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European Standard (Telecommunications series)

**Electromagnetic compatibility
and Radio spectrum Matters (ERM);
Technical characteristics and methods of measurement
for shipborne watchkeeping receivers
for reception of Digital Selective Calling (DSC)
in the maritime MF, MF/HF and VHF bands**



Reference

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

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1 Scope

The present document states the minimum operational and performance requirements for shipborne receivers intended to be connected to an external installation, including a decoder for DSC, and used as receivers for watchkeeping DSC on board ships operating in the mobile MF, MF/HF and VHF band allocated in the ITU Radio Regulations [1] to the maritime mobile service, both in connection with distress and safety communication and in connection with general communication.

These requirements include the relevant provisions of the ITU Radio Regulations [1], ITU-R Recommendations M.493-12 [3], M.541-9 [10], M.489-2 [9] and the IMO Resolutions A.803(19), A.804(19), A.806(19) and A.694(17).

The present document specifies also technical characteristics, methods of testing and required test results for dedicated watchkeeping receivers for use with radio installations in the GMDSS as required by chapter IV of the SOLAS.

It covers both receivers with analogue output or with digital DSC signal output interfaces or with both.

DSC watchkeeping receivers may be a separate equipment or be integrated with a DSC or radiotelephone equipment.

For integrated equipment the present document specifies the requirements and methods of testing of the DSC watchkeeping receivers only.

DSC watchkeeping receivers can be either fixed-frequency receivers or, in MF/HF bands, scanning receivers.

Requirements for the DSC equipment or radiotelephone equipment are given in EN 300 338-2 [12], EN 301 925 [11] and EN 300 373-1 [13] respectively.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

- [1] ITU Radio Regulations (2008).
- [2] ITU-T Recommendation E.161 (2001): "Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network".
- [3] ITU-R Recommendation M.493-12 (2007): "Digital selective-calling system for use in the maritime mobile service".
- [4] ISO 3791 (1976): "Office machines and data processing equipment -- Keyboard layouts for numeric applications".
- [5] IEC 61162-1 (2007): "Maritime navigation and radiocommunication equipment and systems - Digital interfaces - Part 1: Single talker and multiple listeners".
- [6] Void.
- [7] ITU-T Recommendation V.11 (1996): "Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s".

- [8] IEC 60417: "Graphical symbols for use on equipment".
- [9] ITU-R Recommendation M.489-2: "Technical characteristics of VHF radiotelephone equipment operating in the maritime mobile service in channels spaced by 25 kHz".
- [10] ITU-R Recommendation M.541-9 (2004): "Operational procedures for the use of digital selective-calling equipment in the maritime mobile service".
- [11] ETSI EN 301 925: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radiotelephone transmitters and receivers for the maritime mobile service operating in VHF bands; Technical characteristics and methods of measurement".
- [12] ETSI EN 300 338-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics and methods of measurement for equipment for generation, transmission and reception of Digital Selective Calling (DSC) in the maritime MF, MF/HF and/or VHF mobile service; Part 2: Class A/B DSC".
- [13] ETSI EN 300 373-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Maritime mobile transmitters and receivers for use in the MF and HF bands; Part 1: Technical characteristics and methods of measurement".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Void.
- [i.2] ITU-R Recommendation SM.332-4 (1978): "Selectivity of receivers".
- [i.3] Void.
- [i.4] Void.
- [i.5] ETSI TR 100 028-1 (2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

assigned frequency: centre of the frequency band assigned to a station

continuous watch: continuous watch means that the radio watch concerned is not interrupted other than for brief intervals when the ship's receiving capability is impaired or blocked by its own communications or when the facilities are under periodical maintenance or check

F1B: frequency modulation with digital information, without a sub-carrier for automatic reception

G2B: phase-modulation with digital information, with a sub-carrier for automatic reception

J2B: single sideband with digital information, with the use of a modulating sub-carrier for automatic reception, with the carrier suppressed to at least 40 dB below peak envelope power

performance check: check of calling sensitivity (see clause 7.2)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

a.c.	alternating current
d.c.	direct current
DSC	Digital Selective Calling
e.m.f.	electromotive force
EUT	Equipment Under Test
FSK	Frequency Shift Keying
GMDSS	Global Maritime Distress and Safety System
HF	High Frequency
IF	Intermediate Frequency
IMO	International Maritime Organization
MF	Medium Frequency
MF/HF	Medium and High Frequency
r.m.s.	root mean square
RF	Radio Frequency
SOLAS	(International Convention for the) Safety of Life at Sea
VHF	Very High Frequency

4 General and operational requirements

4.1 General

The manufacturer shall declare that compliance to the requirement of clause 4 is achieved and shall provide relevant documentation.

4.2 Construction

4.2.1 General

The equipment shall be so constructed that it is capable of keeping continuous watch on relevant DSC channels (see clause 5.1) and of being operated readily.

4.2.2 Design

In all respects the mechanical and electrical design and construction and the finish of the equipment shall conform with good engineering practice, and the equipment shall be suitable for use on board ships at sea.

The equipment shall be designed for continuous operation.

4.2.3 Accessibility

All parts of the equipment that are subject to inspection and maintenance adjustments, shall be easily accessible. Components shall be easily identifiable either by markings within the equipment, or with the aid of technical descriptions.

4.2.4 Calibration and maintenance

The equipment shall be so constructed that its main modules can easily be replaced and put into operation without elaborate recalibration or readjustment.

4.2.5 Antenna static protection

In order to protect against damage due to static voltages that may appear at the input of the receiver, there shall be a d.c. path from the antenna terminal to ground not exceeding 100 k Ω .

4.2.6 Digital input panels

Where a digital input panel with the digits "0" to "9" is provided, the digits should be arranged to conform with ITU-T Recommendation E.161 [2]. However, where an alphanumeric keyboard layout, as used on office machinery and data processing equipment, is provided, the digits "0" to "9" may, alternatively, be arranged to conform with ISO 3791 [4].

4.3 Controls and indicators

4.3.1 General

The number of operational controls, their design and manner of functioning, location, arrangement and size should provide for simple, quick and efficient operation. All operational controls shall permit normal adjustments to be easily performed and shall be arranged in a manner which minimizes the risk of inadvertent activation.

4.3.2 Identification

All operational controls and indicators shall be easy to identify and read from the position at which the equipment is normally operated.

The controls and indicators shall be identified in English. Symbols as specified in IEC 60417 [8] may be used in addition.

4.3.3 Protection against possible maladjustment

Controls not required for normal operation shall not be readily accessible.

Operational controls, the inadvertent exercise of which could switch off the equipment, lead to its performance degradation or to false indications not obvious to the operator, shall be protected especially against unintentional operation.

4.3.4 Light sources

Equipment with controls and indicators shall be provided with adequate adjustable illumination to enable identification of controls and facilitate reading of indicators at all times. Means shall be provided for dimming the output of any equipment light source.

4.3.5 Operation

The equipment shall be so designed that misuse of the controls cannot cause injury to personnel.

4.4 Software

Facilities shall be provided to protect all operational software incorporated in the equipment.

Any software required in an equipment to facilitate operation, including that for its initial activation/reactivation, shall be permanently installed within the equipment, in such a way that it is not possible for the user to have access to this software.

Means shall be provided to monitor the operation of the equipment at appropriate regular intervals and to activate an alarm or signal in the event of a failure which is not recoverable automatically.

4.5 Memory

Pre-programmed DSC distress calling frequencies and information inherent to the operation of the equipment shall be stored in non-volatile devices.

If the equipment contains information in operator programmable memory devices, such devices shall be protected from interruptions in the power supply up to at least 10 hours duration.

4.6 Interfaces

The equipment submitted for test, when integrated with a DSC or radiotelephone equipment, shall be provided with an accessible test point at the watchkeeping receiver analog or digital signal output.

