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Agricultural and forestry machinery - Electromagnetic compatibility - Test methods and acceptance criteria (ISO 14982:1998)

Machines agricoles et forestières - Compatibilité électromagnétique - Méthodes d'essai et critères d'acceptation (ISO 14982:1998)

This European Standard was approved by CEN on 26 January 2009.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

The text of ISO 14982:1998 has been prepared by Technical Committee ISO/TC 23 “Tractors and machinery for agriculture and forestry” of the International Organization for Standardization (ISO) and has been taken over as EN ISO 14982:2009 by Technical Committee CEN/TC 144 “Tractors and machinery for agriculture and forestry” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 14982:1998.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directives.

For relationship with EC Directives, see informative Annex ZA, ZB and ZC, which are integral part of this document.

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

Endorsement notice

The text of ISO 14982:1998 has been approved by CEN as a EN ISO 14982:2009 without any modification.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This International Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 98/37/EC on machinery, amended by the New Approach Directive 98/79/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses 1, 2, 3, 4, 5.1, 5.2, 6.3, 6.6, 6.8 and 7 of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the relevant *Essential Requirement 1.5.11 limited to EMC immunity* of that Directive and associated EFTA regulations.

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

Annex ZB
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC on machinery

This International Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC on machinery.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses 1, 2, 3, 4, 5.1, 5.2, 6.3, 6.6, 6.8 and 7 of this standard, confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirement *1.5.11 limited to EMC immunity* of that Directive and associated EFTA regulations.

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

Annex ZC
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2004/108/EC on electromagnetic compatibility

This International Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2004/108/EC on electromagnetic compatibility.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard, confers, within the limits of the scope of this standard, a presumption of conformity with the relevant protection requirements of Annex I (1) of that Directive and associated EFTA regulations.

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

INTERNATIONAL STANDARD

ISO 14982

First edition
1998-07-01

Agricultural and forestry machinery — Electromagnetic compatibility — Test methods and acceptance criteria

Machines agricoles et forestières — Compatibilité électromagnétique — Méthodes d'essai et critères d'acceptation

Reference number
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International Organization for Standardization
Case postale 56 CH-1211 Genève 20 Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 14982 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 2, *Common tests*.

Annexes A to E form an integral part of this International Standard. Annexes F to H are for information only.

Introduction

In the past years more and more electronic devices designed to control, supervise and indicate multiple functions have been used in agricultural machines and tractors. The electrical and electromagnetic environment in which these devices work needs to be taken into consideration.

Electrical and high frequency disturbances emerge during the normal operation of many parts of the machine devices. They are generated within a large frequency range with different electrical characteristics and, by conduction and/or radiation, can be imparted to other electronic devices and systems of the machine.

Narrowband signals generated by sources of interference inside or outside the agricultural machines and tractors can also be coupled in electrical and electronic systems where they can influence the normal function of electrical devices. Sources of narrowband electromagnetic disturbances are, for example, machines with integrated micro-processors.

The elaboration of this International Standard is based upon the Commission Directive 95/54/EC (31 October 1995) "Commission Directive 95/54/EC of 31 October 1995 adapting to technical progress Council Directive 72/245/EEC on the approximation of the laws of the Member States, relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type approval of motor vehicles and their trailers". This procedure was chosen due to the large conformity of the disturbance phenomena in many domains (motor vehicles, tractors, self-propelled machinery), similar operation and ambient conditions and the possibility of using the same measuring rig and measuring apparatus. As far as possible, the measuring procedures described in Directive 95/54/EC have been replaced by equivalent internationally standardized measuring procedures. However, it was not possible to refer to International Standards for radiated broadband and narrowband electromagnetic disturbances from machines and for radiated broadband and narrowband electromagnetic disturbances of electrical/electronic sub-assemblies (ESA). Therefore the necessary procedures are described in detail in annexes B, C, D and E. International standardization of the measuring procedures for all types of machines would be desirable for the future.

The electrostatic discharge and the conducted transients are considered to be relevant for agricultural machines and tractors and therefore (in contrast with the Directive 95/54/EC) are included in this International Standard.

Electrostatic discharges are relevant because also control elements can be positioned outside the cabin and potential differences can emerge at contact. Conducted transients have to be taken into account because agricultural machines often represent open systems and several machines are combined with one another. Up to now, however, only conducted transients along supply lines in 12 V- and 24 V-onboard systems have been dealt with. The manufacturer is therefore responsible for ensuring that the equipment may withstand conducted transients which may occur at the switching under load and interactions between systems. Internal cabling and networks should comply with the state of the art. Conducted transients at signal lines have not yet been treated.

This International Standard has been established as a means of achieving conformity with the requirements of the EMC Directive (89/336/EEC) and the EMC requirements of the Machine Directive (89/392/EEC).

Agricultural and forestry machinery — Electromagnetic compatibility — Test methods and acceptance criteria

1 Scope

This International Standard specifies test methods and acceptance criteria for evaluating the electromagnetic compatibility of tractors and all kinds of mobile (including hand-held) agricultural machinery, forestry machinery, landscaping and gardening machinery [referred to hereafter as machine(s)] as supplied by the machine manufacturer. It is applicable to machines and electrical/electronic sub-assemblies (ESA's) which are manufactured after the date of publication of this International Standard.

Electrical/electronic components or sub-assemblies intended for fitting in machines are also within the scope of this standard, except regarding immunity for those parts whose functions are not involved in the direct control and modification of the state of the functions of the machine.

This International Standard is not applicable to machines directly supplied with low voltage current from public electrical mains. Exceptions to machines or electrical/electronic systems or ESA's that may not require testing in accordance with this International Standard are given in clause 7.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7637-0:1990, *Road vehicles — Electrical disturbance by conduction and coupling — Part 0: Definitions and general.*

ISO 7637-1:1990, *Road vehicles — Electrical disturbance by conduction and coupling — Part 1: Passenger cars and light commercial vehicles with nominal 12 V supply voltage — Electrical transient conduction along supply lines only.*

ISO 7637-2:1990, *Road vehicles — Electrical disturbance by conduction and coupling — Part 2: Commercial vehicles with nominal 24 V supply voltage — Electrical transient conduction along supply lines only.*

ISO/TR 10605:1994, *Road vehicles — Electrical disturbance from electrostatic discharge.*

ISO 11451-1:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods — Part 1: General and definitions.*

ISO 11451-2:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods — Part 2: Off-vehicle radiation source.*

ISO 11452-1:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 1: General and definitions.*

ISO 11452-2:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 2: Absorber-lined chamber.*

ISO 11452-3:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 3: Transverse electromagnetic mode (TEM) cell.*

ISO 11452-4:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 4: Bulk current injection (BCI).*

ISO 11452-5:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods — Part 5: Stripline.*

IEC 50-161:1990, *International electrotechnical vocabulary — Chapter 161: Electromagnetic compatibility*.

CISPR 12:1990, *Limits and methods of measurement of radio interference characteristics of vehicles, motor boats, and spark-ignited engine-driven devices.*

CISPR 16-1:1993, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 1: Radio disturbance and immunity measuring apparatus*.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
electromagnetic compatibility
ability of a machine or components or a separate technical unit to function satisfactorily in its electromagnetic environment, without introducing intolerable electromagnetic disturbances to anything in that environment

[IEC 50-161:1990, 161-01-07]

3.2
electromagnetic disturbance
any electromagnetic phenomenon which may degrade the performance of a machine or component or separate technical unit

NOTE — An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself

[IEC 50-161:1990, 161-01-05]

3.3
electromagnetic immunity
ability of a machine or component or separate technical unit to perform in the presence of specified electromagnetic disturbances without degradation of performance

[IEC 50-161:1990, 161-01-20]

3.4
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

[IEC 50-161:1990, 161-01-01]

3.5
reference limit
limit value with which the production shall conform

3.6
reference antenna
⟨frequency range 30 MHz to 80 MHz shortened balanced dipole which is a half-wave resonant dipole at 80 MHz frequency [see CISPR 16-1:1993]

3.7
reference antenna
⟨frequency range above 80 MHz⟩ balanced half wave resonant dipole tuned to the measurement frequency [see CISPR 16-1:1993]

3.8
broadband emission
emission which has a bandwidth greater than that of a particular measuring apparatus or receiver

[IEC 50-161:1990, 161-06-11]

3.9
narrowband emission
emission which has a bandwidth less than that of a particular measuring apparatus or receiver

[IEC 50-161:1990, 161-06-13]

3.10
electrical/electronic system
electrical and/or electronic component or set of components intended to be part of a machine, together with any associated electrical connections

3.11
electrical/electronic sub-assembly
ESA
electrical and/or electronic component or set of components intended to be part of a machine, together with any associated electrical connections and wiring, which performs one or more specialised functions

3.12
machine type
⟨electromagnetic compatibility⟩ machines which do not differ in such essential respects as:

— the structural shape;

— the general arrangement of the electrical and/or electronic components and the general wiring arrangement;

— the primary material of which the design of the machine consists (for example a steel, aluminium or fibreglass covering parts)

3.13
ESA type
⟨electromagnetic compatibility⟩ ESA's which do not differ in such essential respects as:

— the function performed by the ESA;

— the arrangement of the electrical and/or electronic components, if applicable;

— the primary material of the casing

3.14
electrostatic discharge
ESD
transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

[IEC 50-161:1990, 161-01-22]

3.15
conducted transients
transient voltage or current distributed in the power supply wiring of a machine or component or separate technical unit via a conductor between the source of the transient and the drain

4 Fulfilment of the requirements

The requirements of this International Standard shall be met by a machine (and its electrical/electronic installation or its ESA) operating in accordance with its final purpose. According to the choice of the machine manufacturer, the following alternatives are possible to demonstrate conformity with this International Standard.

a) The requirements of this International Standard are deemed to be fulfilled for a complete machine when the requirements identified in clauses 5 and 6, as applicable, are fulfilled. If the machine manufacturer has chosen this alternative, no routine tests of the electrical/electronic systems or ESA's are required.

b) The requirements of this International Standard are also deemed to be fulfilled if it is confirmed by the machine manufacturer that all electrical/electronic systems or ESA's are in accordance with this International Standard and have been installed in conformance with the recommended requirements of the ESA.

c) The requirements of this International Standard are also deemed to be fulfilled when the machine has no such equipment for which an immunity or interference test is required. In this case no tests are necessary (see clause 7).

5 Testing

5.1 Procedure

A kind of "type testing" has been chosen as test procedure, in which a type (designated "test specimen" hereafter) which has been chosen from the series according to certain criteria is tested (see definitions 3.12 and 3.13).

In every test procedure reference limits are determined to which the complete production has to correspond. Tightened limit values apply for the test specimen (except for the electrostatic discharge and the conducted transients) which shall be 2 dB (20 %) below the reference limits (at emission) respectively 2 dB (25 %) above the reference limits (at immunity).

NOTE 1 — This additional margin is used in order to account for the minor differences between the test specimen and the series-product (equivalence of the test specimen) and the minor differences of different testing laboratories (reproducibility of results).

If the test specimen fulfils the tightened limit values, it is assumed that all series-products which are represented by the test specimen comply with the reference limits.

NOTE 2 — This means that the reference limits are taken as basis for a 100 % testing of the production and for an inspection.

Referring to the electrostatic discharge and conducted transients, the reference limits are also valid for the test specimen.

NOTE 3 — The test procedure for the electrostatic discharge and the conducted transients depend in a less substantial way from the environmental influences and minor modifications of the test specimen and consequently the additional margin does not apply.

5.2 General requirements for immunity testing

No disturbances shall occur during testing which may affect the driver's direct control of the machine. The driver's direct control of the machine is exercised by means of, for example, steering, braking, the ground speed, or engine speed control. This also concerns movements of parts of the machine and modifications of the state of function which may generate hazards or mislead others.

