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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Evaluation of human exposure to electromagnetic fields from a stand-alone broadcast transmitter (30 MHz – 40 GHz)

Evaluation de l'exposition des personnes aux champs électromagnétiques provenant des émetteurs de radiodiffusion isolés (30 MHz – 40 GHz)

IEC 62577:2009

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EVALUATION OF HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS FROM A STAND-ALONE BROADCAST TRANSMITTER (30 MHz – 40 GHz)

FOREWORD

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

FDIS	Report on voting
106/176/FDIS	106/179/RVD

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

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

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EVALUATION OF HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS FROM A STAND-ALONE BROADCAST TRANSMITTER (30 MHz – 40 GHz)

1 Scope and object

This International Standard applies to a single stand-alone broadcast transmitter operating in the frequency range 30 MHz to 40 GHz when put on the market (see Note 1).

The objective of the standard is to specify, for such equipment operating in typical conditions, the method for assessment of compliance distances according to the basic restrictions (directly or indirectly via compliance with reference levels) related to human exposure to radio frequency electromagnetic fields.

NOTE 1 This standard only applies to broadcast transmitters being placed on the market (type approval) and does not apply to broadcast transmitters being commissioned or placed into service.

NOTE 2 Compliance certification depends on the policy of national regulatory bodies.

2 Normative references

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

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995))*

EN 50413, *Basic standard on measurement and calculation procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz – 300 GHz)*

3 Terms and definitions

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

3.1
antenna
device that serves as a transducer between a guided wave (e.g. coaxial cable) and a free space wave, or vice versa

3.2
basic restriction
restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects

3.3
broadcasting service
radiocommunication service in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, television transmissions or other types of transmission

3.4
compliance distance
minimum distance from the antenna where a point of investigation is deemed to be compliant. The set of compliance distances therefore defines the boundary outside which the exposure levels do not exceed the basic restrictions irrespective of the time of exposure. The distances are measured related to the nearest point of the antenna in each investigation direction

3.5
conductivity
σ
ratio of the conduction-current density in a medium to the electric field strength. Conductivity is expressed in units of siemens per metre (S/m)

3.6
contact current
current produced in the body involved by human contact with metallic objects in the field. Shocks and burns can be the adverse indirect effects. Contact current relates to an instantaneous effect and so can't be time-averaged

3.7
electric field strength
E
magnitude of a field vector at a point that represents the force (*F)* on a positive small charge (*q)* divided by the charge

$$E = \frac{F}{q} \tag{1}$$

Electric field strength is expressed in units of volt per metre (V/m).

3.8
electric flux density
D
magnitude of a field vector that is equal to the electric field strength (E) multiplied by the permittivity (ε)

$$D = \varepsilon E \tag{2}$$

Electric flux density is expressed in units of coulomb per square metre (C/m²).

NOTE See also IEV 121-11-40.

3.9
equipment under test
EUT
device (such as transmitter, or antenna as appropriate) that is the subject of the specific test investigation being described

3.10
induced current
currents circulating inside a human body resulting directly from an exposure to an electromagnetic field

3.11
intrinsic impedance (of free space η_0)
η
ratio of the electric field strength to the magnetic field strength of a propagating electromagnetic wave. The intrinsic impedance of a plane wave in free space is 120 π (approximately 377 Ω)

3.12
isotropic radiator
a hypothetical antenna, without loss, having equal radiation intensities in all directions and serving as a convenient reference for expressing the directional properties of actual antennas

NOTE Deviations of isotropy have to be considered at all measured values of EMF with regard to various angles of incidence and polarization of the measured field. In this document it is defined for incidences covering a hemisphere centred at the tip of the probe, with an equatorial plane normal to the probe and expanding outside the probe. The axial isotropy is defined by the maximum deviation of the measured quantity when rotating the probe along its main axis with the probe exposed to a reference wave with normal incidence with regard to the axis of the probe. The hemispherical isotropy is defined by the maximum deviation of the measured quantity when rotating the probe along its main axis with the probe exposed to a reference wave with varying angles of incidences and polarisation with regard to the axis of the probe in the half space in front of the probe.

