BS EN 12999:2020+A1:2025

BSI Standards Publication

Cranes — Loader cranes

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee MHE/3/5, Mobile cranes.

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EN 12999:2020+A1

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Appareils de levage à charge suspendue - Grues de chargement

Krane - Ladekrane

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European foreword

[A1] This document (EN 12999:2020+A1:2025) has been prepared by Technical Committee CEN/TC 147 “Cranes - Safety”, the secretariat of which is held by SFS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2025, and conflicting national standards shall be withdrawn at the latest by September 2025.

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

This document supersedes EN 12999:2020.

The major changes are the following:

— addressing the risk to be crushed by stabilizer legs with powered tilting devices (5.8.1, 5.6.1.3, C.2.5);

— clarification of cabin type (crane or vehicle) throughout the document;

— clarifying that timber handling cranes may only be operated from a high seat or a cabin (5.8.1);

— changing into a recommendation the requirement to make an additional stability test after having completed a stability test with the test pressure method (6.2.5.3);

— adding requirement of sufficient field of view when operating the crane from the vehicle cabin (5.8.1).

This document includes Amendment 1 approved by CEN on 20 January 2025.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1] ⟨A1⟩.

This document has been prepared under a standardisation request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom. ⟨A1]

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Introduction

This document is a harmonized standard to provide one means for loader cranes to conform to the essential health and safety requirements of the Machinery Directive 2006/42/EC.

This document is a type-C standard as stated in EN ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organizations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

The machinery concerned and the extent to which hazards are covered are indicated in the scope of this document.

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1 Scope

This document specifies minimum requirements for design, calculation, examinations and tests of hydraulic powered loader cranes and their mountings on vehicles or static foundations.

This document applies to loader cranes designed to be installed on:

— road vehicles, including trailers, with load carrying capability;

— tractors (road or agricultural), where only a towed trailer has capability to carry goods;

— demountable bodies to be carried by any of the above;

— other types of carriers (e.g. separate loaders, crawlers, rail vehicles, non-seagoing vessels);

— static foundations.

This document also applies to loader cranes equipped with special tools or interchangeable equipment (e.g. grapple, clamshell bucket, pallet clamp, etc.), as specified in the operator's manual.

This document does not apply to loader cranes used on board sea going vessels or to articulated boom system cranes which are designed as total integral parts of special equipment such as forwarders.

The hazards covered by this document are identified in Clause 4.

This document does not cover hazards related to the lifting of persons.

NOTE The use of cranes for lifting of persons can be subject to specific national regulations.

This document is not applicable to loader cranes manufactured before the publication of this document. For loader cranes designed before the publication of this document, the provisions concerning stress calculations in the version of EN 12999 that was valid at the time of their design, are still applicable.

2 Normative references

〈A1〉 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.

NOTE In the event of conflicting statements between referenced documents and this document, the statements in this document apply.

EN 1677-2:2000+A1:2008, *Components for slings — Safety — Part 2: Forged steel lifting hooks with latch, Grade 8*

EN 12077-2:1998+A1:2008, *Cranes safety — Requirements for health and safety — Part 2: Limiting and indicating devices*

EN 14492-2:2019, *Cranes — Power driven winches and hoists — Part 2: Power driven hoists*

EN 12644-1:2001+A1:2008, *Cranes — Information for use and testing — Part 1: Instructions*

EN 13001-1:2015, *Cranes — General design — Part 1: General principles and requirements*

EN 13001-2:2021, *Crane safety — General design — Part 2: Load actions*

EN 13001-3-1:2012+A2:2018, *Cranes — General Design — Part 3-1: Limit States and proof competence of steel structure*

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EN 13001-3-2:2014, *Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*

EN 13001-3-5:2016+A1:2021, *Cranes — General design — Part 3-5: Limit states and proof of competence of forged and cast hooks*

EN 13001-3-6:2018+A1:2021, *Cranes — General design — Part 3-6: Limit states and proof of competence of machinery — Hydraulic cylinders*

EN 13135:2013+A1:2018, *Cranes — Safety — Design — Requirements for equipment*

EN 13557:2003+A2:2008, *Cranes — Controls and control stations*

EN 13586:2020, *Cranes — Access*

EN 14033-2:2017, *Railway applications — Track — Railbound construction and maintenance machines — Part 2: Technical requirements for travelling and working*

EN IEC 61000-6-2:2019, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity standard for industrial environments (IEC 61000-6-2:2016)*

EN IEC 61000-6-4:2019, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments (IEC 61000-6-4:2018)*

EN 60204-32:2008, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines (IEC 60204-32:2008)*

EN 62745:2017, *Safety of machinery — Requirements for cableless control systems of machinery*

EN ISO 898-1:2013, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread (ISO 898-1:2013)*

EN ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane (ISO 3744:2010)*

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

EN ISO 4871:2009, *Acoustics — Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)*

EN ISO 5353:1998, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point (ISO 5353:1995)*

EN ISO 6892-1:2019, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2019)*

EN ISO 11201:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections (ISO 11201:2010)*

EN ISO 11688-1:2009, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning (ISO/TR 11688-1:1995)*

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

EN ISO 13849-1:2023, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2023)*

EN ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation (ISO 13849-2:2012)*

EN ISO 13854:2019, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body (ISO 13854:2017)*

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

EN ISO 20607:2019, *Safety of machinery — Instruction handbook — General drafting principles (ISO 20607:2019)* A1

3 Terms, definitions, illustration of parts and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1 Loader crane

3.1.1.1
loader crane
power driven crane comprising a column, which slews about a base, and a boom system which is attached on to the top of the column and being designed for loading and unloading vehicles

Note 1 to entry: Annex A gives examples of configuration and mountings.

