

Construction machinery — Electromagnetic compatibility of machines with internal electrical power supply

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ICS 33.100.20; 91.220

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 45 and a back cover.

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This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 September 2000

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ISBN 0 580 34996 9

Amendments issued since publication

Amd. No.	Date	Comments

English version

Construction machinery - Electromagnetic compatibility of machines with internal electrical power supply

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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Contents

	Page
Foreword	4
0 Introduction	5
1 Scope	6
2 Normative references	6
3 Terms and definitions	7
3.1 Electromagnetic compatibility (EMC)	7
3.2 Electromagnetic disturbance	7
3.3 Electromagnetic immunity	8
3.4 Electromagnetic environment	8
3.5 Reference limit	8
3.6 Reference antenna	8
3.7 Broadband emission	8
3.8 Narrowband emission	8
3.9 Electrical/Electronic system	8
3.10 Electrical/Electronic sub-assembly (ESA)	8
3.11 Construction machinery type	9
3.12 ESA type	9
3.13 Electrostatic discharge (ESD)	9
3.14 Conducted transients	9
4 Requirements	9
4.1 General requirements	9
4.2 Specifications concerning broadband electromagnetic emission radiated from construction machinery	10
4.3 Specifications concerning narrowband electromagnetic emission radiated from construction machinery	11
4.4 Specifications concerning the immunity of construction machinery to electromagnetic radiation	11
4.5 Specifications concerning broadband electromagnetic emissions radiated from ESA's	12
4.6 Specifications concerning narrowband electromagnetic emissions radiated from ESA's	12
4.7 Specifications concerning the immunity of ESA's to electromagnetic radiation	12
4.8 Electrostatic discharge (ESD)	13
4.9 Conducted transients	13
5 Exceptions	15
6 Test report	16
Annex A (normative) Reference limits	17
Annex B (normative) Method of measurement of radiated broadband electromagnetic emissions from construction machinery	23
Annex C (normative) Method of measurement of radiated narrowband electromagnetic emissions from construction machinery	29

Annex D (normative) Method of measurement of radiated broadband electromagnetic emissions from electrical/electronic sub-assembly	33
Annex E (normative) Method of measurement of radiated narrowband electromagnetic emissions from electrical/electronic sub-assemblies	38
Annex F (informative) A guideline for selecting the test specimen configuration	42
Annex ZA (informative) Clauses of this European Standard addressing essential requirements or other provisions of EU Directives	44
Bibliography	45

Foreword

This European Standard 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 2001, and conflicting national standards shall be withdrawn at the latest by January 2001.

This European Standard 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 standard.

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

Annex A is normative and contains "Figures of the reference limits", annex B is normative and contains "Method of measurement of radiated broadband electromagnetic emissions from construction machinery", annex C is normative and contains "Method of measurement of radiated narrowband electromagnetic emissions from construction machinery", annex D is normative and contains "Method of measurement of radiated broadband electromagnetic emissions from electrical/electronic sub-assembly", annex E is normative and contains "Method of measurement of radiated narrowband electromagnetic emissions from electrical/electronic sub-assemblies" and annex F is informative and contains "A guideline for selecting the test specimen configuration".

0 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 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 recognizes 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 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 may 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.

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, except regarding immunity for those parts whose functions are not involved in the direct control and/or modification of the state functions of the machine.

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 may 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

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

CISPR 12:1997	Vehicles, motor boats and spark-ignited engine-driven devices – Radio-disturbance characteristics – Limits and methods of measurement.
CISPR 16-1:1999	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus
CISPR 25:1995	Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles
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 - Passenger cars and light commercial vehicles with nominal 12 V supply voltage - Part 1: Electrical transient conduction along supply lines only

ISO 7637-2:1990	Road vehicles - Electrical disturbance by conduction and coupling - Commercial vehicles with nominal 24 V supply voltage - Part 2: Electrical transient conduction along supply lines only
ISO/TR 10605:1994	Road vehicles - Electrical disturbance from electrostatic discharges
ISO 11451-1	Road vehicles- Electrical disturbances by narrowband radiated electromagnetic energy - Vehicle test methods - Part 1: General and definitions
ISO 11451-2	Road vehicles - Electrical disturbances by narrowband radiated electromagnetic energy - Vehicle test methods - Part 2: Off-vehicle radiation source
ISO 11452-1	Road vehicles - Electrical disturbance by narrowband radiated electromagnetic energy - Component test methods - Part 1: General and definitions
ISO 11452-2	Road vehicles - Electrical disturbance by narrowband radiated electromagnetic energy - Component test methods - Part 2: Absorber-lined chamber
ISO 11452-3	Road vehicles - Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods - Part 3: Transverse electromagnetic mode (TEM) cell
ISO 11452-4	Road vehicles - Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods - Part 4: Bulk current injection (BCI)
ISO 11452-5	Road vehicles - Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods - Part 5: Stripline
EN 1070:1998	Safety of machinery - Terminology

3 Terms and definitions

For the purpose of this European Standard the terms and definitions stated in EN 1070:1998 apply. Additional terms and definitions specifically needed for this European Standard are added below.

3.1 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 (see IEC 60050(161):1990).

