

AS 5144.4:2021



STANDARDS
Australia



Industrial trucks — Safety requirements and verification

Part 4: Driverless industrial trucks and their systems (ISO 3691-4:2020, MOD)



AS 5144.4:2021

This Australian Standard ® was prepared by ME-026, ME-026 Industrial Trucks. It was approved on behalf of the Council of Standards Australia on 07 April 2021.

This Standard was published on 23 April 2021.

The following are represented on Committee ME-026:

- Australian Forklift and Industrial Truck Association
- Australian Industry Group
- Australian Institute of Health & Safety
- Better Regulation Division (Fair Trading, Safework NSW, Testsafe)
- Construction and Mining Equipment Industry Group
- Hire and Rental Industry Association of Australia
- National Road Transport Association
- Telescopic Handler Association of Australia
- Victorian WorkCover Authority (WorkSafe Victoria)

This Standard was issued in draft form for comment as DR AS 5144.4:2020.

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ISBN 978 1 76113 291 9

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Part 4: Driverless industrial trucks and their systems (ISO 3691-4:2020, MOD)

First published as AS 5144.4:2021.

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Preface

This Standard was prepared by the Standards Australia Committee ME-026, Industrial Trucks.

The objective of this document is to specify safety requirements and the means for their verification for driverless industrial trucks and their systems.

This document also contains requirements for driverless industrial trucks which are provided with:

- (a) automatic modes which either require operators' action(s) to initiate or enable such automatic operations;
- (b) the capability to transport one or more riders (which are neither considered as drivers nor as operators);
- (c) additional manual modes which allow operators to operate the truck manually; or
- (d) 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.

This document does not give requirements for additional hazards that can occur—

- (i) during operation in severe conditions (e.g. extreme climates, freezer applications, strong magnetic fields);
- (ii) during operation in nuclear environments;
- (iii) from trucks intended to operate in public zones (in particular ISO 13482);
- (iv) during operation on a public road;
- (v) during operation in potentially explosive environments;
- (vi) during operation in military applications;
- (vii) during operation with specific hygienic requirements;
- (viii) during operation in ionizing radiation environments;
- (ix) during the transportation of (a) person(s) other than (the) intended rider(s);
- (x) when handling loads the nature of which can lead to dangerous situations (e.g. molten metals, acids/bases, radiating materials); and
- (xi) for rider positions with elevation function higher than 1 200 mm from the floor/ground to the platform floor.

This document—

- (A) does not contain safety requirements for trailer(s) being towed behind a truck;
- (B) does not contain safety requirements for elevated operator trucks; and
- (C) is not applicable to trucks manufactured before the date of its publication.

This Standard is an adoption with national modifications, and has been reproduced from,

ISO 3691-4:2020, *Industrial trucks — Safety requirements and verification — Part 4: Driverless industrial trucks and their systems*.

The modifications are additional requirements and are set out in [Appendix ZZ](#), which has been added at the end of the source text.

[Appendix ZZ](#) lists the variations to ISO 3691-4:2020, for the application of this Standard in Australia.

As this document has been reproduced from an International Standard, a full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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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 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 110, *Industrial trucks*, Subcommittee SC 2, *Safety of powered industrial trucks*.

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.

A list of all parts in the ISO 3691 series can be found on the ISO website.

Introduction

General

This document is a type-C 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 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 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.

Structure

An important step forward in the work on the ISO 3691 series of standards was the agreement to issue a new structure of International Standards for industrial trucks having on one side basic standards for all types of trucks and on the other side independent standards to cover the respective specific functions of industrial trucks, e.g. visibility, noise, electrical requirements, etc.

Assessment of hazards

The product needs to be designed in such a way that it is fit for its purpose or function and can be adjusted and maintained without putting persons at risk when used under the conditions foreseen by the manufacturer.

In order to properly design a product and to cover all specific safety requirements, the manufacturer needs to identify the hazards that apply to their product and carry out a risk assessment. The manufacturer then needs to design and construct the product taking this assessment into account.

The aim of this procedure is to eliminate the risk of accidents throughout the foreseeable lifetime of the machinery, including the phases of assembling and dismantling where risks of accidents can also arise from foreseeable abnormal situations.

In selecting the most appropriate methods, the manufacturer needs to apply the following principles, in the order given here:

- a) eliminate or reduce risks as far as possible by design (inherently safe machinery design and construction);

- b) take the necessary protective measures in relation to risks that cannot be eliminated by design;
- c) inform users of any shortcoming of the protective measures adopted;
- d) indicate whether any particular training is required;
- e) specify any need to provide personal protection equipment;
- f) refer to the appropriate user's document for proper operating instructions.