6 Test/measurement methods and reference limits

6.1 Broadband electromagnetic emissions from machines

6.1.1 Method of measurement

The electromagnetic emissions shall be measured using the method described in annex B at either of the defined antenna distances. The choice is left to the user of this International Standard.

6.1.2 Broadband reference limits

If measurements are made using the method described in annex B using a machine-to-antenna distance of 10 m ± 0,2 m, the emission reference limits shall be 34 dB(μV/m) (50 μV/m) in the 30 MHz to 75 MHz frequency band and 34 dB(μV/m) to 45 dB(μV/m) (50 μV/m to 180 μV/m) in the 75 MHz to 400 MHz frequency band; this limit increases logarithmically (linearly) with frequencies above 75 MHz as shown in figure A.1. In the 400 MHz to 1 000 MHz frequency band the limit remains constant at 45 dB(μV/m) (180 μV/m).

If measurements are made using the method described in annex B using a machine-to-antenna distance of 3 m ± 0,05 m, the emission reference limits shall be 44 dB(μV/m) (160 μV/m) in the 30 MHz to 75 MHz frequency band and 44 dB(μV/m) to 55 dB(μV/m) (160 μV/m to 562 μV/m) in the 75 MHz to 400 MHz frequency band; this limit increases logarithmically (linearly) with frequencies above 75 MHz as shown in figure A.2. In the 400 MHz to 1 000 MHz frequency band the limit remains constant at 55 dB(μV/m) (562 μV/m).

On the test specimen, the measured values, expressed in dB(μV/m) (μV/m), shall be at least 2 dB (20 %) below the reference limits.

6.2 Narrowband electromagnetic emissions from machines

6.2.1 Method of measurement

The electromagnetic emission shall be measured using the method described in annex C at either of the defined antenna distances. The choice is left to the user of this International Standard.

6.2.2 Narrowband reference limits

If measurements are made using the method described in annex C using a machine-to-antenna distance of 10 m ± 0,2 m, the emission reference limits shall be 24 dB(μV/m) (16 μV/m) in the 30 MHz to 75 MHz frequency band and 24 dB(μV/m) to 35 dB(μV/m) (16 μV/m to 56 μV/m) in the 75 MHz to 400 MHz frequency band; this limit increases logarithmically (linearly) with frequencies above 75 MHz as shown in figure A.3. In the 400 MHz to 1 000 MHz frequency band the limit remains constant at 35 dB(μV/m) (56 μV/m).

If measurements are made using the method described in annex C using a machine-to-antenna distance of 3 m ± 0,05 m, the emission reference limits shall be 34 dB(μV/m) (50 μV/m) in the 30 MHz to 75 MHz frequency band and 34 dB(μV/m) to 45 dB(μV/m) (50 μV/m to 180 μV/m) in the 75 MHz to 400 MHz frequency band; this limit increases logarithmically (linearly) with frequencies above 75 MHz as shown in figure A.4. In the 400 MHz to 1 000 MHz frequency band the limit remains constant at 45 dB(μV/m) (180 μV/m).

On the test specimen, the measured values, expressed in dB(μV/m) (μV/m), shall be at least 2 dB (20 %) below the reference limits.

6.3 Immunity of machines to electromagnetic radiation

6.3.1 Test method

The immunity to electromagnetic radiation of the machine shall be tested according to ISO 11451-1 and ISO 11451-2. The determination of the reference point(s) and the operating mode(s) shall be machine-specific and noted in the test report. Immunity testing should be conducted as outlined in ISO 11451-1 except forward power may be used as the control regardless of the standing wave ratio of the system. The test report shall indicate which control method was used. The substitution method and the 80 % amplitude modulation (AM) with sinusoidal wave of

1 kHz (see ISO 11451-1) is determined as test method. Testing shall be done in the frequency band 20 MHz to 1 000 MHz. Polarization may be vertical or horizontal based on worse case conditions and shall be noted in the test report.

6.3.2 Machine immunity reference limits

The reference limit shall be 24 V/m referring to the root mean square value of the unmodulated signal. The maximum value of the test signal with modulation shall comply with the maximum value of an unmodulated test signal. The reference limits, increased by 25 %, apply for the test specimen. The general requirements for immunity testing determined in 5.2 shall be fulfilled.

6.4 Broadband electromagnetic emissions radiated from ESA's

6.4.1 Method of measurement

The electromagnetic interference shall be measured using the method described in annex D.

6.4.2 ESA broadband reference limits

If measurements are made using the method described in annex D, the emission reference limits shall be 64 dB(μV/m) to 54 dB(μV/m) (1 600 μV/m to 500 μV/m) in the 30 MHz to 75 MHz frequency band; this limit decreases logarithmically (linearly) with frequencies above 30 MHz, and 54 dB(μV/m) to 65 dB(μV/m) (500 μV/m to 1 800 μV/m) in the 75 MHz to 400 MHz frequency band and increases logarithmically (linearly) with frequencies above 75 MHz as shown in figure A.5. In the 400 MHz to 1 000 MHz frequency band, the limit remains constant at 65 dB(μV/m) (1 800 μV/m).

On the test specimen, the measured values, expressed in dB(μV/m) (μV/m) shall be at least 2 dB (20 %) below the reference limits.

6.5 Narrowband electromagnetic emissions radiated from ESA's

6.5.1 Method of measurement

The electromagnetic interference shall be measured using the method described in annex E.

6.5.2 ESA narrowband reference limits

If measurements are made using the method described in annex E, the emission reference limits shall be 54 dB(μV/m) to 44 dB(μV/m) (500 μV/m to 160 μV/m) in the 30 MHz to 75 MHz frequency band; this limit decreases logarithmically (linearly) with frequencies above 30 MHz, and 44 dB(μV/m) to 55 dB(μV/m) (160 μV/m to 562 μV/m) in the 75 MHz to 400 MHz frequency band and increases logarithmically (linearly) with frequencies above 75 MHz as shown in figure A.6. In the 400 MHz to 1 000 MHz frequency band the limit remains constant at 55 dB(μV/m) (562 μV/m).

On the test specimen, the measured values, expressed in dB(μV/m) (μV/m) shall be at least 2 dB (20 %) below the reference limits.

6.6 Immunity of ESA's to electromagnetic radiation

6.6.1 Test method

Any combination of the test methods of ISO 11452-2, ISO 11452-3, ISO 11452-4 or ISO 11452-5 may be used for the immunity testing of ESA's to electromagnetic energy. The selected test methods shall cover the frequency band 20 MHz to 1 000 MHz. An amplitude modulation (AM) of 80 % together with a sinusoidal wave of 1 kHz (see ISO 11452-1) shall be used. If the substitution method is determined as the calibration method for the anechoic chamber test, the forward power may be used as the control regardless of the standing wave ratio of the system. In the case of ESA's, the substitution method or the closed loop method may be used for the field calibration. The test report shall indicate which control method was used.

6.6.2 ESA immunity reference limits

The immunity reference limits shall be as follows:

48 V/m for the stripline testing method (ISO 11452-5);

60 V/m for the TEM cell testing method (ISO 11452-3);

48 mA for the Bulk Current Injection (BCI) testing method (ISO 11452-4); and

24 V/m for the radiated field (absorber lined chamber) testing method (ISO 11452-2) in vertical polarization only.

The reference limits, increased by 25 %, apply for the test specimen. The reference limits apply to the root mean square value of the unmodulated signal. The maximum value of the test signal with modulation shall comply with the maximum value of an unmodulated test signal. The ESA shall not exhibit any operational change which is unacceptable for its application on the machine. See 5.2 for further definition of operational change which is unacceptable.

6.7 Electrostatic discharge

6.7.1 Test method

The method described in ISO/TR 10605 shall be used as the method of measurement of the machine or on the ESA in areas where an ESD in standard use is possible (e.g. by touching by the operator).

6.7.2 Reference limits

Test level I (± 4 kV) at functional status class A according to ISO/TR 10605 applies.

6.8 Conducted transients

6.8.1 Method of testing

The method described in ISO 7637-0, ISO 7637-1 and ISO 7637-2 shall be used as method of testing.

6.8.2 Reference limits

Test level I at functional status class A according to ISO 7637-1 and ISO 7637-2 applies. Table 1 shows the field of application of the different check pulses in the 12 V- and 24 V-onboard system.[1)] The function performance status shall be specified before the testing of every different check pulse.

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1) The emission of transients is under consideration for a revision of ISO 7637-1 and ISO 7637-2. This has to be taken into account for the future.

Table 1 — Check pulse in 12 V- and 24 V-onboard system

Test pulse	Reference limit 12 V-system V	Reference limit 24 V-system V	Application
1	– 25	– 50[1)]	This test pulse is a simulation of transients due to supply disconnection from inductive loads; it applies to a device under test if, as used in the machine, it remains connected directly in parallel with an inductive load.
2	+ 25	+ 25	This test pulse is a simulation of transients due to the sudden interruption of current in an inductor connected in series with a device under test.
3a	– 25	– 35	These test pulses are a simulation of transients, which occur as a result of the switching processes. The characteristics of these transients are influenced by distributed capacitance and inductance of wiring harness.
3b	+ 25	+ 35	
4	– 4	– 5	This pulse simulates supply voltage reduction caused by energising the starter-motor circuits of internal combustion engines (excluding spikes associated with starting).
5	+ 26,5	+ 70	This test pulse is a simulation of load dump transient occurring in the event of a discharged battery being disconnected while the alternator is generating charging current at the moment of the battery being disconnected with other loads remaining on the alternator circuit at this moment. The load dump amplitude depends on the alternator speed and on the level of the alternator field excitation at the moment of the battery being disconnected. The load dump pulse duration depends essentially on the time constant of the field excitation circuit and on the pulse amplitude.

[1)] Only test pulse 1a according to ISO 7637-2 applies.

7 Exceptions

For the requirements of clauses 5 and 6, the following exceptions are valid.

a) Where a machine or electrical/electronic system or ESA does not include an electronic oscillator with an operating frequency greater than 9 kHz, testing according to 6.2 and 6.5 is not necessary.

b) Machines which do not have electrical/electronic systems or ESA's involved in the direct control and modification of the state of function of the machine need not to be tested for immunity according to 6.3, 6.7 and 6.8.

c) ESA's whose functions are not involved in the direct control and modification of the state of function of the machine need not be tested for immunity according to 6.6, 6.7 and 6.8.

d) If the machine does not possess an interface for the coupling of external electrical/electronic systems, so a testing of the conducted transients according to 6.8 is not necessary. If the machine is self propelled, a testing of the conducted transient immunity according to 6.8 is not required.

e) No specific tests shall be made regarding radio or telephone transmitters. Each machine manufacturer shall, in his owner's handbook, identify what precautions, if any, shall be taken when installing and operating radio, telephone or other transmitters inside the machine.

8 Test report

An example of a test report is given in annex G.

Annex A
(normative)

Reference limits

The reference limits are given in figures A.1 to A.6.

