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Cranes — Safety requirements for loader cranes

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National foreword

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Cranes — Safety requirements for loader cranes

*Appareils de levage à charge suspendue — Exigences de sécurité pour
les grues de chargement*





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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 15442 was prepared by Technical Committee ISO/TC 96, *Cranes*, Subcommittee SC 6, *Mobile cranes*.

This second edition cancels and replaces the first edition (ISO 15442:2005), which has been technically revised.

Introduction

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

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

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

Even though a loader crane mounted on a chassis may be considered as a particular type of mobile crane, with very few exceptions International Standards developed for mobile cranes do not currently include specific requirements for loader cranes.

This International Standard

- identifies specific safety requirements for loader cranes,
- when applicable, refers to existing International Standards which contain provisions that can be applied to loader cranes,
- promotes loader crane safety by both identifying specific requirements and referring to existing applicable standards, so that incorporating all such provisions into the design and use of loader cranes will guard against and minimize injury to workers and damage to equipment,
- facilitates the work of everyone in the field of loader cranes (designers, supervisors and other personnel, as well as people directly or indirectly responsible for their safe use and maintenance) who needs to consult currently available International Standard for loader cranes, and
- contributes to the further international harmonization of loader crane standards.

Cranes — Safety requirements for loader cranes

1 Scope

This International Standard specifies the minimum requirements for the design, calculation, examination and testing of hydraulic powered loader cranes and their mountings onto chassis or static foundations.

It is applicable to all new loader cranes manufactured one year after its publication. It is not the intent of this International Standard to require the retrofitting of existing loader cranes.

It is not applicable to loader cranes used on board ships or floating structures or to articulated boom system cranes designed as a total integral part of special equipment such as forwarders.

It deals with all significant hazards, hazardous situations or hazardous events relevant to loader cranes, with the exception of hazards related to the lifting of persons, when used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer. See Annex A for a list of the significant hazards.

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

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.

ISO 3744, *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 3864-1, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 4302, *Cranes — Wind load assessment*

ISO 4306-1, *Cranes — Vocabulary — Part 1: General*

ISO 4310, *Cranes — Test code and procedures*

ISO 4413, *Hydraulic fluid power — General rules relating to systems*

ISO 5353, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point*

ISO 7752-1, *Cranes — Control layout and characteristics — Part 1: General principles*

ISO 8566-1, *Cranes — Cabins and control stations — Part 1: General*

ISO 8566-2, *Cranes — Cabins — Part 2: Mobile cranes*

ISO 11201, *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 10245-1, *Cranes — Limiting and indicating devices — Part 1: General*

ISO 11660-1, *Cranes — Access, guards and restraints — Part 1: General*

ISO 11660-2, *Cranes — Access, guards and restraints — Part 2: Mobile cranes*

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

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

ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

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

ISO 20332, *Cranes — Proof of competence of steel structures*

IEC 60068-2-64, *Environmental testing — Part 2: Test methods — Test Fh: Vibration, broad-band random (digital control) and guidance*

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-1, ISO 12100 and the following apply.

3.1 Definitions

3.1.1

loader crane

powered crane comprising a column that slews about a base, and a boom system that is attached to the top of the column and which is usually fitted on a vehicle (including trailer) and designed for loading and unloading the vehicle

[SOURCE: ISO 4306-2:2012, 5.2, modified — Note 3 is not included in the source definition.]

NOTE 1 ISO 3833:1977 defines *commercial vehicle* as a motor vehicle which, on account of its design and appointments, is used mainly for conveying goods, and which may also tow a trailer. An example of one type of commercial vehicle equipped with a loader crane is shown in ISO 4306-2:2012, Figure 9.

NOTE 2 A loader crane installed on another type of vehicle or on a static base is still considered a loader crane.

NOTE 3 Annex B gives examples of boom system configurations and installations.

3.1.1.1

recycling crane

loader crane specifically designed, manufactured and equipped with a grapple for loading/unloading of recycling materials (e.g. scrap metal)

NOTE Recycling cranes are designed to operate at higher speeds and with higher dynamic loads than other types of loader crane and these differences are reflected in some of the requirements of this International Standard.

