

Cranes — Mobile cranes

ICS 53.020.20

National foreword

This British Standard is the UK implementation of EN 13000:2010+A1:2014, incorporating corrigendum October 2010. It supersedes BS EN 13000:2010, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

The UK participation in its preparation was entrusted by Technical Committee MHE/3, Cranes and derricks, to Subcommittee MHE/3/5, Mobile cranes.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

The publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English Version

Cranes - Mobile cranes

Appareils de levage à charge suspendue - Grues mobiles

Krane - Fahrzeugkrane

This European Standard was approved by CEN on 19 December 2009 and includes Corrigendum 1 issued by CEN on 6 October 2010 and Amendment 1 approved by CEN on 9 February 2014.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

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Foreword

This document (EN 13000:2010+A1:2014) has been prepared by Technical Committee CEN/TC 147 "Cranes — Safety", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2014, and conflicting national standards shall be withdrawn at the latest by November 2014.

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

This document supersedes  EN 13000:2010 .

This document includes Amendment 1 approved by CEN on 2014-02-09.

The start and finish of text introduced or altered by amendment is indicated in the text by tags  .

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

 For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document. 

This standard applies to mobile cranes which are put on the market 12 months after the date of ratification by CEN of this standard or at the latest 2015-02-09.

This document has been prepared by Product Working Group CEN/TC 147/WG 11 "Mobile Cranes", the secretariat of which is held by DIN.

 CEN/TC 147 WG11 has reviewed EN 13000:2010 to adapt the standard to the technical progress, new requirements and changes in standards referenced; the main topics are:

- The scope of this standard has been amended to cover gaps and overlaps with other European Standards.
- Several wind related incidents forced the introduction of more clarification on wind loads and the development of explanations to be added in the instruction manual (4.1.2.2.2 and 6.2.2.4).
- The limit value for the noise measured at the operator position has been aligned with the actual legal requirements and the former noise clause has been reorganized to improve readability (5.3, 6.1.2 and Annex G).
- To cover the risk of a wrong setting of the outrigger configuration and to align the standard with other European Standards and recently introduced regulations outside of the EEA, requirements for outrigger monitoring are introduced (4.2.6.2.5). 

Annexes A, C, D, E, F, G.1 and G.2, H, J.1 to J.4, K.1 to K.5, L, M, P, R, S and U are normative. Annexes B.1 and B.2, N.1 to N.3, Q, T, V and W are informative.

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

Introduction

This European Standard is a type C standard.

This European Standard has been prepared to provide one means for mobile cranes to conform with the essential health and safety requirements of the Machinery Directive.

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

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

✎ CEN/TC147 WG11 had set up a dedicated working group with representatives from crane manufacturers, electronic component suppliers and Health and Safety organizations. This group did a thorough investigation in the transition from EN 954 to EN ISO 13849 and came to the conclusion that this transition is not currently feasible for mobile cranes.

The required Performance Level was determined by risk assessment according to EN 1050; it was established as PL_r=c; this value is not achievable with components currently available on the market and is as such beyond the state of the art for mobile cranes. This is mainly due to the amount of signals to be processed simultaneously.

Therefore, in the present amendment A1, the requirements given for safety related parts of control systems will refer to EN 954. ✎

1 Scope

This European Standard is applicable to the design, construction, installation of safety devices, information for use, maintenance and testing of mobile cranes as defined in ISO 4306-2 ~~1) deleted text 1)~~. 1) Examples of mobile crane types are given in Annex A. 1)

1) This European Standard does not apply to:

- loader cranes (see EN 12999)
- off-shore cranes (see EN 13852-1)
- floating cranes (see EN 13852-2)
- variable reach truck (see EN 1459)

NOTE 1 Variable Reach Trucks are commonly known as telehandlers.

- mobile self-erecting tower cranes
- earth-moving machinery used for object handling (see EN 474-series). 1)

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

1) NOTE 2 1) The use of mobile cranes for the lifting of persons is subject to specific national regulations.

Mobile cranes covered by this European Standard are designed for a limited number of stress cycles and particular properties of motions, e.g. smooth application of the driving forces and loading conditions according to ISO 4301-2:1985, group A1.

For a duty cycle such as grab, magnet or similar work, additional provisions are required which are outside the scope of this European Standard.

The hazards covered by this European Standard are identified by Annex C.

This document is not applicable to mobile cranes which are manufactured before the date of publication of this document by CEN.

2 Normative references

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

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EN 294:1992, *Safety of machinery — Safety distance to prevent danger zones being reached by the upper limbs*

EN 349:1993, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

EN 547-1:1996, *Safety of machinery — Human body measurements — Part 1: Principles for determining the dimensions required for openings for whole body access into machinery*

EN 614-1:2006, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

EN 626-1:1994, *Safety of machinery — Reduction of risk to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

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- EN 842:1996, *Safety of machinery — Visual danger signals — General requirements, design and testing*
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- EN 954-1:1996, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*
- EN 982:1996, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*
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- EN 1005-3:2002, *Safety of machinery — Human physical performance — Part 3: Recommended force limits for machinery operation*
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- [A₁]** *deleted text [A₁]*
- EN 12644-1:2001, *Cranes — Information for use and testing — Part 1: Instructions*
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- EN 13586:1999, *Cranes — Access*
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- EN 60204-32:2008, *Safety of machinery—Electrical equipment of machines — Part 32: Requirements for hoisting machines (IEC 60204-32:2008)*
- EN 61000-6-2:2005, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments (IEC 61000-6-2:2005)*

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EN 61310-1:2008, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals (IEC 61310-1:2007)*

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EN ISO 3411:2007, *Earth-moving machinery - Physical dimensions of operators and minimum operator space envelope (ISO 3411:2007)*

EN ISO 3744:1995, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane (ISO 3744:1994)*

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

EN ISO 5349-1:2001, *Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 1: General requirements (ISO 5349-1:2001)*

EN ISO 5349-2:2001, *Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 2: Practical guidance for measurement at the workplace (ISO 5349-2:2001)*

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

EN ISO 6385:2004, *Ergonomic principles in the design of work systems (ISO 6385:2004)*

EN ISO 6683:2008, *Earth-moving machinery - Seat belts and seat belt anchorages - Performance requirements and tests (ISO 6683:2005)*

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

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ISO 2631-1:1997, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 3795:1989, *Road vehicles, and tractors and machinery for agriculture and forestry — Determination of burning behaviour of interior materials*

ISO 3864-1:2002, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs in workplaces and public areas*

ISO 4301-1:1986, *Cranes and lifting appliances — Classification — Part 1: General*

ISO 4301-2:1985, *Lifting appliances — Classification — Part 2: Mobile cranes*

ISO 4305:1991, *Mobile cranes — Determination of stability*

ISO 4306-1:2007, *Cranes — Vocabulary — Part 1: General*

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ISO 4308-1:2003, *Cranes and lifting appliances — Selection of wire ropes — Part 1: General*

ISO 4308-2:1988, *Cranes and lifting appliances — Selection of wire ropes — Part 2: Mobile cranes — Coefficient of utilization*

ISO 4309:2004, *Cranes — Wire ropes — Care, maintenance, installation, examination and discard*

ISO 4310:1981, *Cranes — Test code and procedures*

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ISO 7296-1:1991, *Cranes — Graphic symbols — Part 1: General*

ISO 7296-2:1996, *Cranes — Graphic symbols — Part 2: Mobile cranes*

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ISO 8087:1985, *Mobile cranes — Drum and sheave sizes*

ISO 8566-2:1995, *Cranes — Cabins — Part 2: Mobile cranes*

ISO/CIE 8995-1:2002, *Lighting of indoor work places — Part 1: Indoor*

ISO/DIS 8995-2:2006, *Lighting of indoor work places — Part 2: Outdoor*

ISO/CIE 8995-3:2006, *Lighting of indoor work places — Part 3: Lighting requirements for safety and security of outdoor work places*

ISO 11660-2:1994, *Cranes — Access, guards and restraints — Part 2: Mobile cranes*

ISO 11662-1:1995, *Mobile cranes — Experimental determination of crane performance — Part 1: Tipping loads and radii*

ISO 12480-1:1997, *Cranes — Safe use — Part 1: General*

ISO 13200:1995, *Cranes — Safety signs and hazard pictorials — General principles*

FEM 1.001:1998, *Rules for the design of hoisting appliances (3rd edition)*

FEM 5.004:1994, *Rules for the design of the steel structures of general use mobile cranes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-1:2007 and ISO 4306-2:1994 and the following apply¹⁾.

3.1

angle indicator

device to display the actual angle of parts of the crane to the horizontal

EXAMPLES  Boom  angle indicator, fixed fly jib angle indicator, luffing fly jib indicator and/or mast angle indicator.

