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

Part 2: Additional EMC requirements for functional safety

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

Partie 2: Exigences CEM supplémentaires pour les fonctions de sécurité

Reference number
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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 13766-2:2018, together with ISO 13766-1:2018, 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 construction machinery operates, there is a need to ensure that the machinery is provided with adequate immunity to electromagnetic disturbances. As more machinery is fitted with electrical and electronic devices, it is also necessary to ensure that the internal electromagnetic interference caused by emissions of subsystems of the machinery itself (machine disturbance) does not exceed the immunity of the respective subsystems.

The electrical and high-frequency disturbances covered by this document refer to electromagnetic effects caused due to technical appliances (man-made effects). These effects generally can be considered as singular ones and additionally are located and restricted to defined narrowly defined areas.

While these effects on machinery cannot be considered as being general, their consequences on machinery still need to be taken into account. They might be generated within a large frequency range with different electrical characteristics or by conduction or radiation, and then imparted to other electrical/electronic devices and systems by conduction or radiation. Narrowband, and sometimes broadband, signals generated by sources of interference inside or outside the machinery can also be coupled in electrical/electronic systems and 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.

This document provides information on the kind and the level of effects as presently known. Indicative test methods and criteria can derive from these values, given that possible test levels acceptable for the machinery and, in the case of testing conducted on a voluntary basis, considering the unique characteristics and operating parameters of the machinery. However, the functions of the machinery

are not evaluated by testing alone. Functional safety with respect to EMC phenomena can also be achieved by organizational measures on the job site where the machinery is located and in use.

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 electrical/electronic sub-assemblies (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.

Programmable electronic systems (PES) as defined in ISO 13849-1:2015 and intended for use as a safety-related part of a machine control system (SRP/CS) as defined in ISO 15998:2008 have a specification of intended functionality. If a disturbed function will become dangerous or not is sometimes unknown to the manufacturer of the PES because it depends on the future application in a safety-related system of the whole machine.

Testing according to this document is required to be performed so that the behaviour of the PES in that safety-related system can be demonstrated.

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

Part 2: Additional EMC requirements for functional safety

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 classified 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 EMC requirements related to the functional safety of the machinery, its electrical/electronic subassemblies (ESA) and of separate ESA.

This document is relevant only to the safety-related parts of control systems (SRP/CS) as defined in ISO 13849-1:2015 using electrical/electronic components which meet design requirements equal to or greater than safety-related performance level PL b as defined in ISO 13849-1:2015. It also deals with electrical and electronic components or separate ESA intended to be fitted on machinery under the restriction of PL b. The following electromagnetic disturbance phenomena are evaluated:

— radiated electromagnetic fields from off-board sources with various field strengths and frequencies;

— radiated electromagnetic fields from on-board sources (antenna inside/outside) with various field strengths and frequencies;

— electrostatic discharge;

— conducted and coupled electrical 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 Grid-connected machines are covered by IEC 61000.

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 7637-3:2016, *Road vehicles — Electrical disturbances from conduction and coupling — Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines*

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

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 11452-2:2004, *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 13766-1:2018, *Construction machinery — Electromagnetic compatibility of machines with internal electrical power supply — Part 1: General EMC requirements under typical EMC environmental conditions*

ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 15998:2008, *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms, definitions and abbreviated terms given in ISO 6165:2012, ISO/TR 12603:2010, ISO 13766-1:2018 and ISO 13849-1:2015, 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
bulk current
total amount of common mode current in a harness

3.2
PM
pulse modulation

3.3
AM
amplitude modulation

3.4
fail safe
FS
behaviour of the safety-related machine/control system using electrical/electronic components to enter into a safe state as defined by the methodology of ISO 13849-1:2015

4 General principles

The functional safety of machinery and systems is sufficiently covered in other International Standards. However, those standards consider neither

— the effects of electromagnetic fields on the particular aspects of earth-moving and construction machinery, nor

— the effect of EMC phenomena on the functional safety of the safety-related machine controls of this machinery using electrical/electronic components.

The EMC phenomena covered by this document need to be evaluated in terms of their effect on the functional safety of the machine controls in order to represent the totality of all significant technically occurring and known such phenomena.

The performance parameters linked to these phenomena thereby represent the generally known and normally non-military technical performance measures (magnitudes).

Testing shall be at the levels specified in Clause 5 for all functions with a required performance level greater than or equal to performance level PL b as defined in ISO 13849-1:2015, thereby verifying that the machine is able to either maintain the function as intended by the manufacturer or to perform a changeover into the defined *safe state-condition* according to ISO 13849-1:2015.

For ESA testing, it is required that the machine level behaviour of immunity failures be determined for the device under test, e.g. a corrupted signal from a controller could cause a loss of braking or steering.

5 EMC phenomena

5.1 General

The electrical and high-frequency disturbances described in this document refer to electromagnetic effects caused due to technical applications (man-made effects). These effects generally can be considered as singular and additionally located, and as being restricted to narrowly defined areas.

These strong electromagnetic disturbances can cause systematic or “common-cause” faults.

The following subclauses present known technically induced EMC phenomena and quantify these, indicating their typical values under the aspect of functional safety.

Compliance with the requirements of this document shall be proven by means of any one or a combination of

— testing of the complete machine as per 5.1.1, below, or

— testing safety relevant ESA as per 5.1.2, below, 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 shall 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.