3.1.1.2

timber crane

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

NOTE 1 The operator controls the crane from a high seat or from a cabin.

NOTE 2 Timber cranes are designed to operate at higher speeds and with higher dynamic loads than other types of loader crane and these differences are reflected in some of the requirements of this International Standard.

3.1.2

articulated movement

movement of boom members pivoting about a pin joint

3.1.3

base

housing incorporating anchoring points and bearings for the slewing column

3.1.4

boom

structural member in the boom system of the loader crane

3.1.4.1

hydraulic boom extension

part of the boom which is capable of hydraulic telescopic movement to vary its length

3.1.4.2

manual boom extension

part of the boom which can be manually extended or retracted

3.1.4.3

boom system

complete system, consisting of booms, boom extensions and cylinders

3.1.5

column

structural member which supports the boom system

3.1.6

control system

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

3.1.7

control station

position from which the loader crane may be operated

3.1.7.1

raised control station

control station at a height above the ground level, comprising a high seat attached to the column of the loader crane or a platform positioned above the base of the loader crane

NOTE See Annex K.

3.1.8

crane inclination

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

3.1.9

danger zone

hazard zone

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

[SOURCE: ISO 12100:2010, 3.11.]

3.1.10

dead load

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

3.1.11

dynamic pressure

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

3.1.12

fixed load lifting attachment

equipment from which the net load may be suspended and which is fitted directly to the boom head as an integral part of the crane

3.1.13

flow-sensitive check valve

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

3.1.14

gross load

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

3.1.15

high seat

control station connected to the column, consequently rotating with the crane

3.1.16

hoist

machine for lifting and lowering suspended loads over predetermined distances, using ropes, chains or belts

3.1.17

hydraulic line rupture

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

3.1.18

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

3.1.19

main relief valve

valve which limits the pressure supplied to the hydraulic system of the crane

3.1.20

maximum working load

maximum load that may be lifted

NOTE It is the largest load appearing in the load plate.

3.1.21

maximum working pressure

maximum pressure in pump circuit or individual working function

3.1.22

net lifting moment

rated capacity multiplied by outreach

3.1.23

non-fixed load lifting attachment

lifting accessory 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

3.1.24

outreach

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

3.24.1.1

hydraulic outreach

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

3.1.25

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)

3.1.26

port relief valve

valve which limits the pressure supplied to a hydraulic actuator

3.1.27

pressure relief valve

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

3.1.28

rated capacity

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

3.1.29

rated capacity indicator

device which gives, within tolerance limits specified in 4.6.3.2, 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

3.1.30

rated capacity limiter

system that automatically prevents the crane from handling loads in excess of its rated capacity

NOTE See also Annex C.

3.1.32

setting-up function

crane function used to prepare the crane for lifting

3.1.33

sink rate

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

3.1.34

slewing

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

3.1.35

stabilizer

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

3.1.35.1

stabilizer extension

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

3.1.35.2

stabilizer leg

part of the stabilizer capable of contacting the ground to provide the required stability