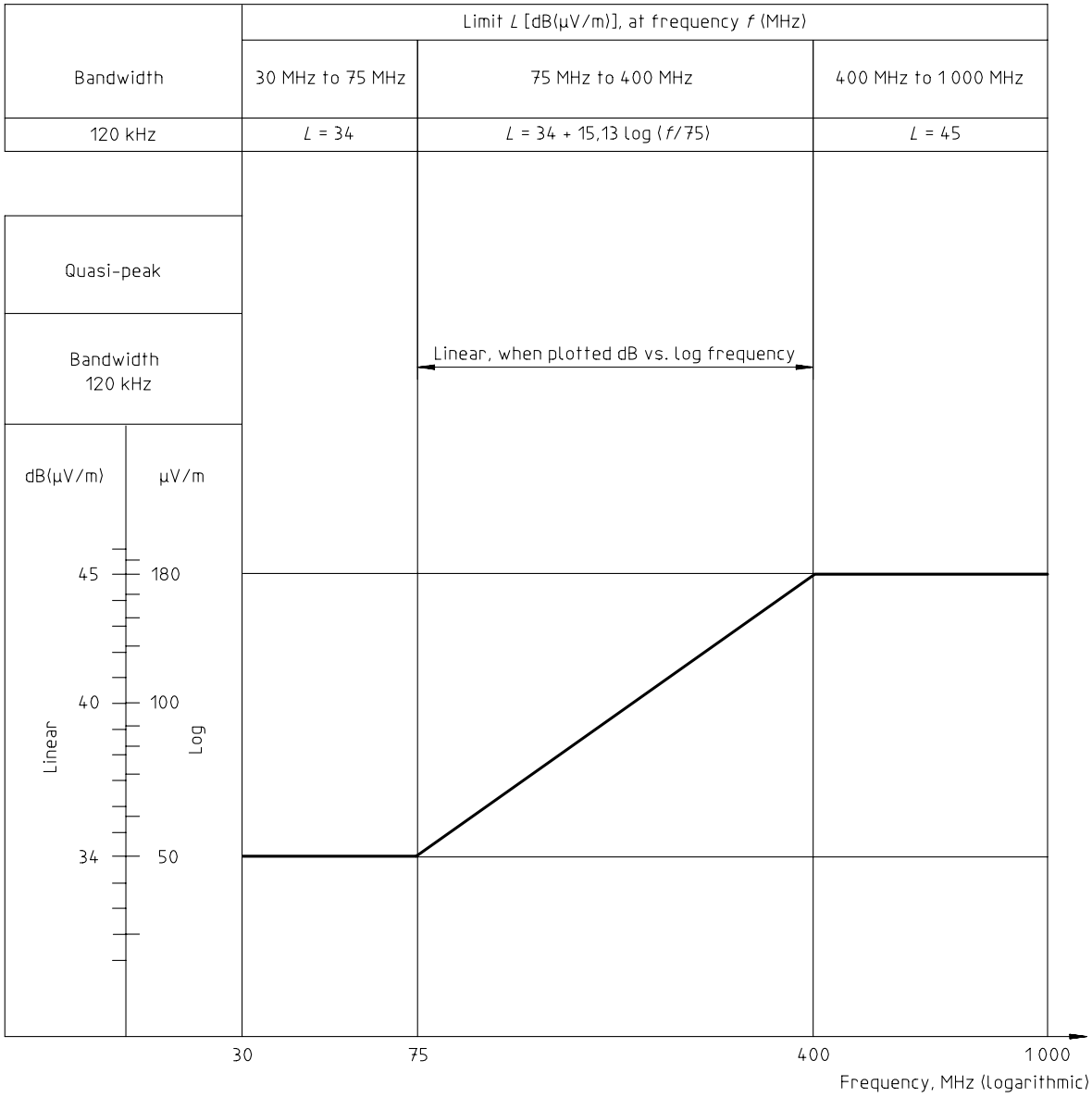


Figure A.1 — Machine broadband reference limits for a machine-to-antenna distance of 10 m

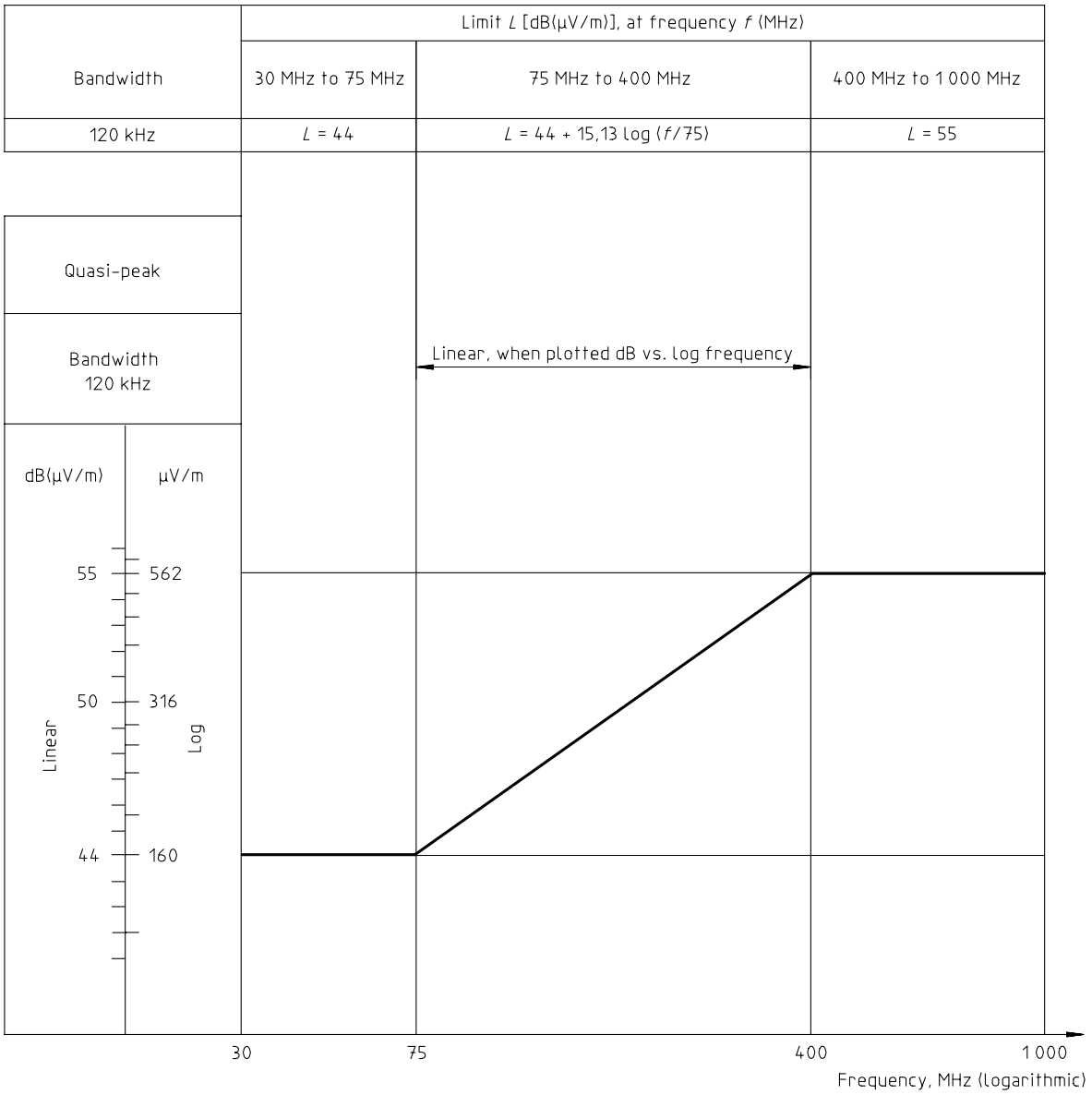


Figure A.2 — Machine broadband reference limits for a machine-to-antenna distance of 3 m

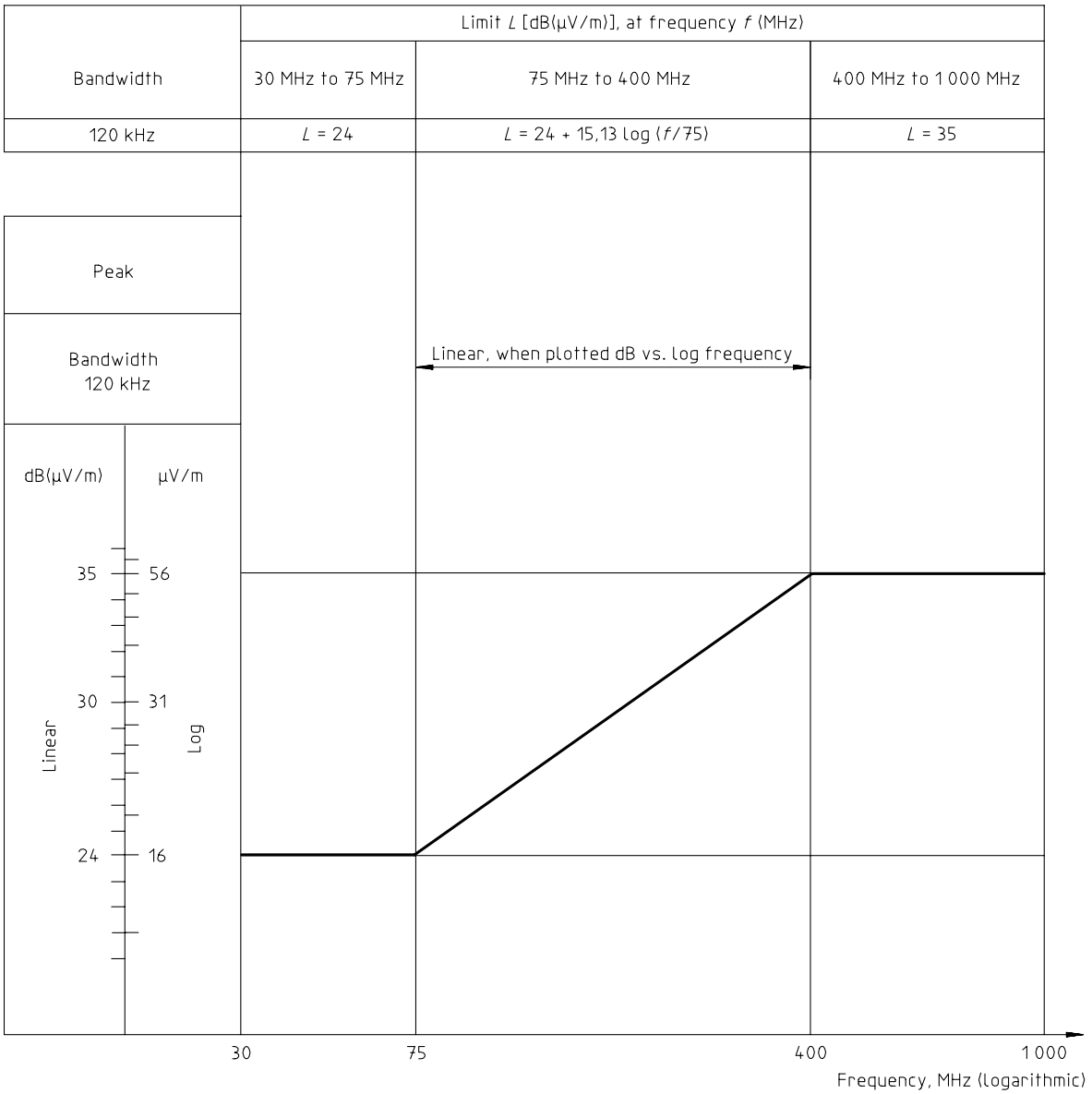


Figure A.3 — Machine narrowband reference limits for a machine-to-antenna distance of 10 m

