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Construction machinery — Electromagnetic compatibility of machines with internal power supply

National foreword

This British Standard is the UK implementation of EN 13309:2010. It supersedes BS EN 13309:2000 which is withdrawn.

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

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Machines de génie civil - Compatibilité électromagnétique des machines équipées de réseau électrique de distribution interne

Baumaschinen - Elektromagnetische Verträglichkeit von Maschinen mit internem elektrischen Bordnetz

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Foreword

This document (EN 13309:2010) has been prepared by Technical Committee CEN/TC 151 “Construction equipment and building material machines - Safety”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2011, and conflicting national standards shall be withdrawn at the latest by January 2011.

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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 EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This document supersedes EN 13309:2000.

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, Croatia, 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.

Introduction

With the use of more electronic devices in areas where construction machinery operates, there is a need to ensure that construction machinery is provided with adequate immunity to external electromagnetic fields. As more construction machinery is fitted with electrical and electronic devices, it is necessary to ensure that the emissions of electromagnetic fields from the construction machinery meet acceptable limits.

Electrical and high frequency disturbances emerge during the normal operation of many parts of the construction machinery devices and systems. They are generated within a large frequency range with different electrical characteristics and, by conduction and/or radiation, can be imparted to other electrical/electronic devices and systems of the construction machinery. Narrowband signals generated by sources of interference inside or outside the construction machinery can also be coupled in electrical/electronic systems whereby they can influence the normal function of electrical/electronic devices.

Electrostatic discharges are relevant to construction machinery because control elements can be positioned outside the operator's station and potential differences can emerge at contact points. Conducted transients in power supply wiring have to be taken into account because construction machinery often represents open systems and several devices and/or components of construction equipment are combined with one another.

While there are many existing standards for a variety of products and systems, the test method presented in this European Standard provides for the specific test conditions of construction machinery and the "electrical/electronic sub-assemblies or separate technical units" of construction machinery. The test method recognises that because of the size and usage of construction machinery, the arrangement of the construction machinery in the test facility needs to be responsive to the operating characteristics of these types of construction machinery. This European Standard provides test methods and criteria which are acceptable for construction machinery considering the unique characteristics and operating parameters of construction machinery.

Because construction machinery has a number of systems that consist of components that may be used on a number of different construction machinery the approach of defining "electrical/electronic sub-assemblies or separate technical units" for these components is applied for the immunity and emissions test methods. This allows these components to be evaluated by the test method in existing laboratory facilities consisting of specially equipped shielded rooms. When electrical/electronic sub-assembly tests are conducted, it is necessary to consider the effects of the wiring systems used to connect the sub-assemblies into the construction machinery. The tests can also be conducted on the construction machinery.

1 Scope

This European Standard provides test methods and acceptance criteria for the evaluation of the electromagnetic compatibility of construction machinery with respect to free trade of goods in the European Union. It deals with functional EMC requirements under typical EMC environmental conditions.

This European Standard does not deal with safety requirements.

Electrical and/or electronic component(s) or separate technical unit(s) intended to be fitted in construction machinery are also dealt with in this European Standard. The following electromagnetic disturbance phenomena are evaluated:

— broadband and narrowband electromagnetic interference;

— electromagnetic field immunity test;

— broadband and narrowband interference of electrical/electronic sub-assemblies;

— electromagnetic field immunity test of electrical/electronic sub-assemblies;

— electrostatic discharge;

— conducted transients.

Construction machinery can have DC and/or AC internal electrical power supply systems.

Machines that are designed to be supplied by the "Public Mains Network" are specifically excluded.

2 Normative references

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

EN 55016-1-1:2007, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 1-1: Radio disturbance and immunity measuring apparatus — Measuring apparatus (CISPR 16-1-1:2006)*

EN 55025:2008, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of on-board receivers (CISPR 25:2008)*

EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

ISO 7637-1:2002, *Road vehicles — Electrical disturbances from conduction and coupling — Part 1: Definitions and general considerations*

ISO 7637-2:2004, *Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only*

ISO 10605:2008, *Road vehicles — Test methods for electrical disturbances from electrostatic discharge*

ISO 11451-1:2005, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology* (including ISO 11451-1:2005/Amd 1:2008)

ISO 11451-2:2005, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Off-vehicle radiation sources*

ISO 11452-1:2005, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology* (including ISO 11452-1:2005/Amd 1:2008)

ISO 11452-2:2004, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Absorber-lined shielded enclosure*

ISO 11452-3:2001, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 3: Transverse electromagnetic mode (TEM) cell*

ISO 11452-4:2005, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Bulk current injection (BCI)* (including ISO 11452-4:2005/Cor 1:2009)

ISO 11452-5:2002, *Road vehicles — Component test methods for electrical disturbances by narrowband radiated electromagnetic energy — Part 5: Stripline*

CISPR 12:2007+Amd1:2009, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of off-board receivers*

CISPR 16-1-4:2007+Amd1:2008, S*pecification for radio disturbance and immunity measuring apparatus and methods — Part 1-4: Radio disturbance and immunity measuring apparatus — Ancillary equipment — Radiated disturbances*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 and the following apply.

3.1
internal electrical power supply
is to be understood which is absolutely independent from outside sources (mains supply) and the connection to mains is not intended during operation

3.2
electromagnetic compatibility
EMC
ability of construction machinery or component(s) or separate technical unit(s) to function satisfactorily in its electromagnetic environment, without introducing intolerable electromagnetic disturbances to anything in that environment

NOTE See IEC 60050-161:1990 with amendments 1997 and 1998.

3.3
electromagnetic disturbance
electromagnetic phenomenon which may degrade the performance of construction machinery or component(s) or separate technical unit(s)

NOTE An electromagnetic disturbance can be electromagnetic noise, an unwanted signal or a change in the propagation medium itself (see IEC 60050-161:1990).

3.4
electromagnetic immunity
ability of construction machinery or components(s) or separate technical unit(s) to perform in the presence of specific electromagnetic disturbances without degradation of performance

NOTE See IEC 60050-161:1990.

3.5
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

NOTE See IEC 60050-161:1990.

3.6
reference limit
limit value with which the production has to conform

3.7
reference antenna
<frequency range of 30 MHz to 80 MHz> shortened balanced dipole which is a half-wave resonant dipole at 80 MHz

<frequency range above 80 MHz> balanced half wave resonant dipole tuned to the measurement frequency

NOTE See CISPR 16-1-4:2007+Amd1:2008.

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

NOTE See IEC 60050-161:1990.

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

NOTE See IEC 60050-161:1990.

3.10
out-of-band emission
emission on a frequency or frequencies immediately outside the necessary bandwidth of radio frequency equipment which results from the modulation process, but excluding spurious emissions

[Article 1, No 1144 of the radio regulations]

3.11
necessary bandwidth
for a given class of emission of radio-frequency-equipment, width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

NOTE See Article 1, No 1152 of the ITU radio regulations.

3.12
spurious emission
emission on a frequency or frequencies which are outside the necessary RF-bandwidth and the level of which may be reduced without affecting the corresponding transmission of information

NOTE 1 In every modulation process of radio-frequency-equipment additional undesired signals exist. They are summarised under the expression "spurious emissions".

NOTE 2 Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions (see Article 1 No 1145 of the ITU radio regulations).

3.13
electrical/electronic system
electrical and/or electronic component(s) or set of components intended to be part of construction machinery, together with any electrical connections

3.14
electrical/electronic sub-assembly
ESA
electrical and/or electronic component(s) or set of components intended to be part of construction machinery, together with any associated electrical connections and wiring, which performs one or more specialised functions

3.15
electrostatic discharge
ESD
transfer of electrostatic charge between bodies of different electrostatic potential in proximity or through direct contact

NOTE See IEC 60050-161:1990.

3.16
conducted transients
transient voltage or current distributed in the power supply wiring of construction machinery or component or separate technical unit via conductor between the source of the transient and the drain

3.17
construction machinery type
construction machinery which does 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 construction machinery consists (for example steel, aluminium or fibreglass covering parts)

3.18
ESA type
ESAs 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

3.19
operator's control
is exercised by means of, for example, steering, braking, or propulsion control. This also concerns movements of parts of the machine and modifications of the state of function, which may generate uncommanded, random or unresponsive machine operation (i.e. hazardous machine behaviour)

4 Requirements

4.1 General requirements

4.1.1 Fulfilment of the requirements

The requirements of this European Standard are met by construction machinery, and the electrical/electronic sub-assemblies when the requirements in 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9, as applicable, are fulfilled. The user of this European Standard may choose either the clauses pertaining to the complete construction machinery, or those clauses pertaining to the electrical/electronic sub-assemblies. When the clauses pertaining to the electrical/electronic sub-assemblies are chosen, to fulfil the requirements of this European Standard, the electrical/electronic sub-assemblies shall be installed on the construction machinery in conformity with relevant provisions which have been considered in determining that the electrical/electronic sub-assemblies meet the requirements of the appropriate clauses of this European Standard.

The requirements of this European Standard are also deemed to be fulfilled when the construction machinery has no such equipment for which an immunity or interference test is required. In this case no tests are necessary (see Clause 5).

4.1.2 Test specimen

The test specimen may be chosen in accordance with the definitions given in 3.17 and/or 3.18.

Because the test of a single test specimen is to be used to judge the performance of a population of like construction machinery, the reference limits for emissions and immunity shall be made more restrictive by a 20 % reduction for emissions limits and a 25 % increase for immunity limits so as to account for variability of emission and immunity due to manufacturing variations of construction machinery, or ESA types and testing factors.