3.1.36

static foundation

fixed support incorporating mounting points for a crane

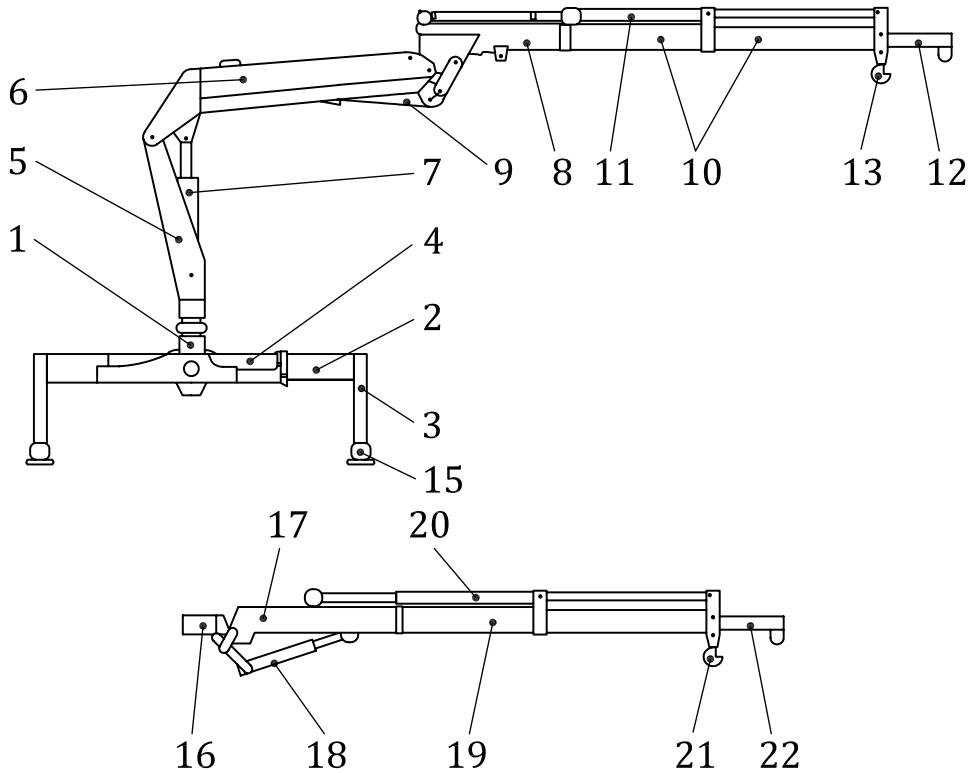
3.1.37

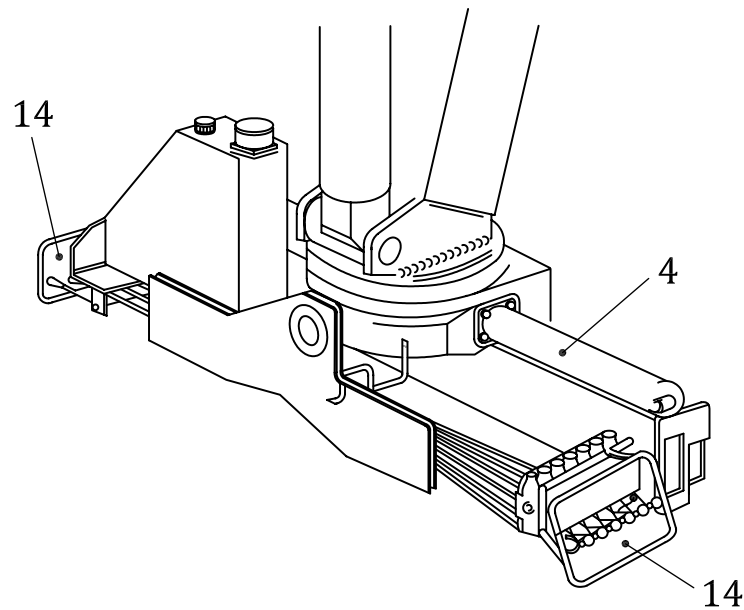
total lifting moment

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

3.2 Terminology

See Figure 1.





Key

1	base	12	2nd manual boom extension
2	stabilizer extension	13	load hook
3	stabilizer leg	14	controls
4	slewing mechanism	15	stabilizer foot
5	column	16	3rd boom attachment
6	1st boom	17	3rd boom
7	1st boom cylinder	18	3rd boom cylinder
8	2nd boom	19	3rd hydraulic boom extension
9	2nd boom cylinder	20	3rd boom extension cylinders
10	2nd hydraulic boom extension	21	load hook
11	2nd boom extension cylinders	22	3rd manual boom extension

Boom systems consist of items 6 to 12 plus items 16 to 22, as applicable.

Figure 1 — Main parts of loader crane

4 Safety requirements and/or protective measures

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

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

4.1 Calculation of rated capacity

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 kinematics;
- d) dead loads;

- e) load combinations;
- f) hoist loads.

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

4.2 Structural calculation

4.2.1 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;
- 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.

4.2.2 Dynamic factors

4.2.2.1 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 loading by applying the factor, ϕ_1 , to 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 , expressed as

$$\phi_1 = \min(1,1;\phi_2) \quad (1)$$

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

Although generally $\phi_1 = 1,1$, it shall not exceed the value of ϕ_2 (see 4.2.2.2) when ϕ_2 is less than 1,1.