3.2

angle limiter

device to limit the motion of parts of the crane regarding their angles

EXAMPLES  Boom  angle limiter, fly jib angle limiter and/or mast angle limiter.

3.3

cabin

control station with protective enclosure

NOTE See 3.6, 3.7 and 3.9.

3.4

configuration

combination of structural members, counterweights, support or outrigger position, hook block reeving and similar items assembled, positioned and erected according to manufacturer's instructions and ready for operation

3.5

control station

permanent position of controls on or off the crane

3.6

crane

machine for cyclic lifting or cyclic lifting and handling of loads suspended on hooks or other load handling devices, whether manufactured to an individual design, in series or from prefabricated components

NOTE "Suspended" can include additional means fitted to prevent swinging, rotation of the load, etc.

3.7

crane level indicator

device to indicate the "levelled position" of the crane

3.8

crane operating cabin

cabin provided for the operation of the crane motions to move the load

3.9

crane travelling cabin

cabin provided for the transportation of the crane by road from one job site to another

3.10

derricking (luffing) limiter

device to prevent derricking (luffing) motions of the  boom  and/or fly jib beyond specified limits

¹⁾ The definitions are listed alphabetically.

3.11

hoisting limiter

device either to prevent the fixed load lifting attachment from being raised such that it strikes the crane structure, or to prevent any other specified upper limitation of the load lifting attachment from being exceeded

NOTE It can also include any other design limitation imposing a restriction on lifting.

3.12

hook load indicator

device to display the actual mass (weight) of the load

3.13

indicator

device which provides warnings and/or data to facilitate the competent control of the crane within its design parameters

3.14

$\boxed{A_1}$ boom $\langle A_1 \rangle$ length indicator

device to display the actual $\boxed{A_1}$ boom $\langle A_1 \rangle$ length

3.15

load bearing component

single part or assembly of parts of a crane, which are directly subjected to load effects

EXAMPLES Hooks, ropes (stationary or running), traverse beams, pendant bars, wheels, axles, gears, couplings, brakes, hoists, hydraulic cylinders, shafts and pins.

NOTE In contrast to (steel) structures components can be regarded as independent units.

3.16

lock indicator

device to display the locked condition of a part or function

3.17

lowering limiter

device to ensure that the specified minimum number of turns of rope on the hoist drum is maintained at all times during operation

3.18

mobile crane

$\boxed{A_1}$ self-powered crane with a boom, which may be fitted on a mast (tower) and capable of travelling laden or unladen, without the need for fixed runways and which relies on gravity for stability, the chassis of the crane not having any capability to carry goods $\langle A_1 \rangle$

NOTE 1 Examples of mobile cranes are given in the Annexes A, B.1 and B.2.

NOTE 2 Mobile cranes can operate on tyres, crawlers or with other mobile arrangements. In fixed positions, they can be supported by outriggers or other accessories increasing their stability.

NOTE 3 The superstructure of mobile cranes can be of the type of full circle slewing, of limited slewing or non slewing. It is normally equipped with one or more hoists and/or hydraulic cylinders for lifting and lowering the $\boxed{A_1}$ boom $\langle A_1 \rangle$ and the load.

NOTE 4 Mobile cranes can be equipped either with telescopic $\boxed{A_1}$ booms $\langle A_1 \rangle$, with articulated $\boxed{A_1}$ booms $\langle A_1 \rangle$, with lattice $\boxed{A_1}$ booms $\langle A_1 \rangle$ – or a combination of these – of such a design that they can readily be lowered.

NOTE 5 Loads can be handled by hook block assemblies or other load-lifting attachments for special services.

3.19

off-road mobile crane

mobile crane which travels on site

EXAMPLES Rough terrain crane, crawler crane.

3.20

on-road mobile crane

mobile crane which has the necessary equipment to travel on public roads and on the job site

EXAMPLES All terrain crane, truck crane.

3.21

partial safety coefficient

safety margin for the method of limit states chosen as described in Annex A of ISO 8686-1:1989

NOTE See partial load coefficients γ_p .

3.22

performance limiter

device which automatically prevents a design performance characteristic from being exceeded

3.23

radius indicator

device to display the actual radius of the load

3.24

rated capacity

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

NOTE For mobile cranes the mass (weight) of the hook block is part of the load.

3.25

rated capacity indicator

device which gives, within specified tolerance limits, at least a continuous indication that the rated capacity is exceeded, and another continuous indication of the approach to the rated capacity

3.26

rated capacity limiter

device that automatically prevents the crane from handling loads in excess of its rated capacity, taking into account the dynamic effects during normal operational use

3.27

slack rope limiter

device to automatically prevent dangers from slack rope situations

3.28

slew position indicator

device to indicate to the crane operator the actual slew position

3.29

slew range indicator

device to indicate to the crane operator the permitted slew range for the selected configuration

3.30

slewing limiter

device to prevent slewing beyond specified limits

3.31

telescoping limiter

device to prevent telescoping beyond specified limits

3.32

wind speed indicator

device to indicate to the crane operator the actual wind speed

3.33

working load

load on the hook plus mass (weight) of hook and block

3.34

working load factor

safety margin for the permissible stress method chosen as described in Annex A of ISO 8686-1:1989

NOTE See coefficients applied to the specified strength γ_F .

4 Safety requirements and/or protective measures

4.1 Structures and components

4.1.1 General

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 EN ISO 12100 (all parts) for hazards relevant but not significant, which are dealt with by this document (e.g. sharp edges).

Mechanical hazards can arise when loads acting on a crane exceed limiting conditions. Such an overload can cause the entire crane and/or its components to lose stability (elastic or rigid body) as well as cause the supporting structure and/or components to be subjected to failure.

In order to prevent this potential danger, verification shall be provided for the extreme values of load effects based on all forces which act simultaneously on the crane multiplied by adequate (partial) safety factors to ensure that the corresponding loading limits are not exceeded.

This standard defines loads and load combinations as well as specific values of factors and coefficients to be applied to mobile cranes.

The limit state for materials and components shall be indicated in the form of nominal values, which are laid down in relation to the nominal load effects (internal forces or stresses) defined in the relevant standards.

All cases in which limits are exceeded and can endanger the mechanical structure, e.g. creeping, elastic instability, loss of stability, significant displacements, fatigue or wear (including discard of ropes), uncontrolled motions and temperature limits shall be taken into account.

The procedure for the design and calculations is described in this clause. The procedure consists of identifying load effects (see 4.1.2), determining the limit states (see 4.1.3) and the proof of competence (see Annex L). Alternatively advanced and recognized theoretical methods (e.g. elastokinetic analysis to simulate load effects) or experimental methods (e.g. measurement of load effects or tests for determining limit states or strain gauge testing) may be used. These methods shall provide the same level of safety.

4.1.2 Load effects

4.1.2.1 General

All loads which act on the crane or its supporting sections including dead weights, additional loads (e.g. due to gravity, wind loads or other ambient influences), test loads and special loads during erection or dismantling (of A_1 boom/jib A_1 systems) shall not cause damage, such as fracturing, permanent deformations or unintentional displacements.

Load effects shall be determined based on an elastostatic/rigid body kinetic model of the crane and load models. Loads acting on the crane at the same time shall be combined as given in Annex D.

For mobile cranes a load spectrum factor $Q_1 = \text{"light"}$ ($K_p = 0,125$) according to ISO 4301-1 shall be applied as minimum. The minimum number of load cycles shall be $3,2 \times 10^4$.

It is assumed that:

- a) the number of important stress cycles (i.e. stress cycles contributing significantly to fatigue: minimum one stress cycle per lift) is not higher than the number of operating cycles;
- b) critical notch conditions are avoided by careful design and construction;
- c) there are no predominant alternating stresses.

With these assumptions, it is not necessary to carry out a fatigue analysis on the load bearing structure.

When considering test loads the crane shall be in the same configurations as intended for use without any modification (e.g. without changing outriggers, counterweight, counterweight position).

When the method of permissible stresses (see L.2.2) is applied, the working load shall be multiplied by the working load factor.

When the method of partial safety coefficients and limiting stresses (see L.2.3) is applied, the working load shall be multiplied by the working load factor and its partial safety coefficients and all other loads by their respective partial safety coefficients.

Loads with a low number of stress cycles and low amplitudes are to be seen as mean values multiplied by the working load factor and/or the respective partial safety coefficients.

The analysis of load effects with alternative advanced methods, i.e. from individual events (dynamic factors) or representative use of a crane shall provide at least equivalent levels of safety. It shall take into account unfavourable operating conditions and sequences of movements of the crane and/or the load.

4.1.2.2 Wind loads

4.1.2.2.1 Wind speeds and pressures

To calculate the wind loads, it is assumed that the wind blows horizontally from the most unfavourable direction, but at an elevation-related speed.