3.1.1.2
self -powered loader crane
loader crane that has power source and hydraulic pump as integral parts of the machine

3.1.1.3
timber handling crane
loader crane specifically designed, manufactured and equipped with a grapple for loading/unloading of unprepared timber (e.g. tree trunks, branches)

3.1.1.4
separate loader
vehicle, with no load carrying capacity, equipped with a loader crane and designed to load or unload other vehicles and trailers

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3.1.1.5
demountable body
detachable frame designed to be carried by a vehicle or trailer

3.1.2 Components

3.1.2.1
base
housing incorporating anchoring points and bearings for the slewing column

3.1.2.2
boom
structural member in the boom system of the loader crane

3.1.2.3
boom extension, hydraulic
part of the boom system which is capable of hydraulic telescopic movement to vary its length

3.1.2.4
boom extension, manual
part of the boom system which can be manually attached or manually extended to increase the outreach of the boom system

3.1.2.5
boom system
complete system, consisting of booms, boom extensions and cylinders

3.1.2.6
column
structural member which supports the boom system

3.1.2.7
control system
interface between the operating levers and the actuating components which provide movements of the loader crane

3.1.2.8
control station
position from which the loader crane may be operated

3.1.2.9
fixed load lifting attachment
lifting attachment which is fitted directly to the boom of a crane but does not increase the outreach of the boom system

EXAMPLE Grapple, pallet clamp, clamshell bucket.

3.1.2.10
high seat
control station connected to the column, consequently rotating with the crane

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3.1.2.11
hoist
machines for lifting and lowering suspended loads over predetermined distances, using ropes, chains or belts

3.1.2.12
non-fixed load lifting attachment
lifting attachment which can be fitted directly or indirectly to the hook or any other coupling device of a crane by the user without affecting its integrity and does not increase the outreach of the boom system

3.1.2.13
raised control station
control station at a height above the ground level, i.e. a high seat attached to the column of the loader crane or a platform positioned above the base of the loader crane

Note 1 to entry: See Annex J.

3.1.2.14
stabilizer
aid to the supporting structure connected to the base of the crane or to the vehicle to provide stability, without lifting the vehicle from the ground

3.1.2.15
stabilizer extension
part of the stabilizer capable of extending the stabilizer leg laterally from the transport position to the operating position

3.1.2.16
stabilizer leg
part of a stabilizer capable of contacting the ground to provide the required stability

3.1.2.17
static foundation
fixed support incorporating mounting points for a crane

[A1] 3.1.2.18
crane cabin
cabin attached to the crane, designed to operate the crane [A1]

[A1] 3.1.2.19
vehicle cabin
cabin being part of the vehicle, mainly designed to operate the vehicle [A1]

[A1] 3.1.2.20
leg tilting device
powered device that enables rotating the stabilizer leg to a raised position [A1]

[A1] 3.1.2.21
stabilizer control station
position from which the stabilizers can be operated [A1]

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3.1.3 Hydraulics

3.1.3.1
current working pressure
working pressure acting on the piston area, giving the same resultant force as the actual pressures acting on both sides of the piston, and that corresponds to the rated capacity at any time

3.1.3.2
dynamic pressure
pressure in a hydraulic system component or part of hydraulic system caused by dynamic forces on actuators when handling the load

3.1.3.3
hydraulic line rupture
failure of a hydraulic line which results in a loss of pressure in the line

3.1.3.4
maximum working pressure
maximum pressure in pump circuit or individual working function

3.1.3.5
sink rate
distance in a given time at which the load lowers due to internal leakage of hydraulic components

3.1.3.6
stability test pressure
equivalent pressure acting on the piston area of the 1st boom cylinder, used for stability testing and giving the same resultant force as the actual pressures acting on both sides of the piston

3.1.4 Kinematics

3.1.4.1
articulated movement
movement of boom members pivoting about a pin joint

3.1.4.2
crane inclination
angle between the slewing axis and a vertical line, due to working on slanted or uneven ground

3.1.4.3
lifting movement
raising or lowering of the boom system and/or the load which causes a change in its vertical position

3.1.4.4
maximum outreach
largest outreach shown on the load chart

3.1.4.5
outreach
horizontal distance between the axis of rotation of the column and point of load attachment

3.1.4.6
outreach, hydraulic
outreach which can be obtained with hydraulically actuated parts of the boom system

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3.1.4.7
slewing
rotational movement of the column and boom system about the axis of the column

3.1.5 Loads

3.1.5.1
dead load
force due to masses of fixed and movable crane parts which act permanently on the structure while the crane is being used

3.1.5.2
gross load
sum of payload, lifting attachments and if applicable a portion of the hoist rope

3.1.5.3
maximum working load
maximum load that may be lifted shown on the load plate

3.1.5.4
payload
load which is lifted by the crane and suspended from the non-fixed load-lifting attachment(s) or, if such an attachment is not used, directly from the fixed load lifting attachment(s)

3.1.5.5
rated capacity
load that the crane is designed to lift for a given operating condition (e.g. configuration, position of the load)

3.1.5.6
rated capacity indicator
device which gives, within tolerance limits specified in 5.6.2.1, at least a continuous indication that the rated capacity is exceeded, and another continuous indication (on certain crane types) of the approach to the rated capacity

3.1.5.7
rated capacity limiter
system that automatically prevents the crane from handling loads in excess of its rated capacity (see also C.1)

3.1.6 Moments

3.1.6.1
net lifting moment
rated capacity multiplied by outreach

3.1.6.2
total lifting moment
sum of net lifting moment and the moment produced by dead loads

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3.1.7 Valves

3.1.7.1
flow sensitive check valve
valve which stops the flow when a pre-set pressure drop level is exceeded

3.1.7.2
load holding valve
valve which is normally closed and is opened by an external force to enable flow of fluid out of a hydraulic actuator

3.1.7.3
main relief valve
valve which limits the pressure supplied to the hydraulic system of the crane

3.1.7.4
port relief valve
valve which limits the pressure supplied to a hydraulic actuator

3.1.7.5
pressure relief valve
valve which automatically relieves the hydraulic oil to the tank when the pressure exceeds a specified value

3.1.8 Miscellaneous

3.1.8.1
danger zone
any space within and/or around machinery in which a person can be exposed to a hazard

[SOURCE: EN ISO 12100:2010, 3.11]

3.1.8.2
setting-up function
crane function used to prepare the crane for lifting

3.1.8.3
vessel
floating installation that the crane is mounted on

3.2 Illustration of parts

The terms which are used in this document for the main parts of a loader crane are indicated in Figure 1 a) and b).

Boom system consists of items 6 to 12 plus items 16 to 22, if applicable.