4.6.1 DSC signal output; analogue interface

For equipment designed for analogue DSC signal output to an external DSC decoder, the audio frequency signal output shall have an impedance of 600 Ω , balanced and free of earth and the closed circuit level shall be adjustable to any r.m.s. voltage between 0,245 V and 2,450 V (0 dBm \pm 10 dB).

The audio frequency subcarrier shall be 1 700 Hz and the sideband shall be preserved.

The higher frequency corresponds to the B-state and the lower frequency corresponds to the Y-state of the signal elements.

4.6.2 DSC signal output; digital interface

For equipment designed for binary signal output to an external DSC decoder, the logic level of the digital signal output shall be compatible with ITU-T Recommendation V.11 [7].

The B-state shall be the logic "0", and the Y-state shall be the logic "1".

4.6.3 Operational interfaces

Where provided:

- interfaces for stop and start of the scanning sequence of scanning receivers shall comply with ITU-T Recommendation V.11 [7]; and
- interfaces for frequency control or read-out of scanning receivers shall comply with IEC 61162-1 [5];
- the control of scanning receivers by DSC equipment.

Additional interfaces may be provided but connection of, or failure within any external circuits, shall not degrade the performance of the equipment.

4.7 Marking and identification

Each unit of the equipment shall be marked externally with the following information which, shall be clearly visible:

- 1) identification of the manufacturer;
- 2) equipment type designation or model identification;
- 3) serial number of the unit;
- 4) details of the power supply.

Additionally, the marking may be presented on a display.

The title and version of the installed software shall be either marked or displayed on the equipment or displayed on command.

When the title and version of the software are shown only on the display, such information shall also be included in the equipment manual.

For fixed-frequency receivers, the DSC frequencies or channels on which the equipment may operate shall be clearly indicated. For programmable scanning receivers, it shall be possible to display the programmed frequencies or to print them via an external controller.

4.8 Instructions

Adequate information shall be provided to enable the equipment to be properly operated and maintained.

Operating and servicing manuals shall:

- be written at least in English;
- identify that the equipment is intended to be protected from the weather;
- in the case of equipment so designed that fault diagnosis and repair down to component level are practicable, the instructions shall provide full circuit diagrams, component layouts, a component parts list; and
- in the case of equipment containing complex modules in which fault diagnosis and repair down to component level are not practicable, the instructions shall contain sufficient information to enable a defective complex module to be located, identified and replaced. Other modules and those discrete components which do not form part of modules shall also meet the requirements above.

4.9 Warming-up period

The equipment shall be operational one minute after switching on.

4.10 Safety precautions

4.10.1 Excessive current and voltage

Means shall be incorporated for the protection of equipment from the effects of excessive current and voltage and accidental reversal of the power supply polarity or phase sequence.

4.10.2 Earthing

Means shall be provided for earthing exposed metallic parts of the equipment, but this shall not cause any terminal of the source of electrical energy to be earthed.

4.10.3 Protection

As far as practicable, accidental access to dangerous voltages shall be prevented. All parts and wiring in which the direct or alternating voltages or both (other than radio frequency voltages) combine to give a peak voltage greater than 50 V, shall be protected against accidental access and shall be isolated automatically from all sources of electrical energy when the protective covers are removed.

Alternatively, the equipment shall be so constructed that access to such voltages can only be gained after having used a tool for this purpose, such as a spanner or screwdriver, and warning labels shall be prominently displayed both within the equipment and on protective covers.

4.11 Compass safe distance

The compass safe distance to a standard or steering magnetic compass shall be stated on the equipment or in the manual.

5 Technical requirements

5.1 Frequency bands and channels

The equipment can be designed as a single-frequency receiver, as a multiple-frequency receiver or as scanning receiver in one or more of the frequency bands:

- MF: 1 606,5 kHz to 4 000 kHz;
- HF: 4 MHz to 27,5 MHz; and
- VHF: 156 MHz to 174 MHz.

MF/HF DSC frequencies shall be designated in terms of the assigned frequency.

On MF/HF DSC calling frequencies for distress, urgency and safety calling are different from those for general communication calling.

The MF/HF DSC distress calling frequencies are:

- 2 187,5 kHz;
- 4 207,5 kHz;
- 6 312 kHz;
- 8 414,5 kHz;
- 12 577 kHz; and
- 16 804,5 kHz.

For general communication, other MF/HF frequencies may also be used.

Watchkeeping receivers for the MF DSC frequency for distress, urgency and safety calling shall be a single-frequency receiver for 2 187,5 kHz.

MF/HF scanning receivers shall be designed for scanning of up to 6 frequencies for either DSC distress calling only, or for DSC general communication calling only.

If scanning of factory set DSC distress calling frequencies can be customized by the operator, it shall not be possible to scan fewer than three different distress frequencies, and the 2 and 8 MHz bands must be included amongst those three frequencies (see ITU-T Recommendation M.541-9 [10], annex 1 clause 3.1.3.2).

For general communication calling only, MF or MF/HF watchkeeping receivers may be capable of receiving on DSC frequencies in MF/HF bands as detailed by the ITU Radio Regulations [1].

On VHF the calling channel for distress, urgency and safety calling and for general communication calling is channel 70 (156,525 MHz).

Watchkeeping receivers for VHF distress, urgency and safety calling shall be single-channel receivers set to channel 70.

For general communication calling only, VHF watchkeeping receivers may be switched to other channels of appendix 18 of the Radio Regulations [1].

5.2 Mode of reception

Equipment for reception of MF/HF DSC transmissions shall provide for classes of emission F1B or J2B.

Equipment for reception of VHF DSC transmissions shall provide for class of emission G2B.

5.3 Scanning receivers

5.3.1 Scanning sequence

A MF/HF scanning receiver shall be able to complete the scanning sequence within 2 s.

5.3.2 Scanning frequencies

Scanning watchkeeping receivers shall be dedicated to either scan DSC distress frequencies or to scan DSC frequencies for general communication.

5.3.2.1 DSC distress frequencies

Scanning watchkeeping receivers for MF/HF DSC distress frequencies shall scan the frequencies 2 187,5 kHz and 8 414,5 kHz and at least one other HF DSC distress frequency listed in clause 5.1.

Other HF DSC distress frequencies listed in clause 5.1 may be added up to a total of 6 frequencies in the scanning sequence.

5.3.2.2 DSC frequencies for general communication

Scanning watchkeeping receivers for MF and HF DSC frequencies for general communication may scan any general communication frequency up to a total of 6 frequencies in the scanning sequence.

5.3.3 Stop/start of scanning

The scanning receiver shall be provided with means for stop and start of the scanning under the control of an external DSC decoder/encoder equipment. Such control shall be a stop/start signal in accordance with ITU-T Recommendation V.11 [7].

The stop signal shall be logic "0" and the start signal shall be logic "1".

The stop and restart signals may be substituted by direct frequency setting of the scanning receiver by the DSC equipment using IEC 61162-1 [5] protocol.

Means shall be provided at the MF/HF receiver to transmit information, to the DSC Controller, of the frequency or channel on which scanning has stopped using IEC 61162-1 [5] protocol.

5.3.4 Frequency information

The selected receiver frequency shall be clearly identified.

Means shall be provided for automatic transfer of information of the frequency or channel on which the scanning has stopped for use and display in an external installation (normally an independent DSC equipment). The interface for such transfer shall be in accordance with IEC 61162-1 [5].

6 General test conditions

6.1 General

Conformance testing shall be carried out under normal test conditions and also, where stated, under extreme test conditions.

6.2 Test power source

During conformance testing the equipment shall be supplied from a test power source, capable of producing normal and extreme test voltages as specified in clauses 6.3.2 and 6.4.2.

For the purposes of tests, the voltage of the power supply shall be measured at the input terminals of the equipment.

If the equipment is provided with a power cable permanently connected, the test voltage shall be that measured at the point of connection of the power cable to the equipment.

