BRITISH STANDARD

BS EN
12198-1:2000

Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery —

Part 1: General principles

The European Standard EN 12198-1:2000 has the status of a British Standard

ICS 13.110; 13.280

National foreword

This British Standard is the official English language version of EN 12198-1:2000.

The UK participation in its preparation was entrusted to Technical Committee MCE/3, Safeguarding of machinery, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Cross-references

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Safety of machinery – Assessment and reduction of risks arising from radiation emitted by machinery – Part 1: General principles

Sécurité des machines – Estimation et réduction des risques engendrés par les rayonnements émis par les machines – Partie 1: Principes généraux

Sicherheit von Maschinen – Bewertung und Verminderung des Risikos der von Maschinen emittierten Strahlung – Teil 1: Allgemeine Leitsätze

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 114, Safety of machinery, the Secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2000, and conflicting national standards shall be withdrawn at the latest by December 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

For relationship with EC Directive(s), see informative annex ZA, which is an integral part of this standard.

This European Standard deals with the essential requirement “Radiation” (see EN 292-2, annex A, paragraph 1.5.10).

Annexes A and B are normative, and annex C is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Machinery supplied by electrical power or containing radiation sources may emit radiation or generate electric and/or magnetic fields. The radiation emissions and fields will vary in frequency and magnitude.

The European Machinery Directive requires precautions to avoid or reduce risks caused by the emission of radiation from a machine. Machinery must be so designed and constructed that any emission of radiation is limited to the extent necessary for its operation and that the effects on exposed persons are non-existent or reduced to non-dangerous proportions (EN 292-2:1991/A1:1995).

To assess the risk of injury caused by radiation emissions and fields from a machine, it is necessary to know the type of radiation emission, the level of the emission and the intensity of this emission with respect to possible adverse health effects.

This European Standard is intended to give manufacturers and type C-standards makers advice on how to identify radiation emissions from machinery, how to decide on their magnitude and significance, how to assess the risks and what means could be used to avoid or reduce the radiation emissions from machines.

This European Standard reflects the general principles for the identification and the assessment of radiation emission by machinery. Details of the measurement of the radiation emission will be given in Part 2 of this standard. Part 3 of this standard will contain details of protective measures for avoiding or reducing radiation exposure of persons by reducing emissions and requiring the provision of information.

Radiation emitted by machinery may be intended for processing or may occur unintentionally. Clause 7 of this standard requires that the manufacturer shall assign the machine to a design radiation emission category. For undesirable radiation emission the emission level should be reduced to values corresponding to category 0.

Functional radiation emission shall be limited to the necessary degree for the operation of the machine.

The remaining emission levels shall be assessed and an emission category shall be determined. If necessary, protective measures will have to be applied.

This European Standard is a standard of B1-type in a series of standards for the safety of machinery.

1 Scope

This standard deals with the emission of radiation from machinery. This European Standard gives advice to manufacturers for the construction of safe machinery, if no relevant C-type standard exists. This radiation emission may be **functional** for processing or may be **undesirable**.

The issues of electromagnetic compatibility are not addressed in the standard.

This European Standard is intended to give advice to C-type standardization groups, on how to identify radiation emissions or fields[1)], how to determine their significance and intensity, how to assess the possible risks and what means may be used to avoid or reduce radiation emissions. This advice should be elaborated in C-type standards for specific classes of machines as assessable requirements.

This standard deals with the emission of all types of electromagnetic non-ionizing radiation.

Ionizing radiation may be dealt with in other documents or in future revisions.

This standard does not deal with the emission of laser radiation.

Radiation sources fixed to a machine which are used only for lighting are excluded from the scope of this standard.

