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Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply —

Part 1: General EMC requirements under typical electromagnetic environmental conditions

Engins de terrassement et machines pour la construction des bâtiments — Compatibilité électromagnétique (CEM) des machines équipées de réseaux électriques de distribution interne —

Partie 1: Exigences CEM générales dans des conditions électromagnétiques environnementales typiques

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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety, ergonomics and general requirements*.

This first edition of ISO 13766-1:2018, together with ISO 13766-2:2018, cancels and replaces ISO 13766:2006, of which it constitutes a technical revision and contains the following changes:

— the scope has been extended to specify building construction machinery as well as earth-moving machinery;

— the provisions have been brought up to date with technological change;

— normative references have been updated to the latest editions;

A list of all parts in the ISO 13766 series can be found on the ISO website.

Introduction

This document is a type-C standard as stated in ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance etc.)

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

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

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

Electrostatic discharges are relevant to the machinery because control elements can be positioned outside the operator station where potential differences could emerge at contact points. Conducted transients in power supply wiring must be considered because the machinery can contain open systems, in which several devices or components can be combined to complement machine functionality.

While there are many existing standards for a variety of products and systems, the test method presented by ISO 13766:2018 provides for the specific test conditions of the machinery within its scope as well as the electrical/electronic sub-assemblies (ESA) or ESA separate from the machinery. The test method recognizes that due to their size and usage, the arrangement of the machines in the test facility needs to be representative of their typical operating characteristics. This document provides test methods and criteria which are acceptable for the machine types it covers, considering their unique characteristics and operating parameters.

Because the machinery has a number of systems that consist of components that can be used on a variety of machine types, the approach of defining ESA or separate ESAs 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 any additional effects imparted by wiring systems used to connect the sub-assemblies into the machinery. The tests can also be conducted on the machinery.

Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply —

Part 1: General EMC requirements under typical electromagnetic environmental conditions

1 Scope

This document provides test methods and acceptance criteria for the evaluation of the electromagnetic compatibility (EMC) of earth-moving machinery, as defined in ISO 6165:2012, and of the following building construction machinery as defined in ISO/TR 12603:2010:

— drilling and foundation equipment;

— equipment used for the preparation, conveyance and compaction of concrete, mortar and processing reinforcement;

— road construction and maintenance machinery and equipment.

It deals with general EMC requirements under typical electromagnetic environmental conditions. (ISO 13766-2:2018 deals with EMC requirements specifically related to functional safety).

Electrical/electronic subassemblies (ESA) and separate ESA intended to be fitted to the machinery are also dealt with. The following electromagnetic disturbance phenomena are evaluated:

— broadband and narrowband electromagnetic interference;

— electromagnetic field immunity;

— electrostatic discharge;

— conducted transients.

The machinery can have DC or AC or a combination of both as the internal electrical power supply system.

This document is not applicable to machines that are designed to be supplied by an external mains network or to phenomena caused by military applications.

NOTE 1 Grid-connected machines are covered by IEC 61000.

NOTE 2 *Hybrid* machines are covered in UN ECE R10-Rev. 5.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 6165:2012, *Earth-moving machinery — Basic types — Identification and terms and definitions*

ISO 7637-1:2015, *Road vehicles — Electrical disturbances from conduction and coupling — Part 1: Definitions and general considerations*

ISO 7637-2:2011, *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 11451-1:2015, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

ISO 11451-2:2015, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Off-vehicle radiation sources*

ISO 11451-4:2013, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Bulk current injection (BCI)*

ISO 11452-1:2015, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

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

ISO 11452-3:2016, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 3: Transverse electromagnetic (TEM) cell*

ISO 11452-4:2011, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Harness excitation methods*

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

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO/TR 12603:2010, *Building construction machinery and equipment — Classification*

ISO 16750-1:2006, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 16750-2:2012, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads*

ISO 21848:2005, *Road vehicles — Electrical and electronic equipment for a supply voltage of 42 V - Electrical loads*

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 16-1-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 1-1: Radio disturbance and immunity measuring apparatus — Measuring apparatus*

CISPR 16-1-4:2012, *Specification for radio disturbance and immunity measuring apparatus and methods —Part 1-4: Radio disturbance and immunity measuring apparatus — Antennas and test sites for radiated disturbance measurements*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6165:2012, ISO/TR 12603:2010 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp;

— IEC Electropedia: available at http://www.electropedia.org/.