Industrial trucks need to be designed to prevent foreseeable misuse wherever possible, if such would engender risk. In other cases, the manufacturer's instructions need to draw the user's attention to ways shown by experience in which the machinery ought not to be used.

This document does not repeat all the technical rules which are state-of-the-art, and which are applicable to the material used to construct the industrial truck. Refer to ISO 12100.

Global relevance

From the very beginning, the task was to revise ISO 3691:1980 to establish international basic standards to align with the major legislative regulations in, for example, the EU, Japan, Australia and North America.

Every effort was made to develop a globally relevant International Standard. That goal was achieved for most of the issues addressed. For several potential problem areas, compromises were needed and will still be needed in the future. Where divergent regional requirements remain, these are addressed by ISO/TS 3691-8.

Australian Standard®

Industrial trucks — Safety requirements and verification

Part 4: Driverless industrial trucks and their systems (ISO 3691-4:2020, MOD)

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 of ISO 5053-1) can also be known as: “automated guided vehicle”, “autonomous mobile robot”, “bots”, “automated guided cart”, “tunnel tugger”, “under cart”, etc.

This document also contains requirements for 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.

It 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 deals with 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.

It does not give requirements for 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 (in particular ISO 13482);
- 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 is not applicable 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 3691-1:2011, *Industrial trucks — Safety requirements and verification — Part 1: Self-propelled industrial trucks, other than driverless trucks, variable-reach trucks and burden-carrier trucks*

ISO 3691-2:2016, *Industrial trucks — Safety requirements and verification — Part 2: Self-propelled variable-reach trucks*

ISO 3691-6:2013, *Industrial trucks — Safety requirements and verification — Part 6: Burden and personnel carriers*

ISO/TS 3691-8:2019, *Industrial trucks — Safety requirements and verification — Part 8: Regional requirements for countries outside the European Community*

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 5053-1:2015, *Industrial trucks — Terminology and classification — Part 1: Types of industrial trucks*

ISO 12100:2010, *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 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13851:2019, *Safety of machinery — Two-hand control devices — Functional aspects and design principles*

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 13857:2008, *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 15870:2000, *Powered industrial trucks — Safety signs and hazard pictorials — General principles*

ISO 22915-1:2016, *Industrial trucks — Verification of stability — Part 1: General*

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

ISO 22915-3:2014, *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 22915-5:2014, *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 22915-8:2019, *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 22915-10:2008, *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 22915-15:2013, *Industrial trucks — Verification of stability — Part 15: Counterbalanced trucks with articulated steering*

ISO 22915-20:2008, *Industrial trucks — Verification of stability — Part 20: Additional stability test for trucks operating in the special condition of offset load, offset by utilization*

ISO 22915-21:2019, *Industrial trucks — Verification of stability — Part 21: Additional stability test for order-picking trucks with operator position elevating above 1 200 mm*

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

IEC 61496-2:2013, *Safety of Machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*

IEC 61496-3:2008, *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, *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*

EN 1175-1:1998, +A1:2010, *Safety of industrial trucks — Electrical requirements — Part 1: General requirements for battery powered trucks*

EN 1175-2:1998, +A1:2010, *Safety of industrial trucks — Electrical requirements — Part 2: General requirements for internal combustion engine powered trucks*

EN 1175-3:1998, +A1:2010, *Safety of industrial trucks — Electrical requirements — Part 3: Specific requirements for the electric power transmission systems of internal combustion engine powered trucks*

EN 12895:2015, *Industrial trucks — Electromagnetic compatibility*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5053-1:2015 and 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 <http://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 equipment (PSPE) fitted to the truck that generates a signal to stop the truck on 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 prior to physical contact

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

- 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 an automatic mode with a rider who can enable or disable 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 defined by the manufacturer

3.18**enabling device**

additional manually operated device used in conjunction with a start control and which, when continuously actuated, allows a machine to function

[SOURCE: ISO 12100:2010, 3.28.2]

3.19**personnel detection means**

system to detect persons in the path of a truck

3.20**rated speed**

travel speed of the truck as defined by the manufacturer

3.21**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.

3.22**automatic mode with a rider**

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

3.23**confined zone**

truck operating space in which the risk reduction is provided by perimeter safeguarding

3.24**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.

3.25**operating zone**

defined area in which a truck operates

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

3.26**public zone**

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

3.27**restricted zone**

physically separated space in which only authorized persons are permitted to enter

3.28**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.

3.29**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).

3.30**operator**

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

[SOURCE: ISO 3691-1:2011, 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.]

3.31**rider designated position**

position that is defined by the manufacturer for (a) person(s) to safely ride on the truck

3.32**belt conveyor**

conveyor with an endless belt acting as a carrying and traction element

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

[SOURCE: EN 619:2002+A1 2010, 3.6, modified — The reference to the Figure has been removed and the second sentence has been moved to Note 1 to entry.]