This standard applies to machinery as defined in clause 3.1 of EN 292-1:1991.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 292-1:1991, *Safety of machinery – Basic concepts, general principles for design – Part 1: Basic terminology, methodology.*

EN 292-2:1991 + A1:1995, *Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles and specifications (and Amendment A1:1995).*

EN 1050, *Safety of machinery – Principles for risk assessment.*

EN 1070, *Safety of machinery – Terminology.*

EN 50082-1, *Electromagnetic compatibility – Generic immunity standard – Part 1: Residential, commercial and light industry.*

EN 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments (IEC 61000-6-2:1999).*

prEN 12198-2:1999, *Safety of machinery – Assessment and reduction of risks arising from radiation emitted by machinery – Part 2: Radiation emission measurement procedure.*

prEN 12198-3:1999, *Safety of machinery – Assessment and reduction of risks arising from radiation emitted by machinery – Part 3: Reduction of radiation by attenuation or screening.*

[1)] In the rest of the present document, the generic term “radiation” covers either the different types of radiation emitted by a machine (i.e. optical radiation), or fields (i.e. electromagnetic and/or magnetic fields) or waves (i.e. electromagnetic waves).

IEC 60050-845, *International electrotechnical vocabulary; chapter 845: Lighting.*

3 Definitions

For the purposes of this European Standard, the following definitions apply in addition to the definitions given in EN 1070 and in IEC 60050-845.

3.1
functional radiation emission
emission of radiation by a machine needed for its function in the process area

NOTE An example of functional radiation emission is a radiation beam used for thickness gauging.

3.2
undesirable radiation emission
all radiation emissions, other than functional radiation emissions, emitted to any points outside the process area

NOTE An example of an undesirable radiation emission is the leakage radiation from a printing machine, in which the printing inks are cured by ultraviolet radiation.

3.3
trivial radiation emission
radiation emissions and fields, the intensity of which are so very low that they cannot influence the categorization of the machine, according to clause 7

3.4
accessible surface
hypothetical surface, just enveloping the machine, from which the measurement points are located

4 Classification of radiation emissions

4.1 Classification of radiation by frequency and wavelength

For the purposes of this standard, the classification of radiation by frequency and wavelength or energy is given in Table 1.

Table 1 — Classification of non-ionizing radiation

Nature	Type	Frequency/ wavelength
Electric and/or magnetic fields	Extremely low and low frequency	$0 < f < 30$ kHz
Electromagnetic waves	Radio frequency	30 kHz < f < 300 GHz
Optical radiation	Infrared	1 mm > λ > 780 nm
Optical radiation	Visible	780 nm > λ > 380 nm
Optical radiation	Ultraviolet	380 nm > λ > 100 nm
f = frequency λ = wavelength		

NOTE The above specified intervals of the frequency and wavelength of the radiation may be different in other documents dealing with radiation.

4.2 Characteristics of radiation emissions

Radiation emissions can also be characterized by their intensity, duration, frequency, spatial and spectral distribution, for example:

— continuous wave;

— modulated, pulsed;

— broad-band (covering several frequencies);

— with continuous or discrete spectrum (line spectrum);

— geometrical characteristics;

— coherent, non-coherent;

— polarization.

5 General procedure

The manufacturer of a machine shall carry out a risk assessment according to EN 1050. This includes the determination of the limits of the machinery, an identification of all hazards, a risk estimation and a risk evaluation. After the risk assessment, measures for the reduction of unacceptable risks shall be applied if necessary. After that a repetition of the risk assessment, or only parts of it, may be necessary.

For those risks which are related to the emission of radiation from a machine the procedure of risk assessment and risk reduction which shall be carried out by the manufacturer consists of:

— an assessment of the risks due to the emission of all types of radiation (see clause 6);

— application of appropriate measures for the elimination or reduction of the radiation emissions, in order to reach the emission requirements (see clauses 7 and 8);

— verification of compliance with the requirements of this standard (see clause 9).

It may be reasonable to integrate the “verification” step into the “risk assessment” procedure (see 6.2).

When specifying C-type-standards for particular machines or a group of machines, details of this procedure shall be included.

6 Risk assessment

6.1 General

The machine manufacturer shall identify the radiation emissions and assess the risks from those radiation emissions. This assessment shall include any foreseeable personal exposures arising from any machine emissions at any stage in its life (see annex A).

The radiation emissions may arise from:

a) the whole machine or parts of it;

b) material processed in the machine;

c) interaction between the machine and the material being processed.

NOTE 1 Details of the methodology of the risk assessment are given in EN 292-1 and EN 1050.