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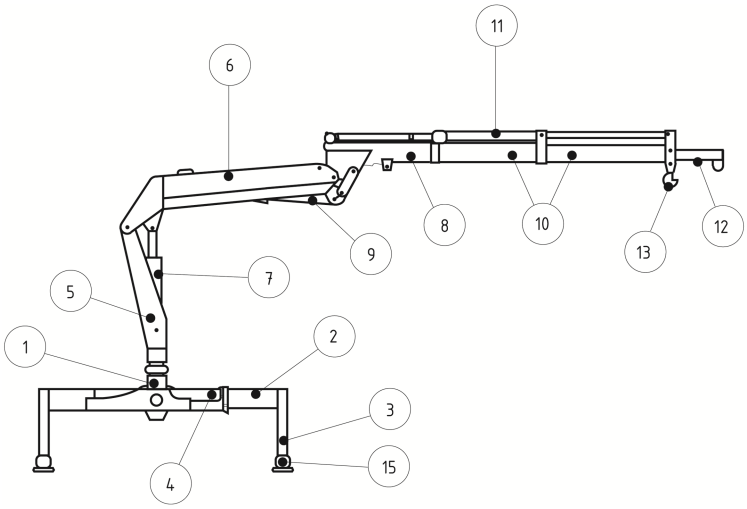
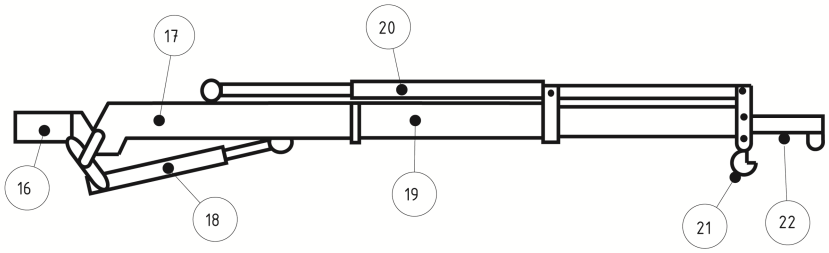
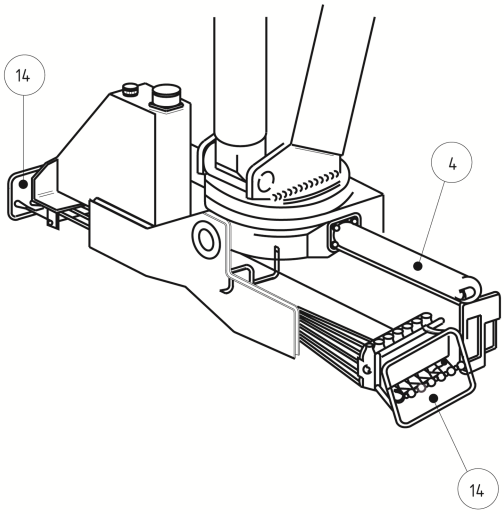


a)





b)

Key

1	base	9	2nd boom cylinder	17	3rd boom
2	stabilizer extension	10	boom extension, hydraulic	18	3rd boom cylinder
3	stabilizer leg	11	extension cylinders	19	boom extension, hydraulic
4	slewing mechanism, e.g. rack and pinion, slewing ring	12	boom extension, manual	20	extension cylinders
5	Column	13	hook	21	hook
6	1st boom	14	controls	22	boom extension, manual
7	1st boom cylinder	15	stabilizer foot		
8	2nd boom	16	3rd boom adapter		

Figure 1 — Main parts of a loader crane

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3.3 Abbreviated terms

Table 1 — Abbreviated terms

Abbreviation	Meaning
SRP/CS	Safety Related Parts of Control System
PL	Performance Level
PFH_D	Average probability of dangerous failure per hour
PLr	Performance Level Required
$MTTF_D$	expectation of the mean time to dangerous failure

4 List of significant hazards

Table 2 shows a list of significant hazardous situations and hazardous events that could result in risks to persons during intended use and foreseeable misuse. It also contains corresponding cross-references to the relevant clauses in this document that are necessary to reduce or eliminate the risks associated with those hazards. Before using this document, it is important to carry out a risk assessment of the crane. ⟨A1⟩ As a minimum, the hazards covered by Table 2 shall be included in the risk assessment. A1⟩

Table 2 — List of significant hazards and associated requirements

No.	Hazards	Relevant clause(s) in this document
1	**Mechanical hazards due to:**	
1.1	- Inadequacy of mechanical strength of the crane and its parts	5.1, 5.2, 5.3, 5.4, 5.5.8, 5.8.2.1, 5.8.2.2
1.2	Crushing hazard	5.8.1, 5.8.2.3, 5.10.2.3
1.3	Shearing hazard	5.8.1, 5.8.2.3, 5.10.2.3
1.4	Entanglement hazard	5.8.1, 5.8.2.2, 5.8.2.3, 5.10.2.3
1.5	Drawing-in or trapping hazard	5.8.1, 5.8.2.2, 5.8.2.3, 5.10.2.3
1.6	Impact hazard	5.8.1, 5.8.2.3, 5.10.2.3
1.7	High pressure fluid injection or ejection hazard	5.5.1, 5.5.5, 5.10.2.3, 5.10.7, 7.2.3.6, 7.2.4.2
1.8	Ejection of parts	5.4.1.2, 5.4.1.3, 5.4.2, 5.4.3
1.9	Loss of stability	5.4.1, 5.6.1, 5.6.3, 5.10.2.1, 5.10.3
1.10	Slip, trip, fall	5.8.2.2, 5.8.2.3, 5.8.2.4, 5.10.8

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No.	Hazards	Relevant clause(s) in this document
2	**Electrical hazards due to:**	
2.1	Contact of persons with live parts (direct contact)	5.9, 5.10.6, 7.2.3.1 d)
A1 2.2	Approach to live parts under high voltage	7.2.3.1 d) A1
2.3	Electrostatic phenomena	Not applicable.
2.4	Thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short circuits, overloads, etc.	Not applicable.
3	**Thermal hazards, resulting in:**	
3.1	Burns, scalds and other injuries by possible contact of persons with objects or materials with an extreme high or low temperature, by flames or explosions and also by radiation of heat sources	5.5.5, 5.10.2.3
A1 3.2	Damage to health by hot or cold working environment	5.8.1, Annex I A1
A1 **4**	**Hazards generated by noise** - Hearing loss. - Tinnitus, physiological disorders, stress. - Risks (accidents, reduced intelligibility of messages) due to interference with speech communication and perception of acoustic signals.	5.10.4, 6.3, 7.2.3.9 A1
A1 **5**	**Hazards generated by materials and substances (and their constituent elements) processed or used by the machinery**	A1
5.1	Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes and dusts	5.10.2.3, 7.2.4.1
6	**Hazards generated by neglecting ergonomic principles in machinery design, as e.g. hazards from:**	
6.1	Unhealthy postures or excessive effort	5.4.1.3, 5.4.2, 5.7, 5.8, 5.10.8
6.2	Inadequate consideration of hand-arm or foot-leg anatomy	5.7, 5.8
6.3	Inadequate local lighting	7.2.3.7 f)