3.33**roller conveyor**

conveyor in which some or all of the rollers are driven or can rotate freely

[SOURCE: EN 619:2002+A1:2010, 3.11, modified — The references to figures, wheels and wheel conveyors, and, balls and ball transfer tables have been removed.]

3.34**drag chain conveyor**

conveyor with chains as traction or carrying elements, possibly with pushers attached to the chains

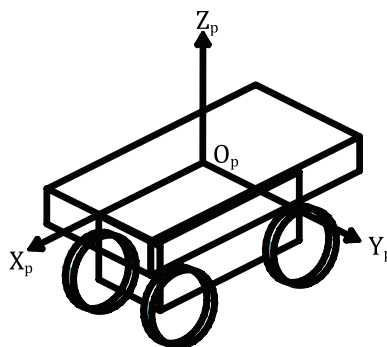
[SOURCE: EN 619:2002+A1:2010, 3.7.1, modified — The reference to the figure has been removed.]

3.35**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

3.36**forward direction**

movement of the truck following $+X_p$ axis

Note 1 to entry: See coordinate system of the truck in [3.35](#).

Note 2 to entry: See [Figure 1](#).

3.37**backward direction**

movement of the truck following $-X_p$ axis

Note 1 to entry: See coordinate system of the truck in [3.35](#).

Note 2 to entry: See [Figure 1](#).

3.38**lateral direction**

movement of the truck following the Y_p axis

Note 1 to entry: See coordinate system of the truck in [3.35](#).

Note 2 to entry: See [Figure 1](#).

3.39**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 in [3.35](#).

Note 2 to entry: See [Figure 1](#).

3.40**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 in [3.35](#).

Note 2 to entry: See [Figure 1](#).

3.41**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 in [3.35](#).

Note 2 to entry: See [Figure 1](#).

3.42**tiller**

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

Note 1 to entry: It can incorporate other functions.

3.43**floor****ground**

level smooth prepared surface to support the weight of a loaded truck

EXAMPLE Concrete, asphalt.

3.44**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 defined by its actual capacity.

[SOURCE: ISO 3691-1:2011, 3.15]

3.45**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 defines 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, 3.14]

3.46**protective stop**

safety related stop function initiated by a protective device

3.47**truck speed**

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

3.48**braking system**

combination of parts which fulfil one or more of the following functions:

- control (usually to reduce) a vehicle's speed,
- bring the vehicle to a halt or hold it stationary

[SOURCE: ISO 611:2003, 3.2]

3.49**fixed closed structure**

structure acting as a guard and preventing persons from entering or reaching into the path

Note 1 to entry: This structure is mainly providing a peripheral guard, and composed of walls, panels, fences.

3.50**muting**

temporary automatic suspension of a safety function

3.51**override**

manual suspension of a safety function

3.52**deactivation**

action to make a function no longer active

Note 1 to entry: It can be a manual or automatic action.

4 Safety requirements and/or protective/risk reduction measures**4.1 General****4.1.1 Overall requirements**

Trucks shall comply with the safety requirements and/or protective measures of this clause.

In addition, the truck shall be designed according to the principles of ISO 12100 for relevant but not significant hazards which are not dealt with by this document.

Zones where the trucks operate, shall comply with requirements defined in [Annex A](#).

4.1.2 Normal climatic conditions

The following climatic conditions apply:

- average ambient temperature for continuous duty: +25 °C;
- maximum ambient temperature, short term (up to 1 h): +40 °C;
- lowest ambient temperature for trucks intended for use in normal indoor conditions: +5 °C;
- lowest ambient temperature for trucks intended for use in normal outdoor conditions: -20 °C;
- altitude: up to 2 000 m.

4.1.3 Electrical requirements

	Subclause(s) in			
	EN 1175-1:1998 +A1:2010	EN 1175-2:1998 +A1:2010	EN 1175-3:1998 +A1:2010	IEC 60204-1:2016
Generals (Electricity supply)	5.7, 5.8, 5.10, 5.11, 5.12, 5.13, 5.14, 5.15, 6.1, 6.2, 6.3, 6.4, 6.5, 6.1.2, 6.1.3	5.1, 5.2, 5.4, 5.5	5.1, 5.2, 5.3, 5.5, 5.6	all except 4.3.2, 4.4.5, 5.3.5, 6.2.5, 6.2.6, 6.3.3, 7.2.2, 9.1.1, 9.4.3.1.2, 9.4.3.1.4, 9.4.3.1.5, 11.5, 18.2.4
Starting	5.9.3, 5.9.5, 5.9.8, 5.12.1	5.3.1	5.4.1, 5.4.2, 5.4.3	7.3.1, 7.5, 9.2.3.2, 9.3.1
Stopping	5.13, 6.2.2, 6.4	5.3.4	5.4.4	N/A
Failure of power supply	5.6, 5.9.1, 5.9.11	5.3.1, 5.3.6	5.4.5	5.4, 7.5
Machinery maintenance	7.1, 7.2, 7.3	6.1, 6.2	6.1, 6.2	N/A
Isolation of energy sources	5.1.3, 5.2, 5.5, 5.7, 5.13, 6.2, 6.4	5.1.3	5.1, 5.2, 5.5	5.3, 10.8
Batteries	5.1 (whole), 5.2, 5.12, 5.15.3, 6.1, 6.2, 6.5.3	5.1, 5.3.1	N/A	N/A

