

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Safety in installations for electroheating and electromagnetic processing –
Part 6: Particular requirements for high frequency dielectric and microwave
heating and processing equipment**

**Sécurité dans les installations destinées au traitement électrothermique et
électromagnétique –
Partie 6: Exigences particulières pour les équipements de chauffage et de
traitement diélectriques à hautes fréquences et à hyperfréquences**



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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY IN INSTALLATIONS FOR ELECTROHEATING
AND ELECTROMAGNETIC PROCESSING –****Part 6: Particular requirements for high frequency dielectric
and microwave heating and processing equipment**

FOREWORD

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IEC 60519-6 has been prepared by IEC technical committee 27: Industrial electroheating and electromagnetic processing. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2011.

This edition constitutes a technical revision.

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

- a) the structure has been redrafted according to the IEC 60519-1:2020;
- b) the scope and object have been redrafted;
- c) the terms/definitions, normative references and bibliography have been updated and completed;

- d) all requirements and content from IEC 60519-6:2011 which are included in IEC 60519-1:2020 were removed to avoid any duplication;
- e) inclusion of high frequency equipment which was previously covered by IEC 60519-9:2005 (withdrawn). This edition constitutes an extension to high frequency equipment.

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

Draft	Report on voting
27/1142/FDIS	27/1144/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.

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/standardsdev/publications.

A list of all parts in the IEC 60519 series, published under the general title *Safety in installations for electroheating and electromagnetic processing*, can be found on the IEC website.

The clauses of this part 6 of the IEC 60519 series (called Particular Requirements) supplement or modify the corresponding clauses of IEC 60519-1:2020 (*General Requirements*), hereinafter called Part 1.

In this standard, the following print types are used:

- requirements and definitions: in roman type;
- NOTES: in smaller roman type;
- terms defined in Clause 3 in this document and in Part 1 are in **bold type**, from Clause 1.

This part of IEC 60519 is to be read in conjunction with Part 1. It supplements or modifies the corresponding clauses of Part 1. Where the text indicates a “modification” of, “addition” to or a “replacement” of the relevant provision of Part 1, these changes shall be made to the relevant text of Part 1. Where no change is necessary, the words “This clause of Part 1 is applicable” are used. When a particular subclause of Part 1 is not mentioned in this part, that subclause applies as far as is reasonable. When a particular subclause of Part 1 is not applicable, the word “void” is used.

Additional specific provisions to those in Part 1, given as individual clauses or subclauses, are numbered starting from 101.

NOTE The following numbering system is used:

- subclauses, tables and figures that are numbered starting from 101 are additional to those in Part 1;
- unless notes are in a new subclause or involve notes in Part 1, they are numbered starting from 101, including those in a replaced clause or subclause;
- additional annexes are lettered AA, BB, etc.

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

- reconfirmed,
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INTRODUCTION

Some types of **electroheating equipment**, including the **workload**, can emit hazardous levels of infrared radiation. It has been agreed in the IEC Technical Committee 27 that IEC 60519-12 addresses these infrared radiation aspects for this document.

This document presumes that the **manufacturer** possesses sufficient knowledge in equipment design, manufacturing and documentation in accordance with good engineering practise, and that the installation or equipment is operated and maintained only by personnel consisting of **skilled or instructed persons**.

This document is intended to verify whether the installation or equipment meets the requirements of safety, by design, and numerical verification if carefully carried out, site acceptance tests, routine tests or inspection.

SAFETY IN INSTALLATIONS FOR ELECTROHEATING AND ELECTROMAGNETIC PROCESSING –

Part 6: Particular requirements for high frequency dielectric and microwave heating and processing equipment

1 Scope

This clause of Part 1 is modified by the following regarding the areas of application.

Modification:

This part of IEC 60519 is applicable to equipment using high frequency or microwave energy alone or in combination with other kinds of energy for industrial heating and processing of materials. It is also applicable to **HF** and **MW generators** made available to **users** as separate units.

This part is applicable to equipment operating in the frequency range 3 MHz to 300 GHz, with the following limitations.

- This document applies to only high frequency **dielectric heating** and **processing** as defined in 3.1.103. It does not apply to induction heating, which it is possible to carry out in the lower part of the specified frequency band and is covered by IEC 60519-3, with magnetic field safety aspects addressed in IEC TS 62997:2017, the latter to be replaced by a technical report (TR) or by a revised technical specification (TS).
- The ISM centre frequencies for **dielectric heating** and **processing** of industrial interest are narrow bands about 6,78 MHz, 13,56 MHz, 27,12 MHz and 40,68 MHz. Different field **emission** measurement procedures and limiting values are applicable, depending on the **processing frequency** in the high frequency range 3 to 300 MHz. Specifications are in Annex BB.
- This document specifies limits for microwave **emission** only for the ISM frequencies between 800 MHz and 6 MHz, as specified in Annex CC. For other microwave frequencies the **basic restriction** and IEC 62311 apply.
- The foundations for compliance with **emission** values are the **basic restrictions**, referred to in the IEEE/ANSI C95.1:2019 and Directive 2013/35/EU. However, maximum **HF processing frequency** electric and magnetic field values are taken from the IEEE/ANSI C95.1:2019 standard, as indicated in Annex BB.
- This document is not applicable to:
 - appliances for household and similar use (covered by e.g. IEC 60335-2-25);
 - commercial use (covered by IEC 60335-2-90 and IEC 60335-2-110);
 - laboratory use (covered by IEC 61010-2-010);
 - medical high frequency equipment and accessories (covered by IEC 60601-2-2).

NOTE 101 Since high frequency and microwave tunnel ovens and also some other types of microwave and high frequency equipment are sometimes intended either for commercial, laboratory or industrial use, the following criteria are suitable for determination of the classification as industrial equipment:

- commercial equipment is typically designed and planned for series production of many identical units, whereas industrial equipment is typically produced in small series or even as single units. The processed goods are consumed or ready for final use at the end of the heating process.
- laboratory heating equipment is for preparing material in a laboratory environment, and the processed material is immediately available for investigations or further processing. Regular production of large quantities of material is not foreseen.

- with industrial equipment, the processed goods are not immediately accessible to the end user, and the goods are sometimes not in a final state from the perspective of the end user.

2 Normative references

This clause of Part 1 is applicable with the following addition.

Addition:

IEEE/ANSI C95.1:2019, *IEEE standard for safety levels with respect to human exposure to electric, magnetic, and electromagnetic fields, 0 Hz to 300 GHz*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60519-1 and the following apply.

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

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

Additions:

3.1 General concepts

3.1.101

basic restrictions

BR

restrictions on *in situ* (i.e. internal) electric fields or specific absorption rates (SAR) or power densities with time and spatial averaging or integration, resulting from a part of or the whole body being subjected to an external alternating electric (*E*) field, magnetic (*B*) flux or electromagnetic field, and that are intended to be based directly on resulting established pathophysiological effects

Note 1 to entry: The term exposure is defined in 3.4.14 in Part 1. Other definitions are provided in Annex DD.2.1. There are no exposure requirements in this document since its definition does not consider any specific characteristics of the source and **accessible emission**, as in this document. See Note 3 to entry.

Note 2 to entry: **Basic restrictions** have a safety margin to harm.

Note 3 to entry: Sources of scientific and medical information on numerical values of limits for workers are e.g. IEEE, ICNIRP and EU; see the Bibliography. Another term for the **basic restrictions** is exposure limit values (ELV).

Note 4 to entry: Time factors of **specific absorption rates (SAR)** or power densities, i.e. energy absorption versus time and over which tissue volumes are necessary for establishing criteria.

