BS EN 61307:2011

BSI Standards Publication

# Industrial microwave heating installations — Test methods for the determination of power output

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## National foreword

This British Standard is the UK implementation of EN 61307:2011. It is identical to IEC 61307:2011. It supersedes BS EN 61307:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/27, Electroheating.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.



ISBN 978 0 580 70047 7

ICS 25.180.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2011.

Amendments issued since publication

| Date | Text affected |
| --- | --- |

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

# EN 61307

July 2011

ICS 25.180.10

Supersedes EN 61307:2006

English version

# Industrial microwave heating installations - Test methods for the determination of power output
(IEC 61307:2011)

Installations industrielles de chauffage à hyperfréquence -
Méthodes d'essai pour la détermination de la puissance de sortie
(CEI 61307:2011)

Industrielle Mikrowellen-Erwärmungsanlagen -
Messverfahren für die Bestimmung der Ausgangsleistung
(IEC 61307:2011)

This European Standard was approved by CENELEC on 2011-06-22. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**Management Centre: Avenue Marnix 17, B - 1000 Brussels**



Ref. No. EN 61307:2011 E

## Foreword

The text of document 27/761/CDV, future edition 3 of IEC 61307, prepared by IEC TC 27, Industrial electroheating, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61307 on 2011-06-22.

This European Standard supersedes EN 61307:2006.

EN 61307:2011 includes the following significant technical changes with respect to EN 61307:2006:

a) it covers how to measure not only the microwave power output of all typical equipment designs, but also the system efficiency, including the standby and hibernation modes;

b) the handling of the former A and B types of equipment is replaced by measurements of the available microwave power output and microwave workload power, respectively.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

| | | |
|---|---|---|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2012-03-22 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2014-06-22 |

Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 61307:2011 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

| | |
|---|---|
| IEC 60335-2-25 | NOTE Harmonized as EN 60335-2-25. |
| IEC 60335-2-90 | NOTE Harmonized as EN 60335-2-90. |
| IEC 60705 | NOTE Harmonized as EN 60705. |
| IEC 61010-2-010 | NOTE Harmonized as EN 61010-2-010. |

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# Annex ZA

(normative)

## Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

| Publication | Year | Title | EN/HD | Year |
|---|---|---|---|---|
| IEC 60050-221<br>+ A1<br>+ A2<br>+ A3 | 1990<br>1993<br>1999<br>2007 | International Electrotechnical Vocabulary - Chapter 221: Magnetic materials and components | - | - |
| IEC 60050-726 | 1982 | International Electrotechnical Vocabulary - Chapter 726: Transmission lines and waveguides | - | - |
| IEC 60050-841 | 2004 | International Electrotechnical Vocabulary - Part 841: Industrial electroheat | - | - |
| IEC 60519-6 | - | Safety in electroheat installations - Part 6: Specifications for safety in industrial microwave heating equipment | EN 60519-6 | - |

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# INDUSTRIAL MICROWAVE HEATING INSTALLATIONS – TEST METHODS FOR THE DETERMINATION OF POWER OUTPUT

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61307 has been prepared by IEC technical committee 27: Industrial electroheating.

This third edition cancels and replaces the second edition published in 2006. It constitutes a technical revision .

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

a) it covers how to measure not only the microwave power output of all typical equipment designs, but also the system efficiency, including the standby and hibernation modes;
b) the handling of the former A and B types of equipment is replaced by measurements of the available microwave power output and microwave workload power, respectively.

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

| CDV | Report on voting |
|---|---|
| 27/761/CDV | 27/782/RVC |

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.

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.

# INDUSTRIAL MICROWAVE HEATING INSTALLATIONS – TEST METHODS FOR THE DETERMINATION OF POWER OUTPUT

## 1 Scope

This International Standard specifies test methods for the determination of the available microwave output power and the efficiency of frequency conversion from the electrical input in industrial microwave heating installations.

This standard also specifies test methods for assessing the microwave power deposition in the microwave workload – the microwave workload power, in microwave-only installations.

