



BSI Standards Publication

Rough-terrain trucks — Safety requirements and verification

Part 6: Application of EN ISO 13849-1 to slewing and non-slewing variable-reach rough-terrain truck

National foreword

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**Rough-terrain trucks - Safety requirements and verification –
Part 6: Application of EN ISO 13849-1 to slewing and non-
slewing variable-reach rough-terrain truck**

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European foreword

This document (CEN/TR 1459-6:2015) has been prepared by Technical Committee CEN/TC 150 “Industrial Trucks - Safety”, the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

EN 1459 consists of the following parts, under the general title *Rough-terrain trucks — Safety requirements and verification*:

- *Part 1: Variable-reach trucks*
- *Part 2: Slewing variable-reach trucks*
- *Part 3: Interface between the variable-reach truck and the work platform*
- *Part 4: Additional requirements for variable reach trucks handling freely suspended loads*
- *Part 5: Additional requirements for attachments and attachment interface*
- *Part 6: Application of EN ISO 13849-1 to slewing and non-slewing variable-reach rough-terrain trucks*

Introduction

This Technical Report has been prepared to explain the rationale used to determine the minimum required Performance Levels for rough terrain variable reach trucks as listed in EN 1459 series.

It is intended to provide solid basis to the Performance Level Required (PL_r) required for the Safety Related Part of Control System (SRP/CS) referred to in prEN 1459-1, EN 1459-2 and EN 1459-3. The PL_r have been defined by using approaches from appropriate standards for safety of machinery and proven general principles for design.

The methodology described in this Technical Report may be used by other Technical Committees to assess the risk and determine PL_r for machines covered by other type C-standards.

1 Scope

This Technical Report describes the risk assessment methodology followed to determine the Performance Level required (PL_r), as defined in EN ISO 13849-1:2008, for specific safety related parts of control system (SRP/CS) of rough-terrain variable-reach trucks covered by prEN 1459-1, EN 1459-2 and EN 1459-3.

This Technical Report does not apply to SRP/CS that includes no electrical/electronic components.

NOTE It is the intention of CEN TC150 WG2 to use the same methodology to develop future standards (e.g. further parts of EN 1459).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN 1459-1:2015, *Rough-terrain trucks — Safety requirements and verification — Part 1: Variable-reach trucks*

EN 1459-2:2015 *Rough-terrain trucks — Safety requirements and verification — Part 2: Slewing variable-reach trucks*

EN 1459-3:2015 *Rough-terrain trucks — Safety requirements and verification — Part 3: Interface between the variable-reach truck and the work platform*

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

EN ISO 13849-1:2008 *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

ISO/TR 14121-2:2012 *Safety of machinery — Risk assessment — Part 2: Practical guidance and examples of methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100, prEN 1459-1:2015, EN 1459-2:2015 and EN 1459-3:2015 and the following apply.

3.1

operator

competent person who controls the operation of the truck

3.2

co-worker

trained person who is working in the vicinity of the truck but not in control of the truck

3.3

by-stander

untrained person who is in the vicinity of the truck and not involved in the job site activity

4 General

It is intended that this document be read in conjunction with the corresponding Parts -1, -2 and -3 of this standard (EN 1459).

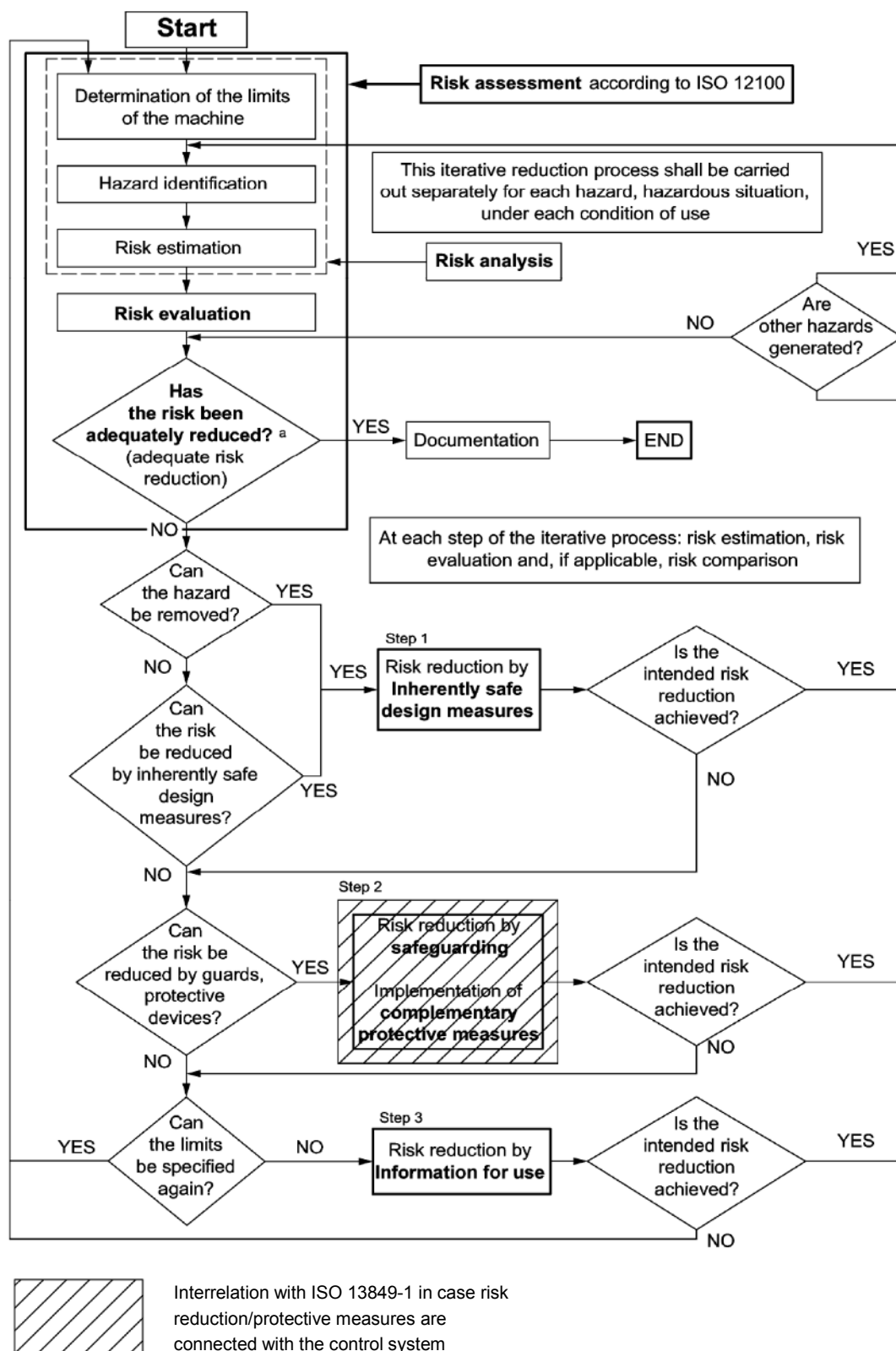
EN ISO 13849-1 applies to the safety related parts of control system including the design of software, regardless of the type of technology and energy used (electrical, electronic, hydraulic, pneumatic, mechanical, etc.), for all kinds of machinery.