3.2 Electromagnetic disturbance

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

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

3.3 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 (see IEC 60050(161):1990).

3.4 Electromagnetic environment

Totality of electromagnetic phenomena existing at a given location (see IEC 60050(161):1990).

3.5 Reference limit

Limit value with which the production shall conform.

3.6 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 (see CISPR 16-1:1999).

3.7 Broadband emission

Emission which has a bandwidth greater than that of a particular measuring apparatus or receiver (see IEC 60050(161):1990).

3.8 Narrowband emission

Emission which has a bandwidth less than that of a particular measuring apparatus or receiver (see IEC 60050(161):1990).

3.9 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.

3.10 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 specialized functions.

3.11 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)

3.12 ESA type

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

3.13 Electrostatic discharge (ESD)

Transfer of electrostatic charge between bodies of different electrostatic potential in proximity or through direct contact, (see IEC 60050(161):1990).

3.14 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.

4 Requirements

4.1 General requirements

4.1.1 Fulfilment of the requirements

The requirements of this standard are met by construction machinery, and the electrical/electronic sub-assemblies when the requirements in clauses 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 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 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 standard.

The requirements of this 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 3.11 and/or 3.12.

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 with the reference limits shall be accepted as fulfilment of the requirements of this 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 $(10,0 \pm 0,2)$ m, the emission reference limits shall be 34 dB(μ V/m) (50 μ V/m) in the 30 MHz to 75 MHz frequency band and 34 dB(μ V/m) to 45 dB(μ V/m) (50 μ V/m to 180 μ V/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 1000 MHz frequency band the limit remains constant at 45 dB(μ V/m) (180 μ V/m).

If measurements are made using the method described in annex B using a construction machinery-to-antenna spacing of $(3,0 \pm 0,05)$ m, the emission reference limits shall be 44 dB(μ V/m) (160 μ V/m) in the 30 MHz to 75 MHz frequency band and 44 dB(μ V/m) to 55 dB(μ V/m) (160 to 562 μ V/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 1000 MHz frequency band the limit remains constant at 55 dB(μ V/m) (562 μ V/m).

On the test specimen, the measured values, expressed in dB(μ V/m) or (μ V/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 $(10,0 \pm 0,2)$ m, the emission reference limits shall be 24 dB(μ V/m) (16 μ V/m) in the 30 MHz to 75 MHz frequency band and 24 dB(μ V/m) to 35 dB(μ V/m) (16 μ V/m to 56 μ V/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 1000 MHz frequency band the limit remains constant at 35 dB(μ V/m) (56 μ V/m).

If measurements are made using the method described in annex C using a construction machinery-to-antenna spacing of $(3,0 \pm 0,05)$ m, the emission reference limits shall be 34 dB(μ V/m) (50 μ V/m) in the 30 MHz to 75 MHz frequency and 34 dB(μ V/m) to 45 dB(μ V/m) (50 μ V/m to 180 μ V/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 1000 MHz frequency band the limit remains constant at 45 dB(μ V/m) (180 μ V/m).

On the test specimen, the measured values, expressed in dB(μ V/m) or (μ V/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 polarization. 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 (see ISO 11451-1) is determined as a test method. The testing has to be done in the frequency band of 20 MHz to 1000 MHz.

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 clause 4.1.3 shall be fulfilled.

4.5 Specifications concerning broadband electromagnetic emissions radiated from ESA's

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(μ V/m) to 54 dB(μ V/m) (1600 μ V/m to 500 μ V/m) in the 30 MHz to 75 MHz frequency band, this limit decreasing logarithmically (linearly) with frequencies above 30 MHz, and 54 dB(μ V/m) to 65 dB(μ V/m) (500 μ V/m to 1800 μ V/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 1000 MHz frequency band the limits remains constant at 65 dB(μ V/m) (1800 μ V/m).

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

4.6 Specifications concerning narrowband electromagnetic emissions radiated from ESA's

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(μ V/m) to 44 dB(μ V/m) (500 μ V/m to 160 μ V/m) in the 30 MHz to 75 MHz frequency band, this limit decreasing logarithmically (linearly) with frequencies above 30 MHz, and 44 dB(μ V/m) to 55 dB(μ V/m) (160 μ V/m to 562 μ V/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 1000 MHz frequency band the limit remains constant at 55 dB(μ V/m) (562 μ V/m).

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

4.7 Specifications concerning the immunity of ESA's 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. The chosen test methods shall cover the frequency band from 20 MHz to 1000 MHz. Use an amplitude modulation (AM) of 80 % together with a sinusoidal wave of 1 kHz (see ISO 11452-1).

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 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 polarization).

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 ISO 11452-1) shall apply to all tests. The reference limits, increased by 25 %, shall apply for the test specimen. The ESA shall not exhibit any operational change which is unacceptable for its application on the construction machinery. See clause 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/TR 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).

4.8.2 Reference limits

Test level I ($\pm 4,0$ kV) at functional status class A of ISO/TR 10605:1994 shall apply.

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 ESA's or components on the construction machinery. Therefore, minimum values concerning emission and susceptibility for ESA's 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 ESA's of the system.