NOTE 2 The level of risk depends on the properties of the radiation, the likelihood that personal exposure will occur and the degree of exposure. The health effects of radiation exposure will depend on the type of radiation as well as the intensity and duration of exposure. These effects may be in the short or long term and may be reversible or irreversible.

6.2 Procedure for the risk assessment

6.2.1 General

The procedure for the risk assessment due to radiation emission of machinery consists of the following steps:

— Identification of the radiation emissions (sources, type of radiation, approximate level of emission, etc.).

Trivial emissions may be ignored in the following steps of the risk assessment procedure and the steps described in clauses 7, 8, 9 and 10. In the absence of relevant type C-standards, the manufacturer shall determine whether radiation emissions are trivial or not on the basis of a technical experts experience, calculations or measurements. Their conclusions shall be documented in a technical data file.

— Measurement or detailed prediction of emission levels shall be made at all points where people may be exposed during normal use.

— Identification of the highest emissions of each radiation type during all phases of use of the machine (see annex A). Foreseeable misuse during these phases shall also be considered (see 3.12 of EN 292-1:1991).

6.2.2 Procedure

— Allocation of a radiation emission category according to clause 7.1 for the operation, setting and cleaning stages of the use of the machine. The allocation shall be made on the basis of measurement including uncertainty as appropriate (see Part 2) and/or prediction of the radiation emission for all relevant points.

— Check that the levels of emission at the machine's accessible surface during the use of the machine are so low that the emission levels do not exceed the category 0 emission limits according to 7.1.

If the machine category is not 0 (see 7.1), then the following steps shall be carried out:

— Assessment of the possible exposure situations during intended use of the machine (exposed people (adults, children, informed, uninformed, etc.), exposure time, frequency of exposure, distance from source, intended or not, radiation emission, etc.).

— Assessment if the allocated radiation emission category for the operation, setting and cleaning stage of the use of the machine is acceptable for the assessed exposure situations.

— Identification of secondary hazards (production of hazardous substances, e.g. ozone, degradation of plastics, disturbance of pacemakers and other electrical implants, hazards caused by electromagnetic interference with safety relevant electrical equipment in the vicinity) (see EN 50082-1 and EN 61000-6-2).

6.2.3 Conclusion

Allocate the overall emission category for the machine in accordance with 7.1.

7 Requirements

7.1 Classification of machines due to radiation emission levels

Depending on the level of radiation emission, the manufacturer shall assign the machine a radiation emission category. Three categories are considered according to Table 2.

The relation between the level of radiation emission and the radiation emission category is specified in annex B for each type of radiation.

Table 2 — Classification of machines due to radiation emission levels

Category	Restrictions and protective measures	Information and training
0	No restriction	No information needed
1	Restrictions: limitation of access, protective measures may be needed	Information about hazards, risks and secondary effects
2	Special restrictions and protective measures essential	Information about hazards, risks and secondary effects; training may be necessary

The assignment of radiation emission category shall be done for the setting, operation and cleaning phases of the use of the machine.

This shall be done for all types of radiation emissions. The manufacturer shall take into account that the radiation emissions may vary with changing environmental or operating conditions and duty cycles of the machine. The overall category for the machine is that with the highest number of the categories determined for all different types of radiation emission during the setting, operation and cleaning phases of the use of the machine.

7.2 Design requirements

7.2.1 Functional radiation emission

All functional radiation emissions shall be established at the lowest level, which is sufficient for the proper function of the machine during setting, operation and cleaning phases of the use of the machine. The remaining emissions shall be measured (see Part 2 of this standard) and the emission category (see 7.1 and annex C) shall be determined. Protective measures shall be applied as necessary (see clause 8, annex C and Part 3 of this standard).

7.2.2 Undesirable radiation emission

Undesirable emissions of radiation from the machine should be avoided.

If undesirable emissions of radiation from the machine cannot be avoided, they should not exceed the values, which correspond to category 0 according to clause 7.1.

If undesirable emissions of radiation from the machine exceed the values which correspond to category 0 appropriate protective measures shall be applied (see clauses 8 and 10).

NOTE C-type standard groups may restrict their particular type of machine to categories 0 or 1.