For safety functions that comprise mechanical parts only, no specific performance level is necessary.

There are many control systems fitted to trucks but not all will be subject to the requirements of EN ISO 13849-1.

EN ISO 13849-1 is relevant for cases where a risk assessment according to EN ISO 12100 has initiated a risk reduction measure that relies on a safety-related control system. In those cases the safety-related control system has to perform a safety function. The application of EN ISO 13849-1 is restricted to those cases only (see figures 1 and 2).

Systems may be subject to specific requirements in other standards e.g ISO 6292 - *Powered industrial trucks and tractors — Brake performance and component strength*.



^a The first time the question is asked, it is answered by the result of the initial risk assessment.

Figure 1 — Process flow chart

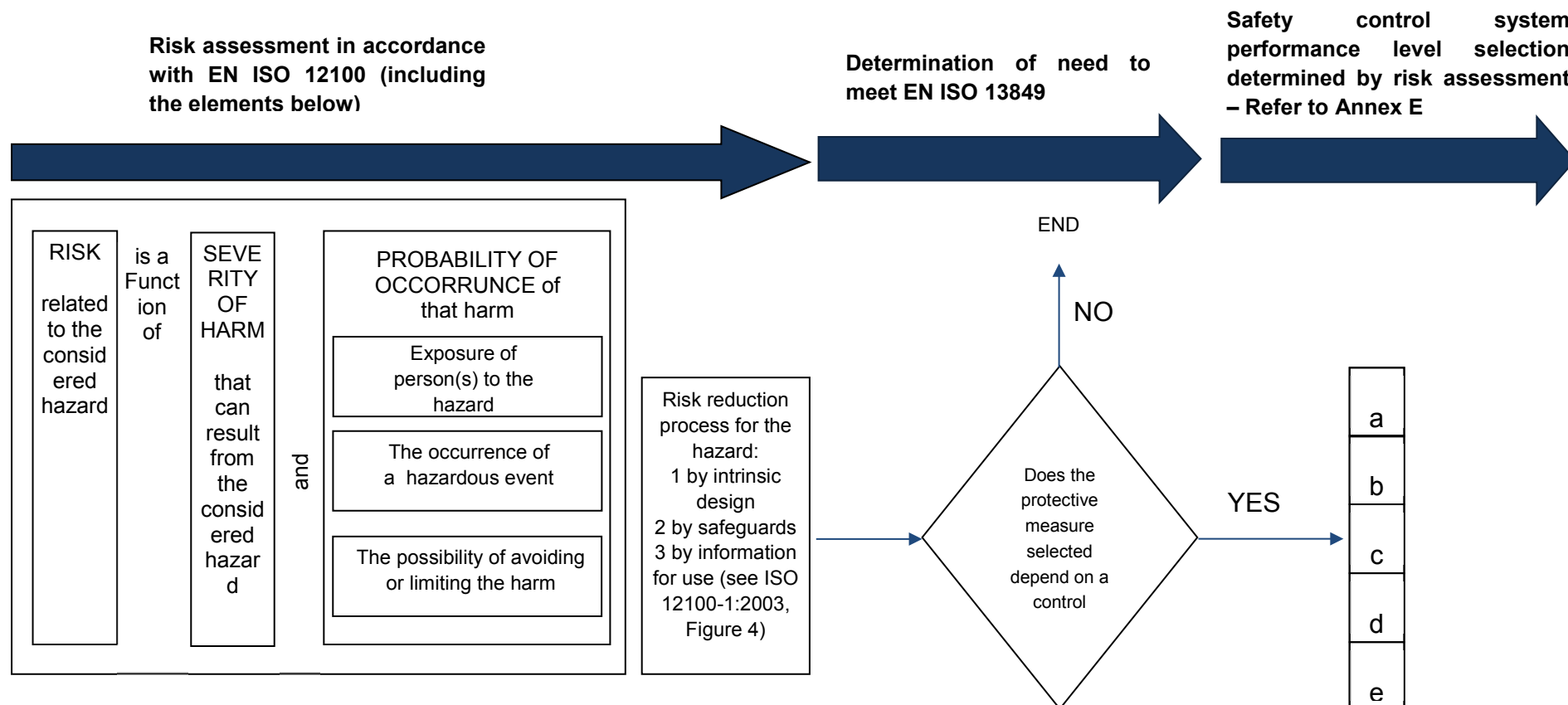


Figure 2 — Abbreviated EN ISO 12100/EN ISO 13849-1 process drawing distinction between risk assessment and control system performance selection

5 Description of the procedure followed to determine PL_r for SRP/CS of trucks

The first stage of meeting EN ISO 13849-1 is to take the risk assessment/risk reduction output from following EN ISO 12100 and to check whether the protective measure selected depends on the control system.

In order to perform the EN ISO 12100 assessment correctly for trucks with respect to EN ISO 13849-1 compliance, any existing control system which has been added / modified for achieving safety should be disregarded at a first stage so that the risk they are addressing can be understood. This is important to get the correct inputs if the system is later determined as SRP/CS and requires a PL_r to be determined.

The following key stages were applied to determine PL_r for SRP/CS:

- a) Identify which functions of the truck involve SRP/CS and identify the relevant clauses in the standard. Determine control systems (mechanical, hydraulic, pneumatic, electrical/electronic, electro-mechanical, electro-hydraulic...) that are necessary for the truck to carry out its intended function 8.2 and Annex A)
- b) Determine the intended truck limits as per EN ISO 12100:2010 clause 5.3 (see 8.1)
- c) Perform risk assessment in accordance with EN ISO 12100:2010 clauses 5.5 and 5.6 (see Annex E)
- d) Take into account any risk reduction measures (intrinsic design and safeguards) and re-assess the system to determine if the intended risk reduction has been achieved at this point any existing control systems that are known to be used/added/modified for achieving safety should be considered as a risk reduction measure. (see 8.3, Annex E and EN ISO 12100:2010 clause 5.6)
- e) Determine if the protective measure selected is dependent upon a control system (and is therefore SRP/CS). If it is not the process ends here.
- f) If the protective measure is dependent upon a control system, use the information from the EN ISO 12100 Risk Assessment to determine the EN ISO 13849-1 performance level that applies to that system (this should consider that other non-control system risk reduction measures intended to be fitted are in-place) (see Annex E)

NOTE The integrity of control systems which are not subject to EN ISO 13849-1 are to be ensured by following sound engineering practice and by following relevant technical requirements and standards as applicable. EN ISO 13849-1 imposes an extra burden to SRP/CS due to the nature and importance of these in providing safety to exposed persons.

