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Industrial trucks — Safety requirements and verification —

Part 4: Driverless industrial trucks and their systems

Chariots de manutention — Exigences de sécurité et vérification —

Partie 4: Chariots sans conducteur et leurs systèmes

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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 110, *Industrial trucks*, Subcommittee SC 2, *Safety of powered industrial trucks,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 150, *Industrial Trucks - Safety,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 3691-4:2020), which has been technically revised.

The main changes are as follows:

— the Scope has been updated to include a list of significant hazards not covered;

— the list of normative references has been updated to include the most recent editions of documents;

— the term entries "active detection field" and "operational stop" have been added to Clause 3;

— Clause 4, Clause 5, Clause 6, Annex A, Annex B and Annex C have been updated, with new requirements added in subclauses 4.1.16 to 4.1.27;

— the verification of the safety requirements lists in Annex E have been reworded.

A list of all parts in the ISO 3691 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 12100:2010.

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 organizations, 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.

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.

This document takes into consideration the current state of the art and especially:

— virtual bumper technology;

— hybrid (i.e. manual and automatic) mode trucks;

— performance level versus category;

— further specified clearances;

— guarding for specific zones.

Industrial trucks — Safety requirements and verification —

Part 4: Driverless industrial trucks and their systems

1 Scope

This document specifies safety requirements and the means for their verification for driverless industrial trucks (hereafter referred to as trucks) and their systems.

Examples of driverless industrial trucks (trucks as defined in ISO 5053-1:2020) include: “automated guided vehicle”, “autonomous mobile robot”, “bots”, “automated guided cart”, “tunnel tugger”, “under cart”, etc.

This document is also applicable to driverless industrial trucks which are provided with:

— automatic modes which either require operators’ action(s) to initiate or enable such automatic operations;

— the capability to transport one or more riders (which are neither considered as drivers nor as operators);

— additional manual modes which allow operators to operate the truck manually; or

— a maintenance mode which allows manual operation of truck functions for maintenance reasons.

This document is not applicable to trucks solely guided by mechanical means (rails, guides, etc.) or to remotely-controlled trucks, which are not considered to be driverless trucks.

For the purposes of this document, a driverless industrial truck is a powered truck, which is designed to operate automatically. A driverless truck system comprises the control system, which can be part of the truck and/or separate from it, guidance means and power system. Requirements for power sources are not covered in this document.

The condition of the operating zone has a significant effect on the safe operation of the driverless industrial truck. The preparations of the operating zone to eliminate the associated hazards are specified in Annex A.

This document is applicable to all significant hazards, hazardous situations or hazardous events during all phases of the life of the truck (ISO 12100:2010, 5.4), as listed in Annex B, relevant to the applicable machines when it is used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer.

In particular, this document does not apply to significant hazards related to:

— noise;

— vibrations;

— ionising and non-ionising radiation;

— laser radiation;

— sales literature (commercial documents);

— declaration of vibrations transmitted by mobile machinery.

It does not apply to additional hazards that can occur:

— during operation in severe conditions (e.g. extreme climates, freezer applications, strong magnetic fields);

— during operation in nuclear environments;

— from trucks intended to operate in public zones (see in particular ISO 13482:2014);

— during operation on a public road;

— during operation in potentially explosive environments;

— during operation in military applications;

— during operation with specific hygienic requirements;

— during operation in ionizing radiation environments;

— during the transportation of (a) person(s) other than (the) intended rider(s);

— when handling loads the nature of which can lead to dangerous situations (e.g. molten metals, acids/bases, radiating materials);

— for rider positions with elevation function higher than 1 200 mm from the floor/ground to the platform floor.

This document does not contain safety requirements for trailer(s) being towed behind a truck.

This document does not contain safety requirements for elevated operator trucks.

