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Foreword

This European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI).

Transposition dates	
Date of adoption:	21 February 1997
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Introduction

There are currently two frequency allocations for the radio location of avalanche victims:

- 2 275 Hz; and
- 457 kHz.

It is expected that the allocation at 2 275 Hz will be removed after a transition period. This ETS therefore covers dual-frequency equipment and equipment intended to operate on 457 kHz only.

It is the purpose of this ETS to ensure the practical interoperability and reliability of products from different manufacturers.

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1 Scope

This European Telecommunication Standard (ETS) standard covers requirements for avalanche beacons. Avalanche beacons are radio location systems used for searching for and/or finding avalanche victims, for the purpose of direct rescue.

These systems comprise a transmitter as well as a receiver part.

This ETS distinguishes between two types of beacons:

- type 1: single frequency beacons (457 kHz);
- type 2: double frequency beacons (2 275 Hz and 457 kHz) temporary type, compatible to beacons with frequency 2 275 Hz.

2 Normative references

This ETS incorporates by dated and 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 ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ETR 028: "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".

[2] CISPR 16-1: "Specification for radio disturbance and immunity measuring apparatus and methods; Part 1: Radio disturbance and immunity measuring apparatus".

[3] Radio Regulations (1994).

3 Definitions, abbreviations and symbols

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

artificial antenna: A tuned reduced-radiating dummy load equal to the nominal impedance specified by the applicant.

conducted measurements: Measurements which are made using a direct connection to the equipment under test.

E-field: The electric component of the field measured as voltage per unit length.

H-field: The magnetic component of the field measured as current per unit length.

H-field test antenna: An electrically screened loop or equivalent antenna, with which the magnetic component of the field can be measured.

identification system: Equipment consisting of a transmitter(s), receiver(s) (or a combination of the two) and an antenna(e) to identify a transponder.

integral antenna: An antenna designed as an indispensable part of the equipment, with or without the use of an antenna connector.

portable station: Equipment intended to be carried.

radiated measurements: Measurements which involve the absolute measurement of a radiated field.

S/N ratio: The ratio, expressed in decibels, between the wanted signal and the noise floor.

type 1: An avalanche beacon intended to operate on 457 kHz only.

type 2: An avalanche beacon intended to operate on both 2 275 Hz and 457 kHz.

3.2 Abbreviations

For the purposes of this ETS, the following abbreviation applies:

RF	Radio Frequency

3.3 Symbols

For the purposes of this ETS, the following symbols apply:

A1A	Class of emission (Radio Regulations [3], Article 4, Regulations 270-273)
E	Electrical field strength
Eo	Reference electrical field strength, (see annex A)
f	Frequency
H	Magnetic field strength
Ho	Reference magnetic field strength, (see annex A)
N	Newton
P	Power
R	Distance
Ro	Reference distance, (see annex A)
t	Time
Z	Wave impedance
λ	Wavelength (see annex A)

4 General

4.1 Presentation of equipment for testing

Each equipment submitted for conformance testing shall fulfil the requirements of this ETS on all frequencies over which it is intended to operate.

The applicant shall supply all relevant ancillary equipment needed for testing.

The applicant should also supply an operating manual for the device(s).

4.2 Mechanical and electrical design

4.2.1 General

The equipment shall be designed, constructed and manufactured in accordance with good engineering practice, and with the aim of minimizing harmful interference to other equipment and services.

Transmitter and receiver shall be combined in one unit and be capable of being attached to the user's clothing.

The equipment shall be portable and capable of being used for rescue operations, caused by avalanche, between persons that are in snowy, arctic areas or in similar areas.

The equipment shall in one unit comprise at least:

- an transmitter/receiver including antenna and battery;
- a control unit including an on/off switch; and
- an internal loudspeaker and/or earphone.

The equipment with battery shall not weigh more than 200 g.

4.2.2 Controls and indicators

The equipment shall have the following controls:

- on/off switch for the equipment with a visual indication that the equipment is switched on;
- an audio-frequency power volume control;
- a sensitivity control; and
- battery indicator.

4.2.3 Switching over from transmit to receive

The equipment shall permit reliable and fast switchover from transmit to the receive mode, without danger of unintentionally turning off the device.

The transmit mode shall include a safety feature against involuntary turn off.

4.2.4 Battery type

The equipment shall use a widely obtained battery type.

4.2.5 Operating time

The equipment equipped with a new set of batteries recommended by the manufacturer shall be capable to operate for a minimum of 200 hours of continuous transmission during normal temperature conditions, see subclause 5.3.1.

4.2.6 Battery check

The equipment shall include a battery check feature.

4.2.7 Carrying system

The equipment shall include a carrying system that gives the possibility for easy operation and safety placing. The carrying system can be a part of the equipment or an accessory device. The carrying system shall have a joint tensile strength of at least 50 N.

4.2.8 Frequencies and power

The equipment shall operate on the following nominal frequencies in the transmit as well as in the receive mode:

- type 1: f = 457 kHz;
- type 2: f = 2 275 Hz and f = 457 kHz.

After switch on the equipment shall be operational within 5 seconds.

4.2.9 Operating instructions

Operating instructions shall be delivered with every equipment. They shall cover the following subjects:

a) a statement on avalanche danger;

b) instruction for checking the battery, transmitter and receiver performance and range;

c) instructions for turning on the transmitter and strapping the beacon to the body;

d) instructions for changing to the receive mode and the search strategy (coarse search and fine search);

e) instructions for changing back to the transmit mode, in particular in the case of secondary avalanche;

f) a statement on the temperature sensitivity of essential parts;

g) a statement on the battery lifetime;

h) device-specific measures on a tour.

4.2.10 Equipment identification and short form operating instruction

The equipment shall be marked in a visible place. This marking shall be legible, tamper-proof and durable.

The marking shall include:

- the name of the manufacturer or his trade mark;

- the type designation.

A short form of the operating instructions shall be printed onto the case. The printing shall be clearly visible and abrasion proof. Also, the proper positioning of the batteries shall be indicated.

4.3 Interpretation of the measurement results

The interpretation of the results recorded in the appropriate test report for the measurements described in this ETS shall be as follows:

- the measured value related to the corresponding limit shall be used to decide whether an equipment meets the requirements of this ETS;

- the measurement uncertainty value for the measurement of each parameter shall be separately included in the test report;

- the recorded value of the measurement uncertainly shall be, for each measurement, equal to or lower than the figures in the table of measurement uncertainty in clause 10.

5 Test conditions, power sources and ambient temperatures

5.1 Normal and extreme test conditions

Type testing shall be made under normal test conditions, and also, where stated, under extreme test conditions.