6 Risk assessment methodology

EN ISO 12100 does not define a risk assessment method but does define the elements to be considered. Users of the above standard are free to choose a risk assessment method and ISO/TR 14121-2 provides practical guidance and examples. It should be noted that the informative "Risk Graph" as presented in EN ISO 13849-1 is not a risk assessment tool that fulfils the needs of EN ISO 12100 as it does not include the important component of "probability of occurrence". It also offers limited selection of exposure, possibility of avoidance or limiting harm and severity as compared to other documented risk graphs (see for example ISO/TR 14121-2, A.4).

The risk graph in EN ISO 13849-1 is a tool to determine a PL_r but is not a risk assessment method, this tool was used to determine risks associated with a press and therefore its value is limited in relation to mobile machinery. See 8.3 for risk evaluation of trucks.

Document ISO/DTR 18670 *Safety of machinery — How EN ISO 12100 relates to EN ISO 13849-1* gives more explanation on this point, for instance in clause 4.1 it's written that:

"For the correct application of EN ISO 13849-1 basic input information resulting from the application of the overall risk assessment and risk reduction process for the particular machine design is necessary. Based on this input information the safety-related parts of the control system can be appropriately designed according to EN ISO 13849-1. Information resulting from a detailed design of safety-related parts of the control system relevant for its integration into the machine design has then to be considered in the overall risk assessment and risk reduction process according to EN ISO 12100."

"...Consequently all necessary input information for the selection of the PL_r (elements of risk values for the considered hazardous situation) are available from the overall risk assessment and risk reduction process according to EN ISO 12100."

Therefore a separate risk assessment for the application of EN ISO 13849-1 is not necessary. The graph given in EN ISO 13849-1:2006, Figure A.1 is used only to select the PL_r for safety functions and is not intended to be used as a risk estimation method for the overall machine according to EN ISO 12100."

The risk evaluation used for trucks is based on the Kinney method machinery safety¹⁾ .

7 Risk Assessment Process

7.1 Determination of Machine limits

The following limits of use for the trucks is determined first in accordance with ISO 14121 to assist with the risk assessment.

a) Intended use:

- Starting
- Driving
- Load handling
- User stabilizers
- Operation (right side window breakage)
- Maintenance
- Lifting of persons (only EN 1459-3)
-

b) Foreseeable misuse:

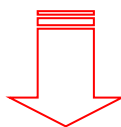
- Overriding of LLMC-LLMI and other safety devices (not emergency situation)
- Use of stabilizers to displace the machine
- Improper use of forks and other attachments

1) Fine, W.T. 1971. Mathematical Evaluation for controlling Hazards, Journal of Safety Research.
Kinney, G & Wiruth A. 1976, Practical Risk Analysis for Safety management

- Overload of the platform (only EN 1459-3)
- Overriding of controls in normal operation condition (only EN 1459-3)
- Use not integrated platform (only EN 1459-3)

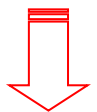
c) Limit to the use of the machine by persons:

- 95% men
- Mostly between 18-60 years, occasionally between 14-18 years and more than 60
- Right hand operator (dominant hand usage)
- Visual limits for placing loads (17-18 m), more for driving (visibility measured at 12 m considered as the reaction time as per EN 15830)
- Hearing limits (regularly checked and medically approved to operate the machine)
- Physical size: 5-95 percentile of human size distribution
- Strength: level for steering and braking in case of failure
- level of training and experience of the operator: newcomers (not trained) and experienced (rely too much on the experience, less prepared to adapt to new machine and devices).
- Increased legal obligation for a training for the operator
- experience or ability of the users



- operators (refer to above)
- maintenance persons
- trainees
- general public (they should not be entitled to operate machines if they are not properly trained)

- exposure of other persons



- other operators
- co-workers in the vicinity
- non-employees and visitors in the vicinity including children (work site supervisor's responsibility)

d) Space limits

- Range of movements (travelling, boom movement, stabilizers movement, cab and guards movement)
- Range of movements (boom movement, platform movement) (only EN 1459-3)
- Space required to interact with the machine
 - For the operator

- For maintenance people
 - Operator-machine interface
 - Machine power supply interface
- e) Time limits
- Life time of machine and/or components
 - Recommended service intervals
 - Stress due to job schedule (quickest way to carry out a task)
- f) Other limits:
- Exposure to animals and human reaction
 - Environmental
 - Minimum and maximum temperature
 - Indoor and outdoor usage
 - Weather (dry/wet/rain/snow/fog/direct sunlight/dust)
 - Ground conditions
 - Level of cleanness required of the machine and cleaning process
 - Characteristic of the material to be handled (not applicable to EN 1459-3)
 - human error/behaviour
 - human behaviour when faced with a failure or incident with the machine

7.2 Hazard identification (5.4 annex B of EN ISO 12100)

Annex A includes tables which were created to identify the clauses which include SRP/CS within prEN 1459-1, EN 1459-2 and EN 1459-3 and therefore a PL_r

The hazard identification numbering corresponds to the references within the risk assessment spread sheet.

Where information is strikethrough an explanation is given rather than deleting the information to demonstrate the thought processes.

In Annex E, each line of the risk assessment is a breakdown of the task and hazardous events that may occur.

NOTE 1 Indicators are not part of control system (SRP/CS) so are not addressed in this analysis.

NOTE 2 Tasks including setting, corrective maintenance (being realized at the factory or at the dealership generally) are considered not applicable to the by-standers assessment because these are carried out by trained personnel.

7.3 Risk evaluation

The complete risk evaluation and calculation is in Annex E.

The risk evaluation is based on the statistical / numerical method of calculating machinery safety first developed by Kinney, G and Wiruth A. 1976, Practical Risk Analysis for Safety management.

The risk is calculated separately for the three pre-determined groups operator, co-worker and bystander

The risk evaluation is made in two steps:

- a) the first step (columns J-O initial assessment) assumes the truck has no safety device fitted or a solution in place for risk reduction on the machine.

The risk priority number (RPN) is calculated using the following formula and the values in Annex B.

$$P \times E \times S \times N = RPN$$

where:

P is the possibility/probability of avoiding the hazard or limiting the harm

E is the exposure (time and frequency) to the hazard

S is the severity of injury

N is the number of persons involved

To determine a performance level the highest RPN is used calculated from the three groups.