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No.	Hazards	Relevant clause(s) in this document
A1 6.4	Human error, human behaviour	5.6, 5.7.1, 5.7.2, 7.2.3, 7.2.4, Annex E A1
A1 6.5	Inadequate design, location or identification of manual controls	5.4.1.3, 5.4.3, 5.7, 5.8, Annex E A1
6.6	Inadequate design or location of visual display units	5.6.1.1
7	**Unexpected start-up, unexpected overrun/overspeed(or any similar malfunction) from:**	
7.1	Failure/disorder of the control system	5.5.6.1, 5.5.6.2, 5.5.7, 5.6.1.3, 5.6.6, 5.6.8, 5.7.1
8	**Hazards caused by missing and/or incorrectly positioned safety related measures/ means**	
8.1	Guards	5.5.5, 5.7.1, 5.8.2.2, 5.8.2.3, 5.10.2.3
8.2	Safety related (protection) devices	5.4.1, 5.4.3, 5.6.3, 5.6.6, 5.6.7
A1 8.3	Safety signs, signals, symbols	5.4.1.3, 5.6.7, 5.7.2, 7.3.4, 7.3.5, Annex E A1
8.4	Information or warning devices	5.6.1, 5.6.4, 5.6.7, 7.1, 7.2, 7.3
8.5	Visibility	5.4.3, 5.8.1, 7.3.4.1
8.6	Emergency devices	5.6.3, 5.6.8
9	**Assembly errors**	7.2.2, 7.2.4
A1 **10**	**Loss of stability/overturning of machine**	5.4.1, 5.6.1, 5.6.2, 5.6.3, 5.6.4, 5.6.5, 5.6.6, 5.10.3, 6.2.5 A1
11	**Mechanical hazards and hazardous events**	
11.1	From load falls, collisions, machine tipping caused by:	
11.1.1	Lack of stability	5.10.3, 6.2.5
11.1.2	Uncontrolled loading – overloading – stabilizing moment exceeded	5.5.4, 5.6.1, 5.6.2, 5.6.3, 5.6.4, 5.6.5
11.1.3	Uncontrolled amplitude of movements	5.6.6
A1 11.1.4	Unexpected/unintended movement of loads	5.5.5, 5.5.6, 5.5.7, 5.5.8 A1

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No.	Hazards	Relevant clause(s) in this document
11.1.5	Inadequate holding devices/ accessories	5.4.2, 7.2.3.7
11.2	From access of persons to load support	7.2.3.1 e)
11.3	From insufficient mechanical strength of parts	5.1, 5.2, 5.3, 5.5.8, 5.10.2
11.4	From abnormal conditions of assembly/testing/use/maintenance	5.10, 7.1, 7.2, 7.3
12	**Hazards generated by neglecting ergonomic principles**	
12.1	Insufficient visibility from the driving position	5.8.1

5 Safety requirements and/or protective/risk reduction measures

5.1 General

Machinery shall conform to the safety requirements and/or protective/risk reduction measures of this clause. In addition, the machine shall be designed in accordance with the principles of EN ISO 12100:2010 for other relevant but less significant hazards, which are not dealt with by this document.

The rated capacity shall be calculated from the following:

a) the working pressure in the cylinders;

b) the area of the load carrying cylinders;

c) the geometry;

d) dead loads;

e) load combinations.

For the purpose of the calculations rated capacity is equal to gross load.

5.2 Structural calculation

5.2.1 Information to be given in the calculation

The following information shall be given in the calculation:

a) type of crane and method of operation;

b) the assumed number of all load or working cycles;

c) details of the load-carrying system reflecting actual service conditions including outline drawings and principal dimensions;

d) the assumed loading conditions including maximum crane inclination;

e) the governing hoisting class, hoist drive class and stress history classes or stress history parameters;

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f) the material for the individual components and joints;

g) the shapes, dimensions and static cross-section values of all load-carrying members;

h) the analyses separately for the individual structural components and essential connections.

5.2.2 Dynamic factors

5.2.2.1 Hoisting and gravity effects of the mass of the crane

The dynamic effects due to vibrations of the structure when raising or lowering a load shall be included in the calculation by applying the factor ϕ_1 on the gravitational forces due to the masses of the crane. It shall be used for the design of the crane structure itself and its supports. For load combinations A1, B1 and C1, the value of ϕ_1 shall be the lowest of the two values 1,1 and ϕ_2, or expressed as an equation:

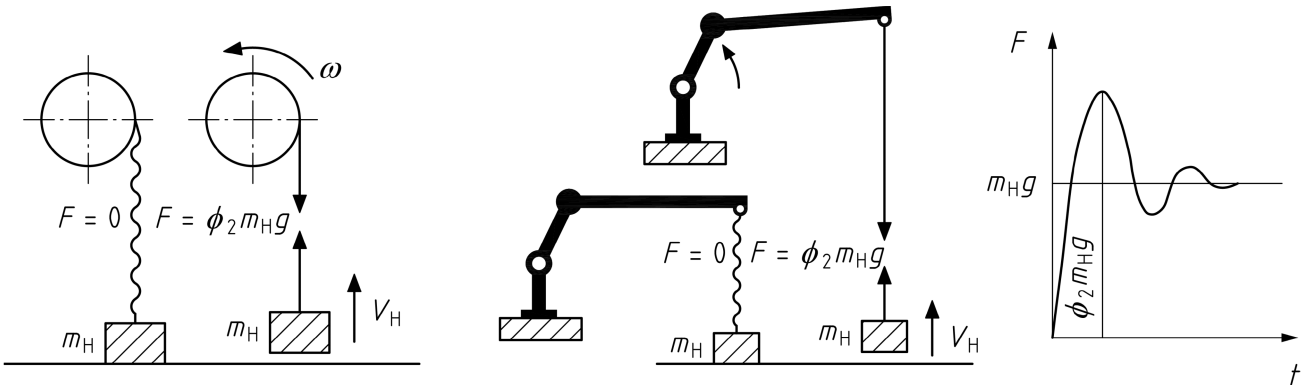
$$\phi_1 = \min (1{,}1 ; \phi_2)$$

In general ϕ_1 = 1,1. However, it shall not exceed the value of ϕ_2 in case ϕ_2 is less than 1,1.