This standard is applicable to industrial microwave heating equipment and installations in the frequency range from 300 MHz to 300 GHz.

This standard relates to industrial microwave heating equipment operating under normal load.

This standard does not apply to appliances for household and similar use (covered by IEC 60335-2-25), commercial use (covered by IEC 60335-2-90) or laboratory use (covered by IEC 61010-2-010).

## 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.

IEC 60050-221:1990, *International Electrotechnical Vocabulary – Chapter 221: Magnetic materials and components*
Amendment 1(1993)
Amendment 2 (1999)
Amendment 3 (2007)

IEC 60050-841:2004, *International Electrotechnical Vocabulary – Part 841: Industrial electroheat*

IEC 60050-726:1982, *International Electrotechnical Vocabulary – Chapter 726: Transmission lines and waveguides*

IEC 60519-6, *Safety in electroheat installations – Part 6: Specifications for safety in industrial microwave heating equipment*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60519-6 and IEC 60050-841 as well as the following apply.

**3.1**
**calorimetric power meter**
**calorimeter power meter**
power meter which uses temperature rise in a medium as a means of measuring absorbed power

NOTE The medium, typically water, is either the power-absorbing agent or has heat transferred to it from a power-absorbing element.

[IEC 60050-726:1982, 726-21-10]

3.2
circulator
passive device having three or more ports in which the power entering any port is transmitted to the next port according to a given order of sequence

NOTE The typical forms are junction circulators [IEC 60050-221:1990, 221-05-14] of the T junction [IEC 60050-726:1982, 726-17-12] or Y junction [IEC 60050-726:1982, 726-17-13].

[IEC 60050-221:1990, 221-05-11, modified]

3.3
cross coupling (between generators)
appearance of undesired microwave energy in a microwave generator or the transmission line output port of a microwave generator assembly caused by one or several other microwave generators or microwave generator assemblies

3.4
electrical efficiency of microwave heating equipment
quotient between the available microwave power output and the electric input to the mains frequency power supply or microwave generator assembly, at power settings for normal operation

3.5
insertion loss
loss resulting from the insertion of a network into a transmission system, the ratio of the power delivered to that part of the system following the network, before insertion of the network, to the power delivered to that same part after insertion of the network

NOTE The insertion loss is generally expressed in decibels.

[IEC 60050-726:1982, 726-06-07]

3.6
isolation (of a three-port circulator)
reverse attenuation between the main output port and main input port, with all ports being impedance matched

NOTE 1 The isolation should not be confused with the reverse loss occurring between adjacent ports.

NOTE 2 This is a special case of cross coupling of a circulator [IEC 60050-726:1982, 726-16-06].

3.7
means of access
all structural features of the microwave heating equipment which can be opened or removed without the use of a tool to provide access to the interior of the microwave applicator or microwave cavity

3.8
microwave applicator
structure which applies the microwave energy to the load

[IEC 60050-841:2004, 841-29-11]

3.9
microwave cavity
space enclosed by inner metal walls and a door or an access opening and in which the microwave load is placed

[IEC 60050-841:2004, 841-29-19, modified]

3.10
microwave enclosure
structure which is intended to confine the microwave energy to a defined region

NOTE Examples are a cavity, door seals and waveguides.

[IEC 60050-841:2004, 841-29-20]

3.11
microwave generator
source used to produce electromagnetic energy in the frequency range from 300 MHz to 300 GHz

[IEC 60050-841:2004, 841-29-16]

NOTE In the context of this standard, the microwave generator is only the component where the frequency conversion takes place. See 3.2.

3.12
microwave generator assembly
part of the microwave heating equipment comprising an apparatus producing microwave energy and its associated transmission line output port

NOTE 1 The assembly includes the microwave generator, the power supply of the microwave generator and its ancillary and control circuits. If a circulator is used, it is also included.

NOTE 2 Microwave heating equipment containing a microwave generator assembly was classified as Type A in earlier editions of this standard; equipment where a transmission line output port is not available was classified as Type B.