For a subsequent test on a like test specimen, conformity to the reference limits shall be accepted as fulfilment of the requirements of this European Standard.

For electrostatic discharge and conducted transients, the reference limits are valid for all testing of the test specimen.

4.1.3 Additional requirements for immunity tests

When a test specimen is subjected to the immunity requirements, operator controls, and any automatic controls for the construction machinery and any attachments or machinery shall remain functional so as to provide continued control of the construction machinery. This also applies to secondary or shut-down systems which are intended to be operated when the primary control has failed.

4.2 Specifications concerning broadband electromagnetic emission radiated from construction machinery

4.2.1 Method of measurement

The electromagnetic radiation shall be measured using the method described in Annex B at either of the defined antenna distances. The choice shall be made by the user of the standard.

4.2.2 Broadband reference limits

If measurements are made using the method described in Annex B using a construction machinery-to-antenna spacing of (10,0 ± 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 increasing 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 construction machinery-to-antenna spacing of (3,0 ± 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 increasing 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 a single test specimen, the measured values, expressed in dB (µV/m) or (µV/m) shall be at least 2,0 dB or (20 %) below the reference limits.

4.3 Specifications concerning narrowband electromagnetic emission radiated from construction machinery

4.3.1 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 shall be made by the user of the standard.

4.3.2 Narrowband reference limits

If measurements are made using the method described in Annex C using a construction machinery-to-antenna spacing of (10,0 ± 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 increasing 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 construction machinery-to-antenna spacing of (3,0 ± 0,05) m, the emission reference limits shall be 34 dB (µV/m) (50 µV/m) in the 30 MHz to 75 MHz frequency 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 increasing 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 a single test specimen, the measured values, expressed in dB (µV/m) or (µV/m), shall be at least 2,0 dB or (20 %) below the reference limits.

4.4 Specifications concerning the immunity of construction machinery to electromagnetic radiation

4.4.1 Test method

The immunity to electromagnetic radiation of the construction machinery shall be tested according to ISO 11451-1 and ISO 11451-2 with horizontal and vertical polarisation. The determination of the reference points and the operating modes 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 note which control method was used. The substitution method and the 80 % amplitude modulation (AM) with sinusoidal wave of 1 kHz is determined as a test method in the frequency band of 20 MHz to 800 MHz (see ISO 11451-1). Pulse Modulation (PM) with t_{on} 577 µs, period 4 600 µs is determined as test method in the frequency band of 800 MHz to 2 000 MHz (see ISO 11451-1).

NOTE 1 In the frequency range from 800 MHz to 1 000 MHz the amplitude modulation may alternatively be applied.

NOTE 2 Alternative test methods:

If construction machinery is longer than 12 m and/or wider than 3,00 m and/or higher than 4,00 m, the BCI method according to ISO 11451-4 can be used in the extended frequency range 20 MHz to 2 000 MHz with level limit 48 mA as defined in 4.7.2, if the technology permits.

NOTE 3 The manufacturer should consider the use of Onboard RF-transmitters even if the construction machinery is not equipped with RF-transmitters at the time of delivery e.g. by definition of frequency bands, power levels, antenna positions and installation provisions. For further information see ISO 11451-3.

4.4.2 Construction machinery immunity reference limits

Reference limit 24 V/m referring to the root mean square value of the unmodulated signal applies. The maximum value of the test signal with modulation shall comply with the maximum value of an unmodulated test signal. On the test specimen the immunity requirements are fulfilled by a field strength of 30 V/m (25 % above the reference limit). The general requirements for immunity testing according to 4.1.3 shall be fulfilled.

4.5 Specifications concerning broadband electromagnetic emissions radiated from ESAs

4.5.1 Method of measurement

The electromagnetic interference shall be measured by the method described in Annex D.

4.5.2 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 decreasing 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, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in Annex A (Figure A.5). In the 400 MHz to 1 000 MHz frequency band the limits remain constant at 65 dB (µV/m) (1 800 µV/m).

On a single test specimen, the measured values, expressed in dB (µV/m) or (µV/m) shall be at least 2,0 dB or (20 %) below the reference limits.

4.6 Specifications concerning narrowband electromagnetic emissions radiated from ESAs

4.6.1 Method of measurement

The electromagnetic interference shall be measured by the method described in Annex E.

4.6.2 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 decreasing 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, this limit increasing logarithmically (linearly) with frequencies above 75 MHz as shown in Annex A (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 a single test specimen, the measured values, expressed in dB (µV/m) or (µV/m) shall be at least 2,0 dB or (20 %) below the reference limits.

4.7 Specifications concerning the immunity of ESAs to electromagnetic radiation

4.7.1 Method of testing

For the testing of the immunity of ESA to electromagnetic fields the testing methods of ISO 11452-2, ISO 11452-3, ISO 11452-4 or ISO 11452-5 apply.

The substitution method and the 80 % amplitude modulation (AM) with sinusoidal wave of 1 kHz (see ISO 11452-1) is determined as a test method in the frequency band of 20 MHz to 800 MHz. Pulse Modulation (PM) with t_{on} 577 µs, period 4 600 µs is determined as test method in the frequency band of 800 MHz to 2 000 MHz (see ISO 11452-1).

NOTE In the frequency range from 800 MHz to 1 000 MHz the amplitude modulation may alternatively be applied.

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 ESAs, the substitution method or the closed loop method may be used for the field calibration. The test report shall note which control method was used.

4.7.2 ESA immunity reference limits

If tests are made according to ISO 11452-1, ISO 11452-2, ISO 11452-3, ISO 11452-4, ISO 11452-5, the immunity reference limits shall be:

— 48 V/m for the 150 mm stripline test 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 with vertical polarisation).

The reference limits shall 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.

Functional status class A (see 4.9.4, Table 3) shall apply to all tests. The reference limits, increased by 25 %, shall apply for the single test specimen. The ESA shall not exhibit any operational change which is unacceptable for its application on the construction machinery. See 4.1.3 for further definition of operational change which is unacceptable.

4.8 Electrostatic discharge (ESD)

4.8.1 Method of testing

The method described in ISO 10605 shall be used as the method of measurement of the construction machinery or on the component in such areas where an ESD in standard use is possible (e.g. by touching by the operator). Choose a generator capacitance of 330 pF for areas that can easily be accessed from the inside of the construction machinery and for ESAs and a generator capacitance of 150 pF for areas that can easily be touched only from the outside of the construction machinery. In every case the resistance is 2 kΩ. Packaging and handling tests according to ISO 10605 are not required in this European Standard.

4.8.2 Reference limits

The following test levels apply:

a) construction machinery:

1) ± 4,0 kV air discharge at functional status class A (see Table 3);

2) ± 8,0 kV air discharge at functional status class C (see Table 3);

b) ESA:

1) ± 4,0 kV contact and air discharge at functional status class A (see Table 3);

2) ± 6,0 kV contact discharge and ± 8,0 kV air discharge at functional status class C (see Table 3).

In every case uncommanded movement and creation of hazardous machine behaviour is not allowed.

4.9 Conducted transients

4.9.1 General

With remotely located ESA connected to the construction machinery through the wiring system, there is a possibility of a pulse generated in a remote ESA energizing the circuit and affecting other ESAs or components on the construction machinery. Therefore, minimum values concerning emission and susceptibility for ESAs fitted to construction machinery are required. It shall be considered that the emission value for an ESA shall be less than the susceptibility for all ESAs of the system.

4.9.2 Method of testing

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

4.9.3 Conducted emission − Reference limits

The maximum levels of emitted pulses shall have a minor level than the test levels for immunity test by the appropriate pulse forms.

4.9.4 Conducted immunity − Reference limits and functional status

The test levels at functional status class according Table 1 shall apply. The function performance status shall be specified before the testing of every different check pulse. Table 2 shows the field of application of the different check pulses in the 12 V and 24 V onboard systems.

For each ESA, as applicable, instructions should be added to describe the correct installation and connections to the construction machinery or its devices to avoid malfunction of the ESA and/or the construction machinery.

Table 1 — Check pulse in 12 V and 24 V onboard systems

Test pulse	Test Level		Functional status for systems	
	12 V onboard system V	24 V onboard system V	Related to immunity-related functions	Not related to immunity-related functions
1	– 75	– 450	C [a]	D
2a	+ 37	+ 37	B [a]	D
2b	+ 10	+ 20	C [a]	D
3a	– 112	– 150	A	D A for – 25 V/– 35 V
3b	+ 75	+ 150	A	D A for + 25 V/+ 35 V
4	– 6	– 12	B [a] for ESAs which shall be operational during engine start phases C [a] for other ESAs	D
5 [b]	+ 65	+ 123	C [a]	D

[a] Without uncommanded movement and without creating hazardous machine behaviour.

[b] If the ESA is designed for use only in machines with clamped generators, testing with the suppressed load dump 5 b according to 7637-2 is sufficient. In this case this has to be mentioned in the documentation for the customer. The value of the clamping voltage has to be agreed.

Table 2 — Application of test pulses

Test pulse	Application
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 machinery, it remains connected directly in parallel with an inductive load.
2a	This test pulse is a simulation of transients due to the sudden interruption of current in an inductor (e.g. the wiring harness) connected in series with a device under test.
2b	This test pulse is a simulation of transients due to the castor of a DC-motor when the ignition switch is opened and the motor is connected in parallel with a device under test.
3a, 3b	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.
4	This pulse simulates supply voltage reduction caused by energizing the starter-motor circuits of internal combustion engines (excluding spikes associated with starting).
5	This test pulse is a simulation of a 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.