The speed of a 3-s wind gust $v(z)$ [m/s] acting on an elevated point z [m] and decisive for calculations is based on a mean wind speed determined over 10 min $\bar{v}$ [m/s] at 10 m above ground or sea level.

$$v(z) = [(z/10)^{0,14} + 0,4] \cdot \bar{v}$$

$$\text{for } z = 10 \text{ [m]} \Rightarrow v(z) = 1,4 \cdot \bar{v}$$

see Annex N.1

The quasi-static impact pressure q [N/m²] is as a result of:

$$q = 0,625 \cdot v(z)^2$$

$$\text{for } z = 10 \text{ [m]} \Rightarrow q(z) = 1,225 \cdot \bar{v}^2$$

see Annex N.2

The admissible wind speed for the crane in-service and out-of-service is derived from the wind gust speed $v(z)$ acting on the highest elevated point taken in account for the verifications.

4.1.2.2.2 In-service wind loads

To calculate the wind load during crane operation conservatively, the wind gust speed determined at the highest elevated point v_i (max. z) can be assumed to act all over the height of the crane and its $\boxed{A_1}$ boom/jib $\boxed{A_1}$.

Precise elevation-related calculations of the wind forces acting on the $\boxed{A_1}$ boom/jib $\boxed{A_1}$ are permissible, e.g. in 10 m elevation intervals.

The wind forces acting on the crane and its components as well as the pertaining impact pressures determined shall be combined with the other in-service loads.

The permissible wind speed v_i (max. z) shall be indicated in the rated capacity charts and in the instruction manual.

$\boxed{A_1}$ The reference values of the projected area and drag coefficient used to determine the wind effect on the load shall be indicated; the following minimum values shall be taken:

- Projected area per ton of lifted load: $A_p=1,0 \text{ m}^2/\text{t}$
- Drag coefficient: $c_w=1,2 \boxed{A_1}$

$\boxed{A_1}$ Thus the effective sail area becomes $1,2\text{m}^2/\text{t}$.

The wind loads acting on the suspended load shall be calculated with the effective sail area at the maximum possible lifting height of the suspended load for the given configuration. Special verification is required from case to case for lifting loads with a large "area exposed to wind" ($A \cdot c_w > 1,2 \text{ m}^2/\text{t}$). If the manufacturer provides load charts based on other assumptions than the standard ones, this shall be mentioned in the provided load chart. $\boxed{A_1}$

$\boxed{A_1}$ NOTE 1 $\boxed{A_1}$ Safe crane use is only possible within the range of the permissible wind speed v_i (max. z) while the crane is in service, the speed at the highest elevation can be monitored by means of an anemometer. To prevent any danger, in particular, due to sudden changes in wind speed or direction during the passing of weather fronts, weather reports should be taken into account when lifting operations are being scheduled. Instructions should be laid down in the instruction manual providing suitable measures for lowering the crane to a safe position.

$\boxed{A_1}$ NOTE 2 $\boxed{A_1}$ Mobile cranes are normally equipped with $\boxed{A_1}$ boom $\boxed{A_1}$ systems which can be lowered quickly and readily. As a result, the hazards due to sudden changes in wind speeds and increases in gust speed at elevated points can be reduced in a short time, e.g. within 5 min.

4.1.2.2.3 Out-of-service wind loads (when the crane is not in operation)

a) Out-of-service storm winds

To calculate the wind loads when the crane is not in operation, an average, regionally varying, reference wind speed can be assumed. The reference wind speed v_{ref} is determined over 10 min at 10 m above ground or sea level. In Europe the following figures are applicable (see Annex N.3):

Regions	A	B	C	D	E
v_{ref} [m/s]	24	24	28	32	36

The design is considered safe when all the required verifications including the effect of 3-s elevation-related wind gusts are calculated based on a reference wind speed (see formulas in 4.1.2.2.1 and Annexes N.1 and N.2).

b) Out-of-service limiting wind speed

To calculate the wind load effect when the crane is not in operation, the wind gust speed at the highest elevated point v_a (max. z) shall be considered. See Annexes N.1 and N.2. The required safety shall be verified for all permitted configurations and/or positions of the crane.

Precise elevation-related calculations of the wind forces acting on the $\boxed{A_1}$ boom $\boxed{A_1}$ in such a configuration and/or position are permissible, e.g. in 10 m elevation intervals, for the relevant gust speeds (3-s gust speed).

The forces on the crane and its components resulting from the impact pressure shall be combined with the dead weights and, if required, with other geometric influences (e.g. out of level surfaces).

NOTE 1 A crane which is safe with respect to the effect of the wind speeds v_a (max. z) based on crane-specific limits, should only remain in this configuration and/or position up to the derived wind gust speed.

Information shall be provided in the instruction manual as to which measures shall be taken by the crane operator in order to maintain the crane in safe condition, e.g. by lowering or telescoping in the $\boxed{A_1}$ boom $\boxed{A_1}$ in the event that v_a (max. z) is exceeded. Instructions shall be laid down in the instruction manual providing suitable measures for securing the crane out-of-service.

NOTE 2 The safety of a crane is only maintained within the range of the permissible wind speed v_a (max. z) while the crane is (in- or) out-of-service. Therefore exceeding of the limiting wind speed out-of-service should be prevented by planning a lift including the weather forecast.

4.1.2.3 Load effects on steel structures

The loads acting on the steel structure of general use mobile cranes shall be calculated in accordance with FEM 5.004:1994, where the group classification A1 of ISO 4301-1:1986 and ISO 4301-2:1985 applies.

If a mobile crane is designed to carry out simultaneous movements, the load effects of two of these movements shall be taken into account (see Annex D). As a minimum requirement the load combinations of the load cases 1, 2 and 3 in Table 1 of FEM 5.004:1994 shall be calculated.

4.1.2.4 Load effects on non steel structures

Non-steel structures shall be designed with equivalent safety margins as for steel structures for their intended lifetime. Special characteristics (e.g. tensile creeping, relaxation, anisotropy, thermal behaviour) shall be considered. The technical requirements for these materials are not dealt with in this standard. Sufficient knowledge and experience shall be proven by the manufacturer of the crane or the supplier of such structures.

4.1.2.5 Load effects on load bearing components

4.1.2.5.1 General

For the purpose of this European Standard, the term "load bearing component" applies to all single parts or assemblies of parts of a crane, which are directly subjected to load effects (see 3.15).

There are two different procedures to design the components of a crane and to proof their competence. Either the components are designed individually, using the applicable standards concerning load effects and proof calculation or the pre-designed components have to be selected.

For individually designed components, the load effects derived from the service conditions shall be established by the crane designer.

For pre-designed components, the crane designer and the component designer/supplier shall identify and agree upon the relevant load effects derived from the service conditions (see 4.1.3.4).

4.1.2.5.2 Load effects on mechanisms

Differing from the (steel) structures, which are loaded by only one important stress cycle per operating cycle, the mechanisms are loaded by multiple stress cycles depending on linear movements, distances and the number of rotational movements.

The estimation of the number of stress cycles during the assumed life time of the mechanisms is based upon the written agreement upon service conditions between the user and the manufacturer of the crane.

Where the use of mechanisms is unknown, the stress cycles and assumed life time shall correspond with those values available from previous experience.

The mechanism group classification shall be in accordance with Table 6 of ISO 4301-1:1986 and Table 2 of ISO 4301-2:1985 (complies with T.2.1.3.4 of FEM 1.001:1998, booklet 2).

The load effects for mechanisms shall be calculated in accordance with 2.5 and 2.6 of FEM 1.001:1998, booklet 2.

4.1.2.5.3 Load effects on ropes

The loads acting on running and stationary ropes used directly for lifting the load or supporting the crane structure shall be calculated from the dead loads and the nominal working loads as specified in Table 1 of FEM 5.004:1994, load combination case 1.

The coefficient of utilization depending on the crane mechanism classification shall be in accordance with ISO 4308-2. The influences of dynamic effects and friction losses shall be covered. For crane classification A1, the working load factor Φ may be taken as 1,0. The friction losses shall be calculated according to Annex P.

4.1.2.5.4 Load effects on chains

The loads acting on chains used as components for lifting the load or supporting the crane structure shall be taken as the maximum value from the two cases: maximum occurring force for the moving chain or calculating the dead loads and the nominal working loads as defined in Table 1 of FEM 5.004:1994, load combination case 1.

The chain group classification shall be in accordance with Table 6 of ISO 4301-1:1986 and Table 2 of ISO 4301-2:1985 (complies with T.2.1.3.4 of FEM 1.001:1998, booklet 2).

Dynamic effects shall be covered by increasing the load with the working load factor. Technical requirements for friction losses are not covered with in this standard.

