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Cranes — Safety requirements for loader cranes

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

Reference number
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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

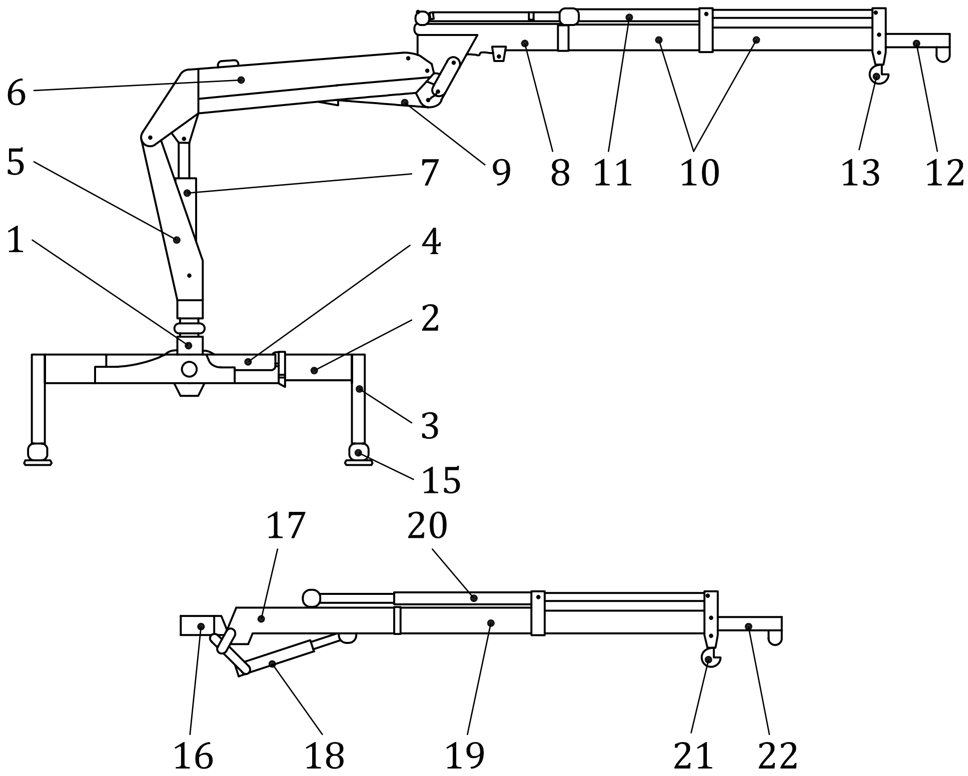
3.1.35.2
stabilizer leg
part of the stabilizer capable of contacting the ground to provide the required stability

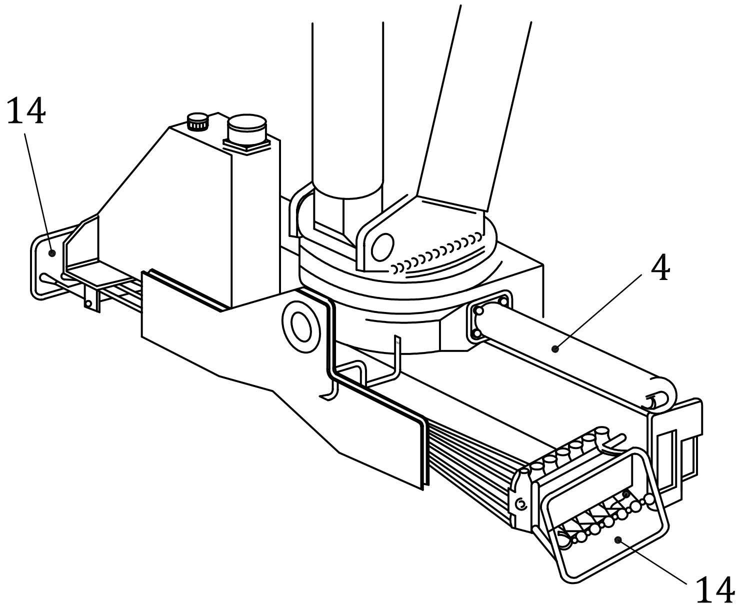
3.1.36
static foundation
fixed support incorporating mounting points for a crane

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

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

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

Although generally ϕ_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

$$\phi_2 = \phi_{2\min} + \beta_2 \times v_{\mathrm{h}} \tag{2}$$

$\phi_{2,\min}$ 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 $\phi_{2,\mathrm{min}}$

Hoisting class of appliance	β_2	$\phi_{2,\mathrm{min}}$
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	$v_{\mathrm{h,max}}$	$0{,}5v_{\mathrm{h,max}}$	$v_\mathrm{h} = 0$
C1	$v_{\mathrm{h,max}}$	$v_{\mathrm{h,max}}$	$0{,}5v_{\mathrm{h,max}}$

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

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

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

In load combination C1, $v_{\mathrm{h,max}}$ 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

$$\phi_3 = \frac{\Delta m \times (1 - \beta)}{m} \qquad (3)$$

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

$$F_{hi} = m_i \times g \times \tan\alpha \qquad \alpha \geq 3° \tag{4}$$

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 α = 3°.

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			Row
			γ_p	A1	A2	γ_p	γ_p	A1	A2	γ_p	γ_p	A1
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	—	—	—	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
Exceptional	Forces due to one exceptional event		—	—	—	—	—	—	1,1	ϕ_2	1	8

[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 rows 3 and 4 is not exceeded.

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

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

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 + Δ %) 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:

$$\Delta \leq 8 + (0{,}5 \times R) \leq 20 \qquad (6)$$

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.

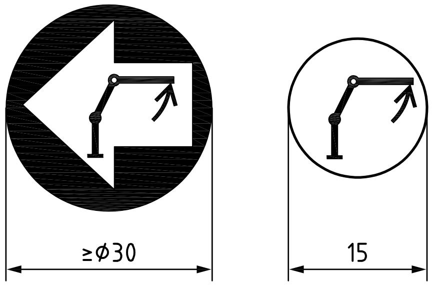
Knob of control lever	Meaning of symbol/arrow combination
	Move control lever left to raise second boom and Move control lever right to lower second boom
For one symbol/arrow combination	

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:

a) ground control;

b) raised control from fixed platform, slewing platform, high seat or cabin;

c) remote control;

d) 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.

Where any guards are provided these shall not (unless specifically designed for the purpose) be able to be used to support the operator's weight or be used as hand holds.

Where it is not practicable to install guards, gaps between moving parts shall comply with the dimensions given in appropriate standards for the prevention of finger, hand and foot trapping (see ISO 13854).

Chassis-mounted loader cranes are generally operated for short periods and therefore a cabin is not normally required. For applications when a cabin *is* required, due, for example, to environmental conditions, the specification shall comply with ISO 8566-1. Minimum cabin dimensions shall comply with ISO 8566-2 with the exceptions as specified in Annex J.

4.8.2 Raised control stations

4.8.2.1 Strength of components

Handrails shall withstand a horizontal force of 300 N distributed over 100 mm. Platforms shall withstand a force of 1 500 N applied on a circular area diameter 125 mm at any location on the surface. Steps and rungs shall withstand a force of 1 500 N applied over 100 mm. The components shall resist these applied forces without any permanent deformation and without any elastic deformation greater than 2 % of the span between supports or 10 mm, whichever is the lesser.

4.8.2.2 High seat (see Annex K)

The construction and mounting of the high seat shall meet the following requirements:

a) accessibility to the seat shall not be inhibited by the controls or configuration of the loader crane in predetermined positions;

b) the seat with supporting members fixing the seat to the loader crane shall withstand a force of 1 500 N acting centrally on the horizontal area of the seat without permanent deformation;

c) horizontal positions shall be adjustable and lockable without the use of tools;

d) the seat shall be provided with a means of reducing the risk of falling when the operator is in the working position and this shall not impair accessibility to the seat; if side-guards are fitted these shall be at a height of minimum 100 mm from the seat index point as defined in ISO 5353.

e) guards shall be provided to prevent moving parts of the loader crane trapping the operator or his clothing;

f) a platform shall be provided for the operator's feet of minimum dimensions 160 mm · 300 mm for each foot.

4.8.2.3 Platform (see Annex K)

The construction of the platform shall meet the following requirements:

a) during operation, the operator shall be protected against moving parts of the crane; guards and/or limitation of the crane movements shall be provided when appropriate;

b) the floor shall be horizontal with minimum dimensions 400 mm · 500 mm;

c) the floor shall be manufactured from slip-resistant material; the design shall provide a means of eliminating the retention of liquid and debris;

d) precautions shall be taken to prevent the operator from falling from the platform, in accordance with ISO 11660-1.

4.8.2.4 Access and egress to raised control stations (see Annex L)

The means of access to raised control stations shall comply with ISO 11660-2.

4.9 Electrical systems and related phenomena

4.9.1 General

The electrical equipment of loader cranes shall comply, as applicable, with IEC 60204-32:2008, including

— 4.3.3, DC electrical supply,

— Clause 12, conductors and cables, and

— Clause 13, wiring practices.

4.9.2 Electromagnetic compatibility (EMC)

For immunity, the EMC of the electrical system shall comply with IEC 61000-6-2 and, for emissions, with IEC 61000-6-4. When the manufacturer of the crane uses certified components for the electrical system which fulfil the requirements of the aforementioned International Standards and these components are installed in accordance with the recommendations of the supplier, testing of the electromagnetic compatibility of the complete electrical system is not necessary.

4.10 Installation

4.10.1 General

Loader cranes can be installed on various types of chassis and foundations. A loader crane cannot normally be operated until it has been installed in its working position and connected to a power supply by the installer.

4.10.2 Mounting

The installer of a loader crane shall adhere to any specific requirements issued by the crane and/or chassis manufacturer, as well as any site conditions (for static installations), in addition to local regulations which may apply.

4.10.2.1 Chassis mounting

The mounting frame shall be constructed and secured to the chassis frame so that it can withstand the imposed loads and meet the requirements of chassis strength specified by the chassis manufacturer.

NOTE Annex M presents the calculation method for determination of mounting frame size.

The loader crane shall be positioned on the chassis so as to ensure that the completed installation complies with the road regulations and does not exceed the maximum permissible axle capacities, width, height and the stability requirements of 4.10.3.

4.10.2.2 Static mounting

The foundation shall be constructed so that it can withstand the imposed loads and provide positive securement for the crane fastenings at the mounting points. The size of the foundation shall not inhibit the normal crane movements. The dimensions of the foundation in the ground shall consider the total imposed loads and the relevant ground conditions.

4.10.2.3 Protection of the operator

The location of the ground control stations and any additional control stations which may be required shall also be considered when determining the crane position. Control stations shall be positioned so as

a) to ensure that operators are not exposed to inhalation of exhaust gases,

b) to ensure that operators cannot touch hot surfaces during normal crane operations, with the requirement that any surface having a temperature exceeding 55 °C be protected, and

c) to minimize the risk of crushing or trapping the operator by movements of any of the loader crane or stabilizer functions, with the requirement that guards be fitted as necessary to protect or prevent the operator from being crushed or trapped in any confined areas between the crane and the chassis.

Danger zones caused by moving parts of the stabilizers and their drives shall be protected by guards or safety measures.

Examples of stabilizer danger zones are

— entanglement zones at pulleys/bogie wheels;

— shearing zones at openings in the moving part of the stabilizer extension, and

— entanglement zones at chains/cables of the stabilizer extension.

The safety distances of ISO 13857 and ISO 13854 shall be applied.

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.

4.10.3 Stability

The stability of a loader crane installed on a chassis shall be such that the working unit does not overturn under foreseen operating conditions with the stabilizers in any position. Verification of the stability shall be made by testing the loading in accordance with 5.2.5.

When determining the position of the crane for installation according to 4.10.2, the stability (for guidance) may be deduced by calculation.

4.10.4 Noise

For loader cranes where the chassis engine is the power source the noise emissions are determined by the chassis manufacturer. A loader crane is generally only used for short periods of time and does not add any significant airborne noise during operation. Information on noise emissions shall be given to the user (see 6.2.3.9).

4.10.5 Vibration

A loader crane is generally only used for short periods of time and the effect of vibration on the operator is not regarded as being significant.

4.10.6 Electrical systems and related phenomena — Installation

4.10.6.1 General

The electrical equipment used for the installation of a loader crane shall comply, where applicable, with the requirements of the following sections of IEC 60204-32:2008:

— 4.3.2, AC electrical supply;

— 4.3.3, DC electrical supply;

— Clause 12, conductors and cables;

— Clause 13, wiring practices.

For loader cranes mounted on chassis, any electrical connection to the chassis's electrical system shall be made only at the manufacturer's designated connection points.

4.10.6.2 Electromagnetic compatibility (EMC)

For immunity, the EMC of the electrical system shall comply with IEC 61000-6-2, and, for emissions, with IEC 61000-6-4. When the installer of the crane uses certified components (for any additional items in the electrical system) which fulfil the requirements of the aforementioned International Standards and these components are installed in accordance with the recommendations of the manufacturer, testing of the electromagnetic compatibility of the modified system is not necessary.

4.10.7 Hydraulic components

Hydraulic components added to a loader crane by the installer to modify the existing hydraulic system for additional crane applications/extra accessories shall fulfil the requirements given in 4.5.

New hydraulic components shall be compatible with existing components and be sized such that the functioning of the modified hydraulic system fulfils all the original design specifications for flow, pressure and temperature.

Additional hydraulic components and modifications to the hydraulic system shall not impair the safe functioning and integrity of any of the safety aspects of the original hydraulic system.

4.10.8 Access

The installer of the loader crane on a chassis shall provide suitable access to any raised control station on the crane from ground level.

The access system shall fulfil the requirements given in 4.8.2.4.

5 Verification of the safety requirements and/or measures

5.1 General

The design of a loader crane shall be checked for conformity with each of the safety requirements and/or measures given in Clause 4 by means of calculation and/or testing.

A conceptual verification to show adequate safety for any hazard due to loss of mechanical strength is normally carried out by the manufacturer on the first crane of a series of cranes of the same type.

Before being put into service for the first time, individual cranes shall be checked for conformity with the safety requirements of this International Standard by the verification testing procedures to ensure fitness of purpose.

Conformity of each safety requirement and/or measure (given in Clause 4) shall be verified by the methods detailed in Table 4 and by the testing and test procedures detailed in 5.2.

For the calibration of limiting and indicating devices, the appropriate loads and crane configurations and methods as specified by the manufacturer shall be used.

All information for use detailed in Clause 6 shall be available with the crane before putting into service.

Table 4 — Methods to be used to verify conformity with the safety requirements and/or measures

Subclause	Method of verification
4.1 and 4.2	Calculations, tests according to 5.2.1 to 5.2.4 and analysis of the results.
4.4.1, 4.4.1.1 and 4.4.1.2	Inspection and testing to confirm that devices are functioning correctly.
4.4.2	Inspection and testing to confirm that devices are functioning correctly.
4.4.3,	Inspection and testing to confirm that devices are functioning correctly.
4.5.1	Check specification of components and test to confirm that devices are functioning correctly. Check hydraulic diagram in accordance with ISO 4413.
4.5.2	Check specification of components and test to confirm that devices are functioning correctly.
4.5.3	Check specification of components and test to confirm that devices are functioning correctly.
4.5.4	Review of hydraulic circuit diagram to confirm that devices according to the standard are fitted. Check setting of pressure relief valves.
4.5.5	Burst pressure: examination of supplier's specifications. Chafing, trapping and guards inspection.
4.5.6.1	Testing, by simulating line rupture and inspection of mounting.
4.5.6.2	Inspection, to confirm that devices are fitted on cranes where required. Testing of lowering speed.
4.5.7	Testing according to 4.5.7. Test performed with most unfavourable combination of fluid and fluid temperature according to manufacturer's recommendation.
4.5.8	Calculation, testing and analysis of the results.
4.5.9	Calculation, testing and analysis of the results.
4.6.1	Review of crane specification to ensure that appropriate devices are fitted. See also ISO 10245-1 for compliance.
4.6.2	Ensure that the crane fulfils the timber or recycling crane definition. Check the specifications of the hydraulic circuit for correct port relief valves. Test to ensure that the relief valves are functioning correctly and prevent dangerous movements.
4.6.3.1	When fitted, functional test to ensure correct operation. Stability test according to 5.2.5.
4.6.3.2	Determination of accuracy of rated capacity indicator/limiter: a) Plot a graph of rated capacity against radius (see Figure 3) for the horizontal configuration of the boom assemblies. b) Attach a load approximately equal to the crane's rated capacity, F_1, at 80 % radius to the crane at a radius, R_1, well within the rated capacity . c) Raise the load so that the boom system is in accordance with the position on the load plate as described in 6.3.4.1. For cranes with telescopic booms the booms should be fully retracted. d) Slowly extend the radius of the crane keeping the boom tip at the horizontal position. For cranes with telescopic booms this movement should be by extending the telescopic sections. e) At the point that the rated capacity indicator gives the first warning, measure the radius, R_2. From the graph, measure the rated capacity, F_2, of the crane at R_2. Determine the percentage of the rated capacity i.e. $F_1/F_2 \cdot 100$. f) Subtract 90 from the percentage found in e) and this is the value of the prewarning. g) Continue to slowly extend the radius of the crane in the manner described in (d) until the rated capacity limiter stops the motion. h) Measure the radius, R_3). From the graph, measure the rated capacity, F_3, of the crane at R_3. Determine the percentage i.e. $F_1/F_3 \cdot 100$. i) Subtract 100 from the percentage found to obtain the value of the rated capacity limiter. This value does not exceed the preconditions. j) The greatest value found in f) or i) shall be taken as the tolerance of the rated capacity indicator or limiter. Repeat the test for different loads spanning the range of rated capacities of the crane (see Figure 3) and using different crane motions. The resulting tolerances shall all be less than the tolerance of the rated capacity limiter. Check that the rated capacity limiter operates to prevent dangerous movements, as specified by the crane manufacturer, and allows movements to a safe condition.

