{k=1}^n \Delta \bar{T}_{c2,k}}{n} \quad (23)$$

8.8 Time for heating a load

The time for heating the load shall be calculated and determined in the same way as the energy consumption.

Replace in the Formulas (21) to (23) the E values by the appropriate t values, i.e. replace

- in Formula (21), $E_{\Delta T_0}$ by $t_{\Delta T_0}$;
- in Formulae (22) and (23), E_k by t_k .

Where:

- $t_{\Delta T_0}$ is the calculated nominal time in s for heating a load at $\Delta T_0 = 165$ K for all **heating functions** or **eco functions**.

8.9 Reporting of test results

A supplementary file to calculate the energy consumption and related values is located at <https://www.iec.ch/sc59k/supportingdocuments>. These calculations may be made in any suitable spreadsheet programs.

Report the following data for the measured **heating functions** or **eco functions**:

- a) type of the appliance, available **heating function(s)** and **eco function(s)**;
- b) supply voltage at which the measurements were made;
- c) tested **heating function(s)** and/or **eco function(s)**;
- d) energy consumption(s) $E_{\Delta T_0}$ in kWh to three decimal places, in accordance with 8.7;
- e) time(s) $t_{\Delta T_0}$, rounded to the nearest minute.

For **multiple cavity appliances**, the values shall be reported separately for each cavity.

9 Cooking tests

9.1 General

Owing to the use of food, the tests specified in Clause 9 are considered to be applicable for comparative testing only.

All tests in this clause shall be carried out applying a corrected temperature setting in accordance with the approach determined in 7.4.

The **heating function** that is used for measuring the energy consumption (see Clause 8) should be used for determining the heat distribution on one level (see 9.2.2) and for measuring the ability to supply heat on one level (see 9.3).

If an **eco function** is used for measuring the energy consumption (see Clause 8), that function should be used for determining the heat distribution on one level (see 9.2.2) and for measuring the ability to supply heat on one level (see 9.3.1).

NOTE As already stated in the definition, an **eco function** is used for certain applications. Hence, not all performance tests are applicable.

For baking on two or more levels, the function recommended in the instruction manual is used.

9.2 Heat distribution

9.2.1 Shortbread

9.2.1.1 Purpose

The purpose of this test is to assess the heat distribution within the appliance.

9.2.1.2 Ingredients

- 500 g white wheat flour, without raising agent
- 200 g baking margarine with 80 % fat content, or salted butter
- 200 g castor sugar (max. grain size 0,3 mm)
- 2 eggs (55 g to 60 g, with shell)
- 3 g salt

9.2.1.3 Procedure

Mix together the flour, castor sugar and salt. Rub in the margarine. Beat the eggs and add to the flour mixture, mix lightly in a food mixer until the dough is smooth. Remove the dough from the mixing bowl and form it into a loaf. Cover and store it in a refrigerator at a temperature of $(5 \pm 2) ^\circ\text{C}$ for at least 8 h. Remove the loaf from the refrigerator 60 min to 80 min before further handling.

Extrude the loaf into strips by means of a worm conveyor attachment using the nozzle as shown in Figure 15. Cut the strips to a length that fits the baking tray supplied with the appliance or that recommended by the manufacturer. Position the pastry strips as shown in Figure 16 so that they will be parallel to the appliance door.