[SOURCE: IEC TS 62997:2017, 3.1.2, modified, to be replaced by a technical report (TR) or by a revised technical specification (TS)]

3.1.102

contact current

induced current

current flowing into the body resulting from contact with a conductive object in an electric, magnetic or electromagnetic field

Note 1 to entry: The scientific definition of induced current in IEC 60050-121:1998, 121-11-29 is replaced here, but the definitions are consistent.

Note 2 to entry: A **touch current** flows through the body or body-parts between two defined contact areas as defined in e.g. Entry 3.4.6 in Part 1.

[SOURCE: IEC TR 63167:2018, 3.1]

3.1.103

dielectric heating and processing

electric treatment process in which the heat is generated in lossy dielectric or semiconducting **HF loads** in the frequency range 1 MHz to 300 MHz

Note 1 to entry: The addition of "lossy" is used in this context since the power absorption mechanism can be by dipolar relaxation and ionic or other conductivity phenomena.

Note 2 to entry: **Dielectric heating** and **processing** does not apply to metallic **HF loads**.

[SOURCE: IEC 60050-841:2004, 841-28-01, modified – The entry has been extended by adding "processing", the definition has been completed by adding "lossy" and two notes have been added.]

3.1.104

electric nearfield

accessible emission of an electric field at a distance, characterised by fulfilling the criterion of **dielectric heating and processing**

Note 1 to entry: The practical consequence of the definition is that the **accessible emission** of the electric nearfield energy (proportional to $\epsilon_0|E|^2$) is approximately equal to or higher than the magnetic nearfield energy (proportional to $\mu_0|H|^2$) in the same locations, where ϵ_0 is the electric constant and μ_0 the magnetic constant. Due to the relative phase of these fields, their coupling to body-parts is very different than from a propagating electromagnetic field.

3.1.105

electromagnetic emission

phenomenon by which electric, magnetic or electromagnetic energy is available near a source

Note 1 to entry: The **emission** characteristics and equipment-related precautionary measures are used instead of operator exposure limits in this document, and are intended to result in a tolerable risk as defined in ISO/IEC Guide 51.

Note 2 to entry: The source data used in this document is typically based on field properties of the **accessible emission**, but high frequency fields are also characterised/limited by the particular conditions for **dielectric heating and processing**.

Note 3 to entry: The energy is basically reactive where body-parts are present, i.e. non-radiating (evanescent).

[SOURCE: IEC 60050-161:1990, 161-01-08, modified – The definition has been modified by replacing the words "electromagnetic energy emanates from a source" by "electric, magnetic or electromagnetic energy is available near a source" and notes to entry have been added.]

3.1.106

HF/MW transparency

property of a material having negligible absorption and reflection of high frequency or microwave fields

Note 1 to entry: The relative permittivity of a microwave transparent material is usually less than 7 and the loss factor is usually less than 0,015.

[SOURCE: IEC 60050-841:2004, 841-29-14, modified – In the definition, the word "microwaves" has been replaced by "high frequency or microwave fields".]

3.1.107**prospective primary capacitive current area**

part of the body in its most onerous position facing the live source

[SOURCE: IEC TS 62996:2017, 3.7, to be replaced by a technical report (TR) or by a revised technical specification (TS)]

3.1.108**secondary contact area**

live part or ground, with or without protective insulation, through which the current flows when the primary contact area is being contacted or touched, or through the **prospective primary capacitive current area**

[SOURCE: IEC TS 62996:2017, 3.10, to be replaced by a technical report (TR) or by a revised technical specification (TS)]

3.1.109**spark discharge**

transfer of current across an air gap prior to making contact with another conductive object at a different potential

[SOURCE: IEC TR 63167:2018, 3.6]

3.1.110**reference surface**

fictitious surface in the vicinity of mainly the **entrance and exit ports**, located as a consequence of **HF/MW leakage** measurements of **accessible emission**

Note 1 to entry: See 9.1.1.103 for the practical specifications.

3.1.111**scenario**

in numerical modelling, all relevant geometrical parts/components/body-parts, locations and dimensions, all complex permittivities, boundary conditions, source characteristics, excitation and operating frequency or frequency interval

3.2 Equipment and state of equipment**3.2.101****accessible <HF/MW> emission****HF/MW leakage**

electromagnetic, electric or magnetic field existing near the equipment where practically relevant measurement results related to **induced electric shock** or body-part SAR are considered possible

Note 1 to entry: Measurements of the field characteristics very close to a **processing frequency** source or a mechanically accessible part of the equipment are considered unreliable with regard to the possible specific absorption rate (SAR) in a body-part located there. As a consequence, minimum distances between the field measurement probe and mechanically accessible parts are to be defined, as is done in 9.1.1.103.

[SOURCE: IEC 60519-1:2020, 3.4.15, modified by addition of the necessity of the emission to be measurable]

3.2.102**cover**

structural feature of any part of the **HF/MW equipment** which can be opened or removed by the use of a tool to provide access for routine maintenance, service, replacement of expendable parts, etc.

3.2.103

entrance port

exit port

openings in the **HF/MW enclosure** through which the **HF/MW load** moves

3.2.104

HF applicator

device comprising the heating capacitive device or work electrodes with their fixing and positioning systems, impedance matching circuits (if not situated in the generator assembly) and, where necessary, protective and screening devices, means for transport, supply and ventilation

3.2.105

HF enclosure

MW enclosure

enclosure intended to confine the electromagnetic, electric or magnetic energy to a defined region

Note 1 to entry: Examples are a **microwave cavity**, door seals and waveguides.

Note 2 to entry: **HF/MW barriers** mounted outside the **HF/MW enclosure** are not considered to be a part of it.

[SOURCE: IEC 60050-841:2004, 841-29-20, modified by extension to lower-frequency fields]

3.2.106

high frequency generator

HF generator

source used to produce electromagnetic energy in the **processing frequency** range from 3 MHz to 300 MHz

3.2.107

HF/MW interlock

interlock that prevents unacceptably high **HF/MW emission**

3.2.108

HF/MW load

objects in the treatment region of the **HF/MW applicator**

Note 1 to entry: This includes the **workload** as well as an intermediate electromagnetic ionised gas (plasma), and any containers, as well as **test loads** for determination of **HF/MW generator** characteristics.

[SOURCE: IEC 60050-841:2004, 841-29-12, modified by extension to lower-frequency fields]

3.2.109

MW applicator

structure which applies the electromagnetic energy to the **MW load**

EXAMPLE A **microwave cavity**, a plasma source, or a **handheld applicator**

[SOURCE: IEC 60050-841:2004, 841-29-11, modified by addition of examples]

3.2.110

microwave cavity

space enclosed by inner metal walls and a door or an access opening and in which the **micro-wave load** is placed

[SOURCE: IEC 60050-841:2004, 841-29-19, modified by use of the term microwave load]

3.2.111**microwave generator****MW generator**

source used to produce electromagnetic energy in the **processing frequency** range from 300 MHz to 300 GHz

3.3 Parts and accessories**3.3.101****HF/MW barrier**

barrier which is **HF/MW transparent** and does not influence the HF/MW field

Note 1 to entry: **HF/MW barriers** may be fixed to the equipment or not; in either case they are considered to be a part of the installation.

Note 2 to entry: Devices such as an array of metal chains or hinged metal plates at **entrance and exit ports** intended to reduce **HF/MW leakage** are not considered **HF/MW barriers**.

Note 3 to entry: The **transparency** also applies to **guards**.

