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Earth-moving machinery — Electromagnetic compatibility

Engins de terrassement — Compatibilité électromagnétique

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Foreword

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

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

International Standard ISO 13766 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*.

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

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Introduction

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

Electrical and high frequency interferences emerge during the normal operation of many parts of the earth-moving 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 electric/electronic devices and systems of the earth-moving machinery. Narrowband signals, generated by sources of interference inside or outside the earth-moving 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 earth-moving 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 earth-moving machinery often represent open systems and several devices and/or components of earth-moving machinery are combined with one another.

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

Because earth-moving machinery have a number of systems that consist of components that may be used on a number of different types of earth-moving machinery, the approach of defining "electrical/electronic systems or electronic subassemblies" 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 systems or electronic subassembly tests are conducted, it is necessary to consider the effects of the wiring systems used to connect the subassemblies into the earth-moving machinery. The tests may also be conducted on the earth-moving machinery.

This International Standard is intended to provide the necessary technical specifications to evaluate the electromagnetic performance of earth-moving machinery with respect to government electromagnetic performance laws, directives, rules and/or regulations. An example of such is the European Directive 89/336/EEC.

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Earth-moving machinery — Electromagnetic compatibility

1 Scope

This International Standard provides test methods and acceptance criteria for the evaluation of the electromagnetic compatibility of earth-moving machinery as defined in ISO 6165. The following electromagnetic phenomena are evaluated:

- broadband and narrowband electromagnetic interference,
- electromagnetic field immunity test,
- broadband and narrowband interference of electrical/electronic subassemblies,
- electromagnetic field immunity test of electrical/electronic subassemblies,
- electrostatic discharge,
- conducted transients.

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2 Normative references

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

ISO 5353:1995, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point.*

ISO 6165:1997, *Earth-moving machinery — Basic types — Vocabulary.*

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

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

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

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

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

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

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

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

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

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

IEC 60050-161:1990, *International Electrotechnical Vocabulary — Chapter 161: Electromagnetic compatibility.*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test.*

CISPR 12:1997, *Vehicles, motorboats and spark-ignited engine-drive devices — Radio disturbance characteristics — Limits and methods of measurement.*

CISPR 16-1:1998, *Specification for radio disturbance and immunity measuring apparatus and method — Part 1: Radio disturbance and immunity measuring apparatus.*

CISPR 25:1995 *Limits and method of measurement of radio disturbance characteristics for the protection of receivers used on board of vehicles.*

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3 Definitions

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

3.1

electromagnetic compatibility EMC

ability of an earth-moving machinery or (a) component(s) or (a) electrical/electronic systems or electronic subassemblies to function satisfactory in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

NOTE — Adapted from IEC 60050:1990, 161-01-07.

3.2

electromagnetic disturbance

any electromagnetic phenomenon which may degrade the performance of an earth-moving machinery or (a) component(s) or (a) electrical/electronic systems or electronic subassemblies

NOTES

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

2 Adapted from IEC 60050:1990, 161-01-05.

3.3

electromagnetic immunity

ability of earth-moving machinery or (a) components(s) or (a) electrical/electronic systems or electronic subassemblies to perform without degradation of performance in the presence of specific electromagnetic disturbances

NOTE — Adapted from IEC 60050:1990, 161-01-20.

3.4

electromagnetic environment

totality of electromagnetic phenomena existing at a given location

[IEC 60050:1990, 161-01-01]

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 being a half wave resonant dipole at 80 MHz, and for the frequency range above 80 MHz means a balanced half wave resonant dipole tuned to the measurement frequency

NOTE — See CISPR 16-1.

3.7**broadband emission**

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

[IEC 60050:1990, 161-06-11]

3.8**narrowband emission**

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

[IEC 60050:1990, 161-06-13]

3.9**electrical/electronic system**

electrical and/or electronic component(s) or set of components intended to be part of an earth-moving machinery, together with any electrical connections

3.10**electrical/electronic subassembly****ESA**

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

3.11**earth-moving machinery type**

earth-moving machinery which do not differ in such essential respects as:

- the structural shape;
- the general arrangement of the electrical and/or electronic components and the general wiring arrangement;
- the primary material of which the design of the earth-moving machinery consists (for example a 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

[IEC 60050:1990, 161-01/22]

3.14

conducted transients

transient voltage or current distributed in the power supply wiring of a machine via a conductor between the source of the transient and the receiver

4 Fulfilment of the requirements

The requirements of this International Standard are to be met by earth-moving machinery and its electric/electronic subassemblies when the machinery operates in conformity with its final purpose. The user of this International Standard may choose either of the following alternatives to give evidence of conformity with this International Standard:

- a) The performance requirements of this International Standard are met if the electrical/electronic systems or electronic subassemblies are in accordance with the applicable criteria of this International Standard and have been installed in accordance with the recommended requirements for the electronic subassembly.
- b) The performance requirements of this International Standard are met for a complete machine when the criteria, as applicable of this International Standard are fulfilled. In the case of the complete machine meeting the performance requirements of this International Standard, no measurement of the electrical/electronic systems or electronic subassemblies is required.