Dimensions in millimetres

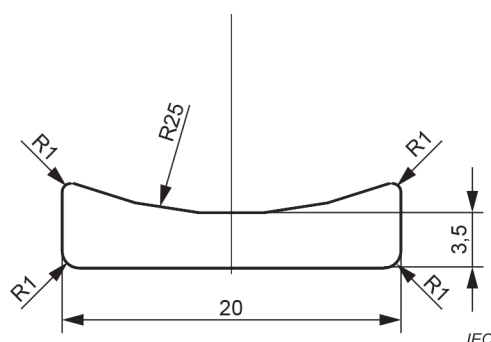


Figure 15 – Shape of the nozzle for extruding pastry

Dimensions in millimetres

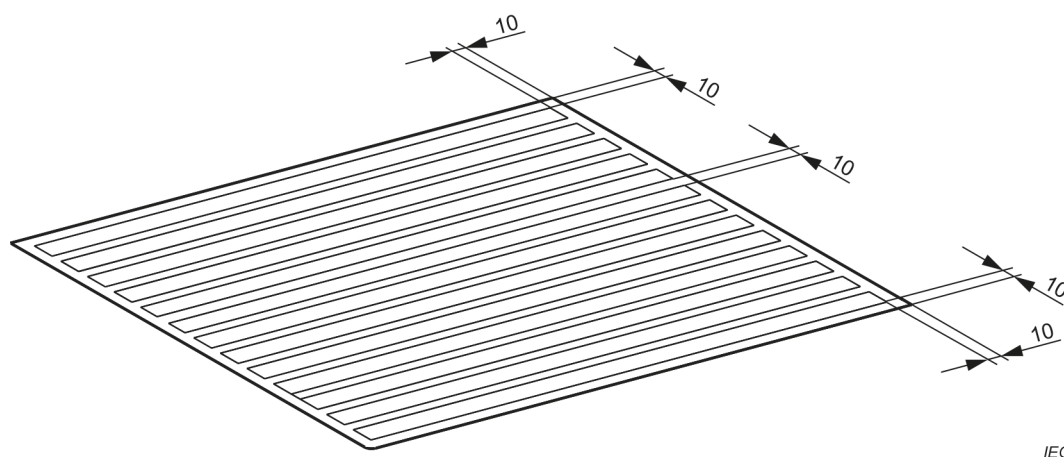


Figure 16 – Position of pastry strips on the baking tray

9.2.1.4 Preliminary measurements

Preliminary tests are carried out to determine the appropriate baking time to achieve the specified browning.

The control is set in accordance with the instructions for use for this type of mixture.

If instructions are not given, the control is set so that the centre **oven** temperature is 175 °C for **ovens** with forced-air circulation and 200 °C for **ovens** with natural convection without preheating.

The tray is inserted into the appliance in accordance with the instructions for use. If instructions are not given, the tray is positioned as close as possible to the centre of the cold appliance. The tray is removed from the appliance when the strips have attained a golden-brown colour. The baking time is noted.

The tray is placed on a grid and allowed to cool down. The browning of the top is measured using the colour measuring instrument specified in Annex A or a digital measuring system in accordance with IEC TS 63350. Circles with a diameter of 20 mm are measured over the strips lengthwise, beginning and ending approximately 20 mm from the centre of the circle from the end of each strip. The measurements are carried out in steps of approximately 50 mm. If the surface at the defined areas is damaged by cracks, holes, etc., the measurement is shifted to other areas.

The average browning is calculated by dividing the sum of the values by their number.

The baking time is suitable when the average browning on top of the strips correlates to a lightness value L^* of $(70,1 \pm 2,35)$.

NOTE Annex B recommends suppliers for the colour measuring instrument and digital measuring systems.

9.2.1.5 Heat distribution test

The procedure stated for preliminary measurements is followed, the strips being baked for the time which has been determined.

The strips are loosened from the tray while still hot but left in their original position.

If the instructions state that a number of trays can be baked simultaneously, an additional test is carried out with the maximum number of trays, the baking time being increased, if necessary.

9.2.1.6 Assessment

Within 1 h after baking, the browning is determined for both the top and bottom of the strips as stated for the preliminary measurements.

The following results are calculated and stated:

- the maximum browning difference on the top;
- the maximum browning difference on the bottom;
- the average browning on the top;
- the average browning on the bottom.

9.2.2 Small cakes

9.2.2.1 Purpose

This test is intended to assess the vertical and horizontal heat distribution, especially for a mixture that rises during cooking.

The test is carried out using the general conditions of measurements as stated in Clause 5.

9.2.2.2 Ingredients

The quantities of ingredients for 30 to 40 small cakes are indicated in Table 5. For a reproducible result, always prepare the same amount and discard any surplus mixture. Ingredients as defined in Annex B should be used.

Table 5 – Ingredients

Ingredients	Quantities g	Remarks
Butter, with a fat content of $(83 \pm 2) \%$	$340 \pm 0,5$	Unsalted butter should be used. If unsalted butter is not available, the salt content of butter should be subtracted from the salt added to the mixture.
White sugar, fine (grain size 0,10 mm to 0,35 mm, d95/d05)	$340 \pm 0,5$	d95/d05: 90 % of the sugar crystals shall have a grain size of 0,10 mm to 0,35 mm.
Eggs	300 ± 1	Medium-sized hen eggs, approximately (55 ± 5) g, are beaten and sieved until homogeneous, then weighed. If frozen egg mixture is used, follow the instructions of Clause B.2.
Wheat flour without raising agent, unbleached. Mineral content: maximum 0,5 % (dry substance)	450 ± 1	Gluten: at least 24 %.
Baking powder	$15 \pm 0,5$	Phosphate baking powder (double acting) shall be used (not baking soda).
Salt	$6 \pm 0,1$	
If more than 40 small cakes are required, two identical kitchen machines should be used simultaneously.		
NOTE The eggs are sieved to remove any chalazae.		