For load combinations A2 and B2, the value of ϕ_1 shall be 0,95.

5.2.2.2 Hoisting and gravity effects of the gross load

In the case of hoisting or grounding a load as well as starting or stopping a vertical motion, the vibrational effects shall be included in the calculation by multiplying the gravitational force due to the mass of the hoisted gross load by a factor ϕ_2., see Figure 2



Key

m_H	mass of the gross load
v_H	vertical hoisting speed
F	force from the gross load
ϕ_2	dynamic factor on the gross load
g	gravity constant

Figure 2 — Dynamic effect when hoisting a load

The factor ϕ_2 shall be taken as follows:

$$\phi_2 = \phi_{2,\min} + \beta_2 \times v_h$$

$\phi_{2,\min}$ and β_2 are given in Table 3 for the appropriate hoisting class. Loader cranes are assigned to hoisting classes HC1 and HC2 in accordance with their dynamic and elastic characteristics:

— HC1 for crane mounted on a vehicle or structures of equivalent flexibility;

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— HC2 for rigidly mounted cranes, e.g. mounted on a static foundation or vessel.

Rigidly mounted cranes, equipped with a device that limits the peak pressure (e.g. an accumulator) in the first boom cylinder, may be assigned to HC1.

v_h is the steady vertical hook speed, in metres per second, related to the lifting attachment. Values of v_h are given in Table 4.

Table 3 — Value of β_2 and $\phi_{2,min}$

Hoisting class of appliance	β_2	$\phi_{2,min}$ for HD1 and HD4	$\phi_{2,min}$ for HD5
HC1	0,17	1,05	1,05
HC2	0,34	1,10	1,05

Table 4 — Values of v_h

Load combination	Type of control system and its operation method		
	HD1	HD4	HD5
A1, B1	$v_{h,max}$	$0,5 \times v_{h,max}$	$v_h = 0$
C1	$v_{h,max}$	$v_{h,max}$	$0,5 \times v_{h,max}$

Key

HD1 is when the lifting movement can only be operated at a fixed speed, e.g. simple on-off control;

HD4 is when the start of the lifting movement is performed with continuously increasing speed, e.g. proportional spool valve;

HD5 is when the step-less control automatically ensures that the dynamic factor ϕ_2 does not exceed $\phi_{2,min}$, e.g. electronically controlled proportional pressure compensated spool valve;

$v_{h,max}$ is the maximum vertical hook speed.

In load combinations A1 and B1, $v_{h,max}$ is the maximum vertical hook speed that is given by any single hydraulic drive action.

In load combination C1, $v_{h,max}$ is the maximum vertical hook speed from all booms being rotated (i.e. articulated) simultaneously.

NOTE In load combinations A and B it is assumed that the dynamic peaks from simultaneous movements do not coincide. The unlikely event that the dynamic peaks coincide and are superimposed is covered by load combination C1.

5.2.2.3 Effect of sudden release of a part of the gross load

For cranes that release or drop a part of the gross load as a working procedure during intended use, such as when grabs or magnets are used, the peak dynamic effect on the crane can be simulated by multiplying the gross load by the factor Φ_3.

The value is given by:

$$\Phi_3 = 1 - \Delta m \times (1 + \beta)/m$$

where

m is the mass of the gross load;

Δm is the released or dropped part of the gross load;

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β = 0,5 for cranes equipped with grabs or similar slow-release devices;

β = 1,0 for cranes equipped with magnets or similar rapid-release devices.

5.2.2.4 Effects caused by acceleration/deceleration of the slewing drive

The dynamic factor Φ_{5h} shall have the value 1,05 for hook duty and 1,3 for bucket or grapple duty.

5.2.3 Loads and forces

5.2.3.1 General

The following loads and forces shall be taken into account:

a) regular loads:

   1) dead loads;

   2) gross load;

   3) dynamic forces;

   4) centrifugal forces;

b) occasional loads:

   1) in-service wind loads;

   2) other climatic and environmental effects such as temperature, snow and ice;

   3) loads due to vessel motions and accelerations;

   4) loads on stairways, platforms and handrails;

c) exceptional loads:

   1) test loads;

   2) loads caused by movements suddenly stopped by a mechanical device, e.g. end stroke of slewing cylinder or a safety device, e.g. emergency stop, hydraulic line rupture valve;

   3) sudden release of the load, e.g. rope failure, sling failure;

   4) forces due to simultaneous dynamic peaks caused by raising or lowering a load at the maximum sum of the vertical speeds from all articulation drives.

5.2.3.2 Regular loads

5.2.3.2.1 Dead loads

See 3.1.5.1.

5.2.3.2.2 Gross load

See 3.1.5.2.

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5.2.3.2.3 Forces due to acceleration/deceleration of the slewing drive

The horizontal loads from the masses of the crane and of the gross load shall be calculated as follows:

$$F_{hi} = m_i \times g \times \tan \alpha, \alpha \geq 3°$$

where

F_{hi} is the horizontal load i acting on the gross load or a mass point of the boom;

m_i is the gross load or mass point of boom;

g is the gravity acceleration;

α is the maximum inclination for the crane in accordance with the manufacturer's specification. This value shall include the effect of list and trim of vessel with cranes mounted. However, the minimum value that may be used is $\alpha = 3°$.

5.2.3.2.4 Centrifugal forces

The centrifugal forces acting on slewing cranes shall only be calculated from the dead load of the boom system components, the counterweight, if applicable, and the gross load without applying the factors mentioned in 5.2.2.

5.2.3.2.5 Forces on stabilizer legs

The stabilizer legs shall be loaded by simultaneously acting vertical and horizontal forces. The horizontal force shall act at the stabilizer foot with the leg at its maximum length and in the most unfavourable direction. The magnitude of the horizontal force shall be at least 5 % of the vertical force.

5.2.3.3 Occasional loads

5.2.3.3.1 Wind loads

〚A1〛 Wind loads shall be calculated according to EN 13001-2:2021. 〚A1〛 Only in-service wind needs to be applied.

5.2.3.3.2 Loads on stairways, platforms and handrails

See 5.8.2.