3.13
microwave heating equipment
assembly of electric and mechanical devices intended for the transfer of microwave energy to the microwave load and comprising in general power supplies, microwave generators or microwave generator assemblies with cooling arrangements and circulators if used, microwave applicators or cavities with ventilation arrangements if used, interconnecting cables and waveguides, control circuitry, and means for transporting the microwave load if used

[IEC 60050-841:2004, 841-29-06, modified]

3.14
microwave load
objects introduced into the applicator or cavity, or put in the intended position near an open applicator

[IEC 60050-841:2004, 841-29-12]

3.15
microwave transparency
property of a material having negligible absorption and reflection of microwaves

NOTE The relative permittivity of a microwave transparent material is usually less than 7 and the loss factor is usually less than 0,015. However, if the microwave workload has a low loss factor, more stringent requirements apply.

[IEC 60050-841:2004, 841-29-14, modified]

3.16
microwave workload
object to be treated by microwaves

[IEC 60050-841:2004, 841-29-13]

NOTE Workload containers are not a part of the microwave workload but of the microwave load.

3.17
normal load
nominal microwave load at full microwave output power as specified by the manufacturer's documentation

3.18
normal operation
range of microwave output power with the normal loads in allowable working conditions of the microwave heating equipment, as specified by the manufacturer's documentation

3.19
standby (mode of) operation
condition allowing immediate normal operation

NOTE 1 This mode typically occurs immediately before and after normal operation.

NOTE 2 If the treatment of the workload requires non-ambient conditions such as elevated temperature, this is maintained.

NOTE 3 By "immediate" is meant a time period consistent with normal loading, unloading or replacement of the workload.

NOTE 4 The magnetron cathode heater circuit may be switched on in this mode of operation.

# 4 Methods of microwave power measurements

## 4.1 General

Three different methods are described. Their applicability depends on the microwave frequency and power level, and if the equipment comprises a microwave generator assembly.

NOTE 1 Since the wavelength of frequencies above about 20 GHz is very short, the power deposition may be of the irradiation type with a short penetration depth. Water may not be useable with the calorimetric method, and some of the methods of measuring microwave power deposition in this standard may not be applicable. In the low end of the microwave band at 300 MHz, the microwave absorption capability of loads may be highly variable during the heating process, large load masses may be needed, and representative artificial liquid loads for calorimetry may be difficult to use.

NOTE 2 There are variabilities of the microwave absorption capability of microwave loads, and in particular the unevenness of heating of these. Therefore, the microwave workload power data or the effective microwave power data with a substitute liquid load obtained according to this standard should be treated with care. Power data is, however, important and objective factors related to the overall energy utilisation efficiency are by that also a performance factor.

NOTE 3 A method for measuring the microwave power output in household microwave ovens is specified in IEC 60705. It uses a large water load, with compensation of heat capacity of the container and of heat exchange with ambient. Technically, the method gives what is defined as the available microwave power output in this standard.

## 4.2 Available microwave power output

Measurements at the microwave generator assembly output port give the available microwave power output (see Clause 5).

## 4.3 Microwave workload power

Calorimetric measurements in a normal load, including the power losses in any containers for the microwave workload, give the microwave workload power (see Clause 6).

This is the amount of power required to achieve an aimed enthalpy change in the microwave workload within a fixed period of time. It depends on the type of microwave workload, the change of its complex permittivity with temperature, as well as any workload containers or supports, and the design of the microwave applicator or cavity.

The available microwave power output is always larger than the microwave workload power, due to some or all of the following power loss mechanisms:

- impedance mismatching of the microwave generator;
- microwave enclosure metal surface losses;
- absorption by imperfect microwave transparency of containers for the workload and any other ancillary objects in the microwave enclosure;
- microwave leakage out of the microwave enclosure;
- power losses due to cross coupling.

### 4.4 Effective microwave power and efficiency

Typically, actual microwave workloads are not well suited for calorimetric measurements. Liquid substitutes are then used in calorimetric measurements, and give the effective microwave power (see Clause 7 and Clause 8).