9.2.2.3 Paper cases

As the paper quality affects the rising height and spreading, only the paper cases specified in Annex B shall be used for reproducible results. The paper cases are 48 mm in base diameter and 29 mm in height. They are made of 70 g/m² bleached greaseproof paper.

NOTE A supplier of paper cases is indicated in Annex B.

9.2.2.4 Number of small cakes and positioning on the baking tray

The baking tray shall be measured in accordance with 6.4 and cover at least 80 % of the usable width and 70 % of the usable depth of the cavity measured in accordance with 6.2. If the supplied baking tray or the tray recommended in the instructions fits these dimensions, this baking tray shall be used. If the supplied or recommended baking tray does not fit the above condition or no recommendation is given, then a baking tray fitting the above condition, made of aluminium, no coating, matt finished, $(0,9 \pm 0,1)$ mm thickness, lip height maximum 6 mm shall be used.

The width and the depth of the baking trays are measured in accordance with 6.4 and each divided by 75 mm to give the number of small cakes to be placed along its sides. The numbers are rounded to give a whole number of cakes. Multiply the number of cakes from the depth and the width to give the total number for the whole tray.

EXAMPLE

A width of 470 mm divided by 75 mm equals 6,3. This gives 6 columns of cakes.

A depth of 295 mm divided by 75 mm equals 3,9. This gives 3 rows of cakes.

Therefore the total number of cakes on the tray is 18.

The base of the outermost cakes should be at a distance of $14 \text{ mm} \pm 4 \text{ mm}$ from the edge of the usable area of the baking tray, measured in accordance with 6.4. Distribute the cakes evenly on the tray, in such a way that they do not touch each other.

The manufacturer's instructions regarding the number of baking trays that can be cooked simultaneously are followed.

9.2.2.5 Procedure

Beat together butter and sugar in a food mixer until the mixture becomes soft and pale in colour so that all the sugar is incorporated into the mix. Gradually add the egg mixture. Sift the flour, baking powder and salt together and gently fold into the mixture; loosen the mixture as required from the edge of the bowl to ensure that the mixture is homogeneous.

The temperature of the mixture shall be $(23 \pm 2) ^\circ\text{C}$ directly after mixing.

NOTE 1 A suitable food mixer for which the mixing time has been determined is indicated in Annex B.

Ensure that the paper cases maintain a uniform circular shape by carefully peeling cases from the outside of the batch without distortion.

Weigh $(28 \pm 0,5)$ g of the mixture into the centre of the paper cases and place them evenly on the baking trays. Bake immediately.

NOTE 2 The tests are carried out using corrected temperature control settings according to the differences determined by the test of 7.4.

a) Baking on one level

Follow the operating instructions with respect to the function, temperature, shelf position and preheating. If preheating is recommended, small cakes are placed in the appliance when the end of the preheating phase is indicated, for example by visual or acoustic signal, or after a recommended preheating time. If no instructions are given, the appliance is set to $160 ^\circ\text{C}$ for a forced air circulation function or to $185 ^\circ\text{C}$ for a conventional **heating function** and the baking tray is placed in the middle of the cold appliance. While the small cakes are baking, the position of the baking tray shall not be changed.

The baking time shall not exceed 40 min when baking on one level (including preheating time).

b) Baking on two levels

The baking trays are placed simultaneously in the appliance one above the other and removed simultaneously at the end of baking. While the small cakes are baking, the position of the baking trays shall not be changed. Follow the operating instructions with respect to the function, temperature, shelf position and preheating. If preheating is recommended, the small cakes are placed in the appliance when the end of the preheating phase is indicated, for example by visual or acoustic signal, or after a recommended preheating time.

If no instructions for small cakes on two levels are given, the appliance is set to $160 ^\circ\text{C}$ for a forced air circulation function and the baking trays are spaced evenly in the cold appliance. The horizontal position of the baking trays shall be in the middle of the cavity base area. The vertical position of the trays shall be spaced as near as possible to one-third and two-thirds of the usable height without modifying the shelf racks.