During tests, the test power source voltages shall be maintained within a tolerance of ± 3 % relative to the voltage at the beginning of each test.

6.3 Normal test conditions

6.3.1 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 %.

6.3.2 Normal test power source

6.3.2.1 ac voltage and frequency

The normal test voltage for equipment to be connected to the a.c. power supply shall be the declared voltage or any one of the declared voltages for which the equipment was designed.

The frequency of the test power supply shall be 50 Hz \pm 1 Hz.

6.3.2.2 Secondary battery power sources

Where the equipment is designed to operate from a battery, the normal test voltage shall be the nominal voltage of the battery (e.g. 12 V, 24 V, etc.).

6.3.2.3 Other power sources

For operation from other power sources, the normal test voltage shall be as stated by the manufacturer.

6.4 Extreme test conditions

6.4.1 Extreme temperature tests

For tests at extreme temperatures, measurements shall be made at a lower temperature of -15 °C and an upper temperature of +55 °C.

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

6.4.2 Extreme values of test power source

6.4.2.1 a.c. voltage and frequency

The extreme test voltages for equipment to be connected to an a.c. power supply shall be the normal voltage $\pm 10\%$.

The frequency of the test power mains shall be $50\text{ Hz} \pm 1\text{ Hz}$.

6.4.2.2 Secondary battery power sources

When the equipment is intended for operation from a secondary battery power supply, the extreme test voltage shall be 1,3 and 0,9 times the nominal voltage of the battery (e.g. 12 V, 24 V, etc.).

6.4.2.3 Other power sources

For equipment using other power sources, the extreme test voltages shall be as stated by the manufacturer.

6.5 Connection of test signals to the receiver

For the purpose of conformance testing, the receiver shall be connected to sources of test signals such that the impedance presented to the receiver input is $50\ \Omega$ resistive. In the frequency range 1 606,5 kHz to 4 000 kHz, at the request of the manufacturer, a network consisting of a $10\ \Omega$ resistor in series with a 250 pF capacitor may be used.

The arrangement used shall be stated in the test report.

NOTE: This does not imply that the receiver should operate satisfactorily only with antennas having these impedance characteristics.

6.5.1 Sources

Test signals shall be connected through a network as specified in clause 6.5. This requirement shall be met irrespective of whether one, two or more test signals are applied to the receiver simultaneously. In the case of multiple test signals, steps shall be taken to prevent any undesirable effects due to interaction between the signals in the generators or other sources.

6.5.2 Levels

The levels of test input signals shall be expressed in terms of the e.m.f. that would exist at the output terminals of the source including the associated network.

6.6 Testing frequencies

6.6.1 General test frequencies

Unless otherwise stated, the testing frequencies shall be:

- MF band: 2 187,5 kHz or 2 177 kHz;
- HF band: 8 414,5 kHz or 8 436,5 kHz;
- VHF band: 156,525 MHz (channel 70).

6.6.2 Additional test frequencies for HF equipment

Where stated, the testing frequencies for HF equipment shall additionally be:

- for equipment intended for distress/safety purposes, the test frequencies shall be the DSC distress/safety frequencies 4 207,5 kHz, 6 312 kHz, 12 577 kHz and 16 804,5 kHz as applicable for the range of the equipment (see clause 5.1);
- for the equipment not intended for distress and safety purposes, the test frequencies shall be any of the DSC calling frequencies in each of the 4 MHz, 6 MHz, 12 MHz, 16 MHz, 18 MHz, 22 MHz and 26 MHz bands as applicable for the range of the equipment.

6.7 Test signals

Except where otherwise stated, radio frequency test signals applied to the receiver input shall be as described in the following clauses.

A standard test signal shall simulate DSC modulation as specified in ITU-R Recommendation M.493-12 [3] and shall be of sufficient duration for the measurements to be performed or it shall be possible to repeat it without interruption as long as necessary to make the measurement.

6.7.1 Standard test signal No. 1

Standard test signal No. 1 for MF/HF DSC watchkeeping receivers shall be an FSK modulated signal with a nominal radio frequency as specified in clause 6.6. The modulating signal shall have a frequency shift of ± 85 Hz keyed by a square-wave signal with a frequency of 50 Hz simulating a continuous dot pattern. Phase coherent switching between B-state and Y-state is preferable.

6.7.2 Standard test signal No. 2

Standard test signal No. 2 for VHF DSC watchkeeping receivers shall be a phase modulated signal with a nominal radio frequency assigned to VHF channel 70. The modulating signal shall have a centre frequency of 1 700 Hz and a frequency shift of ± 400 Hz keyed by a square wave signal with a frequency of 600 Hz simulating a continuous dot pattern. The modulation index shall be 2. Phase coherent switching between B-state and Y-state is preferable.

6.8 Measurement of bit error ratio

For tests on receivers with digital output, all measurements shall be performed by measuring the bit error ratio at the digital output.

For tests on receivers with analogue output, the measurements shall be performed by using a linear FSK discriminator connected to the analogue output. All receiver measurements shall then be made by measuring the bit error ratio at the discriminator output.

NOTE: IMO Resolutions are phrased in terms of Character Error Ratio. In the present document, equivalent bit error ratio measurements are taken to demonstrate compliance with IMO requirements.

6.9 Measurement uncertainty and interpretation of the measuring results

6.9.1 Measurement uncertainty

Table 1: Maximum values of measurement uncertainty

Absolute measurement uncertainties	Maximum values
RF level	$\pm 0,75$ dB
Audio output power	$\pm 0,5$ dB
Sensitivity of receiver	± 3 dB
Conducted emission of receiver	± 3 dB
Two-signal measurement	± 4 dB
Three signal measurement	± 3 dB

For the test methods according to the present document the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in TR 100 028-1 [i.5].

6.9.2 Interpretation of measurement results

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report;
- the recorded value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in table 1.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR 100 028-1 [i.5] and shall correspond to an expansion factor (coverage factor) $k = 1,96$ or $k = 2$ (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

7 Environmental tests

7.1 Procedure

Environmental tests shall be carried out before tests of the same equipment in respect of the other requirements of the present document are performed.

Unless otherwise stated, the equipment shall be connected to an electrical power source during the periods for which it is specified that electrical tests shall be carried out. These tests shall be performed using the normal test voltage.

7.2 Performance check

A performance check shall be a test of the calling sensitivity with the receiver connected as specified in clause 6.5:

- for MF band with standard test signal No. 1 applied at a level of $+11$ dB μ V;
- for HF band with standard test signal No. 1 applied at a level of $+6$ dB μ V;
- for VHF band with standard test signal No. 2 applied at a level of $+6$ dB μ V.

The bit error ratio shall be less than 10^{-2} .

7.3 Vibration test

7.3.1 Definition

This test determines the ability of equipment to withstand vibration without resulting in mechanical deterioration or degradation in performance.

7.3.2 Method of measurement

The EUT, complete with any shock and vibration absorbers with which it is provided, shall be clamped to the vibration table by its normal means of support and in its normal attitude. The EUT may be resiliently suspended to compensate for weight not capable of being withstood by the vibration table. Provision may be made to reduce or nullify any adverse effect on EUT performance which could be caused by the presence of an electromagnetic field due to the vibration unit.

The equipment shall be subjected to sinusoidal vertical vibration at all frequencies between:

- 5 Hz and 13,2 Hz with an excursion of $\pm 1 \text{ mm} \pm 10 \%$ (7 m/s^2 maximum acceleration at 13,2 Hz);
- 13,2 Hz and 100 Hz with a constant maximum acceleration of 7 m/s^2 .

The frequency sweep rate shall be slow enough to allow the detection of resonances in any part of EUT.