5.2.3.3.3 Loads from vessel accelerations due to waves

Where relevant, loads arising from crane support accelerations caused by wave motions (sway, surge and heave for translational motions and roll, pitch and yaw for angular motions of the vessel) shall be accounted for. The accelerations shall be applied to the masses of the crane and the gross load.

5.2.3.3.4 Loads from relative motions of vessel

Where relevant, loads due to relative motions between the crane supporting vessel and the load supporting fixed (e.g. quay constructions) or moving structure (e.g. floating units, vessels, barges) shall be accounted for and applied to the masses of the crane and the gross load.

5.2.3.3.5 Loads from acceleration due to quay landing impact of vessel

Where relevant, loads caused by external excitation of the crane support due to quay landing impact of the vessel shall be accounted for and applied to the masses of the crane and the gross load.

5.2.3.4 Exceptional loads

Such loads may act in exceptional situations (e.g. testing, hydraulic line rupture).

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5.2.4 Load combinations

5.2.4.1 Basic load combinations

Loads shall be combined to determine the stresses the crane will experience during operation. Basic load combinations are given in Table 5.

NOTE In general, load combinations A cover regular loads, load combinations B cover regular loads combined with wind loads, and load combinations C cover regular loads combined with occasional and exceptional loads.

5.2.4.2 Load combinations to be covered

Safety factors for the following load combinations are specified in Table 5:

A1 and B1	Intended service conditions, raising/lowering loads with dynamic peak from any single hydraulic function while slewing: A1 without wind effects, B1 with wind effects.
A2 and B2	Intended service conditions, with grapple, magnet or similar accessory allowing sudden release of a part of the gross load while slewing: A2 without wind effects, B2 with wind effects.
C1	Simultaneous dynamic peaks caused by raising or lowering a load at the maximum sum of the vertical speeds from all booms being rotated (i.e. articulated), taking into account the available oil flow.
C3	Crane under test condition.

5.2.4.3 Application of Table 5

Basic load combinations for the calculation to prove that mechanical hazards from yielding and elastic instability from extreme values do not occur are given in Table 5.

For the proof of fatigue strength, load combinations A1 and A2, with all partial safety factors γ_p set to 1,00, shall be applied.

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Table 5 — Load combinations to be covered

Categories of load	Loads		Load comb. A			Load comb. B			Load comb. C			Row
			γ_p	A1	A2	γ_p	B1	B2	γ_p	C1	C3	
Regular	Gravity, Acceleration of lifting drives	Moved masses of the crane	1,22	ϕ_1	ϕ_1	1,16	ϕ_1	ϕ_1	1,1	ϕ_1	1	1
		Mass of the gross load	1,34	ϕ_2	ϕ_3	1,22	ϕ_2	ϕ_3	1,1	ϕ_2	-	2
	Acceleration of slewing drive	Moved masses of the crane	1,22	ϕ_{5h}	ϕ_{5h}	1,16	ϕ_{5h}	ϕ_{5h}	-	-	-	3
		Mass of the gross load	1,34	ϕ_{5h}	ϕ_{5h}	1,22	ϕ_{5h}	ϕ_{5h}	-	-	-	4
	Centrifugal loads[a]	Masses of the crane	1,22	1	1	1,16	1	1	-	-	-	5
		Mass of the gross load	1,34	1	1	1,22	1	1	-	-	-	6
Occasional	Climate effects	In service wind[b]	-	-	-	1,22	1	1	-	-	-	7
	Loads due to vessel motion	All masses	-	-	-	1,22	1	1	-	-	-	8
Exceptional	Forces due to one exceptional event		-	-	-	-	-	-	1,1	-	1	9

[a] [A1] Only centrifugal forces that increase the load effects shall be included. [A1]

[b] Forces acting simultaneously with wind forces shall only be applied to such an extent that the drive force in row 3 and row 4 is not exceeded.

5.2.4.4 Loads from foreseeable misuse

When calculating the effects of foreseeable misuse, all partial safety factors γ_p shall be set to 1,1.

5.3 Stress analysis

5.3.1 General

[A1] The strength of the steel structure shall be assessed in accordance with EN 13001-1:2015, EN 13001-2:2021 and EN 13001-3-1:2012+A2:2018. The strength of hydraulic cylinders that are part of the load carrying structure of the crane shall be assessed in accordance with EN 13001-3-6:2018+A1:2021, with the addition that the flattening test may be used as an alternative to the impact test in the transversal direction.

The limit states given in EN 13001-3-1:2012+A2:2018 shall be used in conjunction with a static analysis that is made for all boom positions and for all crane configurations. [A1]

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Welded details not given or deviating from those in Annex D and Annex H of EN 13001-3-1:2012+A2:2018 require special investigation of the fatigue strength.

For series production, a fatigue test of the crane model and applying loads consistent with the stress history class *S* or the stress history parameter *s* may be used for the investigation of the fatigue strength of the welded details not given or deviating from those in EN 13001-3-1:2012+A2:2018.

5.3.2 Bolted connections

Bolts of the property classes (bolt grades) 4.6, 5.6, 8.8, 10.9 or 12.9 in accordance with EN ISO 898-1:2013 shall be used.

In addition, for bolt grade 12.9 the characteristics tested in accordance with EN ISO 898-1:2013 and given in Table 6 shall be applied as minimum for load carrying purposes.

Table 6 — Bolt grade 12.9 characteristics

Bolt grade	**Impact energy (single minimum) / Test temperature**	**Percentage elongation A5 according to EN ISO 6892-1:2019**
12.9	25 J / −20 °C	≥ 10 %

Slewing ring bolts shall have rolled threads and bolt grade 8.8 as minimum and the surface-treatment shall minimize the risk of hydrogen embrittlement.

5.4 Mechanical arrangements

5.4.1 Stabilizers

5.4.1.1 General

Stabilizers shall be provided when necessary to fulfil the stability requirements (see 5.10.3) when loader cranes are fitted on vehicles.

5.4.1.2 Stabilizer leg

Each stabilizer leg shall be fitted with a foot for ground support.

Stabilizer feet shall be designed to adjust to a ground unevenness of at least 10°. Timber handling cranes may however have fixed stabilizer feet, in which case the leg shall be designed for the additional bending moment.