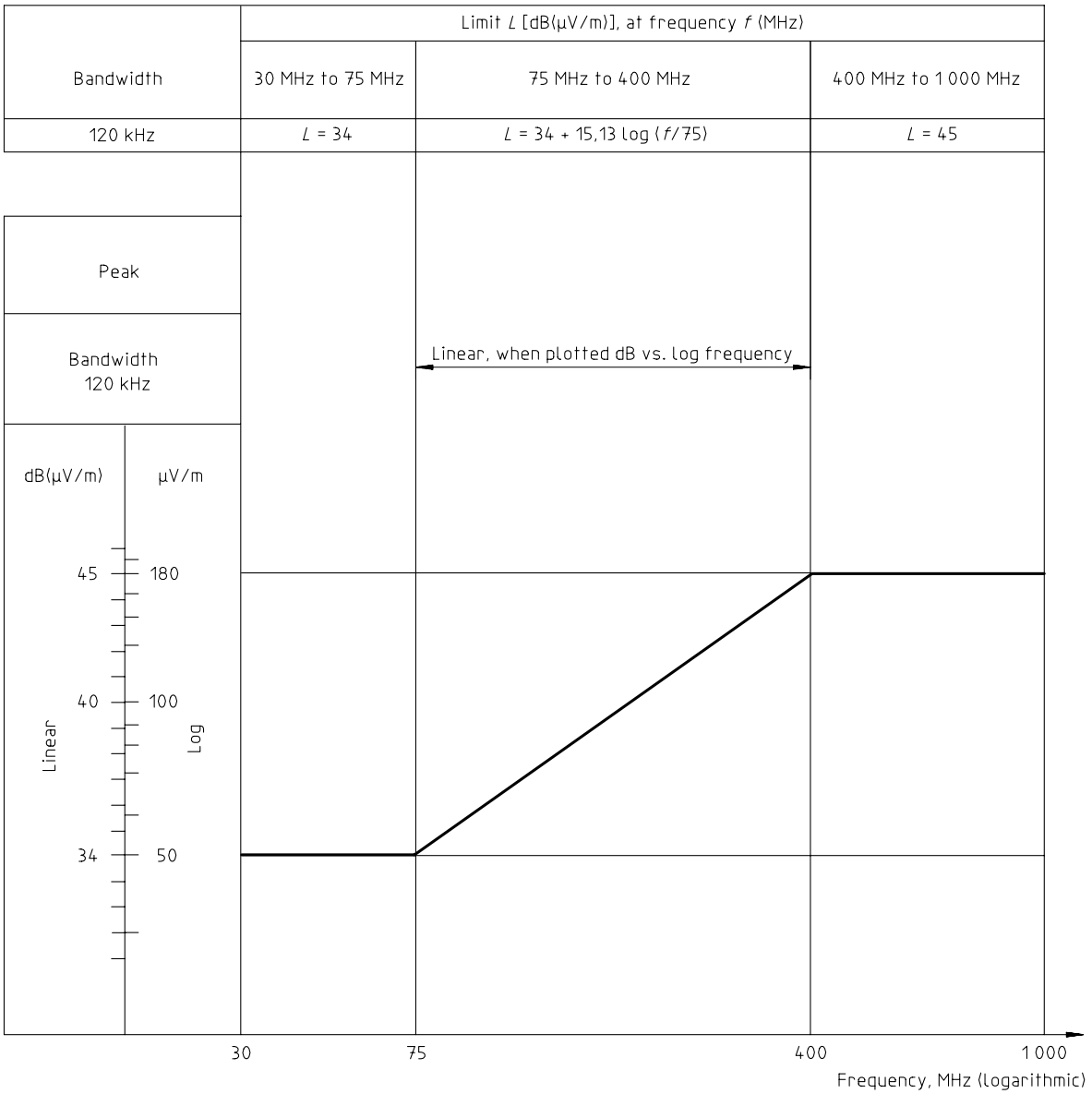


Figure A.4 — Machine narrowband reference limits for a machine-to-antenna distance of 3 m

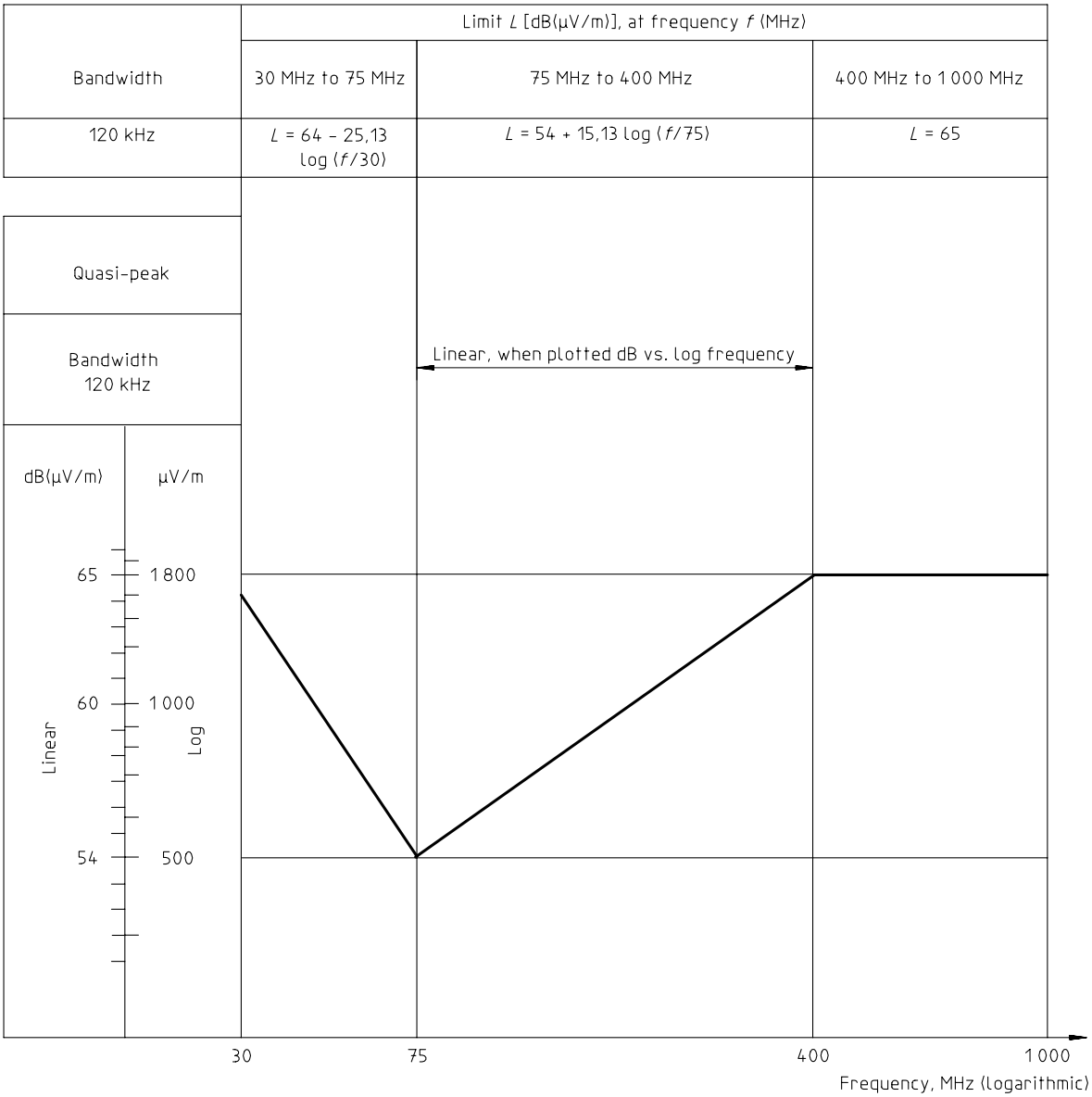


Figure A.5 — ESA broadband reference limits

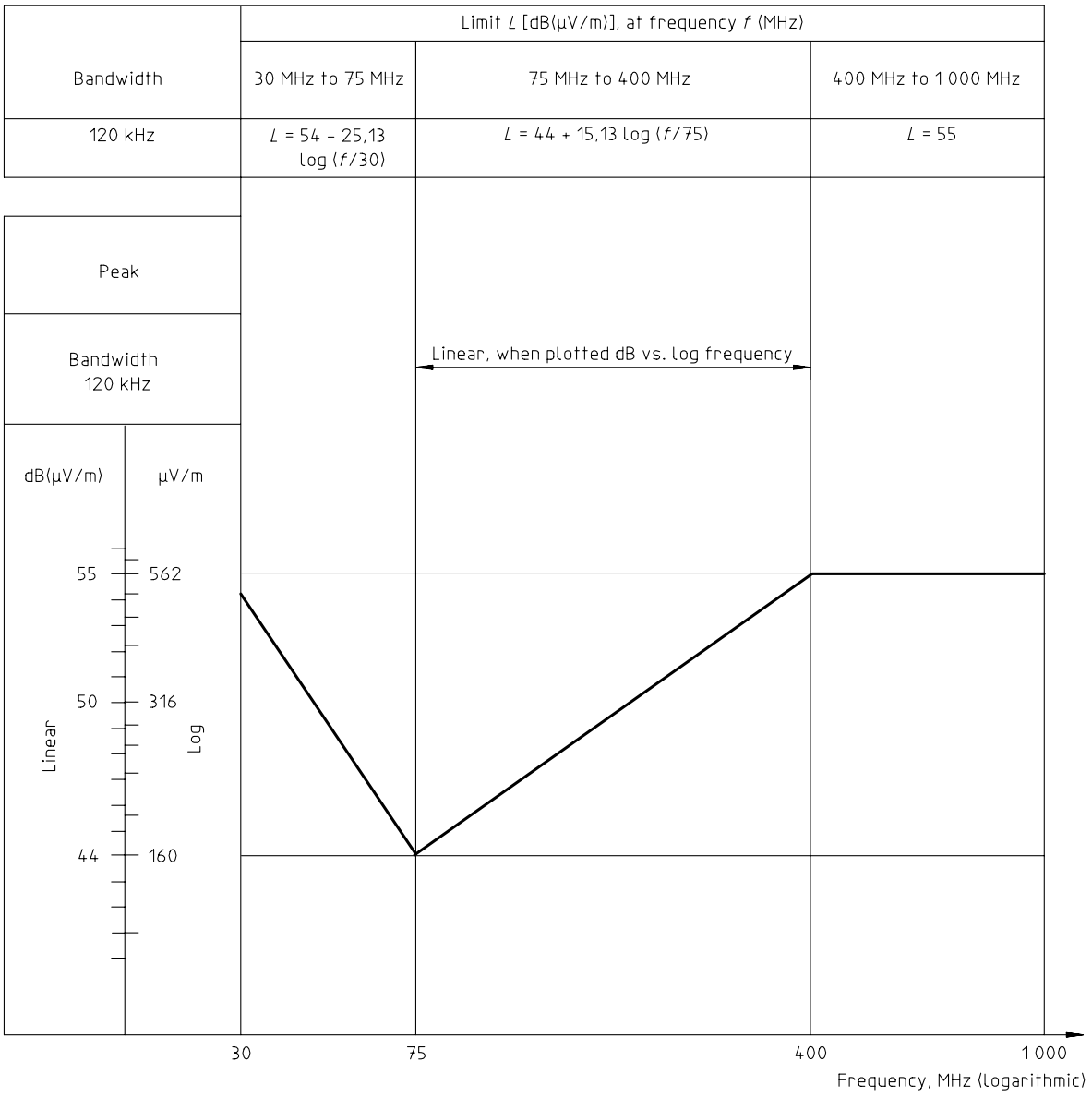


Figure A.6 — ESA narrowband reference limits

Annex B
(normative)

Method of measurement of radiated broadband electromagnetic emissions from machines

B.1 General

B.1.1 Application

The test method described in this annex shall only be applied to machines.

B.1.2 Measuring equipment

The measuring equipment shall comply with the requirements of CISPR 16-1.

A quasi-peak-detector shall be used for the measurement of broadband electromagnetic emissions, or if a peak-detector is used an appropriate correction factor shall be used (see clause B.6 and CISPR 12).

B.1.3 Test method

This test is intended to measure the broadband emissions from machines. Two alternative reference antenna distances are permissible, 10 m or 3 m from the machine. In either case the requirements of B.2 shall be complied with.

B.1.4 Results

The results of measurement shall be expressed in dB(μV/m) (μV/m) for 120 kHz bandwidth. If the actual bandwidth *B* (expressed in kilohertz) of the measuring apparatus differs from 120 kHz, the readings shall be converted to 120 kHz bandwidth through multiplication by a factor 120/*B*.