5 General tests requirements

5.1 Test specimen

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The test specimen may be chosen in accordance with definition 3.11 (earth-moving machinery type) and/or definition 3.12 (ESA type).

Because the test of single-test specimen is to be used to judge the performance of a population of like earth-moving 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 emissions and immunity due to manufacturing variations of earth-moving 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 International Standard.

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

5.2 Additional requirements for immunity tests

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

6 Test/measurement methods and reference limits

6.1 Broadband electromagnetic emission radiated from earth-moving machinery

6.1.1 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 this International Standard.

6.1.2 Broadband reference limits

If measurements are made using the method described in annex B using an earth-moving machinery-to-antenna spacing of $10 \text{ m} \pm 0,2 \text{ m}$, the emission reference limits shall be $34 \text{ dB}(\mu\text{V}/\text{m})$ ($50 \mu\text{V}/\text{m}$) in the 30 MHz to 75 MHz frequency band and $34 \text{ dB}(\mu\text{V}/\text{m})$ to $45 \text{ dB}(\mu\text{V}/\text{m})$ ($50 \mu\text{V}/\text{m}$ to $180 \mu\text{V}/\text{m}$) 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.1). In the 400 MHz to 1 000 MHz frequency band the limit remains constant at $45 \text{ dB}(\mu\text{V}/\text{m})$ ($180 \mu\text{V}/\text{m}$).

If measurements are made using the method described in annex B using an earth-moving machinery-to-antenna spacing of $3 \text{ m} \pm 0,05 \text{ m}$, the emission reference limits shall be $44 \text{ dB}(\mu\text{V}/\text{m})$ ($160 \mu\text{V}/\text{m}$) in the 30 MHz to 75 MHz frequency band and $44 \text{ dB}(\mu\text{V}/\text{m})$ to $55 \text{ dB}(\mu\text{V}/\text{m})$ ($160 \mu\text{V}/\text{m}$ to $562 \mu\text{V}/\text{m}$) 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.2). In the 400 MHz to 1 000 MHz frequency band the limit remains constant at $55 \text{ dB}(\mu\text{V}/\text{m})$ ($562 \mu\text{V}/\text{m}$).

On the test specimen, the measured values, expressed in $\text{dB}(\mu\text{V}/\text{m})$ ($\mu\text{V}/\text{m}$) shall be at least 2 dB below the reference limits.

6.2 Narrowband electromagnetic emission radiated from earth-moving machinery

6.2.1 Method of measurement

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

6.2.2 Narrowband reference limits

If measurements are made using the method described in annex C using an earth-moving machinery-to-antenna spacing of $10 \text{ m} \pm 0,2 \text{ m}$, the emission reference limits shall be $24 \text{ dB}(\mu\text{V}/\text{m})$ ($16 \mu\text{V}/\text{m}$) in the 30 MHz to 75 MHz frequency band and $24 \text{ dB}(\mu\text{V}/\text{m})$ to $35 \text{ dB}(\mu\text{V}/\text{m})$ ($16 \mu\text{V}/\text{m}$ to $56 \mu\text{V}/\text{m}$) 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.3). In the 400 MHz to 1 000 MHz frequency band the limit remains constant at $35 \text{ dB}(\mu\text{V}/\text{m})$ ($56 \mu\text{V}/\text{m}$).

If measurements are made using the method described in annex C using an earth-moving machinery-to-antenna spacing of $3 \text{ m} \pm 0,05 \text{ m}$, the emission reference limits shall be $34 \text{ dB}(\mu\text{V}/\text{m})$ ($50 \mu\text{V}/\text{m}$) in the 30 MHz to 75 MHz frequency and $34 \text{ dB}(\mu\text{V}/\text{m})$ to $45 \text{ dB}(\mu\text{V}/\text{m})$ ($50 \mu\text{V}/\text{m}$ to $180 \mu\text{V}/\text{m}$) 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.4). In the 400 MHz to 1 000 MHz frequency band the limit remains constant at $45 \text{ dB}(\mu\text{V}/\text{m})$ ($180 \mu\text{V}/\text{m}$).