This document does not apply to trucks 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 2867:2011, *Earth-moving machinery — Access systems*

ISO 3691-1:2011 ISO 3691-1:2011/Amd 1:2020, *Industrial trucks — Safety requirements and verification — Part 1: Self-propelled industrial trucks, other than driverless trucks, variable-reach trucks and burden-carrier trucks*

ISO 3691-2:2023, *Industrial trucks — Safety requirements and verification — Part 2: Self-propelled variable-reach trucks*

ISO 3691-6:2021, *Industrial trucks — Safety requirements and verification — Part 6: Burden and personnel carriers*

ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 5053-1:2020, *Industrial trucks — Vocabulary — Part 1: Types of industrial trucks*

ISO 7010:2019, ISO 7010:2019/Amd 1:2020, ISO 7010:2019/Amd 2:2020, ISO 7010:2019/Amd 3:2021, ISO 7010:2019/Amd 4:2021, ISO 7010:2019/Amd 5:2022 and ISO 7010:2019/Amd 6:2022, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 10896-1:2020, *Rough-terrain trucks — Safety requirements and verification — Part 1: Variable-reach trucks*

ISO 10896-2:2016, *Rough-terrain trucks — Safety requirements and verification — Part 2: Slewing trucks*

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 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13851:2019, *Safety of machinery — Two-hand control devices — Principles for design and selection*

ISO 13856-2:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars*

ISO 13856-3:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar devices*

ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14119:2013, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14122-2:2016, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 15870:2000, *Powered industrial trucks — Safety signs and hazard pictorials — General principles*

ISO 22915-2:2018, *Industrial trucks — Verification of stability — Part 2: Counterbalanced trucks with mast*

ISO 22915-3:2021, *Industrial trucks — Verification of stability — Part 3: Reach and straddle trucks*

ISO 22915-4:2018, *Industrial trucks — Verification of stability — Part 4: Pallet stackers, double stackers and order-picking trucks with operator position elevating up to and including 1 200 mm lift height*

ISO 22915-5:2020, *Industrial trucks — Verification of stability — Part 5: Single-side-loading trucks*

ISO 22915-7:2016, *Industrial trucks — Verification of stability — Part 7: Bidirectional and multidirectional trucks*

ISO 22915-8:2018, *Industrial trucks — Verification of stability — Part 8: Additional stability test for trucks operating in the special condition of stacking with mast tilted forward and load elevated*

ISO 22915-9:2014, *Industrial trucks — Verification of stability — Part 9: Counterbalanced trucks with mast handling freight containers of 6 m (20 ft) length and longer*

ISO 22915-10:2023, *Industrial trucks — Verification of stability — Part 10: Additional stability test for trucks operating in the special condition of stacking with load laterally displaced by powered devices*

ISO 22915-11:2011, *Industrial trucks — Verification of stability — Part 11: Industrial variable-reach trucks*

ISO 22915-12:2015, *Industrial trucks — Verification of stability — Part 12: Industrial variable-reach trucks handling freight containers of 6 m (20 ft) length and longer*

ISO 22915-13:2012, *Industrial trucks — Verification of stability — Part 13: Rough-terrain trucks with mast*

ISO 22915-14:2010, *Industrial trucks — Verification of stability — Part 14: Rough-terrain variable-reach trucks*

ISO 22915-15:2020, *Industrial trucks — Verification of stability — Part 15: Counterbalanced trucks with articulated steering*

ISO 22915-17:2020, *Industrial trucks — Verification of stability — Part 17: Towing tractors, burden and personnel carriers*

ISO 22915-20:2023, *Industrial trucks — Verification of stability — Part 20: Additional stability test for trucks operating in the special condition of offset load, offset by utilization*

ISO 22915-22:2014, *Industrial trucks — Verification of stability — Part 22: Lateral- and front-stacking trucks with and without elevating operator position*

IEC 61496-2:2020, *Safety of Machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*

IEC 61496-3:2018, *Safety of machinery —Electro-sensitive protective equipment — Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)*

IEC 60204-1:2016+AMD1:2021, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 61558-1:2017, *Safety of power transformers, power supply units, reactors and similar — Part 1: General requirements and tests*

IEC 62046:2018, *Safety of machinery - Application of protective equipment to detect the presence of persons*

EN 1175:2020, *Safety of industrial trucks — Electrical/electronic requirements*

EN 12895:2015+A1:2019, *Industrial trucks — Electromagnetic compatibility*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5053-1:2020 and ISO 12100:2010 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
actuating force
force applied on the bumper that initiates a stop signal

3.2
authorized person
authorized personnel
authorized individual
person designated by the user, trained on specific hazards and if required, trained to operate or maintain the truck or system

3.3
automatic mode
operating mode where no operator intervention is required for the operation

3.4
bumper
pressure-sensitive protective device (PSPD) fitted to the truck that generates a signal to stop the truck upon physical contact

3.5
virtual bumper
electro sensitive (non-contact) protective equipment (ESPE) fitted to the truck, having one or more detection zones that generates a signal for the truck to take further actions when actuated

Note 1 to entry: Further action can include stopping the truck or changing its path or speed.