4.1.2.5.5 Load effects on other load bearing components

The loads acting on other load bearing components shall be calculated as specified in 4.1.2.1, if they are loaded with only one important stress cycle per operating cycle and the other conditions of Clause 6 of FEM 5.004:1994 are fulfilled.

The classification of each component, which is loaded by multiple stress cycles per operating cycle, shall be in accordance with 2.1.4 of FEM 1.001:1998, booklet 2. The load effects for these components shall be calculated in accordance with 2.2 and 2.3 of FEM 1.001:1998, booklet 2.

4.1.2.6 Load effects for determination of rigid body stability

4.1.2.6.1 General

The rigid body stability of the crane shall be in accordance with ISO 4305.

The values to be considered for the rigid body stability shall be taken as specified in Tables 1 and 2 of ISO 4305:1991.

Tipping lines of mobile cranes depend on the individual design. Examples for tipping lines are given in Annex A of ISO 4305:1991. For crawler cranes special attention has to be given to forward or backward tipping over the sprocket and/or first roller.

It is assumed that the crane is operated on a firm and level surface (up to 1 % gradient of the ground). If greater gradients of the slewing plane are allowed by the manufacturer, special capacity charts shall be provided. A minimum side gradient of 0,5 % for cranes on outriggers and/or 1 % for cranes free on tyres or crawlers shall be taken into account.

The maximum values of forces and pressures resulting thereof shall correspond to the allowable values of the inclination of the crane level and the limits shall be established for the relevant capacity charts. Special attention shall be given to the elastic deformation of the crane structure and the crane movements (slewing, luffing, travelling, etc.) increasing the supporting forces and ground pressure.

4.1.2.6.2 Stability for sudden release of the load

Accelerations due to sudden release of the load can cause tipping backwards of the crane or can cause unintended backward motions of parts of the crane. Instead of an exact calculation, a vertical upward force acting on the unloaded crane without wind loads may be used.

The vertical upward force shall be taken as $\geq 10\%$ of the rated capacity for cranes with classification A1 according to ISO 4301-2:1985.

4.1.2.6.3 Stability during erection and dismantling

The rigid body stability for erection of the unloaded crane and its dismantling procedure shall be considered as a special loading condition. The dead loads and the additional loads (gravitational, wind loads, etc.) increasing the tipping moment shall be amplified with a safety coefficient $\geq 1,1$.

4.1.2.6.4 Additional effects

The following additional effects shall be considered to determine adequate stability of the crane:

a) Additional effects due to elasticity of the crane

Special attention shall be paid to the elastic behaviour of the crane, considering:

- 1) effects due to elastic deformation of carrier, wheels, tyres, crawlers and outriggers;
- 2) effects due to angle displacement of the A_1 boom/jib A_1 system during slewing of the load according to different stiffness of the carrier in different slew ranges.

b) Additional effects due to acceleration

Accelerations due to abrupt starting/stopping of movements of the crane and/or the load can cause unintended movements of the crane and/or the load (kinetic energy). To determine adequate stability to avoid tipping of the crane sufficient potential energy shall be provided.

These dynamic effects shall be covered by calculation or by a simplified procedure using a tipping angle, see Annex F.

4.1.3 Limit states

4.1.3.1 General

Limit states shall be as specified below. Where the limit states of materials and components are not given below, they shall be laid down as written agreement between the crane manufacturer and the supplier of these materials and components on the basis of recognized methodology and standards.

The limiting values for materials shall include the static and dynamic (where required) properties for strength and ductility – depending on the dimension, the kind of fabrication (heat treatment), the allowed temperature for in- and out-of-service conditions, the elastic properties and their suitability for the production process and use.

NOTE The limit states may be found by tests of material specimen and of components or by applying theoretical methods and using basic test results additionally, if appropriate.

4.1.3.2 Limit states for steel structures

The limit values for structural and fine grained steel types of common use shall be taken from the table in Annex H (see Table 2 of FEM 5.004:1994).

The limit states for steel structures shall be calculated from the values of the relevant European Standards for materials or, where not existing, the specialized data sheets for those materials, which are not covered by harmonized standards, as provided by the manufacturers of these materials.

The permissible and/or limiting stresses of structural components and welds shall be calculated by the yield stresses and the (safety) factors according to L.2.2 and L.2.3.

4.1.3.3 Limit states for non steel structures

The limit states for non steel structures shall be calculated from the values of the relevant European Standards for materials or, where not existing, the specialized data sheets for those materials, which are not covered by harmonized standards, as provided by the manufacturers of these materials. The requirements for these materials are not dealt with in this standard.

4.1.3.4 Limit states for load bearing components

4.1.3.4.1 Limit states for mechanisms

The limit states for mechanisms shall be specified by the manufacturer/supplier of the mechanism. They are based upon information about dimensions, loading, assembly and service conditions which were taken into account when designing the crane.

The minimum requirements for the technical specification agreed between crane manufacturer and manufacturer/supplier of mechanisms shall be based upon uniform formats given for the particular type of mechanism. The technical specification for gears and drums shall include the parameters shown in the related annexes:

- Gears: Hoist/derrick gear **see Annex J.1**
- Slew gear **see Annex J.2**
- Travel gear **see Annex J.3**
- Drums: Hoist/derrick drum **see Annex J.4**

4.1.3.4.2 Limit states for ropes

The design of a rope system including its end termination shall permit the desired lifetime under the estimated conditions of service specified for the particular application. The limit states for ropes and/or the components of the rope system can be derived either from European Standards or from long term experience and tests by the crane manufacturer and/or the rope manufacturer or by other equivalent experimental methods.

All ropes used shall have a rope certificate giving the limit states as determined by the rope manufacturer (see Annex R).

The limit states of a stationary rope are determined by the design of the rope and given as the minimum breaking load identified by series of tensile strength tests.

The minimum breaking load of the rope is the decisive value for the limit states under the following conditions:

- a) crane and mechanism group classification in accordance with ISO 4301-2;
- b) ratio of the pitch diameters of drums, sheaves and pulleys to the nominal diameter of the rope is in accordance with ISO 8087 (for running ropes only);

c) code of practice for examination and discard is in accordance with ISO 4309.

NOTE The limit states of a running rope depend on the design of the rope itself, the design of drums, sheaves and pulleys and on the ratio of the pitch diameters to the nominal diameter of the rope. The limit states of running ropes can be identified by the minimum breaking load and the permissible number of bending cycles.

The minimum breaking load shall be compared with the nominal load (see L.4.3, proof of competence for ropes).

Rope end termination shall not be made by means of rope clips (bulldog clips). The use of rope clips on the tail end only of a rope passing through a wedge socket to prevent the rope slide back through the socket is permitted.

4.1.3.4.3 Limit states for chains

All chains used as components for a mobile crane shall have a chain certificate giving the limit states as determined by the chain manufacturer (see Annex S).

NOTE The limit states for chains are based upon information about dimensions, assembly, service conditions, cleaning and maintenance conditions specified by the crane manufacturer and a Wöhler curve given by the supplier in relation to the stress cycles occurring during the assumed life time.

4.1.3.4.4 Limit states for other components

NOTE The limit states for other load bearing components should be specified by the manufacturer/supplier of the component. They are based upon information about dimensions, loading, assembly and service conditions which were taken into account when designing the crane.

The minimum requirements for the technical specification agreed between crane manufacturer and manufacturer/supplier of components shall be based upon the uniform format given for the particular type of component. The technical specification shall include the parameters shown in the related annexes:

- Lifting hooks: **see Annex K.1**
- Sheaves: **see Annex K.2**
- Hook blocks: **see Annex K.3**
- Hydraulic cylinders: **see Annex K.4**
- Slew rings: **see Annex K.5**

4.2 Equipment and devices

4.2.1 General principles

The ergonomic requirements for the general design of equipment and devices shall be in accordance with EN 547-1, EN ISO 7250, EN ISO 6385. The principles of EN 626-1 for selection of materials shall apply. Hazards shall be avoided according to EN 294, EN 349 and EN 811.

Sharp edges of equipment and devices which have to be accessed during normal use shall be avoided by means as laid down in 4.2.2.3.

Electrical cables shall not be installed in close proximity to hot pipes or hoses (e.g. A1 *deleted text* A1, exhaust system) that are likely to cause damage to the cables.

A1 Space for a first aid box shall be available on the crane at a place easily accessible, preferably in a cabin. A1

4.2.2 Control station

4.2.2.1 General

Control stations and control devices shall be designed and placed to enable the safe use of the crane.

Control stations for the movement of the load and/or the travelling of the crane shall be provided with a cabin (crane operation cabin, crane travelling cabin). This does not apply to the provision of remote controls.