Table 3 — Functional status

Functional status	Description
A	All functions of a device/system perform as designed during and after exposure to a disturbance.
B	All functions of a device/system perform as designed during exposure; however, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain criterion A.
C	One or more functions of a device/system do not perform as designed during exposure but returns automatically to normal operation after exposure is removed.
D	One or more functions of a device/system do not perform as designed during exposure and does not return to normal operation until exposure is removed and the device/system is reset by simple "operator/use" action.
E	One or more functions of a device/system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

5 Exceptions

For the requirements described in Clause 4, the following exceptions are valid:

— Where construction machinery or electrical/electronic system or ESA does not include an electronic oscillator with an operating frequency greater than 9 kHz, it shall be deemed to comply with the requirements of 4.3 and 4.6.

— Construction machinery which does not have electrical/electronic systems or does not have ESAs involved in the direct control and modification of the state of function of the construction machinery need not be tested for immunity according to 4.4 and 4.8.

— ESAs whose functions are not involved in the direct control and modification of the state of the function of the construction machinery need not be tested for immunity according to 4.7 and 4.8.

— If the construction machinery does not possess an interface for the coupling of external electrical/electronic systems, a test of the conducted transients according to 4.9 is not necessary.

— Each construction machinery manufacturer shall in the operator's manual identify what precautions in respect of electromagnetic compatibility, if any, are applicable when installing and operating radio, telephone or other transmitters which comply with the relevant EMC-standards. For the application of this European Standard specific tests regarding radio or telephone transmitters are not necessary.

— Systems that contain electromechanical parts only are deemed to meet the requirements of this European Standard for immunity.

— Loss of function of RF receivers during the immunity test is acceptable within the receiver bandwidth (RF exclusion band), as long as the construction machinery shifts into the manufacturer's predefined safe state. The RF exclusion band as specified for the specific radio service/product in the harmonised EMC-standard, and whose reference is published in the Official Journal of the European Union, shall for this purpose be applied.

— Wanted emissions (e.g. from RF transmitting systems) within the necessary bandwidth and out of band emissions are disregarded for the purpose of this European Standard. Spurious emissions are subject to this European Standard but need not be tested if the transmitter has a Declaration of Conformity according to Directive 1999/5/EC using a harmonised standard.

6 Test report

If a test report is made, the following information shall be included in the report:

— description of the test specimen in accordance with 3.17 or 3.18 (machine model, or electrical/electronic sub-assembly or separate technical unit(s) identification);

— description or classification of the test facilities or test site;

— description of the instrumentation or the standards that the instrumentation meets;

— level of broadband electromagnetic emissions according to 4.2.2;

— level of narrowband electromagnetic emissions according to 4.3.2;

— identification of any loss of functional control of the construction machinery according to 4.4.2;

— level of broadband electromagnetic interference according to 4.5.2;

— level of narrowband electromagnetic interference according to 4.6.2;

— identification of deviation from the specification of functional control exhibited by the ESA according to 4.7.2;

— identification of components not meeting the requirement of 4.8.2;

— identification of components not meeting the requirement of 4.9.3 and 4.9.4;

— machine "configuration", place and date, person(s) responsible, instruments and methods used;

— instrument or calibration number.

Annex A
(normative)

Reference limits

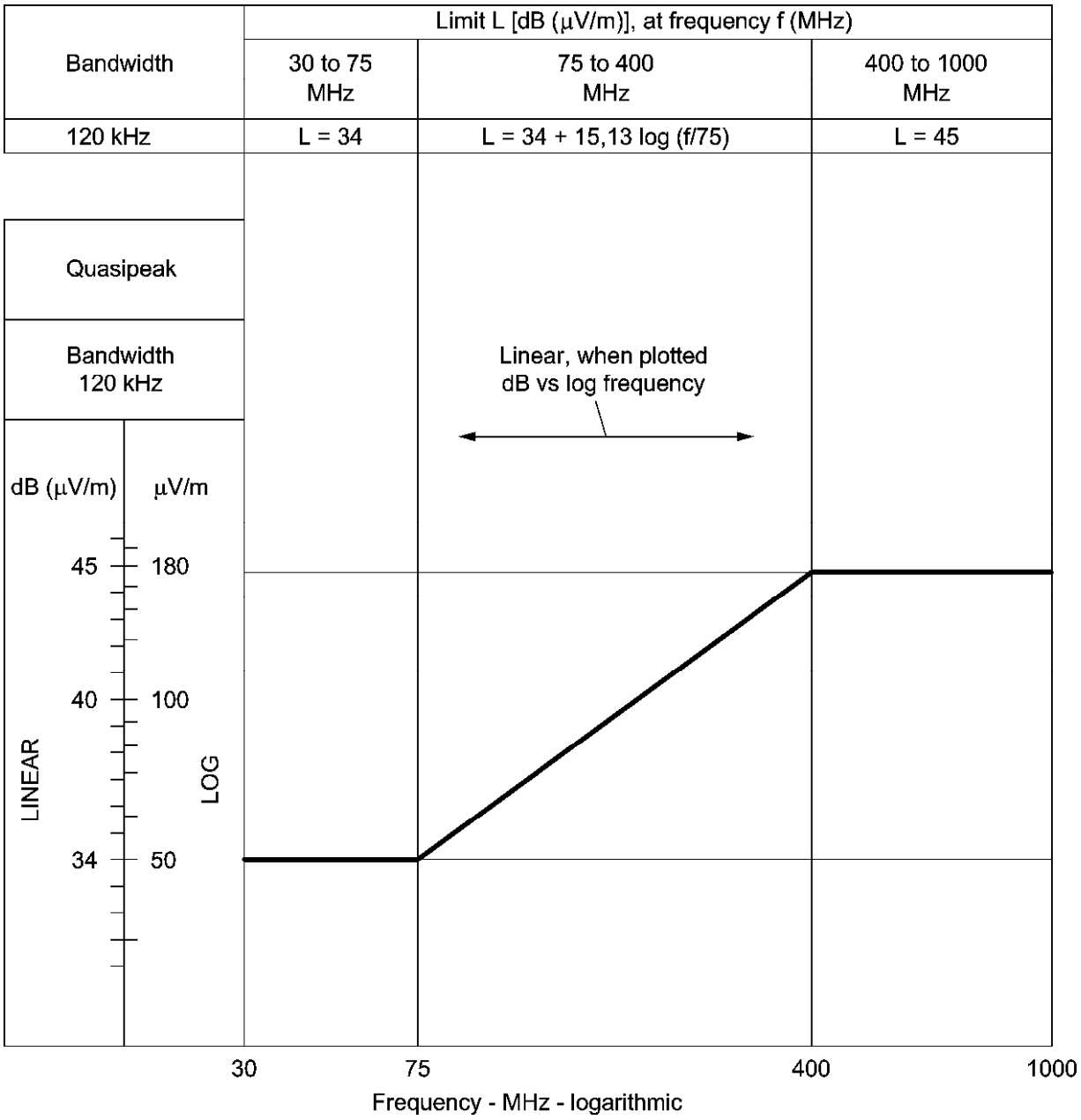


Figure A.1 — Construction machinery broadband reference limits for a construction machinery-to-antenna distance of 10 m