3.3.102**HF screen**

screen that, when removed, significantly increases the **HF emission** in the region which it is intended to protect

Note 1 to entry: **HF screens** are reflective or absorptive, or both.

Note 2 to entry: **HF screens** may be fixed to the equipment or not; in either case they are considered to be a part of the installation.

Note 3 to entry: Devices such as hinged metal plates at **entrance and exit ports** intended to reduce **HF emission** are considered to be **HF screens**.

Note 4 to entry: The non-**transparency** also applies to **obstacles**.

3.3.103**maintenance door**

all structural features of any part of the MW/HF equipment which can be opened or removed without the use of a tool to provide access to locations other than the **HF/MW applicator** or **microwave cavity**

3.3.104**test load**

artificial power-absorbing device used for testing **HF/MW generators** with similar equivalent impedance to the actual **HF/MW load** for which the equipment is designed, to allow the output power to be applied under **normal operation** in the absence of the actual load

4 Classification and subdivision of equipment and installations

This clause of Part 1 is applicable with the following.

4.1 Classification by processing frequency

Modifications:

4.1.101 High frequency in this document means rated **processing frequencies** between 3 MHz and 300 MHz, and microwave means **processing frequencies** which are higher than 300 MHz.

NOTE **Dielectric heating and processing** frequencies less than 3 MHz are not considered industrially feasible.

4.1.102 For **HF dielectric heating and processing frequencies** up to 300 MHz, field measurement principles, methods and **emission** limits are specified in Annex BB. Magnetic fields shall also be measured for **HF processing frequencies** 100 MHz and higher, and both the maximum electric and magnetic emission levels shall then be complied with. For **HF processing frequencies** less than 100 MHz, **contact currents** are measured as an alternative to magnetic field measurements.

NOTE There are relaxations of the electric field emission levels as specified in Clause BB.6 for equipment with processing frequencies less than 41 MHz, determined to fulfil the criteria in BB.3.2 for **dielectric heating and processing**.

4.1.103 For microwave **processing frequencies** from 800 MHz to 6 GHz, probes sensing the electric field only are accepted. Measurement principles, methods and **electromagnetic emission** limits are specified in Annex CC. IEC 62311 applies for lower and higher microwave **processing frequencies**.

5 Risk assessment

This clause of Part 1 is applicable.

6 General provisions

This clause of Part 1 is applicable except as follows:

6.4 Physical environment and operating conditions for electrical equipment caused by operation of the processing equipment

Additions to 6.4.2:

6.4.2.101 Unintended conveyor stops during HF/MW operation and operation under conditions which are not **normal operation** are defined as a single fault condition. Requirements for these kinds of abnormal operation regarding excessive heating of the **HF/MW load** are in 11.101; requirements for HF and microwave leakage are in 9.1.103, and for interlock functions in 14.4.101 to 14.4.103.

6.4.2.102 The following applies to HF equipment: Operation without a load or interruption of the flow of **HF loads** is a case of **normal operation** for some types of equipment and shall not result in a non-compliant **HF emission**. Compliance with this requirement can be checked by detection of the **HF emission** or by the equipment operation being stopped by other means. Defeating the safety circuit is considered to be a single fault condition. The requirements on **HF emission** levels for this condition are those for **normal operation** in 9.1.1.103.

6.4.2.103 The following applies to MW equipment: no-load operation of MW equipment and interruption of the flow of **MW load(s)** shall be protected against. Compliance with this requirement can be checked by detecting the **MW emission** by an active leakage monitor which switches off the **MW generator** in order for the requirements of Annex CC to be fulfilled. Defeating the safety sensor circuit is considered a single fault condition. Requirements on **MW emission** levels for this condition are in 9.1.1.102.

6.4.2.104 Any single electrical or mechanical fault in the HF/MW equipment under **normal operation** shall not result in energising the **HF/MW generator**.

NOTE 1 A mechanical fault in an array of metal chains or hinged metal plates at entrance and exit ports intended to reduce MW or HF field leakage is a single fault condition.

NOTE 2 Compliance with this requirement can be checked by inspection of the circuit diagrams and/or with the measurements as specified in Annex BB or Annex CC.

For the purpose of testing, all **maintenance doors**, **means of access** and **HF/MW barriers** and **HF screens** are removed or opened, except those which incorporate **HF/MW interlocks** which prohibit generation of HF/MW power when removed or open. Attempts to start **normal operation** shall be made and shall not result in **HF emission or MW leakage** exceeding the limits in 9.1.1.103 and Annex BB or Annex CC.

6.4.2.105 The following applies to HF equipment: If no-load operation is likely to damage the equipment, suitable interlock(s) shall be provided to ensure that this cannot occur.

6.4.2.106 If a reduction occurs of the liquid flow of any microwave-absorbing means which require flow of a liquid, its flow shall operate at least one interlock, if the said reduction results in microwave emission in excess of the limit specified in Annex CC.

NOTE Measurements according to Annex CC are limited to the microwave frequencies 800 MHz to 6 GHz. Clause 1 applies for other frequencies.

6.4.2.107 In MW equipment with means for absorbing microwave energy without any dedicated cooling, the absorbing function shall not be impaired by excessive temperature rises in the absorber. This is tested under **normal operation**, and also under conditions of abnormal operation as specified in 9.1.1.102. The absorbing means shall remain securely in place and not be degraded.

6.6 Access

Addition to 6.6.1:

6.6.1.101 MW/HF equipment shall be designed, constructed and operated as to provide adequate protection against hazards due to electric, magnetic and electromagnetic emissions.

The HF/MW equipment shall be provided with a device giving adequate indication of when the **processing frequency** power is switched on and which is clearly visible to anyone entering the general area of the installation.

Where the **processing frequency** power can be or is varied by a user control, an indicator shall show the operator the level of applied power.

Addition to 6.6.2:

6.6.2.101 The following applies for fixed equipment and installations: There shall be a key switch, code panel, card reader or similar device on the control panel requiring the insertion of a key, input of a code or card or similar before **processing frequency** power can be generated.

7 Protection against hazards from electric shock

This clause of Part 1 is applicable except as follows:

7.3 General provisions

Addition to 7.3.4:

7.3.4.101 Maintenance doors allowing access to high voltage parts of the **HF/MW generator** assembly shall be provided with key locks or interlocks as appropriate according to the voltage band of the supply. If **HF/MW emission** is possible, 14.101 also applies.

7.4 Basic protection

NOTE The particular requirements on **HF/MW barriers** and **screens** are given in 8.5.5.

Addition to 7.4.6

7.4.6.101 The potential grading impedance of the **HF processing frequency** earth circuit is important, in particular that of earthed electrodes and that which is due to the small energy penetration depth of metals at these frequencies (see Formula (1) in 8.5.4 in Part 1).

7.6 Protective equipotential bonding

Addition to 7.6.2:

7.6.2.101 Earthing of the **HF processing frequency** circuit is allowed, to the mains earth at single suitable point directly in galvanic contact with the **enclosure**. Current loops shall be avoided, since they may cause HF emission and also interference with radio frequency communication.

Replacement of 7.6.3:

7.6.2.102 Earthing of one of the high voltage poles of the **HF/MW generator** power supply (or supplies) is allowed. If the power supply and the microwave generator are not in the same metal housing and thus have a common chassis, an additional high voltage cable, in addition to normal means for earthing, and having the same class of insulation as for the high voltage cables, shall be mounted between the chassis of the high voltage power supply and the **HF/MW generator** chassis, and marked so that no confusion is possible. The mounting point shall not be used for any other purpose and be marked with a label containing the equivalent of "HIGH VOLTAGE RETURN – DO NOT DISCONNECT" in at least 3 mm lettering. The warning text shall be in the necessary language(s).