A resonance search shall be carried out throughout the test. If any resonance of the EUT has Q greater than or equal to 5 measured relative to the base of the vibration table, the EUT shall be subjected to a further endurance test at each resonant frequency at the vibration level specified in the test with a duration of 2 hours. If only resonance with Q less than 5 occurs this further endurance test shall be carried out at one of these resonant frequencies. If no resonance occurs, this further endurance test shall be carried out at a frequency of 30 Hz.

Performance check(s) (see clause 7.2) shall be carried out before at the end of each two hour endurance test period.

The procedure shall be repeated with vibration in each of two mutually perpendicular directions in the horizontal plane.

After conducting the vibration tests, the equipment shall be inspected for any mechanical deterioration.

7.3.3 Requirement

The equipment shall meet the requirements of the performance check.

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

7.4 Temperature tests

The immunity against the effects of temperature is the ability of the equipment to maintain the specified mechanical and electrical performance after the following tests has been carried out.

The maximum rate of raising or reducing the temperature of the chamber in which the equipment is being tested shall be $1 \text{ }^{\circ}\text{C/minute}$.

7.4.1 Dry heat

7.4.1.1 Definition

This test determines the ability of equipment to be operated at high ambient temperatures.

7.4.1.2 Method of measurement

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The EUT and, if appropriate, any climatic control devices with which it is provided shall then be switched on. The temperature shall then be raised to $+55\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ and maintained for a test period of 10 hours to 16 hours.

At the end of the test period, the EUT shall be subjected to the performance check according to clause 7.2.

The temperature of the chamber shall be maintained at $+55\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ during the whole performance check period.

At the end of the test, the EUT shall be returned to normal room temperature and relative humidity.

7.4.1.3 Requirement

The equipment shall meet the requirements of the performance check to clause 7.2.

7.4.2 Damp heat

7.4.2.1 Definition

This test determines the ability of equipment to be operated under conditions of high humidity.

7.4.2.2 Method of measurement

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be raised to $+40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$, and the relative humidity raised to $93\% \pm 3\%$ over a period of 3 hours $\pm 0,5$ hours. These conditions shall be maintained for a period of 10 hours to 16 hours.

Any climatic control devices provided in the EUT may be switched on at the conclusion of this period.

The EUT shall be switched on 30 minutes later, or after such period as agreed by the manufacturer, and shall be operational for at least 2 hours during which period the EUT shall be subjected to the performance check according to clause 7.2.

The temperature and relative humidity of the chamber shall be maintained as specified during the whole test period.

At the end of the test period and with the EUT still in the chamber, the chamber shall be brought to room temperature in not less than 1 hour.

At the end of the test the EUT shall be returned to normal room temperature and relative humidity.

7.4.2.3 Requirement

The equipment shall meet the requirements of the performance check according to clause 7.2.

7.4.3 Low temperature

7.4.3.1 Definition

These tests determine the ability of equipment to be operated at low temperatures. They also allow equipment to demonstrate an ability to start up at low ambient temperatures.

7.4.3.2 Method of measurement

The EUT shall be placed in a chamber at normal room temperature and relative humidity. The temperature shall then be reduced to and maintained at $-15\text{ °C} \pm 3\text{ °C}$, for a period of 10 hours to 16 hours. Any climatic control devices provided in the EUT may be switched on at the conclusion of this period.

The EUT shall be switched on 30 minutes later, or after such period as agreed by the manufacturer, and shall be operational for at least 2 hours during which period the EUT shall be subjected to the performance check according to clause 7.2.

The temperature of the chamber shall be maintained at $-15\text{ °C} \pm 3\text{ °C}$ during the whole test period.

At the end of the test the EUT shall be returned to normal room temperature and relative humidity.

7.4.3.3 Requirement

The equipment shall meet the requirements of the performance check to clause 7.2.

7.5 Corrosion test

7.5.1 General

This test shall be waived where the manufacturer is able to produce evidence that the components, materials and finishes employed in the equipment would satisfy the requirements of this clause.

7.5.2 Definition

This test determines the ability of an equipment to be exposed to a salt laden atmosphere without physical degradation. The cyclic nature of the test produces an acceleration of effects compared with service conditions.

7.5.3 Method of measurement

The EUT shall be placed in a chamber and sprayed with a salt solution for 2 hours at normal temperature. The salt solution shall be prepared by dissolving 5 ± 1 parts by weight of sodium chloride (NaCl) in 95 parts by weight of distilled or demineralized water.

At the end of the spraying period the EUT shall be placed in a chamber which shall be maintained at a temperature of $40\text{ °C} \pm 2\text{ °C}$ and a relative humidity between 90 % and 95 % for a period of seven days.

The EUT shall be subjected to a test comprising four spraying periods, each of duration 2 hours, with a storage period of seven days after each.

At the conclusion of the test the EUT shall be inspected with the naked eye without magnification. The EUT shall then be subjected to the performance check.

7.5.4 Requirements

There shall be no undue deterioration or corrosion of metal parts. The equipment shall meet the requirements of the performance check according to clause 7.2.

8 MF/HF watchkeeping receiver

8.1 Calling sensitivity

8.1.1 Definition

The calling sensitivity of the receiver is a defined RF-signal level at which the bit error ratio at the output of the receiver is better than or equal to 10^{-2} .

8.1.2 Method of measurement

The arrangements for applying the test signals shall be in accordance with clause 6.5.

Standard test signal No. 1 shall be applied on the relevant frequencies in clause 6.6.1:

- for MF the input level shall be +5 dB μ V under normal and +11 dB μ V under extreme test conditions; and
- for HF the input level shall be 0 dB μ V under normal and +6 dB μ V under extreme test conditions.

The bit error ratio in the output shall be determined as described in clause 6.8.

The measurements shall be carried out under normal test conditions (see clause 6.3) and under extreme test conditions (see clauses 6.4.1 and 6.4.2 applied simultaneously).

For MF/HF equipment the test shall be repeated with test signal no.1 on the frequencies specified in clause 6.6.2, only under normal test conditions.

The measurement shall be repeated at the nominal input frequency ± 10 Hz only under normal test conditions.

8.1.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

8.2 Adjacent channel selectivity

8.2.1 Definition

Adjacent channel selectivity is defined as the suppression of an unwanted signal, expressed as the bit error ratio caused by the unwanted signal in the output from the demodulator.

8.2.2 Method of measurement

The arrangements for applying the test signals shall be in accordance with clause 6.5.

The wanted RF signal shall be standard test signal No. 1 on the relevant frequencies specified in clause 6.6.1 and the level of the wanted signal shall be 20 dB μ V.

The level of the unwanted signal shall then be 60 dB μ V.

The unwanted signal shall be an unmodulated signal at the frequency +500 Hz relative to the nominal frequency of the receiver (centre frequency).

The bit error ratio in the output shall be determined as described in clause 6.8.

The measurement shall be repeated with the unwanted signal at a frequency -500 Hz relative to the nominal frequency of the receiver (centre frequency).

The bit error ratio in the output shall be determined as described in clause 6.8.

8.2.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

8.3 Co-channel rejection

8.3.1 Definition

The co-channel rejection is the ability of the receiver to receive a wanted signal in the presence of an unwanted signal, both signals being at the nominal frequency of the receiver.

8.3.2 Method of measurements

The arrangements for applying the test signals shall be in accordance with clause 6.5.

The wanted signal shall be standard test signal No. 1 on the relevant frequencies specified in clause 6.6.1 and the level of the wanted signal shall be 20 dBμV.

The unwanted signal shall be unmodulated.

The level of the unwanted signal shall be 14 dBμV.

The bit error ratio in the output shall be determined as described in clause 6.8.

8.3.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

8.4 RF intermodulation response

8.4.1 Definition

The RF intermodulation response is defined as the rejection of intermodulation products originating from two unwanted signals with given levels and frequencies, expressed as that level at which the bit error ratio is 10^{-2} .

