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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Cranes - Safety - Design - Requirements for equipment

Appareils de levage à charge suspendue - Sécurité -
Conception - Prescriptions relatives à l'équipement

Krane - Sicherheit - Konstruktion - Anforderungen an
die Ausrüstungen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 147.

If this draft becomes a European Standard, 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.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (prEN 13135:2025) has been prepared by Technical Committee CEN/TC 147 “Cranes - Safety”, the secretariat of which is held by SFS.

This document is currently submitted to the CEN Enquiry.

This document supersedes EN 13135:2013+A1:2018.

prEN 13135:2025 includes the following significant technical changes with respect to EN 13135:2013+A1:2018:

- updating of normative references;
- revision of List of significant hazards, move it to Annex A and re-numbering of other Annexes;
- revision and update of Table A.1;
- revision of Annex ZA.

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

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

For the relationship with other European Standards for cranes, see Annex B.

Introduction

This document is a harmonized standard to provide one means for equipment for cranes to conform with the essential health and safety requirements of the Machinery Regulation, as mentioned in Annex ZA.

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

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

- machine manufacturers (small, medium and large enterprises);
- health and safety bodies (regulators, accident prevention organizations, market surveillance etc.).

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

- machine users/employers (small, medium and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e.g. for maintenance (small, medium and large enterprises);
- consumers (in case of machinery intended for use by consumers).

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

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

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

1 Scope

This document specifies requirements for the design and selection of electrical, mechanical, hydraulic and pneumatic equipment used in all types of cranes and their associated fixed load lifting attachments with the objectives of protecting personnel from hazards affecting their health and safety and of ensuring reliability of function.

NOTE Specific requirements for particular types of cranes, and for load lifting attachments, are given in the appropriate European Standard.

The electrical equipment covered by this document commences at the point of connection of the supply to the crane (the crane supply switch) including systems for power supply and control feeders situated outside the crane, e.g. flexible cables, conductor wires or bars, electric motors and cableless controls.

The principles to be applied for cranes transporting hazardous loads are given in this document. Particular requirements are given for cranes transporting hot molten metal.

This document does not cover the detail design of individual items of equipment except with regard to their selection for specific aspects of use.

The proof of competence calculations and related strength requirements or safety margins of equipment and components are not covered by this document.

NOTE Some safety margins are given here for issues not covered in the EN 13001 series.

Hazards due to noise are not covered by this document. They are addressed in safety standards specific to each type of crane.

The specific hazards due to potentially explosive atmospheres, ionising radiation, and operation in electromagnetic fields beyond the range of EN 61000-6-2 are not covered by this document.

The significant hazards covered by this document are identified in Annex A.

This document is not applicable to cranes manufactured before the date of its publication.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 818-1:1996+A1:2008, *Short link chain for lifting purposes - Safety - Part 1: General conditions of acceptance*

EN 818-7:2002+A1:2008, *Short link chain for lifting purposes - Safety - Part 7: Fine tolerance hoist chain, Grade T (Types T, DAT and DT)*

EN ISO 14118:2018, *Safety of machinery - Prevention of unexpected start-up (ISO 14118:2017)*

EN 12077-2:2024, *Cranes safety - Requirements for health and safety - Part 2: Limiting and indicating devices*

EN 12385-4:2002+A1:2008, *Steel wire ropes - Safety - Part 4: Stranded ropes for general lifting applications*

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

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

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

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

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

EN 13155:2020, *Crane - Safety - Non-fixed load lifting attachments*

EN 13411-1:2002+A1:2008, *Terminations for steel wire ropes - Safety - Part 1: Thimbles for steel wire rope slings*

EN 13411-3:2022, *Terminations for steel wire ropes - Safety - Part 3: Ferrules and ferrule-securing*

EN 13411-4:2021, *Terminations for steel wire ropes - Safety - Part 4: Metal and resin socketing*

EN 13411-6:2004+A1:2008, *Terminations for steel wire ropes - Safety - Part 6: Asymmetric wedge socket*

EN 13480-3:2024, *Metallic industrial piping - Part 3: Design and calculation*

EN 13557:2024, *Cranes - Control devices and control stations*

EN IEC 60204-11:2019, *Safety of machinery - Electrical equipment of machines - Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV (IEC 60204-11:2018)*

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

EN 62745:2017, ¹ *Safety of machinery - Requirements for cableless control systems of machinery (IEC 62745:2017)*

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

EN ISO 4414:2010, *Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010)*

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

EN ISO 13732-1:2008, *Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces - Part 1: Hot surfaces (ISO 13732-1:2006)*

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

EN ISO 13850:2015, *Safety of machinery - Emergency stop function - Principles for design (ISO 13850:2015)*

¹ As impacted by EN 62745:2017/A11:2020.