7.7 Additional provisions for fault protection for frequencies above 200 Hz

Replacement of 7.7.4:

7.7.4.101 Earthing of the **HF processing frequency** circuit is allowed.

NOTE This relaxation is also addressed in 7.6.2.101 and 7.6.2.102.

7.9 Touch current and touch voltage

Addition:

7.9.101 HF processing frequency touch voltages, and by that also such **touch currents** shall be protected against.

Typically with dielectric heating and processing equipment, the processing frequency voltages are high and touch currents would be harmful and shall therefore be protected against, eliminated, or reduced to insignificant levels by design.

NOTE 1 See the additions in this document to Clause 6 and in 8.5.5.104.

NOTE 2 Contact currents are dealt with in 8.1.2.101.

MW processing frequency touch voltages and **touch currents** are irrelevant and are replaced by the specifications in Annex CC.

8 Protection against hazards from electric or magnetic fields

This clause of Part 1 is applicable except as follows:

8.1 General

Addition to 8.1.1:

8.1.1.101 Additional provisions for **HF emission** are given in Annex BB, and for **MW emission** in Annex CC.

Addition to 8.1.2:

8.1.2.101 Induced currents at the HF **processing frequency**, in principle between the feet of a standing earthed operator and the floor or similar are the most onerous and typically maximum in the ankles. They shall be measured in cases where direct conductive contact between the feet and floor is possible. The measurements are specified in Annex BB for this case, and the case where the operator is sitting on a fully earthed chair.

If required in the manufacturer's specifications, special insulating and protecting footwear are allowed. The capacitance and risk of arcing of the special footwear shall be controllable and shall not deteriorate with time, or it should be regularly replaced. Such information shall be included in the **manufacturer's** instructions to the **user** and information signs about maintenance, cleanliness, etc, shall be posted near the operator position.

Alternatively, if an insulated standing area is used instead, this should be designed and have such a large area that the operator using the equipment is not able to use the equipment when standing outside the area and at arm's reach, 850 mm, away from the normal operating position. Furthermore, it shall not be possible for the operator to touch any objects in the installation other than those intended by the manufacturer to be accessible.

The measurements of the induced current are made with one or two naked feet of the operator with or without the protective footwear standing on a slightly raised and insulated flat metal plate with a surface just covering the contact area and the floor as earthed or with the insulated stand. The current measurement is made with special low HF impedance instrumentation connected between the flat metal plate and ground. The operation of the equipment shall be started after the operator is standing in the test position. The other procedures in BB.4.3 shall be adhered to.

As an alternative, an HF current clamp meter around the ankle is used for the current measurements, as described in BB.4.3.

The operator should move the body, arms and hands into various positions during the test, for obtaining the most onerous reading.

Addition to 8.1.3

8.1.3.101 Limits for **HF emission** are given in Clauses BB.5 and BB.6, and for **MW emission** in 9.1.1.102 and Annex CC. Any national regulations on HF and MW **emission** based on the reference surface concept should be adhered to; also see Note 101 in Annex J.

8.5 Requirements related to barriers and screens

Additions to 8.5.5:

8.5.5.101 The equipment including **HF/MW barriers** or **HF screens** installed in order to limit access of personnel to a distance from the **HF/MW enclosure** are either enclosing the **entrance or exit port** and mounted on the equipment, or not a part of it but of the installation and are then essentially only vertical, unless their mechanical strength and that of the supports are sufficient to allow them to be leant upon. All types shall comply with the following:

- **HF/MW barriers** shall not be constructed of metal or a **processing frequency** power absorbing material in such a way that they can guide or absorb such power;
HF/MW screens shall be so designed that no significant heating of them occurs under **normal operation** and single fault condition;
- dimensions of any accessible opening in the **HF/MW barrier or HF screen** as such shall not be larger than the openings of the **HF/MW enclosure** which they protect, with a maximum of 65 mm × 65 mm; the requirement of maximum dimensions 65 mm × 65 mm is not applicable for any openings in **HF/MW barriers** or **HF screens** through which the **HF/MW loads** move;
- **HF windows** in the **HF enclosure** shall have maximum openings 65 mm × 65 mm or maximum diameter 75 mm.
- **MW windows** in the **microwave enclosure** shall have metal tube lengths and maximum openings which create an efficient cut-off of any propagation; see Table 101.
- the **HF/MW barriers** and **HF screens** shall either be removable only with the aid of a tool, or their removal shall operate at least one interlock, and shall have a warning label to advise of its function;
- **HF/MW barriers** and **HF screens** that are only vertical and located along the **MW/HF load** transport direction shall start at maximum 75 mm and end at least 1 800 mm above the floor. This height is applicable if HF/MW emission at levels comparable to the maximum allowed emission levels or risk of **touch currents** exist just inside the **barrier/screen**; lower vertical barrier/screen heights which only require persons to stand at a certain minimum distance from the equipment are allowed if the arm's reach criterion of 850 mm to regions with maximum allowed emission levels is fulfilled.

NOTE 1 The ≤75 mm limit in the last dashed item above is intended to prohibit access by arm's length while simplifying cleaning of the floor. It can be modified by national sanitation requirements for food processing or similar justifiable reasons. The ≥1 800 mm (or modified) **HF/MW barrier** height requirement, with the appropriate warning sign as specified in Annex AA and shown there and in Annex G is intended to make it obvious that access is not allowed.

NOTE 2 **HF/MW barriers** and **screens** that are only vertical can be supported by metal poles or similar, provided that these poles do not increase the emissions or otherwise detract from the purpose of the **HF/MW barrier** or **screen**.

NOTE 3 For **HF/MW barriers** and **HF screens** which are not fixed to the HF/MW equipment and are instead a part of the installation, Annex BB or Annex CC also applies.

NOTE 4 The ≤65 mm × ≤65 mm requirement for accessible opening dimensions in **HF/MW barriers** and **HF screens** and **windows** are to prevent insertion of the human hand, as is the <Ø 75 mm requirement for **MW barriers** in Table 101; this is also applicable to **HF windows**.

8.5.5.102 The dimensional and location requirements for **HF barriers, screens, guards and obstacles** are set in relation to the type of protection and the field decay properties in the **reference surface** region, and are given in Table 101. Instructions and warning signs or labels should be provided to warn against insertion of e.g. metal objects through openings in the **barriers** or **screens**.

For **HF barriers**, the geometry is calculated from the **reference surface**, which is at the probe positions obtained in 9.1.1.103. In order for this to be determined, **HF barriers** are removed and their associated interlocks are defeated.

NOTE 1 Electric and magnetic field measurements closer than the specified 150 mm from any metallic surface of the **HF enclosure** are not realistic, due to the nearfield characteristics.

8.5.5.103 The dimensional and location requirements for **MW barriers** in relation to the type of **barrier** and the dimension and type of opening are given in Table 101. The **barrier** geometry is calculated from the **reference surface**, which is 50 mm from the probe position inwards to the **MW enclosure**, as specified in 9.1.1.103. In order for this to be determined, the **MW barriers** are removed and their associated interlocks are defeated.

The location of the **MW reference surface** is determined as follows: Microwave **emission** is measured according to Annex CC. The spacer tip of the microwave leakage instrument is moved over and away from the external surface of the MW equipment to locate the highest **MW emission**, particular attention being given to the openings. The region inside a geometric opening into the **MW enclosure** is not regarded as accessible during these measurements; see 9.1.1.103.

If the **MW emission** reading is less than the limit of Annex CC, the reference surface is at the surface of the geometric opening of the **MW enclosure**.