8.4.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

The wanted signal shall be standard test signal No. 1 on the relevant frequencies specified in clause 6.6.1 and the level of the wanted signal shall be 20 dBμV.

The two unwanted signals are both unmodulated and at the same level of +70 dBμV. Neither of the two signals shall be at a frequency nearer to the wanted signal than 30 kHz (frequency combinations capable of resulting in unwanted intermodulation products are given in ITU-R Recommendation SM.332-4 [i.2]).

The bit error ratio in the output shall be determined as described in clause 6.8.

8.4.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

8.5 Spurious response rejection

8.5.1 Definition

The spurious response rejection is the ability of the receiver to discriminate between a wanted signal and unwanted signals with frequencies outside the passband of the receiver.

8.5.2 Method of measurement

Frequencies likely to cause a spurious response are at the image frequencies of the mixers and at the various IF frequencies used in the receiver. The manufacturer shall provide the test house with a simple block diagram showing:

- IF frequencies used;
- local oscillator frequencies used;
- coverage range;
- pre-first mixer filtering arrangement.

Tests shall be made with two signal generators connected to the input of the receiver in accordance with clause 6.5.

The wanted signal shall be on the test frequencies as specified in clause 6.6. The wanted signal shall be the standard test signal N°1 at an input level of +8 dBμV e.m.f. for MF and +3 dBμV e.m.f. for HF.

The coverage range is:

- between 1 606,5 kHz and 4 000 kHz for MF receivers;
- between 1 606,5 kHz and 27 500 kHz for MF/HF receivers.

The unwanted signal shall be unmodulated and be set to at least 80 dB above the wanted signal and shall be varied in frequency to search for spurious response between 100 kHz and 2 GHz, except for a band of ±20 kHz of the wanted signal. For each spurious found, the level of the unwanted signal shall be reduced until the level is 70 dB above the wanted signal.

Tests shall be made with various frequencies of the unwanted signal to achieve the following:

- a complete search of the coverage range;
- a measurement of all IF frequencies outside the coverage range;
- a measurement of all frequencies defined by:

$$n \times f_{lo1} \pm f_{if1}$$

$$p \times f_r \pm f_{if1}$$

$$(f_{lo2} \pm f_{if2}) \pm f_{lo1}$$

where:

- n and p are integers;
- f_{lo1} is the local oscillator frequency of the first mixer;
- f_{if1} is the first IF;
- F_{lo2} is the local oscillator frequency of the second mixer;
- f_{if2} is the second IF;
- f_r is the receive frequency.

If no measurements are within 10 dB of the limit, the integers n and p shall not exceed 10, otherwise the upper frequency of the test shall be 2 GHz.

Care shall be taken when measuring IF rejection within the coverage range. If the wanted signal frequency causes a filter to be introduced that improves the IF response, then another wanted frequency shall be chosen in the same band as the IF frequency without being closer than 100 kHz to the IF frequency.

When measurements are made close to the wanted signal, the level and tests provided for these conditions in the present document shall take precedence. No testing is necessary closer than 20 kHz of the IF frequency.

The bit error ratio in the output shall be determined as described in clause 6.8.

8.5.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

8.6 Dynamic range

8.6.1 Definition

The dynamic range of the equipment is the range from the minimum to the maximum level of a radio frequency input signal at which the bit error ratio in the output of the receiver does not exceed a specified value.

8.6.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

Standard test signal No. 1 on the relevant frequencies specified in clause 6.6.1 shall be applied to the receiver input. The level of the RF signal shall be 80 dB μ V.

The bit error ratio in the output shall be determined as described in clause 6.8.

NOTE: The bit error ratio under minimum signal level conditions is assessed under clause 8.1.

8.6.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

8.7 Conducted spurious emissions into the antenna

8.7.1 Definition

Conducted spurious emissions are all internally generated signals conducted to the antenna terminal.

8.7.2 Method of measurement

The receiver input shall be connected to a 50 Ω artificial antenna and the spurious emission be measured using a selective measuring instrument. The r.m.s value of any component of the spurious emission shall then be evaluated.

The measurement shall be made over the frequency range from 9 kHz to 2 GHz.

The bandwidth of the selective measuring instrument shall be:

- 200 Hz in the frequency range from 9 kHz to 150 kHz;
- 9 kHz to 10 kHz in the frequency band from 150 kHz to 30 MHz;
- 100 kHz to 120 kHz in the frequency band 30 MHz to 1 GHz;

- 1 MHz above 1 GHz.

The detector shall be a peak detector.

8.7.3 Limits

The power of any spurious emission shall not exceed 2 nW.

8.8 Radiated spurious emissions

8.8.1 Definition

Radiated spurious emissions from the receiver are components at any frequency radiated by the equipment cabinet and the structure.

8.8.2 Method of measurements

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

The test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver.

The output of the test antenna shall be connected to a measuring receiver.

The receiver shall be switched on without modulation, and measuring receiver shall be tuned over the frequency range 30 MHz to 2 GHz. The bandwidth of the measuring receiver shall be as specified in clause 8.7.2.

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 receiver shall 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 receiver shall be replaced by a substitution antenna as defined in annex A;
- the substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the spurious component detected;
- the substitution antenna shall be connected to a calibrated signal generator;
- 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;
- the input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver that is equal to the level noted while the spurious component was measured, corrected for the change of input attenuator setting of the measuring receiver;
- the input level to the substitution antenna shall be recorded as power level, corrected for the change of input attenuator setting of the measuring receiver;
- the measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization;

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

8.8.3 Limit

The power of any spurious radiation shall not exceed 2 nW at any frequency in the range between 30 MHz and 2 GHz.

8.9 Protection of receiver antenna input circuits

8.9.1 Definition

The protection of receiver antenna input circuits is the ability of the antenna input to withstand large voltages for a specified time.

8.9.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

An unmodulated radio frequency test signal at a level of 30 V r.m.s. at a single frequency in the range 100 kHz to 27,5 MHz shall be applied to the receiver antenna input for a period of 15 minutes. The signal shall then be removed and the EUT be subjected to a performance check.

8.9.3 Limits

The receiver shall not suffer damage and shall meet the requirement of the performance check.

8.10 Scanning efficiency

8.10.1 Definition

Scanning efficiency is the ability of the receiver to correctly receive calls preceded by more than 20 bits of a 200 bit dot pattern and transmitted on one frequency whilst scanning up to six frequencies ignoring all other signals and noise.

8.10.2 Method of measurement

Two RF test signals with a level of 20 dBμV shall be applied to the receiver.

One of the RF signals shall have a nominal frequency corresponding to a frequency in the scanning sequence and shall be equal to standard test signal No. 1 modulated with a single DSC distress call.

The other RF signal shall have a nominal frequency corresponding to another frequency being scanned. It shall be equal to standard test signal No. 1 modulated with DSC calls with 20 dot pattern.

The distress call sequences shall be repeated after a random interval of 2,5 s to 4,0 s.

The receiver shall be set to scan the maximum number of frequencies for which it is designed.

The number of transmitted distress calls shall be 200 and the bit error ratio shall be determined.

8.10.3 Limits

The total number of received distress calls shall be equal to or exceed 95 % of distress calls transmitted and the bit error ratio shall be less than or equal to 10^{-2} .

8.11 Stop/start of scanning (Watchkeeping receiver without DSC decoder)

8.11.1 Definition

The stop/start of scanning is the ability of the watchkeeping receiver to stop or start its scanning sequence or to change frequencies by direct frequency commands of an independent DSC equipment.

8.11.2 Method of measurement

Control input signals in accordance with clause 5.3.3 shall be applied to the interface for stop/start of the scanning receiver.

8.11.3 Limits

It shall be possible to stop and start the scanning process.

9 VHF watchkeeping receiver

9.1 Calling sensitivity

9.1.1 Definition

The calling sensitivity of the receiver is a defined RF-signal level at which the bit error ratio at the output of the receiver is better than or equal to 10^{-2} .

