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International Standard

ISO/FDIS 18497-1

Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery —

Part 1: Machine design principles and vocabulary

Tracteurs et matériels agricoles — Sécurité des machines partiellement automatisées, semi-autonomes et autonomes —
Partie 1: Principes de conception des machines et vocabulaire

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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 144, *Tractors and machinery for agriculture and forestry,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 18497-1, together with ISO 18497-2, ISO 18497-3 and ISO 18497-4, cancels and replaces ISO 18497:2018, which has been technically revised.

The main changes are as follows:

— machine design principles and vocabulary were made as its own part (i.e. ISO 18497-1) and substantially revised to account for the wide range of functionality and use cases within agricultural machines and tractors.

A list of all parts in the ISO 18497 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-B1 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.

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.

The purpose of the ISO 18497 series is to establish general design principles for partially automated, semi-autonomous and autonomous (see Clause 3) functions of agricultural machinery and tractors.

Manual non-automated functions are addressed in existing agricultural machinery and tractor safety standards. Due to the potential number of different functions of agricultural machinery and tractors and the mixed type and mode to which these functions can exist, it is necessary to establish general design principles. In this way, the combination, operator location, and types of interaction of these functions can be guided so that further type-C safety standards can be developed consistently and explicitly to address the mitigation of risk of injury to operators and bystanders. This is the primary focus of safety standards. Attempting to specify risk mitigation requirements based on combinations of type and mode of functions alone cannot be accomplished accurately for all agricultural machinery and tractors due to the wide variety of the machinery and variety of functionality.

Therefore, the familiar representation of SAE J3016[1] with six levels of automation was deliberately not chosen as a basis for the ISO 18497 series. It is necessary to develop more specific type-C safety standards,

using the general design principles of this document, to adequately account for the risks of agricultural machinery and tractors used in a specified way with various types of partially automated, semi-autonomous and autonomous functions.

When the requirements of the ISO 18497 series for partially automated, semi-autonomous and autonomous functions of agricultural machinery and tractors are different from those which are stated in a machine-specific type-C standard dealing with partially automated, semi-autonomous and autonomous functions of agricultural machinery and tractors, the requirements of the machine-specific standard take precedence over the requirements of the ISO 18497 series.

Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery —

Part 1:
Machine design principles and vocabulary

1 Scope

This document specifies principles for the design of agricultural machinery and tractors that are used in agricultural applications and that have partially automated, semi-autonomous and autonomous functions. Additionally, it provides guidance on the type of information to be provided by the manufacturer on safe working practices (including information about residual risks).

The purpose of this document is to assist in the provision of more specific safety requirements, means of verification and information for use to ensure an appropriate level of safety for agricultural machinery and tractors with partially automated, semi-autonomous and autonomous functions used in a specified way.

This document deals with the significant hazards relevant to agricultural machinery and tractors with partially automated, semi-autonomous and autonomous functions when used as intended and under the conditions of misuse reasonably foreseeable by the manufacturer during normal operation and service.

Applicability of the design principles and any additional detailed requirements for design, verification, validation or information for use are outside the scope of this document. When risk assessment concludes that hazards are not significant hazards, the principles of this document do not apply.

NOTE Safety requirements for specific non-automated functions of agricultural machinery and tractors can be available in machine-specific type-C standards.

This document is not applicable to:

— forestry applications;

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

This document is not applicable to agricultural machinery and tractors which are manufactured before the date of its publication, or to systems applied to agricultural machinery and tractors put into use 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 3767-1:2016, *Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Symbols for operator controls and other displays — Part 1: Common symbols*

ISO 3767-1:2016/Amd 1:2020, *Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Symbols for operator controls and other displays — Part 1: Common symbols — Amendment 1*

ISO 3767-2:2016, *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 3767-2:2016/Amd 1:2020, *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 — Amendment 1*

ISO 4254-1:2013, *Agricultural machinery — Safety — Part 1: General requirements*

ISO 4254-1:2013/Amd 1:2021, *Agricultural machinery — Safety — Part 1: General requirements – Amendment 1*