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

3.2
electromagnetic compatibility
EMC
ability of the machinery or components or separate ESA to function satisfactorily in its *electromagnetic environment* (3.5), without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:1990, IEV ref. 161-01-07, modified — The machinery, components and ESA have been specified.]

3.3
electromagnetic disturbance
any electromagnetic phenomenon which can degrade the performance of machinery or components or separate ESA

Note 1 to entry: 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
immunity

ability of the machinery or components or separate ESA to perform in the presence of specific *electromagnetic disturbances* (3.3) without degradation of performance

Note 1 to entry: See IEC 60050-161:1990.

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

[SOURCE: IEC 60050-161:1990, IEV ref. 161-01-01, modified — The Note has been excluded.]

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

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

[SOURCE: CISPR 16-1-4:2012]

3.8
reference antenna
<frequency range above 80 MHz> balanced half wave resonant dipole tuned to the measurement frequency

[SOURCE: CISPR 16-1-4:2012]

3.9
broadband emission
emission which has a bandwidth greater than that of a particular measuring apparatus or receiver

Note 1 to entry: See IEC 60050-161:1990.

3.10
narrowband emission
emission which has a bandwidth less than that of a particular measuring apparatus or receiver

Note 1 to entry: See IEC 60050-161:1990.

3.11
out-of-band emissions
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[SOURCE: Article 1, No 1144 of the ITU Radio Regulations[6].]

3.12
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[SOURCE: Article 1, No 1152 of the ITU Radio Regulations[6].]

3.13
spurious emission
emissions on a frequency or frequencies which are outside the necessary RF-bandwidth and the level of which can be reduced without affecting the corresponding transmission of information

Note 1 to entry: In every modulation process of radio-frequency-equipment additional undesired signals exist and are summarized under "spurious emissions". They include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude *out-of-band emissions* (3.11)

[SOURCE: Article 1, No 1145 of the ITU Radio Regulations,[6] modified — Subsidiary information has been transferred to the Note.]

3.14
electrical/electronic system
electrical and electronic components or set of components intended to be part of the machinery, together with any electrical connections

3.15
electrical/electronic sub-assembly
ESA
electrical and electronic components or set of components intended to be part of the machinery, together with any associated electrical connections and wiring, which perform one or more specialised functions

3.16
electrostatic discharge
ESD
transfer of electrostatic charge between bodies of different electrostatic potential in proximity or through direct contact

[SOURCE: IEC 60050-161:1990, IEV ref. 161-01-22, modified — The Note has been excluded.]

3.17
conducted transients
transient voltage or current distributed in the power supply wiring of the machinery or component or separate *ESA* (3.15) via a conductor between the source of the transient and the drain

3.18
machine type
machinery which does not differ in such essential respects as

— the structural shape,

— the general arrangement of the electrical and electronic components and the general wiring arrangement, or

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

3.19
ESA type
ESA (3.15) which does not differ in such essential respects as

— the function performed by the ESA,

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

— the primary material of the casing

3.20
operator control
control exercised by the operator by means of, for example, steering, braking, or propulsion control

Note 1 to entry: This also concerns movements of parts of the machine and modifications of the state of function, which can generate uncommanded, random or unresponsive machine operation (e.g. hazardous machine behaviour).

3.21
immunity-related functions

functions related to *operator control* (3.20), and to the direct control or operation of the machine by affecting visibility, or which, when disturbed, cause confusion to the operator or others nearby or to machine statutory data, and functions related to machine data bus functionality

Note 1 to entry: Immunity-related functions affecting visibility include driving lights, windscreen wipers and demisting systems.

Note 2 to entry: Immunity-related functions which, when disturbed, cause confusion to the operator or others neaby include the following:

— optical disturbances from incorrect operation of, for example, direction indicators, stop lamps, end outline marker lamps, rear position lamp, light bars for emergency system, wrong information from warning indicators, lamps or displays related to the functions of *operator control* (3.20);

— acoustical disturbances from incorrect operation of, for example, anti-theft alarms, horns;

— “reverse/movement alarm” devices.