	Subclause(s) in			
	EN 1175-1:1998 +A1:2010	EN 1175-2:1998 +A1:2010	EN 1175-3:1998 +A1:2010	IEC 60204-1:2016
Fire	5.2, 5.4, 5.5, 5.8	5.2, 5.4 (whole)	5.3, 5.5.2, 5.5.4, 5.5.5	N/A

4.1.4 Stored energy components

Components which store energy and that would pose a hazard during removal or disassembly (e.g. hydraulic accumulator, capacitors or spring applied brakes), shall be provided with means to release the energy before removal or disassembly.

4.1.5 Edges or angles

There shall be no sharp edges or angles posing a hazard in the area of the:

- a) rider in the normal operating position;
- b) operator in the operating position;
- c) access during daily checks.

4.1.6 Guards

Technical principle for guards shall comply with ISO 12100:2010. Guards shall comply with ISO 14120:2015.

Safety distances shall comply with ISO 13857:2008. In addition, safety distances to prevent reaching over protective structures shall comply with ISO 13857:2008, Table 2, High risk. In addition, continuous fixed closed structures shall have a minimum height of 2,1m.

4.1.7 Interlocking devices for guards

Interlocking devices associated with guards shall comply with ISO 14119:2013.

4.1.8 Two hand control devices

Two hand control devices shall comply with ISO 13851:2019.

4.1.9 Transmission parts

Transmission parts such as drive shafts, couplings and belt drives, which are within the reach of a person, shall be protected with fixed guards.

4.1.10 Electro-sensitive protective equipment

Electro-sensitive protective equipment (ESPE) shall comply with IEC 61496-2:2013 and IEC 61496-3:2018.

4.1.11 Pressure-sensitive protective devices

Pressure-sensitive protective devices shall comply with ISO 13856-2:2013 and ISO 13856-3:2013, Table 2, Test piece 5 or Test piece 6 (for both, only shapes and dimensions).

4.1.12 Hydraulic systems

Hydraulic systems and their components shall comply with ISO 4413:2010.

4.1.13 Pneumatic systems

Pneumatic systems and their components shall comply with ISO 4414:2010.

4.1.14 Avoidance of automatic restart

Trucks shall be designed in such way that an automatic restart is not permitted after the actuation of any of the following:

- a) emergency stop device;
- b) short stroke bumper, see [4.8.2.1 e\)](#);
- c) presence of the operator as described in [4.9.3](#) (e.g. seat, tiller, handles, foot pedal);
- d) manual control commands (e.g. throttle, steering wheel, joystick), see [4.9.3.1 c\)](#);
- e) virtual reachable stop function according to [Table A.1](#), footnote c).

Trucks shall be designed in such way that an automatic restart is not permitted after interruption of power.

4.1.15 Foot protection

Means shall be provided to prevent injury to the feet of persons standing nearby the truck.

Examples of measures are:

- a) follow manufacturer specifications of ESPE concerning additional stopping distances margins for feet;
- b) reduce clearance of the chassis to equal to or less than 40 mm, for a person wearing safety shoes. This will prevent feet from being entrapped under the chassis;
- c) foot clearance below the chassis according to ISO 3691-1:2011, Figure 5. This will prevent contact with the drive and stabilizing wheels.

4.2 Braking system

The truck shall be equipped with a braking system that is designed to do the following:

- a) operate on the interruption of the power supply;
- b) activate automatically at the loss of control of the speed or steering;
- c) stop the truck within the operating range of the personnel detection means as defined in [4.8.2](#) in the worst condition in the limits specified by the manufacturer (e.g. speed, friction, floor/ground, gradient, rated load);
- d) maintain the truck and its maximum permissible load stationary on the maximum operational gradient specified by the manufacturer.

The safety-related parts of the braking systems shall be in accordance with [Table 1](#), item 1 and item 2.

NOTE Braking systems can consist of one or more braking function (e.g. spring-loaded brake, service brake).

4.3 Speed control

The safety-related parts of the speed control system shall be in accordance with [Table 1](#), item 3 and item 8.