4.2.2.2 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 vibration effects shall be included in the loading by multiplying the gravitational force due to the mass of the hoist load by a factor, ϕ_2 .

Factor ϕ_2 shall be taken as

$$\phi_2 = \phi_{2\min} + \beta_2 \times v_h \quad (2)$$

$\phi_{2,\min}$ and β_2 are given in Table 1 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 chassis or structures of equivalent flexibility;
- HC2 for rigidly mounted cranes.

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.

Table 1 — Values of β_2 and $\phi_{2,\min}$

Hoisting class of appliance	β_2	$\phi_{2,\min}$
HC 1	0,17	1,05
HC 2	0,34	1,10

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 2.

Table 2 — Values of v_h

Load combination	Type of hoist drive and its operation method		
	HD1	HD4	HD5
A1, B1	$v_{h,\max}$	$0,5v_{h,\max}$	$v_h = 0$
C1	$v_{h,\max}$	$v_{h,\max}$	$0,5v_{h,\max}$
HD1 is the hoist drive can only be operated at a fixed speed HD4 is the start of the lift is performed with continuously increasing speed HD5 is the hoist drive control is automatic and ensures that the speed influence on the dynamic force is negligible $v_{h,\max}$ 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 articulation hydraulic drives acting simultaneously.

NOTE 1 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.

NOTE 2 Dynamic factor ϕ_2 can be calculated using rigid body kinetics or determined by experimental means.

4.2.2.3 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 a factor, ϕ_3 , the value of which is given by

$$\phi_3 = 1 - \Delta m \times (1 + \beta) / m \quad (3)$$

where

m is the mass of the gross load;

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

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

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

4.2.2.4 Effects caused by acceleration/deceleration of the slewing drive

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

4.2.3 Loads and forces

4.2.3.1 General

The following loads and forces shall be taken into account:

- a) regular loads:
 - 1) dead loads (3.10);
 - 2) gross loads (3.14);
 - 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 on stairways, platforms and hand rails;
- 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.

4.2.3.2 Regular loads

4.2.3.2.1 Forces due to acceleration/deceleration of the slewing drive

The horizontal loads from the masses of the crane and of the payload shall be calculated from

$$F_{hi} = m_i \times g \times \tan \alpha \quad \alpha \geq 3^\circ \quad (4)$$

where

- F_{hi} is the horizontal load i acting on the payload or a mass point of the boom;
- m_i is the payload or mass point of boom;
- g is the acceleration due to gravity;
- α is the maximum inclination for the crane in accordance with the manufacturer's specification.

However, the minimum value that may be used is $\alpha = 3^\circ$.

4.2.3.2.2 Centrifugal forces (see Table 3)

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 4.2.2.

4.2.3.2.3 Forces on stabilizer legs

The stabilizer legs shall be loaded by simultaneously-acting vertical and horizontal forces. The horizontal force shall act on 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.

4.2.3.3 Occasional loads

4.2.3.3.1 Wind loads

Wind loads shall be calculated according to ISO 4302. Only in-service wind need be applied.

4.2.3.3.2 Loads on stairways, platforms and hand rails

See 4.8.2.

4.2.3.4 Exceptional loads

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

4.2.4 Load combinations

4.2.4.1 Basic load combinations

Loads shall be combined to determine the stresses the crane will experience during operation. Basic load combinations are given in Table 3.

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.

4.2.4.2 Load combinations covered (see Table 3)

- A1 and B1** are the 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** are the 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** represents the simultaneous dynamic peaks caused by raising or lowering a load at the maximum sum of the vertical speeds from all articulation drives, taking into account the available oil flow.
- C3** is the crane-under-test condition.

4.2.4.3 Application of Table 3

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 3.

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.