8 Protective measures for the elimination or reduction of the risks due to radiation emission

8.1 Principles

The following requirement have to be fulfilled simultaneously.

— in the process area, the functional radiation emission shall be established at the lowest level which is sufficient for the proper function of the machine during the different phases of use;

— in the other areas, the undesirable radiation emission shall be eliminated or reduced in such proportion that the effects to exposed persons are non-existent or limited to non-dangerous proportions.

With respect to these requirements, the manufacturer shall take the appropriate protective measures. If not sufficient, and depending on the allocation of the radiation emission category of the machine, additionally protective measures may have to be taken by the user of the machine. The manufacturer shall provide the necessary information to the users of the machine.

Category 0

There is no need for special protection measures.

Category 1

According to the technical files of the machine given by the manufacturer and the information about remaining radiation emission levels at different areas around the machine, the manufacturer shall specify in the information for use, the appropriate protective measures which have to be taken.

Category 2

Protective measures are necessary. Which protective measures are needed depend on the emission level, how the machine is used, and other factors. Information about hazards, risks and secondary effects shall be provided. Training may be necessary.

When C-type standards for particular types or groups of machines are being prepared they shall include the necessary protection measures.

NOTE Independent of the category of the machine, certain individuals, e.g. hyper-photosensitive people or those with electric or ferromagnetic implants, may need to take additional protective measures.

8.2 Choice of the appropriate measures

In selecting the most appropriate methods, account shall be taken of the state of the art. In selecting the most appropriate methods of reducing radiation, the manufacturer shall take measures to reduce the radiation emissions as close to the source of emission as is possible. The manufacturer shall apply the following measures, in the order given (as far as possible):

— eliminate or prevent risks of exposure by design;

— reduce risks, if elimination is not achievable, in the following order:

  — reduction of emission (reduction of radiated power);

  — reduction by shielding or other engineering means;

  — reduction of exposure by separation between processing unit and operation at control unit;

— inform users of the residual risks and state any necessary additional measures.

NOTE A list of possible measures is given in annex C. Part 3 of this standard contains details of the procedure of reduction of radiation emissions.

8.3 Protective measures against secondary hazards

If secondary hazards are identified during the risk assessment (see 6.2), appropriate protective measures shall be applied. Which protective measures are applicable depend on the nature of the secondary hazard and has to be specified in each particular case. Secondary hazards and the appropriate protective measures shall be specified in C-type standards.

9 Verification of compliance with requirements

The verification of compliance with the requirements of clause 7 consists of the steps:

— measurement in accordance with Part 2 of this standard and/or prediction of the radiation emission;

— comparison of the results with the specifications in clause 7 (elimination of the emission, reduction to the specified values or comparison with the values stated in the information for use and maintenance);

— statement of the emission category for each type of radiation;

— statement of the overall category.

10 Information for use and maintenance

10.1 Information for use

10.1.1 The manufacturer shall state in the instructions for use, the intended uses of the machine, the radiation emission category, and the operating procedures. The manufacturer shall specify, if necessary, the level of competence to be achieved by training. Where setting and operating conditions of the machine result in a reduction of the emission the manufacturer shall give appropriate details in the instructions.

If the radiation emission category is 1 or 2, the manufacturer shall additionally state the type and level of radiation which can be emitted by the machine.

10.1.2 According to the radiation emission category the information shall contain one of the following statements:

a) the radiation emission category is 0. *No further protective measures are needed when using the machine alone (see 8.1). In other cases (if two or more machines irradiate the same point) restrictions and/or additional protective measures may be necessary;*

b) the radiation emission category is 1. *No restrictions are necessary when the machine is used alone at the work place. In other cases (if two or more machines irradiate the same point) restrictions and/or additional protective measures may be necessary;*

c) the radiation emission category is 2. *Appropriate protective measures shall be taken.*

10.1.3 When the machine is supplied with the means of reducing the emission, the machinery manufacturer shall supply information on its correct use and factors that may adversely affect its performance.

10.1.4 When there is no such provision of the means of reducing the emission, such methods of reduction and/or testing which are suitable and proven shall be specified by the manufacturer.

10.1.5 The manufacturer shall provide information on the necessity of the use of personal protective equipment. If the use of personal protective equipment is necessary, the manufacturer shall give details of the kind of personal protective equipment.