The test conditions and procedures shall be as specified in subclauses 5.2 to 5.4.

5.2 External test power source

During type tests, the power source of the equipment shall be replaced by an external test power source capable of producing normal and extreme test voltages as specified in subclauses 5.3.2. and 5.4.2. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible. For the purpose of the tests, the voltage of the external test power source shall be measured at the input terminals of the equipment.

The battery shall be removed and the external test power source shall be suitably de-coupled and applied as close to the equipment battery terminals as practicable. For radiated measurements fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the applicant.

During tests the external test power source voltages shall be within a tolerance ±1 % relative to the voltage at the beginning of each test.

5.3 Normal test conditions

5.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature: +15 °C to +35 °C;
- relative humidity: 20 % to 75 %.

When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

5.3.2 Normal test voltage

The normal test voltage shall be declared by the applicant. The values shall be stated in the test report.

5.4 Extreme test conditions

5.4.1 Extreme temperatures

The extreme test temperatures shall be -30 °C to +45 °C.

5.4.2 Extreme test voltages

The extreme test voltages shall be declared by the applicant.

5.4.3 Procedure for tests at extreme temperatures

Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilizing period.

In the case of equipment containing temperature stabilization circuits designed to operate continuously, the temperature stabilization circuits shall be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements.

If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the accredited test laboratory, shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

5.4.3.1 Procedure for equipment designed for intermittent operation

The test procedure shall be as follows:

- before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained in the oven. The equipment shall then be switched on in the transmit position condition for a period of one minute, followed by a period in the off or standby mode for four minutes;

- for tests at the lower extreme temperature, the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for one minute.

6 General conditions

6.1 Normal test signals

Tests on the transmitter shall be performed with the equipment switched on in the transmit condition.

For tests on the receiver, the test signal shall be an A1A signal modulated as indicated in subclause 8.1.

6.2 Test fixture

A test fixture shall be supplied by the applicant to enable extreme temperature measurements to be made, where applicable. The test fixture shall couple to the generated electromagnetic field from the equipment under test without disturbing the operation of the said device. The test fixture shall be provided with a 50 Ω standard connector, where the generated field can be sampled.

The test laboratory shall calibrate the test fixture by carrying out the required field measurements at normal temperatures at the prescribed test site and then by repeating the same measurements on the equipment under test using the test fixture for all identified frequency components.

The test fixture is only required for extreme temperature measurements and shall be calibrated only with the equipment under test.

6.3 Test sites and general arrangements for radiated measurements

For guidance on radiation test sites and detailed descriptions of radiated measurement arrangements, see annex A.

6.4 Measuring receiver

The term "measuring receiver" refers to a selective voltmeter or a spectrum analyser. The bandwidth of the measuring receiver shall be according to CISPR 16-1 [2]. The quasi-peak detector for the measuring receiver shall be applied, see table 1.

Table 1

Frequency (f)	Detector type	Bandwidth
9 kHz ≤ f <135 kHz	Quasi-peak	200 - 300 Hz
135 kHz ≤ f < 30 MHz	Quasi-peak	9 - 10 kHz
30 MHz ≤ f ≤ 1000 MHz	Quasi-peak	100 - 120 kHz

7 Environmental tests

7.1 Procedure

Environmental tests shall be carried out before tests of the same equipment in respect to the other requirements of this ETS are performed. The following tests shall be carried out in the order they appear in this clause.

Where electrical tests are required the equipment shall be powered by its internal battery.

7.2 Drop test on hard surface

7.2.1 Definition

The immunity against the effects of dropping is the ability of the equipment to maintain the specified mechanical and electrical performance after being subjected to a series of drops on a hard wooden test surface.

7.2.2 Method of measurement

The test shall consist of a series of 6 drops, one on each surface.

During the test the equipment shall be fitted with a suitable set of batteries and it shall be switched off. The test shall be carried out under normal temperature and humidity conditions.

The hard wooden test surface shall consist of a piece of solid hard wood with a minimum thickness of 15 cm and a mass of 30 kg or more.

The height of the lowest part of the equipment under test relative to the test surface at the moment of release shall be 1 m.

Equipment shall be subjected to this test configured for use as in operational circumstances.

7.3 Temperature tests

7.3.1 General

The maximum rate of raising or reducing the temperature of the chamber in which the equipment is being tested shall be 1 °C/minute.

7.3.2 Dry heat cycle

The equipment shall be placed in a chamber of normal temperature. The temperature shall then be raised to and maintained at +70 °C (±3 °C) for a period of at least 10 hours. After this period any climatic control device provided in the equipment may be switched on and the chamber cooled to +55 °C (±3 °C). The cooling of the chamber shall be completed within 30 minutes.

The equipment shall then be switched on and shall be kept working continuously for a period of two hours. The transmitter shall be keyed with a duty cycle of five minutes transmission and five minutes reception.

The temperature of the chamber shall be maintained at +55 °C (±3 °C) during the two hour period.

At the end of the test, and with the equipment still in the chamber, the chamber shall be brought to room temperature in not less than one hour. The equipment shall then be exposed to normal room temperature and humidity for not less than three hours before the next test is carried out.

7.3.3 Low temperature cycle

The equipment shall be placed in a chamber at normal room temperature. Then the temperature shall be reduced to, and maintained at, -30 °C (±3 °C) for a period of at least 10 hours.

The chamber shall be warmed to -20 °C (±3 °C). The warming of the chamber shall be completed within 30 (±5) minutes.

The temperature of the chamber shall be then maintained at -20 °C (±3 °C) during a period of one hour 30 minutes.

At the end of the test, and with the equipment still in the chamber, the chamber shall be brought to room temperature in not less than one hour. The equipment shall then be exposed to normal room temperature for not less than three hours, or until moisture has dispersed, which ever is longer, before the next test is carried out.

Throughout the test the equipment shall be in the receive condition.

7.4 Immersion test

7.4.1 Method of measurement

The equipment shall be immersed into water for one hour in a horizontal position at a depth of 15 cm and at +10 °C.

After the end of the test period the equipment shall be inspected for damage and visible ingress of water.

Following inspection, the equipment shall be resealed in accordance with the manufacturer's instructions.

7.4.2 Requirements

No damage or ingress of water shall be visible to the naked eye.

7.5 Solar radiation

7.5.1 Method of measurement

The equipment shall be placed on a suitable support and exposed continuously to a simulated solar radiation source as specified in annex C for 80 hours.

7.5.2 Requirements

There shall be no harmful deterioration of the equipment visible to the naked eye.

7.6 Tensile test

7.6.1 Method of measurement

All joints between essential parts of the equipment shall be submitted to a tensile stress of at least 10 N by suitable means.