NOTE — This factor depends on the spectral distribution of the disturbance signal. For spark-like disturbance voltages the factor is as described. For harmonic disturbance signals the factor is $\sqrt{120 / B}$.

B.2 Measuring location

B.2.1 Test site

The test site shall be a clear, level area free of electromagnetic reflecting surfaces within a circle of minimum radius 30 m measured from a point midway between the machine and the antenna (see figure B.1).

B.2.2 Measuring facility

The test hut or vehicle in which the measurement set is located may be within the test site, but only in the permitted region shown in figure B.1. Other measuring antennas are allowed within the test area, at a minimum distance of 10 m both from receiving antenna and the machine under test, provided that it can be shown that the test results will not be affected.

B.2.3 Enclosed test facilities

Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of figure B.1 other than the distance

from the antenna to this machine and the height of the antenna, nor do they need to have ambient emissions checked before or after the test as indicated in B.2.4.

B.2.4 Ambient measurements

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect materially the measurement, measurements shall be taken before and after the main test. If the machine is present when ambient measurements are taken, steps shall be taken to ensure that any emission from the machine do not affect the ambient measurements significantly, for example by removing the machine from the test area, removing the ignition key, or disconnecting the battery. For both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 6.1.2 (except for intentional narrowband ambient transmissions).

B.3 Machine state during test

All sources of broadband emissions which are to be continuously used should be switched on during test.

If the machine is engine-driven the engine shall be running at its normal operating temperature and the transmission shall be in neutral. Care shall be taken to ensure that the speed setting mechanism does not influence electromagnetic radiations. During each measurement, the engine shall be operated as shown in table B.1.

Table B.1 — Engine speed during test

Engine type		Engine speed	
		Method of measurement	
		quasi-peak	peak
Spark ignition	one cylinder	2500 r/min ± 250 r/min	2500 r/min ± 250 r/min
	more than one cylinder	1500 r/min ± 150 r/min	1500 r/min ± 150 r/min
Diesel		Normal operation speed, with a relative tolerance of ± 10 %	

Measurements shall not be made while rain or other precipitation is falling on the machine or within ten minutes after precipitation has stopped.

B.4 Antenna

B.4.1 Antenna type

Any antenna may be used provided it can be normalised to the reference antenna. The method described in annex A of CISPR 12:1990 may be used to calibrate the antenna.

B.4.2 Antenna position

B.4.2.1 General

No part of any antenna's receiving elements shall be closer than 0,25 m to the plane on which the machine rests.

If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving elements shall be no closer than 1 m to any radio-absorbent material and no closer than 1,5 m to the wall of the enclosed facility. There shall be no absorbent material between the receiving antenna and machine under test.

B.4.2.2 Test with 10 metres antenna distance

The phase centre of the antenna shall be 3 m 0,05 m above the plane on which the machine rests.

The horizontal distance from the tip or other appropriate point of the antenna defined during the measurement procedure mentioned in B.4.1 to the outer body surface of the machine shall be 10 m ± 0,2 m.

B.4.2.3 Test with three metres antenna distance

The phase centre of the antenna shall be 1,8 m ± 0,05 m above the plane on which the machine rests.

The horizontal distance from the tip or other appropriate point of the antenna defined during the measurement procedure mentioned in B.4.1 to the outer body surface of the machine shall be 3 m ± 0,05 m.

B.4.3 Antenna orientation

The antenna shall be located successively on the left- and right-hand sides of the machine, with the antenna parallel to the plane of longitudinal symmetry of the machine and in line with the engine mid-point or the machine mid-point for machines without engine (see figure B.2).

At each of the measuring points, readings shall be taken both with the antenna in a horizontal and in a vertical polarisation (see figure B.2).

B.5 Readings

The maximum of the four readings taken in accordance with B.4.3 shall be taken as the characteristic reading at the frequency at which the measurements were made.

B.6 Frequencies

Measurements shall be made over the whole frequency range from 30 MHz to 1 000 MHz. The minimum scan time shall comply with the requirements of CISPR 12.

In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the machine and not to background radiation.

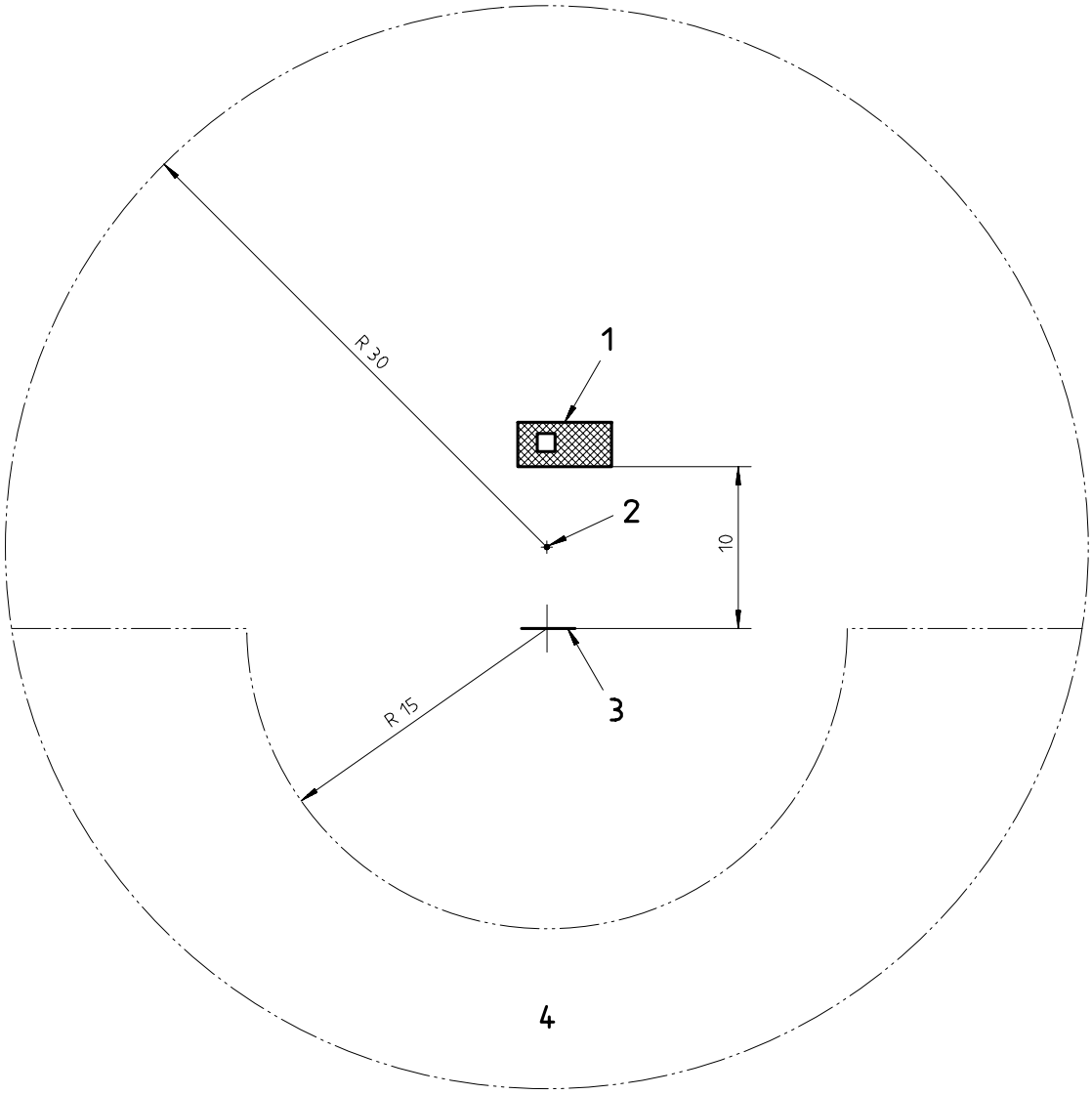
Measurements can be performed with either quasi-peak or peak detectors. The limits given in 6.1.2 are for quasi-peak. If a peak-detector is used, add 38 dB for 1 MHz bandwidth or subtract 22 dB for 1 kHz bandwidth, that is,

— limit (peak, 1 MHz) = limit (quasi-peak, 120 kHz) + 38 dB;

— limit (peak, 1 kHz) = limit (quasi-peak, 120 kHz) – 22 dB.

NOTE — In accordance with CISPR 12, the correlation factor between quasi-peak and peak measurements is + 20 dB at 120 kHz bandwidth, and has been included in the above equations.

Dimensions in metres



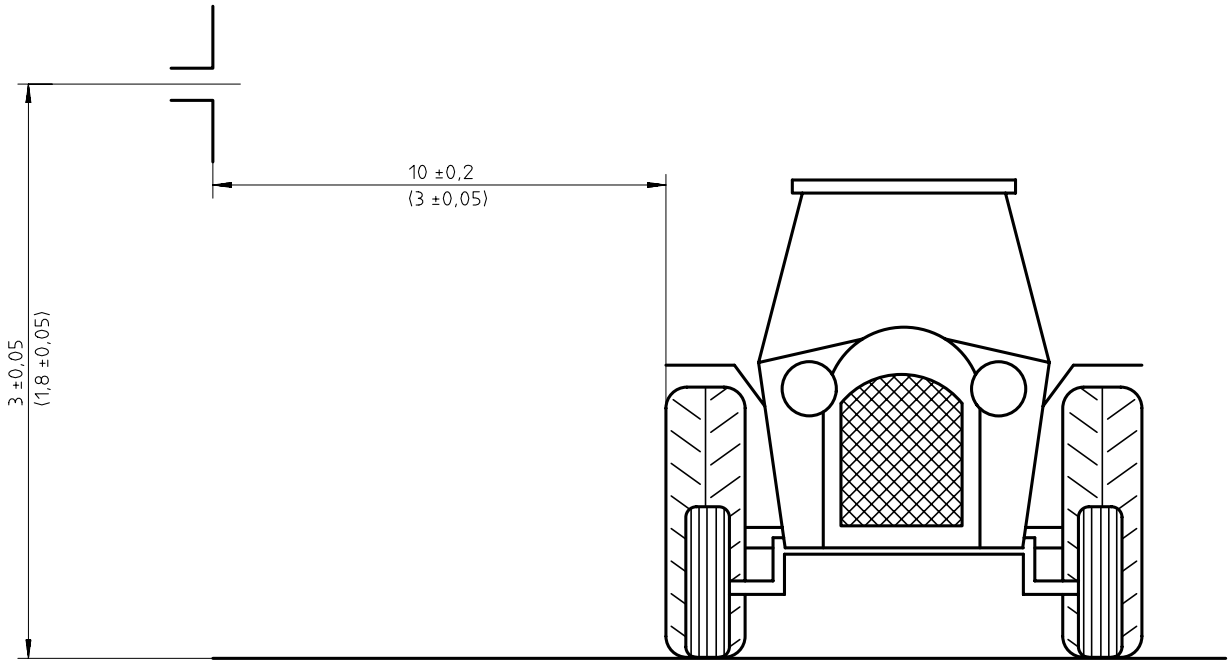
Key

1 Machine
2 Centre of clear area midway between antenna and machine
3 Antenna
4 Permitted region for measuring set (in hut or vehicle)