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

ISO 13849-1:2023, *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 18497-2:2024, *Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery — Part 2: Design principles for obstacle protective systems*

ISO 18497-3:2024, *Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery — Part 3: Autonomous operating zones*

ISO 18497-4:2024, *Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery — Part 4: Verification methods and validation principles*

ISO 25119-1:2018, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 1: General principles for design and development*

ISO 25119-1:2018/Amd 1:2020, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 1: General principles for design and development — Amendment 1*

ISO 25119-2:2019, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 2: Concept phase*

ISO 25119-3:2018, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 3: Series development, hardware and software*

ISO 25119-3:2018/Amd 1:2020, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 3: Series development, hardware and software — Amendment 1*

ISO 25119-4:2018, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 4: Production, operation, modification and supporting processes*

ISO 25119-4:2018/Amd 1:2020, *Tractors and machinery for agriculture and forestry — Safety-related parts of control systems — Part 4: Production, operation, modification and supporting processes — Amendment 1*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4254-1:2013, ISO 4254-1:2013/Amd 1:2021, ISO 12100:2010 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 https://www.electropedia.org/

3.1
manual non-automated
non-automated (3.6) only machine *functions* (3.5) that are intended to operate in *manual mode* (3.9) during all of the machine's *operating cycle* (3.11)

EXAMPLE Implement height above ground controlled manually by the operator.

Note 1 to entry: See Figure 1.

Note 2 to entry: Manual non-automated is not a level or a category of a machine. It is a term only to describe the combination of functions, and modes of functions.

<table>
<tr><th></th><td>Manual non-automated (3.1)</td><td>Partially automated (3.2)</td><td>Semi-autonomous (3.3)</td><td>Autonomous (3.4)</td></tr>
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<tr><td></td><td colspan="3">Autonomous mode (3.10)</td></tr>
</table>

Figure 1 — Terms used for combinations of functions and modes

3.2
partially automated
non-automated (3.6) and *automated* (3.7) machine *functions* (3.5) that are intended to operate in *manual mode* (3.9) during all of the machine's *operating cycle* (3.11)

EXAMPLE Implement height above ground maintained automatically to a set point controlled by the operator.

Note 1 to entry: See Figure 1.

Note 2 to entry: Partially automated is not a level or a category of a machine. It is a term only to describe the combination of functions, and modes of functions.

3.3
semi-autonomous
automated (3.7) machine *functions* (3.5) that are intended to operate in *autonomous mode* (3.10) during part of the machine's *operating cycle* (3.11) in addition to *non-automated* (3.6) and automated machine functions that are intended to operate in *manual mode* (3.9) to complete some of the tasks assigned

EXAMPLE 1 Implement height above ground maintained automatically to a set point controlled by the operator in specific conditions, and maintained automatically to a set point controlled by machine without operator interaction during all of the machine's other operating cycles.

EXAMPLE 2 Automated field cultivating machine completing entire operating cycle of field work without operator interaction and also used to complete other operating cycles of field work in specific conditions manually by an operator.

Note 1 to entry: See Figure 1.

Note 2 to entry: Semi-autonomous is not a level or a category of a machine. It is a term only to describe the combination of functions, and modes of functions.

3.4
autonomous
automated (3.7) machine *functions* (3.5) that operate in *autonomous mode* (3.10) during all of the machine's *operating cycle* (3.11)

EXAMPLE 1 Implement height above ground maintained automatically to a set point controlled by the machine without operator interaction during all of the machine's operating cycles.

EXAMPLE 2 Automated field cultivating machine completing all operating cycles of work without operator interaction.

Note 1 to entry: See Figure 1.

Note 2 to entry: Autonomous is not a level or a category of a machine. It is a term only to describe the combination of functions, and modes of functions.

3.5
function
defined activity or behaviour of a machine or a machine system

EXAMPLE Machine propel, steering, braking, lights, 3-point hitch, hydraulic driven unit, implement control (ISOBUS CAN, power-take-off, hydraulic), etc.