7.6.2 Requirements

No damage shall be visible to the naked eye.

8 Methods of measurement and limits for transmitter parameters

8.1 Modulation and carrier keying

The modulation shall be of type A1A.

The carrier keying shall be (figure 1):

- on time: 70 ms minimum;
- off time: 200 ms minimum;
- period: 0,9 ± 0,4 s (on time plus off time).

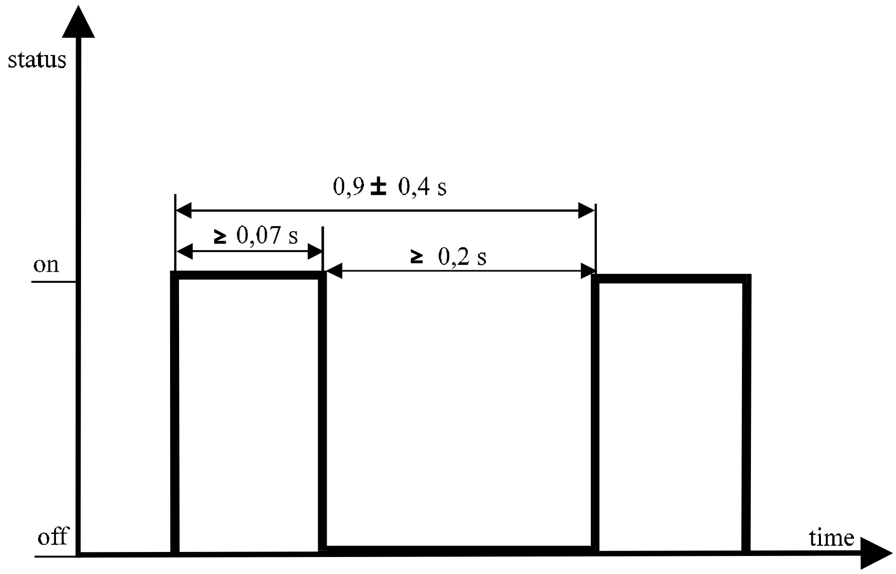

Figure 1

8.2 Frequency error

8.2.1 Definition

The frequency error of the transmitter system is the difference between the operating carrier frequency and the nominal carrier frequency.

8.2.2 Method of measurement

The carrier frequency shall be measured in a test fixture (subclause 6.2). The measurement shall be made under normal test conditions (subclause 5.3), and extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously).

8.2.3 Limits

The frequency error shall not exceed the values given in table 2.

Table 2

Type	Frequency	Maximum frequency error
Type 1	f_1 = 457 kHz	± 100 Hz
Type 2	f_1 = 457 kHz f_2 = 2 275 Hz	± 100 Hz ± 20 Hz

8.3 Output field strength (H-field)

8.3.1 Definition

The H-field is measured in the direction of maximum field strength under specified conditions of measurement.

8.3.2 Method of measurement

The H-field produced by the equipment shall be measured at distances of 10 m on an open field test site (see annex A).

The equipment shall be rotated and the field strengths shall be measured in the directions of maximum and minimum emission.

8.3.3 Limits

The minimum transmitted field strength shall not be lower than the values given in table 3.

Table 3

Type	Frequency	10 m measuring distance (μA/m)
Type 1	f_1 = 457 kHz	0,5
Type 2	f_1 = 457 kHz f_2 = 2 275 Hz	0,5 10

The maximum transmitted field strength shall not exceed the values given in table 4.

Table 4

Type	Frequency	10 m measuring distance (μA/m)
Type 1	f_1 = 457 kHz	2,16
Type 2	f_1 = 457 kHz f_2 = 2 275 Hz	2,16 108

8.4 Spurious emissions

8.4.1 Definition

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal test modulation. The level of spurious emissions shall be measured at normal conditions as their effective radiated power or field strength radiated by the cabinet and the integral antenna.

8.4.2 H-field strength

8.4.2.1 Method of measurement (< 30 MHz)

The field strength shall be measured for frequencies below 30 MHz. The equipment under test shall be measured at a distance of 10 m on an outdoor test site. The test antenna shall be a calibrated shielded magnetic field antenna. The equipment under test and test antenna shall be arranged as stated in annex A, clause A.1.

The equipment under test shall be switched on with normal modulation (subclause 8.1). The characteristics of the modulation signal used shall be stated on the test report. The measuring receiver shall be tuned over the frequency range 9 kHz to 30 MHz, except for the frequency band ± 20 kHz from the frequency on which the transmitter is intended to operate.

At each frequency at which a spurious signal is detected the equipment under test and the test antenna shall be rotated until maximum field strength is indicated on the measuring receiver. This level shall be noted.

If the transmitter can be operated in the standby mode, then the measurements shall be repeated in the standby mode.

The limits are quoted in dBµA or dBµA/m, so it is necessary to reduce the reading by 51,5 dB for measuring equipment calibrated in dBµV or dBµV/m.

8.4.2.2 Limits

Radiated emissions below 30 MHz shall not exceed the generated H-field at 10 m given in table 5.

Table 5

State	Frequency 9 kHz ≤ f < 4,78 MHz	Frequency 4,78 MHz ≤ f < 30 MHz
Transmit	24,5 to -2,8 dBµA/m	-2,8 dBµA/m
Standby	3,5 to -23,7 dBµA/m	-23,7 dBµA/m
NOTE: The limit reduces by 3 dB per octave in the frequency range 9 kHz to 4,78 MHz		

A graphical representation is shown in annex B, figure B.1.

8.4.3 Effective radiated power

8.4.3.1 Method of measurement (≥ 30 MHz)

On a test site, selected from annex A, the equipment shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the applicant.

The test antenna shall be oriented for vertical polarization. The output of the test antenna shall be connected to a measuring receiver.

The transmitter shall be switched on with normal modulation, and the measuring receiver shall be tuned over the frequency range 30 MHz to 1 000 MHz.

At each frequency at which a spurious component is detected, the test antenna shall be raised and lowered through the specified range of heights until a maximum signal level is detected on the measuring receiver.

The transmitter shall then be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver.

The maximum signal level detected by the measuring receiver shall be noted.

The substitution antenna shall be oriented for vertical polarization and calibrated for the frequency of the spurious component detected.

The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected. The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver, if necessary.

The test antenna shall be raised and lowered through the specified range of heights to ensure that the maximum signal is received.

When a test site according to clause A.3 is used, there is no need to vary the height of the antenna.

The input signal to the substitution antenna shall be adjusted until an equal or a known related level to that detected from the transmitter is obtained on the measuring receiver.

The input signal to the substitution antenna shall be recorded as a power level and corrected for any change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna oriented for horizontal polarization.