4.4 Automatic battery charging

Automatic charging connections rated above 60 VDC or 25 VAC shall be designed to prevent shock hazards arising from accidental contact with live parts according to IEC 61558-1:2017.

A truck equipped with an automatic charging system shall be designed such that the reachable charging contacts are only activated when the truck is connected to the charging device.

Where the truck is removed from the charging points, the charging contacts of the truck shall be disconnected from the battery.

The safety-related parts of these systems shall be in accordance with [Table 1](#), item 9.

4.5 Load handling

The load-carrying device shall be so designed that the load stays within the limits of position(s) determined by the manufacturer in any operational mode, including an emergency stop and load transfer. This can be achieved by integrating clamps, mechanical locks, stops, etc.

As an alternative, means shall be provided to prevent the truck from moving when the load is not in the designated position on the load carrying device as determined by the manufacturer. This can be achieved by integrating camera, sensing device, switch, etc.

Systems for lifting and tilting shall comply with ISO 3691-1:2011, 4.6.

The safety-related parts of the control systems performing these functions shall be in accordance with [Table 1](#), items 10, 11 and 12.

4.6 Steering

The safety-related parts of the controls for the steering system shall be in accordance with [Table 1](#), item 13.

4.7 Stability

4.7.1 General

The truck shall remain stable in all operating conditions and during all load-handling and travelling movements, including an emergency stop.

The safety-related parts of the controls for stability shall be in accordance with [Table 1](#), item 14.

4.7.2 Tilting platform stability test

Stability for trucks with lift height more than 500 mm, shall be tested according to the applicable standard(s) below:

- ISO 22915-1:2016,
- ISO 22915-2:2018,
- ISO 22915-3:2014,
- ISO 22915-4:2018,
- ISO 22915-5:2014,
- ISO 22915-7:2016,
- ISO 22915-8:2018,

- ISO 22915-9:2014,
- ISO 22915-10:2008,
- ISO 22915-11:2011,
- ISO 22915-12:2015,
- ISO 22915-13:2012,
- ISO 22915-14:2010,
- ISO 22915-15:2013,
- ISO 22915-20:2008,
- ISO 22915-21:2019,
- ISO 22915-22:2014.

The stability of trucks lifting less than 500 mm shall be tested according to the test requirements defined for travelling by the appropriate International Standard for stability for a similar truck design equipped with a mast or see [4.7.3](#).

Stability for burden carrier-type trucks shall comply with requirements as defined by ISO 3691-6:2013, 4.7.

4.7.3 Stability requirements for trucks not covered by [4.7.2](#)

When trucks are designed only for a specific pre-determined automated task in a defined operating space and conditions, the truck shall comply with [5.3.2](#) when tested.

Compliance with the specified stability values can be determined by calculation. Calculation shall be based on empirical data for similar trucks. Such calculations shall take into account manufacturing variations and deflections of mast, tyres, etc.

Compliance with the specified stability values can be determined by calculation. Calculation shall be based on empirical data for similar trucks. Such calculations shall take into account manufacturing variations and deflections of mast, tyres, etc.

4.8 Protective devices and complementary measures

4.8.1 Emergency stop

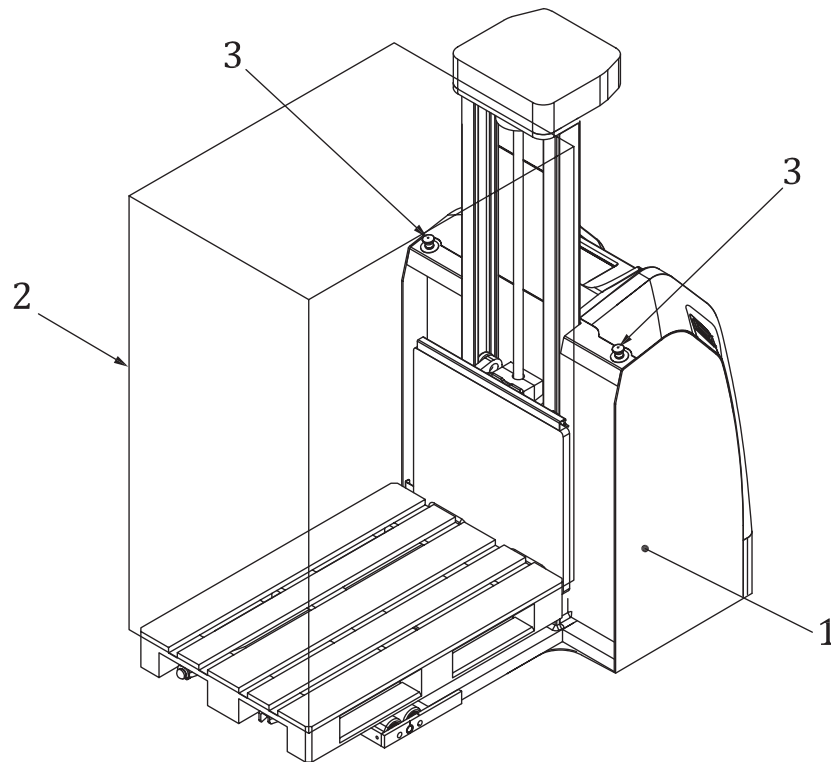
Trucks shall be provided with an emergency stop function that complies with ISO 13850:2015. When the emergency stop device is actuated, all truck movements shall stop.