Table 3 — Load combinations to be covered

Load category	Load		Load comb. A			Load comb. B			Load comb. C		
			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
		Mass of the gross load	1,34	ϕ_2	ϕ_3	1,22	ϕ_2	ϕ_3	—	—	—
	Acceleration of slewing drive	Moved masses of the crane	1,22	ϕ_{5h}	ϕ_{5h}	1,16	ϕ_{5h}	ϕ_{5h}	—	—	—
		Mass of the gross load	1,34	ϕ_{5h}	ϕ_{5h}	1,22	ϕ_{5h}	ϕ_{5h}	—	—	—
	Centrifugal loads ^a	Masses of the crane	1,22	1	1	1,16	1	1	—	—	—
		Mass of the gross load	1,34	1	1	1,22	1	1	—	—	—
Occasional	Climate effects	In service wind ^b	—	—	—	1,22	1	1	—	—	—
Exceptional	Forces due to one exceptional event		—	—	—	—	—	—	1,1	ϕ_2	1
^a Only centrifugal loads that increase the load effects shall be included.											
^b Forces acting simultaneously with wind forces shall only be applied to such an extent that the drive force in Acceleration of slewing drive is not exceeded.											

A1

4.3 Stress analysis

The competence of the steel structure should be assessed in accordance with ISO 20332. Alternatively, any other advanced and recognized standard, which conforms to similar principles, may be used. If a standard based on the allowable stress method is used, the partial safety factors, γ_p , in Table 3 shall be set to 1, and 1.5 shall be used as the overall safety factor. For fatigue classification according to ISO 20332, see Annex O.

4.4 Mechanical arrangements

4.4.1 Stabilizers

Stabilizers shall be provided when needed to fulfil the stability requirements (see 4.10.3) when loader cranes are fitted on chassis.

4.4.1.1 Stabilizer leg

The stabilizer leg shall have means (e.g. foot plate) for ground support. The stabilizer foot plate shall be constructed to accept ground unevenness of at least 10°. The area of each foot shall be such that the resultant maximum ground pressure is less than 4 MPa. For the main stabilizers, the maximum ground pressure, P , shall be calculated as

$$P = \frac{M_{dyn}}{L \times A} \quad (5)$$

where

- M_{dyn} is the maximum moment at slewing centre including dynamic factors;
- L is the distance from slewing centre to stabilizer leg;
- A is the area of stabilizer foot.

The feet of auxiliary stabilizers shall have the same size as for the main stabilizers. Alternatively, a detailed calculation of the entire installation shall be carried out or stabilizers forces shall be measured.

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 4.4.3). If stabilizer legs have to be tilted (rotated) up or down manually, the maximum force to activate any one of them shall not exceed 250 N, measured at the stabilizer foot.

4.4.1.2 Stabilizer extension

Stabilizer extensions shall be marked to show when they are correctly deployed. Manually operated extensions shall be fitted with

- a) handles for manual operation,
- b) devices for locking extensions in the working and transport positions (see 4.4.3), and
- 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 the load handling.

4.4.2 Manual boom extensions

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

4.4.3 Securing for transport

4.4.3.1 General

An indicator (e.g. angle sensor) detecting the boom system in the transport position shall be provided, see 4.6.7.

Locking means shall be provided to prevent uncontrolled movements of the crane and stabilizers installed on chassis when travelling.

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

4.4.3.2 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 which 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.

It shall be clearly visible to the operator when the manual locking devices are in the locked and unlocked positions. In addition, it shall be indicated when the stabilizers are not locked in the transport position, see 4.6.7.

4.4.3.3 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 4.5.6.1. A mechanical locking device shall be designed to withstand, without permanent deformation, the force due to attempting to extend the stabilizers with the locking devices engaged.

4.4.4 Hoists

4.4.4.1 Protection against overload

Where a power-driven hoist is fitted, the crane shall be fitted with a rated capacity limiter. The capability of the hoist shall be included in the safety function of the rated capacity limiter (see 4.6.3) to ensure that the hoist cannot be overloaded by movements of the crane (e.g. by driving the boom extension against the hook block), and the crane cannot be overloaded by the hoist.

4.4.4.2 Rope spooling

Hoist drums with rope grooves are preferred to facilitate proper spooling of the rope onto the drum.

4.4.4.3 Unintentional lowering of the load

Hoists shall be protected against unintentional lowering of the load, for example, following a hydraulic line rupture or a power failure.