The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the substitution antenna if necessary.

If standby mode is available, the measurements shall be repeated in that mode.

8.4.3.2 Limits

The power of any radiated emission shall not exceed the values given in table 6.

Table 6

State	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies between 30 to 1 000 MHz
Operating	4 nW	250 nW
Standby	2 nW	2 nW

9 Methods of measurement and limits for receiver parameters

9.1 Receiver sensitivity

9.1.1 Definition

The maximum usable sensitivity of the receiver is the minimum level of the signal (H-field strength) at the nominal frequency of the receiver which, when applied to the receiver input with normal test modulation (subclause 8.1), produces:

- a S/N ratio of 6 dB, measured at the terminals of the electroacoustic transducer.

S/N=(S + N)/N)

- where: S = wanted signal;
  N = noise.

9.1.2 Method of measurement

The terminals of the transducer shall be made accessible for the purposes of this test.

A test signal at a carrier frequency equal to the nominal frequency of the receiver, modulated by the normal test modulation (subclause 8.1) shall be applied in the best coupling position, i.e. when the antenna rod is parallel to the lines of the magnetic field. An audio frequency load and a measuring instrument for measuring the S/N ratio shall be connected to the terminals of the electroacoustic transducer.

The level of the test signal shall be adjusted until a S/N ratio of 6 dB is obtained. The field strength at the receiver shall be measured by a substitution method. Under these conditions, the level of the test signal at the input measured flat over a bandwidth of 20 kHz is the value of the reference maximum usable sensitivity which shall be recorded.

9.1.3 Limits

The S/N of minimum 6 dB shall be achieved for the field strengths values given in table 7.

Table 7

Type	Frequency	Field strengths
Type 1	f_1 = 457 kHz	80 nA/m
Type 2	f_1 = 457 kHz f_2 = 2275 Hz	200 nA/m 10 µA/m

9.2 Changes in the received signal

9.2.1 Definition

Changes in the received signal are changes related to variation of the distance between the transmitter and the receiver.

9.2.2 Requirement

Reducing the distance between transmitter and receiver by 25 % shall produce a change of > 3 dB in the received signal over the whole receiving range down to a distance of 1 m. In the receive mode, there shall be means to modify the received signal manually.

10 Measurement uncertainty

The accumulated measurement uncertainties of the test system in use for the parameters to be measured should not exceed those given in table 8. This is in order to ensure that the measurements remain within an acceptable uncertainty.

Table 8

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
RF power, conducted	±0,75 dB
Conducted emission of transmitter, valid up to 1 GHz	±3 dB
Conducted emission of receivers	±3 dB
Radiated emission of transmitter, valid up to 1 GHz (Substitution method)	±2 dB
Radiated emission of transmitter, valid up to 1 GHz (Direct measurement, using calibrated antennas)	±6 dB
Temperature	±1°C
Humidity	±5 %
NOTE: For the test methods according to this ETS the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in the ETR 028 [1].	

Annex A (normative): Radiated measurements

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

A.1.1 Outdoor test site

The outdoor test site shall be on a reasonably level surface or ground. For measurements at frequencies below 30 MHz a non-conducting ground plane shall be used. For measurements at frequencies 30 MHz and above, a conducting ground plane of at least 5 m diameter shall be provided at one point on the site. In the middle of this ground plane, a non-conducting support, capable of rotation through 360^{o} in the horizontal plane, shall be used to support the test sample in its standard position (subclause A.1.1.2), at 1 m above the ground plane, with the exception of equipment with floor standing antenna. For this equipment, the antenna shall be raised, on a non-conducting support, 100 mm above the turntable, the point(s) of contact being consistent with normal use. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of 10 m. The distance actually used shall be recorded with the results of the tests carried out on the site.

Sufficient precautions shall be taken to ensure that reflections from extraneous objects adjacent to the site do not degrade the measurements results.

A.1.1.1 Test support for body worn equipment

For equipment intended to be worn close the body, but excluding hand-held equipment, the non-conducting support shall be replaced with the simulated man.

The simulated man shall consist of a plastic tube, filled with salt water (9 g NaCl per litre). The tube shall have a length of 1 m and an internal diameter of 10 cm ± 0,5 cm. The upper end of the tube is closed by a metal plate with a diameter of 15 cm, which is in contact with the water. To meet the requirements made on equipment with rigid outside antenna, this antenna has to be in a vertical position during the measurement and the metal plate shall, if necessary, be prepared in such a way that a second hinged metal plate of 10 cm x 15 cm can be fastened to its narrow side. It shall be possible to change the supporting point of the hinged metal plate as far as the centre.

The position of the hinged metal plate shall be adjusted within 0° to 90° with respect to the lower metal plate.

The sample shall be fastened in such a way that:

- the centre of its largest area rests on the revolving metal plate; and
- this centre, on its part, is located above the centre of the lower metal plate by changing the supporting point of the revolving plate.

In the case of a sample, whose largest area is smaller than 10 cm x 15 cm, the centre of the sample shall (deviating from point 1) above) be so changed in its longitudinal axis so that the antenna base is at the edge outside the metal plate.

A.1.1.2 Standard position

The standard position in all test sites, except for equipment which is intended to be worn on a person, shall be as follows:

- for equipment with an integral antenna, it shall be placed in the position closest to normal use as declared by the manufacturer;

- for equipment with a rigid external antenna, the antenna shall be vertical;

- for equipment with non-rigid external antenna, the antenna shall be extended vertically upwards by a non-conducting support.

A.1.2 Test antenna

A.1.2.1 Below 30 MHz

A calibrated loop antenna shall be used to detect the field strength from the test sample. The antenna shall be supported in the vertical plane and be rotated about a vertical axis. The lowest point of the loop shall be 1 m above ground level.

A.1.2.2 Above 30 MHz

The test antenna is used to detect the radiation from both the test sample and the substitution antenna, when the site is used for radiation measurements. Where necessary, it is used as a transmitting antenna, when the site is used for the measurement of receiver characteristics.

This antenna is mounted on a support such as to allow the antenna to be used in either horizontal or vertical polarization and for the height of its centre above ground to be varied over the range 1 m to 4 m. Preferably a test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20 % of the measuring distance.

For receiver and transmitter radiation measurements, the test antenna is connected to a measuring receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input.

A.1.3 Substitution antenna

When measuring in the frequency range up to 1 GHz the substitution antenna shall be a $\lambda/2$ dipole, resonant at the operating frequency, or a shortened dipole, calibrated to the $\lambda/2$ dipole. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted inside the cabinet, or the point where an external antenna is connected to the cabinet.