Elevated control stations shall be solidly designed and built. They shall be reliably attached to the crane. The material in the supporting structure shall be fire retardant. Damage to shock absorbers or absorbent material as a result of fire shall not allow the control station to come loose from its supports. For guidance see ISO 8566-2 and ISO 11660-2.

Elevating control stations shall be designed and built in accordance to EN 14502-2:2005.

The dimension of railings (handrail, knee and foot ledge) shall be in accordance with Figures 4, 7, 12 and Table 6 of EN 13586:1999.

4.2.2.2 Crane operating cabin

Covering and insulation of walls, floor and ceiling shall be made of fire retardant material, see 4.5.1. These materials shall minimize optical reflections disturbing the operator.

The cabin floor shall be designed to be cleaned easily without edges preventing the removal of dirt.

The cabin floor shall have a slip resistant surface (e.g. bulb plate/checker plate, open mesh, sanded paint).

 Information for the operation of the crane shall be provided to the operator in a directly readable format in the cabin. This may be in electronic or paper format. If paper documents are supplied, adequate space for storage of these documents shall be provided on the crane. 

Where a cabin roof is to be used during assembly and/or dismantling the surface shall be slip resistant. The loads arising from persons standing on the roof, including tools, etc. shall be taken into consideration. A proof load of 1 000 N applied evenly over an area of a 125 mm diameter disc anywhere on the surface shall not cause permanent deformation.

Where the surface of the cabin roof is intended to drain off water, the water shall not run down the windows.

4.2.2.3 Sharp edges

Parts of the equipment inside the cabin which are accessible during normal use shall not present any sharp edges or points which could cause injuries. Edges shall have radii (minimum 1 mm) or be chamfered (minimum 1 mm × 1 mm) or be covered achieving an equivalent level of safety.

4.2.2.4 Emergency exit

The crane operating cabin shall have exit routes for emergency evacuation in at least two directions. Emergency exits shall be easily recognised and opened from inside the cabin. The emergency exit route in a direction other than that of the normal entrance to the cabin may take the form of an opening with a size of an emergency exit as specified in ISO 11660-2. For example, an opening window or a window opening with an easily removable window pane of that size is suitable.

4.2.2.5 Space envelope

The space inside the cabin shall permit all operating controls to be actuated from the working position. The space shall also afford accessibility for the supervision, repair, etc. of the equipment inside the cabin. The minimum internal dimensions shall be in accordance with Figure 1 of ISO 8566-2:1995.

For cranes designed exclusively for use in confined spaces (e.g. lifting/travelling under low headroom conditions) the cabin dimensions can deviate from ISO 8566-2.

4.2.2.6 Heating and ventilation

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 in such a way that there is an adequate supply of fresh air to ensure complete combustion and that the exhaust gases cannot ingress into the  closed  cabin regardless of wind direction and speed.

4.2.2.7 Doors and windows

All crane operating cabin doors, whether of sliding or swinging type, shall be provided with a means of restraint from inadvertent opening or closing during travelling or operation of the crane. The door adjacent to the crane operator shall open outward or slide backward to open. The door shall be capable of being retained in the open position.

Crane operating cabin doors shall be lockable from the outside but not the inside. The door shall always be able to be opened from the inside without a key whether locked or not.

Crane operating cabin windows shall be equipped with latches which guard against opening the windows from outside the cabin.

All cabin windows shall be made of a material which will not produce sharp edges if broken (e.g. toughened or laminated glass) and that do not lose transparency in exposure to natural light.

Roof windows shall withstand or be protected against  falling objects , see 4.2.3.

4.2.2.8 Cabin lighting

All cabins shall be equipped with lighting to allow all information contained within the cabin, such as manuals, signs, labels or rated capacity charts, to be readily legible during operating conditions in accordance with ISO/CIE 8995-1, 2 and -3. The lighting shall be provided by a permanent installation.

4.2.2.9 Specific requirements for crane travelling cabins

Crane travelling cabins with a floor higher than 0,65 m above ground shall have entrances and exits with:

- a) step width of min. 300 mm;
- b) step depth of min. 80 mm;
- c) foot space height of min. 150 mm;
- d) foot space depth of min. 150 mm.

Steps shall:

- e) have the same distance of max. 400 mm to each other;
- f) be arranged in one straight line.

The access shall have ergonomic handrails.

4.2.2.10 Specific requirements for crane operating cabins

Cabins with a floor higher than 1,0 m (to be measured from ground level) shall be provided with handholds.
[A1] *deleted text* [A1]

Cabins with a floor higher than 2,5 m (to be measured from ground level) shall be provided with a platform and railings. This platform shall have enough space for at least two persons. Other control stations above 2,5 m height shall be provided with a platform with handholds and railings.

4.2.3 [A1] Protection against falling objects [A1]

As a minimum, the roof of the crane operating cabin including windows in the roof shall be able to withstand the impact of a steel ball weighing 7 kg, falling from a height of 2 m, without plastic deformations exceeding 50 mm.

4.2.4 Seats

4.2.4.1 General

The crane operating cabin shall be fitted with a seat having sufficient adjustments to enable the crane operator to operate the crane according to the ergonomic principles given in EN ISO 6385.

The seat shall be able to be locked in its adjusted positions. If foot supports and/or armrests are provided, accessibility to the crane operator's seat shall be maintained and the operation of the crane shall not be limited.

NOTE The seat should be provided with a [A1] *deleted text* [A1] headrest.

4.2.4.2 Dimensions

The seat dimensions shall conform to Annex E. The Seat Index Point (SIP) is given in EN ISO 5353.

NOTE The dimensions are based on EN ISO 3411.

4.2.4.3 Adjustments

All adjustments to accommodate the crane operator's size and weight shall be readily achievable without the use of any tool.

4.2.4.4 Vibrations

The value of vibrations transmitted by the crane operator's seat shall not exceed the limiting values specified in EN ISO 7096 and ISO 2631-1. The weighted acceleration shall be less than the given health guidance zones in ISO 2631-1. The vibration transmitted by the crane operator's handles/armrests shall be measured and valued according to EN ISO 5349-1 and EN ISO 5349-2.

4.2.4.5 Restraint system

If a restraint system is required, it shall conform to EN ISO 6683 unless otherwise specified by prevailing road regulations.

It is preferred to have the seat belt anchorage attached to the seat with the belt locking device to the side of the crane operator. Anchorage shall permit the restraint system to be readily installed or replaced.

4.2.5 Controls and control systems

4.2.5.1 General

All safety related functions of the controls mentioned in the subclause below shall be in accordance with EN 954-1:1996 category 1, all electronic evaluation devices with category 2.

NOTE 1 The crane operator interacts via a man-machine interface with the machine in an open loop system. This interface consists of control devices by means of which the crane operator initiates actions and by indicators the crane operator receives information. In addition certain motions of the crane are limited by motion/performance limiters and the rated capacity limiter. These limiters form an integral part of the control system.

NOTE 2 With the present state of art the control system of a mobile crane with the crane operator as a part of the system cannot prevent every dangerous situation. There are several influences which cannot be automatically controlled. The following list is not exhaustive:

- wind forces on the crane and/or the load;
- dynamic influences due to abrupt motions (influences outside the control system);
- ground conditions;
- demolition work.

4.2.5.2 Control devices

Control devices shall be in accordance with EN 614-1, EN 894-3, EN 1005-3 and EN 61310-2. The arrangement and the direction of movements of the control devices shall be in accordance with ISO 7752-2.

A1 If other arrangements for control devices are chosen due to the nature of the machine, the basic principles of the directions of movements of ISO 7752-2:2011 shall be followed (i.e. movements towards the body of the operator = lifting/raising/retracting, movements away from the body of the operator = lowering/extending, movements to the right = slewing right, movements to the left = slewing left).

NOTE 1 ISO 7752-2:2011 establishes the arrangement, requirements, and direction of movement of the basic controls for slewing, load hoisting and lowering and boom luffing and telescoping. **A1**

In case of more than one control device, the use of one of them precludes the use of the others.

The starting of a movement shall be possible only by intended actuation of a control device provided for this purpose.

The crane shall be provided with means to give an audible warning to persons in the vicinity of the crane (e.g. when the engine is started, when motions are initiated). This device shall only be able to be activated by the crane operator. The acoustic warning shall conform to the appropriate clauses of EN ISO 7731.

Control devices for extending/retracting the outrigger beams shall be in a position or provided with means where the movements of the outriggers can clearly be seen by the crane operator and from where crushing of the crane operator is not possible. If the horizontal movement of the outriggers is controlled from ground level, it shall only be possible to affect that movement on the side where the controls are situated.

With the present state of art, it is not possible to provide a complete view of all the danger zones from one control station. Therefore means for the viewing of danger zones (e.g. mirrors, TV-cameras) or control stations at different places related to the hazardous movement shall be provided.