The emergency stop devices shall be clearly visible, identifiable and accessible from both ends and both sides of the truck. If the truck has a defined operator position with controls, an emergency stop device shall be fitted near these controls.

However, in the case of trucks carrying a load that restricts access to the emergency stop device(s), the emergency stop device(s) shall be mounted on accessible rigid part(s) of the truck closest to the hazard zone (see [Figure 2](#), for example).

The safety-related parts of the control system for emergency stop function shall be in accordance with [Table 1](#), item 15.

NOTE Depending on the size and design of the truck, more than one device can be necessary on each side of the truck.



Key

- 1 truck
- 2 load
- 3 emergency stops on both sides

Figure 2 — Example of emergency stops positions in case of truck with a load on fork side

4.8.2 Detection of persons in the path

4.8.2.1 Detection of persons in the intended path in automatic mode

The safety-related parts of the detection of persons in the intended path in automatic mode shall be in accordance with [Table 1](#), items 4, 16, 17 and 20.

Trucks shall be fitted with personnel detection means, the following requirements apply.

- a) Trucks shall be fitted with pressure-sensitive device according to [4.1.11](#) (e.g. bumpers) or ESPE (e.g. virtual bumpers) according to [4.1.10](#) for the detection of persons.
- b) Personnel detection means shall operate at least over the maximum width of the truck and its load in the direction(s) of travel.
- c) Personnel detection means shall be so designed that trucks shall stop before contact between the rigid parts of the truck or load and a stationary person (not a person stepping into the truck path or moving toward it) and comply with [5.2](#) or in case of contact they shall be designed such that forces shall not exceed the values of [5.2](#). In turning direction and in pivoting direction, for the truck side protection measures, compliance with [5.2](#) Test B is sufficient.

NOTE 1 For non-contact protective equipment, additional requirements according to non-contact protective equipment manufacturer's information for use (e.g. reflection) can apply.

- d) When the truck has stopped due to the detection of a person in its path, and after the person has moved out of the detected range of the detecting devices mounted on the truck, the truck may

restart automatically following appropriate warnings (e.g. optical and/or acoustic). If pressure-sensitive protective equipment (PSPE) is fitted, a minimum delay of 2 seconds before restart is required. Automatic restart shall only be possible according to the "automatic restart permitted" column of [Tables A.1](#) and [A.2](#).

NOTE 2 Warning systems are defined in [6.2](#).

- e) In the direction(s) of the actuation of the protective device where all the requirements a), b) and c) cannot be met (e.g. where the stroke of the bumper is too short or where the load extends over the sides when the truck is under it while towing or carrying the load), the following shall apply:
 - i) in the actuation direction, the truck speed shall not exceed 0,3 m/s;
 - ii) an additional stop function (can be installed on the truck or in the environment) in accordance with [Table A.1](#) or with [Table A.2](#) initiated by a device (e.g. laser scanner or proximity switch) which shall be clearly identifiable and shall be possible to be actuated within 600 mm from the hazardous point. Automatic restart shall be in accordance with [Table A.1](#) or [Table A.2](#).

4.8.2.2 Measures in cases where requirements of [4.8.2.1](#) have to be limited or deactivated

Where trucks working within operating hazard zone (area of the operating zone in which a person can be exposed to a crush/shearing hazard) (e.g. at load transfer areas), then the following requirements shall be met:

- a) if there is an escape route (at least 0,5 m wide and 2,1 m high for a pedestrian), refer to [Tables A.1](#) and [A.2](#) for the maximum speed limit, warnings (acoustic and/or optical), the automatic restart function and classification of the zone;
- b) if there is no escape route for a pedestrian as defined in a), then refer to [Tables A.1](#) and [A.2](#) for the maximum speed limit, warnings (e.g. acoustic and/or optical), the automatic restart function and classification of the zone. An additional stop function shall be implemented:
 - i) a personnel detection function shall be implemented and activated in order to check that the hazard zone is free of personnel. If a person is detected and the truck has stopped, automatic restart is not allowed in the same direction.
 - ii) if the personnel detection function cannot be implemented, an emergency stop device or a stopping device in accordance with [Table 1](#), shall be installed within 600 mm from the hazardous point on the truck (e.g. point of contact on or with the truck or cause of entrapment) or in the workplace.