10.2 Information for maintenance

10.2.1 The machinery manufacturer shall provide sufficient and adequate instructions for the maintenance of the machine without risk to health.

10.2.2 Especially in the case of removal of incorporated protective parts of the machine during maintenance (e.g. shields, guards, etc.), instructions for adequate alternative protection measures shall be given.

10.2.3 The manufacturer shall specify in maintenance instructions when it is necessary to measure the radiation emission levels before the machine is returned to normal use.

10.2.4 If leaks or uncontrolled release of radiation can be foreseen, the manufacturer shall provide information on how to limit the extent of emission and to regain adequate control as soon as possible. The information should cover, where appropriate, emergency procedures and suitable protective equipment to enable the source of release to be safely identified and repairs to be made.

11 Marking

Machines allocated to categories 1 and 2 shall be marked.

This marking consists of:

— A safety sign reminding of the type of radiation emission (magnetic field, electromagnetic, optical radiation).

— The category number (category 1 or category 2).

— The number of this standard: EN 12198.

Figures 1, 2 and 3 give examples of marking.

Magnetic field emission
Category 1
(EN 12198)

Safety sign for magnetic field emission category 1

Figure 1

Electromagnetic emission
Category 2
(EN 12198)

Safety sign for electromagnetic emission category 2

Figure 2

Optical radiation emission
Category 1
(EN 12198)

Safety sign for optical radiation emission, category 1

Figure 3

If additional safety measures are necessary (see clause 8) the relevant information should be marked on the machine.

If during maintenance, radiation levels could exceed those defined for normal use of the machine, all those higher radiation emission levels shall be clearly marked, e.g. on or under the incorporated protective parts (shields, guards, etc.).

12 Signals and warning devices

If needed, visual signals such as flashing lights and audible systems such as sirens shall be used to warn the user of the presence of radiation.

Annex A
(normative)

Stages in the “life” of a machine

The stages in the “life” of the machine are (according to 3.11 of EN 292-1:1991):

1) construction;

2) transport and commissioning:

   — assembly, installation;

   — adjustment;

3) use:

   — setting, teaching/programming or process changeover;

   — operation;

   — cleaning;

   — fault finding;

   — maintenance;

4) decommissioning, dismantling and, as far as safety is concerned, disposal.

Annex B
(normative)

Correlation between the level of radiation emission and the radiation emission category

In the following subclauses for each type of radiation a distance from the accessible surface of the machine is specified at which the radiation emission level shall be measured. It is assumed that in most cases the measurement at this distance represents the maximum emission level around the machine. However in some cases the emitted radiation may be focused at a point further from the machine, so that the maximum emission level is at a distance greater than that which is specified in the following clauses. In these cases the measurement shall be carried out at the distances specified in annexes B.1 to B.4 and additionally at the point where the maximum emission level occurs. The greater of the two values shall be used to determine the radiation emission category.

In the following subclauses an averaging time is defined for the purpose of classifying the radiation emission category. It means that a measurement of the radiation emission shall be carried out and that a emission value averaged over the specified averaging time shall be determined. If the radiation emission is constant or if it is periodic, it is not necessary to measure during the whole averaging time. It will be sufficient to measure during some typical emission periods and calculate the value for the specified averaging time.

The correlation between the level of radiation emission and the radiation emission category applies for optical radiation (annexes B.1, B.2 and B.3) only if the intensity of the radiation emission is constant in time or just varying smoothly. The specified correlations shall not apply to optical radiation emissions which last for less than 10 s, like single or repeated pulses. In these cases radiation emission category shall be defined by using the peak intensity.

When a C-type standard relating to a particular machine or group of machines exists, all requirements concerning measurement, such as distance, averaging time, etc., specified in that standard shall be used for determining the radiation emission categories.

Further details of measurements are specified in Part 2 of this standard.