The distance between the lower extremity of the dipole and the ground shall not be less than 0,3 m.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for spurious radiation measurements and transmitter effective radiated power measurements. The substitution antenna shall be connected to a calibrated measuring receiver when the site is used for the measurement of receiver sensitivity.

The signal generator and the receiver shall operate at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

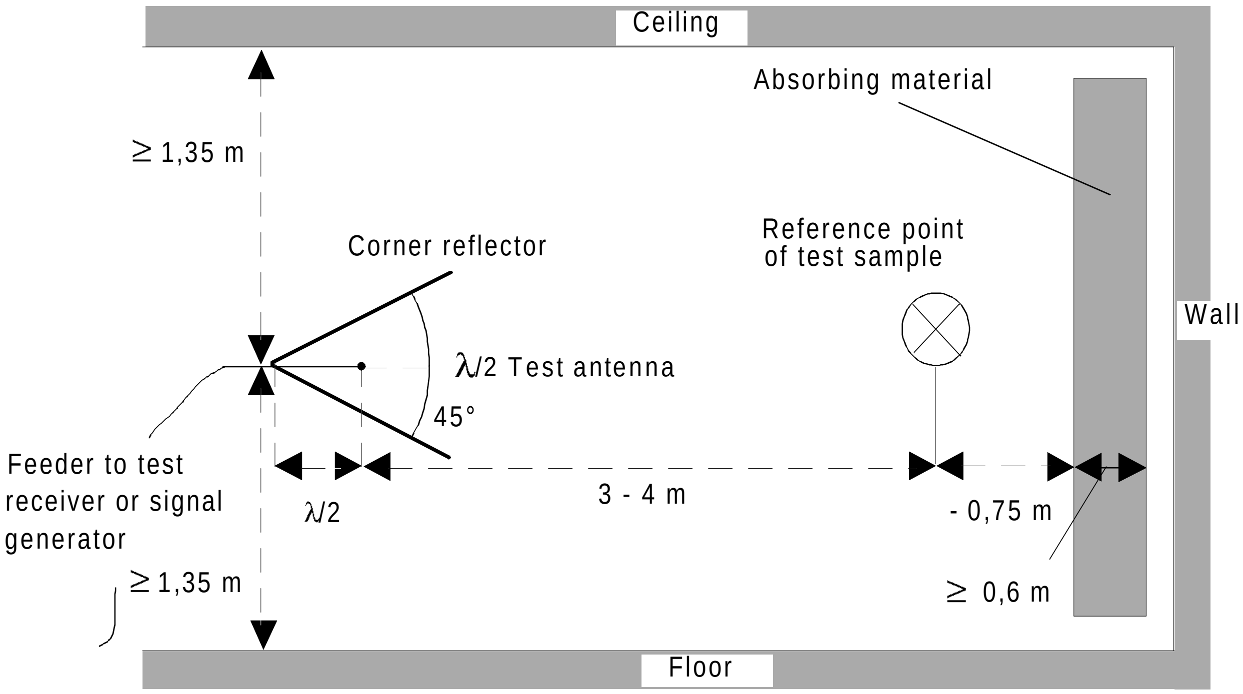

Figure A.1: Indoor site arrangement (shown for horizontal polarization)

A.1.4 Optional additional indoor site

When the frequency of the signals being measured is greater than 80 MHz, use may be made of an indoor test site. If this alternative site is used, this shall be recorded in the test report.

The measurement site may be a laboratory room with a minimum area of 6 m by 7 m and at least 2,7 m in height.

Apart from the measuring apparatus and the operator, the room shall be as free as possible from reflecting objects other than the walls, floor and ceiling.

The potential reflections from the wall behind the equipment under test are reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna is used to reduce the effect of reflections from the opposite wall and from the floor and ceiling, in the case of horizontally polarized measurements. Similarly, the corner reflector reduces the effects of reflections from the side walls for vertically polarized measurements. For the lower part of the frequency range (below approximately 175 MHz), no corner reflector or absorbent barrier is needed.

For practical reasons, the λ/2 antenna in figure A.1 may be replaced by an antenna of constant length, provided that this length is between λ/4 and λ at the frequency of measurement, and the sensitivity of the measuring system is sufficient. In the same way, the distance of λ/2 to the apex may be varied.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method. To ensure that errors are not caused by the propagation path approaching the point at which phase cancellation between the direct and the remaining reflected signals occurs, the substitution antenna shall be moved through a distance of ±0,1 m in the direction of the test antenna as well as in the two directions perpendicular to this first direction.

If these changes of distance cause a signal change of greater than 2 dB, the test sample should be re-sited until a change of less than 2 dB is obtained.

A.2 Guidance on the use of radiation test sites

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of clause A.1. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

A.2.1 Measuring distance

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than $\lambda/2$ at the frequency of measurement, and that the precautions described in this annex are observed. Measuring distances of 3 m, 5 m, 10 m and 30 m are in common use in European test laboratories.

A.2.2 Test antenna

Different types of test antenna may be used, since performing substitution measurements reduces the effect of the errors on the measuring results.

Height variation of the test antenna over a range of 1 m to 4 m is essential in order to find the point at which the radiation is maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below approximately 100 MHz.

A.2.3 Substitution antenna

Variations in the measuring results may occur with the use of different types of substitution antenna at the lower frequencies below approximately 80 MHz. Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the test site. Correction factors shall be taken into account when shortened dipole antennas are used.

A.2.4 Artificial antenna

The dimensions of the artificial antenna used during radiated measurements should be small in relation to the sample under test.

Where possible, a direct connection should be used between the artificial antenna and the test sample. In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

A.2.5 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables etc.) which are not adequately de-coupled, may cause variations in the measurement results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non conducting support).

A.3 Further optional alternative indoor test site using an anechoic chamber

For radiation measurements, when test frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor test site being a well-shielded anechoic chamber simulating a free space environment. If such a chamber is used, this shall be recorded in the test report.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method, subclause A.1. In the range 30 MHz to 100 MHz, some additional calibration may be necessary.

An example of a typical measurement site may be an electrically shielded anechoic chamber being 10 m long, 5 m broad and 5 m high. Walls and ceiling should be coated with Radio Frequency (RF) absorbers of 1 m height. The base should be covered with absorbing material 1 m thick, and a wooden floor, capable of carrying test equipment and operators. The construction of the anechoic chamber is described in the following subclauses.

A.3.1 Example of the construction of a shielded anechoic chamber

Free-field measurements can be simulated in a shielded measuring chamber where the walls are coated with RF absorbers. Figure A.2 shows the requirements for shielding loss and wall return loss of such a room. As dimensions and characteristics of usual absorber materials are critical below 100 MHz (height of absorbers < 1 m, reflection attenuation < 20 dB) such a room is more suitable for measurements above 100 MHz. Figure A.4 shows the construction of an anechoic shielded measuring chamber having a base area of 5 m by 10 m and a height of 5 m.