4.8.2.3 Muting of the personnel detection means

In certain load transfer conditions, it can be necessary to mute the personnel detection means.

Personnel detection means shall be muted as late as possible to ensure the absence of persons, for example less than 180 mm from an object (e.g. load, interface, transfer station, fixed structure, block stacking).

Muting of the personnel detection system in the automatic mode is only allowed in speeds below 0,3 m/s.

The safety-related parts of the muting the personnel detection means shall be in accordance with [Table 1](#), item 19.

4.8.2.4 Override of the personnel detection means

Override of the personnel detection system is only allowed in the manual or maintenance mode.

The safety-related parts of the override of the personnel detection means shall be in accordance with [Table 1](#), item 18.

4.8.2.5 Deactivation of the personnel detection means

The personnel detection means can be automatically deactivated when a truck is working in a confined zone (according to [A.2.4](#)). The personnel detection means can be deactivated in manual mode of operation on a truck with a defined operator position (see [4.9.3.1](#)) or tiller (see [4.9.3.2](#)), because of the mode selection.

The safety-related parts of the deactivation of the personnel detection means shall be in accordance with [Table 1](#), item 18.

4.8.2.6 Selection of the active detection zone fields

Trucks can have an automatic selection of the safe detection fields based on truck speed and direction, size of the load or other criteria. This automatic selection of the safe detection fields of the ESPE is part of the personnel detection system.

The selection of the active detection fields (in which the detection of an object shall trigger the protective stop function) can depend on the conditions that affect the stopping performance of the truck (e.g. loaded or unloaded, narrow or wide load, position of the truck in different zones).

Where this function is provided, the safety related parts of the control system shall be designed that they do not decrease the overall performance of the detection of the persons in the path as stated in [Table 1](#).

The safety-related parts of the selection of the active detection zone fields, shall be in accordance with [Table 1](#), items 5, 6, 7, 21 and 22.

4.9 Modes of operation

4.9.1 General

Trucks can have different operating modes.

The following modes, if foreseen, shall be selected with a mode selector:

- automatic mode;
- manual mode;
- maintenance mode.

The mode selector shall prevent both unauthorized and inadvertent mode selection. Unauthorized and/or inadvertent mode selection shall be prevented by suitable means (e.g. by lockable key switch, code, magnetic card).

Actuation of the mode selector shall only enable the selected mode and shall not initiate truck operation by itself. A separate activation shall be required to initiate truck operation.

The selected mode shall be clearly indicated.

The manual mode may not be selected by the selector but with a manual control if the truck is fitted with a tiller according to [4.9.3.2](#) or with a rider platform or seat according to [4.9.3.1](#).

NOTE 1 See [4.9.3](#) for more explanations about operations by operator.

NOTE 2 See [4.9.2.3](#) for more explanations about operations by the rider.

The safety-related parts of the modes of operation shall be in accordance with [Table 1](#), item 25.

4.9.2 Automatic mode

4.9.2.1 Configuration

Automatic mode may have three configurations:

- 1) automatic mode (no operator nor rider);
- 2) automatic mode with an operator input;
- 3) automatic mode with a rider.

When trucks are not designed to have automatic mode with an operator input, and provision is made for an operator position (e.g. tiller, seat, platform), the presence of the operator shall deactivate all automated functions and shall initiate a protective stop.

When trucks are not designed to have automatic mode with a rider and provision is made for a rider position, the presence of the rider shall deactivate all automated functions and shall initiate a protective stop.

The safety-related parts of the automatic mode of operation shall be in accordance with [Table 1](#), item 25.

4.9.2.2 Automatic mode with an operator input

During the automatic mode, manual operations may be permitted between two full automatic sequences. Then, the truck shall stop at designated positions and manual operation shall be under the following conditions:

- a) the truck shall stand still and wait for an input from an operator;
- b) control shall be “hold to run” type;
- c) when manual controls are activated, it shall not be possible to start the next sequence in automatic mode;
- d) the manual controls shall provide means of stopping all movement;
- e) where the operator’s position is not determined by the design of the truck, any motion of moving parts (e.g. forks, attachments) shall be safeguarded by guards according to [4.1.6](#). Otherwise, the truck shall comply with ISO 3691-1:2011, 4.4.2.6;
- f) the translation and pivoting of the truck are not allowed during the operation;
- g) the restart of the next sequence in the automatic mode is only possible after a voluntary action of the operator.

The safety-related parts of the automatic mode with an operator input shall be in accordance with [Table 1](#), items 24 and 25.