EXAMPLE Active opto-electronic protective devices responsive to diffuse reflection (AOPDDRs).

3.6
driverless truck system
combination of one (or more) driverless truck(s) and ancillary components to control and manage the automatic operation of the truck(s)

Note 1 to entry: Ancillary components can be integrated or external (e.g. guidance, traffic control, power system, communication system, guarding, signs, warnings, floor marking).

3.7
driverless industrial truck
powered truck, designed to operate automatically to transport loads

3.8
escape route
space provided for a person to exit away from the hazard(s)

3.9
path
area swept by the truck with its load including trailer(s)

3.10
load
item intended to be handled by the truck

3.11
load handling
load lifting, lowering, conveying and manipulating

EXAMPLE Rotation, reach, tilting, clamping and towing.

3.12
manual mode
operating condition where all operations are under the control of an operator

3.13
static force
force applied by the bumper when an automatic stop is completed

3.14
rider
intended rider
person on the truck in automatic mode with a rider who can enable or disable functions of the truck

3.15
stopping device
control device that when actuated, generates a signal to stop all movements of the truck

3.16
emergency stop device
manually actuated control device used to initiate an emergency stop function

[SOURCE: ISO 13850:2015, 3.3]

3.17
direction of travel
one or more directions of travel based upon the operating conditions of the truck as specified by the manufacturer

3.18
personnel detection means
system to detect persons in the path of a truck

3.19
rated speed
travel speed of the truck as specified by the manufacturer

3.20
automatic restart
resumption of the truck operation without outside input

Note 1 to entry: The truck starts only after the conditions which have stopped the truck have been cleared.

3.21
automatic mode with a rider
operating condition where (a) rider(s) is (are) present on the truck during automatic movement

3.22
confined zone
enclosed truck operating space that is intended to prevent access of persons

3.23
operating hazard zone
area of the operating zone in which a person can be exposed to a hazard

Note 1 to entry: This can be found in load transfer areas or low clearances.

Note 2 to entry: The operating hazard zone is considered a hazard zone according to ISO 12100:2010, 3.11.

3.24
operating zone
defined area in which a truck operates

Note 1 to entry: Examples of defined areas: areas signalled by navigation systems, signs, floor markings, fencings, guarding.

3.25
public zone
space opened to all persons without specific training, instruction or awareness

3.26
restricted zone
enclosed truck operating space that is intended to prevent access of unauthorized persons

3.27
method statement
safe system of work
document that details the way a work task or process is to be completed and outlines the hazards involved

Note 1 to entry: This can include a step by step guide on how to do the job safely and detail which control measures have been introduced to ensure the safety of anyone who is affected by the task or process.

3.28
load transfer area
location where a load can be picked up or deposited by the truck

Note 1 to entry: The location can be on the floor/ground (e.g. rack, machines and conveyors).

3.29
operator
designated person, appropriately trained and authorized to operate the truck

[SOURCE: ISO 3691-1:2011 and ISO 3691-1:2011/Amd 1:2020, 3.7, modified — In the definition, “who is responsible for the movement and load handling of an industrial truck” has been replaced with "to operate the truck”. Notes 1 and 2 have been removed.]

3.30
rider designated position
position on the truck that is specified by the manufacturer for (a) person(s) to safely ride on the truck

3.31
belt conveyor
conveyor with one or more endless belt(s) acting as a carrying and traction element

Note 1 to entry: The belt is supported by rollers or slides on a surface.

Note 2 to entry: The carrying belt may also be made of flexible elements.

[SOURCE: EN 619:2022, 3.7, modified — The reference to the figure has been removed.]