On the test specimen, the measured values, expressed in $\text{dB}(\mu\text{V}/\text{m})$ ($\mu\text{V}/\text{m}$), shall be at least 2 dB below the reference limits.

6.3 Immunity of earth-moving machinery to electromagnetic radiation

6.3.1 Test method

The immunity to electromagnetic radiation of the earth-moving machinery shall be tested in accordance with ISO 11451-1 and ISO 11451-2 with horizontal and vertical polarisation. (Immunity testing should be conducted as outlined in ISO 11451-1, except that forward power may be used as the control regardless of the standing wave ratio of the system.) The determination of the reference point and relevant operating mode shall be machine-specific, as specified in this International Standard. 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 shall be done in the frequency band of 20 MHz to 1 000 MHz.

6.3.2 Earth-moving machinery immunity reference limits

Reference limit $24 \text{ V}/\text{m}$ (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. The immunity requirements are fulfilled by a field strength of $30 \text{ V}/\text{m}$ (25 % above the reference limit). The general requirements for immunity testing given in 5.2 shall be fulfilled.

6.4 Broadband electromagnetic emissions radiated from ESA's

6.4.1 Method of measurement

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

6.4.2 ESA broadband reference limits

If measurements are made using the method described in annex D, the emission reference limits shall be 64 dB(μ V/m) to 54 dB(μ V/m) (1 600 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 1 800 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 1 000 MHz frequency band the limits remains constant at 65 dB(μ V/m) (1 800 μ V/m).

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

6.5 Narrowband electromagnetic emissions radiated from ESA's

6.5.1 Method of measurement

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

6.5.2 ESA narrowband reference limits

If measurements are made using the method described in annex E, the emission reference limits shall be 54 dB(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 1 000 MHz frequency band the limit remains constant at 55 dB(μ V/m) (562 μ V/m). <https://standards.iteh.ai/catalog/standards/sist/29497a1e-ccc5-43ba-af73-5d74605150f/iso-13766-1999>

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

6.6 Immunity of ESA's to electromagnetic radiation

6.6.1 Test method

For the testing of the immunity of ESA to electromagnetic fields, the test methods specified in ISO 11452-2, ISO 11452-3, ISO 11452-4 or ISO 11452-5 apply. Immunity testing should be conducted in accordance with ISO 11452-1 except forward power may be used as the control regardless of the standing wave ratio of the system. The chosen combination shall cover the 20 MHz to 1 000 MHz band. 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.

6.6.2 ESA immunity reference limits

The reference limits apply to the root mean square values of the unmodulated signal. The maximum value of the test signal with modulation shall comply with the maximum value of an unmodulated test signal. If tests are made in accordance with ISO 11452, parts 1 to 5, the immunity reference limits are:

- 48 V/m for the 150 mm stripline test method (ISO 11452-5),
- 60 V/m for the TEM cell test method (ISO 11452-3),
- 48 mA for the Bulk Current Injection (BCI) test method (ISO 11452-4), and,
- 24 V/m for the radiated field (absorber lined chamber) test method (ISO 11452-2).

Functional status class A applies to all tests. The reference limits increased by 25 % apply for the test specimen. The ESA shall not exhibit any operational change which is unacceptable for its application on the earth-moving machinery. See 5.2 for further definition of operational change which is unacceptable.

6.7 Electrostatic discharge (ESD)

6.7.1 Test method

The method described in IEC 61000-4-2 is used as the method of measurement of the earth-moving machinery or on the component in such areas where an ESD in standard use is possible (e.g. by touching by the operator).

6.7.2 Reference limits

Test level I (± 4 kV) at functional status class A as specified in IEC 61000-4-2 applies.

6.8 Conducted transients

6.8.1 General

With remotely located ESA connected to the earth-moving machinery only through the wiring system, there is a possibility of pulse generated in a remote ESA to energize the circuit and affect other ESA's or components on the earth-moving machinery. Therefore, minimum values concerning emission and susceptibility for ESA's and earth-moving machinery are required.

6.8.2 Test method

The method described in ISO 7637-0, ISO 7637-1 and ISO 7637-2, is used as the test method. For the test of conducted transients, the ESA's can be installed on the earth-moving machinery.

6.8.3 Reference limits

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

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

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