Ceilings and walls are coated with pyramidal formed RF absorbers approximately 1 m high. The base is covered with absorbers forming a non-conducting sub-floor or with special ground floor absorbers. The available internal dimensions of the room are 3 m x 8 m x 3 m, so that a maximum measuring distance of 5 m length in the middle axis of this room is available.

At 100 MHz the measuring distance can be extended up to a maximum of 2λ.

The floor absorbers reduce floor reflections so that the antenna height need not be changed and floor reflection influences need not be considered.

All measuring results can therefore be checked with simple calculations and the measurement uncertainties have the smallest possible values due to the simple measuring configuration.

A.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field condition the correlation E = Eo (Ro/R) is valid for the dependence of the field strength E on the distance R, whereby Eo is the reference field strength in the reference distance Ro.

It is useful to use this correlation for comparison measurements, as all constants are eliminated with the ratio and neither cable attenuation, nor antenna mismatch, or antenna dimensions are of importance.

Deviations from the ideal curve can be seen easily if the logarithm of the above equation is used, because the ideal correlation of field strength and distance can then be shown as a straight line and the deviations occurring in practice are clearly visible. This indirect method more readily shows the disturbances due to reflections and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in subclause A.3 at low frequencies up to 100 MHz, there are no far field conditions and therefore reflections are stronger so that careful calibration is necessary; in the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well.

A.3.3 Calibration of the shielded RF anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 1 GHz.