## 5 Calorimetric power measurements

### 5.1 General

Only the principles are outlined in this standard. The applied measurement instrumentation and use shall conform to known engineering techniques. Water is the directly or indirectly power-absorbing substance.

### 5.2 Direct water power measurements

It is important that any directly power-absorbing water has a microwave absorption capability and load geometry which provides a good and essentially temperature independent impedance matching over the actually used temperature interval. A sodium chloride solution with specific conductivity between 200 μS/cm and 600 μS/cm shall be used for the direct absorption at frequencies below 900 MHz.

The power meter typically consists of a waveguide section, equipped with a microwave transparent tube through which the water can flow. The water shall be thoroughly mixed. The recommended water flow rate is about 1 l/min for each kilowatt but not less than 0,5 l/min. The difference between the outlet and inlet temperature shall be at least 10 K.

The inlet temperature of the water shall not exceed 35 °C, and the outlet temperature shall not exceed 60 °C. However, for microwave power levels less than 3 kW, these temperatures should be on both sides of the ambient temperature, to reduce heat loss errors.

Under operating conditions, the voltage standing wave ratio (VSWR) as measured by a network analyser with a matched waveguide transition or an equivalent measurement device replacing the microwave generator assembly and within the water temperature interval specified above, shall not exceed 1,25.

If a circulator is used, its isolation shall be greater than 20 dB and the impedance matching of the circulator with dissipative termination is to comply with this subclause.

The water flow shall be monitored, for instance by means of flow interlock switches, to avoid the formation of steam which may lead to eruption.

The power dissipated in the water is measured directly or compared with a calibrated heated water standard.

The measurement shall be carried out only when the flow rate is stable, and both the microwave generator and load operate under stable conditions. It is necessary to use high-accuracy thermometers and flowmeters to ensure that the inaccuracy of power output measurement is less than 5 %.

The available microwave power output P is calculated from the following equation:

$$P = \frac{4187 \cdot Q \cdot \Delta T}{60} \qquad (1)$$

where

- P is the available microwave power output, in W;
- Q is the water flow rate, in kg/min; the factor 4187 is its specific heat in J/(kg · K) and 60 is a factor resulting from units applied;
- ΔT is the temperature difference in K between the water outlet and inlet temperature.

NOTE If the microwave generator assembly contains a circulator with a dissipative termination protecting the microwave generator, this may be used as power meter by short-circuiting the load port. It is then to be noted that twice the insertion loss applies for this measurement, but not in the evaluation for determination of the available microwave power output.

### 5.3 Dummy load power measurements

The dummy load is a matched low-reactance resistor, cooled by natural air convection, by forced air or by water. It is generally connected to the microwave generator or generator assembly by a 50 W coaxial feeder, or by a TE10 waveguide. At low power levels, natural air convection is applied and at higher power levels up to about 2 kW, forced air cooling can be applied.

NOTE Applicable dummy loads in two-port design are commercially available, providing a calibrated insertion loss at levels of -30 dB to -60 dB, suitable for the use of a commercially available power meter at its output port.

It is necessary to use high-accuracy components and instruments, to ensure that the inaccuracy of power output measurement is less than 5 %.

## 6 Determination of microwave workload power

This test is applicable only if the normal load is well specified with regard to specific heat and temperature rise in the process. Furthermore, it shall be possible to accurately measure the average temperature rise after processing. If the set-up is suspected to provide an inaccuracy of more than 5 % of the final result, the method described in Clause 5 or Clause 7 is instead used.

NOTE Typically, accurate tests according to this clause can be made only in continuous processing of pumpable workloads. These loads are representative only if their microwave properties are similar to those of the normal load.

The input temperature $T_{in}$ (°C) of the microwave workload is measured. During steady-state processing, a suitable length of processed microwave workload exiting the microwave heating equipment during a predetermined time t (s) is quickly taken out as sample and thermal insulation is provided. Temperature equilibration is then accomplished by either forced convection (stirring or kneading of the sample) or by internal heat conduction, after which the output temperature $T_{out}$ and the mass m of the sample are measured. Its specific heat c has
been pre-determined.