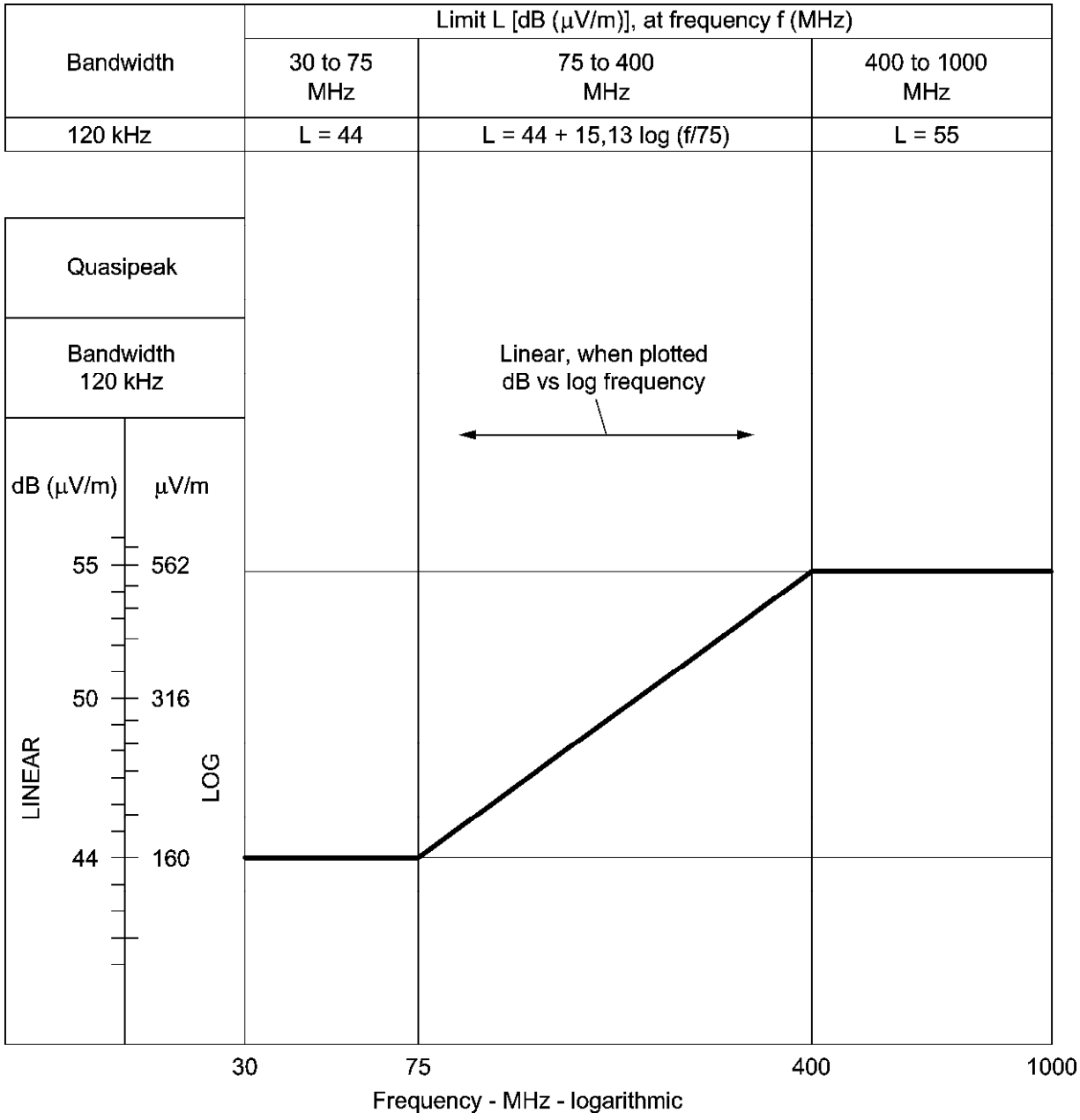
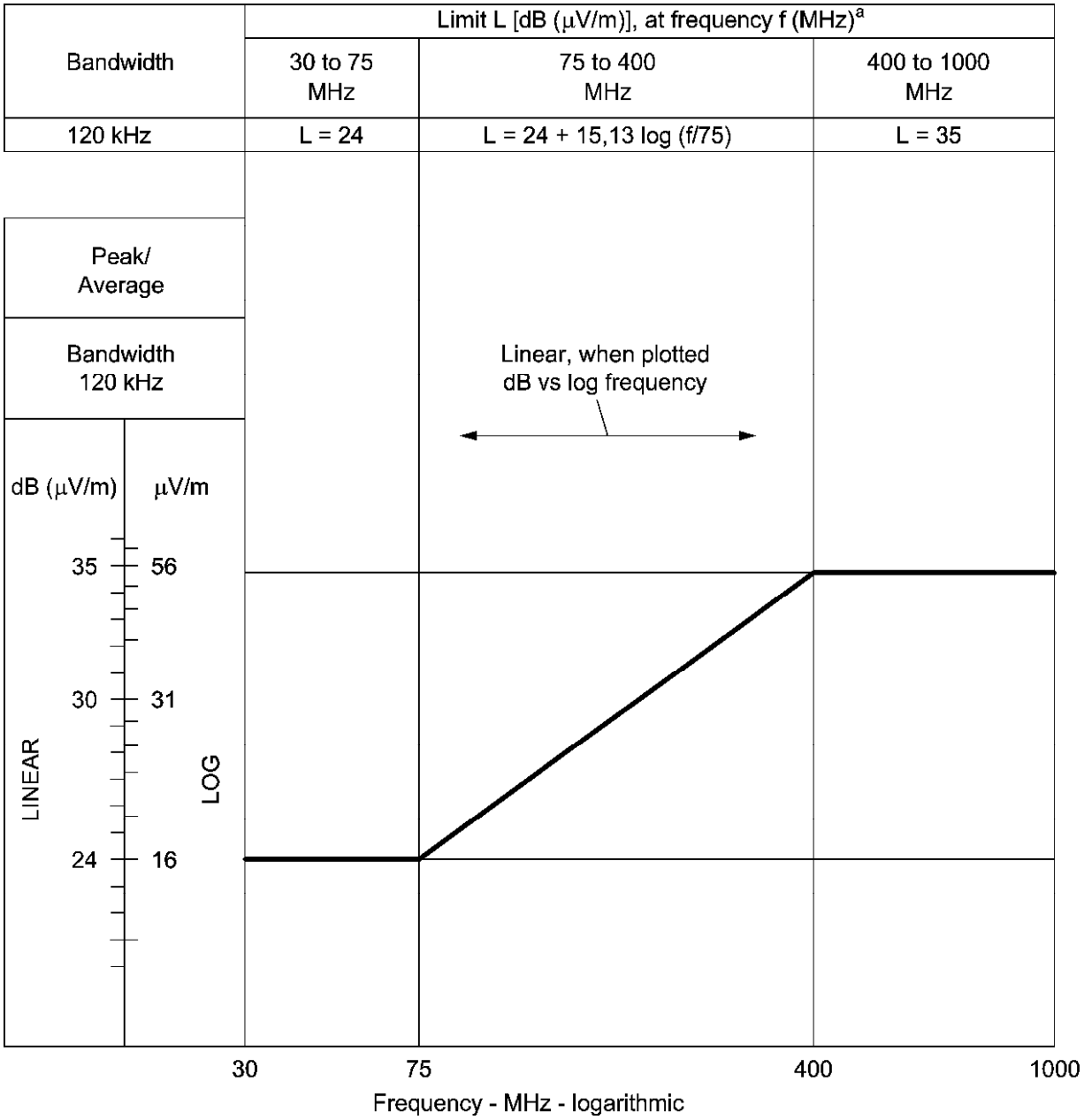
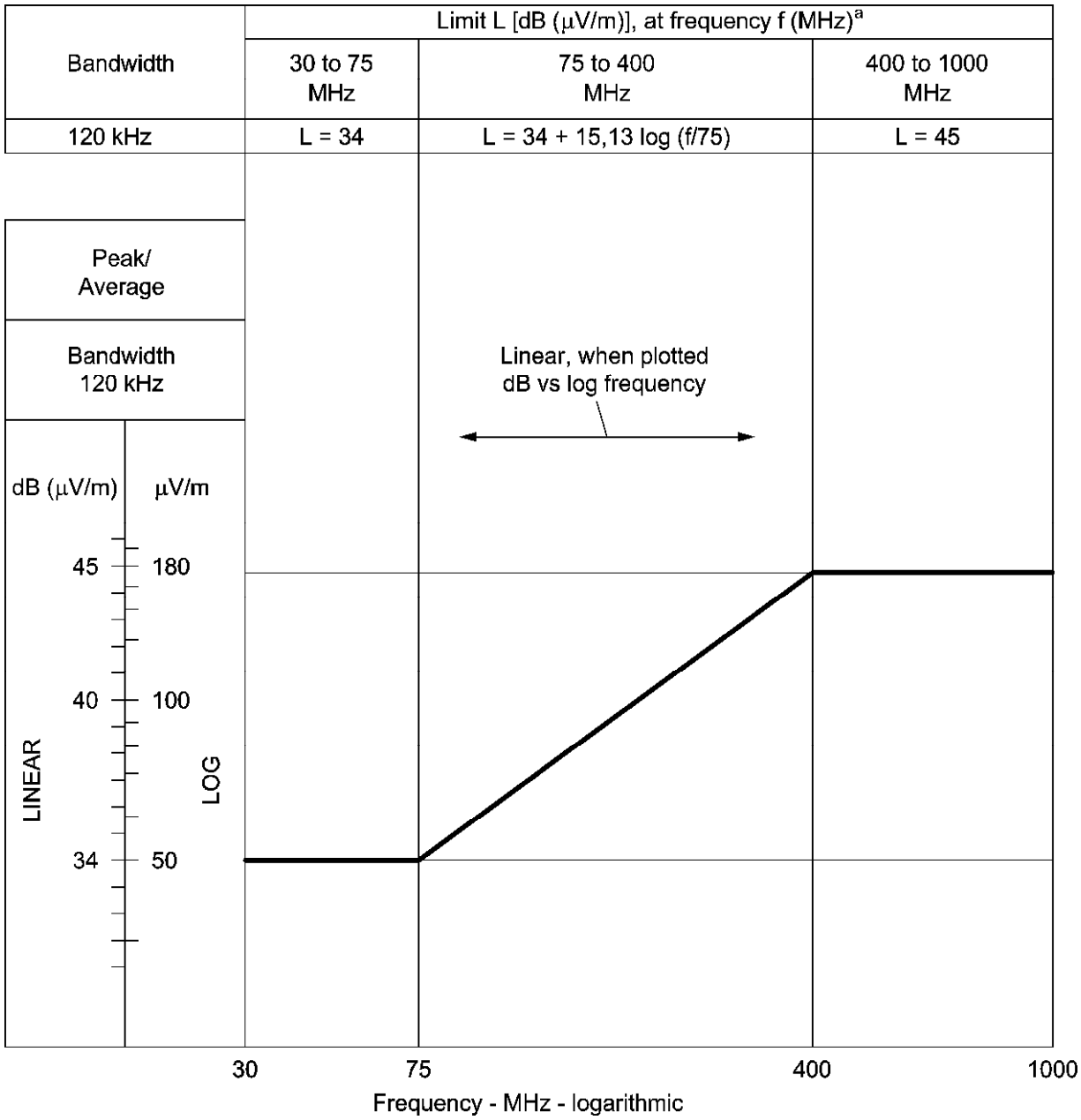


Figure A.2 — Construction machinery broadband reference limits for a construction machinery-to-antenna distance of 3 m



[a] If measurements are made which exceed the above emission reference limits, an analysis and evaluation of these peaks shall be made according to the method of determining conformance of radiated disturbance presented in Figure A.7.

Figure A.3 — Construction machinery narrowband reference limits for a construction machinery-to-antenna distance of 10 m



[a] If measurements are made which exceed the above emission reference limits, an analysis and evaluation of these peaks shall be made according to the method of determining conformance of radiated disturbance presented in Figure A.7.