3.6
non-automated
technique, method, or system of operating and controlling machine *function(s)* (3.5) by *operator interaction* (3.12)

3.7
automated
technique, method, or system of operating and controlling machine *function(s)* (3.5) by *automatic* (3.8) means

3.8
automatic
process or part of a process when machine *functions* (3.5) follow defined rules

Note 1 to entry: Complex computer functions (e.g. closed loop control, artificial intelligence) can be included in the machine *function* (3.5) following defined rules to accomplish a process or part of a process.

Note 2 to entry: *Automatic* (3.8) means are typically accomplished through minimal *operator interaction* (3.12), but can be accomplished without *operator interaction*.

3.9
manual mode
mode of machine operation in which machine *function(s)* (3.5) are controlled by an operator

Note 1 to entry: Manual mode definition infers *operator interaction* (3.12) to accomplish direct or *automatic* (3.8) means by which *non-automated* (3.6) and *automated* (3.7) machine *function(s)* (3.5) are controlled.

3.10
autonomous mode
mode of machine operation in which a machine performs *functions* (3.5) related to its defined tasks without *operator interaction* (3.12)

Note 1 to entry: States of *autonomous mode* (3.10) of a machine may require human interaction, for example: preparing, configuring, setting-up or programming the machine. This type of human interaction is not considered *manual mode* (3.9) or *operator interaction* (3.12) *as the functions* (3.5) of the machine are not involved.

3.11
operating cycle
complete set of tasks carried out within a defined operation

3.12
operator interaction
involvement of an operator to provide information to or control of a machine *function(s)* (3.5)

Note 1 to entry: Examples of operator interaction are: starting, maintaining or stopping machine *function(s)* (3.5); providing exception handling information to a machine, etc.

3.13
hazardous function
defined activity or behaviour of a machine or a machine system which can be a source of harm

Note 1 to entry: A hazardous function is different than a safety function. A safety function (per ISO 12100:2010) is defined as: *function of a machine whose failure can result in an immediate increase of the risk(s)*. Risk(s) (per ISO 12100:2010) is defined as: *combination of the probability of occurrence of harm and the severity of that harm*. Hazardous functions are those functions which are potential sources of harm (e.g. machine propel) in normal operation without failure. Per ISO 12100:2010, risk analysis is required for hazardous functions and risk evaluation to determine if acceptable risk reduction objectives have been achieved.

3.14
obstacle
object or ground condition which can cause harm, or is harmed, if it comes into contact or collision with the machinery

Note 1 to entry: Examples of objects which can cause harm: tree, rock, etc. Examples of objects which can be harmed: persons or animals.

Note 2 to entry: Risk assessment is used to analyse the degree of harm related to an obstacle. Machine specific type-C safety standards may also contain specific protective measures (e.g. reduce speed, change trajectory, etc.) for risk reduction of specific types of obstacles (e.g. persons, animals, etc.).

3.15
obstacle protective system
system that reacts to information received from machine components or systems (e.g. sensors, *perception systems* (3.16), *supervisory systems* (3.17), bumpers) to avoid harmful contact with a person and/or *obstacle* (3.14)

Note 1 to entry: Risk assessment is used to determine the appropriate level of risk reduction achieved by an obstacle protective system. Machine specific type-C safety standards can also contain specific protective measures (e.g. reduce speed, change trajectory, etc.) for risk reduction of specific types of obstacles (e.g. persons, animals, etc.). While avoiding all contact with a person and/or other obstacles is desired in many cases, there can be machine forms that allow for contact which does not cause harm by contact.

3.16
perception system
system that gathers and processes information about the environment in which the machine is operating

3.17
supervisory system
system that has *situational awareness* (3.18) and can take decisions for systems of the machine operation

3.18
situational awareness
machine's computational assimilation of how the machine and the environment are interacting and the context of that interaction from knowledge of the machine state and the environment through the use of a *perception system* (3.16)

3.19
warning zone
area where if an *obstacle* (3.14) is within and no action is taken, then the obstacle might enter the *hazard zone* (3.20)

3.20
hazard zone
area which is a subset of the *warning zone* (3.19) and where if an *obstacle* (3.14) is within that area, then the potential for injury can exist

3.21
autonomous operating zone
designated area in which machines operate in *autonomous mode* (3.10)