If the microwave leakage reading exceeds the limit of Annex CC, the locations of the sensor (not the tip) further away from the **MW enclosure** where this value is measured are recorded. The position of the **reference surface** away from the surface of the microwave equipment is then determined as 50 mm straight inwards from these sensor positions and towards the surface of the microwave equipment.

The minimum distance between the plane of a meshed **MW barrier** and the **reference surface** shall be according to Table 101, using the mesh opening dimension limitations. The same principle applies to the **barrier** start height above the floor.

In the determination of the location for **MW barriers** that are only vertical and located along the **MW load** transport direction, the horizontal projection of the maximum extension of the **reference surface** shall be used.

NOTE 101 In order to simplify the design of **MW barriers**, the projections of the maximum horizontal and vertical extensions of the **reference surface** are normally used. These, and the use of Table 101 and Figure CC.3 are exemplified in Figure BB.1, Figure BB.2 and Figure CC.3.

8.5.5.104 **Guards** and **obstacles** for preventing **touch currents** or **contact currents** are designed and fixed:

- at minimum 80 mm from the **reference surface** or the live or charged part, with dimensions allowing the insertion of an object with dimensions between 20 mm × 50 mm and Ø 12 mm;
- at minimum 15 mm from the **reference surface** or the live part, allowing the insertion of an object with dimensions less than Ø 12 mm.

Addition to 8.5.6:

8.5.6.101 **Windows** in the **HF/MW enclosure** shall limit the **emission** to safe levels under **normal operation** and **single fault condition**. If viewing through the **window** at a close distance is possible, there shall be an **obstacle** allowing **emission** measurements at the obstacle location with it removed. Complementing these measurements with reliable calculations can also be used to demonstrate that the **emission** limits are complied with at the external plane of the window opening thus considered to be a part of the **HF/MW enclosure**, so that the exposure hazard is in risk class 0 or 1 (see 4.4.2 in Part 1) for a body-part at the external **window** opening. Any uncertainty about the relevance of the measurements and calculations shall result in risk class 1 or 2.

NOTE 101 Table 101 provides some microwave waveguide mode cut-off data for metal tubes used as see-through **windows**.

9 Protection against hazards from radiation

This clause of Part 1 is applicable with the following.

Additions to 9.1.1:

9.1.1.101 This document specifies the protection from **HF processing frequency** and **MW emission** as such for frequencies addressed in its Clause 1.

9.1.1.102 The following applies to MW equipment:

- Operation of equipment for continuous processing under conditions of interruption of the flow of **MW load(s)** shall not result in a temporary microwave leakage exceeding the limit specified in Annex CC, but with a limit of 100 Wm^{-2} .
- Attempts to operate the equipment without the **MW load** shall not result in microwave leakage exceeding the condition specified in Annex CC, but with an increased limit of 100 Wm^{-2} .

NOTE There are no analogue relaxations of allowed field values for **dielectric heating** and **processing equipment**.

9.1.1.103 The requirements in this 9.1.1.103 are applicable to all parts of and openings into the **HF/MW enclosure**, as well as for **screens** and **obstacles**. For **entrance** and **exit ports**, the HF or MW measurement probe is not inserted inside the plane of the opening.

Entrance and exit ports shall be marked with appropriate warning notices.

NOTE 1 An example of this is given in the mid-image in Figure AA.1.

Compliance with the safety requirements for **HF accessible emission** is checked by measurements according to the detailed descriptions in the normative Annex BB. The minimum distance between the measurement probe and any accessible metallic parts is 150 mm. The probe is allowed to be touching **HF transparent** parts such as **barriers** (including **guards**). This is the specification for the **HF reference surface**. Measurement examples and rationales are given in Annex DD.

Compliance for **MW accessible emission** with the safety requirements is checked by measurements according to the detailed descriptions in the normative Annex CC. The minimum distance between the measurement probe and any accessible parts is 50 mm. This is the specification of the **MW reference surface**. Measurement examples are in Annex CC and the rationales are given in Annex EE.

9.1.1.104 Body-parts such as hands and fingers are in principle allowed inside the 150 mm (HF) and 50 mm (MW) **reference surface**, for which the informative Annex DD and Annex EE, respectively, provide rationales. However, for HF/MW equipment intended for intermittent operation where the load is handled by the operator or the equipment is handheld so that the load is openly accessible under **normal operation**, means shall be provided for hindering such access close to the treatment zone. This is then by **guards**, **screens** or **obstacles**. A further alternative is to use more than one operator control, which shall then fulfil the requirements in 14.2.4 in Part 1.

Table 101 – Dimensional requirements for HF/MW barriers

Opening dimension	Allowed use	Required barrier length	Notes on microwave frequencies
Allows the insertion of a Ø 75 mm or 65 mm × 65 mm object	Entrance or exit ports, and barriers that are only vertical	5 × the minor axis length of an ellipse inscribing the opening, but maximum 850 mm from the reference surface; only sideways/behind for MW barriers that are only vertical	At about 915 MHz, there is unattenuated propagation in a 160 mm long but narrow slot, and an energy decay distance of about 50 mm in a Ø 130 mm opening. However, loads may convey surface waves.
Allows the insertion of an object with dimensions between Ø 75 mm and 20 mm × 50 mm	Entrance or exit ports , and barriers that are only vertical	80 mm from the HF reference surface ; only sideways/ behind for HF barriers that are only vertical 180 mm from the MW reference surface ; only sideways/ behind for MW barriers that are only vertical	At Ø 75 mm, the energy decay distance is quite short at about 915 MHz, and very long at 2,45 GHz. There is unattenuated propagation at 5,8 GHz. However, high permittivity loads may convey surface waves.
Allows the insertion of an object with dimensions between 20 mm × 50 mm and Ø 12 mm	Any purpose	80 mm from the HF/MW reference surface , throughout	At 20 mm × 50 mm, cut-off is very efficient for about 915 MHz; the energy decay distance is 30 mm at 2,45 GHz and there is unattenuated propagation at 5,8 GHz. However, continuous high permittivity loads may convey surface waves.
Allows the insertion of an object with dimensions less than Ø 12 mm	Any purpose	—	There is a very efficient cut-off in air for all ISM frequencies, but surface wave propagation may exist at continuous loads in the opening.

10 Protection against hazards from thermal influences

This clause of Part 1 is applicable.

11 Protection against hazards from fire

This clause of Part 1 is applicable with the following addition.

Addition:

11.101 Excessive heating of the HF/MW load

NOTE 1 A load can emit noxious flames or maintain a plasma in a HF/MW field even if the fire requires field energy to be sustained.

HF/MW heating equipment and installations shall be so designed and installed that all necessary measures to limit any hazard from excessive heating of the **HF/MW load** are undertaken.

If the equipment is to be used to process a **workload** that can ignite or cause damage after an emergency stop, the design and installation of the equipment shall include, alternatively:

- means for an instant removal of the **HF/MW load** from the equipment, provided it is deemed safe to do so, and that the rapid removal of the **load** will not cause further additional safety problems;
- thermal insulating shields which instantly separate the **HF/MW load** from those parts of the equipment that can ignite or can otherwise be damaged by the residual heat stored in the **HF/MW load**;

- means of closing the **entrance and exit ports** and stopping the **HF/MW load** movement and any air circulation in the **HF/MW enclosure** so that the oxygen supply maintaining the **workload** fire vanishes;
- means for quickly filling the **HF/MW enclosure** with an inert gas such as carbon dioxide so that a fire is extinguished, provided the introduction of such gas would not present a hazard to the operator or other personnel;

Additionally, with certain flammable loads, fires may start unnoticed even after some hours due to internal HF/MW overheating, so the user should be instructed that previously processed material should not be left unattended.