Figure A.4 — Construction machinery narrowband reference limits for a construction machinery-to-antenna distance of 3 m

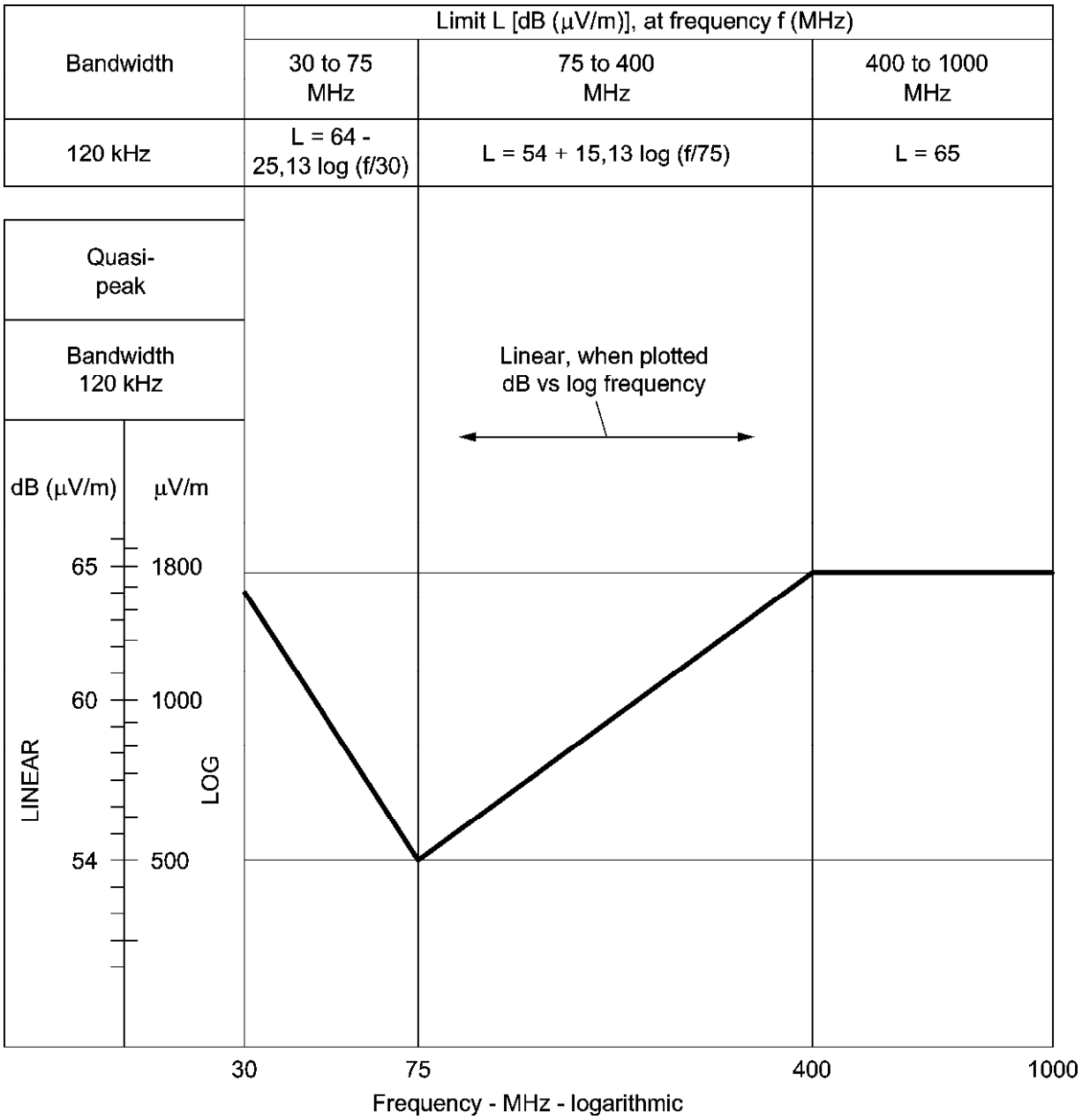
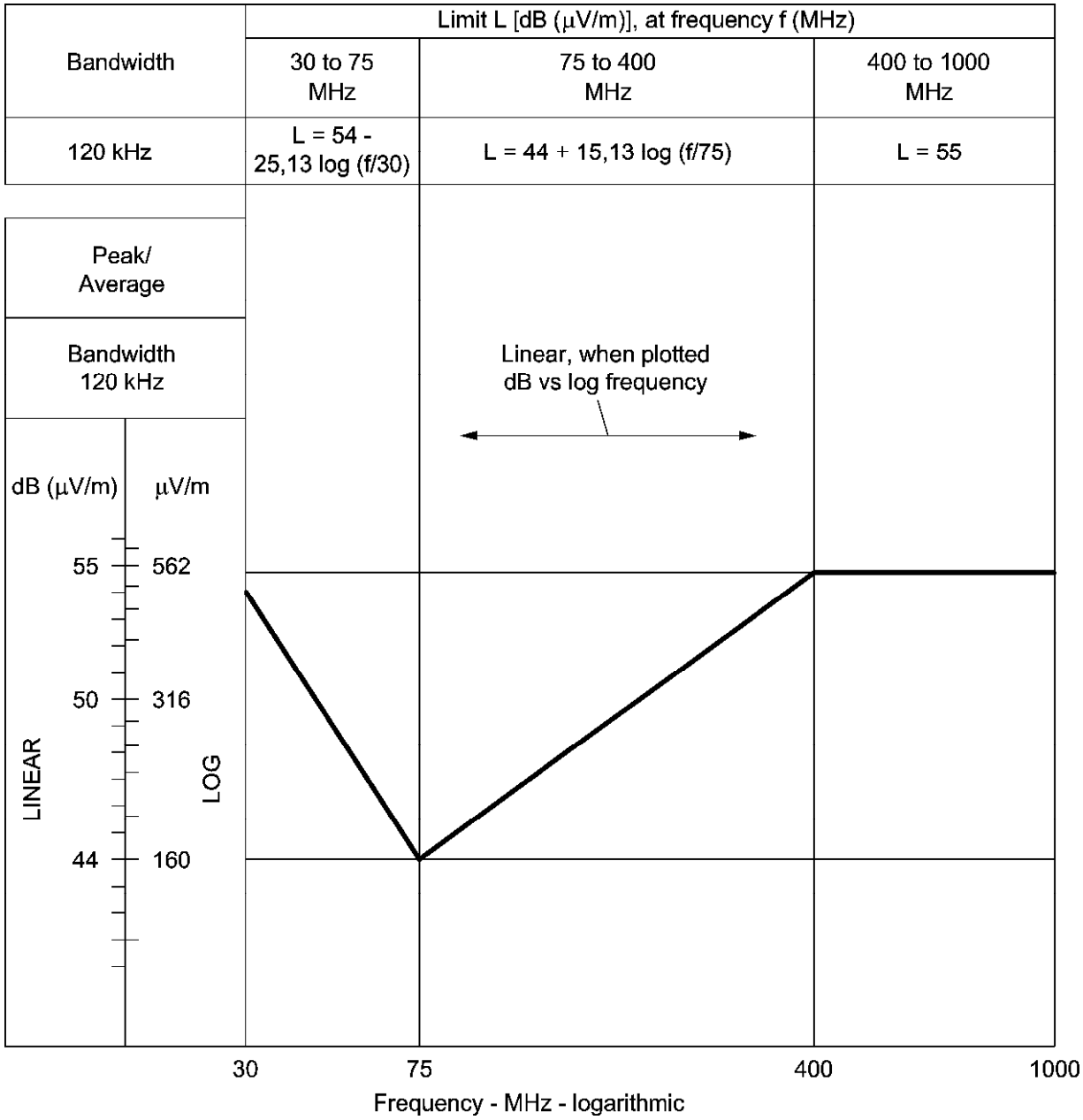


Figure A.5 — ESAs broadband reference limits



NOTE If measurements are made which exceed the above emission reference limits, an analysis and evaluation of these peaks shall be made according to the method of determining conformance of radiated disturbance presented in Figure A.7.