In case crane functions including all outrigger movements (e.g. sliding beams, slewing beams, support cylinders), pinnings, assembly devices, etc. are controlled by cable less control systems, EN 13557 applies.

A1 NOTE 2 **A1** By means of cableless control systems all danger zones can be completely monitored by direct view, whilst being out of the danger zone

Resetting devices where fitted require additional protection to avoid inadvertent activation (e.g. key switch).

On systems with electronic selector switches (e.g. keyboards) the breakdown of the power supply with loss of the stored information, the recovery of power supply shall result in a reset whereby no selection is activated.

To enable the crane operator to check the selected configuration and compare it easily with the configuration of the machine itself the following shall be provided:

- symbols and figures at or near to the configuration selector switch; or
- in case of coded information (e.g. thumbwheel with code numbers), the code number shall refer to each different configuration. Each code number shall be printed in the relevant place on the capacity chart;
-  permanent information on the outriggers position. 

4.2.5.3 Starting

The starting system shall be in accordance with EN 1037.

Means shall be provided so that no unintended movement of the crane is possible until the crane operator is in the prescribed operating position (e.g. armrest switch, dead man switch, seat switch).

4.2.5.4 Stopping

All control devices shall move to the neutral position (stop) when released.

 An emergency stop equipment according to EN ISO 13850 stopping category 1 shall be provided. It shall be located at a prominent place in the operator's cabin which is easily accessible through the cabin door (for activation by third parties in case of emergency). This stopping device is not required for specific engine(s) related to travel on public roads. 

NOTE Emergency stop equipment according to EN ISO 13850 does not reduce the stopping time for dangerous motions. Contrarily emergency stop can generate additional hazards due to inertia of moving masses if they are stopped abruptly (e.g. swinging of the load).

4.2.6 Limiting and indicating devices

 *deleted text* 

4.2.6.1 Requirements for indicators, displays and limiters

4.2.6.1.1 General

All information provided by the indicators and displays shall be visible from the control positions, including remote controls, where that information is required.

Indicators and displays to ensure safe operation of the crane shall be in accordance with the appropriate clauses of EN 894-2 and EN 61310-1. Audible indicators shall be in accordance with EN ISO 7731. Visual indicators and displays shall be in accordance with the appropriate clauses of EN 842.

All safety related parts of limiting and indicating devices mentioned in the subclause below shall be in accordance to EN 954-1 category 1, all electronic evaluation devices with category 2.

If two or more motions can be carried out simultaneously, the motion/performance limiters shall take into account the effects of the possible combinations.

The effect of one motion upon another shall also be taken into account by the system where movement of that motion may cause another limit of motion or characteristic of performance to be exceeded.

The response of indicators and displays shall follow the corresponding motion with a suitable precision (e.g. $\pm 5\%$) and speed, so that they always show the current situation.

For stepped values (e.g. lattice  boom  length, or telescoping  boom  length with locking pins) the indicated values shall correspond directly to the related capacity chart.

At or near to each indicator at the control station(s) there shall be a legible and durable explanation of the function of the device (preferably by a symbol, see 7.3 or e.g. by the position of a selection device, by a turn wheel for falls of hoisting line).

4.2.6.1.2 Motion limiters

Any motion which has a designed restriction of movement has to be kept in the designed range. This can be done either by motion limiters or by the design of the device itself, e.g. limited stroke of a hydraulic cylinder.

NOTE 1 Regarding the state of the art, it is impossible to prevent automatically every dangerous motion or to prevent automatically every collision, e.g. man-machine, machine-machine, machine-fixed obstacle.

NOTE 2 Working space limiters and/or anti-collision devices can be provided if agreed between manufacturer and user of the crane. These devices cannot prevent hazards due to swinging of the load and/or the crane or parts of the crane caused by abrupt starting or stopping of movements caused by incorrect operation.

Where a motion is provided with a motion limiter, after the triggering of that motion limiter, movement in the opposite direction to a safe condition shall be possible without resetting.

Movements of attachment parts (for example luffing jibs), with restricted visibility and designed restrictions which cannot be easily monitored by the crane operator, shall be equipped with two consecutive motion limiters or with other devices ensuring the same level of safety (for example two independent angle sensors).

Where a motion is provided with two consecutive limiters, it shall not be possible to operate the limited motion after the second limiter has been activated. A reset action is necessary before the movement in the opposite direction is possible.

4.2.6.1.3 Performance limiters

A motion shall have a performance limiter if:

- the motion has a designed performance limitation which if exceeded can cause a failure of the structure or the mechanisms, overturning of the crane or falling of the load;
- there is an external influence which can cause the performance limitation to be exceeded (e.g. gravity).

NOTE Performance limiters are often an integral part of the system (e.g. a given diameter of a tube in a hydraulic system restricts the flow of hydraulic oil and therefore restricts the speed of lowering the load).

Performance limiters shall operate automatically when the respective performance limit is reached.

4.2.6.2 Mandatory limiters and indicators

4.2.6.2.1 General

The rated capacity limiter/indicator shall conform to **A1** 4.2.6.2.2 **A1** and **A1** 4.2.6.2.3 **A1** for all rated capacities given on the rated capacity chart and the test certificate for the crane.

A1 *deleted text* **A1**

Where a crane can be operated in different configurations, there shall be a precise and continuous indication of the crane configuration for which the rated capacity limiter/indicator has been set. As a minimum requirement, the configuration selection device shall provide a direct description of the configuration selected, or indicate a code which can be checked against a separate list of codes/configurations which are given on the capacity chart or attached to it.

The location/design of any configuration selecting device shall prevent alteration of the setting by the operator from the application of a load to the release of that load, but it shall be readily accessible whenever the configuration is changed.

On mobile cranes which can be operated in different configurations (e.g. on wheels, on outriggers, different counterweights, different A_1 boom/jib A_1 length, different number of falls) no unintended change of the configuration selection shall be possible (e.g. location of selection device, separate confirmation of settings).

A_1 NOTE Normally there is no check (automatic plausibility check), whether the selected configuration corresponds with the real configuration, except for the indication of the horizontal position of outriggers and/or crawlers (see 4.2.6.2.5.). A_1

Selections of configurations not referring to configurations of the crane permitted by the manufacturer shall not allow the crane to operate.

The design and installation of rated capacity limiters and indicators shall be able to withstand overloads during test and verification without dismantling and without affecting their performance (see 5.1).

4.2.6.2.2 Rated capacity limiter

All mobile cranes having a rated capacity of not less than 1 000 kg or an overturning moment of not less than 40 000 Nm shall be fitted with a rated capacity limiter.

The rated capacity limiter shall prevent the crane from supporting a load outside the limits of the permitted radii, and outside the positions and loads shown and/or described on the rated capacity chart and current test certificate or the permissible working load of the ropes.

The rated capacity limiter shall operate, with lowest possible working speed, between 100 % and 110 % of the rated capacity. This tolerance shall be achieved by the complete installation as fitted to the crane.

In case of increased tolerances additional structural strength and stability shall be provided to achieve the same level of safety as for above mentioned standard tolerance. The values of increased tolerances shall be given in the crane documentation.

The rated capacity limiter shall operate to override the controls of the crane:

- a) to prevent any motion that will lead to an overload condition; and
- b) to prevent dangerous movements of the load.

For a mobile crane the motions that shall normally be overridden by the rated capacity limiter when triggered are:

A_1 a) A_1 derricking out;

A_1 b) A_1 derricking in;

A_1 c) A_1 hoisting;

A_1 d) A_1 telescoping out.

NOTE 1 An override key for A_1 b) A_1 may be provided within the reach of the operator (for derricking in a suspended load).

NOTE 2 The derricking in/luffing in of a grounded load is not to be permitted (see 6.2.2.2, g)).

The rated capacity limiter shall not prevent the crane operator from returning the controls to the "stop" position and starting any motions that will move the crane to a safer condition.

The rated capacity limiter, once triggered, shall remain active until the overload has been removed. In all working areas of the crane, for which load charts are available, the crane control system shall ensure that it is not possible to override the rated capacity limiter excepted in the particular cases (see A_1 4.2.6.2.3 A_1).

4.2.6.2.3 Particular cases for the rated capacity limiter

Two particular cases in crane operation shall be covered as follows:

- a) For **rigging-/de-rigging procedures** and for **special operating conditions**, such as deadlock of the rated capacity limiter, a set-up button may be provided:

NOTE The set-up button is an electrical momentary contact switch that is not mechanically latched.