NOTE 2 Important additional requirements and information is given in Annex F, in particular Clause F.4 of IEC 60519-1:2020.

NOTE 3 Residual heat stored in the equipment can be released over a long period after switching off.

NOTE 4 Surfaces can increase in temperature after switch-off due to the release of stored heat or a **HF/MW load** fire or a plasma.

12 Protection against hazards from fluids

This clause of Part 1 is applicable.

13 Specific requirements for components and subassemblies

13.2 Electrical equipment and conductors

This subclause of Part 1 is applicable with the following.

Additions:

13.2.101 The applicability of this subclause to **processing frequencies** shall also satisfy the safety requirements identified by the **manufacturer**.

Addition:

13.2.102 Metal components and joints in **HF/MW applicators** and **MW cavities** or circuits carrying high surface current densities shall be selected for avoiding the so-called microwave corrosion effect that can result by the deterioration of the passivation of metals such as aluminium and stainless steels in humid environments.

NOTE Conditions for microwave corrosion increase in folded metal joints and with contaminated residual water in these.

14 Control of the installation or equipment

This clause of Part 1 is applicable except as follows.

Additions:

14.4 Control systems and their safety functions

14.4.101 The opening of a **means of access** shall operate two separate **HF/MW interlocks**, designed for high fail-safe security and long-term operation. Each of these **HF/MW interlocks** shall prohibit the operation of any **HF/MW generator**.

NOTE 1 If not obvious from the main electrical circuit diagram, the operation of the **HF/MW generator** is verified by the **HF/MW emission** measurements according to Annex BB or Annex CC.

The failure of any single electrical or mechanical component, including one **HF/MW interlock**, shall not cause all **HF/MW interlocks** on any **means of access** to be inoperative.

The failure of one of the two **HF/MW interlocks** on the **means of access** to perform its intended function shall trigger an alarm and at the same time render the equipment inoperative.

This supervision function shall be of at least one of the **HF/MW interlocks**.

14.4.102 The opening or removal of each **maintenance door** or **cover** shall operate at least one **HF/MW interlock**, or be provided with a key lock, if it is possible that the **HF/MW emission** exceeds the value specified in Annex BB or CC with the **maintenance door** or **cover** removed.

Detachable panels which are intended to be removed only very occasionally shall as an alternative be fastened with a minimum of two safety screws or similar, which cannot be removed by the use of a commonly available hand tool.

14.4.103 Interlock functions for open-ended applicators

The first interlock is allowed to be mechanical on a flexing **means of access** or a switch system which shuts off the **HF/MW generator** when the **HF/MW applicator** is lifted away from the **HF/MW load**. The second interlock is allowed to be either a device detecting **HF/MW emission** by an active microwave monitor which switches off the **HF/MW generator** in order for the requirements of Annex BB and Annex CC to be fulfilled, or a combination of a start switch and operation switch. The combination of a device detecting **HF/MW emission**, a start switch and an operation switch is also allowed.

15 Protection against mechanical hazards

This clause of Part 1 is applicable.

16 Protection against hazards resulting from use

This clause of Part 1 is applicable.

17 EMC

This clause of Part 1 is applicable, with the following additional text.

Addition:

In the case of HF/MW equipment, particular attention should be paid to the electromagnetic compatibility of the equipment with other nearby equipment. This is due to the possibility of interference with the circuits and systems of other equipment (then often due to the poor EMC compatibility of that equipment), irrespective of the compliance of the HF/MW equipment with statutory emission levels.

18 Verification and testing

This clause of Part 1 is applicable.

19 Information for use

This clause of Part 1 is applicable with the extensions for HF/MW installations in Annex AA.

Annex A (normative)

List of significant hazards

This annex of Part 1 is applicable with the following.

Additions:

- capacitively coupled electric fields at 1 kHz and higher frequencies (8.1.1.101 and 8.1.3.101);
- protection against hazards from fire (11.101);
- abnormal operation (6.4.2.101 to 6.4.2.107);
- high frequency emission (Annex BB);
- microwave emission (Annex CC);
- protection against electric shock (7.3.4.101);
- requirements on HF/MW interlocking devices (14.4.101. to 14.4.103).

Annex B (normative)

Limits to touch currents

This annex of Part 1 is not applicable to **HF/MW processing frequencies**.

NOTE 101 **Contact currents** are dealt with in 8.1.2.101, and their limits in Clause BB.5.

Annex C (normative)

Non coherent optical radiation – Limits and risk classes

This annex of Part 1 is applicable.

Annex D (normative)

Electric and magnetic fields

This annex of Part 1 is applicable, except Clause D.2 which is replaced by the primary specifications in 9.1.1.103, 8.1.2.101, 8.5.5.101, Annex BB and Annex CC.

Annex E (normative)

Surface temperature limits

This annex of Part 1 is applicable.

Annex F
(normative)

EH, EPM and fire

This annex of Part 1 is applicable.

Annex G (normative)

Marking and warning

This annex of Part 1 is applicable with the additions in Annex AA.

Annex H (informative)

Guidelines on using this document

This annex of Part 1 is applicable.

Annex I
(informative)

Connection with ISO 13577 (all parts)

This annex of Part 1 is applicable.

Annex J (informative)

Requirements specific to the EU and associated countries

This annex of Part 1 is applicable with the following note:

NOTE 101 The Directive 2013/35/EU on exposure to electric, magnetic and electromagnetic fields is too general in the sense that the HF/MW power source characteristics and the means by which these fields are dispersed are unspecified. Worker protection against these basic fields is by exposure limits. Furthermore, the influence by the worker's body or body-parts is not dealt with. The exposure limits appear to consider essentially plane wave radiation, i.e. approximately equal electric and magnetic field energies in time phase, this actually constituting the most onerous (i.e. far-field) case. However, the **electric nearfield** energy usually dominates in the kinds of **HF equipment** dealt with in this document. This results in a much weaker coupling of the field into human body-parts, in turn resulting in a much increased safety factor under adherence to the exposure limits in the Directive. There is thus a need to include modern state-of-the art considerations in safety standards. The maximum **emission** specifications in this document are bound to the equipment as such, by using the **reference surface** concept and a number of different other measures for improving safety. Exposure limits are related to the field energy actually received or absorbed by a person or animal, as defined in 3.4.14 of Part 1.

Annex AA (normative)

Information for use

AA.1 General

This annex is an addition to Clause 19 and Annex G in Part 1. There is also a special labelling requirement in 7.6.2.102.

When voltage, high voltage or current is addressed, the mains frequency or an up-transformed mains or rectified voltage is meant. Otherwise, the **processing frequency** is meant.

NOTE 1 Warning labels are defined in IEC 60417 and in principle contain only the graphical symbol; the surrounding triangle at some are for indicating the position of a surrounding warning triangle as defined by ISO. Warning labels are usually in black print on a white background. They are located in the immediate vicinity of the potential source of harm.

NOTE 2 Warning signs are defined in ISO 7000. They are for improved observation at a distance, and are therefore typically larger than warning labels and are designed according to ISO 3864-1 (black symbols and text on yellow background). An example is given in the mid Figure AA.1.

NOTE 3 Two labels and text can be combined, as shown in the example at right in Figure AA.1.