The supporting area of each foot shall be such that the resultant maximum ground pressure is less than 4 MPa. For crane stabilizers, the maximum ground pressure shall be calculated as:

$$p_{ground} = \frac{M_{dyn}}{L \cdot A}$$

where

M_{dyn} = $\phi_2 \cdot P \cdot R \cdot g + \phi_1 \cdot G_b \cdot Y_b, \cdot g$, the maximum moment at slewing centre including dynamic factors;

L is the distance from slewing centre to stabilizer leg at maximum spread;

A is the supporting area of the stabilizer foot;

P is the rated capacity

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R is the working radius

g is the gravity constant

G_b is the mass of the boom system

Y_b is the radius to the centre of gravity of the boom system

In case of auxiliary stabilizers, their feet shall have at least the same size as for the crane stabilizers. Alternatively, a detailed calculation of the entire installation shall be carried out or stabilizers forces shall be measured.

NOTE The actual ground pressure during operation can be higher than 4 MPa due to reduced stabilizer spread or partly lifted vehicle.

When the stabilizer leg has a tilting device, locking means which can withstand operational forces from intended use (e.g. pins) shall be provided to secure the leg in both the working and transport position (see 5.4.3). If stabilizer legs have to be tilted (rotated) up or down manually, the maximum force to activate one of them shall not exceed 250 N, measured at the stabilizer foot.

5.4.1.3 Stabilizer extension

There shall be an indication showing that the stabilizer extensions are fully extended.

Manually operated extensions shall be fitted with:

a) handles for the manual operation;

b) devices for locking extensions in the working and transport positions (see 5.4.3);

c) pull out stops.

Locking means in the working position shall be fitted if the hydraulic cylinders are not able to resist the forces during load handling.

5.4.2 Manual boom extensions

Manual boom extensions shall have pull out stops and mechanical locking means for their retracted and extended positions.

5.4.3 Securing for transport

5.4.3.1 General

A system (e.g. angle sensor) detecting that the first boom is not stowed below permissible transport height shall be provided to all vehicle mounted loader cranes, see 5.6.1.4.

〚A1〛 Means shall be provided to prevent uncontrolled movements of the crane and stabilizers installed on vehicles when travelling. 〈A1〉

Each of the stabilizer extension locking devices shall be designed to withstand, with no permanent deformation, the forces resulting from an acceleration of 2 g, applied in the direction of the movement.

5.4.3.2 Manually operated extensions

Manually operated stabilizer extensions shall be locked in the transport position by two separate locking devices for each stabilizer, at least one of these shall be automatically operated, e.g. a spring-operated cam lock and an automatic spring latch. These shall be attached to the crane and/or stabilizers and shall be protected against unintentional removal, e.g. by locking pins with spring clips.

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It shall be clearly visible to the operator when the manual locking devices are in the locked and unlocked position. In addition, it shall be indicated when the stabilizers are not locked in the transport position, see 5.6.1.6.

5.4.3.3 Hydraulically operated extensions

Hydraulically operated stabilizer extensions shall be fitted with an automatic hydraulic or automatic mechanical locking device for the transport position, in addition to a control valve that is closed in its neutral position. Any valve used for automatic hydraulic locking shall be in accordance with 5.5.6.1. A mechanical locking device shall be designed to withstand, without permanent deformation, the force due to the foreseeable misuse of attempting to extend the stabilizers with the locking devices engaged.

5.4.4 Hoists

Power driven hoists shall be in accordance with EN 14492-2:2019. Rope reeving systems shall be designed in accordance with EN 13001-3-2:2014.

5.4.5 Load hooks

〚A1〛 Load hooks which are incorporated into the loader crane shall fulfil the requirements of EN 13001-3-5:2016+A1:2021 or EN 1677-2:2000+A1:2008. 〚/A1〛 Load hooks that are not incorporated into the loader crane and are designed to be replaced by the operator are not covered by this document.

Hooks shall be such that the unintentional detachment of the load is prevented. This can be achieved by:

— a safety device or

— the shape of the hook.

Hooks equipped with a safety-latch fulfil these requirements.

5.5 Hydraulic system

5.5.1 General

The hydraulic system and components shall conform to the requirements specified in EN ISO 4413:2010.

The hydraulic components and lines shall be sized such that the hydraulic system can be operated at the intended working pressure and flow (including any pressure required during test procedures) without any failures and excessive temperatures being created.

Hydraulic systems shall be designed such that all components are compatible with each other and with the fluid being used in the system at specified environmental conditions. The hydraulic system shall have adequate filters to ensure that the fluid does not become contaminated.

Each hydraulic circuit shall be provided with means for checking the pressure.

Pressure and flow control devices or their enclosures shall be fitted with tamper-evident devices where an unauthorized alteration to pressure or flow can cause a hazard. Means shall be supplied for locking the setting of adjustable components or of locking their enclosures, if changes or adjustment can cause a hazard.

5.5.2 Pump

A pump shall have the capacity to deliver the correct flow and pressure specified by the crane manufacturer for the hydraulic system when being driven at the specified speed. The pump size and its specified driven speed shall be chosen to ensure that the capacity of the power supplier is utilized efficiently. There shall be a device that limits the pressure supplied by the pump to the loader crane.

NOTE See Annex L for guidance on selecting the correct pump size.

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The pump shall be suitable for the fluid used in the hydraulic system.

5.5.3 Hydraulic reservoir

The hydraulic reservoir shall have sufficient fluid capacity for the pump to operate correctly when all the hydraulic cylinders are fully extended, including any auxiliary equipment. There shall also be sufficient capacity for the fluid in the system when all the cylinders are retracted. Devices shall be incorporated to enable monitoring the maximum and minimum fluid level. An access opening and a drain valve with plug shall be provided for cleaning purposes.

5.5.4 Pressure limiting device

If a load carrying circuit cannot withstand the maximum pressure that can occur, means shall be provided to limit the maximum pressure to the design value.

Such pressure limiting devices shall, except for

— loader cranes with a rated capacity of less than 1 000 kg and a maximum net lifting moment of less than 40 000 Nm;

— timber handling cranes,

be set so that no uncontrolled movement can occur at a pressure lower than 1,1 times the pressure corresponding to the tolerance limit of the rated capacity limiter as specified in 5.6.2.1.

5.5.5 Hoses, tubes and fittings

Burst pressure for complete hoses with end fittings shall in general be at least four times the maximum working pressure of the hose. However, for HD5 drives, they may have a burst pressure that is minimum 3,5 times the maximum working pressure.

NOTE The factor 3,5 is used as HD5 drives induces reduced pressure peaks.