- 1) For rigging/de-rigging procedures, where no load charts provided by the manufacturer are available, it is admissible to override the rated capacity limiter using the set-up button. These rigging/de-rigging procedures shall be described in the crane operator instructions and available to the operator.
- 2) For special operating conditions (e.g. deadlock), the shut-off limits of the rated capacity limiter shall not exceed 110 % (plus tolerance) of the load chart when the set-up button is actuated. Here, the speeds of all movements shall be only max. 15 % of the permissible working speed for the corresponding load case.

For mobile cranes where an actuating device controls the hydraulic pressure, this speed reduction may be provided by a central control pressure reduction. All speeds must be hereby reduced to max. 25 %.

This set-up button shall not allow any movement which can lead to component failure or loss of stability.

The increase of the shut off limits by the set-up button shall automatically reset when the control lever(s) is/are in neutral position, or at engine stop, with a delay of 10 s being permissible.

- b) In case of a **failure of components** of the rated capacity limiter/the load moment limiter, or in emergency situations, a bridging device may be necessary. For this case, bridging device may be provided, if:

- 1) the bridging device is located outside of the crane operator's cab and is under lock and key (e.g. a switch in a locked cabinet or a key switch); and
- 2) the bridging of the rated capacity limiter resets automatically:
 - i) at engine stop;
 - ii) not later than after 30 min; and
- 3) upon actuation of the bridging device, the speeds of all **movements increasing the loading condition** are only max. 15 % of the permissible working speed for the corresponding load case.

For mobile cranes where an actuating device controls the hydraulic pilot pressure, this speed reduction may be provided by a central control pressure reduction. This shall reduce **the speeds of all movements increasing the loading condition** to max. 25 %.

If the mobile crane is equipped with a set-up button and/or a bridging device, then an $\boxed{A_1}$ event recorder $\langle A_1 \rangle$ shall be available which meets the following criteria:

- the data shall be recorded automatically, independent of the crane operator;
- each actuation of the set-up button or the bridging device, which leads to an overloading of the crane (> 100 % of the set load chart), shall be recorded. Here, the size of the overloading shall be recorded;
- in addition, if the set-up button, or the bridging device, is activated, all data shall be recorded which are relevant to reconstruct the last load case;
- a suitable interface to read out the data shall be available;
- suitable measures shall prevent the manipulation of the recorded data;
- the function of the $\boxed{A_1}$ event recorder $\langle A_1 \rangle$ shall be automatically checked each time the crane is put into operation. An $\boxed{A_1}$ event recorder $\langle A_1 \rangle$ malfunction shall be indicated to the crane operator.

4.2.6.2.4 Rated capacity indicator

All mobile cranes having a rated capacity of not less than 1 000 kg or an overturning moment of not less than 40 000 Nm shall be fitted with a rated capacity indicator.

The rated capacity indicator shall give warnings in accordance with EN ISO 7731 and EN 842, for all motions that induce an approach to the rated capacity or an excess of the rated capacity as shown on the rated capacity chart and the test certificate for the crane.

The rated capacity indicator shall warn:

- a) the crane operator both visually and audibly of the approach to the rated capacity;
- b) the crane operator both visually and audibly and persons in the danger zone of the crane audibly so that they can take heed of the warning when the rated capacity limiter is activated;
- c) persons in the danger zone of the crane visually and audibly when the rated capacity limiter has been overridden.

Warnings for both the approach to the rated capacity, and for the rated capacity being exceeded, shall be continuous. There shall be a clear difference between the warning for approach and the warning for overload.

The rated capacity indicator shall give a warning of approach to the rated capacity starting between 90 % and 97,5 % of the rated capacity of the crane.

NOTE This gives the crane operator time to react to the warning and prevent the crane from being overloaded, e.g. slowing down of movements, to prevent the load from swinging.

No provisions shall be made for the crane operator to cancel a warning from the control station, except for the audible warning required by a) and b) above where a cancellation facility may be provided for this warning that only becomes operable after the warning has been active for 5 s. If such a cancellation facility is used, followed by the crane returning to a condition requiring an audible warning, the warning shall automatically operate.

The rated capacity indicator shall continue its function when the rated capacity limiter is overridden during testing, rigging or de-rigging.

Provisions can be made to cancel the audible warning during calibration and testing of the crane. Provisions can also be made for a rigging setting that inhibits audible warnings during the rigging of the crane.

The rated capacity indicator shall be such that its operation, but not necessarily its accuracy, can be checked without applying loads to the crane.



4.2.6.2.5 Outrigger and crawler position indicator

The rated capacity limiter/indicator shall monitor the horizontal position of the outriggers or retractable/extendable crawlers used during lifting of loads, as an operational aid. In the event that the horizontal position does not correspond with the selected crane configuration, a visual and audible warning will be given to the operator. This event shall be recorded by the event recorder as soon as:

- the operation mode is chosen and/or the configuration is acknowledged
- or crane movements affecting stability and/or structural integrity, are initiated.

The event recorder shall record physical setting and selected configuration.

The audible warning may be cancelled by the operator. Any change of the selected crane configuration or the horizontal outrigger/crawler position shall reinstate the audible warning.

The visual warning shall remain whilst the actual horizontal outrigger/crawler position does not correspond with the selected crane configuration.

The event recorder shall meet the requirements of 4.2.6.2.3.

NOTE 1 This requirement on warning represents a new state of the art that is introduced at the date of publication of this standard. Development is needed to further integrate outrigger monitoring into the Rated Capacity Limiter of the crane; mobile crane manufacturers are embarked on a program for this development.

NOTE 2 This requirement applies for all outriggers/crawlers used during lifting of loads; it does not apply for outriggers/crawlers used as assembly or erection aid. 

4.2.6.2.6 Crane level indicator

The crane level shall be indicated at or near at the crane operating cabin within the view of the crane operator. Mobile cranes supported by outriggers shall have in addition a crane level indicator at each outrigger control station where the levelling motion(s) can be controlled. The crane level indicator shall have an accuracy better than $\pm 0,1^\circ$.

4.2.6.2.7 Hoisting limiter

All cranes shall be fitted with a hoisting limiter to stop all motions which can cause the hook block to make contact with the  boom/jib or the boom/jib head  and cause damage. Bridging of the hoisting limiter shall only be possible for rigging operations and transport. The bridging device has to be of the type that requires to be held in the override position.

4.2.6.2.8 Lowering limiter

All cranes shall be fitted with a lowering limiter. As a minimum the lowering limiter shall ensure three turns of rope on the drum. Bridging the lowering limiter shall only be possible for rigging operations, transport and changing of the rope. The bridging device has to be of the type that requires to be held in the override position.

4.2.6.2.9 Additional mandatory indicators

All mobile cranes having a rated capacity of not less than 1 000 kg or an overturning moment of not less than 40 000 Nm the following indications shall be given to the operator on the indicator(s) for the current configuration and position of the crane with the following requirements:

a) Continuous display during crane operation:

- 1) utilization of rated capacity: for all configurations, given as an analogue display with marking of the loading status of the crane (e.g. green; yellow – approach to rated capacity; red – overload condition);
- 2) rated capacity: for cranes with a rated capacity in excess of 5 t a display of permitted load in accordance with the rated capacity at the actual radius/outrreach or  boom  angle;
- 3) working load: for cranes with a rated capacity in excess of 5 t (indication of load on the hook plus mass (weight) of hook and block).

NOTE For the purpose of error checking or adjustments special displays superseding the continuous display may be selected temporarily during crane operation(s).

b) Selected display (to be selected manually by the crane operator):

- 1) Related to capacities – display of:
 - i) radius/outrreach: when the crane is on radius/outrreach related rated capacities; on non-slewing cranes the outreach to the tipping axis shall be displayed;
 - ii)  boom  angle: when the crane is on angle related rated capacities;

- iii) fly jib angle: for luffing fly jib configurations, when the crane is on angle related rated capacities;
- 2) display of wind speed: when the crane has a $\langle A_1 \rangle$ boom/jib $\langle A_1 \rangle$ combination length in excess of 65 m, or where the stowing time is more than 5 min;
- 3) display of slew range: when the crane has slew range related rated capacities;
- 4) display of $\langle A_1 \rangle$ boom $\langle A_1 \rangle$ length: for telescopic $\langle A_1 \rangle$ boom $\langle A_1 \rangle$ cranes;
- 5) display of $\langle A_1 \rangle$ boom $\langle A_1 \rangle$ lock: for telescopic $\langle A_1 \rangle$ booms $\langle A_1 \rangle$ with locking mechanisms;
- 6) display of axle lock: for cranes with axle locking mechanisms;
- 7) display of falls of hoisting line: for all configurations;
- 8) display of slew position: when the crane is on slew range related rated capacities;
- c) Audible indicator:
 - 1) During travelling/slewing (audible warning): on cranes (on tyres and crawlers) where the operator has no clear view immediately behind the crane when travelling backwards. On cranes with additional counterweight (see A.7) when slewing.