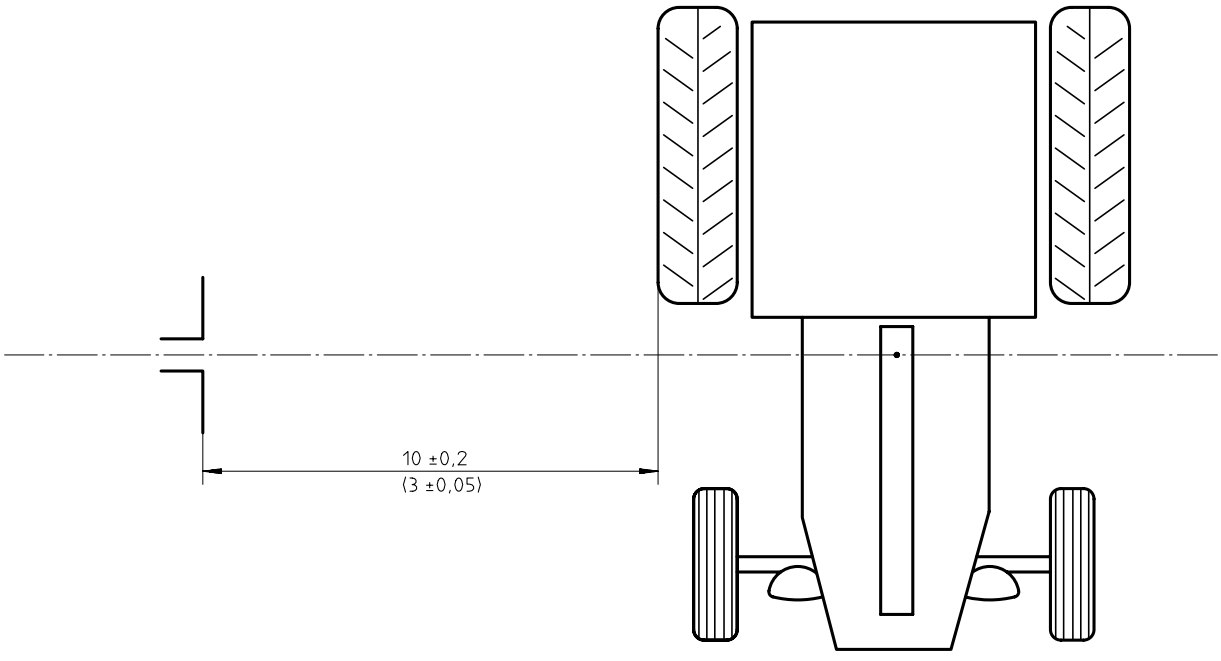
NOTE — The area shall be clear, level and free of electromagnetic reflecting surfaces (see CISPR 12)

Figure B.1 — Machine test area

Dimensions in metres



a) Dipole antenna position to measure vertical component of radiation



b) Dipole antenna position to measure horizontal component of radiation

Figure B.2 — Position of antenna relative to machine

Annex C
(normative)

Method of measurement of radiated narrowband electromagnetic emissions from machines

C.1 General

C.1.1 Application

The test method described in this annex shall only be applied to machines.

C.1.2 Measuring equipment

The measuring equipment shall comply with the requirements of CISPR 16-1.

A peak detector shall be used for the measurement of narrowband electromagnetic emissions.

C.1.3 Test method

This test is intended to measure the narrowband emissions such as might emanate from a microprocessing-based system or other narrowband sources. Two alternative antenna distances are permissible, 10 m or 3 m from the machine. In either case the requirements of C.2 shall be complied with.

C.1.4 Results

The results of measurement shall be expressed in dB(μV/m) (μV/m).

C.2 Measuring location

C.2.1 Test site

The test site shall be a clear level area free of electromagnetic reflecting surfaces within a circle of minimum radius 30 m measured from a point midway between the machine and the antenna (see figure B.1).

C.2.2 Measuring facility

The test hut or vehicle in which the measurement set is located may be within the test site, but only in the permitted region shown in figure B.1. Other measuring antennas are allowed within the test area, at a minimum distance of 10 m both from receiving antenna and the machine under test, provided that it can be shown that the test results will not be affected.

C.2.3 Enclosed test facilities

Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of figure B.1 other than the distance from the antenna to this machine and the height of the antenna, nor do they need to have ambient emissions checked before or after the test as indicated in C.2.4.

C.2.4 Ambient measurements

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect materially the measurement, measurements shall be taken before and after the main test. If the machine is present when ambient measurements

are taken, steps shall be taken to ensure that any emission from the machine do not affect significantly the ambient measurements, for example by removing the machine from the test area, removing the ignition key, or disconnecting the battery. For both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 6.1.2 (except for intentional narrowband ambient transmissions).

C.3 Machine state during test

The machine's electronic system(s) which may generate narrowband emissions shall be operating during the measurement. If necessary, systems which may generate broadband emissions shall be cut off.

The ignition shall be switched on. The engine shall not be operating.

Measurements shall not be made while rain or other precipitation is falling on the machine or within ten minutes after precipitation has stopped.

C.4 Antenna

C.4.1 Antenna type

Any antenna may be used provided it can be normalised to the reference antenna. The method described in annex A of CISPR 12:1990 may be used to calibrate the antenna.

C.4.2 Antenna position

C.4.2.1 General

No part of any antenna's receiving elements shall be closer than 0,25 m to the plane on which the machine rests.

If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving elements shall be no closer than 1 m to any radio absorbent material and no closer than 1,5 m to the wall of the enclosed facility. There shall be no absorbent material between the receiving antenna and machine under test.

C.4.2.2 Test with 10 metres antenna distance

The phase centre of the antenna shall be 3 m ± 0,05 m above the plane on which the machine rests.

The horizontal distance from the tip or other appropriate point of the antenna defined during the measurement procedure mentioned in C.4.1 to the outer body surface of the machine shall be 10 m ± 0,2 m.

C.4.2.3 Test with three metres antenna distance

The phase centre of the antenna shall be 1,8 m ± 0,05 m above the plane on which the machine rests.

The horizontal distance from the tip or other appropriate point of the antenna defined during the measurement procedure mentioned in C.4.1 to the outer body surface of the machine shall be 3 m ± 0,05 m.

C.4.3 Antenna orientation

The antenna shall be located successively on the left- and right-hand sides of the machine, with the antenna parallel to the plane of longitudinal symmetry of the machine and in line with the engine mid-point or the machine mid-point for machines without engine (see figure B.2).

At each of the measuring points, readings shall be taken both with the antenna in a horizontal and in a vertical polarisation (see figure B.2).

C.5 Readings

The maximum of the four readings taken in accordance with C.4.3 shall be taken as the characteristic reading at the frequency at which the measurements were made.

C.6 Frequencies

Measurements shall be made over the whole frequency range from 30 MHz to 1 000 MHz. The minimum scan time shall comply with the requirements of CISPR 12.

In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the machine and not to background radiation.

Annex D
(normative)

Method of measurement of radiated broadband electromagnetic emissions from electrical/electronic sub-assemblies

D.1 General

D.1.1 Application

The test method described in this annex shall only be applied to ESA's.

D.1.2 Measuring equipment

The measuring equipment shall comply with the requirements of CISPR 16-1.

A quasi-peak-detector shall be used for the measurement of broadband electromagnetic emissions, or if a peak-detector is used an appropriate correction factor shall be used (see clause D.6 and CISPR 12).

D.1.3 Test method

This test is intended to measure the broadband electromagnetic emissions from ESA's.

D.1.4 Results

The results of measurement shall be expressed in dB(μV/m) (μV/m) for 120 kHz bandwidth. If the actual bandwidth B (expressed in kilohertz) of the measuring apparatus differs from 120 kHz, the readings shall be converted to 120 kHz bandwidth through multiplication by a factor 120/B.

NOTE — This factor depends on the spectral distribution of the disturbance signal. For spark-like disturbance voltages the factor is as described. For harmonic disturbance signals the factor is $\sqrt{120 / B}$.

D.2 Measuring location

D.2.1 Test site

The test site shall comply with the requirements of the CISPR 16-1 (see figure D.1).

D.2.2 Measuring facility

The test hut or vehicle in which the measurement set is located shall be outside the boundary shown in figure D.1.

D.2.3 Enclosed test facilities

Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of figure D.1 other than the distance from the antenna to ESA under test and the height of the antenna (see figures D.2 and D.3).

D.2.4 Ambient measurements

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect the measurement, measurements shall be taken before and after the main test. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 6.4.2 (except for intentional narrowband ambient transmissions).

D.3 ESA state during test

D.3.1 General

The ESA under test shall be in normal operation mode.

Measurements shall not be made while rain or other precipitation is falling on the ESA or within ten minutes after precipitation has stopped.

D.3.2 ESA set-up

The ESA under test and its wiring harnesses shall be supported 50 mm ± 5 mm above the metallic ground plane by a wooden or equivalent non-conducting table. However, if any part of the ESA under test is intended to be electrically bonded to the machine's metal bodywork, that part shall be placed on a ground plane and shall be electrically bonded to the ground plane.

The ground plane shall be a metallic sheet with a minimum thickness of 0,5 mm. The minimum size of the ground plane depends on the size of the ESA under test but shall allow for the distribution of the ESA's wiring harness and components. The ground plane shall be connected to the protective conductor of the earthing system. The ground plane shall be situated at a height of 1 m ± 0,1 m above the test facility floor and shall be parallel to it.

The ESA under test shall be arranged and connected according to its requirements. The power supply harness shall be positioned along and within 100 mm ± 10 mm of the edge of the ground plane/table closest to the antenna.

The ESA under test shall be connected to the grounding system according to the manufacturer's installation specification, no additional grounding connections shall be permitted.

The minimum distance between the ESA under test and all other conductive structures, such as walls of a shielded area (with the exception of the ground plane/table underneath the test object) shall be 1 m.

D.3.3 Power to ESA

Power shall be applied to the ESA under test via a 5 µH/50 Ω Artificial Network (AN) which shall be electrically bonded to the ground plane. The electrical supply voltage shall be maintained to ±10 % of its nominal system operating voltage. Any ripple voltage shall be less than 1,5 % of the nominal system operating voltage measured at the AN monitoring port.

D.3.4 Multiple ESA's

If the ESA under test consists of more than one unit, the interconnecting cables should ideally be the wiring harness as intended for use in the machine. If these are not available, the minimum length between the electronic control unit and the AN shall be 1,5 m. All cables in the loom should be terminated as realistically as possible and preferably with real loads and actuators. If extraneous equipment is required for the correct operation of the ESA under test, compensation shall be made for the contribution it makes to the emissions measured.

D.4 Antenna

D.4.1 Antenna type

Any linearly polarised antenna may be used provided it can be normalised to the reference antenna.

D.4.2 Antenna position

The phase centre of the antenna shall be 150 mm ± 10 mm above the ground plane.

The horizontal distance from the phase centre or tip of the antenna as appropriate, to the edge of the ground plane shall be 1 m ± 0,05 m. No part of the antenna shall be closer than 0,5 m to the ground plane.

The antenna shall be placed parallel to a plane which is perpendicular to the ground plane and coincident with the edge of the ground plane along which the principal portion of the harness runs.

If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving elements shall be no closer than 0,5 m to any radio absorbent material and no closer than 1,5 m to the wall of the enclosed facility. There shall be no absorbent material between the receiving antenna and the ESA under test.

D.4.3 Antenna orientation

At each of the measuring points, readings shall be taken both with the antenna in a horizontal and in a vertical polarisation.

D.5 Readings

The maximum of the two readings taken in accordance with D.4.3 shall be taken as the characteristic reading at the frequency at which the measurements were made.

D.6 Frequencies

Measurements shall be made over the whole frequency range from 30 MHz to 1 000 MHz. The minimum scan time shall comply with the requirements of CISPR 12.

In the event that the limit is exceeded during the test, investigations shall be made to ensure that this is due to the ESA and not to background radiation.