3.13
linearity
when all relationships between a reference quantity and the deviations of this quantity lie along a straight line (e.g. of an antenna or any other technical device). The maximum deviation over the measurement range of the measured quantity value from the closest linear reference curve defined over a given interval should be taken into account in measurement procedures

3.14
magnetic field strength
H
magnitude of a field vector in a point that results in a force (F) on a charge q moving with the velocity v

$$F = q(v \times \mu H) \quad (3)$$

The magnetic field strength is expressed in units of ampere per metre (A/m).

3.15
magnetic flux density
B
magnitude of a field vector that is equal to the magnetic field strength H multiplied by the permeability (μ) of the medium

$$B = \mu H \quad (4)$$

Magnetic flux density is expressed in units of tesla (T).

3.16
modulation
process, or the result of the process, where some characteristic of the wave (amplitude, frequency or phase) is varied in accordance with another wave or signal. It must also be taken into consideration when carrying out measurements and calculations to determine whether or not the limits are being exceeded

3.17
permeability
μ
magnetic permeability of a material defined by the magnetic flux density *B* divided by the magnetic field strength *H*:

$$\mu = \frac{B}{H} \tag{5}$$

where

μ is the permeability of the medium expressed in henry per metre (H/m).

3.18
permittivity
ε
property of a dielectric material (e.g., biological tissue) defined by the electrical flux density *D* divided by the electrical field strength *E*

$$\varepsilon = \frac{D}{E} \tag{6}$$

The permittivity is expressed in units of farad per metre (F/m).

3.19
point of investigation
PI

location in space at which the value of *E*-field, *H*-field, power flux density or *SAR* is evaluated. This location is defined in cartesian, cylindrical or spherical co-ordinates relative to the reference point on the EUT

3.20
power density
S
radiant power incident perpendicular to a surface, divided by the area of the surface. The power density is expressed in units of watt per square metre (W/m²)

3.21
reference levels
reference levels of exposure are provided for comparison with measured values of physical quantities

NOTE 1 Compliance with all reference levels given in these guidelines will ensure compliance with basic restrictions. If measured values are higher than reference levels, it does not necessarily follow that the basic restrictions have been exceeded, but a more detailed analysis is necessary to assess compliance with the basic restrictions.

NOTE 2 In the frequency range 30 MHz to 40 GHz the reference levels are expressed as electric field strength, magnetic field strength, power density values and contact currents.

3.22
relative permittivity
ε_r
ratio of the permittivity of a dielectric material to the permittivity of free space i.e.:

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \tag{7}$$

3.23
root-mean-square
r.m.s.
value obtained by taking the square root of the average of the square of the value of the periodic function taken throughout one period. See also IEV 101-14-15.

3.24
specific absorption rate
SAR
time derivative of the incremental energy *(*d*W)* absorbed by (dissipated in) an incremental mass *(*d*m)* contained in a volume element *(*d*V)* of given mass density (ρ)

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right) \qquad (8)$$

SAR is expressed in units of watt per kilogram (W/kg).

NOTE *SAR* can be calculated by:

$$SAR = \frac{\sigma E_i^2}{\rho} \qquad (9)$$

where

E_i is the r.m.s. value of the electric field strength in the tissue in V/m;

σ is the conductivity of body tissue in S/m;

ρ is the density of body tissue in kg/m³.

3.25
transmitter
device to generate radio frequency power for the purpose of communication but on its own is not intended to radiate it

4 Physical quantities, units and constants

4.1 Quantities

The internationally accepted SI-units are used throughout the standard.