Note 3 to entry: Machine data bus immunity-related functions are those that can block data transmission on machine data bus-systems used to transmit data, and which are required to ensure the correct functioning of other immunity-related functions.

Note 4 to entry: Immunity-related functions which, when disturbed, affect machine statutory data include hour meters and odometers.

3.22
non-immunity related functions
functions other than *immunity related functions* (3.21)

EXAMPLE Entertainment devices, air conditioning, fuel gauge.

4 Requirements

4.1 General requirements

4.1.1 Fulfilment of requirements

4.1.1.1 General

The user of this document shall prove compliance with the requirements by any one or a combination of

— testing the complete machine, as per 4.1.1.2, or

— testing ESA, as per 4.1.1.3, if the availability of an immunity test site proves restrictive due to machine size, regional environmental conditions or legal requirements.

Evaluations not restricted by the above may be made; however remaining gaps in the requirements should be evaluated at the ESA level.

NOTE In most regions of the world radiated immunity testing for large machines in open area test sites is legally prohibited. Below 1 GHz conducted testing methods are available as a substitute. Above 1 GHz there is no alternative to radiated immunity testing, and it is possible to perform the radiated immunity testing on ESA level in an anechoic chamber.

When testing ESA it recommended that the integrity of the final system when combined at machine level be tested.

The requirements of this document are also deemed to be fulfilled when the machinery has no such equipment for which an immunity or emission test is required. In this case, no tests are necessary. For all exceptions, see Clause 5.

4.1.1.2 Performance criteria for complete machines

The performance requirements are met if the machinery operates as intended and without unacceptable degradation when tested in accordance with the requirements of 4.2, 4.3, 4.4 and 4.8.

4.1.1.3 Performance criteria for ESA

The performance requirements of this document are met if the machine's ESA or separate ESA operate as intended and without unacceptable degradation for their application in machinery in accordance with the requirements of 4.5, 4.6, 4.7, 4.8 and 4.9.

4.1.2 Test specimen

The test specimen may be of a machine type or ESA type as defined in 3.18 and 3.19.

If a single test specimen is to be used to judge the performance of a population of like 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 any manufacturing variations of machine or ESA types and testing factors.

For a subsequent test on similarly configured machinery, conformity to the reference limits shall be accepted as fulfilment of the requirements of this document.

For electrostatic discharge and conducted transients, the reference limits are valid for all testing of any 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 machinery and any attachments or machinery shall remain functional so as to provide continued control of the 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 for broadband electromagnetic emission radiated from machinery

4.2.1 Method of measurement

The electromagnetic radiation shall be measured using the method specified in Annex B at either of the defined antenna distances. The choice of antenna distance is at the option of the user.

4.2.2 Broadband reference limits

For measurements made using the method specified in Annex B and a machinery-to-antenna spacing of (10,0 ± 0,2) m, the emission reference limit shall be

— 34 dB (μV/m) (50 μV/m) in the 30 MHz to 75 MHz frequency band,

— 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, and

— in the 400 MHz to 1 000 MHz frequency band, shall remain constant at 45 dB (μV/m) (180 μV/m).

For measurements made using the method specified in Annex B using a machinery-to-antenna spacing of (3,0 ± 0,05) m, the emission reference limit shall be

— 44 dB (μV/m) (160 μV/m) in the 30 MHz to 75 MHz frequency band,

— 44 dB (μV/m) to 55 dB (μV/m) (160 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, and

— in the 400 MHz to 1 000 MHz frequency band, shall remain 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.

NOTE The 20 % factor applies regardless of the use of CISPR 12:2007 or CISPR 12:2007+AMD1:2009.

4.3 Specifications concerning narrowband electromagnetic emission radiated from machinery

4.3.1 Method of measurement

The electromagnetic emission shall be measured using the method specified in Annex C, at either of the defined antenna distances. The choice of antenna distance is at the option of the user.

4.3.2 Narrowband reference limits

For measurements made using the method specified in Annex C using a machinery-to-antenna spacing of (10,0 ± 0,2) m, the emission reference limit shall be

— 24 dB (μV/m) (16 μV/m) in the 30 MHz to 75 MHz frequency band,

— 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, and

— in the 400 MHz to 1 000 MHz frequency band, shall remain constant at 35 dB (μV/m) (56 μV/m).