Table 4 *(continued)*

Subclause	Method of verification
4.6.4	Where fitted, inspection and test to confirm that devices are functioning correctly.
4.6.5	Check of the hydraulic schematic and functional check.
4.6.6	Functional check.
4.6.7	Check of the crane installation specifications for requirement of travelling indicators. When fitted, functional test to ensure correct operation.
4.6.8.1	Check that appropriate devices, if needed, are fitted and function correctly.
4.6.8.2	Check the hydraulic schematic and measure the speed.
4.6.9	Visual inspection and functional check.
4.6.10	Inspection to ensure every control station has a stopping control device. Ensure its correct function.
4.6.11,	If hoist is fitted, check for correct function.
4.6.12	If hoist is fitted, check for correct function.
4.7.1	Inspection of crane to ensure that controls are correctly fitted and marked. Check that all controls automatically return to neutral position. See also ISO 7752-1 for compliance.
4.7.2	Check to ensure correct marking.
4.7.3	Visual inspection and functional check.
4.7.4	Visual inspection and functional check.
4.8.1	Visual inspection and functional check. If cabin is fitted, verify the dimensions. See also ISO 13857, ISO 13854, ISO 8566-1 and ISO 8566-2 for compliance.
4.9.1	Inspection of installation to ensure that the requirements are fulfilled. See IEC 60204-32 for compliance.
4.9.2	Tests in accordance with IEC 60204-32:2008, Clause 18.
4.10.2	Check instructions of the chassis and crane manufacturer, or verify with a static analysis according to the method shown. Inspect the installation to ensure that the requirements are fulfilled. See also ISO 13857 and ISO 13854 for compliance.
4.10.3	Check the stability according to the procedure described in 5.2.5.
4.10.4	Measurements according to 6.2.3.9.
4.10.5	No check is normally required.
4.10.6.1	Inspection of installation to ensure that the requirements are fulfilled. See IEC 60204-32 for compliance.
4.10.6.2	Tests in accordance IEC 60204-32:2008, Clause 18.
4.10.7	Inspection and test to confirm that devices are functioning correctly. See 4.5.1 to 4.5.5 above.
4.10.8	Check to ensure suitability and that the requirements according to 4.8.2.4 are fulfilled.

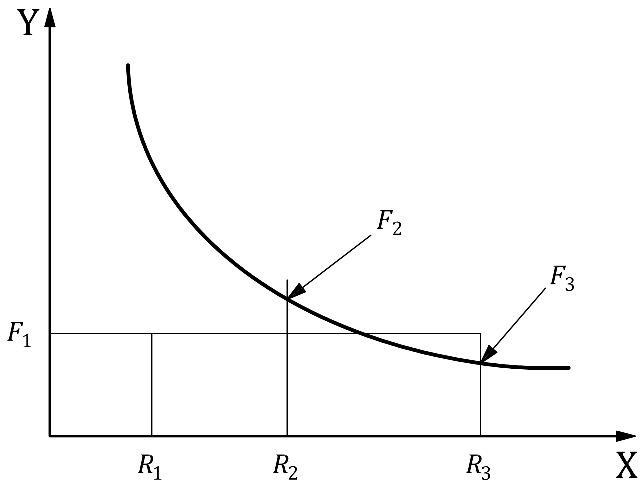


Figure 3 — Horizontal configuration of boom assembly — Rated capacity plotted against radius
(see Table 3/ref. 4.6.3.2)

5.2 Testing and test procedures

5.2.1 General

Testing shall be carried out in order to verify that the loader crane and the installation conform to the operational requirements stipulated by the manufacturer's specification and to verify the stability and the integrity of the structure and all the components.

All tests shall be performed in those positions and configurations that will impose maximum loads, maximum bending moments and maximum axial forces, as applicable, on the major crane components.

During the tests, the wind speed shall not exceed 8,3 m/s (30 km/h), chassis tyres shall be inflated to the pressure stipulated by the chassis manufacturer, and the crane shall be set up and controlled in accordance with the manufacturer's instructions as detailed in the crane manual.

For some tests it may be necessary to override or disable any safety and limiting devices that are installed on the crane. Care shall be taken to ensure that any such devices are reconnected, re-calibrated and re-tested after testing has been completed.

For the calibration of the limiting and indicating devices, the appropriate loads and crane configurations and methods specified by the manufacturer shall be used.

5.2.2 Functional test

The crane functions shall be operated throughout the range of all permitted movements up to the maximum speeds and up to the rated capacity, to demonstrate the satisfactory operation of the control system and any performance-limiting devices fitted.

5.2.3 Static tests

The test load shall be at least 1,25 times the rated capacity.

5.2.3.1 Conceptual (type) test

The manufacturer shall carry out tests on the loader crane in the positions and configurations that impose the maximum loads or maximum stresses on the crane components and structures. The results shall be recorded and retained by the manufacturer.

5.2.3.2 Installed test

The installer shall carry out the tests when the loader crane has been installed in its final working position ready to be put into service.

The tests as detailed below shall be carried out with the test load at the following radii:

a) maximum radius with any manual extensions;

b) maximum radius attainable with hydraulic radius;

c) radius corresponding to maximum load moment.

At each radius the load shall be positioned close to the ground and slewed slowly through the full permissible slewing arc of the crane.

The installed test may be carried out as part of the stability test detailed in 5.2.5.

5.2.3.3 Static test approval criteria

The static test approval criteria given in ISO 4310 apply.

5.2.4 Dynamic tests

The test load shall be at least 1,1 times the rated capacity.

Dynamic tests shall be performed separately for each crane motion or, if stated in the specifications of the crane, simultaneous crane motions using positions and configurations that will impose the maximum loading or maximum stresses in the crane components. Testing shall be carried out at speeds appropriate for normal crane operation and shall include repeated starting and stopping of each motion throughout the range of the motion.

5.2.4.1 Dynamic tests approval criteria

The dynamic test approval criteria given in ISO 4310 apply.

The temperature of the hydraulic oil shall be within the limits recommended for the oil specification.

5.2.5 Stability test

5.2.5.1 General

The stability for a chassis carrying a loader crane, deduced by calculation, shall be used for guidance only. Verification of stability shall be made by test loading.

The purpose of the test is to verify the stability of the loader crane mounted on the unloaded chassis without the driver. During the test, one or more stabilizer legs or a wheel, on the unloaded side of the chassis, may lift from the ground. However, at least one of the hand-braked wheels shall remain in contact with the ground.

5.2.5.2 Test loads

5.2.5.2.1 Loader crane/chassis combinations with fixed load moment

Stability test loads shall be determined using Formula (7):

$$\mathrm{TL} = K_S \cdot P + (K_S - 1) \cdot G'b \quad (7)$$

where

K_S is the stability factor, K_S = 1,2;

TL is the test load;

P is the rated capacity;

$G'b$ is the point mass at boom tip, giving the same dead load moment around the slewing centre as that provided by the boom system.

For timber and recycling cranes, K_S may be assigned the value of the actual tolerance of the rated capacity limiter $K_S = 1 + \Delta\,\%/100$ according to 4.6.3.2. However, K_S shall at least have a value of 1,1.

For cranes other than timber and recycling cranes, TL shall be at least 1,25P.

The value of TL shall be verified by the manufacturer.

NOTE The application of the test load, TL, constitutes load combination C3, see 4.2.4.2.

Alternatively, the test load may be divided into two parts, one at the boom tip and one closer to the column.

The two parts of the test load shall produce the same tipping moment, with respect to the tipping line under consideration, as test load TL given above. The part of the test load at the boom tip shall be at least 1,25P.

The maximum test load at the boom tip shall be as recommended by the crane manufacturer.

5.2.5.2.2 Loader crane/chassis combinations with variable load moment

Stability test loads for the areas of lower stability shall be determined in accordance with Formula (8):

$$\mathrm{TL} = K_S \cdot P_S \frac{(R-S)}{R} + (K_S - 1) \cdot G'b \tag{8}$$

where

K_S is the stability factor used in the stability calculation (typically, K_S = 1,8);

TL is the test load;

P_S is the reduced rated capacity predicted by the stability calculation at maximum radius in the least-favourable boom configuration;

R is the maximum radius in the least-favourable boom configuration;

S is the shortest distance from the slewing centre to the tipping line;

$G'b$ is the point mass at boom tip, giving the same dead load moment around the slewing centre as that provided by the boom system.

TL shall be at least 1,25P_S.

5.2.5.3 Test conditions

Stability shall be tested in accordance with the least-favourable boom configuration, including the maximum manual boom extension within the whole slewing range. If the rated capacity is lower in part of the slewing range, the test load in those parts shall be determined according to 5.2.5.2.2. The stability test shall be performed under static conditions (v_h = 0). Limiting and indicating devices may be temporarily disconnected during the test.

Stability shall be tested with the crane placed on a firm surface under the least-favourable conditions, with the respect of the tipping line, in accordance with the manufacturer's specification. The crane inclination shall be within the maximum inclination in accordance with the manufacturer's specification.

The appropriate test method depends on whether the crane has a fixed load moment or not.

On the one hand, the stability calculations of a chassis/loader crane combination with a fixed load moment shall be verified by deploying the stabilizers correctly, attaching the test load, and slewing the crane throughout its full slewing arc.

On the other hand, some chassis/loader crane combinations will incorporate a load moment setting that varies with the slew angle (e.g. loader crane over the rear of the chassis, or over the cab), with the amount of stabilizer extension (e.g. stabilizers fully extended, or fully retracted), or both. The stability calculations for these types of installation shall be verified by the requisite overloads (5.2.5.2.2) being applied at the positions with maximum and minimum load moment settings, as identified by the calculations. It will not be necessary to verify (by overload testing) the stability calculations for all the intermediate positions (between a maximum and minimum load moment setting). It will suffice to attach a load equal to the maximum working load at maximum radius, and slew this load through the full slewing arc, reducing the radius of the load as demanded by the loader crane, to confirm that the available load moment at every position conforms to the predictions of the stability calculations.

For stability verification, the required overturning moment with respect to the actual tipping line may be obtained at a reduced outreach.

NOTE Stability calculations may be necessary to establish the least-favourable position.

5.2.5.4 Stability test approval criteria

The test shall be considered to be successful if the test load is held static. During the test loading, one or more stabilizer legs or wheels may lift from the ground. However, at least one wheel braked by the parking brake shall remain in contact with the ground.

6 Information for use

6.1 General

All information for use shall be in accordance with ISO 12100.

6.2 Manuals

6.2.1 Provision of manuals

Manuals (instructions) shall be provided by the crane manufacturer with each crane . The manuals shall be in accordance with the relevant International Standards as specified in this clause.

6.2.2 Instructions for the installer

6.2.2.1 Mounting instructions shall include the following:

a) a description of the chassis on which the crane may be mounted;

b) requirements on bolts and fastenings for mounting the loader crane onto a chassis or a static foundation;

c) masses, centres of gravity and all information required for calculation of axle loadings and stability;

d) the values of TL, $G'b$ and, if applicable, Δ for the stability test in accordance with 5.2.5.2;

e) hydraulic system specifications which shall include

1) pressure and flow requirements,

2) system oil capacity,

3) system oil specification,

4) minimum reservoir capacity recommendations, and

5) recommended filtration;

f) electrical system requirements;

g) requirements for access and egress to control stations, see Annex K;

h) an instruction to carry out the tests in accordance with Clause 6.

6.2.2.2 Equipment added to the loader crane during installations shall have appropriate instructions added to the crane manuals.

6.2.3 Operator's manual

6.2.3.1 The operator's manual shall give technical data and information about the following:

a) a description of the control system, including diagrams and descriptions of the symbols used with the control levers;

b) a description of the limiting and indicating devices;

c) a drawing showing all the warning signs and the positions at which they are affixed to the crane;

d) a warning about working in the proximity of electric overhead power lines;

e) the service conditions for intended use and service conditions for which the crane shall not be used.

6.2.3.2 Information about the rated capacity for all boom configurations and positions and stabilizer positions shall be included.

6.2.3.3 The operator's manual shall include information about maximum inclination under which the crane may be used.

6.2.3.4 The operator's manual shall include all pre-start and post-operational checks necessary before setting up for work, operating and stowing the machine after use. Post-operational checks shall include heights and widths for the chassis in travelling mode. The manual shall also emphasize that it is essential for the operator to ensure that the locking devices are fully engaged before driving off.

6.2.3.5 The operator's manual shall include instructions regarding the need to ascertain that ground or support conditions are adequate for the maximum loadings imposed by the loader crane. The manual shall state the maximum load that the stabilizer can impose on the ground and the need for the operator to ensure that the ground can support the load.

6.2.3.6 The operator's manual shall include the following notice:

"Precautions shall be taken when disconnecting hydraulic tubing and hoses to ensure that no hydraulic pressure is retained in the line when the power supply to the system is switched off."

6.2.3.7 The operator's manual shall include safety requirements for use when planning a lifting operation. These shall include, as a minimum, the following:

a) evaluation of the load and its characteristics;

b) selection of lifting gear, correct use of hook and slings;

c) instructions explaining the correct setting of the boom system mode selector switch;

d) the position of the loader crane, the load and clearances before during and after the lifting operation;

e) the site conditions, including the space and clearances for the operation;

f) the existing environmental conditions and considerations of when the operation may have to be stopped if conditions become unfavourable.

6.2.3.8 Information on the temperature range for operation of the loader crane shall be included.

6.2.3.9 The operator's manual and the technical documentation shall give information on noise emitted by the loader crane installation as follows:

— the A-weighted emission sound pressure level at control stations, where this exceeds 70 dB. Where this level does not exceed 70 dB, this fact shall be indicated;

— the peak C-weighted instantaneous sound pressure value at control stations, where this exceeds 63 Pa (130 dB in relation to 20 µPa);

— the A-weighted emission sound pressure level at defined points around the loader crane installation, where the A-weighted emission sound pressure level at control stations exceeds 80 dB.

The A-weighted emission sound pressure level shall be determined in accordance with ISO 3744 and ISO 11201.

NOTE Details of defined measuring points and information to be provided are included at Annex N

These values shall be either those actually measured for the loader crane in question or those established on the basis of measurements taken for technically comparable crane installations.

The noise emission values shall be declared together with the production variation and measurement uncertainty using the dual-number declaration in accordance with ISO 4871.

6.2.4 Maintenance manual

6.2.4.1 General

The maintenance manual shall contain information and instructions to ensure that the crane can be maintained safely and foreseen hazards which may occur shall be noted. Information and drawings for the identification of parts which may need replacement during maintenance shall be shown.

The maintenance manual shall include information for the in-service inspections and tests that are required by a competent person to ensure that the crane is safe to use. The instructions shall describe the necessary periodic checks and tests procedures for the crane and the limiting and indicating devices. Specific time period and/or monitoring procedures may be listed.

The maintenance manual shall include information on lubrication of the crane. The information shall describe location of lubrication points, lubricants and lubrication intervals.

The maintenance manual shall contain instructions on how to examine and test a crane after alterations or repairs and before putting it back into use.

The maximum allowable in-service sink rate for the boom system shall be specified.

Advice shall be provided on how to disconnect tubing and lines if pressure could be retained in the hydraulic lines when the power supply has been switched off.

The maintenance manual shall include information on materials and parts requiring specialized repairing techniques (e.g. welding at low temperature).

6.3 Marking

6.3.1 General

All plates affixed permanently to the crane shall be manufactured from weatherproof material.

6.3.2 Manufacturer's plate

A manufacturer's plate shall be fixed permanently on the loader crane, containing the following information:

a) manufacturer and, where applicable, his authorized representative;

b) year of manufacture;

c) serial number;

d) type, if there is a type designation.

6.3.3 Installer's plate

An installer's plate shall be fixed to the crane or the supporting item containing the following information:

a) installer's name and address;

b) year of installation;

c) crane serial number, chassis number or registration mark (if applicable).

6.3.4 Load signs

6.3.4.1 General

The following information shall as a minimum be provided.

a) A rated capacity load plate (see example, Figure 4), with the capacity stated at various load attachment positions along a horizontal line drawn from the inner-most fulcrum of the boom system, shall be attached to the crane such that it is clearly visible from all fixed control stations. It shall also be shown in the operator's manual.

   The load indicated for the innermost position shall be the maximum working load. All rated capacities shall be given at specified outreaches. In cases where the rated capacity is dependent upon a particular hook and/or hook attachment point, this shall be indicated on the load plate and the hook attachments points with limited capacity marked with "Max XXX kg". The maximum working load shall be given with all extensions retracted. The picture of the boom system is to be shown at maximum or nearly maximum radius.

   All conditions relating to the unreduced rated capacity given in the load plate (e.g. stabilizer positions, slew range) shall be stated on the crane.

b) A rated capacity load chart for all slewing ranges, boom and stabilizer configurations, including 3rd and 4th booms and hoist (Figures 5, 6 and 7) shall be included in the operators manual. It may also be attached to a suitable position on the crane in addition to the load plate in accordance with a).

