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Agricultural machinery and tractors — Safety of highly automated agricultural machines — Principles for design

Tracteurs et matériels agricoles — Sécurité des machines hautement automatisées — Principes de conception

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Contents

Page

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.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 3, *Safety and comfort*.

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-B1 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 structure of safety standards in the field of machinery is as follows.

— Type-A standards (basis standards) give basic concepts, principles for design, and general aspects that can be applied to machinery.

— Type-B standards (generic safety standards) deal with one or more safety aspects or one or more types of safeguards that can be used across a wide range of machinery:

  — Type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

  — Type-B2 standards on safeguards (e.g. two-hands controls, interlocking devices, pressure sensitive devices, guards).

— Type-C standards (machinery safety standards) deal with detailed safety requirements for a particular machine or group of machines.

Highly automated agricultural machine operations are an enabling technology. Customer benefits are increased; productivity and increased operator comfort.

Highly automated operation is a departure from traditional machine applications in the agricultural machinery and mobile equipment sectors that up to now required an on-board operator to perform work. Highly automated operations require unique safety considerations.

The objective of this document is to specify principles for the design of highly automated agricultural machine operations to achieve safe operation. Should requirements of this document for highly automated operation be different from those which are stated in a machine-specific standard dealing with highly automated operation, the requirements of the machine-specific standard take precedence over the requirements of this document.

Agricultural machinery and tractors — Safety of highly automated agricultural machines — Principles for design

1 Scope

This document specifies principles for the design of highly automated aspects of highly automated machines and vehicles (e.g. agricultural tractors, tractor implement systems, implements and self-propelled machinery) during agricultural field operations. In addition, it provides guidance on the type of information on safe working practices (including information about residual risks) to be provided by the manufacturer.

The purpose of this document is to assist in the provision of safety requirements, means of verification and information for use to ensure an appropriate level of safety for agricultural and forestry tractors and self-propelled machines with functions allowing highly automated operations (see 3.7).

This document deals with all the significant hazards, hazardous situations and events (as listed in Annex A), relevant to agricultural and forestry tractors and self-propelled machines allowing highly automated field operations when used as intended and under the conditions of misuse foreseeable by the manufacturer during normal operation and service.

NOTE 1   While this document gives principles for the design, verification, validation and provision of information for use of a highly automated agricultural machine (HAAM), the detailed specification of requirements for a specific application will be dependent on the machine and its operating conditions. Therefore, the principles for design given in this document need to be extended for specific HAAM by the use of relevant specific (type-C) standards, when available, or by the manufacturer of the machine using risk assessment. Such additional specification of requirements, for design, verification, validation or information for use are outside the scope of this document.

NOTE 2   Safety requirements for specific machines not related to their highly automated operations can be available in machine-specific type-C standards.

This document is not applicable to:

— forestry applications;

— mobile, semi-mobile or stationary machinery used for farm yard or barn operations;

— operations on public roads including relevant requirements for braking and steering systems.

NOTE 3   With respect to implements (e.g. their specific design, functions) and the communication between tractors and implements, additional risks can be relevant and can require additional measures. Such additional measures are outside the scope of this document and are the responsibility of the manufacturer.

This document is not applicable to agricultural and forestry tractors, tractor implement systems, implements and self-propelled machines which are manufactured 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 3767-1, *Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Symbols for operator controls and other displays — Part 1: Common symbols*

ISO 3767-2, *Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Symbols for operator controls and other displays — Part 2: Symbols for agricultural tractors and machinery*

ISO 4254-1, *Agricultural machinery — Safety — Part 1: General requirements*

ISO 7731:2003, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

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

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

ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 25119 (all parts), *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems*

ISO 26322-1, *Tractors for agriculture and forestry — Safety — Part 1: Standard tractors*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4254-1, ISO 12100 and ISO 26322-1 and the following apply.

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

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

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

3.1
audible alarm
signal that is intended to be detected by the human sense of hearing

3.2
communication
information or data transmitted by a data network

3.3
disabled state
machine state in which *highly automated operation* (3.8) is not allowed

3.4
enabled state
machine state in which *highly automated operation* (3.8) is allowed

3.5
guarding system
system that reacts to information received from the *perception system* (3.14) to avoid contact

3.6
hazard zone
area which is a subset of the *warning zone* (3.19) and where if an *obstacle* (3.12) is within that area, then the potential for injury can exist due to movement of the machine or implement

3.7
highly automated agricultural machine
HAAM
mobile vehicle or machine with or without on-board operator allowing *highly automated operation* (3.8)

3.8
highly automated operation
function that is controlled by a control system without direct human input from local or *remote operator* (3.15), does not require an on-board operator for primary control, does or does not include an on-board operator station, and is subject to a *supervisory system* (3.17)

3.9
impaired state
point of degradation where *highly automated operation* (3.8) can no longer be completed safely in the current conditions

3.10
local operator
human in primary control of a machine through the on-board operator controls or through *pendant control* (3.13)

3.11
machine motion control
control of the unshielded highly automated machine components

EXAMPLE   Working tools.