NOTE 3 Baking on two levels is not carried out for **small cavity ovens**.

The baking time shall not exceed 50 min when baking on two levels (including preheating time).

c) Baking on more than two levels

If the operating instructions recommend baking on more than two levels simultaneously, then cakes are baked in accordance with the instructions (**heating function**, temperature, shelf position, preheating and baking time).

9.2.2.6 Assessment

9.2.2.6.1 General

Within 30 min after baking, the paper cases are very carefully removed so that the largest base area possible can be assessed. For assessment in accordance with 9.2.2.6.3, at least 50 % of the base shall be undamaged. Otherwise the test shall be repeated.

NOTE Cooling the small cakes quickly can aid the clean removal of paper cases.

The browning of the top and base of the cakes, the differences of browning between these, and the evenness of rise, are assessed within 1 h after baking. If small cakes have been baked on several levels simultaneously, each tray shall be assessed separately (single result) and they are also assessed together (overall result).

The requirements of the results of these small cakes baked on one or more levels are different. This shall be considered in the evaluation.

9.2.2.6.2 Visual assessment

For comparative results, the evaluation of browning may be done by a visual check using the criteria for assessment in 9.2.2.6.4

The brown shade numbers specified in IEC TS 63350 shall be used to evaluate browning. For a visual check, the same background colour and illumination shall be used for each tray.

NOTE A supplementary file to generate the brown shade chart is located at <https://www.iec.ch/sc59k/supportingdocuments>.

9.2.2.6.3 Digital assessment

For reproducible results of the evaluation of browning, any digital measurement system shall be used which complies with the requirements in IEC TS 63350, except the requirements for colour recognition and verification of resolution.

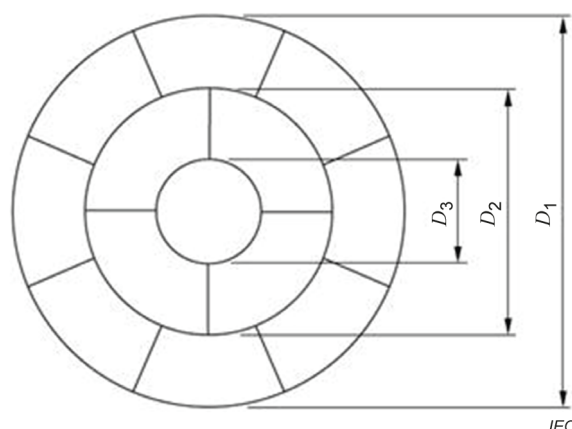
9.2.2.6.4 Criteria for assessment (digital and visual)

The following criteria are relevant for the assessment:

a) Evaluation on the top of the small cakes

The top of each small cake is divided into 13 nearly equally sized sections, as shown schematically in Figure 17.

The values are adapted to the size and shape of each small cake.



Key:

- D_1 dimension of small cake
 D_2 dimension of middle section
 D_3 dimension of central section

$$D_2 = \frac{\sqrt{5}}{\sqrt{13}} \times D_1 \approx 0,6 \times D_1$$

$$D_3 = \frac{1}{\sqrt{13}} \times D_1 \approx 0,3 \times D_1$$

Figure 17 – Template for the sectioning of small cakes

The arithmetic average of lightness value L^* is calculated for the whole area of each section. A brown shade number is determined in accordance IEC TS 63350 and reported for each section.

1) *Acceptable browning on the top*

The average browning on the top of each single tray and of all trays baked simultaneously is calculated by dividing the sum of the shade numbers by thirteen times the number of cakes.

The average browning on the top is reported to one decimal place (single results per tray and overall result).

The results of the test of 9.2.2 shall only be accepted if the average browning on the top of all baking trays baked simultaneously is in the range of shade number 9,5 to 10,5.

NOTE Decimal places result from averaging.

Otherwise, the test shall be repeated with a modified setting. If the baking time exceeds 40 min (preheating time included) for baking on one level or 50 min (preheating time included) for baking on two levels respectively, the **oven** temperature shall be increased accordingly.

The average browning should be within the given range for a comparable result.

2) *"Cakes properly browned" on the top*

All cakes with at least one section having a shade number outside the range 8 to 12 are not included.

Cakes properly browned = number of cakes where all sections have shade numbers between 8 and 12.