The values in Annex C determine the risk rating and where the risk assessment deems this is a safety related part of the control system a corresponding performance level is given.

- a) the second step considers the countermeasures within prEN 1459-1, EN 1459-2 or EN 1459-3 have been implemented fully and are working correctly (columns Q-V).

NOTE For the purpose of the residual risk assessment we have to consider the SRP/CS fitted as a countermeasure is working and $P=0.033$ is considered the most appropriate value to enable closure of the risk assessment.

8 Required performance level for SRP/CS of trucks

Tables 1, 2 and 3 identify performance levels required for the SRP/CS referenced to in prEN 1459-1, EN 1459-2 and EN 1459-3. These PL_r are based upon generic risk assessment for the collective trucks types with certain control system architecture and being used in the specified application. As such the identified PL_r are presented for guidance and manufacturers shall verify that the respective PL_r are in accordance with their own EN ISO 12100 risk assessments.

For electrical, electronic and software based circuits, corresponding Safety Integrity Levels (SILs) according to EN 62061 may be used in accordance with Table 1 of PD ISO/TR 23849:2010 which is replicated below.

ISO/TR 23849:2010 – Table 1:

Performance Level	Average Probability of a Dangerous Failure per Hour (1/h)	Safety integrity level (SIL)
a	$\geq 10^{-5}$ to $< 10^{-4}$	No special safety requirements
b	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$	1
c	$\geq 10^{-6}$ to $< 3 \times 10^{-6}$	1
d	$\geq 10^{-7}$ to $< 10^{-6}$	2
e	$\geq 10^{-8}$ to $< 10^{-7}$	3

Where SILs and PLs are used in the same safety function, combination shall be in accordance with 7.1 and 7.3 of PD ISO/TR 23849: 2010.

8.1 prEN 1459-1

Table 1 — PL_r for variable-reach trucks

Ref No.	SRP/CS (clause of prEN 1459-1:2015)	Performance level
1	4.2.2 unintended movement	PLb
2	4.2.3 uncontrolled motion	PLb
3a	4.2.4.a) powered travel movement	PLc
3b	4.2.4.b) powered travel movement	PLb
3c	4.2.4.c) powered travel movement	PLc
4a	4.2.5 non activation of the parking brake	PLb
4b	4.5.5 Multi-function controls – 2nd para	PLb
4c	4.7 stabilizing devices 2nd indent	PLb
4d	4.7 stabilizing devices 4th paragraph	PLb
6	4.5.1.1 multiple operating positions	PLc
7	4.5.1.3 inadvertent activation	PLb
8	4.5.4.2.1 control with detents	PLb
9	4.5.4.2.2 boom float control	PLc
10	4.7 stabilizing devices 1st indent	PLb

NOTE This reference number in the first column of the table refers to Table A1.

8.2 prEN 1459-2

The comparison of clauses and risks against PL's already determined for prEN 1459-1 is in Annex D

Table 2 — PL_r for slewing variable-reach trucks

Ref No.	SRP/CS (clause of EN 1459-2:2015)	Performance level
1	4.2.2 unintended movement	PLb
2	4.2.3 uncontrolled motion	PLb
3a	4.2.4.a) powered travel movement	PLc
3b	4.2.4.b) powered travel movement	PLb
3c	4.2.4.c) powered travel movement	PLc
4a	4.2.5 non activation of the parking brake	PLb
6	4.5.1.1 multiple operating positions	PLc
7	4.5.1.3 inadvertent activation	PLb
8	4.5.4.2.1 control with detents	PLb
9	4.5.4.2.2 boom float control	PLc
10	4.7 stabilizing devices 1st indent	PLb
11	4.7 stabilizing devices 3rd indent	PLc
20	4.5.1 f) means shall be provided to prevent any possibility of powered movements actuated by controls if the operator is not at one operator's position.	PLc
21	4.5.8. Axle oscillation locking	PLb
22a	4.10.7.1.1 LLD General	PLc
22b	4.10.7.1.1 LLD General (5th paragraph)	PLc
22c	4.10.7.1.1 LLD General (6th paragraph)	PLc
22d	4.10.7.1.1 LLD General (7th paragraph)	PLc

NOTE This reference number in the first column of the table refers to Table A2.

8.3 prEN 1459-3

Table 3 — PL_r for trucks fitted with integrated personnel work platform

Ref No.	SRP/CS (clause of EN 1459-3:2015)	Performance level
18	4.2.2 Engagement of platform	PLc
19	4.2.3 Disengagement of platform	PLc

NOTE this reference number in the first column of the table refers to Table A3.

Annex A (informative)

Hazard identification

A.1 prEN 1459-1

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
4	5.2.1 ~~unauthorized starting~~ Note: 4.2.1 is covered by 4.2.2 and this is the reason why it isn't addressed here	The ~~machine~~ starts inadvertently	Mechanism ~~and~~ function	Start up setting Restart after unscheduled stop Fault finding/troubleshooting Corrective maintenance
1	4.2.2 unintended movement	The machine moves inadvertently after starting	Mechanism function/parts and Environment	Start up setting Restart after unscheduled stop Fault finding/troubleshooting Corrective maintenance Recovery of operation from jam

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
2	4.2.3 uncontrolled motion Note: the analysis is the same of 4.2.2	The machine moves inadvertently from rest	Mechanism and function Environment Parts	Start up setting Restart after unscheduled stop all modes of operation (boom movement + rpm increase) Fault finding/troubleshooting Corrective maintenance Recovery of operation from jam
3a	4.2.4 a) powered travel movement	The machine moves when the operator is not at the primary operating position	Mechanism and function Environment Parts	Start up <i>Note: the machine has already started up, not applicable.</i> Setting Testing ~~Recovery of operation from jam~~ <i>Note: we considered not applicable</i> ~~Fault finding/troubleshooting~~ <i>Note: we considered not applicable</i> all modes of operation (attachment functions and locking, trailers connection, PTO operations) ~~preventive maintenance~~ <i>Note: we considered not applicable</i> Corrective maintenance ~~Stopping of the machine~~ <i>Note: we considered not applicable</i> ~~Stopping the machine in case of emergency~~ <i>Note: we considered not applicable</i>

