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Industrial trucks — Additional requirements for automated functions on trucks

*Chariots de manutention — Exigences supplémentaires pour les
fonctions automatiques des chariots*

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Contents

Page

Foreword.....	iv
1 Scope	1
2 Normative references	2
3 Terms and definitions.....	2
4 List of hazards.....	3
5 Safety requirements	4
5.1 Performance limitation	4
5.2 Automated control system safety	4
5.3 Operator controls and indicators	4
5.4 Emergency switching off	5
5.5 Operational safety.....	5
5.6 Additional requirements for specific movements	5
6 Verification and commissioning	7
6.1 Verification	7
6.2 Commissioning	7
7 Information for use	8
7.1 General.....	8
7.2 Operation of automated functions	8
7.3 Service and maintenance of automated functions.....	8
7.4 Operating information	9
7.5 Housekeeping	9

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 24134 was prepared by Technical Committee ISO/TC 110, *Industrial trucks*, Subcommittee SC 2, *Safety of powered industrial trucks*.

ISO 24134 is based on EN 1526:1997 and ASME B56.5A-1994:Part IV.

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Industrial trucks — Additional requirements for automated functions on trucks

1 Scope

This International Standard specifies the safety requirements for controls and control systems for the following automated functions of industrial trucks:

- steering (excluding direct mechanical guidance);
- travel;
- lifting and lowering operations;
- load manipulations, e.g. rotation, reach, slewing, tilting, clamping;
- combination and/or sequence of the above movements.

NOTE The control system is generally part of the truck but can include components external to the truck, e.g. the means of guidance for automated steering.

This International Standard is intended for use in conjunction with one or more of the applicable parts of ISO 3691.

This International Standard is not applicable to, and does not include, requirements for the following:

- safety equipment (e.g. devices for height limitation, speed limitation) used to override operator control;
- operation in severe conditions (e.g. extreme climates, freezer applications, strong magnetic fields);
- operation in environments subject to special rules (e.g. potentially explosive atmospheres);
- electromagnetic compatibility;
- transportation of passengers;
- handling of loads, the nature of which could lead to dangerous situations (e.g. molten metals, acids/bases, radiating materials).

Limitations in the scopes of the applicable parts of ISO 3691 also apply to this International Standard.

2 Normative references

The following referenced documents are indispensable for the application 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, *Industrial trucks — Safety requirements and verification — Part 1: Self-propelled industrial trucks, other than driverless, variable-reach trucks and burden-carrier trucks* ¹⁾

ISO 3691-2, *Industrial trucks — Safety requirements and verification — Part 2: Self-propelled variable-reach trucks* ¹⁾

ISO 3691-3, *Industrial trucks — Safety requirements and verification — Part 3: Additional requirements for trucks with elevating operator position and trucks specifically designed to travel with elevated loads* ¹⁾

ISO 3691-4, *Industrial trucks — Safety requirements and verification — Part 4: Driverless industrial trucks and their systems* ¹⁾

ISO 3691-5, *Industrial trucks — Safety requirements and verification — Part 5: Pedestrian-propelled trucks* ¹⁾

ISO 3691-6, *Industrial trucks — Safety requirements and verification — Part 6: Burden and personnel carriers* ¹⁾

ISO 12100-2:2003, *Safety of machinery — Basic concepts — General principles for design — Part 2: Technical principles and specifications*

ISO 13849-1—²⁾, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 20898:—³⁾, *Industrial trucks — Electrical requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 automated function
movement for transport or positioning of the truck and/or load initiated by the operator but not requiring continued action by the operator

3.2 automated lifting and lowering
automated function that controls intended vertical movements and/or positioning of the load-carrying device to a preselected height

3.3 automated load manipulation
automated function that controls load movements (e.g. rotation, reach, slewing, tilting, telescoping, clamping)

1) To be published. (Revision of ISO 3691:1980)
2) To be published. (Revision of ISO 13849-1:1999)
3) To be published. (Equivalent to EN 1175-1:1998)

3.4**automated steering**

automated function that takes control of the steering and keeps the truck on a predetermined path

NOTE Automated steering excludes any direct mechanical guidance (e.g. by means of a rail) and manually controlled steering systems equipped with feedback signal(s) for regulating the steering system.

