
**Earth-moving machinery and
mining — Autonomous and semi-
autonomous machine system safety**

*Engins de terrassement et exploitation minière — Sécurité de système
de machine autonome et semi-autonome*



This document is a preview generated by EBS



COPYRIGHT PROTECTED DOCUMENT

© ISO 2017, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms, definitions and abbreviated terms	2
4 Safety requirements and/or protective/risk reduction measures	6
4.1 General.....	6
4.2 Stop systems.....	6
4.2.1 General.....	6
4.2.2 All-stop system.....	6
4.2.3 Remote stop system.....	6
4.3 Warning devices and safety signs.....	6
4.3.1 Visual indicators.....	6
4.3.2 Audible alarms.....	7
4.3.3 Safety signs.....	7
4.4 Fire protection.....	7
4.5 Machine access systems.....	7
4.6 Braking and steering.....	7
4.6.1 General.....	7
4.6.2 Braking.....	8
4.6.3 Steering.....	8
4.7 Adaptation to environmental conditions.....	9
4.8 On-board electrical power.....	9
4.8.1 General.....	9
4.8.2 Requirements.....	9
5 Positioning and orientation (POSE)	10
5.1 General.....	10
5.2 Risk and failure modes.....	10
5.3 Requirements.....	10
6 Digital terrain map (DTM)	10
6.1 General.....	10
6.2 Requirements.....	11
7 Perception	11
7.1 General.....	11
7.2 Risk and failure modes.....	11
7.2.1 Failure to detect or late detection of an object.....	11
7.2.2 False detection of non-existent object.....	12
7.2.3 Erroneous location of a detected object.....	12
7.2.4 Misclassification of an object.....	12
7.3 Requirements.....	12
8 Navigation system	12
8.1 General.....	12
8.2 Risks.....	13
8.3 Requirements.....	13
9 Task planner	13
9.1 General.....	13
9.2 Risks.....	13
9.3 Requirements.....	13
10 Communications and networks	14
10.1 General.....	14

10.2	Risk and failure modes.....	14
10.2.1	Risks.....	14
10.2.2	Failure modes.....	14
10.2.3	Potential causes.....	15
10.3	Communication systems requirements.....	15
10.3.1	Communication security.....	15
10.3.2	Communication security.....	15
10.4	Safety messages.....	15
11	ASAM supervisor system.....	16
11.1	General.....	16
11.2	Requirements.....	16
12	AOZ access, permissions and security.....	17
12.1	Permissions and security.....	17
12.2	AOZ access and warnings.....	17
12.3	Operational risks.....	17
12.4	Mode changes.....	18
13	ASAMS site operating procedures.....	18
13.1	General.....	18
13.2	Incident recording.....	18
13.3	Commissioning.....	18
13.4	Documentation and training.....	18
13.4.1	Documentation.....	18
13.4.2	Training.....	19
14	Operational hazard controls.....	19
15	Verification of safety requirements and/or protective/risk reduction measures.....	19
16	Information for use.....	20
16.1	Safety labels and machine markings.....	20
16.2	User manual.....	20
Annex A (informative) List of significant hazards.....		21
Annex B (informative) Safety and the risk management process.....		23
Annex C (informative) Integration of ASAMS into the site planning process.....		26
Annex D (informative) Access control systems.....		28
Annex E (informative) Change management — Example for mining.....		30
Annex F (informative) Supervision.....		32
Annex G (informative) Commissioning.....		33
Annex H (informative) Operational hazard controls.....		35
Bibliography.....		36

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 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.

This document was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety, ergonomics and general requirements*.

Introduction

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

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 -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.

Mining input for this document was obtained through liaisons with the GMSG (global mining standards and guidelines group) and the Western Australia Mobile Autonomous Machine Systems Working Group.

Earth-moving machinery and mining — Autonomous and semi-autonomous machine system safety

1 Scope

This document provides safety requirements for autonomous machines and semi-autonomous machines used in earth-moving and mining operations, and their autonomous or semi-autonomous machine systems (ASAMS). It specifies safety criteria both for the machines and their associated systems and infrastructure, including hardware and software, and provides guidance on safe use in their defined functional environments during the machine and system life cycle. It also defines terms and definitions related to ASAMS.

It is applicable to autonomous and semi-autonomous versions of the earth-moving machinery (EMM) defined in ISO 6165 and of mobile mining machines used in either surface or underground applications. Its principles and many of its provisions can be applied to other types of autonomous or semi-autonomous machines used on the worksites.

Safety requirements for general mobile EMM and mining machines, as well as operators, trainers or passengers on the machine, are given by other International Standards (e.g. ISO 20474, ISO 19296). This document addresses additional hazards specific and relevant to ASAMS when used as intended.

It is not applicable to remote control capability (covered by ISO 15817) or function-specific automated features, except when those features are used as part of ASAMS.

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 2867, *Earth-moving machinery — Access systems*

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

ISO 5010:2007, *Earth-moving machinery — Rubber-tyred machines — Steering requirements*

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

ISO 9533, *Earth-moving machinery — Machine-mounted audible travel alarms and forward horns — Test methods and performance criteria*

ISO 10265:2008, *Earth-moving machinery — Crawler machines — Performance requirements and test procedures for braking systems*

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

ISO 19296, *Mining and earth-moving machinery — Mobile machines working underground — Machine Safety*¹⁾

ISO 20474-1, *Earth-moving machinery — Safety — Part 1: General requirements*

1) Under preparation.