Quantity	Symbol	Unit	Dimensions
Current density	*J*	ampere per square metre	A/m²
Electric field strength	*E*	volt per metre	V/m
Electric flux density	*D*	coulomb per square metre	C/m²
Electric conductivity	σ	siemens per metre	S/m
Frequency	*f*	hertz	Hz
Magnetic field strength	*H*	ampere per metre	A/m
Magnetic flux density	*B*	tesla (Vs/m²)	T
Mass density	ρ	kilo per cubic metre	kg/m³
Permeability	μ	henry per metre	H/m
Permittivity	ε	farad per metre	F/m
Specific absorption rate	*SAR*	watt per kilogram	W/kg
Wavelength	λ	metre	m
Temperature	*T*	kelvin	K

4.2 Constants

Physical constant		Magnitude
Speed of light in a vacuum	c	2,997 × 10^8 m/s
Permittivity of free space	ε_0	8,854 × 10^{-12} F/m
Permeability of free space	μ_0	4 π × 10^{-7} H/m
Impedance of free space	η_0	120 π (approx. 377) Ω

5 Applicability of compliance assessment methods

5.1 Overview

Guidelines and recommended limits on human exposure to radio waves give basic restrictions in terms of *SAR* or power flux density and also reference levels in terms of contact current and field strengths or power density.

The compliance boundary defines the volume outside which the exposure levels do not exceed the basic restrictions irrespective of the time of exposure for the specific operating conditions of the broadcast transmitter. The compliance boundary is determined via a procedure where sufficient points of investigation are assessed.

It is technically possible to determine the compliance distance through measurements or calculations of *SAR* or electromagnetic fields relating to basic restrictions or reference levels, since compliance to the reference levels guarantees compliance to the basic restrictions.

Where the assessment is made through *SAR*, it should be noted that both localised and whole-body basic restrictions must be considered. Spatial averaging may be used with field strength assessments in order to assess whole-body *SAR*.

5.2 Assessment procedure

5.2.1 Methods

This standard describes measurement and calculation methods that may be used to establish the compliance distances (see Table 1).

Table 1 – Applicable methods for each antenna region

	Applicable methods for each antenna region [a to c]		
	Reactive near-field	**Radiating near-field**	**Far-field**
Basic restriction evaluation	*SAR* or power density evaluation (calculation or measurement) – Clause 6 [b]		
Reference level calculation	*E*-field and *H*-field calculation Clause 8	*E*-field or *H*-field calculation Clause 7 [c]	*E*-field or *H*-field calculation – Clause 8
	Induced currents calculation Clause 10		Induced current calculation Clause 10
Reference level measurement	*E*-field and *H*-field measurement Clause 7 [c] Induced currents measurement Clause 10	*E*-field or *H*-field measurement Clause 7 [c] Induced currents measurement Clause 10	*E*-field or *H*-field measurement Clause 7 [c] Induced currents measurement Clause 10

[a] Compliance with the reference level will ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded. However, whenever a reference level is exceeded, it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary.

[b] *SAR* calculation is the reference, since it takes into account the fine structure of the head/body.

[c] Due to the existing probes on the market, above 2,5 GHz, only the *E-field* is measured and calculation on *H* level has to be performed.

5.2.2 Compliance distances

The distances are measured related to the nearest point of the antenna in each investigation direction. The boundary of all compliance distances may have a complex shape. It may be simplified by a simple boundary (e.g. sphere or cylinder) provided any points of investigation outside the compliance boundary shall be in compliance with the limits. Moreover the shape of the compliance boundary shall be accurately described in the assessment report. Clause 7 gives information on field measurements.

Basic restriction evaluation and field evaluation according to the reference levels can give directly the compliance distances.

In the case of field measurements, the compliance boundary may be deduced by scaling the results with measurement distance, relevant input powers, relevant frequencies, bands and modes, provided the resulting compliance boundary is entirely outside the antenna reactive near field. Clause 8 gives information on field levels calculations.

5.3 Representative antennas for each service

For each band, the representative antennas are defined in Table 2 for defined broadcasting bands. In this example they are bands defined by the European Conference of Postal and Telecommunications Administrations (CEPT).