4.2.6.2.10 Additional mandatory limiters

The following mandatory limiters shall be fitted to the crane under the following conditions:

- a) maximum $\langle A_1 \rangle$ boom $\langle A_1 \rangle$ angle and minimum for all configurations;
- b) maximum and minimum fly jib angle for luffing fly jib configurations;
- c) telescoping for telescopic $\langle A_1 \rangle$ boom $\langle A_1 \rangle$ cranes;
- d) slewing where there are slew range related rated capacities;
- e) control station position for cranes with moveable control stations;
- f) mast/A-frame position where mast/A-frame shall be kept within limits;
- g) slack rope on special configurations (see A.7) where slack rope may cause a special hazard.

4.2.7 Steering system

4.2.7.1 Steering – On-road mobile cranes

The steering shall ensure safe handling of the vehicle at speeds up to those permitted. The steering systems shall have power assistance with minimum two independent circuits and an automatic indication if the power assistance of one of the circuits fails.

NOTE 1 The steering system of on-road mobile cranes is subjected to national and European regulations (e.g. 70/311/EEC as amended, with vehicle category N3).

NOTE 2 Since the above covers steering control effort in the event of a single failure it can be assumed to meet the requirements of A.3.3.5 of EN ISO 12100-2:2003.

4.2.7.2 Steering – Off-road mobile cranes

The steering equipment shall ensure safe handling of the vehicle, including where the crane is permitted to travel with load, at speeds up to those permitted by the manufacturer.

Any crane conforming to the requirements of 4.2.7.1 can be considered to conform to the requirements of this clause.

For on site travel design speeds of 25 km/h and below it is not necessary to fit additional equipment to cater for a power assistance failure.

For travel design speeds on site greater than 25 km/h the steering shall not become inoperative because of the failure of a single power supply (electric, hydraulic, pneumatic) to either the power assistance of the steering system or the controls.

The permitted steering control effort requirements shall be as given in Annex M.

Steering controls for crawler cranes shall meet the requirements of 4.2.5.

4.2.7.3 Steering – Crane operating cabin

Where the crane is steered from a crane operation cabin on the rotating upper structure an indication of the direction of movement or an automatic change of the direction of steering – depending on the position of the rotating upper structure – shall be provided.

4.2.8 Braking systems

4.2.8.1 Braking systems for crane motions

4.2.8.1.1 General

This subclause covers static holding brakes and dynamic braking systems for crane mechanisms (e.g. hoisting, derricking and slewing mechanisms).

Smooth deceleration of each crane motion shall be achieved by a braking system (e.g. hydraulic brake, electric brake, mechanical friction brake). The minimum requirements shall be as follows:

- a) the wearing surface of all brake drums or plates shall be smooth and homogenous;
- b) the wearing surface of disk brakes may be of compound lining type and/or sinus disc type;
- c) brake linings shall be adequately and permanently secure during their effective life;
- d) dry type brake blocks and linings shall be protected from oil, grease and any environmental conditions which might affect brake performance;
- e) wet type brakes shall be reliably sealed for their lifetime;
- f) where the design of brakes requires inspection of the linings for maintenance, it shall be possible to verify the wear of the linings without dismantling. To ensure effective operation of the brake between such inspections or maintenance periods either sufficient torque reserve or a self-compensating system shall be provided;
- g) brake mechanisms that rely upon air or fluid under pressure or an electrical or electro-mechanical mechanism for application shall be such that the brake is applied automatically in the event of loss of energy of the operating system;
- h) static holding brakes for securing hoisting or derricking motions shall be such that the brakes are applied automatically in the event of loss of energy of the operating system. The brakes shall be connected directly to the drive/mechanism;
- i) on mechanisms where the drive can be disconnected from the drum freefall of the load and/or parts of the crane shall be avoided by adequate means (e.g. interlocking arrangement).

4.2.8.1.2 Hoisting and derricking brake

The holding brake for hoisting and for derricking systems operated by hoist and drum mechanisms shall be able to exert a restraining torque at least 33 % greater than the maximum torque transmitted from the rope drum to the brake under working or erection conditions, whichever is greater.

Mechanisms with dynamic braking systems (e.g. hydraulic brake valve, electrical braking) shall have a secondary holding brake system which is independent of the dynamic brakes restraining the same torque as for the primary holding brake.

The holding brake shall perform the function of an emergency brake for at least one operation in the event of failure of the dynamic brake system to avoid freefall. The holding brake shall operate automatically when the energy supply is switched off. The deceleration in an emergency case shall not lead to damage to the structure, ropes, drums and mechanisms.

NOTE After such an emergency stop it may be necessary to carry out maintenance, see 6.4.3, b).

4.2.8.1.3 Slewing brake

Slewing mechanisms shall be provided with a holding brake or a locking mechanism to hold the superstructure and  boom/jib  system during operation with load and during out-of-service condition in a safe position. The holding brake/locking mechanism shall withstand a torque moment at least 25 % above the torque required for holding the acting torque derived from wind loads combined with the inclination permitted by the manufacturer. The locking mechanism shall be able to be actuated in all permissible slewing positions.

The crane shall be equipped with a dynamic braking system which allows smooth deceleration by the crane operator. The deceleration shall not cause any damage to the structure of the crane. The dynamic braking system may be hydraulic, electric or mechanical.

If a mechanical brake is used as holding brake and as dynamic braking system, different controls for both applications shall be provided.

4.2.8.2 Braking systems for travel motions

4.2.8.2.1 On-road mobile cranes

The braking system shall ensure safe deceleration of the vehicle at speeds up to those permitted. The braking system shall have power assistance and have minimum two independent circuits with an automatic indication if the power assistance of one of the circuits fails. A parking brake shall be fitted.

NOTE The braking system of on-road mobile cranes is subject to national and European regulations (e.g. 71/320/EEC as amended with vehicle category N3).

4.2.8.2.2 Off-road mobile cranes on tyres

Off-road mobile cranes on tyres with a on site travel design speed greater than 25 km/h shall conform to 4.2.8.2.1. Off-road mobile cranes on tyres with a on site travel design speed of 25 km/h or below shall conform either to the requirements of 4.2.8.2.1 or at least to the following requirements for travelling, parking and emergency braking systems.

a) Travelling braking system

The travelling braking system shall have an efficiency of at least 25 % of gravitational acceleration measured on a decelerometer when stopping on level, dry and firm ground from half of the manufacturers permitted off-road speed when in normal travelling order without load.

b) Parking braking system

Besides the travelling braking system a parking braking system is required. A parking braking system shall be fitted to restrain all the loading, wind and gradient conditions specified by the manufacturer when the crane is in normal use.

This braking system shall be capable of holding the unloaded crane in normal travelling order on a gradient not less than 15 %. It shall also be operated by a separate system to that for the travel braking. The parking brake function may be achieved by the travelling brake.

Testing shall either be by means of a decelerometer on level ground or facing both up and down a gradient of 15 % minimum.

c) Emergency braking system

An emergency braking system shall be fitted to gain sufficient deceleration in case of failure of the travelling brake system. The emergency braking system shall be operated by fully independent and easily accessible controls.

Parking brake and emergency brake can be combined in the same system provided that it is purely mechanically operated. The emergency brake function may be achieved by the travelling braking system and/or parking braking system.

4.2.8.2.3 Off-road mobile cranes on crawlers

Off-road mobile cranes on crawlers shall conform to the requirements for travelling and parking braking systems following below.

a) Travelling braking system

A travelling braking system shall be fitted capable of slowing down and braking so as to ensure safety under all the operating, loading, speed and gradient conditions specified by the manufacturer when the crane is in normal use.

If braking during travel can safely and smoothly be applied by using the hydraulic driving system an additional travelling braking system is not necessary.

b) Parking brake

A parking braking system shall be fitted to restrain all the loading, wind and gradient conditions specified by the manufacturer when the crane is in normal use.

This braking system shall be capable of holding the unloaded crane in normal travelling order on a gradient not less than 15 %. It shall also be operated by a separate system to that for the travel braking. The parking brake function may be achieved by the travelling brake.

If friction loses in the crawler drive allow adequate braking, an additional parking brake system and a separate activation of the brake is not necessary. When determining these loses the friction and/or the holding torque in the hydraulic motor shall be neglected.

4.2.9 Protection devices

4.2.9.1 Moving parts

The control station shall be provided in such a way that the hands, arms, the head or other parts of the operators body cannot be crushed due to proximity of moving parts (e.g.  boom , derricking, cylinder). The safety distances of EN 294, EN 349 and EN 811 shall apply.

The slewing ring and the hoists shall have protection to avoid the insertion of hands or limbs in the areas of gearing (pinion protection). All points where hazards can occur at open rope and chain drives and other moved parts (for