9.1.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

Standard test signal No. 2 shall be applied to the receiver input.

The bit error ratio at the output shall be determined as described in clause 6.8.

The input level shall be 0 dBμV under normal test conditions and +6 dBμV under extreme test conditions.

The measurement shall be carried out under normal test conditions (see clause 6.3) and under extreme test conditions (see clauses 6.4.1 and 6.4.2 applied simultaneously).

The measurement shall be repeated under normal test conditions at the nominal carrier frequency $\pm 1,5$ kHz.

9.1.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

9.2 Adjacent channel selectivity

9.2.1 Definition

The adjacent channel selectivity is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal that differs in frequency from the wanted signal by 25 kHz.

9.2.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

The wanted signal shall be standard test signal No. 2. The level of the wanted signal shall be +3 dBμV. The unwanted signal shall be modulated by 400 Hz with a deviation of ±3 kHz. The unwanted signal shall be tuned to the centre frequency of the upper adjacent channel.

The bit error ratio at the output of the receiver shall be determined as described in clause 6.8.

The input level of the unwanted signal shall be 73 dBμV.

The measurement shall be repeated with the unwanted signal tuned to the centre frequency of the lower adjacent channel.

9.2.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

9.3 Co-channel rejection

9.3.1 Definition

The co-channel rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal, both signals being at nominal frequency of the receiver.

9.3.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

The wanted signal shall be standard test signal No. 2. The level of the wanted signal shall be +3 dBμV. The unwanted signal shall be modulated by 400 Hz with a deviation of ±3 kHz. Both input signals shall be at the nominal frequency of the receiver under test and the measurement shall be repeated for displacements of the unwanted signal of up to ±3 kHz.

The bit error ratio at the output of the receiver shall be determined as described in clause 6.8.

The input level of the unwanted signal shall be -5 dBμV.

9.3.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

9.4 Intermodulation response

9.4.1 Definition

The intermodulation response is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency.

9.4.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

The wanted signal represented by signal generator A shall be at the nominal frequency of the receiver and shall be standard test signal No. 2. The level of the wanted signal shall be +3 dB μ V.

The unwanted signals shall be applied, both at the same level. The unwanted signal from signal generator B shall be unmodulated and adjusted to a frequency 50 kHz above (or below) the nominal frequency of the receiver. The second unwanted signal from signal generator C shall be modulated by 400 Hz with a deviation of ± 3 kHz and adjusted to a frequency 100 kHz above (or below) the nominal frequency of the receiver.

The bit error ratio at the output of the receiver shall be determined as described in clause 6.8.

The input level of the unwanted signals shall be 68 dB μ V.

9.4.3 Limits

The bit error ratio shall be better than or equal to 10^{-2} .

9.5 Spurious response and blocking immunity

9.5.1 Definition

The spurious response and blocking immunity is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted unmodulated signal with frequencies outside the passband of the receiver.

9.5.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

The wanted signal shall be standard test signal No. 2. The level of the wanted signal shall be +3 dB μ V.

For spurious response test the unwanted signal shall be unmodulated. The frequency shall be varied over the range 9 kHz to 2 GHz except for the channel of the wanted signal and its adjacent channels.

Where spurious responses occur, the input level of the unwanted signal shall be 73 dB μ V.

For blocking test the unwanted signal shall be unmodulated. The frequency shall be varied between -10 MHz and -1 MHz and also between +1 MHz and +10 MHz relative to the nominal frequency of the wanted signal.

Where blocking occurs, the input level of the unwanted signal shall be 93 dB μ V.

The bit error ratio at the output of the receiver shall be determined as described in clause 6.8.

9.5.3 Limits

The bit error ratio shall be equal to or less than 10^{-2} .

9.6 Dynamic range

9.6.1 Definition

The dynamic range of the equipment is the range from the minimum to the maximum level, of a radio frequency input signal at which the bit error ratio in the output of the receiver does not exceed a specified value.

9.6.2 Method of measurement

The signals applied to the receiver input shall be connected in accordance with clause 6.5.

Standard test signal No. 2 shall be applied to the receiver input. The level of the test signal shall be 100 dB μ V.

The bit error ratio at the output of the receiver shall be determined as described in clause 6.8.

9.6.3 Limit

The bit error ratio shall be better than or equal to 10^{-2} .

9.7 Conducted spurious emissions into the antenna

9.7.1 Definition

Conducted spurious emissions are all internally generated signals conducted to the antenna terminal, irrespective of the frequency.

9.7.2 Method of measurement

The receiver input shall be connected to a 50 Ω artificial antenna and the spurious emission measured, using a selective measuring instrument. The r.m.s. value of any component of the spurious emission shall then be evaluated.

The measurement is made over the frequency range from 9 kHz to 2 GHz.

The bandwidth of the selective measuring equipment shall be:

- 200 Hz in the frequency range from 9 kHz to 150 kHz;
- 9 kHz to 10 kHz in the frequency band from 150 kHz to 30 MHz;
- 100 kHz to 120 kHz in the frequency band 30 MHz to 1 GHz;
- 1 MHz above 1 GHz.

The detector shall be a peak detector.

9.7.3 Limit

The power of any spurious emission shall not exceed 2 nW.

9.8 Radiated spurious emissions

9.8.1 Definition

Radiated spurious emissions from the receiver are components at any frequency radiated by the equipment cabinet and the structure.

9.8.2 Method of measurements

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

The test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver.

The output of the test antenna shall be connected to a measuring receiver.

The receiver shall be switched on without modulation, and measuring receiver shall be tuned over the frequency range 30 MHz to 2 GHz. The bandwidth of the measuring receiver shall be as specified in clause 9.7.2.

At each frequency at which a spurious component is detected:

- a) 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;
- b) the receiver shall be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver;
- c) the maximum signal level detected by the measuring receiver shall be noted;
- d) the receiver shall be replaced by a substitution antenna as defined in annex A;
- e) the substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the spurious component detected;
- f) the substitution antenna shall be connected to a calibrated signal generator;
- g) the frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected;
- h) the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver, if necessary;
- i) the test antenna shall be raised and lowered through the specified range of heights to ensure that the maximum signal is received;
- j) the input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver that is equal to the level noted while the spurious component was measured, corrected for the change of input attenuator setting of the measuring receiver;
- k) the input level to the substitution antenna shall be recorded as power level, corrected for the change of input attenuator setting of the measuring receiver;
- l) the measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization;
- m) the measure of the effective radiated power of the spurious components is larger of the two power levels recorded for spurious component at the input to the substitution antenna, corrected for the gain of the antenna if necessary.

9.8.3 Limit

The power of any spurious radiation shall not exceed 2 nW at any frequency in the range between 30 MHz and 2 GHz.