Examples of load charts are shown in Figures 5, 6 and 7 For complex boom systems and multiple stabilizer configurations, more than one load chart may be necessary. These shall be included in the operator's manual.

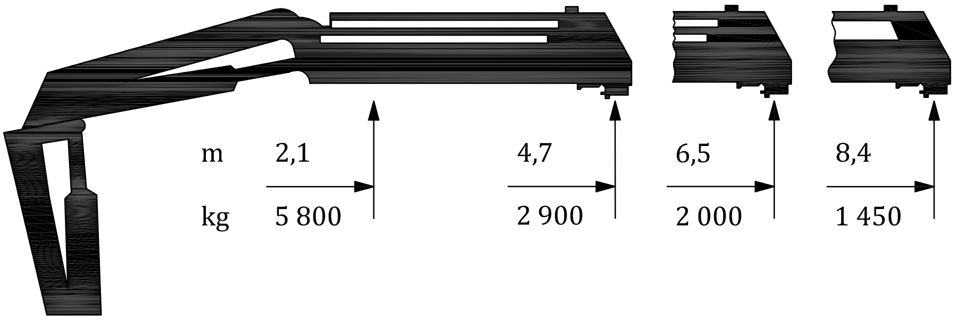


Figure 4 — Example of rated capacity load plate (capacity stated at various load attachment positions along horizontal line drawn from innermost fulcrum of boom)

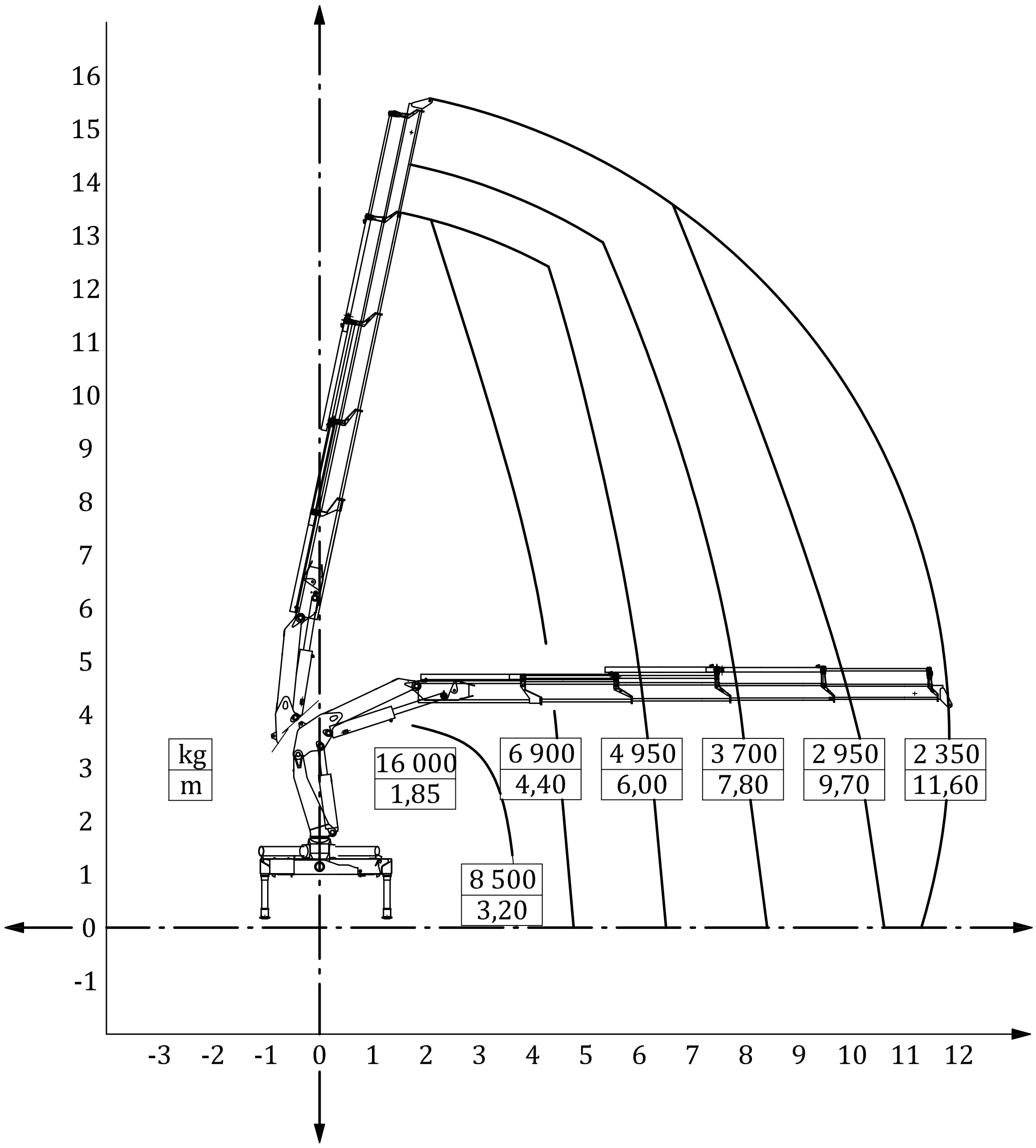


Figure 5 — Example of rated capacity load chart for all boom configurations

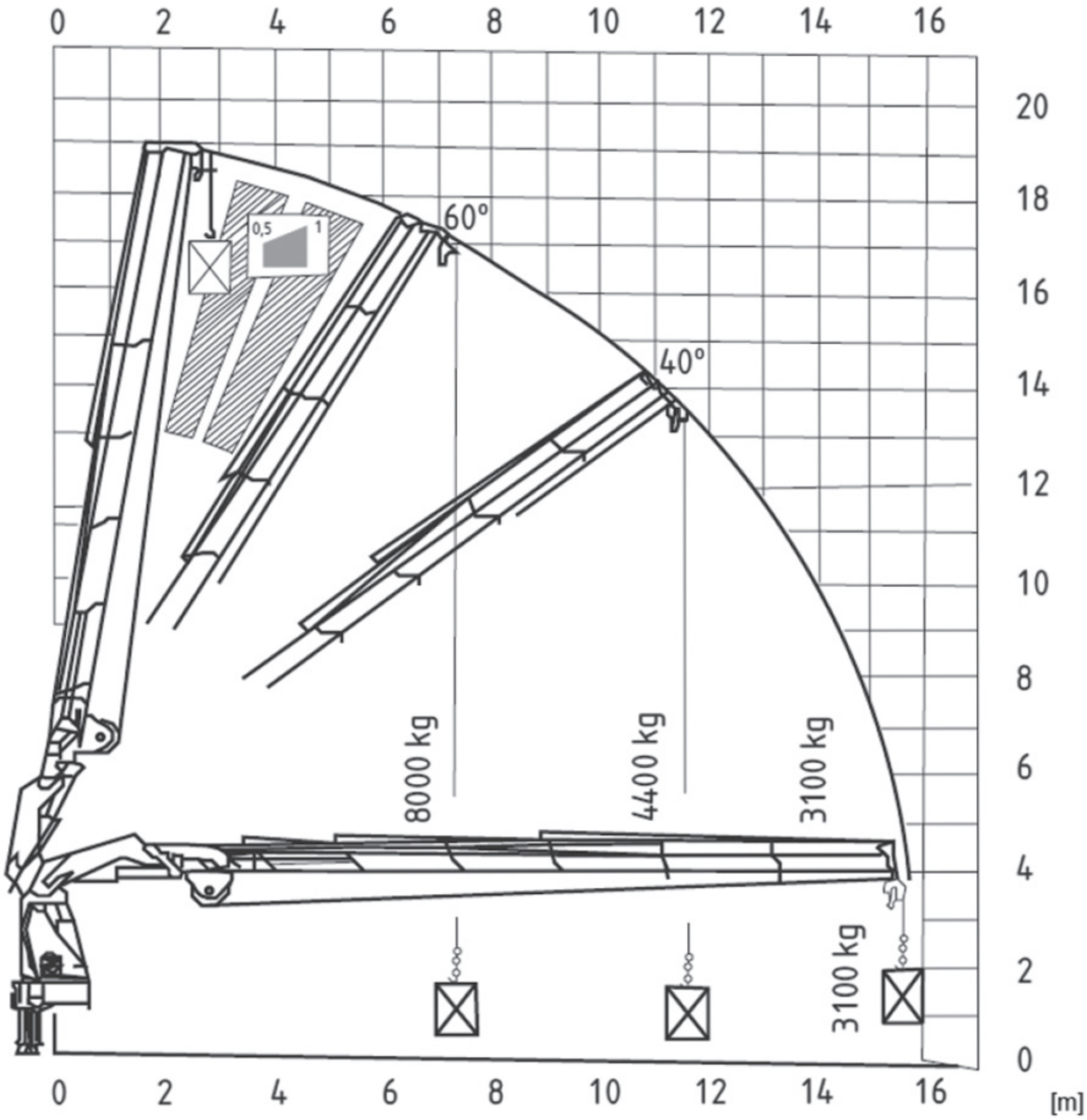


Figure 6 — Example of rated capacity load chart for crane with hoist (load reduced to 50 % above 60° elevation)

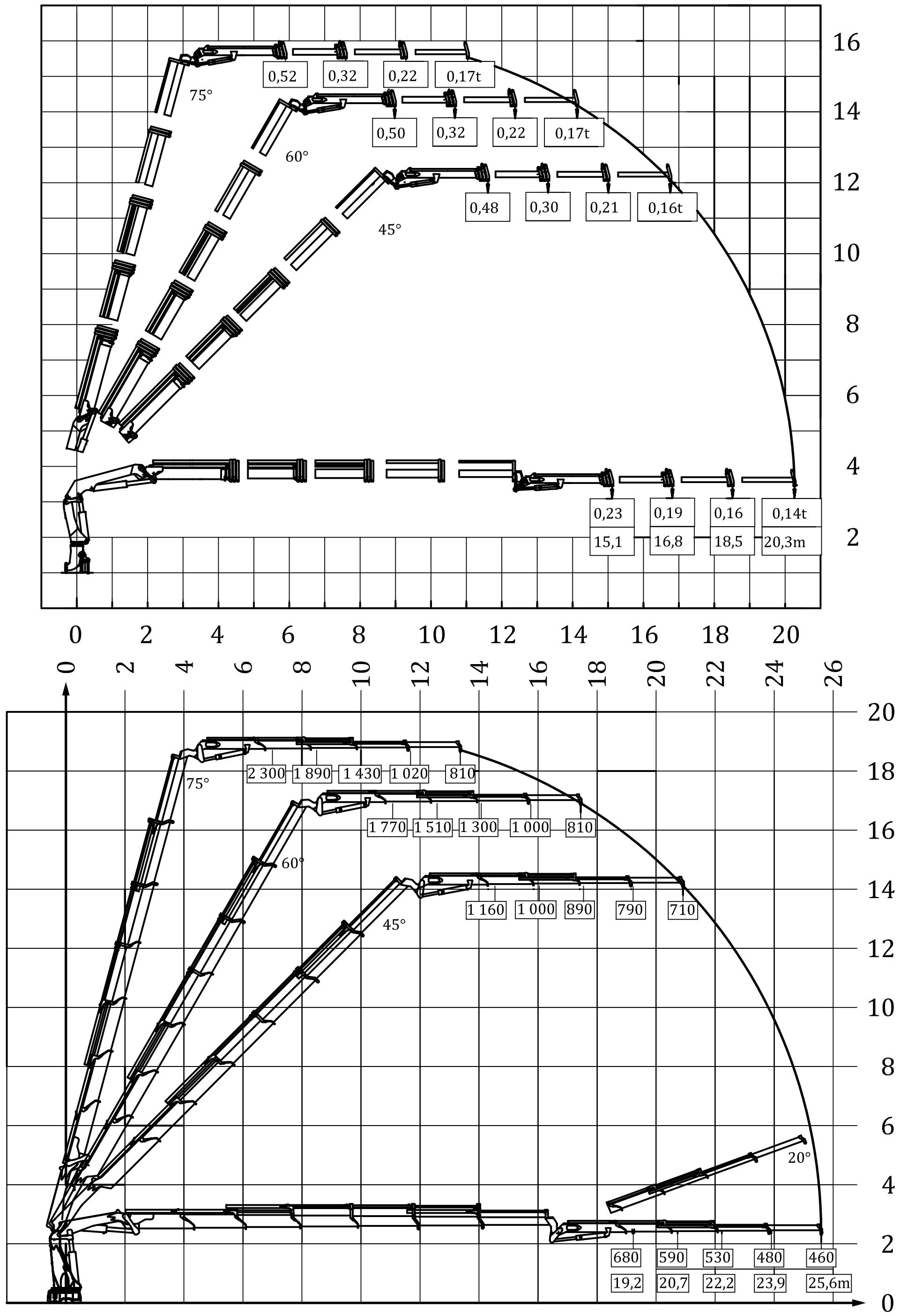


Figure 7 — Examples of rated capacity load charts for crane with third boom

6.3.4.2 Marking of manual boom extensions

Manual boom extensions shall be marked: “Max XXX kg”.

6.3.5 Special signs on timber and recycling cranes

Timber cranes and recycling cranes shall be provided with a special sign at the control station and on the boom system (Figure 8) and a symbol on the second boom indicating that the crane is not intended for hook duty (Figure 9).

Figure 8 — Safety sign

Figure 9 — Safety symbol

As for all signs of interdiction, the circle and diagonal bar shall be coloured red as defined in ISO 3864-1.

6.3.6 Marking of slewing centre

The longitudinal position of the slewing centre shall be clearly marked on both sides of the base.

Annex A
(informative)

List of significant hazards

Table A.1 shows a list of significant hazardous situations and hazardous events that could result in risks to persons during use. It also contains corresponding cross-references to the relevant clauses in this International Standard that are necessary to reduce or eliminate the risks associated with those hazards.

Table A.1 — List of significant hazards and associated requirements

No.	Hazard	Relevant subclause(s) in this International Standard
1	**Mechanical hazards due to** — inadequacy of mechanical strength of the crane and its parts	4.1, 4.2, 4.3, 4.5.1, 4.5.4, 4.5.5, 4.5.8, 4.5.9, 4.8.2.1, 4.8.2.2, 4.10.2.1, 4.10.2.2, 6.2.3
1.1	Crushing hazard	4.8.1, 4.8.2.2, 4.8.2.3, 4.10.2.3
1.2	Shearing hazard	
1.3	Cutting or severing hazard	
1.4	Entanglement hazard	
1.5	Drawing-in or trapping hazard	
1.6	Impact hazard	
1.7	Stabbing or puncture hazard	
1.8	Friction or abrasion hazard	
1.9	High pressure fluid injection or ejection hazard	4.5.1, 4.5.5, 4.10.7, 6.2.3, 6.2.4
1.10	Ejection of parts	4.4.1.1, 4.4.1.2, 4.4.2, 4.4.3
1.11	Loss of stability	4.6.1, 4.6.2, 4.6.3, 4.6.5, 4.6.6.2, 4.10.3
1.12	Slip, trip, fall	4.8.2.2, 4.8.2.3, 4.8.2.4, 4.10.8
2	**Electrical hazards due to**	4.9, 4.10.6, 6.2.3
2.1	contact of persons with live parts (direct contact)	
2.2	contact of persons with parts which have become live under faulty conditions (indirect contact)	
2.3	approach to live parts under high voltage	
2.4	electrostatic phenomena	
2.5	thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short circuits, overloads, etc.	
3	**Thermal hazards, resulting in**	4.5.5, 4.10.2.3, 6.2.4
3.1	burns, scalds and other injuries by a possible contact of persons with objects or materials with an extreme high or low temperature, by flames or explosions and also by the radiation of heat sources.	
3.2	damage to health by hot or cold working environment	
4	**Hazards generated by noise**	4.10.4, 6.2.3.9
5	**Hazards generated by vibration**	4.10.5

Table A.1 *(continued)*

No.	Hazard	Relevant subclause(s) in this International Standard
6	**Hazards generated by materials and substances (and their constituent elements) processed or used by the machinery**	4.10.2.3, 6.2.4
6.1	Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes and dusts	
7	**Hazards generated by neglecting ergonomic principles in machinery design, as e.g. hazards from**	
7.1	unhealthy postures or excessive effort	4.4.1.2, 4.4.2, 4.4.3, 4.7, 4.8, 4.10.8
7.2	inadequate consideration of hand-arm or foot-leg anatomy	4.7, 4.8
7.3	neglected use of personal protection equipment	6.2.4
7.4	inadequate local lighting	4.8.1, 6.2.4, 6.2.3
7.5	human error, human behaviour	4.6, 4.7.1, 4.7.2, 6.2.3, 6.2.4
7.6	inadequate design, location or identification of manual controls	4.4.1.2, 4.4.3, 4.7, 4.8
7.7	inadequate design or location of visual display units	4.6.2
8	**Combination of hazards**	4.2
9	**Unexpected start-up, unexpected overrun/overspeed (or any similar malfunction) from**	
9.1	failure/disorder of the control system	4.5.6.1, 4.5.6.2, 4.5.7, 4.6.6, 4.6.8, 4.6.9, 4.6.10, 4.7.1
10	**Hazards caused by missing and/or incorrectly positioned safety related measures/means**	
10.1	Guards	4.5.5, 4.7.1, 4.8.2.2, 4.8.2.3, 4.10.2.3
10.2	Safety-related (protection) devices	4.4.1, 4.4.3, 4.6.3, 4.6.6, 4.6.7, 4.6.9, 4.6.10
10.3	Safety signs, signals, symbols	4.4.1.2, 4.6.7, 4.7.2, 6.2.3, 6.3.4, 6.3.5
10.4	Information or warning devices	4.6.1, 4.6.2, 4.6.3, 4.6.7, 6.1, 6.2, 6.3
10.5	Visibility	4.4.3, 4.8.1, 6.3.4.1
10.6	Emergency devices	4.6.3, 4.6.8
11	**Assembly errors**	6.2.2, 6.2.4
12	**Loss of stability/overturning of machine**	4.4.1, 4.6.1, 4.6.2, 4.6.3, 4.6.5, 4.6.6, 4.6.9, 4.6.10, 4.10.3
Additional hazards, hazardous situations and hazardous events due to lifting		
13	**Mechanical hazards and hazardous events**	
13.1	from load falls, collisions, machine tipping caused by:	
13.1.1	lack of stability	4.10.3, 5.2.5
13.1.2	uncontrolled loading – overloading – overturning moments exceeded	4.5.4, 4.6.1, 4.6.2, 4.6.3, 4.6.4, 4.6.5
13.1.3	uncontrolled amplitude of movements	4.6.6, 4.6.9, 4.6.10
13.1.4	unexpected/unintended movement of loads	4.5.6, 4.5.7, 4.5.8
13.1.5	inadequate holding devices/accessories	4.4.2, 6.2.3
13.1.6	from access of persons to load support	6.2.3

Table A.1 *(continued)*

No.	Hazard	Relevant subclause(s) in this International Standard
13.1.7	from insufficient mechanical strength of parts	4.1, 4.2, 4.3, 4.5.8, 4.5.9, 4.10.2
13.1.8	from abnormal conditions of assembly/testing/use/maintenance	4.10, 6.1, 6.2. 6.3
29	**Hazards generated by neglecting ergonomic principles**	
29.1	insufficient visibility from the operating position	4.8.1

Annex B
(informative)

Examples of configurations and mountings

B.1 Boom systems

B.1.1 Loader cranes with straight boom systems

Figures B.1 and B.2 show loader cranes with telescopic boom and fixed, straight boom systems.