4.4.4.4 Rope anchorage

Where the rope anchorage to the drum cannot withstand the maximum hoisting load, a lowering limiting device which keeps at least three full turns of rope on the drum shall be fitted.

4.4.4.5 Rope tension

Means shall be provided to maintain some rope tension when the hoist is under no load.

4.4.5 Load hooks

Hooks shall be designed in accordance with the state of the art.

NOTE More information can be found in CEN/TS 13001-3-5.

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.

4.5 Hydraulic system

4.5.1 General

The hydraulic system and components shall comply with the requirements of ISO 4413.

The hydraulic components and lines shall be dimensioned such that the hydraulic system can be operated at the intended working pressure (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 a 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.

4.5.2 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.

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

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

4.5.3 Hydraulic reservoir

The hydraulic reservoir shall be specified by the crane manufacturer and shall have sufficient fluid capacity for the pump to operate correctly when all the hydraulic cylinders are fully extended. 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 of the maximum and minimum fluid levels. An access opening and a drain valve with plug shall be provided for cleaning purposes.

4.5.4 Pressure-relief valves

Each load-carrying circuit shall be equipped with an automatic means (e.g. port relief valves) that limits the pressure to a maximum of 25 % above the maximum working pressure or shall be designed to withstand the maximum pressure that can occur under foreseen operating conditions.

The minimum setting of the pressure relief valves, except for timber and recycling cranes (see 4.5.6.1 and 4.5.6.2), shall be such that no uncontrolled movement can take place with loads up to 1,2 times the rated capacity.

4.5.5 Hoses, tubes and fittings

Burst pressure for hoses shall be a minimum of four times the maximum working pressure for hoses without end fittings. Burst pressure of the raw material for tubes between lock valve and actuator shall be a minimum of three times the maximum working pressure.

Hoses, tubes and fittings shall be so located, installed and, where appropriate, protected such that they do not sustain damage 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 m of the operator, shall be guarded.

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

4.5.6 Precautions against hydraulic line rupture

4.5.6.1 Loader cranes other than timber and recycling cranes

All load-carrying circuits shall be equipped with an automatic means, e.g. load-holding valves, to prevent uncontrolled movement of the crane in the case of hydraulic line rupture. Flow-sensitive check valves shall be used only 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,
- b) directly and rigidly flange mounted, or
- c) placed close to the cylinder or connected to it by means of rigid tubes.

For tubes and fitting between the lock valve and actuator, the safety factor shall be 3, calculated against the maximum working pressure.

4.5.6.2 Timber and recycling cranes

In the event of hydraulic line rupture, the lowering speed of the load shall not exceed the maximum lowering speed at rated capacity by more than 30 %. See Annex C.

Stabilizer leg cylinders shall be equipped as specified in 4.5.6.1.

4.5.7 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 radius per minute. For timber and recycling cranes, however, the sink rate may be 2 % of radius per minute.

The sink rate shall be tested at maximum rated capacity and at maximum hydraulic radius (i.e. without manual extensions).

4.5.8 Slewing mechanism

The slewing mechanism shall be able to withstand the maximum slewing forces (see 4.2.2) to bring it to a stop and sustain the load under the most adverse operating conditions.

4.5.9 Calculation of hydraulic cylinders

Hydraulic cylinders shall be calculated for dynamic working pressure with a safety factor against the yield stress of minimum 1,5.

4.6 Limiting and indicating devices

4.6.1 General

Limiters/indicators shall comply with ISO 10245-1. Safety-related parts of limiting and indicating systems shall comply with ISO 13849-1.

4.6.2 Rated capacity indicator

Rated capacity indicators shall be provided on all cranes except timber cranes.

The rated capacity indicator shall give a visual or audible warning, or both, to the operator when the load exceeds 90 % of the rated capacity. If the rated capacity is being exceeded or when the rated capacity

limiter (if fitted) operates, there shall be a separate warning for overload to the operator and persons in the vicinity of the crane.

There shall be a clear difference between the warning for approach to rated capacity and the warning for overload. Both warnings shall be continuous and shall be distinguishable as a warning to the persons concerned while the crane is being operated.

The warning of persons in the danger zone is not necessary for a loader crane with a radius of less than 12 m, except for cableless remote control.