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
3b	4.2.4 b) powered travel movement	Powered travel shall not occur automatically when the operator returns to the normal operator's position without an additional operation, e.g., by requiring resetting the direction control.	Mechanism function and Environment Parts	Start up <i>Note: the machine has already started up, covered by 5.2.2 unintended movement.</i> Setting Testing ~~Restart after unscheduled stop~~ <i>Note: the machine has already started up, covered by 5.2.2 unintended movement</i> all modes of operation (forward travelling, reverse travelling) Corrective maintenance
3c	4.2.4 c) powered travel movement	Application of the parking brake shall apply neutral travel control, except on trucks with hydro-static transmission	Mechanism function and Environment Parts	Start up Setting Testing Stopping of the machine ~~Stopping the machine in case of emergency~~ <i>Note: we considered this already covered by "stopping of the machine"</i>
4a	4.2.5 non activation of the parking brake	Operator is not warned that the parking brake is engaged.	Mechanism function and Parts	Setting Testing (applicable to operator and co-worker only) Stopping of the machine
4b	4.5.5 Multi-function controls – 2 nd para	Operator is not warned about mode of operation (dangerous movements)	Mechanism function and Parts	Setting Testing (applicable to operator and co-worker only) Fault finding/troubleshooting (applicable to operator and co-worker only) All modes of operation
4c	4.7 stabilizing devices 2 nd indent	Bystanders hit by stabilizers during travel mode	Mechanism function and Parts	Setting Testing (applicable to operator and co-worker only) All modes of operation

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
4d	4.7 stabilizing devices 4 th paragraph	Loss of stability	Mechanism and function Parts	Setting Testing (applicable to operator and co-worker only) All modes of operation
	~~5.10.7.1 and 5.10.7.2 control panels and control displays~~	LLMI is not considered here because it is covered by EN 15000. <i>Note: 5.10.7.1 and 5.10.7.2 are too broad to be covered by the analysis and these clauses already give prescriptions because they have got standards references.</i>		
5	5.3.1 – 5.3.2 Brakes	Note: Will be taken into account electrohydraulic brakes, if added to prEN 1459-1	Mechanism and function Environment Parts	Setting Testing Stopping of the machine Stopping the machine in case of emergency Restart after unscheduled stop recovery of operation from jam or blockage (towing) preventive maintenance Corrective maintenance

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
6a	4.5.1.1 multiple operating positions (the use of the controls at one operator's position shall preclude the use of the controls at other operator's positions)	Uncontrolled load movement Uncontrolled movement of stabilizers, levelling, etc. <i>Note: application of man platform is not considered here but in EN 1459-3 and in EN 280.</i>	Mechanism and function Parts Environment	Setting Testing (daily checks) all modes of operation (boom lifting, lowering, extending, retracting, fork tilting, attachment locking, attachment functions, stabilizers, leveling, steering, forward and reverse travelling) start-up; Stopping of the machine Stopping the machine in case of emergency Restart after unscheduled stop Fault-finding/trouble-shooting (only operator and coworker) ~~Adverse weather conditions (e.g. lightning, wind, etc.)~~ <i>Note: this is something that is not possible to control and we cannot define a performance level for this.</i>
7	4.5.1.3 inadvertent activation (only when the deactivation device is provided)	Uncontrolled load movement (the deactivation device doesn't work properly)	Mechanism and function Parts	~~Testing~~ —(included in “all modes of operation” because it's determined to be a more controlled environment) all modes of operation (boom lifting, lowering, extending, retracting, fork tilting, attachment locking, attachment functions, stabilizers, levelling, steering, forward and reverse travelling) start-up; ~~Stopping of the machine~~ ~~Stopping the machine in case of emergency~~ restart after unscheduled stop Corrective maintenance

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
8	4.5.4.2.1 control with detents (The control mode shall: — be automatically deactivated when the truck is switched off and not be automatically activated when the truck is switched on; or — prevent the truck from being restarted until the detent mode is deactivated)	Unintended activation of auxiliary function	Mechanism and function Parts Environment	~~Setting~~ ~~Testing~~ process/tool changeover start up ~~all modes of operation (boom lifting, lowering, extending, retracting, fork tilting, attachment locking, attachment functions)~~ removal of product from machine / recovery of operation from jam or blockage ~~Stopping of the machine~~ ~~Stopping the machine in case of emergency~~ ~~restart after unscheduled stop~~ (covered by start up) ~~fault finding/trouble shooting~~ (covered by corrective maintenance) corrective maintenance

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
9	4.5.4.2.2 boom float control For trucks equipped with boom float control, protection shall be provided against unintended lowering of the boom. In addition to 4.5.4.2.1, the boom float control mode shall be automatically deactivated when the boom raising/lowering control is operated.	Unintended lowering of the boom – determined that there is no risk to the operator during this action and only co-worker / bystander were assessed. NOTE: additional safety device to avoid unintended operation of the boom float activation control (2-action control...)?	Mechanism and function Parts Environment	~~Setting~~ ~~Testing~~ Start-up / restart after unscheduled stop all modes of operation (boom raising and lowering) ~~Stopping of the machine~~ ~~Stopping the machine in case of emergency~~ ~~recovery of operation from jam or blockage~~ ~~restart after unscheduled stop~~ ~~fault-finding/trouble-shooting~~ (covered by corrective maintenance) corrective maintenance / fault finding / trouble shooting
10	4.7 stabilizing devices 1st indent: “When stabilising devices are provided - Stabilising devices shall be fitted with means, which keep them in position in case of hose failure or oil leakage.	Unintended movement of stabilizers	Mechanism and function Parts Environment ~~Process and material handling~~	~~Testing~~ all modes of operation (stabilizers) corrective maintenance - fault-finding/trouble-shooting ~~preventive maintenance~~ cleaning and housekeeping

A.2 EN 1459-2

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
20	4.5.1 f) <i>f) means shall be provided to prevent any possibility of powered movements actuated by controls if the operator is not at one operator's position.</i>	The machine or its elements move inadvertently when the operator is not at the primary operating position.	Mechanism and function Parts Environment	Setting/Testing Operation: slewing Process/tool changeover Corrective maintenance / fault finding / trouble shooting
21	4.5.8 Axle oscillation locking <i>When operating on wheels, means shall be provided to automatically lock the oscillating axle when the slewing upper structure is not in forward aligned position and when the boom is lifted at height greater than the one corresponding to the travel position as defined by the manufacturer</i>	Non-engagement or disengagement of suspension locking system (with loss of stability)	Mechanism and function Parts Environment	Setting/Testing All modes of operation Corrective maintenance / fault finding / trouble shooting
22a	4.10.7.1.1 LLD General (1 st paragraph) <i>Trucks shall be fitted with a load limiting device, in order to prevent instability and/or overloading whichever is the load carrying attachment fitted</i>	Tip over, falling objects	Mechanism and function Parts Environment	All modes of operation Corrective maintenance / fault finding / trouble shooting Start-up / restart after unscheduled stop