3) *"Percentage properly browned" on the top*

The percentage properly browned is the number of cakes properly browned divided by the total number of cakes and multiplied by 100 %.

4) *Browning difference on the top*

The maximum difference between the shade numbers of all sections is determined and reported as browning difference on the top of each baking tray separately and of all trays baked simultaneously (single results per tray and overall results).

b) Evaluation of the base of the small cakes

The lightness value L^* for the undamaged part of the base of each small cake is determined. A brown shade number is determined in accordance with IEC TS 63350 and noted for each small cake.

At least 50 % of the base of each small cake should not be damaged after removing the paper case. Otherwise, the test shall be repeated.

1) Average browning on the base

The average browning on the base for each tray separately and of all trays baked simultaneously is calculated by dividing the sum of the shade numbers by the number of cakes.

The average browning on the base is reported to one decimal place (single results per tray and overall result).

2) Browning difference on the base

The maximum browning difference between the shade numbers is determined and reported as the browning difference on the base of each baking tray separately and for all trays baked simultaneously (single result per tray and overall result).

c) Evaluation of the browning difference between top and base (top – base)

The browning difference between top and base is calculated by subtracting the average browning on the base from the average browning on the top.

The browning difference between top and base (absolute value) is reported for each tray separately and for all trays baked simultaneously (single results per tray and overall result).

d) Measurement of the height of small cakes

The highest point of each small cake is measured and recorded in millimetres. Cutting or stabbing shall not affect the height of the cake.

The minimum height and the maximum height shall be recorded for each tray separately.

9.3 Ability to supply heat**9.3.1 Fatless sponge cake****9.3.1.1 Purpose**

The purpose of this test is to assess the evenness of the heat supply by cooking a medium load at medium temperature.

NOTE This test is applicable for comparative testing only.

9.3.1.2 Ingredients

- 100 g white wheat flour without raising agent
- 100 g maize starch (corn starch)
- 3 g baking powder
- 150 g castor sugar (max. grain size 0,3 mm)
- 3 eggs (55 g to 60 g, with shell)
- 30 ml water (approximately 45 °C)

These ingredients are sufficient to make one cake.

9.3.1.3 Procedure

Separate the egg whites from the yolks.

Whisk the egg whites with the water until a firm consistency is reached. Add the sugar and egg yolks and whisk for 2,5 min. Sift the wheat flour, maize flour and baking powder together and gently fold into the egg and sugar mixture.

Line the base of an ungreased baking tin with greaseproof paper. The tin is made from steel, black coloured without non-stick coating, not enamelled and has an inner bottom diameter of (260 ± 15) mm and a height of (65 ± 10) mm. Spoon in the dough and distribute to a uniform thickness. Follow the instructions for use for this type of cake with regard to preheating, positioning in the appliance and setting of the control. If no instructions are given, place the cake as close as possible to the centre of the cavity and set the control so that the **oven** temperature is 150 °C for **ovens** with forced-air circulation and 175 °C for **ovens** with natural convection. After baking for approximately 35 min, take the cake out of the appliance and allow it to cool. Remove the cake from the tin and carefully remove the paper lining.

If the instructions for use state that the cakes can be baked on more than one level, the test is carried out accordingly.

9.3.1.4 Assessment

The brown shade chart specified in IEC TS 63350 shall be used. Small irregularities are ignored. Irregularities can be, for example, small bubbles on the top and small cracks in the crust.

The following results are stated:

- the maximum browning difference on the top;
- the maximum browning difference on the bottom.

The cake is cut vertically through the centre and the baking is evaluated. The height of the cake is measured at the centre and at the lowest and highest point of the edge.

The evaluation of baking includes a visual assessment of the thickness of the crust, cracks, craters and texture. Photos can document the baking result.

9.3.2 Apple pie

9.3.2.1 Purpose

The purpose of this test is to assess the ability to supply sufficient heat to cook a heavy load.

NOTE This test is applicable for comparative testing only.

9.3.2.2 Ingredients

Dough:

- 300 g white wheat flour without raising agent
- 175 g butter, with a fat content of (83 ± 2) % (salted)
- 75 g castor sugar (max. grain size 0,3 mm)
- 1 egg (55 g to 60 g, with shell)
- ≤ 50 ml water

Filling:

- 25 g white breadcrumbs
- 50 g seedless raisins
- 400 g fresh cooking apples (prepared weight)
- 75 g castor sugar, grain size max. 0,3 mm

These ingredients are sufficient to make one pie.