Figure A.6 — ESAs narrowband reference limits

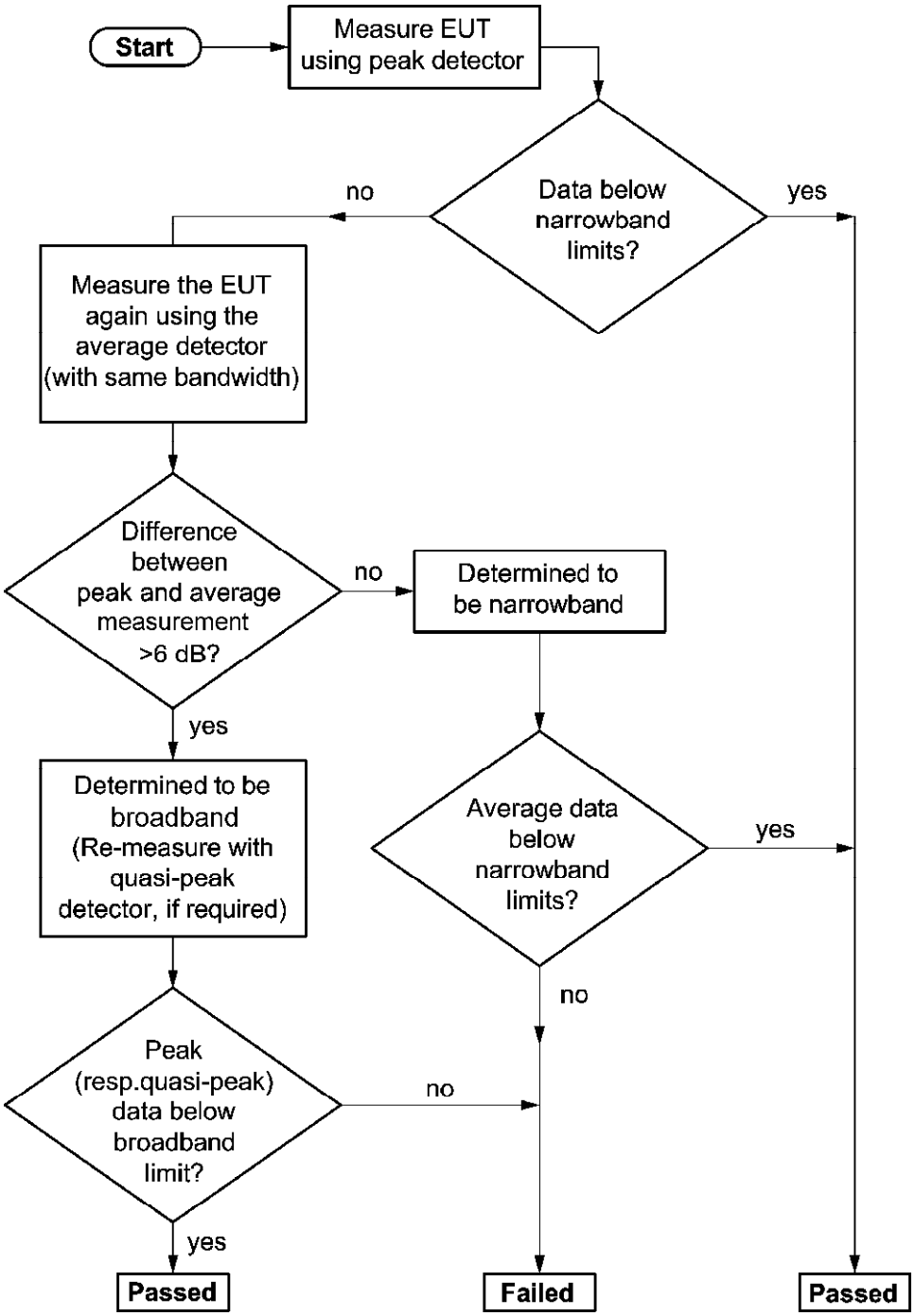


Figure A.7 — Method of determination of conformance of radiated disturbance

Annex B
(normative)

Method of measurement of radiated broadband electromagnetic emissions from construction machinery

B.1 General

B.1.1 Application

The test method described in the annex shall be applied only to complete construction machinery.

B.1.2 Measurement apparatus

The measuring equipment shall comply with the requirements of EN 55016-1-1:2007.

A quasi-peak-detector shall be used for the measurement of broadband electromagnetic emissions in this annex, or if a peak-detector is used an appropriate correction factor shall be used depending on the pulse rate (see CISPR 12:2007+Amd1:2009).

B.1.3 Test method

This test is intended to measure the broadband emissions.

Two alternative reference antenna distances are permissible: 10 m or 3 m from the construction machinery.

In either case the requirements of B.3 shall be complied with.

B.2 Results of measurement

The results of measurement shall be expressed in dB (µV/m) or (µV/m) for 120 kHz bandwidth. If the actual bandwidth B (expressed in kilohertz) of the measuring apparatus differs from 120 kHz, the readings, when given in dB (µV/m), shall be converted through an addition of 20 log (120/B) and, when given in microvolts per metre, shall be converted through multiplication by 120/B.

B.3 Measuring location

B.3.1 Test site

The test site shall be a clear, level area free from electromagnetic reflecting surfaces within a circle of minimum radius of 30 m measured from a point midway between the construction machinery and the antenna (Outdoor test site – see Figure B.1 and CISPR 12:2007+Amd1:2009, 5.2.1).

B.3.2 Measurement facility

The measuring set, test hut, or construction machinery 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 antennae are allowed within the test area, at a minimum distance of 10 m both from the receiving antenna and the construction machinery under test, provided that it can be shown that the test results will not be affected.

B.3.3 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 the construction machinery and the height of the antenna. Neither do they need to have ambient emissions checked before or after the test as indicated in B.3.4.

B.3.4 Ambient

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 construction machinery is present when ambient measurements are taken, it will be necessary to ensure that any emission from the construction machinery does not affect significantly the ambient measurements, for example by removing the construction machinery from the test area, removing the ignition key, or disconnecting the battery. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 4.2.2 (except for intentional narrowband ambient transmissions).

B.4 Construction machinery state during test

B.4.1 General

All sources of broadband emissions which are deemed to be continuously used should be switched on during the test. This could be any device which, when operated, is on for longer than 15 s. If the construction machinery 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 emissions. During each measurement, the engine shall be operated as follows:

Engine type	Method of measurement
	Quasi peak/peak
Spark ignition	Engine speed
One cylinder	2 500 r/min ± 10 %
More than one cylinder	1 500 r/min ± 10 %
Diesel	Nominal speed ± 10 %

B.4.2 Test site ambient

Testing shall not be conducted while rain or other precipitation is falling on the construction machinery or within 10 min after such precipitation has stopped.

B.5 Antenna type, position and orientation

B.5.1 Antenna type

Any antenna may be used provided it can be normalised to the reference antenna. The method described in CISPR 12:2007+Amd1:2009, Annex C, may be used to calibrate the antenna.

B.5.2 Height and distance of measurement

B.5.2.1 Height

B.5.2.1.1 10 m test

The phase centre of the antenna shall be (3,00 ± 0,05) m above the plane on which the construction machinery rests.

B.5.2.1.2 3 m test

The phase centre of the antenna shall be (1,80 ± 0,05) m above the plane on which the construction machinery rests.

B.5.2.1.3 Antenna location

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

B.5.2.2 Distance of measurement

B.5.2.2.1 10 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in B.5.1 to the outer body surface of the construction machinery shall be (10,0 ± 0,20) m.

B.5.2.2.2 3 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in B.5.1 to the outer body surface of the construction machinery shall be (3,0 ± 0,05) m.

B.5.2.2.3 Antenna location

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 1,0 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 construction machinery under test.

B.5.3 Antenna location relative to the construction machinery

The antenna shall be located successively on the left- and right-hand sides of the construction machinery, with the antenna parallel to the plane of the longitudinal symmetry of the construction machinery.

The determination of the reference point(s) shall be machine specific and noted in the test report (for examples see also Figure B.2).

B.5.4 Antenna position

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

B.5.5 Readings

The maximum of the four readings taken in accordance with B.5.3 and B.5.4 at each frequency shall be taken as the characteristic reading at the frequency at which the measurements were made.

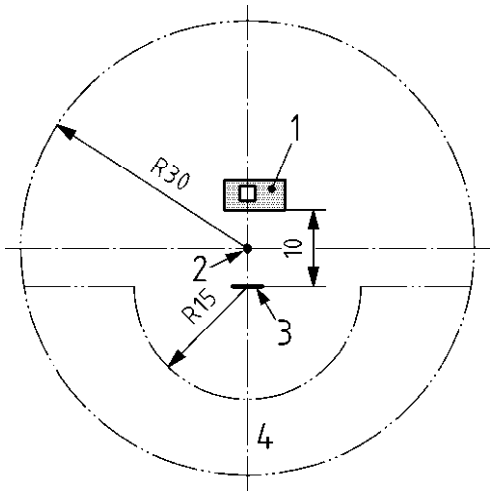
B.6 Frequencies

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 12:2007+Amd1:2009.

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 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.

Dimensions in metres



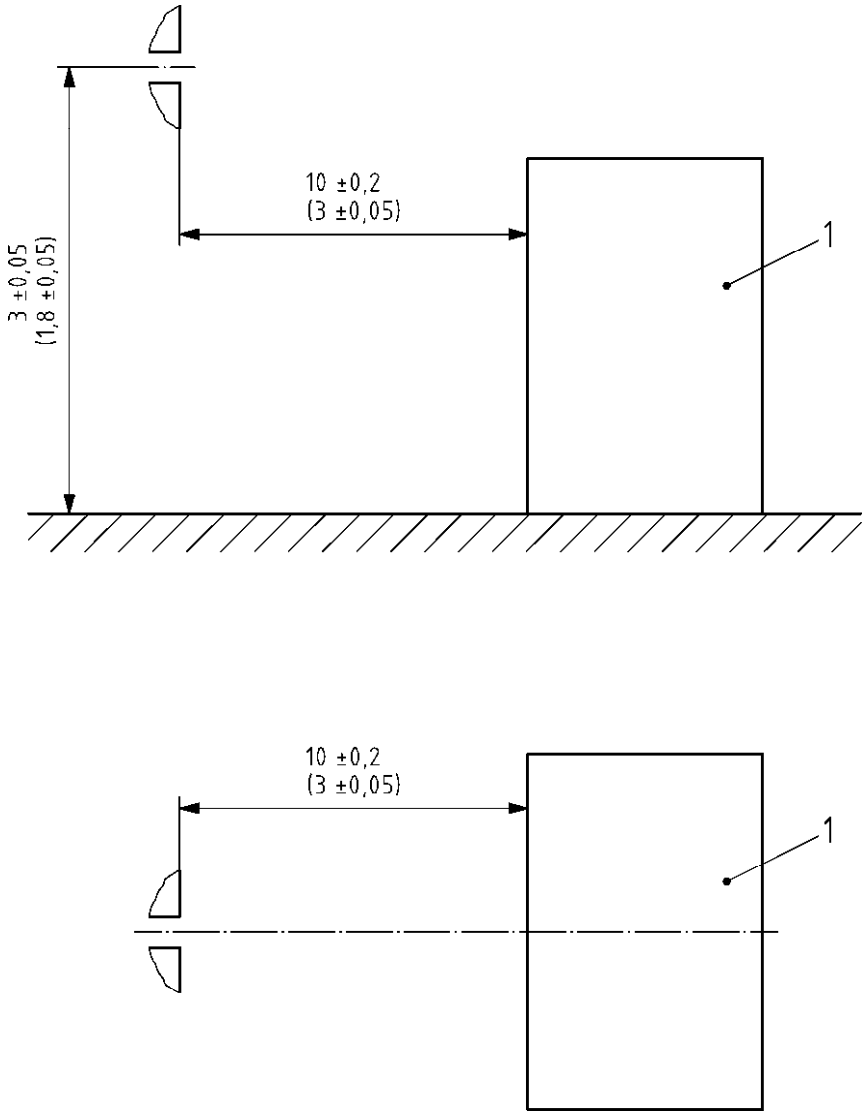
Clear level area, free from electromagnetic reflecting surfaces. Reference: CISPR 12:2007+Amd1:2009.