B.0 Abbreviations and definitions

In B.1, B.2 and B.3, the following symbols and units are used:

λ	wavelength, in m (or multiple of metre)
E	irradiance, in $W \cdot m^{-2}$
E_λ	spectral irradiance, in $W \cdot m^{-2} \cdot nm^{-1}$
E_{eff}	effective irradiance, in $W \cdot m^{-2}$
$\Delta\lambda$	bandwidth, in nm
S_λ	relative spectral effectiveness
L	radiance, in $W \cdot m^{-2} \cdot sr^{-1}$
L_λ	spectral radiance, in $W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$
L_{eff}	effective radiance, in $W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$
t	time, in s
l	length of radiation source, in m
r	viewing distance, in m
α	viewing angle with $\alpha = \frac{l}{r}$, in rad

B.1 Ultraviolet and visible radiation, in the range of 180 nm to 400 nm

Measuring conditions

The effective irradiance E_{eff} or the respective spectral irradiances E_λ of the emitted ultraviolet radiation shall be measured at a distance of 10 cm from the accessible surface of the machine. The measurement shall be carried out in the direction from which the maximum radiation intensity is emitted. The aperture of the apparatus used to carry out the measurement is not defined. However, a detector with a cosine collection characteristic shall be used. The averaging time of the measurement shall be 8 h. A shorter averaging time is allowed if the measurement leads to the same result.

Determination of the effective irradiance

The effective irradiance E_{eff} shall either be directly measured in the wavelength band from 180 nm to 400 nm or shall be determined from measured spectral irradiances E_λ using the formula:

$$E_{\text{eff}} = \sum_{\lambda=180\,\text{nm}}^{\lambda=400\,\text{nm}} E_\lambda S_\lambda \Delta\lambda$$

Values of the relative spectral effectiveness S_λ are to be taken from Table B.1.

Table B.1 — Relative spectral effectiveness S_λ in the wavelength band from 180 nm to 400 nm

Wavelength (nm)	Relative spectral effectiveness S_λ
180	0,012
190	0,019
200	0,030
205	0,051
210	0,075
215	0,095
220	0,120
225	0,150
230	0,190
235	0,240
240	0,300
245	0,360
250	0,430
255	0,520
260	0,650
265	0,810
270	1,000
275	0,960
280	0,880
285	0,770
290	0,640
295	0,540
300	0,300
305	0,060
310	0,015
315 – 400	0,003

Correlation

The correlation between the effective irradiance E_{eff} and the radiation emission category is given in Table B.2.

Table B.2 — Correlation between the effective UV irradiance and the radiation emission category

E_{eff} (180 nm to 400 nm) ($W \cdot m^{-2}$)	Radiation emission category
$E_{eff} \leq 0{,}1 \times 10^{-3}$	0
$0{,}1 \times 10^{-3} < E_{eff} \leq 1{,}0 \times 10^{-3}$	1
$E_{eff} > 1{,}0 \times 10^{-3}$	2

B.2 Visible radiation, in the range of 400 nm to 700 nm

Measuring conditions

The spectral irradiances E_λ or the respective spectral radiances L_λ of the emitted visible radiation shall be measured at a distance of 0,10 m from the accessible surface of the machine. The measurement shall be carried out in the direction from which the maximum radiation intensity is emitted. The aperture of the apparatus used to carry out the measurement shall be 7 mm. A cosine collection characteristic is not required. The averaging time of the measurement shall be 8 h. A shorter averaging time is allowed if the measurement leads to the same result.

The viewing angle α of the radiation source as seen from the measurement point shall be determined.

Determination of the effective irradiance and the effective radiance

Depending on the viewing angle α the effective irradiance E_{eff}, respectively the effective radiance L_{eff}, shall be determined in the wavelength band from 400 nm to 700 nm as follows:

For α < 11 mrad the effective irradiance E_{eff} shall be determined using the formula:

$$E_{\text{eff}} = \sum_{\lambda=400\ \text{nm}}^{\lambda=700\ \text{nm}} E_\lambda S_\lambda \Delta\lambda$$

For $\alpha \geq 11$ mrad the effective radiance L_{eff} shall be determined using the formula:

$$L_{\text{eff}} = \sum_{\lambda=400\,\text{nm}}^{\lambda=700\,\text{nm}} L_\lambda S_\lambda \Delta\lambda$$

Values of the relative spectral effectiveness S_λ are to be taken from Table B.3.

