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Earth-moving machinery — Collision warning and avoidance —

Part 1: General requirements

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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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety, ergonomics and general requirements*, in collaboration with Technical Committee ISO/TC 82, *Mining*, Subcommittee SC 8, *Advanced automated mining systems*, ISO/TC 195, *Building construction machinery and equipment* and ISO/TC 195 Building construction machinery and equipment, Subcommittee SC 3 *Drilling and foundation machinery and equipment*.

A list of all parts in the ISO 21815 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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

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.

In addition, this document is intended for standardization bodies elaborating type-C standards.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines which are covered by the scope of a type-C standard and which have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.

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.

Increasing use of detection systems and avoidance technology in the area of earth-moving machinery has been supporting operators to safely operate machines in the field of mining and construction. At the same time, there are demands to set standards for machines and systems detecting, alerting and intervening to mitigate collision risk.

There are currently two existing standards in the field: ISO 16001 and ISO 17757. These standards provide guidance for visibility aids and object detection systems and for autonomous and semi-autonomous machines, however, there is currently no standard that describes collision risk awareness, warning signals and collision avoidance actions of the machinery operated by humans when there is a risk of collision.

Collision warning and avoidance system is a developing technology and algorithms are not yet mature and well understood. This document is intended to foster innovation and accelerate the pace of improvements in new collision warning and avoidance technologies. The performance requirements of this document are technology-neutral and do not specify technologies to make the requirements.

The systems described in this document are intended to assist the operator of the machine. As current technologies are unable to achieve full collision warning/avoidance in every situation, the responsibility for safe operation of the machine remains with the operator of the machine.

This document is a part of the ISO 21815 series relating to: communication interfaces, collision risk areas and collision risk levels, specific requirements for collision warning and collision avoidance systems, and specific use case requirements.

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Earth-moving machinery — Collision warning and avoidance —

Part 1: General requirements

1 Scope

This document provides terminology and general guidance on the principles of collision warning and collision avoidance systems for:

- earth moving machinery as defined in ISO 6165,
- mobile underground mining machinery as defined in ISO 19296, and
- road construction machinery as defined in ISO 22242.

This document provides general requirements for detection of objects, warnings to the operator, automatic intervention control to avoid collision, and test procedures. It is intended to be used in conjunction with the other parts of the ISO 21815 series, which provide detailed guidance and requirements for collision warning and collision avoidance systems and determining risk areas and risk levels. The specific requirements and definitions for particular types of machines are defined in the use case parts of the ISO 21815 series.

This document covers collision avoidance by speed reduction or motion inhibit: it does not cover avoidance by automatic manoeuvring (e.g. steering) away from the intended object.

The systems described in this document are only intended to assist the operator of the machine. The responsibility for safe operation of the machine remains with the operator of the machine.

This document is not applicable to collision warning and collision avoidance systems installed to the machine before the date of its publication.

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 3450:2011, *Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems*

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

ISO 13766-1, *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*

ISO 13766-2, *Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply — Part 2: Additional EMC requirements for functional safety*

ISO 13849 (all parts), *Safety of machinery — Safety-related parts of control systems*

ISO 19014-1, *Earth-moving machinery — Functional safety — Part 1: Methodology to determine safety-related parts of the control system and performance requirements*

ISO 19014-3, *Earth-moving machinery — Functional safety — Part 3: Environmental performance and test requirements of electronic and electrical components used in safety-related parts of the control system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 interaction

situation where a machine encounters an *intended object* (3.5) when moving or about to move, placing itself or the operator at risk, or exposing the intended objects to risk

3.2 warning

transmission of alert information by visual, audible or other means of signals

Note 1 to entry: Warning is targeted to the operator and also can be for people located in close proximity to the machine in addition to operator.

3.3 evasive action

action initiated by the operator to attempt to prevent or avoid a foreseeable collision

EXAMPLE Braking, steering.

3.4 interventional collision avoidance action

automatic action initiated by a *collision avoidance system (CAS)* (3.9) to attempt to prevent or avoid a foreseeable collision

EXAMPLE Braking, inhibiting motion, slowing down.

3.5 intended object

object, such as a person, machine, vehicle or obstacle, which is intended to be detected by a *collision warning system (CWS)* (3.8) or a *collision avoidance system (CAS)* (3.9) when in the *collision risk area* (3.7)

3.6 collision risk level

value that is assigned each *intended object* (3.5) to determine if a collision is foreseeable

Note 1 to entry: Collision risk levels are described in ISO 21815-3 and a future part of the ISO 21815 series dedicated to risk area and risk level for track movement and swing/rotation.

3.7 collision risk area

space analysed to determine the *collision risk level* (3.6)

3.8 collision warning system

CWS

system which detects *intended objects* (3.5) in the *collision risk area* (3.7), determines the *collision risk level* (3.6) and provides a *warning* (3.2) to the operator

3.9 collision avoidance system CAS

system which detect *intended objects* (3.5) in the *collision risk area* (3.7), determine the *collision risk level* (3.6) and provides *interventional collision avoidance action* (3.4)

3.10

CxS

collision warning system (CWS) (3.8) or *collision avoidance system (CAS)* (3.9) or a system providing both

3.11

detection

acknowledgement of *intended objects* (3.5) by a CxS (3.10)

3.12

CxS action

collision warning system (CWS) (3.8) providing *warning* (3.2) to the operator or *collision avoidance system (CAS)* (3.9) taking *interventional collision avoidance action* (3.4)

3.13

false positive CxS action

unnecessary or inappropriate CxS action (3.12)

Note 1 to entry: This can be caused by incorrect determination of the *collision risk level* (3.6).

3.14

false negative CxS action

lack of necessary or appropriate CxS action (3.12)

Note 1 to entry: This can be caused by incorrect determination of the *collision risk level* (3.6).

3.15

CxS device

CxD

device with sensors providing CxS (3.10) functions to detect *intended objects* (3.5) in the proximity of the machine, determine the *collision risk level* (3.6), warn the operator of the presence of the intended object for a *collision warning system (CWS)* (3.8), and/or provide signals to the machine control system via a communication interface to initiate the appropriate *interventional collision avoidance action* (3.4) on the machine for a *collision avoidance system (CAS)* (3.9)

Note 1 to entry: CxS device is described as CxD in other parts of the ISO 21815 series.

Note 2 to entry: Proximity detection system (PDS) is a colloquial industry term for a physical device providing CWS or CAS functionality.

3.16

normal mode

operational mode whereby a CxS (3.10) is active and ready to provide all functions of the CxS, including *warning* (3.2) information and *interventional collision avoidance action* (3.4)

3.17

stand-by mode

operational mode selected by an authorized person, whereby a CxS (3.10) can be active, but *warning* (3.2) information or *interventional collision avoidance action* (3.4) or both are not provided by the system, and returns to *normal mode* (3.16) by an authorized person

3.18

override mode

operational mode selected by the operator, whereby a CxS (3.10) can be active, but *warning* (3.2) information or *interventional collision avoidance action* (3.4) or both are suspended temporarily and return automatically to *normal mode* (3.16) after a certain condition