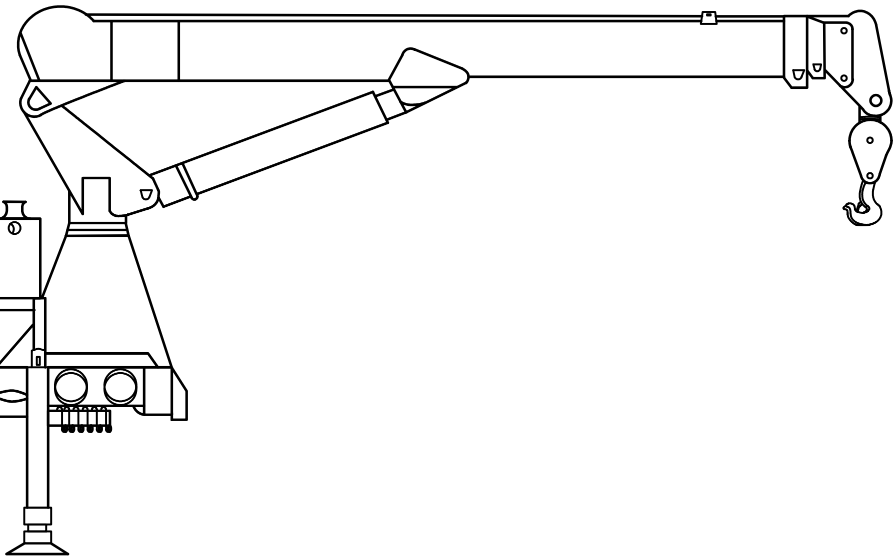


Figure B.1 — Telescopic boom system

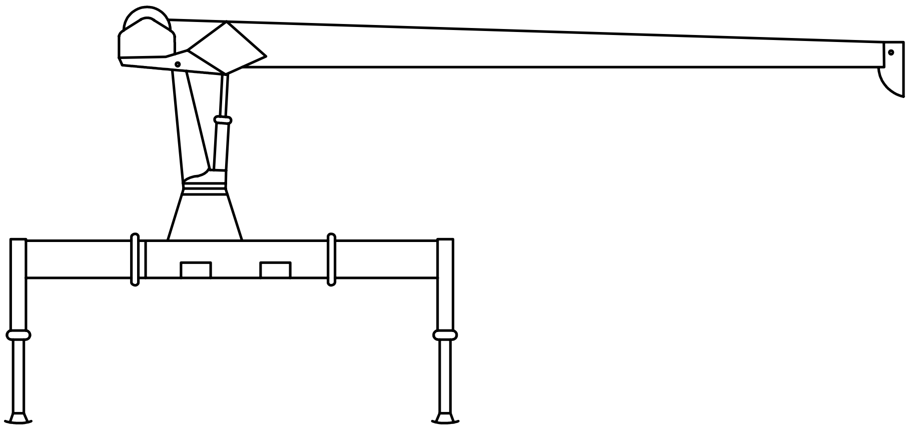


Figure B.2 — Fixed, straight boom system

B.1.2 Loader cranes with articulated boom systems

Figures B.3 and B.4 show loader cranes with articulated boom systems.

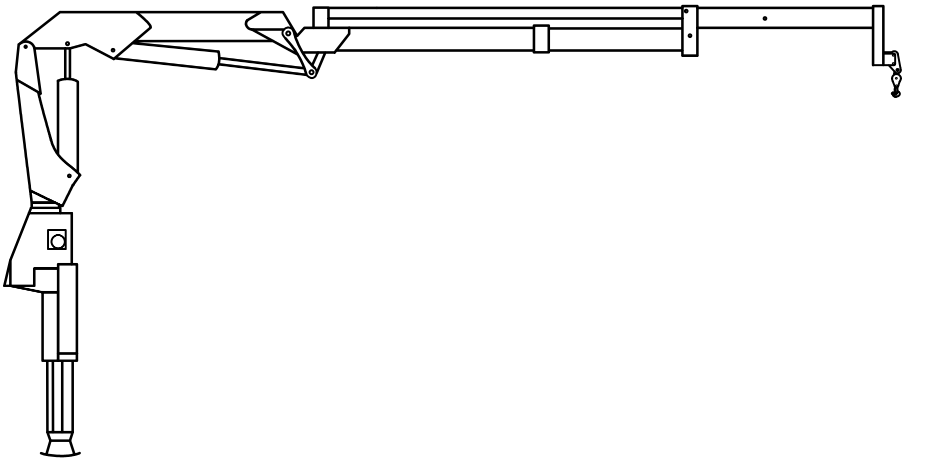


Figure B.3 — Articulated boom system, foldable across the chassis

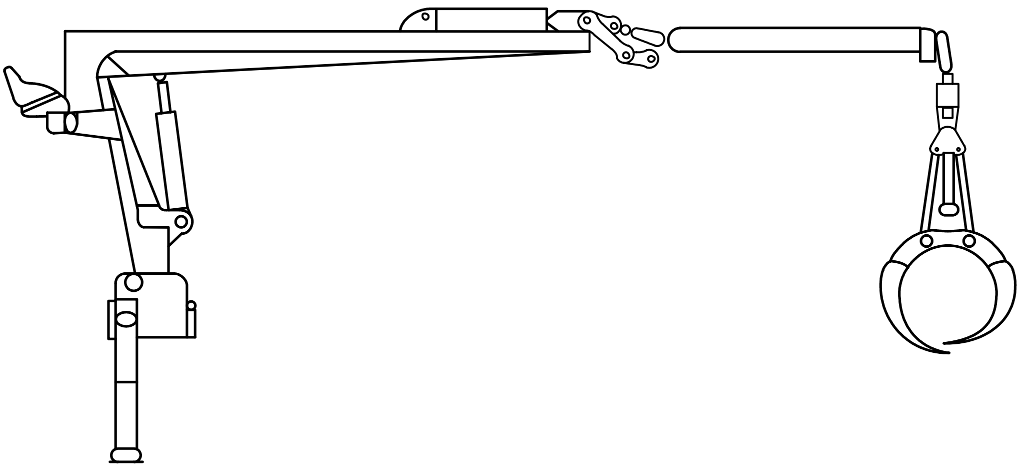


Figure B.4 — Articulated boom system with boom extension, foldable along the chassis

B.2 Mountings

Figures B.5 to B.11 show examples of loader crane mountings.

NOTE Loader cranes are usually mounted fixed to the chassis, but can be mounted on a detachable bracket. Cranes can also be mounted moveable on rails attached to the chassis.

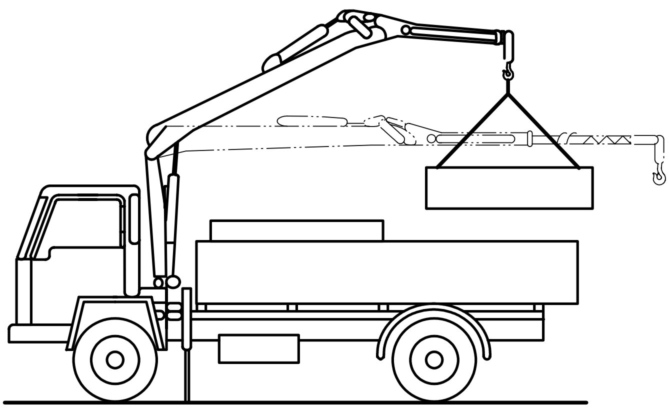


Figure B.5 — Loader crane mounted behind cab

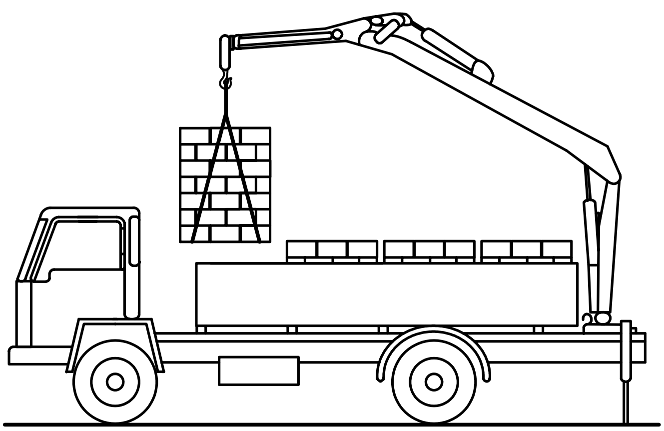


Figure B.6 — Rear-mounted loader crane

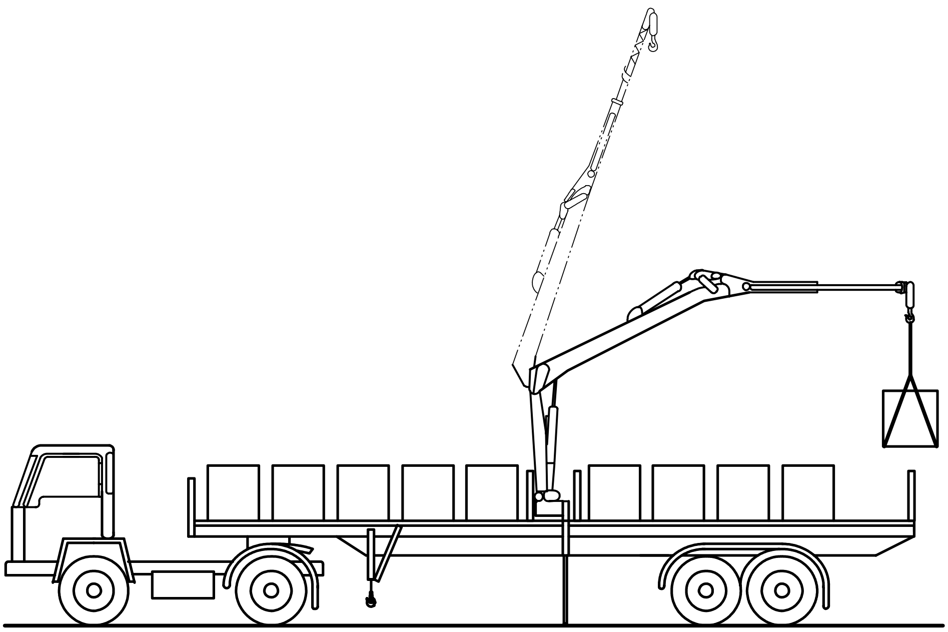


Figure B.7 — Middle-mounted loader crane

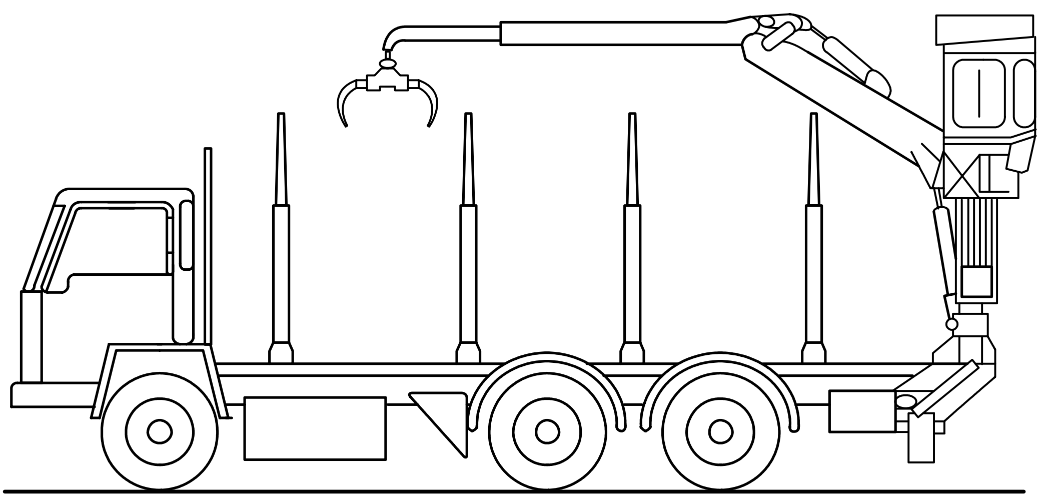


Figure B.8 — Rear-mounted timber crane with cabin

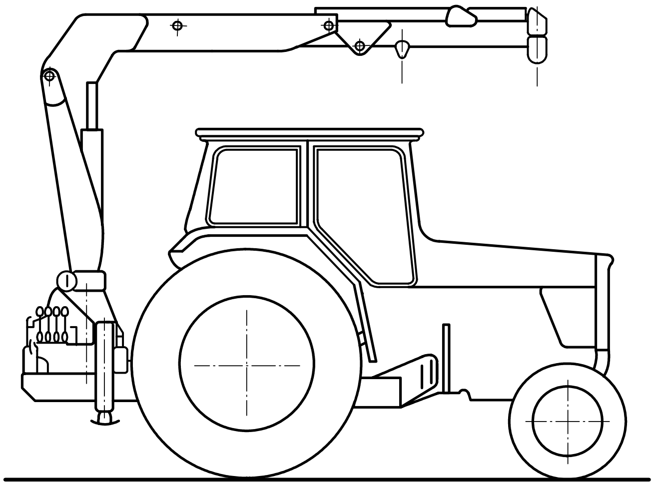


Figure B.9 — Tractor-mounted loader crane

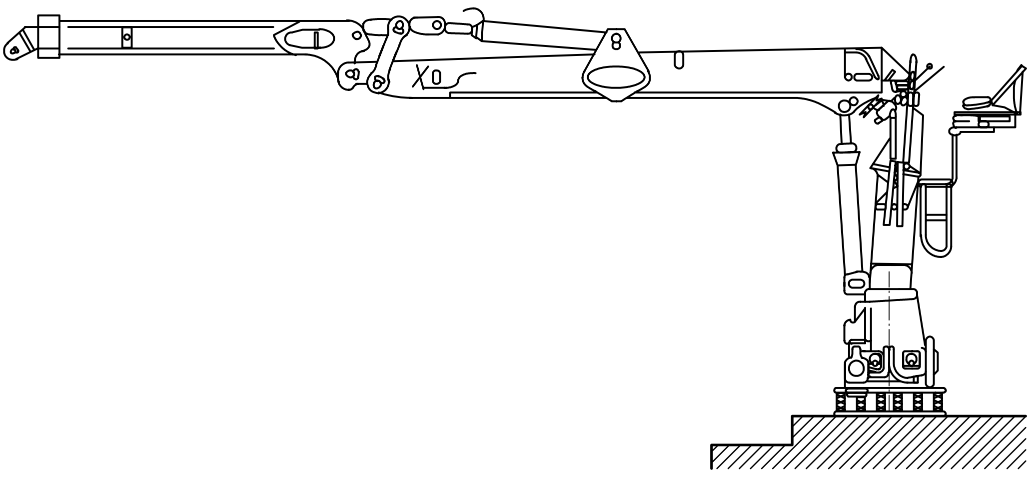


Figure B.10 — Static-mounted loader crane

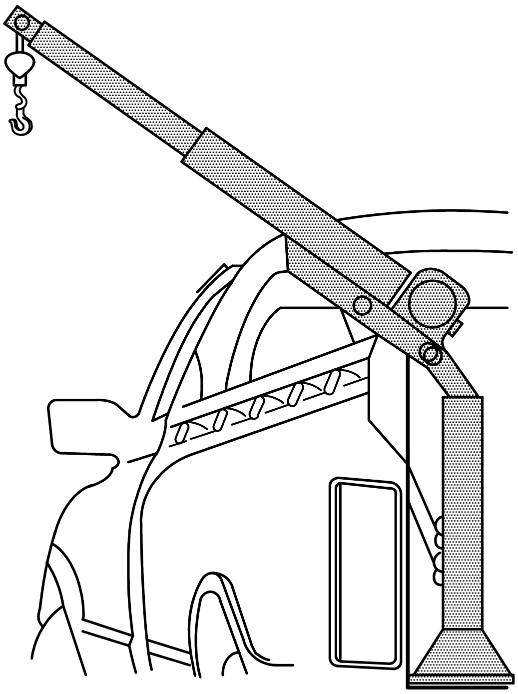


Figure B.11 — Pick-up mounted loader crane

Annex C
(informative)

Explanatory notes

C.1 Rated capacity limiters (see 4.6)

A loader crane is designed and manufactured for a specific force in all load-carrying cylinders. The rated capacity is for all crane positions calculated according to the specific forces.