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)
R radius

Figure B.1 — Construction machinery − Test area

Dimensions in metres



Dipole antenna in position to measure vertical and horizontal component of radiation.

Key

1 machine [1)]

Figure B.2 — Position of antenna relative to construction machinery

1) Machine specific reference point to be determined.

Annex C
(normative)

Method of measurement of radiated narrowband electromagnetic emissions from construction machinery

C.1 General

C.1.1 Application

The test method described in this annex shall be applied only to complete construction machinery.

C.1.2 Measuring apparatus

The measuring equipment shall comply with the requirements of EN 55016-1-1:2007.

A peak and if needed an average detector shall be used for the measurement of narrowband electromagnetic emissions, according to Figure A.7.

Annex D of EN 55016-2-3:2006 explains the differences between the CISPR AV detector and an AV detector (complying with CISPR 16-1:1999). For the purpose of this standard either detector may be used, since the pulse repetition rate for sources on board of construction machinery is above 10 Hz.

C.1.3 Test method

This test is intended to measure the narrowband emissions such as might emanate from a micro processing-based system or other narrowband source.

In the test procedure two alternative antenna distances are permissible: 10 m or 3 m from the construction machinery. In either case the requirements of C.3 shall be complied with.

C.2 Results of measurement

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

C.3 Measuring location

C.3.1 Test site

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

C.3.2 Measuring facility

The measuring set, test hut, or construction machinery 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 the receiving antenna and the construction machinery under test, provided that it can be shown that the test results will not be affected.

C.3.3 Enclosed test facility

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 the construction machinery and the height of the antenna. Neither do they need to have ambient emissions checked before or after the test as indicated in C.3.4.

C.3.4 Ambient

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 construction machinery is present when ambient measurements are taken, it will be necessary to ensure that any emission from the construction machinery does not affect significantly the ambient measurements, for example by removing the construction machinery from the test area, removing the ignition key, or disconnecting the battery. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 4.3.2 (except for intentional narrowband ambient transmissions).

C.4 Construction machinery state during test

C.4.1 Construction machinery systems

The construction machinery's electronic systems shall all be in normal operating mode with the construction machinery stationary.

C.4.2 Construction machinery controls

The ignition or the engine run control shall be switched on. The engine shall not be operating.

C.4.3 Ambient conditions

Measurements shall not be made while rain or other precipitation is falling on the construction machinery or within 10 min after such precipitation has stopped.

C.5 Antenna type, position and orientation

C.5.1 Antenna type

Any antenna may be used provided it can be normalised to the reference antenna. The method described in CISPR 12:2007+Amd1:2009, Annex C, may be used to calibrate the antenna.

C.5.2 Height and distance measurement

C.5.2.1 Height

C.5.2.1.1 10 m test

The phase centre of the antenna shall be (3,00 ± 0,05) m above the plane on which the construction machinery rests.

C.5.2.1.2 3 m test

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

C.5.2.1.3 Antenna location

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

C.5.2.2 Distance of measurement

C.5.2.2.1 10 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in C.5.1 to the outer body surface of the construction machinery shall be (10,0 ± 0,2) m.

C.5.2.2.2 3 m test

The horizontal distance from the tip or other appropriate point of the antenna defined during the normalisation procedure described in C.5.1 to the outer body surface of the construction machinery shall be (3,0 ± 0,05) m.

C.5.2.2.3 Enclosed facility

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 1,0 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 construction machinery under test.

C.5.3 Antenna location relative to the construction machinery

The antenna shall be located successively on the left- and right-hand sides of the construction machinery, with the antenna parallel to the plane of longitudinal symmetry of the construction machinery and in line with the reference point of the construction machinery (see B.5.3).

C.5.4 Antenna position

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

C.5.5 Readings

The maximum of the four readings taken in accordance with C.5.3 and C.5.4 at each frequency shall be taken as a 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 12:2007+Amd1:2009.

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 may be applied to ESAs.

D.1.2 Measuring apparatus

The measuring machinery shall comply with the requirements of EN 55016-1-1:2007.

A quasi-peak detector shall be used for the measurement of broadband electromagnetic emissions in this annex, or if a peak detector is used an appropriate correction factor shall be used depending on the pulse rate (see CISPR 12:2007+Amd1:2009).

D.1.3 Test method

The test is intended to measure the broadband electromagnetic emissions from ESAs.

D.2 Results of measurement

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

D.3 Measuring location

D.3.1 Test site

The test site shall comply with the requirements of CISPR 16-1-4:2007+Amd1:2008 (see Figure D.1).

D.3.2 Measuring facility

The measuring set, test hut, or construction machinery in which the measurement set is located shall be outside the boundary in Figure D.1.

D.3.3 Enclosed facility

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.3.4 Ambient

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. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 4.5.2, except for intentional narrowband ambient transmissions.

D.4 ESA state during test

D.4.1 Operational mode

The ESA under test shall be in normal operation mode.

D.4.2 Test ambient

Testing shall not be conducted while rain or other precipitation is falling on the ESA or within 10 min after such precipitation has stopped.

D.4.3 ESA set-up

The ESA under test and its wiring harnesses shall be spaced 50^{+10}_{0} mm above a metallic ground plane on a non-conductive, low relative permittivity material ($\varepsilon_r \leq 1{,}4$). However, if any part of the ESA under test is intended to be electrically bonded to the construction machinery's metal bodywork, that part shall be placed on a ground plane and shall be electrically bonded to the ground plane.

The length of test harness parallel to the front of the ground plane shall be (1 500 ± 75) mm.

The total length of the test harness between the EUT and the load simulator (or the RF boundary) shall not exceed 2 000 mm (or as defined in the test plan). The wiring type is defined by the actual system application and requirement.

The ground plane shall be a metallic sheet with a minimum thickness of 0,5 mm. The minimum size of the ground plane will depend on the size of the ESA under test but shall allow for the distribution of the ESAs 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 (0,9 ± 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 ± 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 the test and all other conductive structures, such as walls of a shielded area (with the exception of ground plane/table underneath the test object) or to the nearest surface of the absorber material shall be 1,0 m.

D.4.4 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.4.5 Multiple ESAs

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 construction machinery. If these are not available, the minimum length between the ESA and the AN shall be 1,5 m. All cable trees should be terminated as realistically as possible and preferably with real loads and actuators. If extraneous machinery 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.5 Antenna type, position and orientation

D.5.1 Antenna type

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

D.5.2 Height and distance of measurement

D.5.2.1 Height

The phase centre of the antenna shall be (100 ± 10) mm above the ground plane.

D.5.2.2 Distance of measurement

The horizontal distance from the phase centre or tip of the antenna as appropriate, to the longitudinal part of the wiring harness shall be (1,0 ± 0,01) m. No part of the antenna shall be closer than 0,25 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.

D.5.2.3 Enclosed facility

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 1,0 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.5.3 Antenna orientation and polarisation

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

D.5.4 Readings

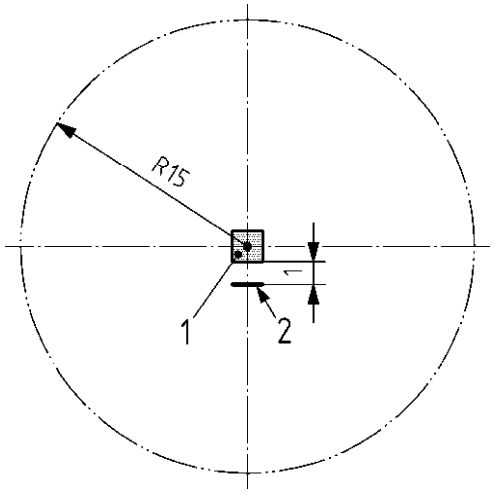
The maximum of the two readings taken in accordance with D.5.3 at each frequency shall be taken as the characteristic reading at the frequency at which the measurements were made.

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 EN 55025:2008.

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.