3.32
roller conveyor
conveyor with rollers as carrying elements

[SOURCE: EN 619:2022, 3.8]

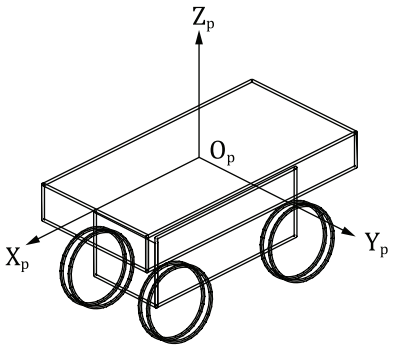
3.33
carrying-chain conveyor
conveyor with chains as traction and carrying elements, with or without tappets attached to the chains

[SOURCE: EN 619:2022, 3.9, modified — The reference to the figure has been removed.]

3.34
coordinate system of the truck
coordinate system (O_p – X_p – Y_p – Z_p) referenced to one of the components which enables the locomotion of the truck

Note 1 to entry: ISO 9787:2013, 5.5, specifies a mobile platform coordinate system, (O_p – X_p – Y_p – Z_p). The origin of the mobile platform coordinate system, O_p, is the mobile platform origin. The $+X_p$ axis is normally taken in the forward direction of the mobile platform. The $+Z_p$ axis is normally taken in the upward direction of the mobile platform.

Note 2 to entry: See Figure 1.



Key

O_p origin of the referential

NOTE This figure is adapted from ISO 9787:2013, Figure 6.

Figure 1 — Coordinate system of the truck

3.35
forward direction
movement of the truck following $+X_p$ axis

Note 1 to entry: See *coordinate system of the truck* (3.34).

Note 2 to entry: See Figure 1.

3.36
backward direction
movement of the truck following $-X_p$ axis

Note 1 to entry: See *coordinate system of the truck* (3.34).

Note 2 to entry: See Figure 1.

3.37
lateral direction
movement of the truck following the Y_p axis

Note 1 to entry: See *coordinate system of the truck* (3.34).

Note 2 to entry: See Figure 1.

3.38
crabbing direction
combined movement of the truck following the X_p and Y_p axes without changing the orientation

Note 1 to entry: See *coordinate system of the truck* (3.34).

Note 2 to entry: See Figure 1.

3.39
turning direction
movement that generates a change of the orientation of the truck coordinate system around the Z_p axis combined with a movement of the truck following the X_p and/or Y_p axis

Note 1 to entry: See *coordinate system of the truck* (3.34).

Note 2 to entry: See Figure 1.

3.40
pivoting direction
movement that generates a change of the orientation of the truck coordinate system around the Z_p axis, without movement of the truck following the X_p and/or Y_p axis

Note 1 to entry: See *coordinate system of the truck* (3.34).

Note 2 to entry: See Figure 1.

3.41
tiller
bar used by the operator on a truck for the purpose of steering

Note 1 to entry: It can incorporate other functions.

3.42
floor
ground
level, smooth, prepared surface to support the weight of a loaded truck

EXAMPLE Concrete, asphalt.

3.43
rated capacity
maximum load, expressed in kilograms, established by the manufacturer based on component strength and truck stability, that the truck can carry, lift and stack to the standard lift height and at the standard position of the centre of gravity

Note 1 to entry: For centre of gravity, see Annex C.

Note 2 to entry: If the lifting height of the mast is lower than the standard lift height *H*, the rated capacity is still assessed at the standard lift height.

Note 3 to entry: The rated capacity is used to compare the capacity of different manufacturers' trucks and to provide the break points used in technical standards and statistics. The operating limits for the truck are specified by its actual capacity.

[SOURCE: ISO 3691-1:2011 and ISO 3691-1:2011/Amd 1:2020, 3.15, modified — "Annex A" changed to "Annex C" in Note 1 to entry.]

3.44
actual capacity
maximum load, expressed in kilograms, established by the manufacturer based on component strength and truck stability that a truck can carry, lift and stack to a specified height, at a specified load centre distance and reach, if applicable, in normal operation

Note 1 to entry: The actual capacity depends on the configuration of the truck, including variables such as the type and lift height of the mast fitted, the actual load centre and any attachments that might be fitted. This actual capacity specifies the load-handling ability of the particular truck, as equipped. Additional actual capacity ratings with removable attachments can also be established where permitted by the appropriate stability tests or by calculation verified by empirical data.

[SOURCE: ISO 3691-1:2011 and ISO 3691-1:2011/Amd 1:2020, 3.14]

3.45
protective stop
safety-related stop function initiated by a protective device

3.46
truck speed
speed of the fastest moving point of the truck and its load(s)