The rated capacity limiter for a loader crane therefore should measure the force in the load-carrying cylinder limiting the rated capacity, rather than measure the load itself. It should be noted that depending on crane geometry and actual position of the boom system the pressure in the limiting load-carrying cylinder is not always the same. For this reason the rated capacity limiter should be designed to take into account all load-carrying cylinders which can limit the rated capacity.

The rated capacity limiter for a loader crane generally has three different tasks to fulfil:

a) prevent the structure from being overloaded;

b) prevent the risk of overturning of the chassis;

c) prevent dangerous movements of the load.

For all loader cranes except timber and recycling cranes all three tasks should be fulfilled, whereas for timber cranes/recycling cranes the prevention of overload and instability alone is considered acceptable.

The reason that dangerous movements due to opening of a port relief valve are accepted for a timber or recycling crane is that there should not be any people within the working area of the machine. The sudden stop induced by a rated capacity limiter combined with the high operating speed of a timber or recycling crane cause risks in excess of the uncontrolled movement due to the relief valve opening.

C.2 Timber and recycling cranes — Line rupture (see 4.5.6.2)

Automatic stopping of boom movement due to a hose failure, for a timber or recycling crane, due to high speeds, can cause higher risks than a controlled lowering of the load.

C.3 Control stations (see 4.8)

In order to ensure a good view of the load in all positions within the slewing range, loader cranes can normally be controlled from both sides of the chassis.

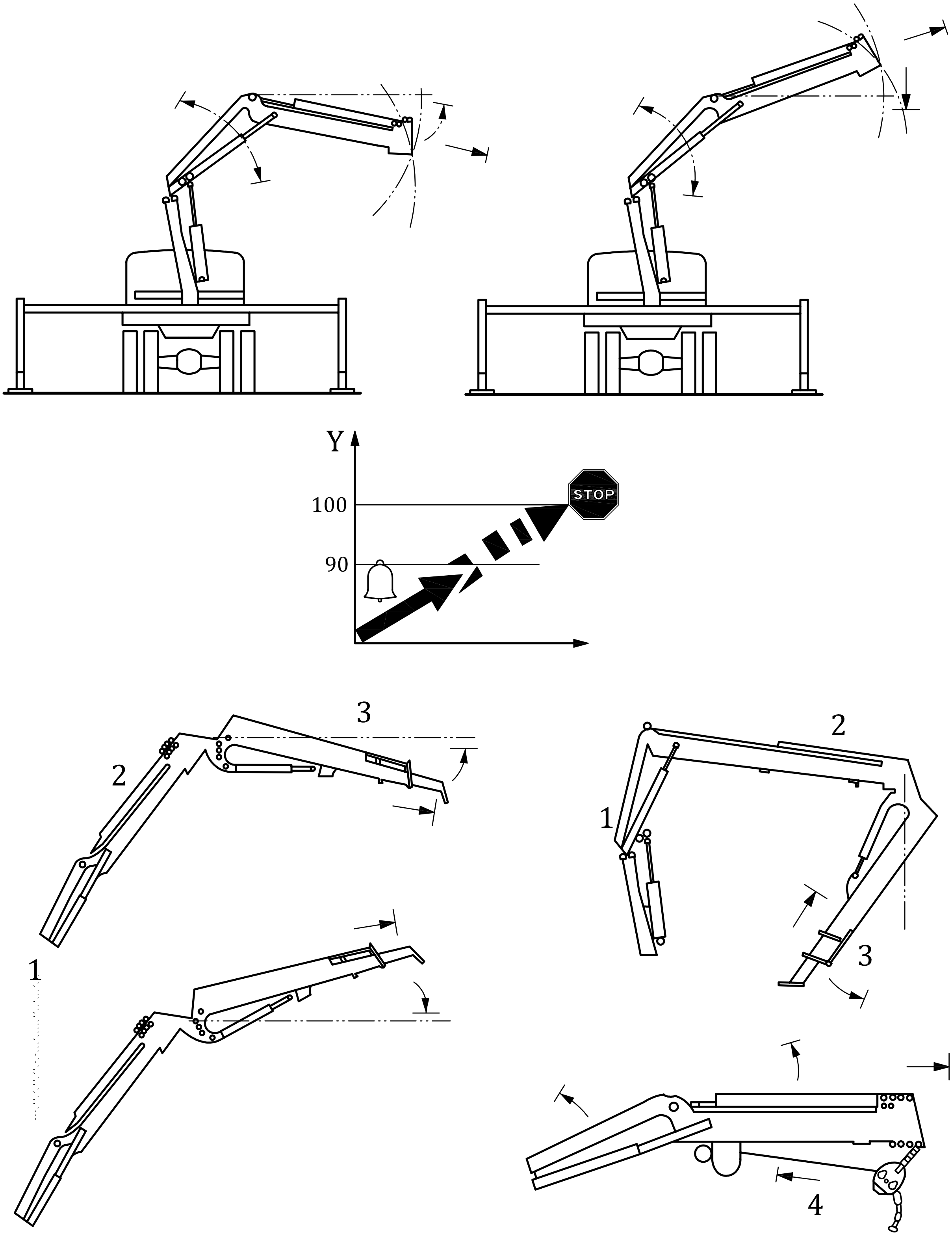
As the operator will have a good view of the controls on the other side of the crane, and as the controls are mechanically linked together it is not necessary to prevent the use of the levers on the opposite side by additional means.

It shall, however, be possible to actuate the stopping device (see 4.6.8) from both sides of the crane.

Annex D
(informative)

Examples of movements to be prevented in event of overload

Rated capacity limiters and indicators are required (see 4.6.2 and 4.6.3) on cranes having a rated capacity of 1 000 kg or more or a net load moment of 40 kN or more. The purpose of these devices is to warn the crane driver and prevent dangerous load movements in the event of excess rated capacity. Figure D.1 shows examples of the dangerous movements (indicated by arrows) to be prevented in the event of overload.



Key

Y	load, %
1	first boom
2	second boom
3	third boom
4	winch

Figure D.1 — Examples of movements (arrow-indicated) **to be prevented in event of overload**

Annex E
(normative)

Additional requirements for cableless controls and control systems

E.1 General

The transmitter shall not transmit while the means to prevent unauthorized use is activated.

Cableless controls shall be designed in accordance with IEC 60204-32:2008, 9.2.7, with the following additions/modifications.

E.2 Control limitation

E.2.1 Activation of the transmitter shall be indicated on the transmitter and shall not initiate any crane movement.

E.2.2 The receiver shall provide output operating commands to the control system only when it is receiving frames containing the right address and correct command.

E.2.3 The crane switch shall only be energized (i.e. controlled to the “on” state) by at least one correctly received frame, without any operating commands but containing a start command.

E.2.4 To avoid inadvertent movements after any situation having caused the crane to stop (e.g. power supply fault, battery replacement or lost signal condition), the system shall only output operating commands resulting in any crane movement after the crane operator has returned the controls to the “off” position for a suitable period of time, i.e. it has received at least one frame without any operating commands.

E.2.5 Whenever the crane switch is de-energized, all operating command outputs for crane movements from the receiver shall cease.

E.3 Stop

E.3.1 The part of the cableless control system used to perform the stop function is a *safety-related part of a control system*, as defined in ISO 13849-1, of the crane. This part of the cableless control system shall be designed to category 3 or higher for safety performance in accordance with ISO 13849-1.

E.3.2 The control system shall initiate a stop of all crane movements when no valid frame has been correctly received within 0,5 s. For those applications where 0,5 s is too short, this value may be extended up to a maximum of 2 s. The foreseen usage of the crane shall be tested to ensure that additional hazards do not result from this extension of the time value.

E.3.3 Unless the receiver monitors that the state of the control system corresponds with the state of the receiver outputs, the stop described in E.3.2 shall also de-energize the crane switch.

If the receiver monitors that the state of the control system corresponds to the state of the receiver outputs, the de-energizing of the crane switch may be delayed up to a maximum of 5 min.

E.3.4 If emergency stop functions of category 0 (IEC 60204-32:2008, 9.2.5.4.2) creates any additional risk, the stop function may be of stop category 1.

E.4 Serial data communication

E.4.1 The frame shall be sent repeatedly during operation.

E.4.2 The system shall provide a transmission reliability to a hamming distance of the total number of bits in a frame divided by 20 and at least 4, or other means which ensure an equal level of reliability such that the probability of an erroneous frame getting through is less than 10^{-8}.

E.5 Use of more than one operator control station

E.5.1 Transferral of control from one transmitter to another shall not be possible until the first transmitter has been de-activated by a deliberate action, specifically designed for this purpose.

E.5.2 Means shall be provided to enable several transmitter/receiver pairs to operate in the transmission range without unwanted interference with each other.

E.5.3 The means provided in E.5.2 shall be protected from accidental or unintentional change.

E.6 Battery-powered operator control stations

After the warning and the period required in IEC 60204-32:2008, 9.2.7.6 (when the transmitter battery voltage becomes so low that reliable transmission cannot be guaranteed), the transmitter shall go automatically to the locked-off condition (i.e. the receiver stops all crane motions and de-energizes the crane switch).

E.7 Receiver

The receiver shall withstand the broad-band random vibration test, test Fh, specified by IEC 60068-2-64.

E.8 Warnings

Where persons can be expected to be in the vicinity of the crane or a part of that crane and the risk exists of persons being trapped, run over etc., then warnings in addition to those in 5.6.7 shall be provided.

The crane shall be provided with

a) a marking on the access to the crane which states that the crane is provided with a cableless control system, and

b) either

   1) a continuous visual warning while a cableless control system is engaged, or

   2) an automatic acoustic and/or visual warning prior to movements of the crane.

E.9 Information for use

E.9.1 The instructions for the installer shall include information to ensure that when a cableless control system is in use, it shall not interfere with, or be interfered with, other systems in use at that location.

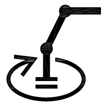
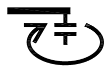
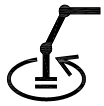
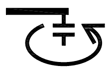
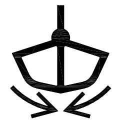
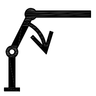
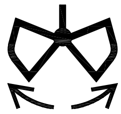
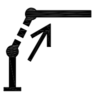
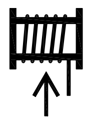
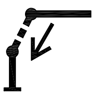
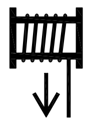
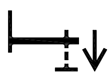
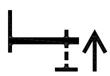
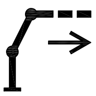
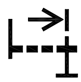
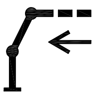
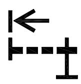
E.9.2 The actual delay for the stop function in E.3.2 shall be stated in the operator's manual.

Annex F
(normative)

Symbols for working and setting-up functions

The parts of the loader crane which move when carrying out a working function shall be indicated by blank circles, thick lines and/or an arrow, in the symbols given in Table F.1.

Table F.1 — Symbols to be used

Symbol	Explanation	Symbol	Explanation
	Column — Slew clockwise		Load-handling device — Slew clockwise
	Column — Slew anticlockwise		Load-handling device — Slew anticlockwise
	1st Boom — Raise		Grab — Close
	1st Boom — Lower		Grab — Open
	1st Boom — Extend		Hoist — Lift
	1st Boom — Retract		Hoist — Lower
	2nd Boom — Raise		Stabilizer leg — Vertical extending
	2nd Boom — Lower		Stabilizer leg — Vertical retracting
	Extension — Extend		Stabilizer extension — Horizontal extending
	Extension — Retract		Stabilizer extension — Horizontal retracting

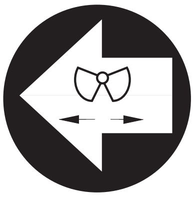
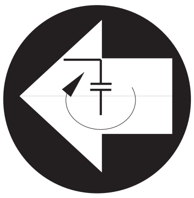
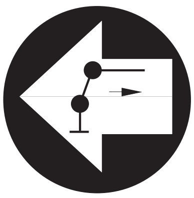
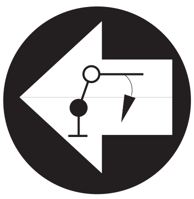
Annex G
(informative)

Control system — Preferred vertical layout for controls operated from the ground

Table G.1 shows the direction of control operations and corresponding movements.

Figure G.1 shows an example of a vertical layout.

Table G.1 — Direction of control operation and corresponding crane movement

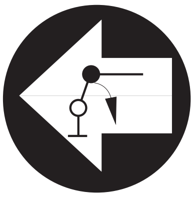
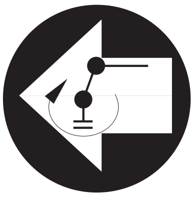
Control unit	To LEFT	Crane movement	To RIGHT
	Opening	Grab	Closing
	Slewing clockwise	Load-handling device	Slewing anticlockwise
	Extending	Boom extension	Retracting
	Lowering	2nd boom	Raising

If one or more functions are not provided, the existing controls are moved down accordingly.

The layout applies to both sides of the crane.

The figures in column 1 show symbols affixed to control lever knobs. The arrow symbols may also be used on a separate sign placed above the levers as shown in Annex H, Figure H.3.

Table G.1 *(continued)*

Control unit	To LEFT	Crane movement	To RIGHT
	Lowering	1st boom	Raising
	Slewing clockwise (slewing right)	Column	Slewing anticlockwise (slewing left)
If one or more functions are not provided, the existing controls are moved down accordingly. The layout applies to both sides of the crane. The figures in column 1 show symbols affixed to control lever knobs. The arrow symbols may also be used on a separate sign placed above the levers as shown in Annex H, Figure H.3.			

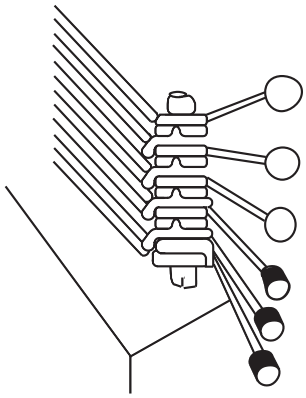


Figure G.1 — Example of vertical layout

Annex H
(informative)

Control systems — Horizontal layout order

This annex gives two alternatives for controls operated from the ground. Either layout A should be used for both sides of the crane and for remote control or layout A should be used for one side and layout B for the other.

The upward-pointing arrows in Figure H.1 can also mean *forward*, as clarified by Figure H.2. Depending on the shape of the control lever, knob movement can deviate from vertical (both levers are shown in the neutral position).

Figure H.1 shows symbols affixed to control lever knobs. The arrow symbols may also be used on a separate sign placed above the levers, as shown in Figure H.3.