3.5**automated steering acquisition**

system condition when automated steering has been selected but the operator is still positioning the truck to acquire the guidance means, i.e. the operator still has control of the manual truck steering system

3.6**automated travel**

automated function that takes control of the speed and direction of travel and/or positioning of the truck

3.7**sequenced automated functions**

succession of automated functions in which each movement can commence only after the completion of the previous movement

3.8**combined automated control**

automated system that takes control of two or more automated functions simultaneously

3.9**responsible person**

designated person suitably trained and qualified by knowledge and practical experience and in possession of the necessary instructions to enable the assigned task to be carried out

4 List of hazards

The following hazards can be applicable and could involve risks to persons if not addressed. The corresponding requirements offer guidance on limiting the risk or reducing these hazards.

Hazard	Corresponding requirement(s)
4.1 Crushing	
— due to failure of truck to stop	5.2.1, 5.3.3, 5.6.2
— from collapse of racking due to contact with truck	5.2.1, 5.3.3, 5.6.1, 5.6.4, 5.6.5, 5.6.6
4.2 Impact	
— from falling loads or parts of loads	5.2.1, 5.3.3, 5.6.3, 5.6.4, 5.6.5, 5.6.6
— from collapse of racking	5.2.1, 5.3.3, 5.6.4, 5.6.5, 5.6.6
— from controls or tillers	5.5.2
4.3 Electrical contact direct or indirect due to unexpected electrical fault	5.2.1
4.4 Electromagnetic radiation	Not dealt with

Hazard	Corresponding requirement(s)
4.5 Programming errors	Not dealt with
4.6 Human error	
— dangerous operation of the truck by unauthorized personnel	5.3.1, 5.3.3
— accidental operation of controls	5.3.1, 5.3.3, 5.3.4, 5.3.5, 5.5.1, 5.6.1.3
— dangerous maintenance or adjustment of truck by unauthorized personnel	6.1, 6.1.3
4.7 Hazard combinations	5.3.3, 5.4, 5.6.5, 5.6.6
4.8 Failure of energy supply	5.2.1
4.9 Failure of control system or unexpected startup	5.2, 5.3.2
4.10 Reliability of coded messages	Not dealt with
4.11 Failure of safety devices	5.2
4.12 Safety signs and signals	5.3.5, 5.6.1.3
4.13 Emergency devices	5.4

5 Safety requirements

5.1 Performance limitation

Performance of functions when automated shall not exceed that permitted by the truck design and shall meet the requirements of the relevant part(s) of ISO 3691.

5.2 Automated control system safety

5.2.1 Automated control systems shall be designed in accordance with ISO 12100-2:2003, 4.11.

Loss of control in an automated control system (e.g. excessive speed, unintended deviations from the guide path, weakening of the onboard control means or their power supply or failure of the guidance signal) that could generate a hazard shall result in the restricting or stopping of associated movements as quickly as possible within the operating parameters of the truck and without introducing new hazards.

5.2.2 Failure of the automated control system need not prevent manual operation of the function.

5.3 Operator controls and indicators

5.3.1 All automated functions shall be selected solely by means of operator controls.

5.3.2 Automated functions shall automatically reset to the manual or off position when the truck and/or automated control system are switched off.

5.3.3 It shall be possible for the operator to override an automated function at any time. It shall only be possible for the automated function to be restarted by the operator.

When manually operated functions are in use, automated operation of these functions shall be deactivated.

5.3.4 The controls for the automated functions shall be clearly marked for their purpose and designed to avoid actuation other than by intentional manual action(s).

5.3.5 Trucks shall be equipped with a warning device(s), either audible or visual or a combination thereof, that acts automatically on the activation of the automatic function(s). This device shall continue to operate while automated motions of the truck are in progress.

5.4 Emergency switching off

5.4.1 On battery-powered trucks, the device specified in ISO 20898:—, 5.2.6, shall also switch off all automated control systems except control logic and memory circuits.

5.4.2 On non-battery powered trucks, an emergency switching-off function shall be provided to perform this function.

5.5 Operational safety

5.5.1 All automated functions, except automated steering, shall be brought to a stop automatically and be switched to the manual mode when the operator leaves the normal operating position. A new initiation shall be required in order for the automated function to resume.

5.5.2 Manual controls (e.g. steering wheel, tiller, control lever) shall be designed such that they do not constitute a hazard for the operator while the truck operates in the automated mode.

5.6 Additional requirements for specific movements

5.6.1 Automated steering

5.6.1.1 If intended by the manufacturer for specific applications (e.g. order picking, lateral stacking), 5.3.2 need not apply when the truck is in the aisle.

5.6.1.2 Where automated steering is provided, the operator must select either automated or manual mode. Manual action or operation of the steering control shall not have the capability to override the automated steering when the automated steering mode has been selected.