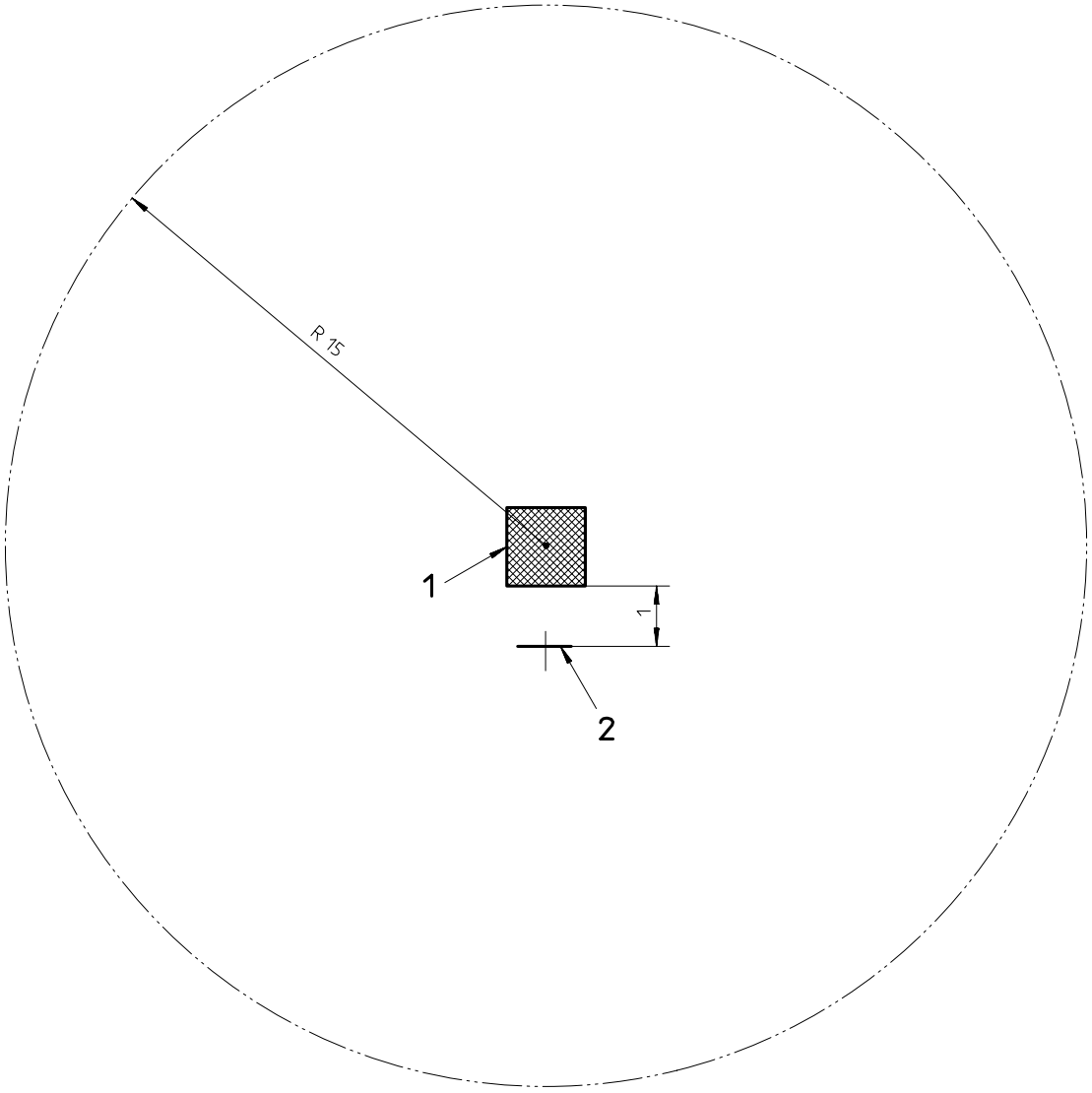
Measurements can be performed with either quasi-peak or peak detectors. The limits given in 6.4.2 are for quasi-peak. If a peak-detector is used, add 38 dB for 1 MHz bandwidth or subtract 22 dB for 1 kHz bandwidth, that is,

— limit (peak, 1 MHz) = limit (quasi-peak, 120 kHz) + 38 dB;

— limit (peak, 1 kHz) = limit (quasi-peak, 120 kHz) – 22 dB.

NOTE — In accordance with CISPR 12, the correlation factor between quasi-peak and peak measurements is + 20 dB at 120 kHz bandwidth, and has been included in the above equations.

Dimensions in metres



Key

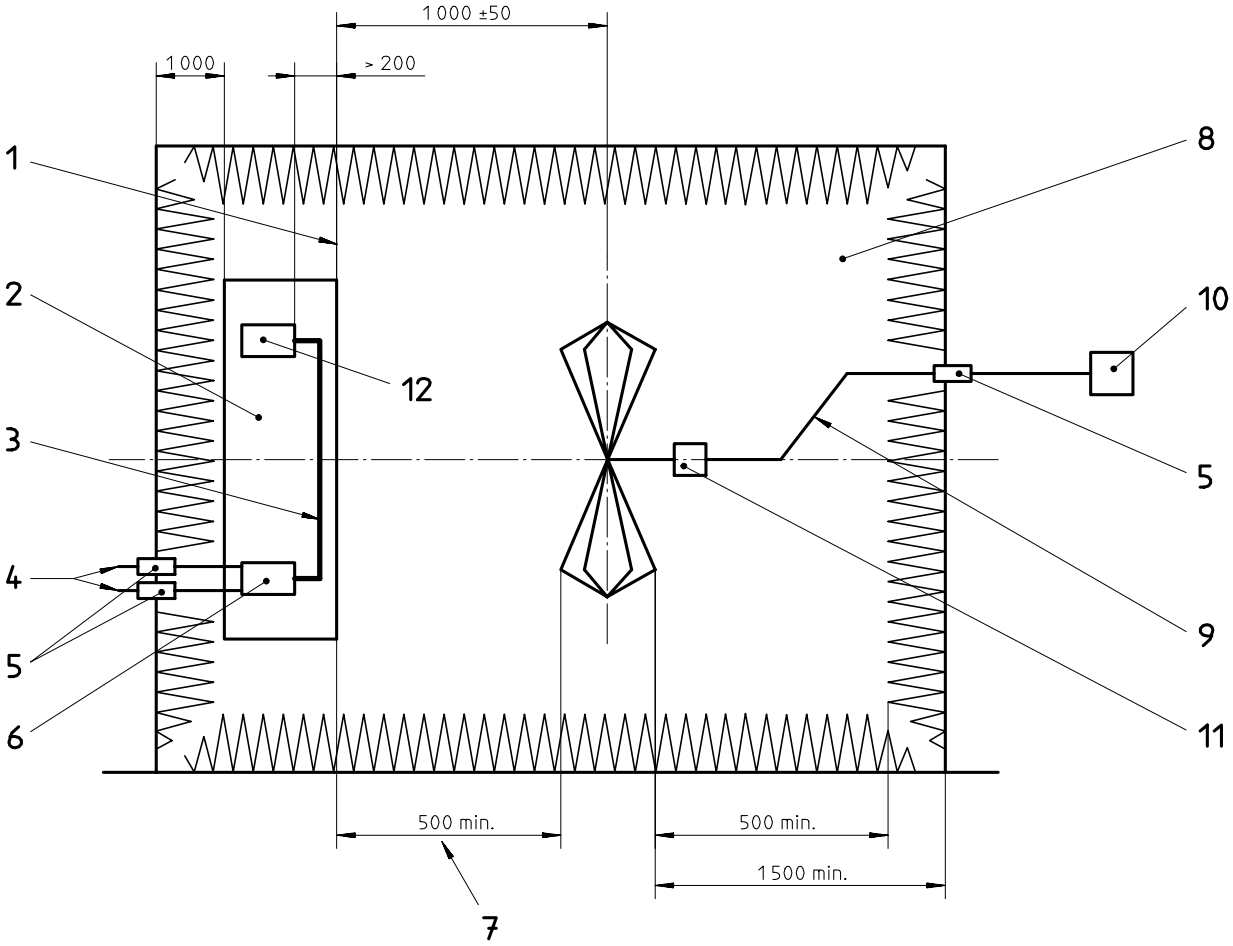
1 Test sample on ground plane

2 Antenna

NOTE — The area shall be clear, level and free of electromagnetic reflecting surfaces (see CISPR 16-1).

Figure D.1 — ESA test area boundary

Dimensions in millimetres



Key

1 To axis of antenna or closest element of log. periodic array: 1 000 mm ± 50 mm

2 Test bench with ground plane bonded to wall

3 Test harness 1 500 mm ± 75 mm long and 50 mm ± 5 mm above ground plane

4 Power supply to subject under test

5 Feedthrough

6 Connecting box including AN

7 Closest radiating elements 500 mm minimum from the edge ground plane

8 Shielded enclosure

9 Double shielded coaxial cable

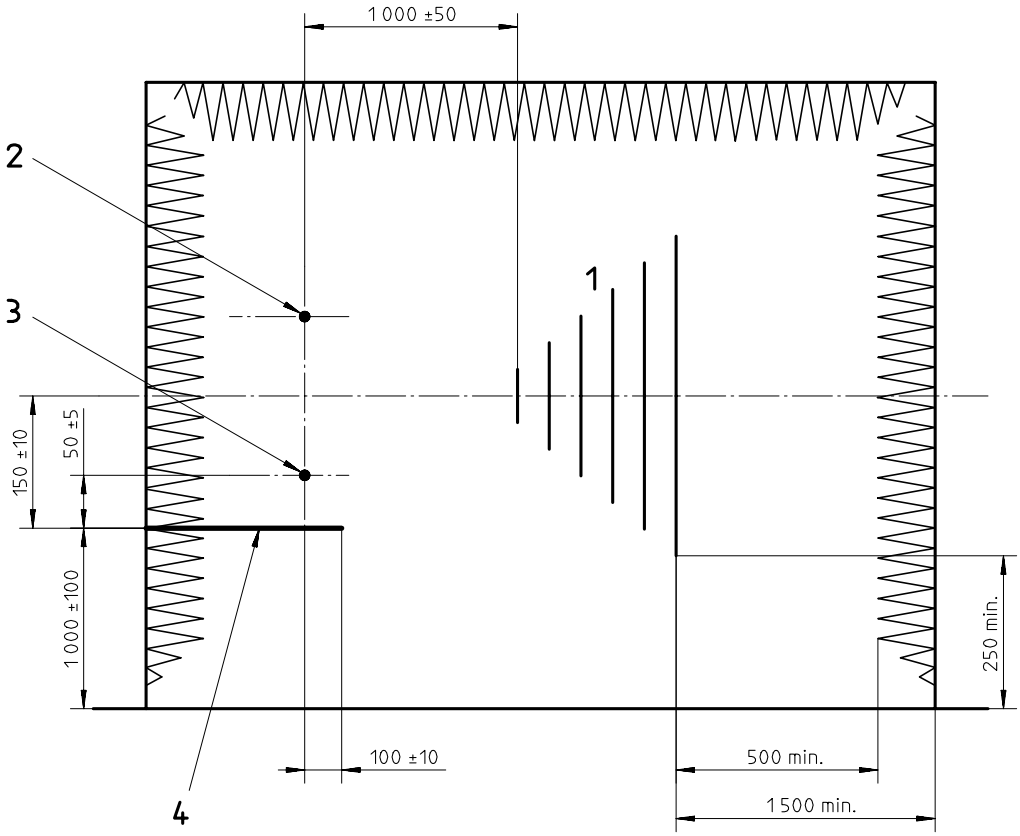
10 Measuring receiver

11 Antenna matching unit (where necessary) in close proximity to antenna

12 ESA

Figure D.2 — Coupled broadband electromagnetic emissions from ESA's — Test layout (general plan view)

Dimensions in millimetres



Key

1 Antenna
2 Plane in which lie the reference point and the main portion of the harness
3 Reference point
4 Base plate

Figure D.3 — Coupled broadband electromagnetic emissions from ESA's —View of test bench plane of longitudinal symmetry

Annex E
(normative)

Method of measurement of radiated narrowband electromagnetic emissions from electrical/electronic sub-assemblies

E.1 General

E.1.1 Application

The test method described in this annex shall only be applied to ESA's.