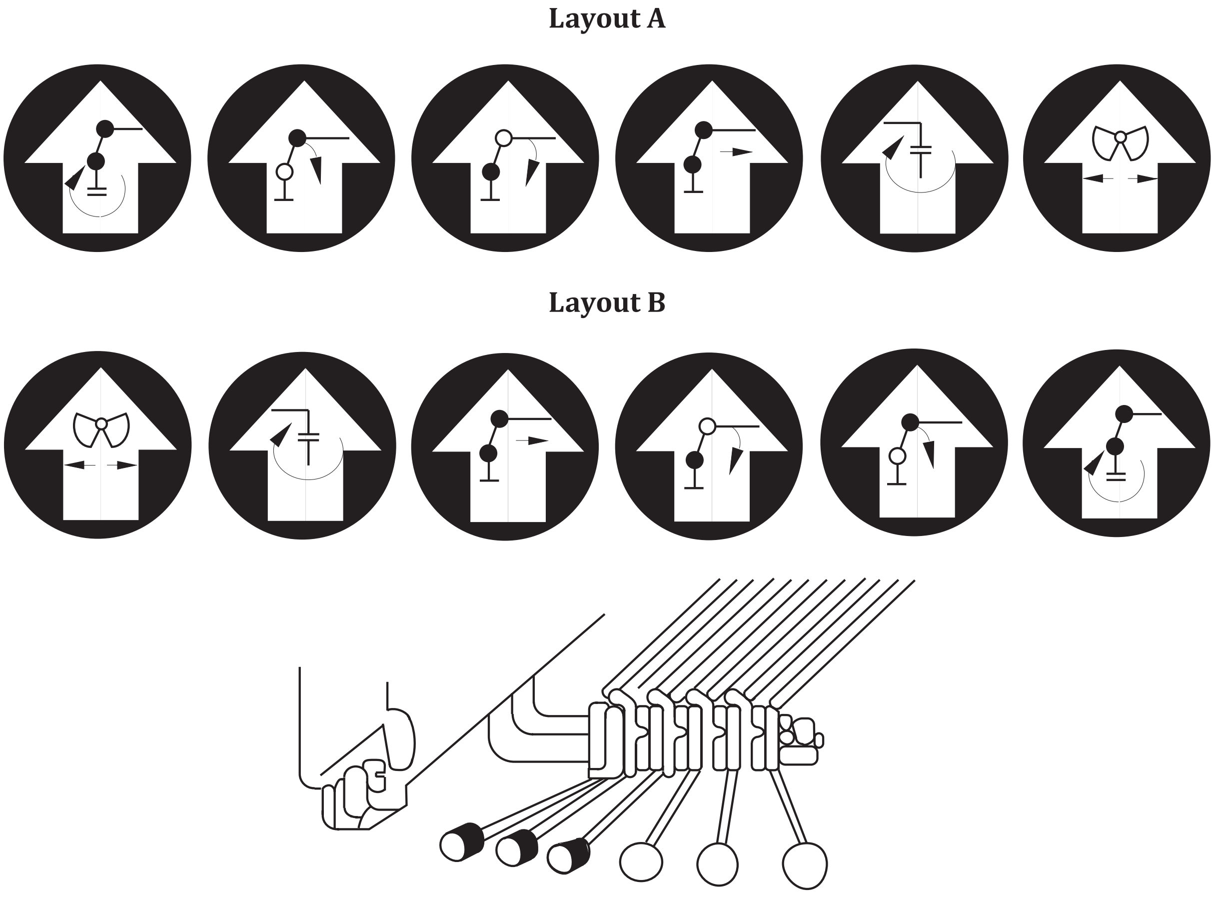


Figure H.1 — Control system with horizontal layout symbols affixed to control lever knobs

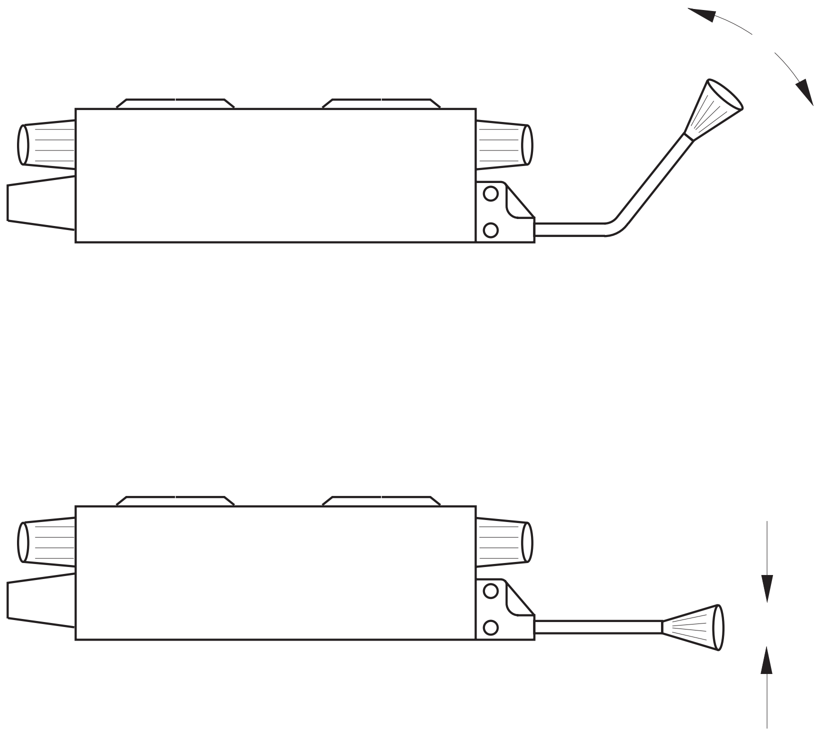
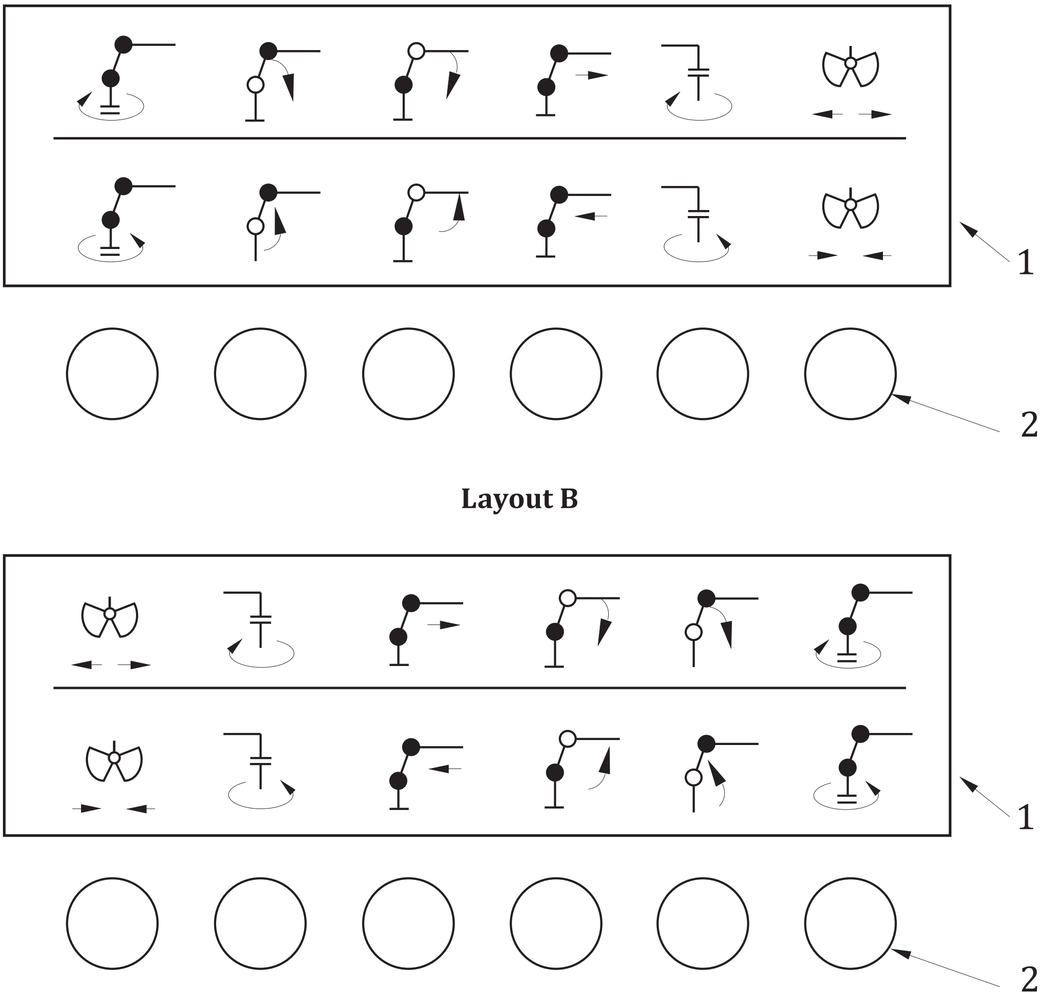


Figure H.2 — Examples of horizontal layout (in the upper drawing, knob movement deviates from vertical)

Layout A

Layout B



Key

1 sign

2 control lever knob

Figure H.3 — Control system with horizontal layout — Symbols on separate sign placed above levers

Annex I
(informative)

Control levers for high seats and remote controls

I.1 High-seat controls

I.1.1 Multidirectional (joy-stick) controls

Figure I.1 shows the arrangement of a two-lever control system.

Figure I.2 shows the arrangement of a control system consisting of two levers and two pedals.

I.1.2 Bi-directional controls

Bi-directional control levers should be arranged according to Figure H.1 Layout A or Figure H.3 Layout A.

I.2 Remote controls

Multidirectional control levers should be arranged according to Figure I.1. Bi-directional control levers should follow Figure H.1 Layout A .

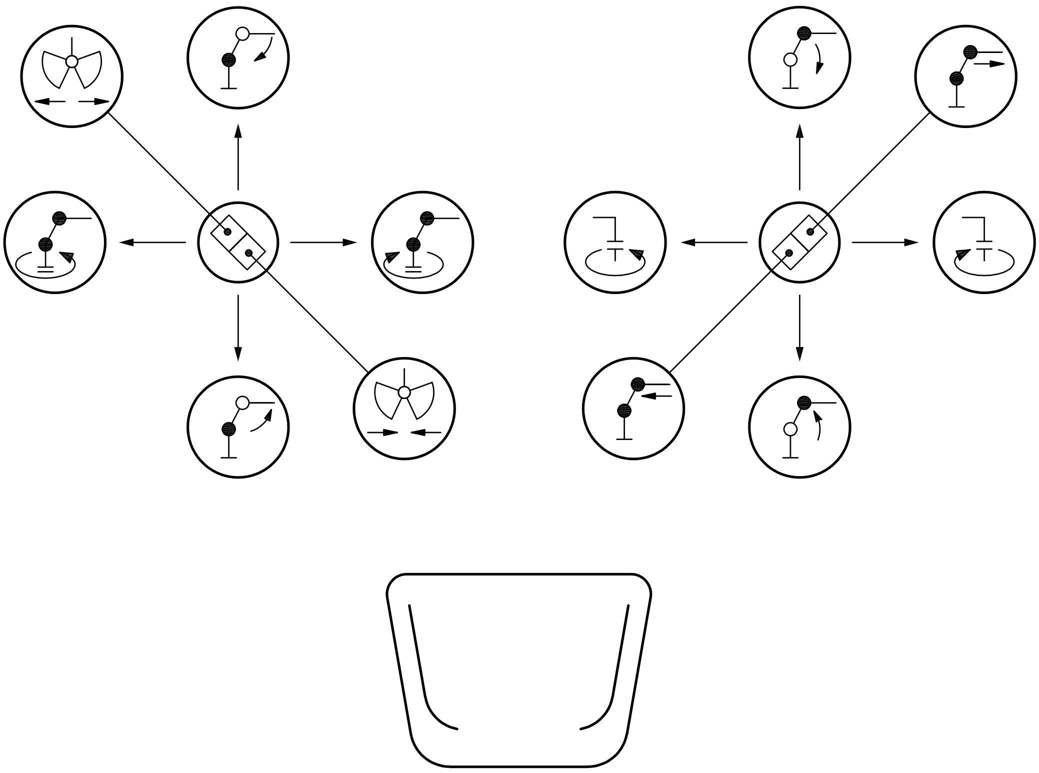


Figure I.1 — Multidirectional controls — Arrangement of two-lever control system

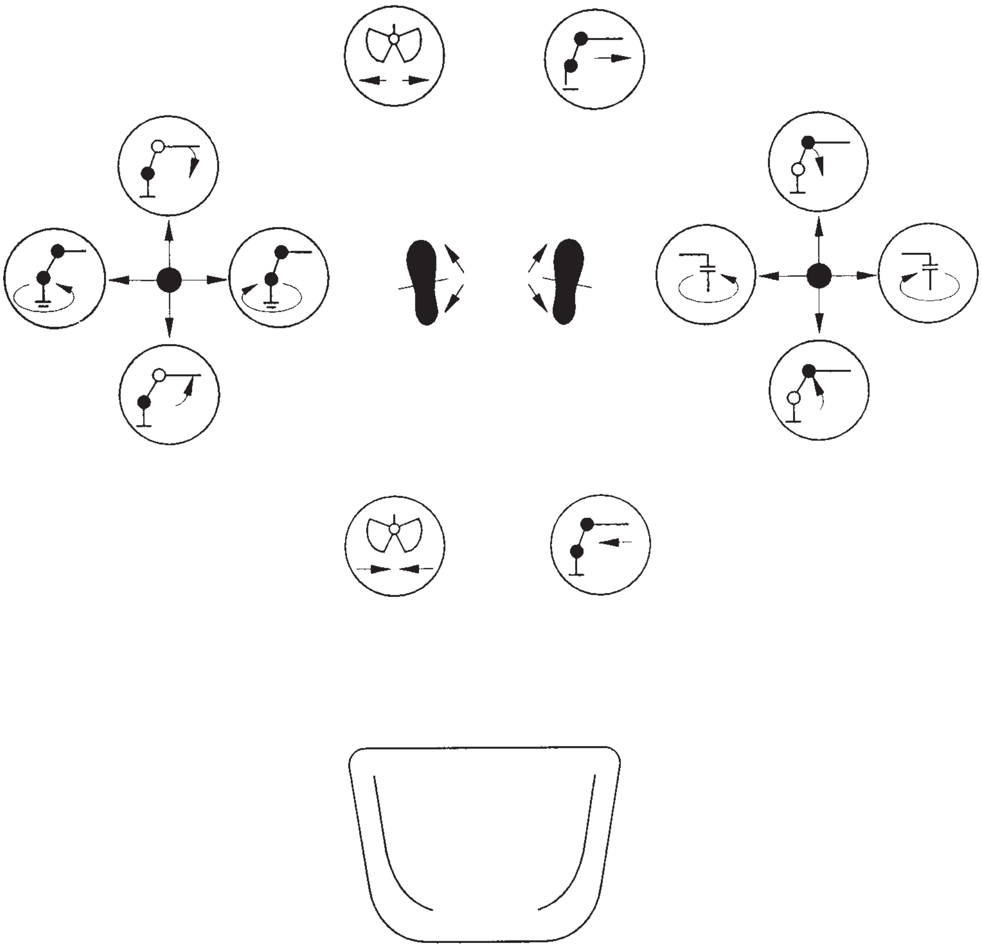


Figure I.2 — Multidirectional controls — Arrangement of control system consisting of two levers and two pedals

Annex J
(normative)

Cabins fitted on chassis-mounted loader cranes up to load moment of 250 kN · m

J.1 Min. dimensions

The following minimum dimensions apply to cabins fitted on chassis-mounted loader cranes up to a load moment of 250 kN · m.

NOTE For cabins on cranes above 250 kN·m, or on static mounted cranes, see ISO 8566-2.

a) The minimum internal dimensions for cabins with a seat shall be

1) height measured vertically from the seat index point (SIP) (see Figure J.1), 1 000 mm;

2) width measured horizontally through the seat index point, 700 mm, and

3) length measured horizontally forward from the seat index point (see Figure J.1), 700 mm.

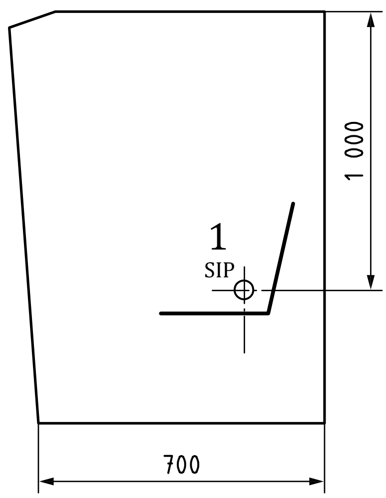
b) The minimum dimensions for effective door apertures for use in an upright posture shall be

1) width, 600 mm, and

2) height, 1 500 mm.

c) The minimum dimensions for emergency exit effective apertures shall be 0,55 m × 0,55 m or 0,5 m × 0,6 m or 0,6 m diameter.

Dimensions in millimetres



Key

1 seat index point (SIP) (see ISO 5353)

Figure J.1 — Minimum internal dimensions

The cabin front window shall

a) be able to withstand without failure the application of 1,25 kN applied at 90° to any 500 mm^2 area of the window and its mounting, or

b) be provided with protection up to a minimum height of 1 m from the cabin floor level:

   1) where the protection is by means of horizontal bars, these bars shall have spaces between them not exceeding 0,4 m, and the height between the cabin and the lowest bar shall not exceed 0,25 m;

   2) where the protection is by means of vertical bars, these bars shall have spaces between them not exceeding 0,3 m;

   3) where the protection is by means of a shock-resistant polycarbonate material of the window, the plate thickness shall be at least 6 mm.

Other cabin windows shall be shatter proof.