4.6.3 Rated capacity limiter

Rated capacity limiters shall be provided on all cranes with power-driven hoists, and all cranes having a rated capacity of 1 000 kg or above, or a maximum net lifting moment of 40 000 N·m or above due to the load. The rated capacity shall be determined at all outreaches corresponding to the boom system being horizontal.

4.6.3.1 Function

The rated capacity limiter shall safeguard against any part of the crane structure (including manual extensions) or hoist (if fitted) being loaded beyond its design limits.

For cranes other than timber cranes, the rated capacity limiter shall also safeguard against the overturning moment becoming sufficiently large to overcome the stability of the chassis for all possible positions of the stabilizers.

NOTE 1 “All possible positions of the stabilizers” means any position that the stabilizers are capable of occupying, and includes the transport position.

The rated capacity limiter shall prevent dangerous movements of the load, but allow all movements that will reduce the load moment on the crane.

NOTE 2 Regarding rated capacity limiters on loader cranes, see also Annex C. For examples of dangerous movement for different crane types, see Annex D.

If a rated capacity limiter is not provided on the crane, then relief valves according to 4.5.4 and 4.6.5 shall be fitted to provide protection against overloading the structure and mounting.

4.6.3.2 Operating tolerance

The rated capacity limiter shall operate within the designed operating accelerations of the crane between 100 % and $(100 + \Delta \%)$ of the maximum total load moment calculated at the slewing centre of the crane. The value of Δ depends on the hydraulic radius, according to the following formula:

$$\Delta \leq 8 + (0,5 \times R) \leq 20 \quad (6)$$

where R is the hydraulic radius, in metres.

For timber and recycling cranes, a tolerance of 20 % may be used independent of the hydraulic radius.

The rated capacity limiter should operate before the pressure due to the total load moment causes the load holding valves or port relief valves to operate.

NOTE It is generally accepted that a capacity limiter for loader cranes limits the total load moment. At long radius the main part of the total lifting moment comes from the dead loads and only a small part from the payload. Tolerances for the rated capacity limiter as stated above have been set to take this into account.

4.6.4 Emergency lowering facility

In order to avoid locking-in of the loader crane after an actuation of the rated capacity limiter, an emergency overriding facility may be provided. This facility shall not allow uncontrolled movement of the crane, such as unintended operation of the load-holding valves, or affect chassis stability.

If this emergency facility is fitted it shall be clearly identified. This facility shall only function while the control is held by the operator and for a period of maximum 5 s at intervals not shorter than 30 s.

4.6.5 Main relief valve

All loader cranes shall be fitted with one or more main relief valves.

The main relief valve (excluding for winch system loader cranes equipped with an indicating device) shall operate within the designed operating accelerations of the crane, between 100 % and 110 % of the maximum system pressure.

4.6.6 Level indicator

Cranes equipped with stabilizers shall be provided with a level indicator in clear view of the operator at the stabilizer control station.

4.6.7 Travelling indicators

For chassis with loader cranes which are used public roads, indicators are required to inform the driver when

- a) the height of the crane exceeds a predetermined maximum height, regardless of whether the boom system folded for travelling or parked on the load platform or on top of the load during transport, in which case the value of the predetermined maximum height shall be displayed on a notice visible to the driver from the driving position, and
- b) any stabilizer is not locked or secured in its transport position.

These indicators shall be visible to the chassis driver from the driving position, and supported by an audible indication which can be cancelled by an acknowledgement action by the driver.

4.6.8 Motion and performance limiters

4.6.8.1 Motion limiters

Slewing (if not continuous) and boom system movement limits shall be determined by the stroke of the cylinder or by appropriate stops.

4.6.8.2 Performance limiters

Speed limiters shall be incorporated into the slewing and boom system motions to ensure that any forces resulting from these motions are restricted to the design criteria of the loader crane.

4.6.9 Acoustic warning

An audible warning, e.g. siren, shall be provided. The warning shall be able to be actuated by the operator from each control station unless the control station is used solely for the set-up functions.