Table B.3 — Relative spectral effectiveness S_λ in the wavelength range from 400 nm to 700 nm

Wavelength (nm)	Relative spectral effectiveness S_λ
400	0,1
405	0,2
410	0,4
415	0,8
420	0,9
425	0,95
430	0,98
435	1,00
440	1,00
445	0,97
450	0,94
455	0,90
460	0,80
465	0,70
470	0,62
475	0,55
480	0,45
485	0,40
490	0,22
495	0,16
500	0,10
505	0,079
510	0,063
515	0,050
520	0,040
525	0,032
530	0,025
535	0,020
540	0,016
545	0,013
550	0,010
555	0,008
560	0,006
565	0,005
570	0,004
575	0,003
580	0,002
585	0,002
590	0,001
595	0,001
600–700	0,001

Correlation

The correlation between the effective irradiance E_{eff} for sources subtending a viewing angle α less than 11 mrad or the effective radiance L_{eff} for sources subtending a viewing angle α equal or larger than 11 mrad and the radiation emission category is given in Table B.4.

Table B.4 — Correlation between the effective irradiance respective the effective radiance and the radiation emission category for visible light

E_{eff} (400 nm to 700 nm) ($W \cdot m^{-2}$)	L_{eff} (400 nm to 700 nm) ($W \cdot m^{-2} \cdot sr^{-1}$)	Radiation emission category
$E_{eff} \leq 1{,}0 \times 10^{-3}$	≤ 10	0
$1{,}0 \times 10^{-3} < E_{eff} \leq 10 \times 10^{-3}$	≤ 100	1
$E_{eff} > 10 \times 10^{-3}$	> 100	2

B.3 Visible and infrared radiation, in the range of 700 nm to 1 mm

Measuring conditions

The irradiance E of the emitted visible and infrared radiation shall be measured at a distance of 0,10 m from the accessible surface of the machine. The measurement shall be carried out in the direction from which the maximum radiation intensity is emitted. The aperture of the apparatus used to carry out the measurement is not defined. A cosine characteristic is not required. The averaging time of the measurement shall be 10 s. If the radiation emission intensity varies in time, a 10 s measurement period shall be chosen which covers the maximum radiation emission intensity.

The irradiance E shall be determined in the wavelength band from 700 nm to 1 mm without spectral weighing.

Correlation

The correlation between the irradiance E and the radiation emission category is given in Table B.5.

Table B.5 — Correlation between the irradiance and the radiation emission category

E (700 nm to 1 mm) ($W \cdot m^{-2}$)	Radiation emission category
$E \leq 33$	0
$33 < E \leq 100$	1
$E > 100$	2

B.4 Electric, magnetic and electromagnetic fields and waves (up to 300 GHz)

The power flux density of radio frequency radiation or the field strength of electric and/or magnetic fields shall be measured at a distance of 0,25 m from the accessible surface of the machine.

The averaging time for the measurement shall be:

— 6 min for frequency greater than 100 kHz;

— 1 s for frequency lower than 100 kHz.

The correlation between the power or field strengths and the emission category is as shown in Tables B.6 and B.7.

If the measured field quantities do not exceed the values given in Table B.6, than the radiation emission category is 0.

If the measured field quantities are between the values given in Tables B.6 and B.7, then the radiation emission category of the machine is 1.

If the measured field quantities exceed the values specified in Table B.7, then the radiation emission category of the machine is 2.

In this range, the physical quantities and units are:

E electric field strength, in $V \cdot m^{-1}$

B magnetic flux density, in T

H magnetic field strength, in $A \cdot m^{-1}$

S power density, in $W \cdot m^{-2}$

f frequency, in Hz

Under near field conditions (f < 300 MHz) the electric field strength E and the magnetic field strength H (corresponding to the magnetic flux density B) shall be measured separately and each quantities has to satisfy the requirements.