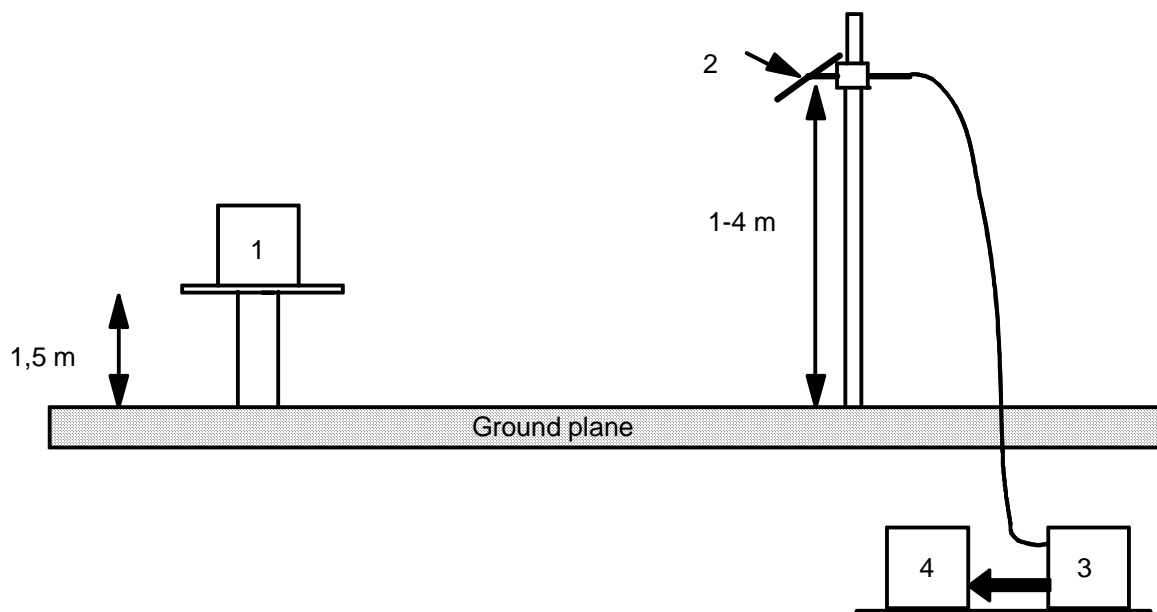
Annex A (normative): Radiated measurements

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. At one point on the site, a ground plane of at least 5 m diameter shall be provided. In the middle of this ground plane, a non-conducting support, capable of rotation through 360° in the horizontal plane, shall be used to support the test sample at 1,5 m above the ground plane. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of $\lambda/2$ or 3 m whichever is the greater. 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 and ground reflections do not degrade the measurements results.



Key:

- 1 Equipment under test
- 2 Test antenna
- 3 High pass filter (necessary for strong fundamental Tx radiation)
- 4 Spectrum analyser or measuring receiver

Figure A.1: Outdoor test site

A.1.2 Test antenna

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. For receiver radiated sensitivity measurements the test antenna is connected to a signal generator.

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 frequency under consideration, or a shortened dipole, calibrated to the $\lambda/2$ dipole. When measuring in the frequency range above 4 GHz a horn radiator shall be used. For measurements between 1 GHz and 4 GHz either a $\lambda/2$ dipole or a horn radiator may be used. 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 be at least 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 be operating at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

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 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 $\lambda/2$ antenna in figure A.2 may be replaced by an antenna of constant length, provided that this length is between $\lambda/4$ and λ at the frequency of measurement and the sensitivity of the measuring system is sufficient. In the same way the distance of $\lambda/2$ 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 direct and the remaining reflected signals occurs, the substitution antenna shall be moved through a distance of $\pm 0,1$ 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.

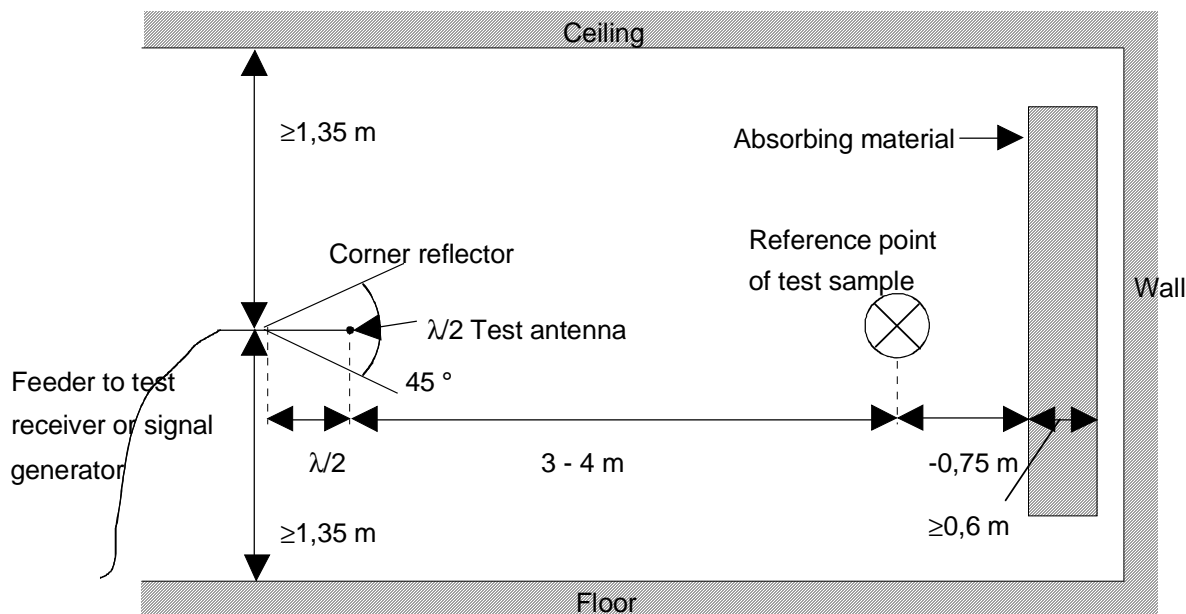


Figure A.2: Indoor site arrangement (shown for horizontal polarization)

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 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 a maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below about 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 about 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 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 decoupled may cause variations in the measuring 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.2.6 Acoustic measuring arrangement

When carrying out measurements of the maximum usable sensitivity (radiated) of the receiver, the audio output shall be monitored by acoustically coupling the audio signal from the receiver loudspeaker/transducer to the test microphone. On the radiation test site all conducting materials shall be placed below the ground surface and the acoustic signal is conveyed from the receiver to the test microphone in a non-conducting acoustic pipe.

The acoustic pipe shall have an appropriate length. The acoustic pipe shall have an inner diameter of 6 mm and a wall thickness of 1,5 mm. A plastic funnel of a diameter corresponding to the receiver loudspeaker/transducer shall be attached to the receiver surface centred in front of the receiver loudspeaker/transducer. The plastic funnel shall be very soft at the attachment point to the receiver in order to avoid mechanical resonance. The narrow end of the plastic funnel shall be connected to the one end of the acoustic pipe and the test microphone to the other.

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

For radiation measurements when the frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor site being a well-shielded anechoic chamber simulating 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, clause A.1. In the range between 30 MHz and 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 RF absorbers of 1 m height.

The base should be covered with absorbing material 1 m thick, and a wooden floor, able to carry test equipment and operators.

A measuring distance of 3 m to 5 m in the long middle axis of the chamber can be used for measurements up to 12,75 GHz.

The construction of the anechoic chamber is described in the following clauses.

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.3 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 preferably suitable for measurements above 100 MHz.

Figure A.4 shows the construction of a 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 absorbers approximately 1 m high. The base is covered with absorbers which are able to carry and which forms a sort of floor.

The available internal dimensions of the room are 3 m × 8 m × 3 m, so that a measuring distance of maximum 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 2 lambda.

The floor absorbers reject 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 measuring tolerances have the smallest possible values due to the simple measuring configuration.

For special measurements it can be necessary to re-introduce floor reflections. Taking away the floor absorbers would mean a removal of approximately 24 m³ absorber material. Therefore the floor absorbers are covered with metal plates of metallic nets instead.

A.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field condition the correlation $E = E_0(R_0/R)$ is valid for the dependence of the field strength E on the distance R , whereby E_0 is the reference field strength in the reference distance R_0 .

It is useful to use just 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 shows the disturbances due to reflections more readily and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in clause 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.

In the frequency range of 1 GHz to 12,75 GHz, because more reflections will occur, the dependence of the field strength on the distance will not correlate so closely.

A.3.3 Calibration of the shielded anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 12,75 GHz.