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
22b	4.10.7.1.1 LLD General (5th paragraph) <i>The LLD shall operate automatically and without the need for resetting when triggered. The LLD, once triggered, shall remain triggered until the overload condition has been removed or the overturning moment has been lessened within the limits permitted by the manufacturer</i>	Tip over, falling objects	Mechanism and function Parts Environment	Setting/Testing All modes of operation Corrective maintenance / fault finding / troubleshooting

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
22c	4.10.7.1.1 LLD General (6th paragraph) <i>Where a truck can be operated in different configurations of wheels, stabilising devices, or slewing angle range, the proper selection of correct LLD settings for the actual configuration shall be automatic and their modification by the operator shall not be possible. This requirement does not cover the interchange of attachment fitted on the load carriage</i>	Tip over, falling objects	Mechanism and function Parts Environment	Setting/Testing (Adjustment and setting or verification of functional parameters of the machine) All modes of operation Corrective maintenance / fault finding / troubleshooting
22d	4.10.7.1.1 LLD General (7th paragraph) <i>When the truck is intended to be used with a range of attachments, the LLD shall be reset accordingly. An attachment selector may allow the operator to set the LLD with reference to the attachment used</i>	Tip over, falling objects	Mechanism and function Parts Environment	Setting/Testing All modes of operation Corrective maintenance / fault finding / troubleshooting Adjustment and setting or verification of functional parameters of the machine (selection of the attachment).

No.	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
23	5.10.8.2 LID ~~Trucks shall be fitted with a load indicating device, in order to warn the operator of instability and/or overloading whichever is the attachment fitted~~	Tip-over	Mechanism ~~and~~ function Parts Environment	Setting/testing All modes of operation Corrective maintenance / fault finding / trouble shooting Start-up / restart after unscheduled stop
24	5.10.8.3 ~~Aligned~~ configuration indicator ~~Two different visual indications according to EN 842 shall be provided to indicate to the operator in normal operating position when the truck is in forward or rearward aligned configuration~~	Inconsistency between steering controls ~~and movement and forward/reverse direction~~ controls and movement	Mechanism ~~and~~ function Parts Environment	Setting/testing All modes of operation Corrective maintenance / fault finding / trouble shooting Start-up / restart after unscheduled stop

A.3 EN 1459-3

	Paragraph of standard	Hazardous event	Areas of the machinery concerned	Tasks
18	4.1 and 4.2 Locking of the work platform EN 1459-3 <i>The truck function shall change to MEWP function only when the work platform is:</i> - <i>mechanically, electrically and, if necessary for the operation of any SRP/CS (see EN ISO 13849-1) fitted to the platform, hydraulically fitted to the truck; and</i> - <i>locked and interlocked</i> The safety related part of the control system (as defined in EN ISO 13849-1) performing the interlocking function shall comply with 4.6	Unintended disengagement of the platform from the truck. (without activation of any control). The disengagement can happen with the platform at height	Mechanism and function Parts	Assembly of the machine Connecting to power supply Fixing, anchoring ~~Testing~~-(covered by assembly and all modes of operation) all modes of operation (boom lifting, lowering, extending, retracting, attachment functions, levelling of platform) ~~Dismantling/removal of parts, components, devices of the machine~~ Recovering from control and protective devices failure ~~Isolation and energy dissipation~~ ~~Rescue of trapped persons~~-(not relevant to interlocking function)

19	4.3 Dismounting of the work platform from the truck EN 1459-3 <i>The dismounting of the work platform from the truck shall require two separate intentional actions (e.g. one to unlock and a second to dismount).</i>	Disengagement of the platform from the truck. (actuated by an action on controls in the cab) The disengagement can happen with the platform at height	Mechanism function Parts	and Testing all modes of operation (boom lifting, lowering, extending, retracting, attachment functions, levelling of platform) ~~Dismantling/removal of parts, components, devices of the machine~~ Recovering from control and protective devices failure ~~Isolation and energy dissipation~~
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Annex B (informative)

Numerical weighting of Risk Priority Number (RPN)

In the risk assessment process, specific numerical values are assigned to the parameters P, E and S depending on qualitative evaluations of the specific risk under assessment.

Probability	N umerical weighting
Almost impossible – possible only under extreme circumstances	0,033
Highly unlikely - though conceivable	1
Unlikely - but could occur	1,5
Possible – but unusual	2
Even chance - could happen	5
Probable - not surprising	8
Likely – only to be expected	10
Certain - no doubt	15

Exposure	N umerical weighting
Annually	0,5
Monthly	1
Weekly	1,5
Daily	2,5
Hourly	4
Constantly	5

Severity	Injuries or damage to the health of persons	N umerical weighting
0	insignificant (no injury or an injury such as a scratch or bruise with less than 3 days loss of work and total	0,1
I	insignificant (injury such as laceration or other mild ill-effect with less than 3 days loss of work and total	0,5
II	minor (injury with 3-56 days loss of work and total recovery – break of a minor bone or minor illness)	2
III	major (injury with more than 2 months loss of work and total recovery or permanent slight incapacity – break of a major bone or major illness)	4
IV	severe (injury/illness resulting in permanent incapacity – loss of one limb, eye, hearing loss)	6
V	severe (injury/illness resulting in permanent incapacity – loss of two limbs or eyes)	10
VI	fatality	15

Number of persons	N umerical weighting
1-2 persons	1
3-7 persons	2
8-15 persons	4
16-50 persons	8
50+ persons	12

Legend:

Probability: the possibility of the event occurring taking into account the possibility to avoid the harm.

Exposure: how often persons are exposed to the hazard

Severity: physical injury or damage to health that could "realistically" occur

Annex C (informative)

Risk priority number and corresponding performance level

The following table explains the RPN equivalent performance level and the required action.

Although similar to the Proctor Risk Assessment Calculator, www.machinerysafety.co.uk, numbers were modified to account for the risk of machine mobility and the requirement of a minimum of 5 performance levels.

Correlation between PLs and RNP has been defined by the sub-group experts on the basis of the available literature and previous companies' experience.

NOTE If a Performance Level e is determined by risk assessment the system generally requires redesigning and / or further assessment.