Burst pressure for fittings and raw material for tubes shall be minimum 2,5 times the maximum working pressure.

Hoses, tubes and fittings shall be so located, installed and, where appropriate, protected so that they do not get damaged by chafing, trapping, etc.

Hydraulic hoses containing fluid with a pressure of more than 5 MPa and/or having a temperature over 50 °C and which are located within 1,0 m of the operator, shall be guarded.

Any part or component which may divert a possible jet of fluid can be considered as a protection device.

Hoses intended to withstand a pressure of more than 15 MPa shall not be fitted with reusable end fittings.

Hydraulic hoses that are used for the connection of interchangeable equipment shall be designed or identified or located to avoid any incorrect connection causing a hazard, e.g. to reverse the direction of movement of a hydraulic cylinder.

5.5.6 Precautions against hydraulic line rupture

5.5.6.1 Loader cranes other than timber handling cranes

All load carrying circuits shall be equipped with automatic means, e.g. load holding valves, to prevent uncontrolled movement of the crane in the case of hydraulic line rupture. This does not apply to rotators attached to the boom tip. Flow sensitive check valves shall only be used for equalizing and pressure sensing lines. The maximum flow through these lines shall not exceed 3 l/min.

Valves used for this means shall be close coupled to the cylinder. They shall be either:

a) integral with the cylinder, or

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b) directly and rigidly flange mounted, or

c) placed close to the cylinder and connected to it by means of short rigid pipes having welded, flanged or threaded connections.

However, for boom extension cylinders or for parallel boom articulation cylinders, one load holding valve may be used for several cylinders that are connected by rigid pipes having welded, flanged or threaded connections.

Burst pressure of the raw material for tubes between lock valve and cylinder shall be minimum 3 times the maximum working pressure.

5.5.6.2 Timber handling cranes

In the event of hydraulic line rupture, the lowering speed of the boom shall not exceed the maximum lowering speed at rated capacity by more than 30 % (see explanatory Note in C.3).

〚A1〛 Cylinders for stabilizer legs shall be equipped as specified in 5.5.6.1. 〚A1〛

5.5.7 Sink rate for boom system

The sink rate measured at the boom system tip caused by leakage in hydraulic components shall not exceed 0,5 % of outreach per minute. For cranes with more than 12 m outreach, the sink rate shall not exceed 0,2 % of outreach per minute. For timber handling cranes, however, the sink rate may be 2 % of outreach per minute for all outreaches. Sink rate shall be tested at rated capacity at maximum hydraulic outreach (i.e. without manual extensions).

5.5.8 Slewing mechanism

〚A1〛 The slewing mechanism shall be able to withstand the maximum slewing forces, to bring it to a stop and sustain the load under the most adverse operating conditions. 〚A1〛

5.6 Limiting and indicating devices

5.6.1 General

5.6.1.1 〚A1〛 Rated capacity limiters shall be provided on all cranes, except timber handling cranes, having a rated capacity of 1 000 kg or above, or a maximum net lifting moment of 40 000 Nm or above due to the load. The rated capacity shall be determined at all outreaches corresponding to the boom system being horizontal. The stability of the vehicle shall be included in the function of the rated capacity limiter on all cranes, except timber handling cranes, having a rated capacity of 1 000 kg or above, or a maximum net lifting moment of 40 000 Nm or above. 〚A1〛

NOTE 1 Stability in this case means 〚A1〛 : deployment 〚A1〛 of every stabilizer is monitored by the rated capacity limiter and the rated capacity can be reduced or the crane can be stopped, if not sufficiently deployed. It is essential that the rated capacity limiter reacts quickly enough in all working boom positions, in particular at high boom angles, where the lifting radius could increase very rapidly, or slewing into potentially unstable areas.

〚A1〛 If the vehicle stability is lower at some slewing angles, all cranes shall have a system that either limits the slewing angle or the load or both, so that the required stability margin is maintained at any slewing angle. 〚A1〛

Rated capacity indicators shall be provided on all cranes. Limiting and indicating devices shall conform to EN 12077-2:1998+A1:2008.

NOTE 2 Regarding rated capacity limiters on loader cranes, see also explanatory note given in C.1.

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In case a recognized fault in the rated capacity limiter causes it not to remain effective, all crane movements shall stop. In the event the crane has been stopped due to the rated capacity being reached or due to a fault in the rated capacity limiter, all movements that increase the load moment of the crane shall be blocked, while other movements may remain available. Blocked movements may only be allowed after that a lowering facility in accordance with 5.6.3 has been activated.

NOTE 3 For examples of dangerous movement for different crane types, see informative Annex D.

5.6.1.2 A1 For loader cranes with a rated capacity of less than 1 000 kg and a maximum net lifting moment of less than 40 000 Nm or timber handling cranes the relief valves in accordance with 5.6.2.2 and 5.6.2.3 shall provide overload protection. When a rated capacity limiter is not provided, then the maximum working load as defined in 7.3.4.1 a) shall be limited by the relief valve.

NOTE This clause means that all rated capacities, including the maximum rated capacity at the innermost position, are physically limited. A1

5.6.1.3 The safety functions listed in Table 7 are required when applicable. For risks not covered by the safety functions listed in Table 7, a risk analysis shall be performed to establish PLr.

Table 7 — Minimum required performance levels for safety functions

Safety Functions	**PLr**
Rated capacity limiter protecting against overloading of load carrying structure	c
Rated capacity limiter protecting against vehicle instability due to crane operation	c
Operator platform protection	c
Stabilizer extension clear view	b
A1 Interlocking of retracting stabiliser extensions with powered tilting devices	b A1

NOTE For more information on safety functions, see C.2.

Each single safety function listed in Table 7 can also be realized as a combination of several safety functions. Each of these safety functions shall achieve the required PLr.

The safety functions of control systems shall be in accordance with EN 13135:2013+A1:2018, 5.7.2, and one of the following two methods shall be used:

A1 Method 1:

— Safety related functions shall be in accordance with EN ISO 13849-1:2023 and EN ISO 13849-2:2012. SRP/CS comprising complex electronic components shall be of at least category 2.

Method 2:

— Method 2 is valid for PLr = c or lower.

The achieved PL or PFH_D of the whole safety function is not considered if each SRP/CS is in accordance with EN ISO 13849-1:2023 and EN ISO 13849-2:2012 and the following is satisfied:

— Safety Function with only mechanical, hydraulic, electromechanical or electrohydraulic components:

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