E.1.2 Measuring equipment

The measuring equipment shall comply with the requirements of CISPR 16-1.

A peak detector shall be used for the measurement of narrowband electromagnetic emissions.

E.1.3 Test method

This test is intended to measure the narrowband electromagnetic radiation that can emanate from a microprocessor-based system.

E.1.4 Results

The results of measurement shall be expressed in dB(μV/m) (μV/m).

E.2 Measuring location

E.2.1 Test site

The test site shall comply with the requirements of the CISPR 16-1 (see figure D.1).

E.2.2 Measuring facility

The test hut or vehicle in which the measurement set is located shall be outside the boundary shown in figure D.1.

E.2.3 Enclosed test facilities

Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of figure D.1 other than the distance from the antenna to ESA under test and the height of the antenna (see figures D.2 and D.3).

E.2.4 Ambient measurements

To ensure that there is no extraneous noise or signal of a magnitude sufficient to affect the measurement, measurements shall be taken before and after the main test. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 6.5.2 (except for intentional narrowband ambient transmissions).

E.3 ESA state during test

E.3.1 General

The ESA under test shall be in normal operation mode.

Measurements shall not be made while rain or other precipitation is falling on the ESA or within ten minutes after precipitation has stopped.

E.3.2 ESA set-up

The ESA under test and its wiring harnesses shall be supported 50 mm ± 5 mm above the metallic ground plane by a wooden or equivalent non-conducting table. However, if any part of the ESA under test is intended to be electrically bonded to the machine's metal bodywork, that part shall be placed on a ground plane and shall be electrically bonded to the ground plane.

The ground plane shall be a metallic sheet with a minimum thickness of 0,5 mm. The minimum size of the ground plane depends on the size of the ESA under test but shall allow for the distribution of the ESA's wiring harness and components. The ground plane shall be connected to the protective conductor of the earthing system. The ground plane shall be situated at a height of 1 m ± 0,1 m above the test facility floor and shall be parallel to it.

The ESA under test shall be arranged and connected according to its requirements. The power supply harness shall be positioned along, and within 100 mm ± 10 mm of, the edge of the ground plane/table closest to the antenna.

The ESA under test shall be connected to the grounding system according to the manufacturer's installation specification, no additional grounding connections shall be permitted.

The minimum distance between the ESA under test and all other conductive structures, such as walls of a shielded area (with the exception of the ground plane/table underneath the test object) shall be 1 m.

E.3.3 Power to ESA

Power shall be applied to the ESA under test via a 5 μH/50 Ω Artificial Network (AN) which shall be electrically bonded to the ground plane. The electrical supply voltage shall be maintained to ±10 % of its nominal system operating voltage. Any ripple voltage shall be less than 1,5 % of the nominal system operating voltage measured at the AN monitoring port.

E.3.4 Multiple ESA's

If the ESA under test consists of more than one unit, the interconnecting cables should ideally be the wiring harness as intended for use in the machine. If these are not available, the minimum length between the electronic control unit and the AN shall be 1,5 m. All cables in the loom should be terminated as realistically as possible and preferably with real loads and actuators. If extraneous equipment is required for the correct operation of the ESA under test, compensation shall be made for the contribution it makes to the emissions measured.

E.4 Antenna

E.4.1 Antenna type

Any linearly polarised antenna may be used provided it can be normalised to the reference antenna.

E.4.2 Antenna position

The phase centre of the antenna shall be 150 mm ± 10 mm above the ground plane.

The horizontal distance from the phase centre or tip of the antenna as appropriate, to the edge of the ground plane shall be 1 m ± 0,05 m. No part of the antenna shall be closer than 0,5 m to the ground plane.

The antenna shall be placed parallel to a plane which is perpendicular to the ground plane and coincident with the edge of the ground plane along which the principal portion of the harness runs.

If the test is carried out in a facility enclosed for radio frequency electromagnetic screening purposes, the antenna's receiving elements shall be no closer than 0,5 m to any radio absorbent material and no closer than 1,5 m to the wall of the enclosed facility. There shall be no absorbent material between the receiving antenna and the ESA under test.

E.4.3 Antenna orientation

At each of the measuring points, readings shall be taken both with the antenna in a horizontal and in a vertical polarisation.

E.5 Readings

The maximum of the two readings taken in accordance with E.4.3 shall be taken as the characteristic reading at the frequency at which the measurements were made.

E.6 Frequencies

Measurements shall be made over the whole frequency range from 30 MHz to 1000 MHz. The minimum scan time shall comply with the requirements of CISPR 12.

Annex F
(informative)

Guide for "worst case" selection

F.1 General

The following paragraphs outline one possible method of selection electronic sub-assemblies (ESA's) and machines for EMC assessment in accordance with the directive 89/336/EEC.

There is little material available which can advise on the most cost effective method for "worst case" selection, and unlike spark-ignition broadband interference from spark-ignition road vehicles, there is no twenty-year experience of type approval to reference. A matrix approach should be considered so that a minimum number of machines or ESA's are submitted for test whilst covering all specifications of the machine type and also electromagnetic phenomena. A variant will include a dual source of supply of an electronic control unit (ECU) or ESA.

The Directive 95/54/EC was originally intended for spark-ignition road vehicles only but has been modified to include diesel engine vehicles. Vehicle types covered by 95/54/EC are defined in 70/156/EEC and are designated the codes M, N, and O. All other vehicles will be required to comply with 89/336/EEC (for example mobile machinery).

It is suggested that the minimum number of machine specifications requiring type approval tests is based on body style and electronic control modules. The manufacturer may be able to demonstrate that similar electronic control systems fitted to different machine specifications are identical with respect to EMC design and performance.

Variations in the machine's wiring harness may be covered by selecting a maximum and a minimum wiring configuration. If it is practice to use only one or as few wiring harness variants as possible, then some branches of the harness may be left unterminated in production. This could be considered as a "worst case" since the unterminated wires may act as receptors for incident radiated electromagnetic disturbances.

F.2 Justification

F.2.1 General

Suggested possible justifications for not carrying out specific EMC tests on sub-systems fitted to machines and equipments are given in F.2.2 to F.2.4. If a machine or equipment is tested as a total system then the EMC performance of all systems fitted shall be assessed. For example, if an air-conditioning unit is not switched on during a machine broadband emissions test then the air-conditioning unit will require a separate ESA test and approval.

Assessment of the specifications of ESA's for EMC validation may make use of a simple tabulated list. A matrix may then be developed, based on body style, that covers all the variants and options identified which will aid the selection of the specifications to be tested.

Justification number	Justification
F.2.2 Narrowband emissions	
1	No oscillator greater then 9 kHz (examples of oscillators that may be greater than 9 kHz are microprocessor clocks, an pulse width modulated signals).
2	The system is already approved to a standard published in the official journal of the EC that also satisfies the requirements of 95/54/EC.
F.2.3 Broadband emissions	
3	No broadband source of EM emissions (examples of sources of broadband noise are wiper motors and spark gaps).
4	Not continuously operated.
F.2.4 Immunity	
5	Degradation in system performance does not affect: a) the driver's direct control of the machine; b) engine speed control; c) steering; d) braking; e) movement of parts of the machine; f) any function which may generate hazards; g) mislead others.
6	The system does not include an active semi-conductor device (examples of active semiconductor devices are transistors and microprocessors).
7	Power to the device is switched directly or via relay contacts.
8	Degradation of system performance is not perceptible to the driver/operator. The manufacturer shall identify or demonstrate a mechanical limit such as the maximum rate of change, a mechanical fail safe mode, etc.

F.3 Requirements

The "worst case" study shall identify

— the specification(s) of machines, equipments or ESA's of a given type that require testing;

— the mode of operation during test ("normal mode of operation");

— how the systems performance will be monitored;

— pass/fail criteria.

Detailed electrical wiring diagrams will be required before the "worst case" review to help in the selection of a representative system.

Table F.1 — Example of an ESA specification assessment

Section	ESA	Narrowband emissions	Immunity	Broadband emissions	Justification number[1)]
Powertrain	Diesel fuel injection	A	A	NA	3
	Engine management	A	A	NA	3
	Alternator	NA	NA	A	1, 5
	Spark-ignition	NA	NA	A	1, 6
	Cooling fan	NA	NA	A	1, 6
	Electrical fuel pump	NA	NA	A	1, 6
Transmission	Automatic gearbox	A	A	NA	3
	Clutch control	A	A	NA	3
	Speed limiter	A	A	NA	3
Suspension	Active suspension	A	A	NA	3
Steering	Power steering	A	A	NA	3
	4WS	A	A	NA	3
Braking	Anti-locking brakes	A	A	NA	4 (+)
	Traction control	A	A	NA	4 (+)
Body Electrical	Wiper control	NA	NA	A	1, 7
	Speedometer and rev. counter	A	NA	NA	3, 5
	Clock	A	NA	NA	3, 5
	Instrument display pack	A	NA(*)	NA	3, 5
	Audio equipment	NA	NA	NA	2, 3, 5
Lighting	Turn indicator	NA	A	NA	1, 3, 4
	beacon	NA	NA	A	1, 5
Other	RF communications	NA	NA	NA	2, 3, 5
	Navigation system	A	A	NA	3

Key
A: Applicable
NA: Not applicable
(*): Depending on functions displayed
(+): Function does not operate continuously

1) See F.2.2 to F.2.4.

Annex G
(informative)

Specimen test report for electromagnetic compatibility

Description of the machine or ESA

Machine/ESA manufacturer's name and address .....

.....

.....

Machine/ESA type and function .....

.....

.....

Equivalent machines/ESA's covered by this test .....

.....

.....

EMC test

	Data and location of test	Standard(s) used	Results	Comments
Broadband emission				
Narrowband emission				
Immunity				
ESD				
Conducted transients				

Annex H
(informative)

Bibliography

H.1 European Directives

72/245/EEC (1972), *Council Directive of 20 June 1972 on the approximation of the laws of the member states relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles*.

95/54/EC (1995), *Commission Directive 95/54/EC of 31 October 1995 adapting to technical progress Council Directive 72/245/EEC on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type approval of motor vehicles and their trailers.*

75/322/EEC (1975), *Council Directive of 20 May 1975 on the approximation of the laws of the member states relating to the suppression of radio interference produced by spark-ignition engines fitted to wheeled agricultural or forestry tractors*.

89/336/EEC (1989), *Council Directive of 3 May 1989 on the approximation of the laws of the member states relating to electromagnetic compatibility*.

89/392/EEC (1989), *Council Directive of 14 June 1989 on the approximation of the laws of the member states relating to machines*.

H.2 International and European Standards

ISO 13766:—[2], *Earth-moving-machinery — Electromagnetic compatibility*. [3]

EN 50081-1:1992, *Electromagnetic compatibility — Generic emission standard — Part 1: Residential, commercial and light industry.*

EN 50081-2:1993, *Electromagnetic compatibility — Generic emission standard — Part 2: Industrial environment.*

EN 50082-1:1992, *Electromagnetic compatibility — Generic immunity standard — Part 1: Residential, commercial and light industry.*

EN 50082-2:1995, *Electromagnetic compatibility — Generic immunity standard — Part 2: Industrial environment.*

ISO 11783-2:—[2], *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 2: Physical layer.*

H.3 Other publications

Guidelines on the application of Council Directive 89/336/EEC. Brussels, October 1993.

CENELEC Report R 110-001 (03/93), *Guide on EMC standardisation for product committees*.

CENELEC Report R 110-002 (03/93), *Guide to generic standards*.

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[2] To be published.

[3] ISO 13766 and ISO 14982 are to be harmonized at a later date.

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Descriptors: agricultural machinery, forest equipment, electronic equipment, electromagnetic disturbances, tests, electrical tests, determination, electromagnetic compatibility, acceptance.

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