5.6.1.3 During automated steering acquisition, speed shall be limited to 2,5 km/h and an audible or visual device shall warn the operator until the truck is steering automatically.

On trucks equipped with automated steering, an audible and/or visual warning device complying with ISO 12100-2:2003, 6.3, shall warn the operator when the truck is entering areas where automated guidance is required if the automated steering system has not been selected.

5.6.1.4 The safety-related parts of the control system shall conform to ISO 13849-1:—, category 3, in the automated steering mode and ISO 13849-1:—, category 2, during automated steering acquisition.

See Table 1.

5.6.2 Automated travel

Automated travel functions, when provided, shall not be shared by, but shall be capable of being overridden by the operator or limited by the automated mode.

The safety-related parts of the control system shall conform to ISO 13849-1:—, category 3.

5.6.3 Automated lifting and lowering

Automated lifting/lowering functions, where provided, may have characteristics of the automated function that require additional sensing, e.g. external truck position sensing device.

The safety-related parts of the control system shall be in accordance with ISO 13849-1:—, category 1.

5.6.4 Automated load manipulation

The safety-related parts of the control system for non-visual monitoring means for each individual movement (e.g. fork tip sensors to monitor pallet positions) shall conform to ISO 13849-1:—, category 2.

5.6.5 Sequenced automated functions

5.6.5.1 Where automated control for each sequenced function is initiated by the operator, the corresponding ISO 13849-1 category for safety-related parts of the control system shall be as for that particular function.

5.6.5.2 Where automated load-handling control for the first function of the sequence is initiated by the operator and subsequent functions are started automatically, the safety-related parts of the control system shall be in accordance with ISO 13849-1:—, category 2.

5.6.6 Combined automated control

5.6.6.1 Where two or more functions depend on each other (e.g. raising and extending the boom of a variable reach truck to achieve horizontal or vertical parallel movements of the load), the safety-related parts of the control system for the combined automated functions shall not be less than the highest ISO 13849-1 category for the individual functions and shall in no case be less than category 2.

5.6.6.2 Where functions are independent of each other (e.g. steering and lifting), the corresponding ISO 13849-1 category for safety-related parts shall be as for that particular function.

Table 1 — Categories of safety-related parts of control system according to ISO 13849-1

Control system	Category
Automated steering (5.6.1.4)	3
Automated steering acquisition (5.6.1.4)	2
Automated travel (5.6.2)	3
Automated lifting and lowering (5.6.3)	1
Automated load manipulation (5.6.4)	2
Sequenced automated functions (5.6.5.2)	2
Combined automated functions (5.6.6.1)	2

Fault exclusion: Deviations from the safety categories in this International Standard shall only take place in accordance with ISO 13849-1:—, Clause 7.

6 Verification and commissioning

6.1 Verification

6.1.1 General

The manufacturer shall have verified that the requirements of Clause 5 have been met. Verification shall be done by competent person(s) and include the following:

- a) design check (see 6.1.2);
- b) type testing (see 6.1.3);
- c) routine testing (see 6.1.4).

Means of checking design other than those listed in 6.1.2 may be used, provided that they give equivalent results.

6.1.2 Design check

The design documents for the controls and control systems for the automated functions shall be verified for compliance with this International Standard. In particular, the design shall be checked to establish that the requirements of 5.1, 5.2.1 and 5.6.1.3 have been fulfilled, and that the safety-related parts of the control systems conform to the categories specified in 5.6.1 to 5.6.6 and Table 1.

6.1.3 Type testing

The following checks shall be carried out on a sample representative of series production:

- a) the truck shall be operated to verify compliance, where applicable, with the requirements of Clause 5;
- b) the performance and speed, where applicable, shall be measured to establish compliance with 5.1 and 5.6.1.3;
- c) a visual check to determine that the requirements of 5.3.4 and 5.5.2 have been fulfilled.

6.1.4 Routine testing

A test shall be made on each truck to establish that the relevant automated functions are working correctly.

The truck shall be operated to confirm that the requirements of 5.3.2, 5.3.5, 5.5.1 and 5.6.1.2, where applicable, have been fulfilled.

The correct operation of warning devices and functioning of the speed limitation for steering acquisition as specified in 5.6.1.3 shall be checked, as applicable.

6.2 Commissioning

6.2.1 Trucks with automated positioning systems that are separate from the truck shall be commissioned at the place of use, by the manufacturer or the authorized representative, before handover.

6.2.2 The manufacturer shall provide a method statement including the necessary information for the commissioning sequence.

6.2.3 The manufacturer shall provide an instruction manual including the necessary technical information (e.g. mechanical and electrical).