AA.2 Labelling

AA.2.1 HF/MW heating equipment, which includes **entrance and exit ports** or accessible openings into the **HF/MW enclosure**, with or without **barriers**, shall be clearly marked in visible areas near each **port** or opening with a warning label. For HF, the graphical symbol IEC 60417-6206:2013-07 (see left Figure AA.1) shall be used. For MW, the graphical symbol of IEC 60417-6166:2012-07 (see mid Figure AA.1, where warning text is added) shall be used. The warning label alternative is allowed up to and including risk class 2, otherwise a warning sign shall be used. Any warning text shall be in the necessary language(s).

AA.2.2 Maintenance doors of **HF/MW heating equipment**, behind which there may be access to high voltage live parts and a **HF/MW generator**, shall be clearly marked at each such maintenance door with a warning label or sign with an additional warning text; see an example in the right Figure AA.1, where the warning text is added, as is the graphical symbol IEC 60417-5036:2002-10; see Table G.1 in Part 1. If there is only high voltage behind, the standard warning signs with only the graphical symbol IEC 60417-5036:2002-10 is used. The marking shall be located near locking points, if applicable.

AA.2.3 Barriers and screens, which are not a part of the **MW heating equipment**, shall be clearly marked with a relevant warning label or a warning text. Additionally, the **HF/MW heating equipment** shall be clearly marked with the relevant warning sign in an area reasonably close to the **barrier**.



Figure AA.1 – Examples of warning sign and labels



Figure AA.2 – Labels at open HF applicators and handheld or open MW applicators

AA.2.4 HF equipment where manual handling of the load just before, during or after the energising is possible shall be marked with a warning label similar to the left image in Figure AA.2 (IEC 60417-6206:2013-07). The label shall be located so that it is visible from the direction of likely positions of the hand or finger.

AA.2.5 MW equipment with handheld microwave applicators or similar potentially accessible microwave-containing regions shall be marked with a warning label (see the right image in Figure AA.2), using the graphical symbol of IEC 60417 (IEC 60417-6167:2012-07). The label shall be located so that it is visible from the direction of likely approach of the hand or finger.

AA.2.6 HF heating equipment, such as addressed in AA.2.3 and AA.2.4, shall be marked with a warning label (see the left image in Figure AA.2), using the graphical symbol of IEC 60417 (IEC 60417-6206:2013-07). It shall also have the applicable following text:

Caution
Personnel must not be exposed to high frequency energy
Do not operate the installation without its intended loading
Do not remove barriers or screens
To maintain any external electromagnetic field at an acceptable value, the heating equipment shall be periodically inspected and kept in good operating condition

AA.2.7 MW heating equipment, such as addressed in AA.2.3 and AA.2.5, shall have the essence of the applicable following text marked in a visible area near the operation controls, in the necessary language(s):

CAUTION
Personnel must not be exposed to microwave energy
Never operate the installation without its intended loading
Do not remove barriers
To maintain the microwave leakage at an acceptable value, the microwave equipment
shall be periodically inspected and kept in good operating condition

In cases when the installation contains accessible waveguides, the following text shall be added:

All connections, waveguides, flanges, gaskets, etc., must be secure in order to ensure that
microwave leakage remains below specified limits

AA.2.8 High frequency heating equipment, such as addressed in AA.2.3 and AA.2.4, shall have the essence of the applicable following text marked in a visible area near the operation controls, in the necessary language(s):

CAUTION
Personnel must not be exposed to high frequency energy
Do not operate the installation without its intended loading
Do not remove barriers or screens
To maintain any external electromagnetic field at an acceptable value, the equipment
shall be periodically inspected and kept in good operating condition

Annex BB (normative)

Measurements and evaluations of the high frequency emission and contact current

BB.1 General

The measurements in Clause BB.2 are to be made under the conditions for both BB.9.2 and BB.9.3, i.e. for

- the equipment classification by the manufacturer for **dielectric heating and processing** and the associated **emission** criteria;
- for routine measurements by the user

The measurements in clauses BB.3 and BB.4 are to be made under the conditions for BB.9.2, i.e. only for classification of the equipment by the manufacturer for **dielectric heating and processing** and the associated **emission** criteria.

As addressed in 18.8 in Part 1, numerical calculations and modelling are allowed to be carried out for emission safety verification, but are in practise usually limited to equipment made in series manufacturing and for clearly specified uses. Normative guidelines for numerical assessments of electric and magnetic emissions are in 18.8.3 in Part 1.

NOTE Some procedure examples of numerical modelling are given in Annex DD in this document.

BB.2 Conditions of equipment operation for measurements

Loads specified for **normal operation** are to be used. The choice of **load** impedances shall be such that the highest possible but not abnormal emissions are obtained. The equipment shall be operated with the controls at the most onerous settings with respect to electric field emission, and/or magnetic field emission if applicable.

Operation as specified in 6.4.2.102 shall also be attempted.

NOTE If a sensing of empty operation or operating with metallic objects exists and shuts off the **HF/MW generator** under such a condition, emission measurements are not made.

BB.3 Evaluation of the HF field characteristics

BB.3.1 The definition of electric nearfield in 3.1.104 shall be adhered to. If this is not clear, i.e. by the load impedance being very low, the equipment is atypical and this Annex is basically not applicable; national or regional requirements for HF exposure apply instead.

NOTE In these atypical situations, both the magnetic and electric exposure fields are to be measured.

BB.3.2 If the validity of this Annex BB for processing frequencies is deemed uncertain for processing frequencies less than 100 MHz as per BB.4.2, measurements of both the electric and magnetic fields shall be carried out, according to Clause BB.4. Otherwise, only the electric fields shall be measured for such frequencies. For frequencies 100 MHz and higher, both the electric and magnetic fields shall be measured.

NOTE Rationales for the measurement principles in this Annex BB are given in Annex DD.

BB.4 Electric, magnetic fields, and contact currents

BB.4.1 Electric and magnetic field measurements

Measurements shall be made without the presence of the normal operator, with the feet of the person performing the measurements standing at a distance of at least 0,5 m but less than 0,85 m (i.e. arm's reach) between the body of the person and the **HF enclosure**, from any fixed part of the **HF enclosure**.

Measurements of the **emission** are made in all locations, with the limitations as specified in 9.1.1.103.

When the magnetic field is also to be measured, a first measurement is made at the location of the electric field maximum. Additional measurements of both the electric and magnetic fields are then made in several locations at about 0,15 m distance and at least 0,15 m apart, from any fixed part of the **HF enclosure** where both field types are comparatively high, in order to determine the position of the maximum field strength.

BB.4.2 Evaluations of $|E|/|H|$

This subclause is applicable only for **processing frequencies** up to 100 MHz. The instrumentation shall comply with BB.9.2, i.e. be of the kind used by manufacturers in their equipment specifications.

The quotient $|E|/|H|$ of the values in Vm^{-1} and Am^{-1} , respectively, shall be calculated for the four data pairs in BB.4.1. If the average of this exceeds 300 Ω , the equipment fulfils the criterion for **dielectric heating and processing**, and the **emission** criteria in this document apply.

If it is found that the average over many measurement points is less than 300 Ω , measurements of only the electric field value in BB.4.1 and **contact currents** in BB.4.3 remain as an option for qualification as **dielectric heating and processing** equipment.

BB.4.3 Measurements of contact currents

These shall be made with a special clamp-on HF current meter. During the measurements, the **processing frequency** power output shall be set to a low value, in order to avoid contact currents which exceed the limits in BB.4.3 or Clause BB.5. Measurements shall then be carried out with a volunteer operator in a typical position only, with one or both bare moist feet contacting the floor or insulated stand. The reference condition for moist feet results from rubbing the skin on a cloth moistened (not soaked) with a 0,9 % saline solution, and then quickly starting the test. Supposing that the contact currents are well within the allowable limits, then the HF power applied shall be increased in stages until maximum HF power of the generator is reached, or the limits are about to be exceeded.