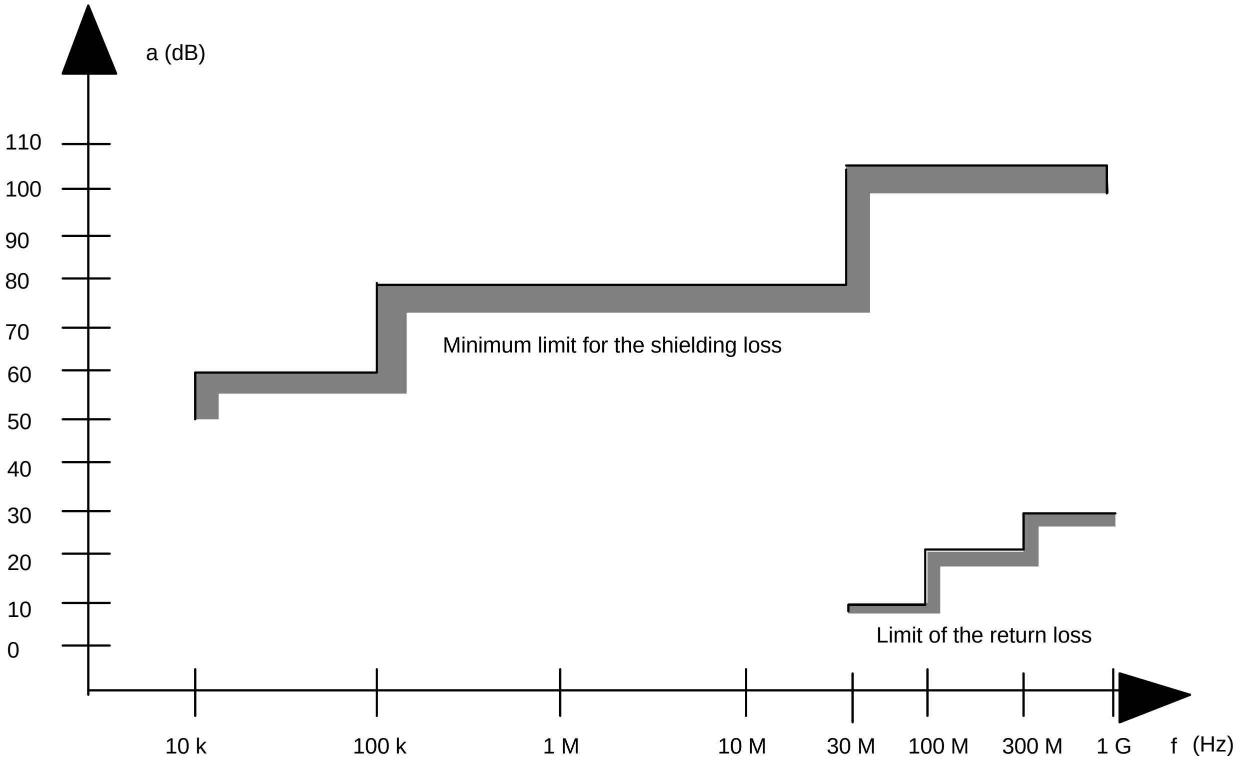

Figure A.2: Specification for shielding and reflections

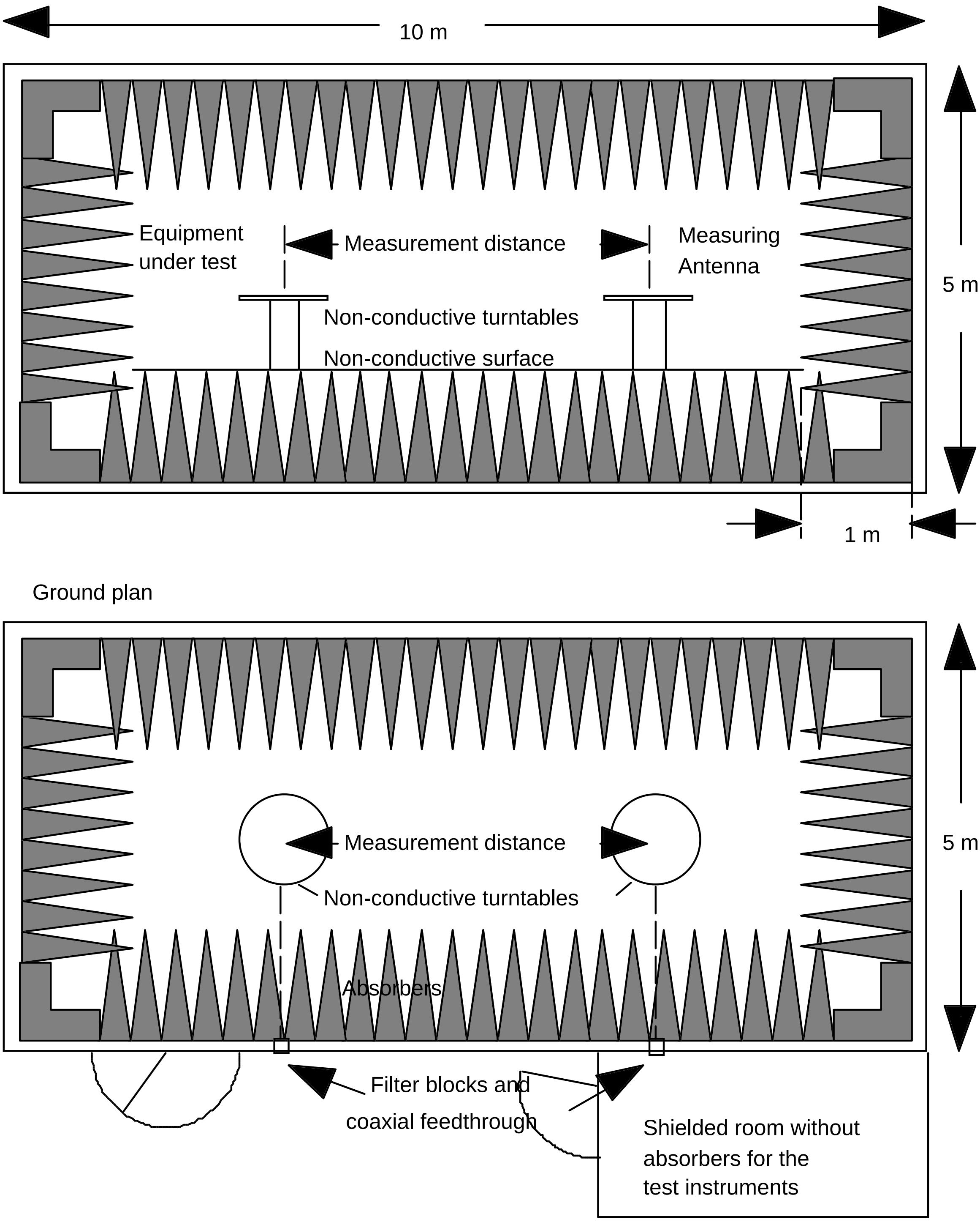

Figure A.3: Example of construction of an anechoic shielded chamber

Annex B (normative): Spurious limits, H-field at 10 m distances

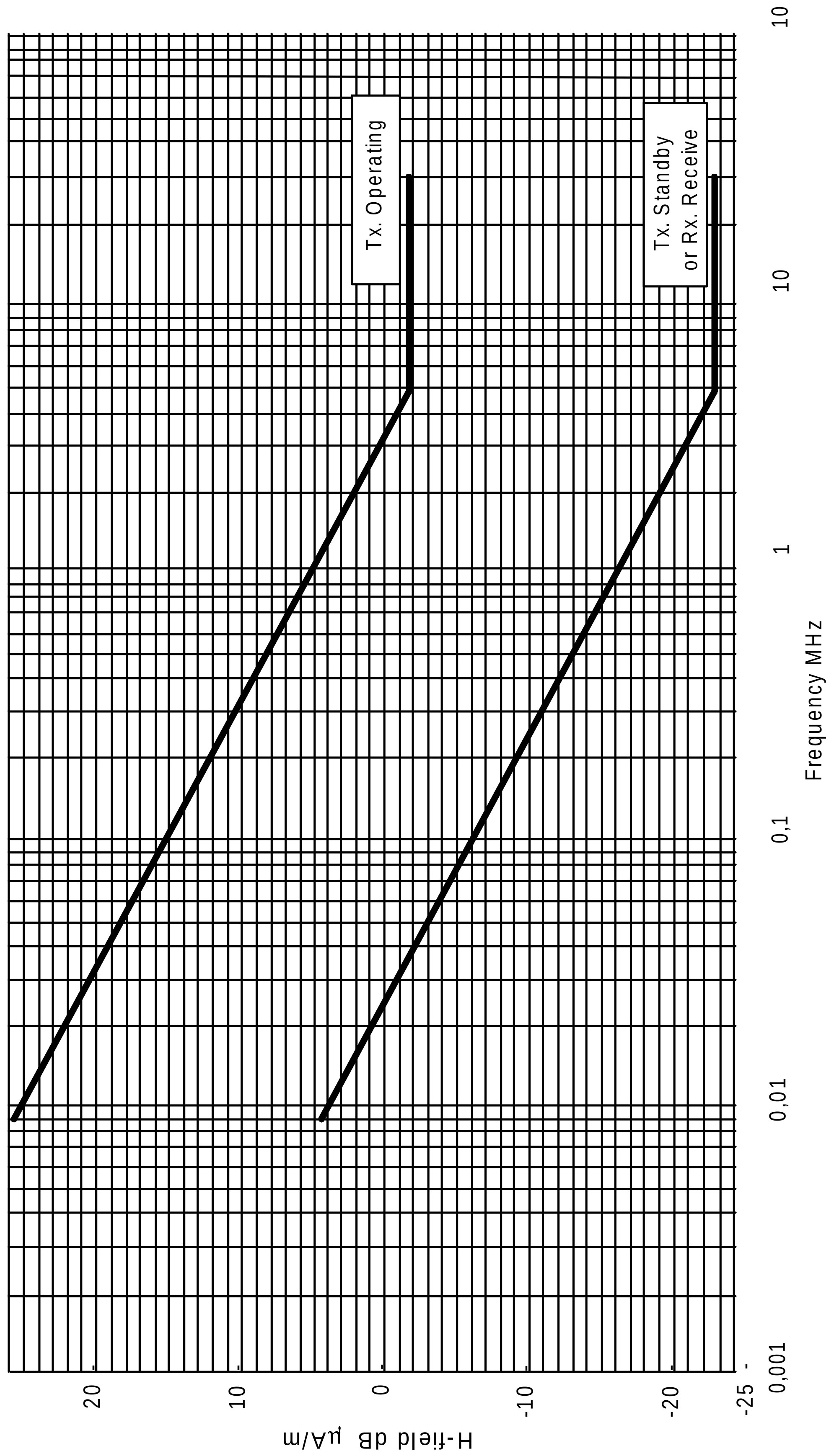

Figure B.1: Spurious limits, H-field at 10 m distances

Annex C (normative): Simulated solar radiation source

The intensity at the test point shall be 1 120 W/m^2 ± 10 % with a spectral distribution given in table C.1.

The value 1 120 W/m^2 shall include any radiation reflected from the text enclosure.