Risk number	rating	Ris	Action
1000	Unacceptable PLe	High	the risk is unacceptable and cannot be justified on any grounds
501 – 1000	Extreme PLe		
301 – 500	Very high PLd	Substantial	the risk should be reduced to a level as low as is reasonably practicable
51 – 300	High PLc		
10 – 50	Moderate PLb	Moderate	the risk is tolerable if the scale of measures required to remove the risk is disproportionate to any improvement gained
6 – 9	Low		
2 – 5	Very low PLa	Lo	the risk is broadly acceptable and no further precautions are needed
0 – 1	Extremely low PLa		

Annex D (informative)

Comparison of risks prEN 1459-1 and EN 1459-2

This comparison was completed to ensure the risk assessment was not duplicated

NOTE Items are only strikethrough to corresponding with ref.no as shown in Annex A

Ref No.	Paragraph of standard prEN 1459-1	Hazardous event	Paragraph of standard EN 1459-2	Hazardous event
1	5.2.2 unintended movement	The machine moves inadvertently after starting	5.2.2 unintended movement	The machine moves inadvertently after starting (Same risk)
2	5.2.3 uncontrolled motion	The machine moves inadvertently from rest	5.2.3 uncontrolled motion	The machine moves inadvertently from rest (Same risk)
3a	5.2.4 powered travel movement	The machine moves inadvertently when the operator is not at the primary operating position	5.2.4 powered travel movement	The machine moves inadvertently when the operator is not at the primary operating position (Same risk)
3b	5.2.4 powered travel movement	Powered travel shall not occur automatically when the operator returns to the normal operator's position without an additional operation, e.g., by requiring resetting the direction control	5.2.4 powered travel movement	Powered travel shall not occur automatically when the operator returns to the normal operator's position without an additional operation, e.g., by requiring resetting the direction control (Same risk)
3c	5.2.4 powered travel movement	Application of the parking brake shall apply neutral travel control, except on trucks with hydro-static transmission.	5.2.4 powered travel movement	Application of the parking brake shall apply neutral travel control, except on trucks with hydro-static transmission. (Same risk)

Ref No.	Paragraph of standard prEN 1459-1	Hazardous event	Paragraph of standard EN 1459-2	Hazardous event
4a	5.2.5 non activation of the parking brake	Operator is not warned that the parking brake is engaged.	5.2.5 non activation of the parking brake	Operator is not warned that the parking brake is engaged. (Same risk)
			5.5.1 f) prevent any powered movement	The machine or its elements move inadvertently when the operator is not at the primary operating position
4b	5.5.5 Multi-function controls – 2 nd para	Operator is not warned about mode of operation (dangerous movements)	No corresponding clause – these may need to be added	
4c	5.7 stabilizing devices 2 nd indent	Bystanders hit by stabilizers during travel mode		
4d	5.7 stabilizing devices 5 th indent	Loss of stability		
6a	5.5.1.1 multiple operating positions	Uncontrolled load movement	5.5.1.1 multiple operating positions	Uncontrolled load movement (Same risk)
6b	5.5.1.1 emergency stop	~~Operable from all active operating positions~~	5.5.1.1 emergency stop	~~Operable from all active operating positions~~ (Same risk)
7	5.5.1.3 inadvertent activation	Uncontrolled load movement	5.5.1.3 inadvertent activation	Uncontrolled load movement (Same risk)
	5.5.2 differential locking	(when the control is not full mechanical) differential not locked, loss of motricity	5.5.2 differential locking	(when the control is not full mechanical) differential not locked, loss of motricity
8	~~5.5.4.1 load handling controls – general~~	~~Uncontrolled movement~~	~~5.5.4.1 load handling controls – general~~	~~Uncontrolled movement~~ (Same risk)
8	5.5.4.2.1 control with detents	Unintended activation of auxiliary function	5.5.4.2.1 control with detents	Unintended activation of auxiliary function (Same risk)

Ref No.	Paragraph of standard prEN 1459-1	Hazardous event	Paragraph of standard EN 1459-2	Hazardous event
9	5.5.4.2.2 boom float control	Unintended lowering of the boom	5.5.4.2.2 boom float control	Unintended lowering of the boom (Same risk)
11	~~5.5.5 Multi-function controls — 2nd para~~ ~~5.10.7.1 and 5.10.7.2 control panels and control displays~~		~~5.5.5 Multi-function controls — 2nd para~~ ~~5.10.7.1 and 5.10.7.2 control panels and control displays~~	
			5.5.9 suspension locking	Tip over
10	5.7 stabilizing devices 1 st indent	Unintended movement of stabilizers	5.7 stabilizing devices 1 st indent	Unintended movement of stabilizers (Same risk)
13	~~5.7 stabilizing devices 2nd indent~~	~~Bystanders hit by stabilizers during travel mode~~	~~5.7 stabilizing devices 2nd indent~~	~~Bystanders hit by stabilizers during travel mode~~ (Same risk)
15	~~5.7 stabilizing devices 5th indent~~	Tip over	~~5.7 stabilizing devices 5th indent~~	Tip over (Same risk)
16	~~5.8.3 Tilttable cab support device 2nd para~~ ~~5.12.3.3 movable guards~~	~~Disengagement of the cab~~ Unintended movement	~~5.8.3 Tilttable cab support device, 2nd para~~	Unintended movement (Same risk)
17	~~5.10.5.6 doors and windows 4th paragraph~~	~~Take into account for RA, no PL required~~		
			5.10.8.1.1 LDD General	Tip over
			5.10.8.1.2 Override of the LDD	Tip over (according to EN ISO 138469-1 § 5.2.5, override function shall have a PL such than the PL of the function it is related to is not reduced).
			5.10.8.2 LID	Tip over
			5.10.8.3 Aligned configuration indicator	Unexpected steering. Tip over related to suspension locking.

Ref No.	Paragraph of standard prEN 1459-1	Hazardous event	Paragraph of standard EN 1459-2	Hazardous event
	C.2.3 Clutch pedal (if not mechanical or hydraulic)	Unintended motricity	B.2.3 Clutch pedal (if not mechanical or hydraulic)	Unintended motricity
	C.2.4 Accelerator pedal (if not mechanical or hydraulic)	Unintended speed	B.2.4 Accelerator pedal (if not mechanical or hydraulic)	Unintended speed
	C.2.5 Inching pedal (if not mechanical or hydraulic)	Unintended movement	B.2.5 Inching pedal (if not mechanical or hydraulic)	Unintended movement

Annex E (informative)

Risk Estimation and Evaluation

E.1 Hazard Identification Risk Estimation and Evaluation from 1.1. to 1.7 Operator

N°	Ref. no.	Hazards (ISO 12100: 2010, Table B.1)			Hazardous situations (ISO 12100: 2010, Table B.3)	
		Type or group of hazard	Origin One origin of hazards can have several potential consequences	Potential consequences For each type or group of hazard, some potential consequences can be related with several origins of hazards	Areas of the machinery concerned	Tasks
1.1	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Start up
1.2	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Start up
1.3	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Setting
1.4	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Restart after unscheduled stop
1.5	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Fault finding/troubleshooting
1.6	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Corrective maintenance
1.7	1	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stubbing or puncture	Mechanism and function-parts	Recovery of operation from jam