4.9.2.3 Automatic mode with a rider

During the automatic mode, persons may ride on the trucks, for example during setting operations or to travel long distances, with the following conditions:

- a) the truck shall stop automatically at designated locations;
- b) the person/rider shall initiate the automatic mode with rider by a voluntary action;
- c) means shall be provided to detect the rider at the rider’s designated position;
- d) when the rider is in the designated position, the selection of the automatic mode will activate the automatic mode with a rider;

- e) stopping means shall be provided within the reach of the rider;
- f) rider's designated position shall be designed to prevent hazardous situations, considering the truck acceleration and deceleration forces (e.g. padding, operator restraint, compartment design);
- g) means shall be provided to keep the rider(s) within the designated position while riding on the truck, [e.g. two-hand control device (according to ISO 13851:2019, 3.1), foot position sensing, fully enclosed cabin];
- h) when the rider is no longer in the designated position, the truck shall come to a safe stop;
- i) rider position with an elevation function shall not be higher than 1 200 mm from the floor/ground to the platform floor.

The safety-related parts of the automatic mode with a rider, shall be in accordance with [Table 1](#), items 23 and 25.

4.9.3 Manual mode

4.9.3.1 Manual mode with operator

During the manual mode, persons may operate the trucks (e.g. during setting operations).

Where the truck is designed to be operated manually (not for the maintenance mode defined in [4.9.4](#)), a manual mode shall be fitted. This manual mode shall comply with the general functional principle for manual controls as defined in ISO 3691-1:2011, 4.4; ISO 3691-2:2016, 4.4; ISO 3691-6:2013, 4.4 or with all the following requirements:

- a) manual controls shall be of the "hold to run" type and shall be designed to allow only intentional manual operations;
- b) manual controls shall be located at the intended operator's position;
- c) release of a manual control shall not cause selection of the automatic mode;
- d) operator leaving their position shall not cause selection of the automatic mode;
- e) the manual controls shall provide means of stopping all movement;
- f) personnel detection means may be deactivated.

The safety-related parts of the manual mode with operator shall be in accordance with [Table 1](#), item 26.

4.9.3.2 Pedestrian controlled trucks with tiller

When a tiller is provided for the operation in the manual mode, the following shall apply:

- a) for travel and braking controls, ISO 3691-1:2011, 4.4.2 shall apply;
- b) automatic operation shall be possible only when the tiller is in the manufacturer's defined position;
- c) return of the tiller to the manufacturer's defined position shall not actuate the automatic mode;
- d) moving the tiller to the manual operating position shall stop all automated functions.

The safety-related parts of the pedestrian control truck with tiller mode shall be in accordance with [Table 1](#), item 27.

4.9.4 Maintenance mode

Where the truck is also designed to operate in maintenance mode, when in maintenance mode the following shall apply:

- a) manual controls shall be of the “hold to run” type and shall be designed to allow only intentional manual operations;
- b) manual controls shall be located at the intended operator’s position;
- c) personnel detection means shall remain active unless there is an intentional action taken by an authorized person;
- d) restrictions or override of personnel detection means are possible only if all the following additional requirements are applied:
 - 1) an additional mode selector to override personnel detection systems shall be fitted (e.g. by key, code, magnetic card);
 - 2) restrictions to hazardous operations (e.g. travel speed reduction or load handling speed restrictions) or their combinations shall be applied;
 - 3) the maintenance mode of the truck shall be designed so that maintenance traction speed can be set (refer to instructions for use);
- e) the maintenance mode of the truck shall be designed so that the speed of other parts of the truck (e.g. forks, conveyors, arms) can be set (refer to instructions for use);
- f) restrictions to some hazardous operations or their combinations may be applied (e.g. speed limit due to lift height, lift height limited, tool speed limited, control of movements);
- g) deactivation of the maintenance mode shall not cause an activation of the automatic mode.

The safety-related parts of the maintenance mode shall be in accordance with [Table 1](#) item 24.

4.10 Trucks intended to tow trailers

Before start-up an acoustical and/or optical signal shall be given automatically for at least 2 s. Start-up speed shall be limited to 0,3 m/s for at least 5 s and the distance equal to 500 mm plus the maximum gap between the trailers or trailer and the truck, whichever is greater.

Trucks intended to tow trailers shall be fitted with towing or coupling devices designed, constructed and arranged to reduce hazardous connections and disconnections and prevent accidental disconnection during use.

Towing and coupling devices shall be designed:

- a) to withstand the traction force and compression effort (e.g. when the truck is braking);
- b) for the maximum carried load.

4.11 Safety-related parts of the control system

Safety-related parts of the control system shall comply at least with the performance levels of ISO 13849-1 listed in [Table 1](#).