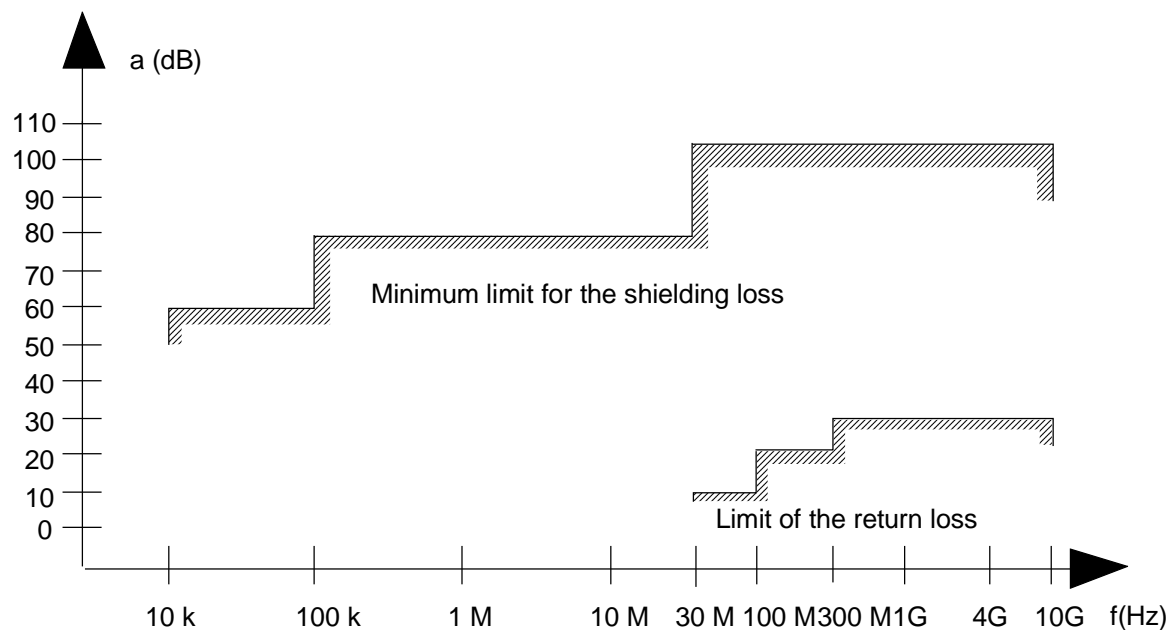
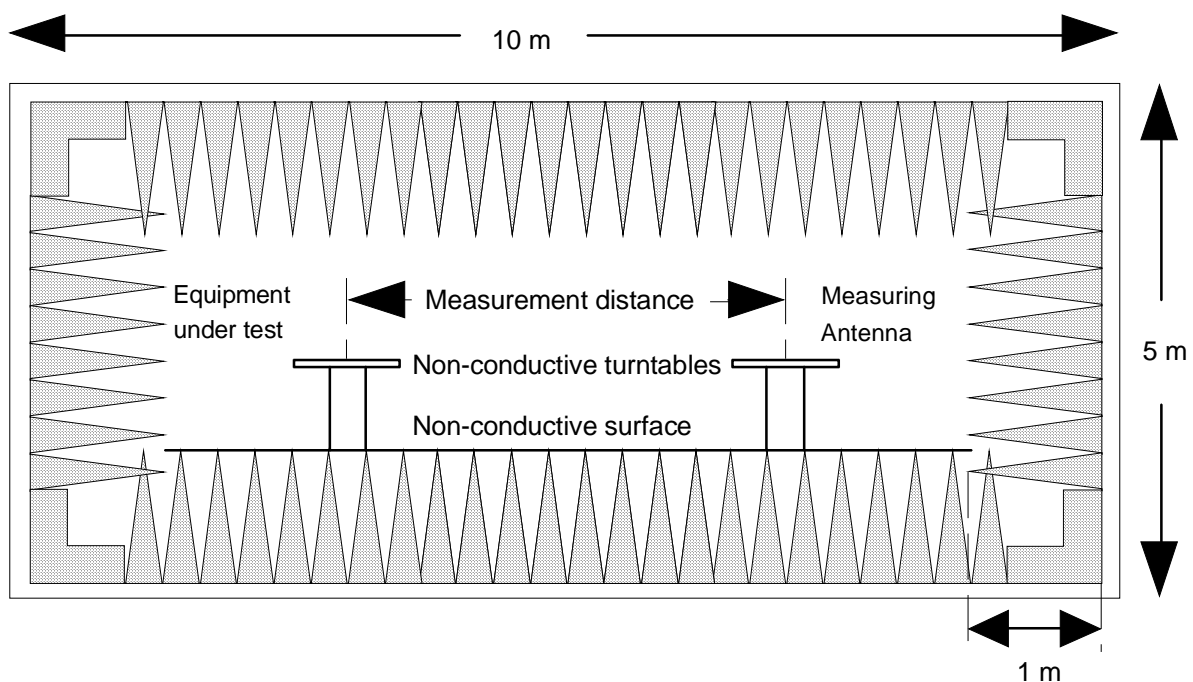
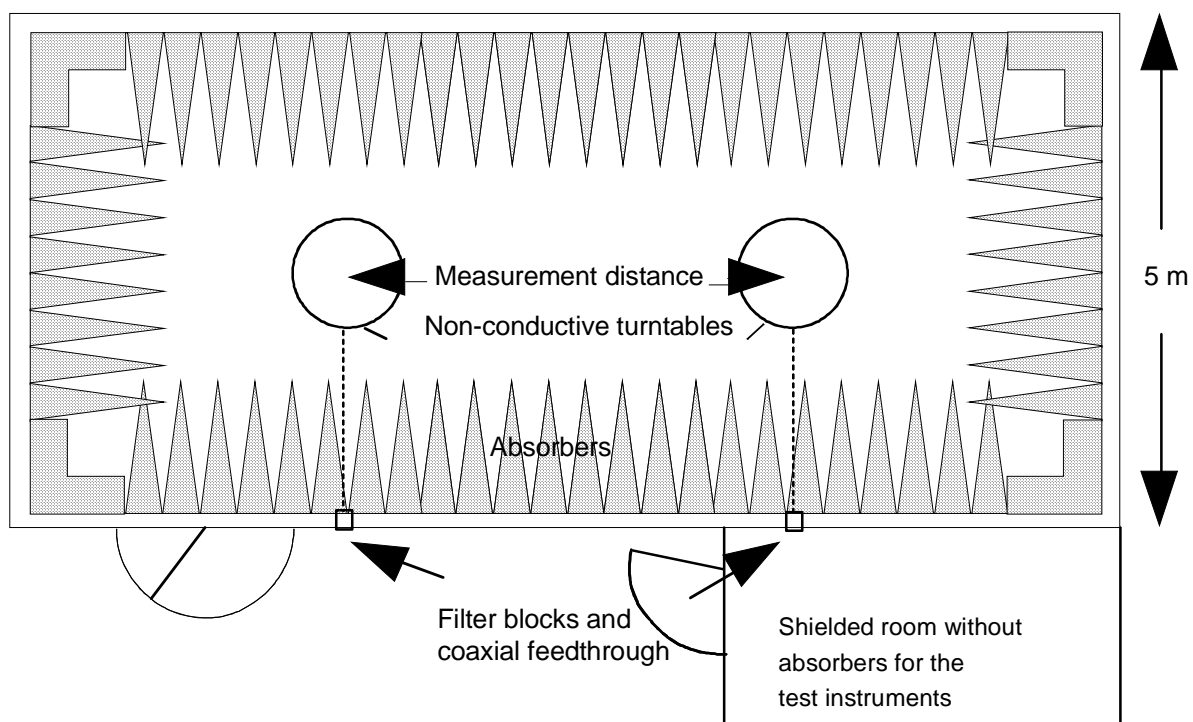


Figure A.3: Specifications for shielding and reflections



Ground plan

**Figure A.4: Example of construction of an anechoic shielded chamber**

Annex B (informative): Bibliography

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History

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