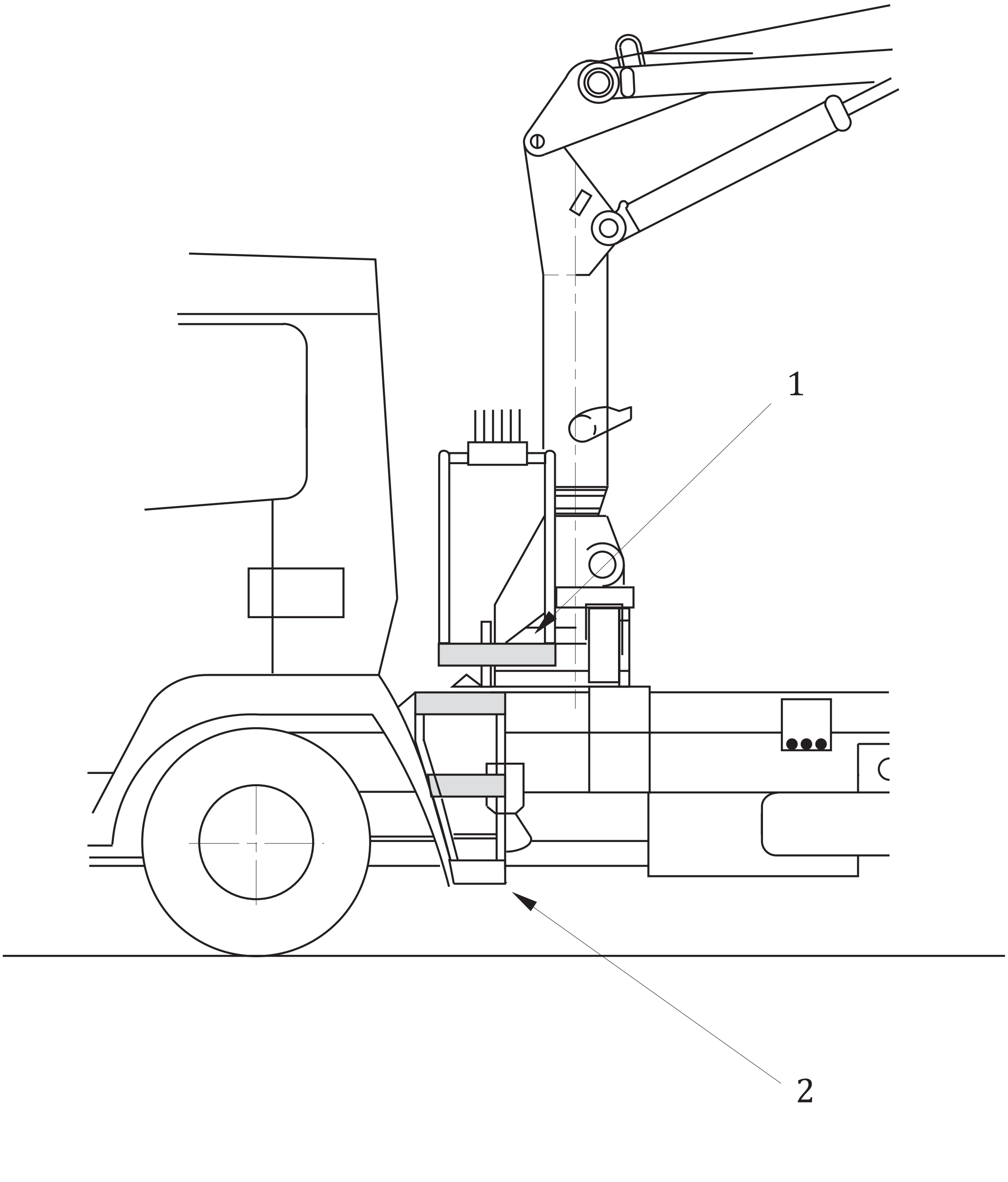
NOTE Vertical positioning of protective bars is known to cause less obstruction to the vision of crane drivers.

Means shall be provided to keep the air temperature inside the closed cabin at 18 °C minimum at a reference outside temperature of −10 °C. The cabin shall be such as to protect against draughts. The cabin shall be provided with adjustable ventilating equipment. The equipment shall be capable of supplying air from the outside. The fresh air valve shall be adjustable. Heating means which are powered by gas, petrol, diesel or burning oil shall be installed such that there is an adequate supply of fresh air to ensure complete combustion and that the exhaust gases cannot ingress into the cabin regardless of wind direction and speed.

Annex K
(informative)

Examples of raised control stations

Figures K.1 to K.3 show different examples of raised control stations.

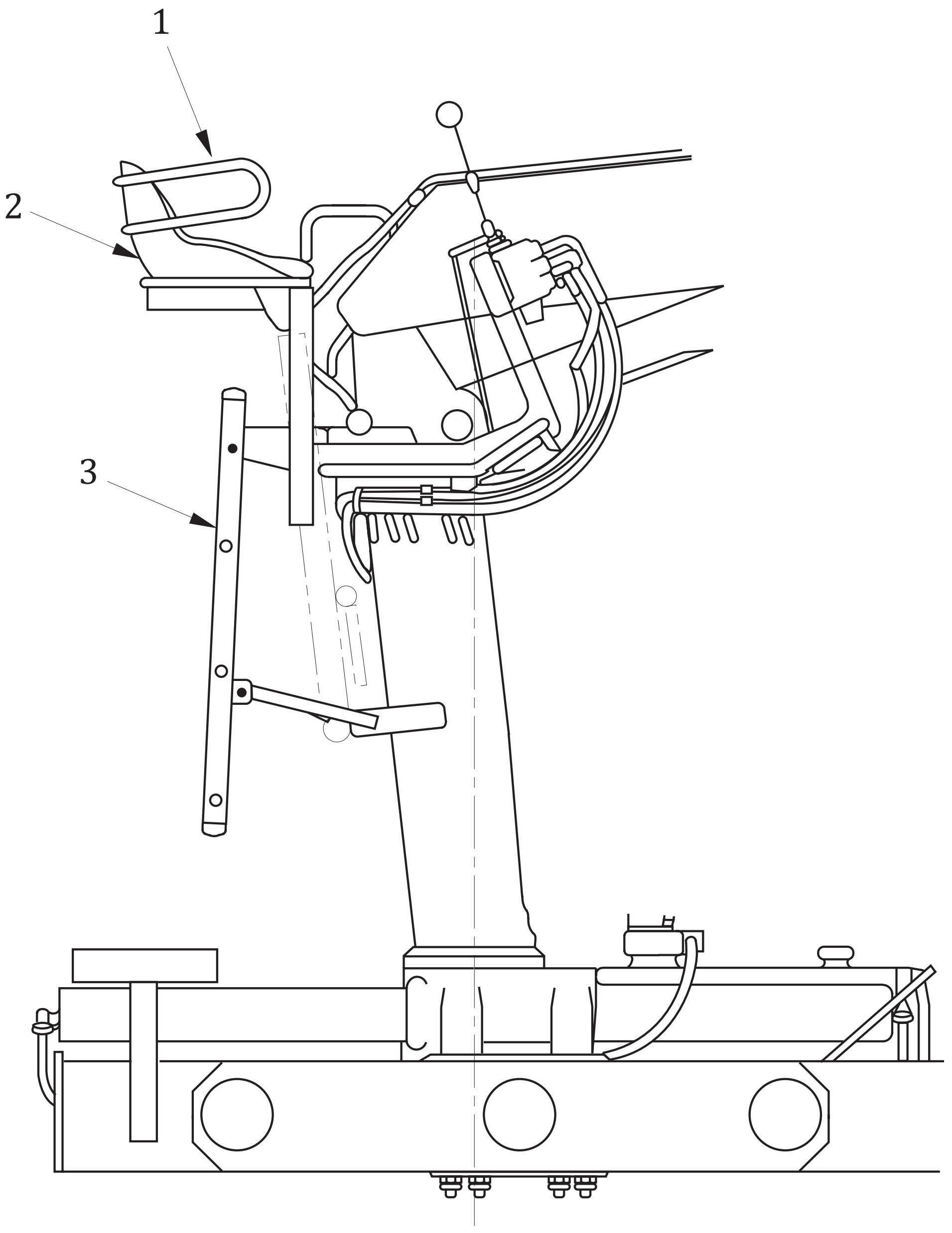


Key

1 control platform

2 steps

Figure K.1 — Control platform with access steps



Key

1 side guard

2 seat

3 ladder

Figure K.2 — High seat on column with access ladders

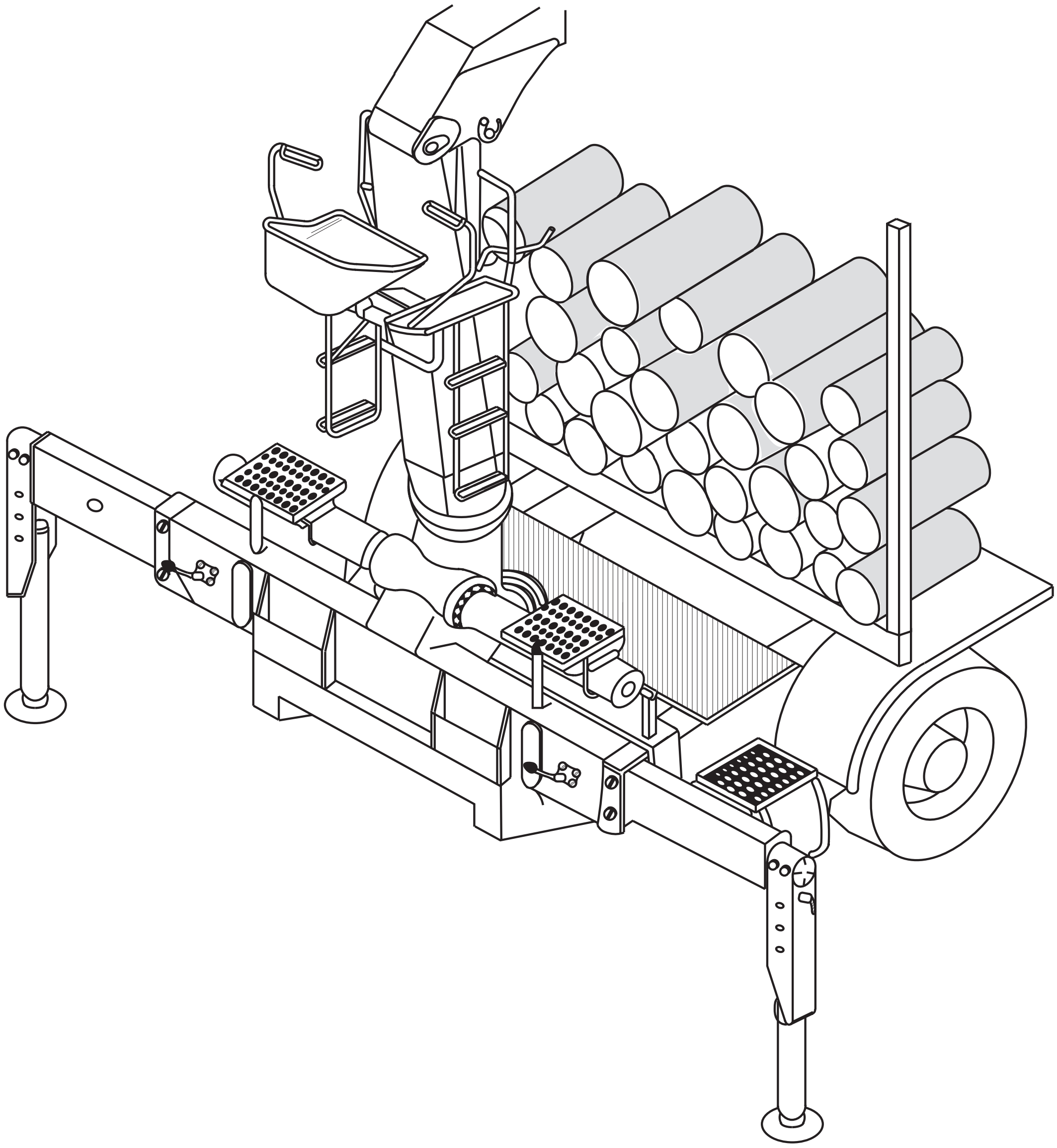


Figure K.3 — High seat on column with access steps

Annex L
(normative)

Raised control stations — Handrails and handholds, ladders and steps

The dimensions of handrails and handholds are specified in Table L.1. See Figure L.1.

NOTE Handrail extension may be an integral part of, or separate from, a ladder.

Table L.1 — Dimensions of handrails and handholds

Symbol	Description	min. mm	max. mm
A	Width (diameter or across flats)	16	40
B	Length between bend radii for support legs of handholds	150	—
C	Hand clearance to mounting surface	75	—
D	Distance above standing surface	—	1 600
E	Vertical distance of handrail continuation above step, platform, stairway or ramp	850	—
F	Offset distance of handrail or handhold from edge of step	75	200
G	Width between parallel handrails	450	—

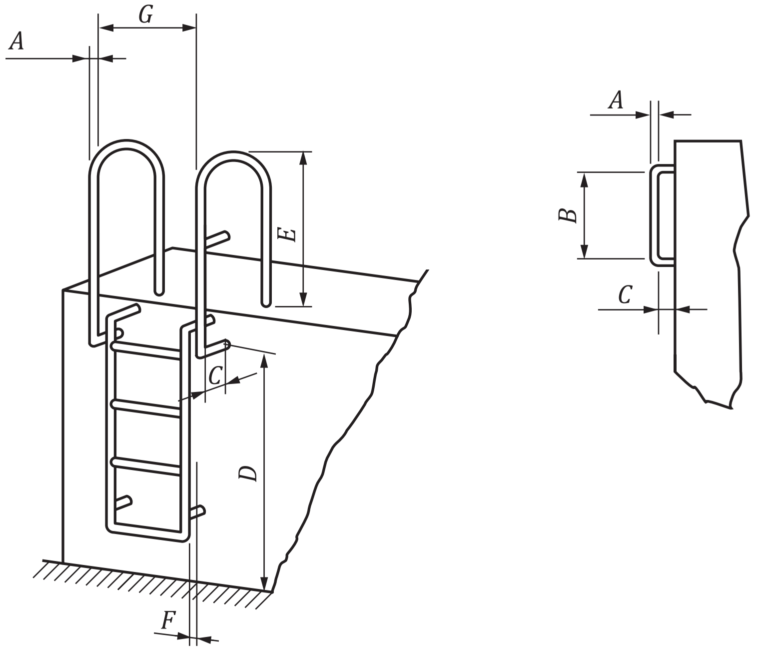


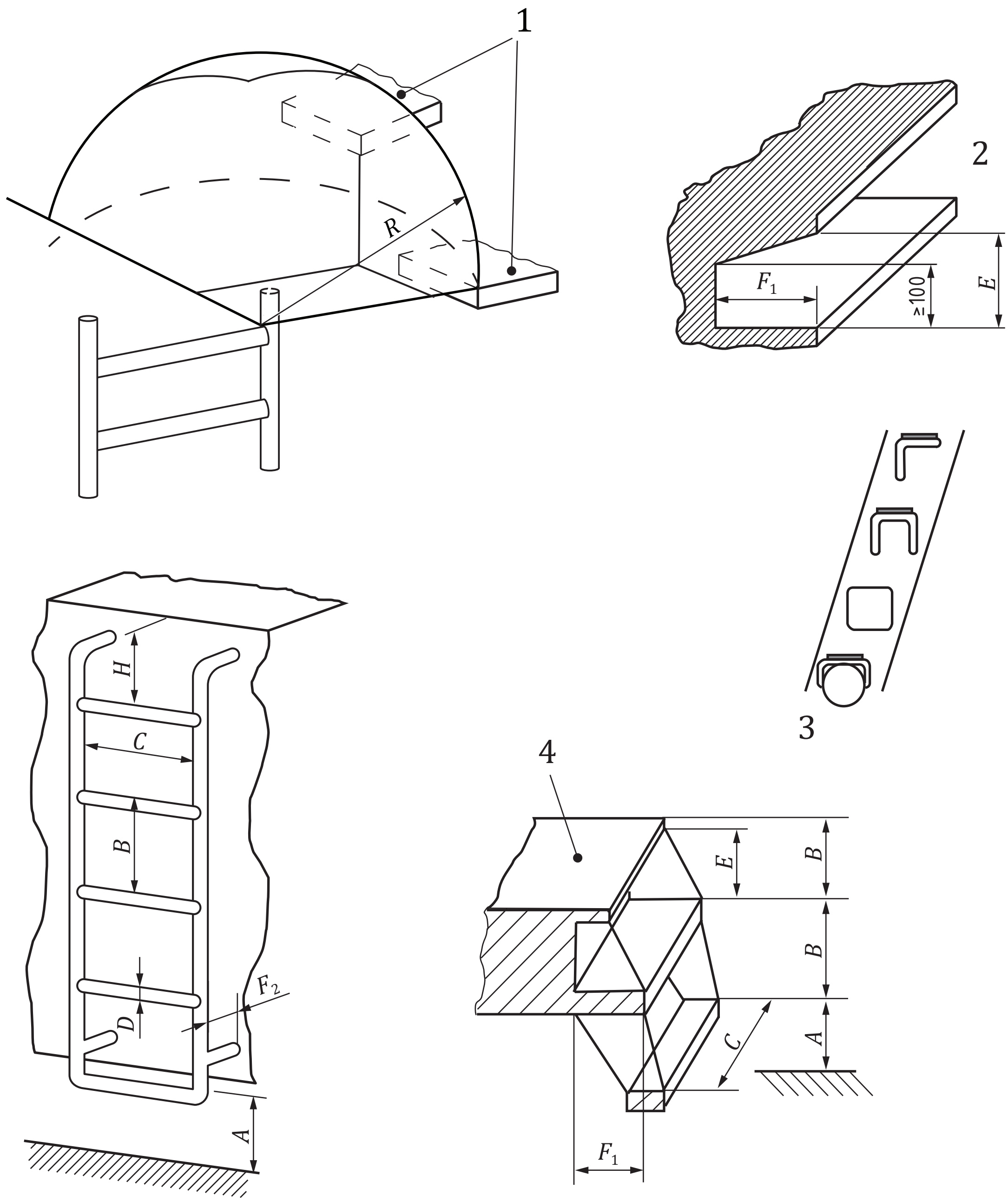
Figure L.1 — Handrails and handholds

The dimensions of steps and ladders are specified in Table L.2. See Figure L.2.

Table L.2 — Dimensions of steps and ladders

Symbol	Description	min. mm	max. mm
A	Height of first step above ground or platform	—	600
B	Riser height	220	300
C	Step width — Rung ladders (for one foot)	300 (150)	—
D	Rung tread — width	19	40
E	Instep clearance	150	—
F_1	Tread depth for steps (stepped ladders, stairways, etc.)	240[a]	400
F_2	Toe clearance (free space behind rungs)	150	—
H	Distance from top rung of ladder to platform	—	150
R	Step placement from ladder	—	300

[a] Can be reduced to 130 when free space for toe clearance is provided.