Table 2 – Representative antennas

Frequency bands and services	Representative antennas (in free space conditions)
VHF Band I (47 MHz – 68 MHz) mainly TV broadcast services	λ/2 dipole tuned at 57 MHz
VHF Band II (88 MHz – 108 MHz) mainly sound FM broadcast services	λ/2 dipole tuned at 98 MHz
VHF Band III (174 MHz – 230 MHz)	λ/2 dipole tuned at 202 MHz
UHF Band IV (470 MHz – 650 MHz) mainly TV broadcast services	λ/2 dipole tuned at 560 MHz
UHF Band V (650 MHz – 862 MHz) mainly TV broadcast services	λ/2 dipole tuned at 706 MHz
SHF band L (1 452 MHz – 1 467,5 MHz)	Horn antenna centred at 1 460 MHz, with gain of 6 dBi
All other broadcasting bands above 2 GHz up to 40 GHz	Horn antenna centred at the middle of the band with a gain of 20 dBi

With this list of representative antennas, it is possible to qualify all broadcast transmitters with three characteristics, power, frequency and modulation, and to fix a compliance boundary.

Compliance boundary examples for representative antennas are detailed in Annex B.

6 *SAR* measurement and calculation

6.1 Whole-body *SAR* inherent compliance

If the maximum r.m.s. power of a transmitter is less than the values specified in the next equation (10), the maximum exposure will not exceed the whole-body averaged *SAR* compliance limits under any conditions and thus whole-body *SAR* measurements are not necessary.

$$P_{max}\ [\mathrm{W}] = SAR_{WB}\ [\mathrm{W/kg}] \times 12{,}5\ [\mathrm{kg}] \qquad (10)$$

where

P_{max} is the maximum r.m.s. power, and

SAR_{WB} is the whole-body SAR limit.

The whole-body *SAR* exclusion power levels have been derived based on the following assumptions:

a) all of the power emitted from the transmitter through the antenna is absorbed in the body (worst-case assumption);
b) the body mass for a 4-year-old child has been taken as 12,5 kg. This is the 3rd percentile body weight data for girls and women.

6.2 *SAR* compliance

Whole-body and localised *SAR* measurements and calculations are described in EN 50413.

7 Electromagnetic field measurement

7.1 Measurement

The methods used are to measure directly or indirectly the *E*-field or *H*-field strength and deduce the field distribution for a given input power and frequency.

Dependent on the application, the field measurements (E and H and therefore the power density) can be obtained at points of investigation, either along a line or by surface or volume scanning.

Table 3 describes the recommended resolution bandwidth (RBW) and video bandwidths (VBW) for different types of radio services to take their modulation into account, but other parameters can be used provided that they are justified.

Table 3 – Recommended parameters

Type of service	**RBW** kHz	**VBW** kHz
FM	300	30
TV video	1 000	300
TV audio	300	30
Digital TV (DVB)	8 000	300
Digital TV (ISDB-T)	6 000	300 [a]
Digital radio (DAB)	2 000	100
Digital radio (ISDB-Tsb)	428,5×N[b]	100 [a]

[a] Example

[b] *N* is total number of segments

Annex A details one possible measurement method: the volume measurement. Other methods can be used with appropriate justifications.

7.2 Measurement uncertainty

7.2.1 Expression of uncertainty in measurement

The evaluation of uncertainty in the measurement of the electromagnetic fields values shall be based on the general rules provided by the *ISO/IEC Guide to the expression of uncertainty in measurement*. An evaluation of type A as well as type B of the standard uncertainty shall be used.

When a type A analysis is performed, the standard uncertainty (u_j) shall be derived from the estimate from statistical observations. When type B analysis is performed, u_j comes from the upper (a_+) and lower (a_-) limits of the quantity in question, depending on the distribution law defining

$$a = (a_+ - a_-)/2$$

then:

- rectangular law: $u_i = a/\sqrt{3}$
- triangular law: $u_i = a/\sqrt{6}$
- normal law: $u_i = a/k$ where k is a coverage factor
- U-shaped (asymmetric): $u_i = a/\sqrt{2}$