The microwave workload power $P_w$ is then calculated from the following equation:

$$P_W = \frac{(T_{out} - T_{in}) \cdot c \cdot m}{t} \qquad (2)$$

where

$P_W$ is the microwave workload power, in W;

$T_{out}$ is the output temperature, in °C;

$T_{in}$ is the input temperature, in °C;

c is the specific heat of the workload, in J/(kg · K);

m is the mass of the sample in kg;

t is the sampling time, in s, during which the mass m of the sample is taken out from the microwave heating equipment.

# 7 Determination of effective microwave power

## 7.1 General

The tests in this clause are applicable in cases where the normal load cannot be well specified with regard to specific heat, consists of individual items, or the process is for other reasons not suitable for power determinations according to Clause 6. The normal load is replaced by an artificial load, intended to have dielectric properties and geometries which result in reasonably similar microwave absorption properties as in the normal load.

In the case of uncertainties with regard to the representativity of the chosen artificial load, a network analyser is to be used to determine the impedance mismatches with the normal load or a suitable substitute used as microwave workload and the artificial load, respectively. The resulting calculated deviation in reflected power should not exceed 10 % of the transmitted power, unless the microwave absorption capability of the normal load is very difficult to characterise or varies significantly during processing. The estimated inaccuracy shall be presented with the calculated effective microwave power.

Measuring devices including workload containers shall not be affected by electromagnetic fields, unless explicitly specified or accepted by the manufacturer. The choice of measurement method and the results shall be described in a document, with a reference to this standard. An indication shall also be given that changes in the loading conditions during the intended use typically have an influence on the efficiency of the microwave heating equipment.

## 7.2 The open container water test

The water shall be placed in thin wall open containers, manufactured from a microwave transparent material.

The amount of water shall be at least 0,5 l for each kilowatt of microwave generator power to which it is exposed, and the height of the water column shall be at least 25 mm. Containers should be distributed with a spacing such that at least 40 % of the available area within the microwave enclosure is covered, unless specific patterns are specified by the manufacturer.

Due to possible effects of cross coupling between multiple microwave generators or microwave generator assemblies, the test shall be made with a number of simultaneously operating microwave generators or microwave generator assemblies and such large areas covered by the containers that any such influence is included in the test result.

NOTE Batch equipment and equipment considered to be of multimode or irradiation character and intended for processing of loads significantly higher than 50 mm, may be tested with single or multiple containers each taking several litres.

As water temperature increases approximately 14 K per minute per litre of water for each kilowatt of dissipated power in it, the processing time for the test is typically significantly shorter than with the normal load. This is for avoiding heat losses to ambient, in particular by evaporation. It shall be observed that stable conditions may not be obtained; any possibly resulting errors by this are to be recorded.

The heat capacity of those parts of the containers which are heated by the water shall be used for corrections in the calculations of effective microwave power, using the energy deposited in both.

### 7.3 Tests using other liquids

If the microwave heating equipment is intended for processing normal loads with a low moisture content such as wood, some types of ceramics, resins or paper, or normal loads having a small or inhomogeneous particulate structure, the dielectric properties of water may not be sufficiently representative.

NOTE 1 The real permittivity of water is very high and its loss factor may be too low at frequencies below or even at the ISM frequency 2 450 MHz, to be representative for the power absorption characteristics of the normal load. Adding sodium chloride may result in edge overheating and subsequent power losses by evaporation at 2 450 MHz. Additionally, the high real permittivity of water may result in a reduction of power absorption by stronger wave reflections at the surface than for microwave workloads with lower real permittivity and a more uneven top surface.

Particularly in microwave heating equipment with separated multiple microwave applicators each having one or some few microwave generators or microwave generator assemblies delivering some few kilowatts of available microwave power output, and intended for drying or similar treatment of small microwave workloads, it is recommended to use liquids having a low real permittivity and good microwave absorption capability.