Hazardous events (ISO 12100: 2010, Table B.4)		Comments
Origin related to	Hazardous event	
control system	Uncontrolled movements (including speed change)	No device fitted to prevent drive system engagement.
control system	Machine action resulting from inhibition (defeating or failure) of protective devices	
control system	Machine action resulting from failure of protective devices	software error during setting
control system	Machine action resulting from failure of protective devices	resetting and testing is necessary before restart
control system	Uncontrolled movements (including speed change)	
control system	Uncontrolled movements (including speed change)	
control system	Uncontrolled movements (including speed change)	jammed lever

RISK ESTIMATION				RISK EVALUATION		RISK REDUCTION	RISK ESTIMATION				RISK REDUCTION	
Initial assessment				Risk rating number	Risk level	Risk reduction methods	Residual assessment				Risk rating number	Risk level
P	E	S	N				P	E	S	N		
2	4,0	0,5	1	4	LOW	Risk reduction device is not disproportional.	0,033	4	0,5	1	0,066	LOW
1	4,0	0,5	1	2	LOW	No other measures are needed						
1	0,5	0,5	1	0,25	LOW	No other measures are needed						
1	1,0	0,5	1	0,5	LOW	No other measures are needed						
1	0,5	0,5	1	0,25	LOW	No other measures are needed						
1	0,5	0,5	1	0,25	LOW	No other measures are needed						
1	0,5	0,5	1	0,25	LOW	No other measures are needed						

E.2 Hazard Identification Risk Estimation and Evaluation from 1.1. to 1.7 Co-worker

N°	Ref. no.	Hazards (ISO 12100: 2010, Table B.1)			Hazardous situations (ISO 12100: 2010, Table B.3)	
		Type or group of hazard	Origin One origin of hazards can have several potential consequences	Potential consequences For each type or group of hazard, some potential consequences can be related with several origins of hazards	Areas of the machinery concerned	Tasks
1.1	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Start up
1.2	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Start up
1.3	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Setting
1.4	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Restart after unscheduled stop
1.5	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Fault finding/troubleshooting
1.6	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Corrective maintenance
1.7	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Recovery of operation from jam

Hazardous events (ISO 12100: 2010, Table B.4)		
Origin related to	Hazardous event	Comments
control system	Uncontrolled movements (including speed change)	No device fitted to prevent drive system engagement.
control system	Machine action resulting from inhibition (defeating or failure) of protective devices	
control system	Machine action resulting from failure of protective devices	software error during setting
control system	Machine action resulting from failure of protective devices	resetting and testing is necessary before restart
control system	Uncontrolled movements (including speed change)	
control system	Uncontrolled movements (including speed change)	
control system	Uncontrolled movements (including speed change)	jammed lever

RISK ESTIMATION				RISK EVALUATION			RISK REDUCTION	RISK ESTIMATION				RISK REDUCTION	
Initial assessment				Risk rating number			Risk level	Residual assessment					
P	E	S	N					P	E	S	N	Risk rating number	Risk level
Risk reduction methods													
2	2,5	10,0	1	50	MODERATE	Trucks shall be fitted with a device that prevents the engine being started whilst the drive-system is engaged	0,033	2,5	10	1	0,825	LOW	
1	0,5	10,0	1	5	LOW	No other measures are needed							
1	0,5	10,0	1	5	LOW	No other measures are needed							
1	1,0	10,0	1	10	MODERATE	Trucks shall be fitted with a device that prevents the engine being started whilst the drive-system is engaged	0,033	1	10	1	0,33	LOW	
1	0,5	10,0	1	5	LOW	No other measures are needed							
1	0,5	10,0	1	5	LOW	No other measures are needed							
1	0,5	10,0	1	5	LOW	No other measures are needed							
1	0,5	10,0	1	5	LOW	No other measures are needed							

E.3 Hazard Identification Risk Estimation and Evaluation from 1.1. to 1.7 Bystander

N°	Ref. no.	Hazards (ISO 12100: 2010, Table B.1)			Hazardous situations (ISO 12100: 2010, Table B.3)	
		Type or group of hazard	Origin One origin of hazards can have several potential consequences	Potential consequences For each type or group of hazard, some potential consequences can be related with several origins of hazards	Areas of the machinery concerned	Tasks
1.1	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Start up
1.2	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Start up
1.4	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Restart after unscheduled stop
1.5	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Fault finding/troubleshooting
1.6	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Corrective maintenance
1.7	1	mechanical hazard	machinery mobility	being run over crushing impact	Mechanism and function-parts	Recovery of operation from jam

Hazardous events (ISO 12100: 2010, Table B.4)		Comments
Origin related to	Hazardous event	
control system	Uncontrolled movements (including speed change)	The risk of the operator is related to the position of the machine (water, slopes, etc.)
control system	Machine action resulting from inhibition (defeating or failure) of protective devices	Situation: Event: Hazard: Additional notes:
control system	Machine action resulting from failure of protective devices	resetting and testing is necessary before restart
control system	Uncontrolled movements (including speed change)	Situation: Event: Hazard: Additional notes:
control system	Uncontrolled movements (including speed change)	
control system	Uncontrolled movements (including speed change)	jammed lever

RISK ESTIMATION				RISK EVALUATION		RISK REDUCTION	RISK ESTIMATION				RISK REDUCTION	
Initial assessment						Risk reduction methods	Residual assessment					
P	E	S	N	Risk rating number	Risk level		P	E	S	N	Risk rating number	Risk level
1,5	1,0	10,0	1	15	MODERATE	Risk reduction device is not disproportional.	0,033	1	10	1	0,33	LOW
1	0,5	10,0	1	5	LOW	no other measures are needed						
1	0,5	10,0	1	5	LOW	no other measures are needed						
1	0,5	10,0	1	5	LOW	no other measures are needed						
1	0,5	10,0	1	5	LOW	no other measures are needed						
1	0,5	10,0	1	5	LOW	no other measures are needed						

E.4 Hazard Identification Risk Estimation and Evaluation from 2.1. to 2.8 Operator

N°	Ref. no.	Hazards (ISO 12100: 2010, Table B.1)			Hazardous situations (ISO 12100: 2010, Table B.3)	
		Type or group of hazard	Origin One origin of hazards can have several potential consequences	Potential consequences For each type or group of hazard, some potential consequences can be related with several origins of hazards	Areas of the machinery concerned	Tasks
2,1	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	Start up
2,2	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	Start up
2,3	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	Setting
2,4	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	Restart after unscheduled stop
2.5	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	all modes of operation (boom movement + rpm increase)
2.7	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	Fault finding/troubleshooting
2.8	2	mechanical hazard	machinery mobility	being thrown impact trapping suffocation stabbing or puncture	Mechanism and function-parts	Corrective maintenance