In cases where the operator is sitting on an earthed chair, measurements shall be carried out at one earth-contacting leg, with the other chair legs insulated.

The use of insulated stands is not recommended, due to the possibility of the operator being charged up, allowing **contact current** to then be created when the operator touches an earthed object. **Touch currents** are typically not allowed; see 7.9.101.

Contact current measurements with a clamp-on current meter on a chair on an insulated stand are typically unreliable. Instead, current measurements shall be made as specified in 8.1.2.101, between a naked operator foot on the insulated metal plate and earth below the insulating stand.

The measured values are recalculated for the conditions of **normal operation** in Clause BB.2. Non-linear phenomena such as **load** behaviour and **processing frequency** stability shall then be observed.

BB.5 Limiting values, continuous energising of the processing frequency source

NOTE 1 Continuous operation for a longer time than any 6 minutes period is considered continuous.

NOTE 2 The numerical E and B limiting values in this Clause BB.5 are the same as for plane wave exposure in IEEE/ANSI C95.1:2019.

- The maximum electric field **emission** intensity reading shall be $1842/f \text{ Vm}^{-1}$ for **processing frequencies** between 3 and 30 MHz and then 61 Vm^{-1} for **processing frequencies** up to 300 MHz, with f being in MHz. A relaxation of the limiting value for **processing frequencies** up to 41 MHz is allowed under the conditions described in Clause BB.7.
- The maximum magnetic field intensity shall be $16,3/f \text{ Am}^{-1}$ up to 100 MHz and $0,163 \text{ Am}^{-1}$ for **processing frequencies** up to 300 MHz.
- The maximum induced contact current as measured in each ankle of a earthed foot shall be less than 100 mA for frequencies up to 100 MHz. No significant contact currents in hands or fingers are allowed. This requirement is under consideration for processing frequencies exceeding 100 MHz.

Due to load movement, the size of and distance between the individual load items, missing load item(s) or load interruption in conveyerised HF heating equipment, and also depending on the conveyor speed, the measured emission may vary considerably in time and space. In such cases, the average value under the most onerous 20 s interval shall be used. Depending on the actual time constant of the instrument, readings shall be then taken every 2 s or 3 s and then be averaged.

BB.6 Limiting values, intermittent energising of the processing frequency source

Up to twice the short-time E field intensity values as those given in Clause BB.5 are allowed for a maximum total of 90 s during any six-minute period, provided any single continuous operation time does not exceed 20 s, in which case this becomes the time limit over any six-minute period.

The same short-time relative limits as above also apply to B fields, in cases where this field is the determining factor for compliance.

The contact current ceiling value is 200 mA for a maximum total of 90 s during any six-minute period, or 500 mA for a maximum total of 15 s during any six-minute period. If any measured short-time current exceeds 200 mA for more than 15 s, this becomes the time limit over the six-minute period.

BB.7 Relaxation for processing frequencies up to 41 MHz

The E values in Clause BB.5 are doubled for **dielectric heating and processing** equipment fulfilling the **electric nearfield** criteria in BB.3.2.

The E values in BB.6 are doubled for **dielectric heating and processing** equipment fulfilling the **electric nearfield** criteria in BB.3.2.

The contact current ceiling value is 500 mA for a total maximum 15 s during any six-minute period.

NOTE Rationales are given in Annex DD.

BB.8 Risk classes

The following risk classes (see Table 3 in Part 1) apply for **dielectric heating and processing equipment**:

- Class 1 for operators of equipment where the **means of access** fulfils 14.4.101;
- Class 2 for operators of equipment which does not require the operator to manually handle the load immediately before, during or after the processing, and the operator is considered earthed;
- Class 2 for maintenance personnel working away from HV or HF zones in equipment with processing frequencies less than 100 MHz;
- Class 3a for operators of other equipment than listed above for Class 1 and the first Class 2 entry, unless the manufacturer can prove that class 2 is realistic;
- Class 3a for operators of equipment which would be class 2 if it is not clearly classified according to the definitions in 3.1.103 and 3.1.104;
- Class 3a for maintenance personnel working in HV and HF zones in equipment with processing frequencies less than 100 MHz;
- Class 3 for maintenance personnel working in HV and HF zones in equipment with processing frequencies 100 MHz and higher.

The difference between risk class 3a and 3 is that access under processing frequency operation is allowed in class 3a when personal protective equipment is used, but no such access is allowed under class 3; see Table 3 in Part 1.

BB.9 Instrumentation

BB.9.1 General

The magnetic B field is the quantity actually measured by coil probes, but many instruments are scaled in H units, applying the scaling factor μ_0 (the magnetic constant), applicable with non-magnetic circuits. It is also to be noted that some instruments are scaled in mW/cm² for both the electric and magnetic fields, but that quantity is only valid for free space propagating waves which do not occur in **dielectric heating and processing**.

The instrument accuracy, and in particular its probe(s) design and specifications, are important. The upper frequency limit 300 MHz is managed with good accuracy only by a very few of the commercially available instruments. This applies to in particular magnetic field coil probes with built-in or separately supplied current transformers. The use of special clamp-on HF current meters at higher frequencies than 100 MHz is not specified in this document.

BB.9.2 Instruments to be used by manufacturers

The desirable instrumentation to be used by equipment manufacturers shall have a maximum inaccuracy of about $\pm 1,5$ dB (i.e. about ± 40 %) after calibration and have minimal coupling to adjacent metal parts. This inaccuracy may then be specified only for the HF ISM frequencies lower than 41 MHz. An anisotropy error of about ± 1 dB can typically not be avoided, but can be reduced by sensor rotation. These instruments fulfil quite stringent requirements and are traceable to national bodies responsible for protection against non-ionising radiation. With such instruments, the obtained values shall then be used without corrections.

NOTE Considerations of these inaccuracies are included in the determination of the safety factors in e.g. the EU Directive 2013/35/EU and the IEEE/ANSI C95.1:2019 standard.

BB.9.3 Minimum specifications

The following specification applies only for routine tests and may also apply for the checking of meters after repair or maintenance.

If the inaccuracy seems questionable for an instrument intended to be used for routine measurements, the alternatives are: to use a better instrument, to calibrate it using substitution mode with a better instrument, or to use one of such reliability that maximally about ± 3 dB (i.e. about -50 %; $+100$ %) correction to the measured values is acceptable. The probe anisotropy shall be checked and used for later corrections by averaging. A doubling of the measured and anisotropy-adjusted E and H values is made in order to obtain the actual corrected **emission** values in cases where the measured values are in the vicinity of the limits according to Clauses BB.5, BB.6, and BB.7. If the measured values are much lower than the limits, a simplified procedure is applicable: the measured values shall be reported, together with a written assessment of the instrumentation inaccuracy.

BB.9.4 Explanatory figures

Figure BB.1 and the related notes shows and describes the data for a large HF barrier used in a conveyor-type tunnel equipment scenario, for heating of a continuous flow of loads. The loads are not shown in the figure. Emission measurements shall be made with typical loads and the average is then taken, whilst observing the requirements in Clauses BB.5, BB.6 or BB.7. Figure BB.1 shows a central vertical cross section. A horizontal cross section of the same type of tunnel is shown in Figure CC.3, but for MW barriers. Note that the definition of the reference surface is different for HF and MW.

Figure BB.2 and the related notes shows and describes the data for a plastic welding equipment **scenario**.