Table C.1: Spectral energy distribution and permitted tolerances

Spectral region	Ultra-violet B (note)	Ultra-violet A	Visible			Infra-red
Wavelength (µm)	0,28 - 0,32	0,32 - 0,40	0,40 - 0,52	0,52 - 0,64	0,64 - 0,78	0,78 - 3,00
Radiance (W/m^2)	5	63	200	186	174	492
Tolerance	±35 %	±25 %	±10 %	±10 %	±10 %	±20 %
NOTE: Radiation shorter than 0,30 µm reaching the earth's surface is insignificant.						

Annex D (informative): E-fields in the near field at low frequencies

E-field at low frequencies is often in the near field and it is in reality only possible to measure with the shielded loop antenna; in this case there is also a relation between the E-field and the H-field by the wave impedance Z. In the near field the wave impedance is highly dependent on the type of radiating antenna (loop or open end wire) and the wavelength. If the power density at a certain distance is the same for a H-field and an E-field generated signal, the following calculation can be made:

In the direction of maximum power in the near field, the power density S is:

$$S = \frac{E^2}{Z_e} = H_e^2 Z_e = H_m^2 Z_m \qquad (1)$$

where:

- S = power density;
- E = electrical field generated by an E-field antenna at distance d;
- H_e = magnetic field generated by an E-field antenna at distance d;
- H_m = magnetic field generated by a H-field antenna at distance d;
- Z_e = wave impedance of a field generated by an E-field antenna at distance d;
- Z_m = wave impedance of a field generated by an H-field antenna at distance d.

$$Z_m = Z_o 2\pi \frac{d}{\lambda} \quad if \quad d < \frac{\lambda}{2\pi} \ (\text{near field}) \qquad (2)$$

$$Z_e = Z_0 \frac{\lambda}{2\pi d} \quad \text{if} \quad d < \frac{\lambda}{2\pi} \ (\text{near field}) \qquad (3)$$

Equation (1) gives:

$$H_e = H_m \sqrt{\frac{Z_m}{Z_e}} \quad (A/m) \qquad (4)$$

Equation (2) and (3) into (4) gives:

$$H_e = H_m \frac{2\pi d}{\lambda} = H_m \frac{2\pi d\, f_c}{300} \qquad (5)$$

where f_c is the carrier frequency in MHz.

For $2\pi d/\lambda = 1$, d = 10 and f_c=4,78 MHz, and using equation (5), this gives:

$$H_e = H_m \frac{f_c}{4{,}78} \quad (f \text{ in MHz}) \qquad (6)$$

For $2\pi d/\lambda < 1$ if f_c < 4,78 MHz then equation (5) is valid, (i.e. near field).

For $2\pi d/\lambda \geq 1$ if f_c > 4,78 MHz then $H_e = H_m$, (i.e. far field).

The method allows an electric generated E-field to be measured as a magnetic generated H-field by adding a correction factor derived from (6).

For a graphical representation of the correction factor, see figure D.1.

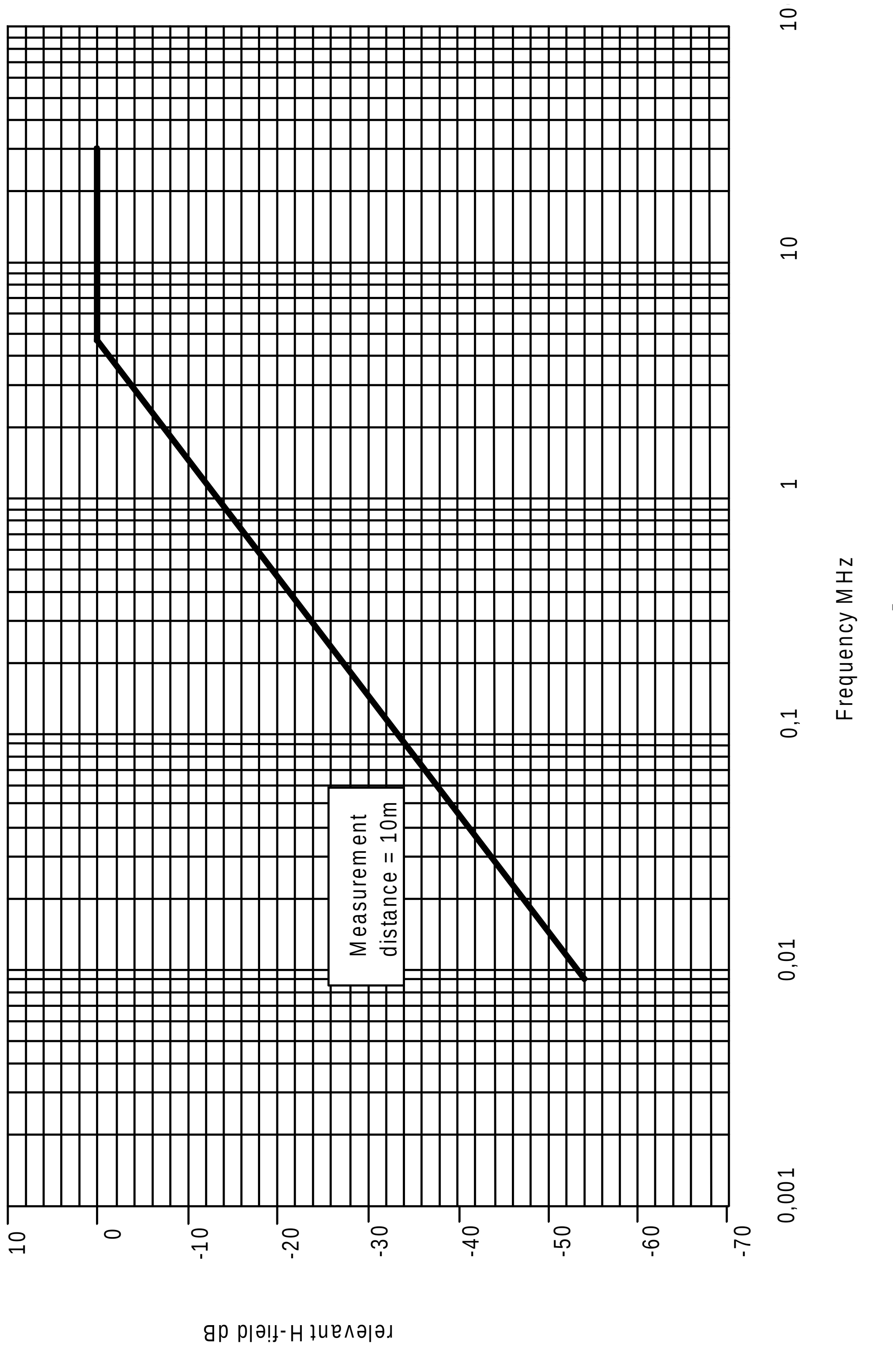

Figure D.1: H-field limit correction factor for generated E-fields

History

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