Table B.6 — Quantities for categorization (category 0)

(Unperturbed rms. values)

Frequency range	Field strength E ($V \cdot m^{-1}$)	Field strength H ($A \cdot m^{-1}$)	Field B (μT)	Equivalent plane wave power density P_{eq} ($W \cdot m^{-2}$)
1 to 8 Hz	10 000	$3{,}2 \times 10^4/f^2$	$4 \times 10^4/f^2$	-
8 to 25 Hz	10 000	$4\,000/f$	$5\,000/f$	-
0,025 to 0,8 kHz	$250/f$	$4/f$	$5/f$	-
0,8 to 3 kHz	$250/f$	5	6,25	-
3 to 150 kHz	87	5	6,25	-
0,15 to 1 MHz	87	$0{,}73/f$	$0{,}92/f$	-
1 to 10 MHz	$87/f^{1/2}$	$0{,}73/f$	$0{,}92/f$	-
10 to 400 MHz	27,5	0,073	0,092	2
400 to 2 000 MHz	$1{,}375\ f^{1/2}$	$0{,}0037\ f^{1/2}$	$0{,}0046\ f^{1/2}$	$f/200$
2 to 300 GHz	61	0,16	0,20	10

For calculation of frequency-dependent values, insert f as in the first column.

Table B.7 — Quantities for categorization (category 1)

(Unperturbed rms. values)

Frequency range	Field strength E ($V \cdot m^{-1}$)	Field strength H ($A \cdot m^{-1}$)	Field B (μT)	Equivalent plane wave power density P_{eq} ($W \cdot m^{-2}$)
1 to 8 Hz	20 000	$1{,}63 \times 10^5/f^2$	$2 \times 10^5/f^2$	-
8 to 25 Hz	20 000	$2 \times 10^4/f$	$2{,}5 \times 10^4/f$	-
0,025 to 0,82 kHz	$500/f$	$20/f$	$25/f$	-
0, 82 to 65 kHz	610	24,4	30,7	-
0,065 to 1 MHz	610	$1{,}6/f$	$2{,}0/f$	-
1 to 10 MHz	$610/f$	$1{,}6/f$	$2{,}0/f$	-
10 to 400 MHz	61	0,16	0,2	10
400 to 2 000 MHz	$3\ f^{1/2}$	$0{,}008\ f^{1/2}$	$0{,}01\ f^{1/2}$	$f/40$
2 to 300 GHz	137	0,36	0,45	50

For calculation of frequency-dependent values, insert f as in the first column.

Annex C
(informative)

Examples of measures for the elimination or reduction of exposure to radiation

These examples may either be incorporated into the machinery design or provided as information for the user.

C.1 Elimination of exposure

A method of eliminating risks caused by the exposure of persons to radiation is the elimination of the radiation emissions. Measures for the elimination of the radiation emissions are:

— elimination of radiation sources by:

a) selecting an alternative production process;

b) selecting alternative operations;

— totally enclosed processes and handling systems.

C.2 Reduction of exposure

Reduction of people's exposure to radiation may either be achieved by the reduction of the radiation emissions or organizational measures.

C.2.1 Reduction of emission

Measures for reduction of emission could be:

— enclosed material handling systems;

— prevention of leaks and uncontrolled release of radiation;

— shielding, screening, filtering;

— earthing;

— process control, e.g. use of radiation measuring devices associated to interlock systems.

See also Part 3 of this standard for further details.

C.2.2 Reduction of exposure by management or segregation

Reduction of exposure by management or segregation can be achieved by using the following measures:

— prohibition of non-essential access to irradiated areas;

— separation of hazardous and non-hazardous operations, e.g. partial enclosures, partitions or separate buildings;

— remote controlled and automatic processes;

— reduction of exposure time;

— increasing the distance between the machine and the operator.

C.3 Information on residual risks and other measures

This concerns for example:

— information on the type and level of the residual emission of radiation;

— information on suitable personal protective equipment;

— adequate information on instruction and training for appropriate personnel;

— information on possible hazards caused by secondary effects of radiation, e.g.:

  — disturbance of pacemakers and other active electrical medical implants;

  — production of ozone or other hazardous substances;

  — hazards caused by electromagnetic interference with other electronic equipment in the vicinity.

Annex ZA
(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EC directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EC Directive

Machinery Directive 98/37/EC.

WARNING: Other requirements and other EC Directives may be applicable to the product(s) falling within the scope of this standard.

Compliance with this standard provides one with means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

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