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International Standard

ISO/FDIS 18497-2

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

Part 2: Design principles for obstacle protection systems

Tracteurs et matériels agricoles — Sécurité des machines partiellement automatisées, semi-autonomes et autonomes —
Partie 2: Principes de conception des systèmes de protection contre les obstacles

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

The main changes are as follows:

— obstacle protective systems were made its own part (i.e. ISO 18497-2) 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 ISO 18497-1:2024, 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 2:
Design principles for obstacle protection systems

1 Scope

This document specifies principles for the design of obstacle protective systems used in 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 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 18497-1:2024, *Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery — Part 1: Machine design principles and vocabulary*

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 18497-1:2024 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/

4 Safety requirements and protective or risk reduction measures

4.1 General

Partially automated, semi-autonomous and autonomous functions (see Figure 1) of agricultural machinery and tractors shall be designed according to the principles of 4.2 when obstacle protective systems are used for protective or risk reduction measures of significant hazards, as defined in ISO 12100:2010, 3.8, related to person and/or obstacle contact.

Significant hazards are dependent on the use case of agricultural machinery and tractors with partially automated, semi-autonomous and autonomous functions and shall be determined using a risk assessment in accordance with ISO 12100:2010.

In addition, partially automated, semi-autonomous and autonomous functions of machines shall be designed according to the principles of ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document. For significant hazards not covered in 4.2, the determination of requirements and corresponding verification procedures shall be done in accordance with ISO 12100:2010.

Specific type-C standards, when available, can give more detailed requirements.

<table>
<tr><th></th><th>Manual non-automated
(see ISO 18497-1:2024, 3.1)</th><th>Partially automated
(see ISO 18497-1:2024, 3.2)</th><th>Semi-autonomous
(see ISO 18497-1:2024, 3.3)</th><th>Autonomous
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<tr><td rowspan="2">Functions
(see ISO 18497-1:2024, 3.5)</td><td colspan="3">Non-automated (see ISO 18497-1:2024, 3.6)</td><td></td></tr>
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<tr><td rowspan="2">Modes</td><td colspan="3">Manual mode (see ISO 18497-1:2024, 3.9)</td><td></td></tr>
<tr><td colspan="2"></td><td colspan="2">Autonomous mode (see ISO 18497 - 1:2024, 3.10)</td></tr>
</table>

NOTE See ISO 18497-1:2024.

Figure 1 — Terms used for combinations of functions and modes

Design of machine systems and systems (perception, supervisory or other) to prevent unintended excursions beyond the boundary of the autonomous operating zone shall be designed in accordance with ISO 18497-1:2024 and ISO 18497-3:2024, respectively.

Verification methods of ISO 18497-4:2024 shall be applied to the design principles of 4.2.

There is no sensing technology that works perfectly in all conditions, machine geometries, or applications. It is especially important that the limitations are recognized and known by both the manufacturer of the machine and the operator of the machine. It is also possible to combine the use of complementary technologies in one system to improve the obstacle protective system performance. Examples of sensing technologies include radar, sonar (ultrasonic) sensors, 2D/3D LIDAR, monocular/binocular/omnidirectional vision systems, thermal sensors and pressure sensors (not exhaustive). The advantages and disadvantages of some known technologies are summarized in Annex A.

4.2 Design principles

4.2.1 General

For ensuring an appropriate level of safety of partially automated, semi-autonomous (when automated machine functions operate in autonomous mode) and autonomous functions of agricultural machinery and tractors, the following protective or risk reduction measures shall be provided in the obstacle protective system design to reduce significant hazards related to person and/or obstacle contact. Design recommendations for warning zones and hazard zones in relation to obstacle protective systems are summarized in Annex B.

4.2.2 Obstacle detection — Perception and supervisory systems

a) Prevention of failures to detect, late detection, misclassification and errors in location of a detected person and/or obstacle shall be provided.

NOTE 1 Due to the variety of perception systems, some of the failures above might not be applicable.

EXAMPLE 1 Reasons for typical failure to detect a person and/or obstacle or late detection of a person and/or obstacle:

1) person and/or obstacles are occluded due to crops, dust, fog, snow, rain or other obscurants;

2) perception results become unreliable due to poor or intense lighting conditions (e.g. direct sunlight, reflected sunlight, darkness, shadows);

3) uneven ground causes scanning plane to vary, (e.g. the laser beam might hit the ground or point to the sky when the vehicle is pitching down or up or tilting side to side);

4) vehicle vibration or motion causes misalignment of sensors;

5) person and/or obstacles are moving too fast to be detected;

6) person and/or obstacles are too small, (e.g. the reliability of the radar technology depends on the effective radar cross-section of the person and/or obstacle to identify it);

7) person and/or obstacles do not reflect back in the direction of the receiver, (e.g. laser beam or radar sensor does not detect reflected signal from organic, or transparent; e.g. ultrasonic sensor does not detect acoustic energy from sound-absorbing person and/or obstacles);

8) person and/or obstacles reflect or emit too much energy and saturate the sensor;

9) person and/or obstacles at the same temperature as the environment are not detected by thermal sensor;

10) person and/or obstacle colour is indistinguishable from that of the background (e.g. camouflage);

11) negative obstacles (e.g. holes in the terrain) are not detected;

12) latency can increase due to other applications or computations running on the processor used for the obstacle detection or classification system;

13) dust or other obscurants on the sensors itself can reduce the sensor field of view;

14) difficult terrain condition (e.g. mud, significant slopes) or body of water are not detected;

15) sensor is moved out of alignment or sensor is blocked by a part of or parts of a machine (e.g. cover, shield, tool);

16) sensors interfere with each other (e.g. an array of ultra-sonic sensors positioned to cause interference);

17) electromagnetic interference from internal or external sources;

18) erratic power supply and/or under/over voltage to system components.

EXAMPLE 2 Reasons for typical misclassification of a person and/or obstacle:

1) dust, fog, snow, rain or obscurants blur the edges;

2) inadequate model to sufficiently interpret the ground truth conditions (e.g. due to training or validation);

3) traversable grass or crops classified as non-traversable obstacle;

4) person and/or obstacles are occluded due to crops, dust, fog, snow, rain, or other obscurants.

EXAMPLE 3 Reasons for typical erroneous location of a detected person and/or obstacle:

1) sensor misalignment causing inaccurate position estimate;

2) positioning and orientation system errors (e.g. GNSS error) causing inaccurate machine position or orientation;

3) vibration of the sensor mounting causing sensor motion that is not accounted for by the perception system;

4) dust, fog, snow, rain or obscurants blurring the edges of the person and/or obstacle or environment;

5) inaccurate sensor calibration or registration;

6) wrong estimated location of person and/or obstacle due to multi-path propagation.

b) Restriction of adjustment outside the manufacturer's defined operational limits of the obstacle protective system shall be provided.