4.6.10 Stopping device

A control device to bring the loader crane safely to a complete stop by removing the energy supply to the crane shall be fitted on the crane and at every control station unless the control station is solely used for

the set-up functions. The device shall initiate the stop function by de-energizing and shall be designed, fitted and function according to the following:

- a) it shall be easily visible due to red-coloured actuators, where practicable, before of a yellow background;
- b) activating the device shall not require any decision by the operator about the resultant function and effects, e.g. mushroom-type push button;
- c) the actuator shall be arranged for easy access and for non-hazardous operation by the operator;
- d) after stopping of the crane, no further movements of the boom system shall occur.

4.6.10.1 Lowering limiter (hoist)

Cranes fitted with hoists shall be fitted with a limiter to ensure that at least three turns of rope remain on the hoist drum, except in those cases where the rope anchor is designed to withstand the full rope force.

4.6.11 Hoisting limiter

Cranes fitted with hoists shall be fitted with a hoisting limiter.

4.7 Controls

4.7.1 General

The following requirements specify arrangement and direction of movements of controls assigned to working functions, such as slewing column, raising/lowering boom. Stabilizer functions are also included.

The requirements cover bi-directional and multidirectional (joy-stick) control levers.

The layout order of bi-directional controls has to follow the sequence of working functions from the base of the loader crane to the load-handling device. Control levers for setting-up functions shall be separated by space or clearly distinguished (other than by symbols) from other control levers.

All controls (except the stopping device) shall return automatically to the neutral position when they are released. They shall be marked permanently with clearly visible symbols as given in 4.7.2.

All controls shall be in accordance with the safety and ergonomic principles specified in ISO 7752-1.

Control levers shall be located or guarded against unintended operation.

Additional requirements for cableless controls and control systems are given in Annex E.

4.7.2 Symbols

Symbols for the working and setting-up functions of loader cranes having boom systems with two articulated booms shall be in accordance with Annex F. For loader cranes having other boom systems, any additional symbols that are necessary shall be derivatives of Annex F. The symbols shall be used as follows for bi-directional control levers:

- a) on the control lever knobs — inside arrows indicate the movement of the corresponding lever, and only one symbol for a crane function and one arrow for the lever movement shall be combined (see Figure 2);
- b) when placed on a separate plate adjacent to the control levers, the symbols can be used without lever movement arrows, in which case, two symbols for each lever shall be used (see Figure H.3);
- c) the minimum size of a symbol shall be that it is circumscribed by a 15 mm circle (12 mm in case of remote controls), while in the case of multi-symbols the minimum size shall relate to the smallest, e.g. according to Figure 2.

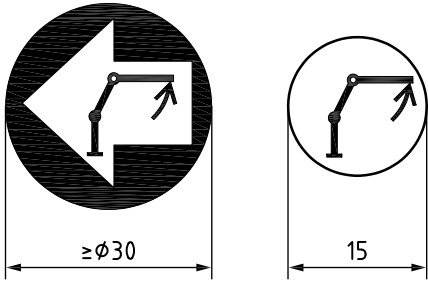
Knob of control lever	Meaning of symbol/arrow combination
	Move control lever left to raise second boom and Move control lever right to lower second boom
For one symbol/arrow combination	

Figure 2 — Symbols for working function

4.7.3 Layout of bi-directional controls

4.7.3.1 General

The principles laid down in 4.7.1 apply to both vertical and horizontal control lever arrangements.

4.7.3.2 Vertical layout order

Information is given in Annex G regarding the layout order for vertical control lever arrangements operated from ground level.

4.7.3.3 Horizontal layout order

Information is given in Annex H regarding the layout order for horizontal control lever arrangements operated from ground level.

4.7.4 Guidance for high seat controls

See Annex I.

4.8 Control stations

4.8.1 General

Control stations can be of the following types:

- ground control;
- raised control from fixed platform, slewing platform, high seat or cabin;
- remote control;
- cabin.

When more than one control station is provided there shall be a means for preventing simultaneous operation from two stations unless the controls are mechanically linked to each other (see C.3)

The control station for a stabilizer extension function shall be positioned so that the operator has an unobstructed view of the movements being controlled.

Control stations shall be such that the operator cannot be crushed or his clothing become trapped due to moving parts of the crane. The safety distances given in ISO 13857 shall apply.