3.12
obstacle
object or ground condition which can cause harm, or is harmed, if it comes into contact or collision with the highly automated machinery

3.13
pendant control
wireless or wired hand-held control unit with interfaces to the control system and with only local operation allowed

3.14
perception system
system that gathers and processes information about the environment in which the machine is operating

3.15
remote operator
human who is

— in primary control of a machine through the *supervisory system* (3.17),

— receiving data for the purpose of supervising machine activity, and

— is not on the machine but is located in the field, close to the field, or away from the field

3.16
safe state
operating state of a system with acceptable level of risk for operator or bystander even when the control system fails or partly fails

[SOURCE: ISO 11783-14:2013, 3.10, modified — in the definition, "operating mode" has been changed to "operating state".]

3.17
supervisory system
means to inform the operator responsible for the *highly automated operation* (3.8) about the machine and its operational status

3.18
visual alarm
signal that is intended to be detected by the human sense for sight

3.19
warning zone
area where if an *obstacle* (3.12) is within and no action is taken, then the obstacle might enter the *hazard zone* (3.6)

3.20
wheel motion control
control of the highly automated machine moving with a direction and speed across the ground

4   Safety requirements and protective or risk reduction measures

4.1   General

The highly automated agricultural machine (HAAM) shall comply with the relevant portions of machine-specific safety standards [e.g. ISO 4254 (all relevant parts), ISO 26322 (all relevant parts)] and the safety requirements and protective or risk reduction measures of 4.2 to 4.13. In addition, the HAAM shall be designed according to the principles of ISO 12100 for relevant but not significant hazards which are not dealt with by this document.

Requirements based on the principles for design given in this document may be dependent on the type of machine and the necessary operating conditions. When this applies, the specification of requirements and corresponding verification procedures shall be determined using risk assessment. Machine specific type-C standards, when available, can give machine specific requirements.

NOTE   The application of the risk assessment by the manufacturer is relevant for the application of this document in general to develop the given design principles into detailed machine specific requirements. Specific examples are 4.4.2.2.1 (pre-start and total warning time), 4.4.2.6 (safe state), 4.4.2.8 (safe state and duration of loss of communication), 4.4.3.2.1 (pre-start and warning time), 4.4.3.3.1 (pre-start and warning time), 4.4.3.6 (safe state), 4.4.3.9 (time delay and safe state), 4.6, 4.7 and 4.11.3.2 (safe state and enabling subsequent highly automated operation), 4.10 (time delay between loss of communication and safe state), 4.12 (safe state).

4.2   Principles for protection

For ensuring an appropriate level of safety:

— the HAAM shall be provided with a perception system capable of detecting and locating persons or other obstacles relative to the machine;

— the HAAM shall be provided with a perception system capable of locating and positioning the HAAM as required for the operations involved while preventing unintended excursions beyond the boundary of the working area;

— before each movement of the HAAM, it shall be ensured, by the safeguarding system, that there is no obstacle in the hazard zone;

— while performing highly automated operations, the HAAM shall, when an obstacle is detected in or enters the hazard zone, give an audible or visual alarm and enter its defined safe state;

— the HAAM shall be provided with the means to enable a local or remote operator to stop or start highly automated operation;

— the HAAM shall allow adequate supervision by a local or remote operator.

4.3 Machine enabling operations

4.3.1 General requirements

The HAAM shall be equipped with a means to enable and disable highly automated operations. The means provided shall be:

— easily identifiable;

— readily accessible by the operator;

— installed on the HAAM or in the cab (if provided) or at the operator station (if provided) or available to the remote operator;

— protected against unintentional actuation.

4.3.2 Labelling and identification

Symbols shall comply with ISO 3767-1 and ISO 3767-2. The HAAM state indicators shall be unambiguous and easily identifiable.

4.3.3 Functional requirements

Available control states shall include highly automated system disabled and highly automated system enabled.

In the disabled state, all highly automated machine operations shall be stopped and disabled. In the enabled state, highly automated operations shall be permitted.

Only the local operator shall be able to enable the highly automated machine.

It shall always be possible to disable the highly automated operation either at the local operator position and, for remote supervision, at the remote operating position.

4.4 Operational procedures

4.4.1 General requirements

It shall not be possible to initiate highly automated operation without the perception system confirming that the hazard zone is obstacle-free. In addition, initiating highly automated operation shall require confirmation by a local operator unless it can be shown by risk assessment that no significant hazards will arise.

When a highly automated operation is stopped (whatever the reason), the procedure for restarting the highly automated operation shall require initiation by the operator.

4.4.2 Automated engine control

4.4.2.1 General

Automated engine control shall only be allowed when highly automated operations are enabled.

Engine start requirements also apply to the engagement of the machine's power source (for example, main contact closing on a battery powered system).