Key

1 platform

2 instep clearance

3 typical profiles for ladder rungs

4 platform level

Figure L.2 — Steps, ladders and stairways

Annex M
(informative)

Installation of loader cranes on chassis

M.1 General

This annex supplies the minimum information necessary for the correct installation of a loader crane on a chassis. The installation of a loader crane on the chassis requires the addition of a mounting frame, commonly referred to as a subframe. Most truck manufacturers provide guidance for fitting loader cranes to their range of chassis which will need to be adhered to. In the absence of specific recommendations for a fitting the loader crane to the chassis, the subframe dimensions and characteristics can be determined from Clause M.4. Approval for fitting the subframe will then need to be sought from the chassis manufacturer. The crane stabilizers and additional stabilizers, if fitted, are presumed to be extended and in full contact with the ground, in accordance with the operating instructions of the crane manufacturer.

M.2 Installation — Minimum data

M.2.1 Crane dimensions in transport position

The data has to be referred to a system of Cartesian coordinates *(*X, Y, Z*)* which coincide at the point of intersection of the crane's axis of rotation (axis Z), and the horizontal bearing surface of the crane's base unit (planes X, Y). The direction of the three axes and their symbols are indicated in Figure M.1. It is necessary to obtain the position of the centre of gravity of the crane in its travelling position. Coordinates need to be given with the sign according to the coordinate system shown below.

Longitudinal:	A =	mm
Transverse:	B =	mm
Vertical:	H =	mm
Coordinate of longitudinal centre of chassis (offset):	Y_a =	mm
Total mass of crane:	G =	kg
Coordinates of centre of gravity of crane (G) in transport position:	X_g =	mm
	Y_g =	mm
	Z_g =	mm

M.2.2 Crane data (see Figure M.2)

Max. total lifting moment ($PR + G_bY_b$):	M_{st} =	mm
Max. total dynamic lifting moment ($\varphi_2PR + \varphi_1G_bY_b$):	M_{dyn} =	mm

M.2.3 Mounting data

Number of tie rods or frame bolts:		
Diameter of tie rods or frame bolts:		mm
Grade of tie rods or frame bolts:		
Tightening torque:	T =	N · m

M.2.4 Power requirements

Pump type (fixed/variable):		
Max allowable delivery at control valve:	Q_r =	l/min
Working pressure:	P =	bar
Main relief valve setting on crane:	p_r =	bar
Hydraulic power requirement:	P_r =	kW
Electric power requirement:		volts
		amps

NOTE On systems with constant flow pumps, the working pressure measured close to the pump can be higher than the main relief valve setting on the crane due to pressure losses, i.e. efficiency. On systems with variable flow pumps, the working pressure, including the standby pressure, is limited by the pump regulator.

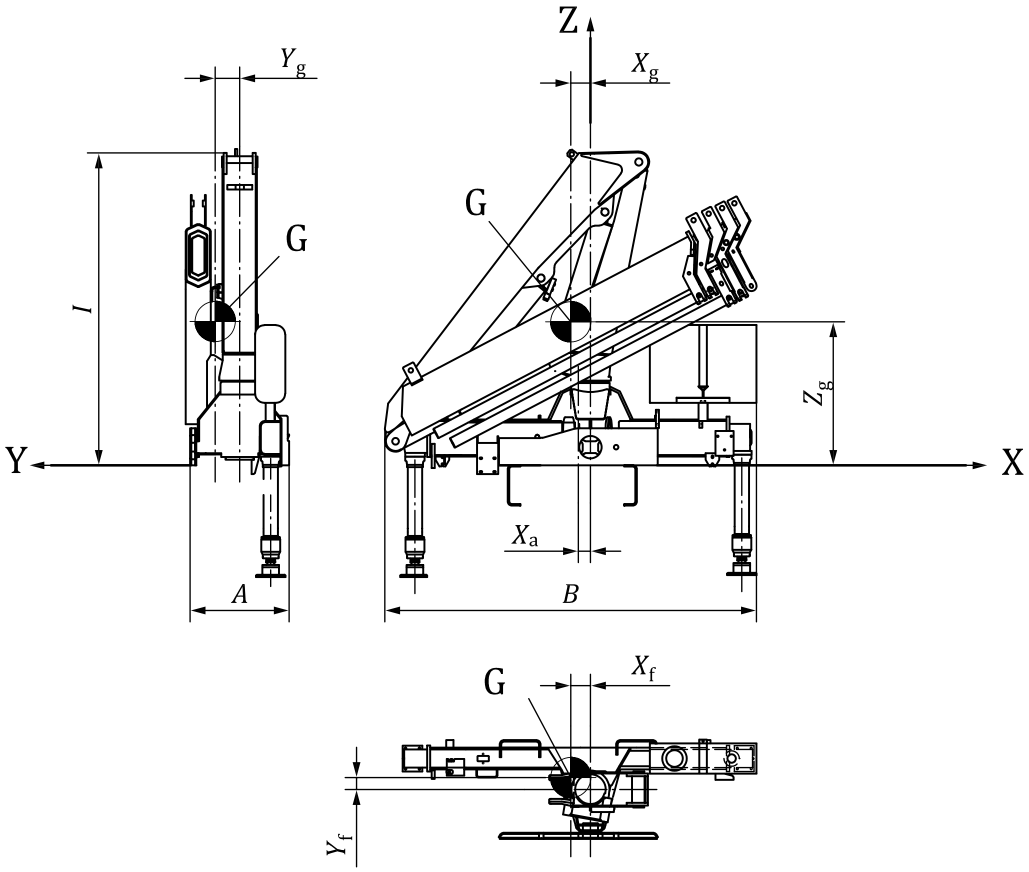


Figure M.1 — Axis directions and dimensions of folded crane

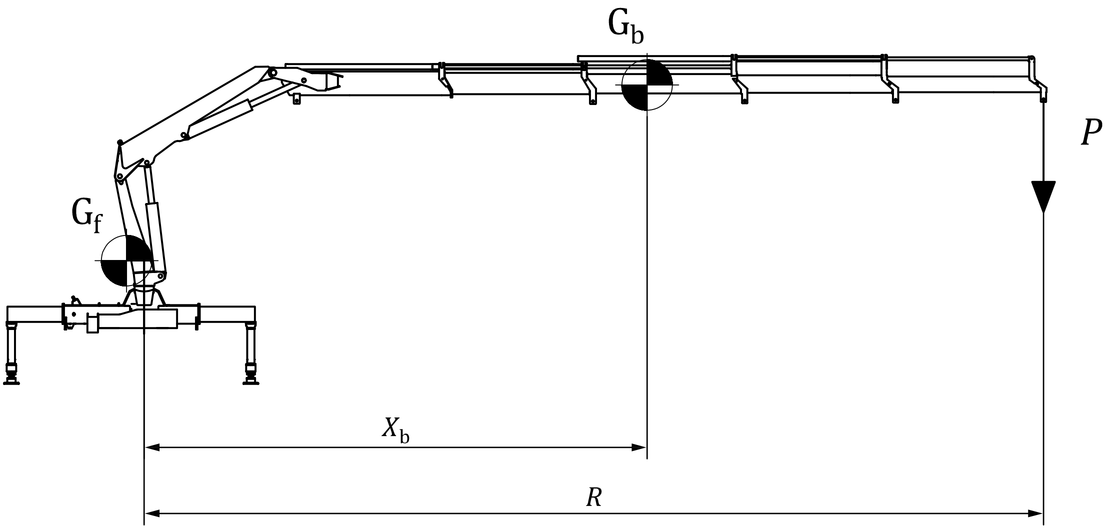


Figure M.2 — Crane dimensions at maximum hydraulic outreach

M.2.5 Stability calculations

The manufacturer of the crane should supply the following data for the maximum hydraulic outreach as defined in the load chart.

Mass of crane base unit plus column and 1st boom cylinder:	G_F =	kg
Coordinates of centre of gravity of base and column with 1st boom cylinder:	X_F =	mm
	Y_F =	mm
Mass of boom system:	G_b =	kg
Coordinate of centre of gravity (G) of boom system:		mm

M.3 Power take-off (PTO) and pump displacement

It is common practice for the company fitting the crane to give the supplier of the pump and PTO the following data:

— chassis manufacturer;

— chassis type;

— gross weight;

— gearbox details;

— type of pump (fixed/variable);

— maximum working pressure of crane;

— nominal flow of oil required by the crane.

The choice of the PTO's gear ratio has to be made so that the power output takes place within the specified torque band of the chassis engine.

The power available from the PTO (which is a product of the maximum recommended torque, at the specified r/min) should be in excess of the power requirements of the hydraulic system. The following formulae can be used to compute the power requirements for fixed pumps:

Available mechanical power (kW): $P_w = \frac{M \times n}{9\,550}$

Mechanical power required (kW): $P_r = \frac{Q \times p}{600 \times \eta}$

To calculate the power required, it is essential to consider auxiliary equipment which is connected to the same PTO/hydraulic pump.

It is essential that

$$P_w \geq P_r \quad \text{and} \quad Q_r \geq \frac{C \times n}{1\,000}$$

where

M is the maximum permitted PTO torque (N · m);

n is the PTO/pump speed (min^{-1});

C is the pump displacement per revolution (cm^3);

Q is the pump delivery (L/min);

p is the working pressure (bar);

η is the total pump efficiency.

M.4 Calculation method for determination of subframe dimensions

M.4.1 General considerations

The type of subframe construction to be used is dependent on the contribution it makes in terms of strength and stiffness.

a) Flexible mounting enables limited horizontal movement between the chassis and the sub-frame, and can be considered as two separate beams working together in parallel. The chassis and the sub-frame sections will each be subjected to a part of the total bending moment in proportion to their respective second moments of area.

b) Rigid mounting does not permit any movement between the chassis and the sub-frame and can be considered as a single compound beam. It is essential that the spacing and size of the side plates be of sufficient strength to withstand the resultant shear stress.

c) Cranes fitted behind the cab of the truck: To retain, as near as possible, the original bending and torsional characteristics of the chassis, the mounting of the sub-frame to the chassis may be of a flexible type. Some truck manufacturers recommend a flexible fitting along the entire length of the sub-frame. The majority of truck manufacturers recommend that the crane portion of the sub-frame be rigidly attached to the chassis and the rest of the sub-frame flexibly mounted.

d) Rear installation: Because the crane mass is concentrated on the rear overhang of the chassis, it is necessary to provide torsional stiffness to ensure good ride characteristics while travelling and improved stability while operating the crane. To achieve this, the sub-frame needs to be rigidly mounted to the chassis. In addition, most chassis manufacturers recommend fitting a diagonal brace to the sub-frame, extending from the loader crane position to the centre of the drive axle(s). Many chassis manufacturers also recommend that the side plates closest to the truck cab be of the flexible type. This creates a more gradual reduction in the value of the combined second moment of area of the chassis and sub-frame.

M.4.2 Stresses

The maximum dynamic moment of the crane is assumed to act along the longitudinal axis of the chassis This will either coincide or be parallel with the longitudinal axis of the chassis.

If the crane's axis of rotation is offset from the longitudinal axis of the chassis, or if the crane base does not provide a uniform distribution of the load moment along the two longitudinal members of the sub-frame, the load moment should be distributed by introducing a factor $\beta \geq 0{,}5$, which derives from the eccentricity of the crane and from the base properties and constraints. Factor β should be given by the crane manufacturer.

The dimensioning of the sub-frame should be made in accordance with the maximum value of load moment acting on one side. The load moment varies linearly from the maximum value at the point of attachment of the crane, to a zero value on the front or rear axles of the chassis, or on the additional stabilizers.

M.4.3 Material and limit states

See 4.3.

M.4.4 Formulae

M.4.4.1 General and symbols

The chassis and sub-frame sections are considered as resisting the total load moment. Dimensions referring to the chassis frame are designated "*t*" and dimensions referring to the sub-frame "*c*":

M_{dyn} is the maximum dynamic moment;

β is the distribution factor;

M_{e} is the moment to be assumed for the calculation, $M_{\mathrm{e}} = \beta \times M_{\mathrm{dyn}}$;

M is the load moment acting on the chassis or subframe;

I is the second moment of the area of the chassis or subframe sections;

W is the section modulus of the chassis or subframe sections;

σ is the bending stress;

σ_{a} is the allowable stress of the material.

M.4.4.2 Flexible mounting (chassis and subframe)

$$M_{\mathrm{e}} = M_{\mathrm{c}} + M_{\mathrm{t}} \text{ and } \frac{M_c}{M_t} = \frac{I_c}{I_t} \Rightarrow M_{\mathrm{c}} = M_{\mathrm{e}}\left(\frac{I_c}{I_c + I_t}\right) \text{ and } M_{\mathrm{t}} = M_{\mathrm{e}}\left(\frac{I_t}{I_c + I_t}\right)$$

$$\frac{M_c}{W_c} \leq \sigma_{\mathrm{a}}$$

$$\frac{M_t}{W_t} \leq \sigma_{\mathrm{a}}$$

M.4.4.3 Rigid mounting

$$\sigma_1 = \frac{M_e}{W_1} \leq \sigma_a$$

$$\sigma_2 = \frac{M_e}{W_2} \leq \sigma_a$$

where

W_1 is the bending resistance with respect to the distance from the neutral axis to the extreme point of the chassis frame;

W_2 is the bending resistance with respect to the distance from the neutral axis to the extreme point of the subframe.

Annex N
(normative)

User information pertaining to noise

Information on noise emitted by the loader crane installation is required to be provided in accordance with 6.2.3.9. This annex specifies the records of sound measurements for cranes mounted on commercial chassis. A class one/type one sound level meter, laboratory calibrated in the previous 2 years should be used. Wind speeds should not exceed 5 m/s (level 3 on the Beaufort Scale).

Record of noise test — Sound pressure levels			
Chassis details		**Loader crane details**	
Chassis make and model		Crane make	
Axle configuration		Crane model	
Chassis number		Crane serial no.	
Exhaust position		Control type	
Engine euro type		Flow required	
PTO operating speed		Working pressure	
Body fitted		Mounting position	
Test environment		**Measurements**	
Relative humidity, %		Background noise	
Barometric pressure, Pa		A-weighted pos. 1	
Wind speed (Beaufort)		A-weighted pos. 2	
Temperature, °C		A-weighted pos. 3	
Floor surface type		C-weighted pos. 1	
Additional measurements if A-weighted sound pressure levels > 80 dB			
	1		8 × A-weighted sound pressure measurements to be taken at 1,6m above ground and at maximum crane radius + 2 m for 30 s duration
8	CAB	2	
7	BODY	3	
6		4	
	5		

Annex O
(informative)

Stress history parameter *s* and stress history classes *S*

For loader cranes, the stress spectrum factor, k, at a certain point of the structure, expressed as relative damage per lifting cycle, may be computed as

$$k = \frac{1}{N} \cdot \sum_i \left(\frac{\Delta\sigma_i}{\Delta\sigma_{max}} \right)^3 \cdot n_1$$

The corresponding stress history parameter, s, may be calculated as

$$s = \frac{N_{tot}}{2 \times 10^6} \cdot k$$

where

i	is an index running from 1 to the number of stress range classes used;
$\Delta\sigma_i$	is the stress range of class i;
N_i	is the number of stress cycles that fall into class i;
$\Delta\sigma_{max}$	is the maximum stress range at the point;
N	is the number of lifting cycles used for evaluation of k;
N_{tot}	is the number of lifting cycles during the life of the crane.

Simulations or field measurements using, e.g. the rain flow method, may be used to establish values for stress spectrum factors k.

Stress history parameter s is classified into various stress history classes, S, in accordance with Table O.1.

Table O.1 — Classes of stress history parameter

Class, S	Value of stress history parameter, s	Characteristic value of s
S_0	$s \leq 0{,}008$	0,008
S_1	$0{,}008 < s \leq 0{,}016$	0,016
S_2	$0{,}016 < s \leq 0{,}032$	0,032
S_3	$0{,}032 < s \leq 0{,}063$	0,063
S_4	$0{,}063 < s \leq 0{,}125$	0,125
S_5	$0{,}125 < s \leq 0{,}250$	0,250
S_6	$0{,}250 < s \leq 0{,}500$	0,500
S_7	$0{,}500 < s \leq 1{,}000$	1,000

Different parts of the crane may be assigned different S classes or specific s values.

Based on experience of the service conditions, the basic stress history class for a crane may also be selected from Table O.2, which shows S of the most severely loaded crane part — generally the column. Different parts of the crane may be assigned a lower S if the service conditions are fully known.

Table O.2 — Examples of S for different crane duties

Duty type	Intensity of usage/S classes		
	Very light	**Moderate**	**Intensive**
Hook, Brick and block	S_0	S_1	S_2
Digging	S_1	S_2	S_3
Recycling scrap	S_2	S_3	S_4
Timber handling	S_3	S_4	S_5

Bibliography

[1] ISO 7000, *Graphical symbols for use on equipment — Registered symbols*

[2] ISO 7296-2, *Cranes — Graphical symbols — Part 2: Mobile cranes*

[3] ISO 8686-2, *Cranes — Design principles for loads and load combinations — Part 2: Mobile cranes*

[4] ISO 9927-1, *Cranes — Inspections — Part 1: General*

[5] ISO 9928-1, *Cranes — Crane driving manual — Part 1: General*

[6] ISO 9942-1, *Cranes — Information labels — Part 1: General*

[7] ISO 12478-1, *Cranes — Maintenance manual — Part 1: General*

[8] ISO 15513, *Cranes — Competency requirements for crane drivers (operators), slingers, signallers and assessors*

[9] CEN/TS 13001-3-2, *Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*

[10] CEN/TS 13001-3-5, *Cranes — General design — Limit states and proof of competence of forged hooks*

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