NOTE 2 Glycerol may be used. Technical glycerol contains about 15 % water and may be acceptable, but its thermal data should then be checked.

Isopropanol has favourable microwave properties (low real permittivity, high microwave absorptivity) up to 50 °C for all ISM frequencies from 434 MHz to 5 800 MHz. Its boiling temperature at atmospheric pressure is 82 °C and its specific heat c is 2 560 J/(kg · K). It is to be used with care due to its low flashpoint.

Instead of open containers, reasonably flat, thin-walled and sealed plastic bags, each containing a suitable amount of a lossy dielectric liquid, are used. The recommended average height of the liquid is 15 mm to 30 mm and there is to be as little air as possible in the bag. The liquid volume in each bag is to be at least about 200 ml at 2 450 MHz; less for the generator frequency 5 800 MHz and more for frequencies below 1 000 MHz.

The bags shall be cooled to a temperature between 5 °C and 10 °C. Immediately before placing them in the microwave enclosure, they are kneaded and the input temperature $T_{in}$ is measured by a small sensor covered by the folded bag.

The microwave heating is to a maximum temperature of about 40 °C; pre-testing is recommended. Bags are then taken out of the microwave enclosure, kneaded again and the output temperature $T_{out}$ is measured as before.

The effective microwave power $P_e$ is then calculated using the Equation (2) of Clause 6.

## 8 Electrical efficiency

### 8.1 Available microwave power output

If the microwave heating equipment has no transmission line output port from the microwave generator, the generator shall be tested separately, according to Clause 5.

NOTE 1 The measurement result in Clause 5 will not include any significant microwave losses by impedance mismatching of the generator and by wall losses in the applicator or cavity. Therefore, microwave workload power (Clause 6) and in particular the effective microwave power (Clause 7) will be lower.

NOTE 2 There are some magnetron manufacturer procedures for magnetron testing and performance evaluation purposes, using a particular standardised waveguide transition. However, the power supply specified in such manufacturer procedures may not have the same output current curveform as the power supply of the actual microwave heating equipment. This may result in a different magnetron efficiency.

### 8.2 Electric input

The following equipment circuits are to be included in the measurement of the electric input, at specified available microwave power output(s):

- the main power circuit, with its particular curveform supplied to the microwave generator;
- the cathode filament heating circuit (the power may vary with output power setting);
- any other immediate circuits necessary for generator operation, such as electromagnets;
- all control circuits, including contactors;
- additional electric power consumption, e.g. illumination, water pumps, air cooling fans and valves.

Other consumption is described separately and is not included in the efficiency value.

## 9 Standby power consumption

This clause applies to microwave heating equipment for:

- batch operation, where opening of the means of access stops the microwave generator(s) or the microwave generator assembly and the microwave heating equipment enters standby operation;
- continuous operation where load flow interruptions automatically stop the microwave generator(s) or microwave generator assembly and the microwave heating equipment enters standby operation.

Standby operation may be automatically followed by a secondary switch-off of additional electric power and other consumption after a pre-programmed time period, then requiring manual restart or causing a delayed restart of the microwave heating equipment. This secondary mode is labelled hibernation mode.

The power consumption in the standby mode is measured. The measurements shall include all items of Clause 8. In addition, the power consumption of conveyor motors and load pumps are also included, if operating.

If the equipment automatically shuts off or enters a hibernation mode after a pre-determined time, this is also recorded. The electric power in this mode is measured, as above.

# Bibliography

[1] IEC 60335-2-25, Household and similar electrical appliances – Safety – Part 2-25: Particular requirements for microwave ovens, including combination microwave ovens

[2] IEC 60335-2-90, Household and similar electrical appliances – Safety – Part 2-90: Particular requirements for commercial microwave ovens

[3] IEC 60705, Household microwave ovens – Methods for measuring performance

[4] IEC 61010-2-010, Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-010: Particular requirements for laboratory equipment for the heating of materials

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