Dimensions in metres



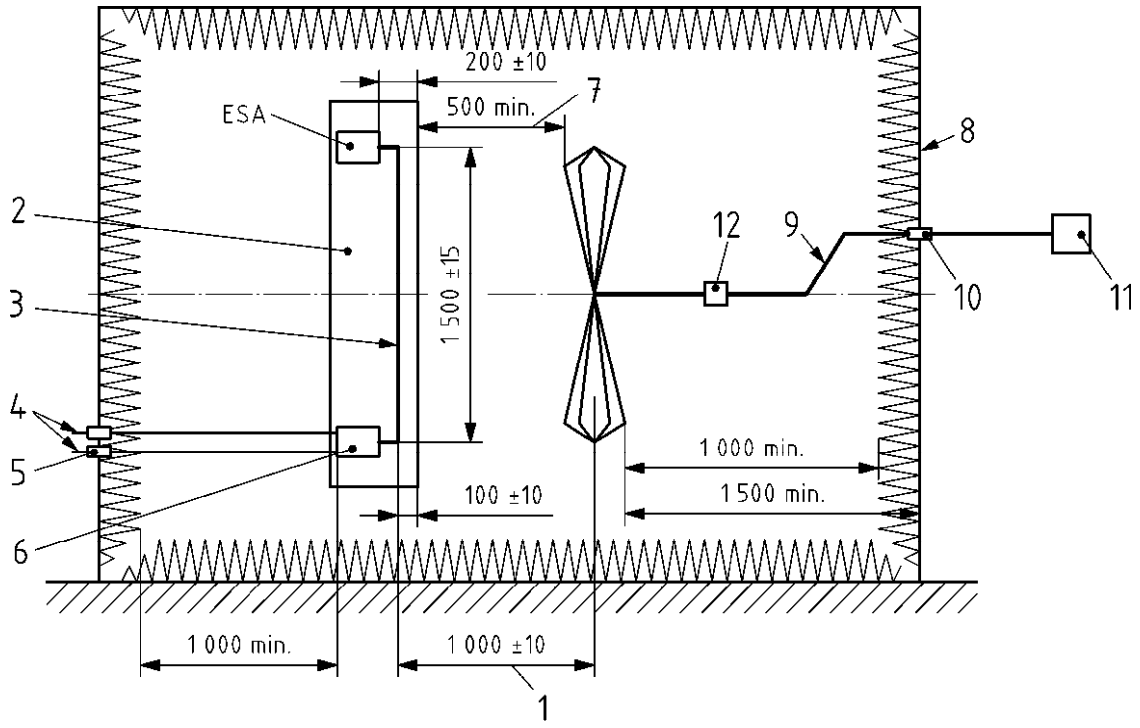
Clear level area, free from electromagnetic reflecting surfaces. Reference: CISPR 16-1-4:2007+Amd1:2008.

Key

1 test sample on ground plane
2 antenna
R radius

Figure D.1 — ESA test area boundary

Dimensions in millimetres

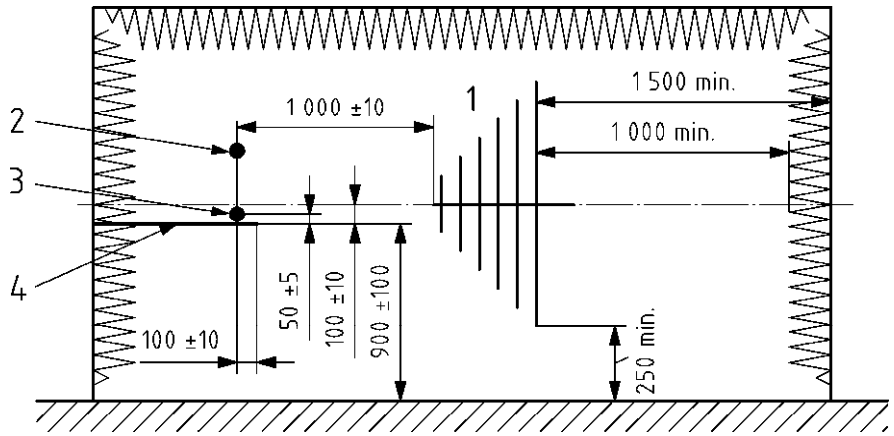


Key

1 to axis of antenna or closest element of log. periodic array: (1 000 ± 50) mm
2 test bench with ground plane bonded to wall
3 test harness (1 500 ± 75) mm long and $50\,^{+10}_{0}$ mm above ground plane
4 power supply to subject under test
5 feedthrough
6 connecting box including AN
7 closest radiating elements 500 min. from the edge ground plane
8 shielded enclosure
9 double shielded coaxial cable
10 feedthrough
11 measuring receiver
12 antenna matching unit (where necessary) in close proximity to antenna

Figure D.2 — Coupled broadband electromagnetic emissions from ESAs − Test layout (general plan view)

Dimensions in millimetres



Key

1 antenna
2 plane in which the reference point and the main portion of the harness lie
3 reference point
4 base plate

Figure D.3 — Coupled broadband electromagnetic emissions from ESAs − View on 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 ESA test method

The test method described in this annex may be applied to ESAs.

E.1.2 Measuring apparatus

The measuring equipment shall comply with the requirements of EN 55016-1-1:2007.

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

Annex D of EN 55016-2-3:2006 explains the differences between the CISPR AV detector and an AV detector (complying with CISPR 16-1:1999). For the purpose of this standard either detector may be used, since the pulse repetition rate for sources on board of construction machinery is above 10 Hz.

E.1.3 Test method

This test is intended to measure the narrowband electromagnetic radiation such as might emanate from a microprocessor-based system.

E.2 Results of measurement

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

E.3 Measuring location

E.3.1 Test site specifications

The test site shall comply with the requirements of CISPR 16-1-4:2007+Amd1:2008 (see Figure D.1).

E.3.2 Measuring facilities

The measuring set, test hut, or construction machinery in which the measurement set is located shall be outside the boundary shown in Figure D.1.

E.3.3 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 the ESA under test and the height of the antenna (see Figures D.2 and D.3).

E.3.4 Ambient

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. In both of the measurements, the extraneous noise or signal shall be at least 10 dB below the limits of interference given in 4.6.2, except for intentional narrowband ambient transmissions.

E.4 ESA state during test

E.4.1 Operational mode

The ESA under test shall be in normal operation mode.

E.4.2 Test ambient

Testing shall not be conducted while rain or other precipitation is falling on the machinery or within 10 min after such precipitation has stopped.

E.4.3 ESA set-up

The ESA under test and its wiring harnesses shall be spaced $50\,^{+10}_{0}$ mm above a metallic ground plane on a non-conductive, low relative permittivity material ($\varepsilon_r \leq 1{,}4$). However, if any part of the ESA under test is intended to be electrically bonded to the construction machinery's metal bodywork, that part shall be placed on a ground plane and shall be electrically bonded to the ground plane.

The length of test harness parallel to the front of the ground plane shall be (1 500 ± 75) mm.

The total length of the test harness between the EUT and the load simulator (or the RF boundary) shall not exceed 2 000 mm (or as defined in the test plan). The wiring type is defined by the actual system application and requirement.

The ground plane shall be a metallic sheet with a minimum thickness of 0,5 mm. The minimum size of the ground plane will depend on the size of the ESA under test but shall allow for the distribution of the ESAs 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 (0,9 ± 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 ± 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 ground plane/table underneath the test object) or to the nearest surface of the absorber material shall be 1,0 m.

E.4.4 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.4.5 Multiple ESAs

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 construction machinery. If these are not available, the minimum length between the electronic control unit and the AN shall be 1,5 m. All cable 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.5 Antenna type, position and orientation

E.5.1 Antenna type

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

E.5.2 Height and distance of measurement

E.5.2.1 Height

The phase centre of the antenna shall be (100 ± 10) mm above the ground plane.

E.5.2.2 Distance of measurement

The horizontal distance from the phase centre or tip of the antenna as appropriate, to the longitudinal part of the wiring harness shall be (1,0 ± 0,01) m. No part of the antenna shall be closer than 0,25 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 principle portion of the harness runs.

E.5.2.3 Enclosed facility

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 1,0 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.5.3 Antenna orientation and polarisation

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

E.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 EN 55025:2008.

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.

Annex F
(informative)

A Guideline for selecting the test specimen configuration

F.1 General

Because of the many electrical/electronic variations which can be presented on construction machinery, the selection of the test specimen of construction machinery or ESAs should be based upon an evaluation of the conditions which are likely to present the most significant emissions and immunity impact to the construction machinery and the environment in which it will be used. Thus to reduce the configurations of construction machinery or ESAs to be presented for testing, the information in this annex can be helpful to the users of this European Standard to make the best choices of what configurations to test.

F.2 Criteria for consideration

F.2.1 Narrowband emissions

The following factor should be considered:

— Are there narrowband sources of emission (oscillator) with frequency higher than 9 kHz (examples of oscillators with frequencies higher than 9 kHz are microprocessor clocks, and pulse width modulated signals)?

F.2.2 Broadband emissions

Are there broadband sources of emissions (examples of sources of broadband noise are wiper motors and spark gaps)?

Are they continuously operated?

F.2.3 Immunity

Could a degradation in system performance affect the following?

— The operator's direct control of the construction machinery;

— engine speed control;

— steering system;

— brake system;

— movement of parts of the construction machinery;

— any construction machinery function which may generate a hazard;

— any construction machinery function which may mislead the operator or persons in close proximity of the equipment.

Does the system include any active semiconductor devices (examples of active semiconductor devices are transistors and microprocessors)?

Is the power for a device switched directly or via relay contacts?

If the degradation of system performance is not perceptible to the operator, the manufacturer shall identify or demonstrate a mechanical limit such as the maximum rate of change.

Annex ZA
(informative)

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

This European 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 conformity to protection requirements of Annex I Clause 1 of the New Approach Directive Electromagnetic Compatibility 2004/108/EC.

Once this standard is cited in the Official Journal of the European Union 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 Essential Requirements 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.

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