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

ISO 4309:2017, *Cranes — Wire ropes — Care and maintenance, inspection and discard*

ISO 4347:2015, *Leaf chains, clevises and sheaves — Dimensions, measuring forces, tensile strengths and dynamic strengths*

ISO 6336-1:2019, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6336-2:2019, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability (pitting)*

ISO 6336-3:2019, *Calculation of load capacity of spur and helical gears — Part 3: Calculation of tooth bending strength*

ISO 6336-5:2016, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials*

ISO 10300-1:2023, *Calculation of load capacity of bevel gears — Part 1: Introduction and general influence factors*

ISO 10300-2:2023, *Calculation of load capacity of bevel gears — Part 2: Calculation of surface durability (macropitting)*

ISO 10300-3:2023, *Calculation of load capacity of bevel gears — Part 3: Calculation of tooth root strength*

ISO 12482:2014, *Cranes — Monitoring for crane design working period*

ISO 12488-1:2012, *Cranes — Tolerances for wheels and travel and traversing tracks — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010, ISO 4306-1:2007, EN 60204-32:2008 and the following apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

backup brake

brake that is additional to the service brake that is able to stop and hold the load

Note 1 to entry: A backup brake can have fewer design cycles than the service brake.

Note 2 to entry: Such a brake is also known as emergency brake or safety brake.

3.2

backup limiter

limiter that is only activated if other (primary) limiting means fail to operate as intended

3.3**belt system**

system for supporting and moving load or crane part via belt and wheel arrangement, comprising the belts and all the attachments and parts which are in contact with the belts

EXAMPLE Belt drive wheels, belts, belt reversing wheels, belt terminations and belt guides.

3.4**chain system**

system for supporting and moving load or crane part via chain and wheel arrangement, comprising the chains and all the attachments and parts which are in contact with the chains

EXAMPLE Chain drive wheels, chains, chain reversing wheels, chain terminations and chain guides.

3.5**compensating beam**

beam to equalise forces at the ends of two ropes

Note 1 to entry: The amount of compensation is limited by the permitted movement of the beam.

3.6**compensating sheave**

sheave which performs the function of compensating beam in a continuous rope system

Note 1 to entry: The amount of compensation is not limited by the movement of the sheave.

3.7**hoisting mechanism**

drive mechanism for lifting and lowering the load

[SOURCE: ISO/DIS 4306-1:2024, 7.1, modified – alternate term is used]

3.8**load bearing chain**

assembly of load bearing components

3.9**load bearing component**

mechanical or structural component which is stressed by the hoist load

3.10**load hook**

device attached to chain, rope, bottom block or lifting attachment from which the load, load handling devices or slings can be suspended

3.11**laminated hook**

load hook consisting of several parallel oriented plates

EXAMPLE Typically used for transporting hot molten substances.

Note 1 to entry: Also known as multi-plate hook.

3.12

rated capacity

rated load

maximum **net load** that the crane is designed to lift for a given crane configuration, load location and operating condition

Note 1 to entry: For mobile cranes, replace **net load** in the definition by **hoist medium load**.

Note 2 to entry: For net load and hoist medium load, see ISO 4306-1:2007.

3.13

redundant

multiple arrangement of components and/or sub-assemblies arranged so that if one of the components or sub-assemblies fails, the function is still operational

Note 1 to entry: The function can be with limited performance.

3.14

rope anchorage

arrangement comprising the parts between the rope termination and the fixed load bearing structure

EXAMPLE Pins, bolts, compensating beams, tension rods.

3.15

sheave

rotating element with one or more grooves for guiding and/or changing the direction of the rope (chain) without essential change of the rope (chain) force

[SOURCE ISO/DIS 4306-1:2023, 7.25]

3.16

rope system

system for supporting and moving load or crane part via rope and sheave arrangement, comprising the ropes and all the attachments and parts which are in contact with the ropes

EXAMPLE Wire ropes, sheaves, compensating sheaves, rope terminations and rope guides.

Note 1 to entry: Rope attachment on the drum is included but the rope drum itself is outside of this definition.

3.17

rope termination

equipment to connect the end of the rope to a rope anchorage

3.18

self-locking braking device

braking device whose braking effect is accomplished solely as a result of movement to be braked

3.19

single failure proof hoisting mechanism

hoisting mechanism comprising several parallel chains of components, arranged so that in case of failure of any single component in the total mechanism, the hoisted mass is not dropped

Note 1 to entry: After the failure, the mechanism is not necessarily functional as such.

3.20

vertical movement

movement of hoist load or of a crane part, where the slope of the path of the moved mass is 5 % or steeper in relation to horizontal level

4 Safety requirements and/or protective measures

4.1 General

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

NOTE Specific requirements for particular crane types can be given in the appropriate European Standards, see Annex B.

4.2 Electrical equipment

4.2.1 General

The electrical equipment shall conform to EN 60204-32:2008 as amended in this document.

High voltage equipment (exceeding 1 000 V AC or 1 500 V DC) shall conform to EN IEC 60204-11:2019. All references to EN 60204-1 in EN IEC 60204-11:2019 shall be considered as references to the respective clauses in EN 60204-32:2008.

4.2.2 Physical environment and operating conditions

When the physical environment or the operating conditions are outside those specified in 4.4 of EN 60204-32:2008, the specification of the electrical equipment shall be amended accordingly.

Wind chill effects and solar heat gain shall be taken into account where appropriate.

4.2.3 Electrical supply

The electrical equipment shall be designed to operate correctly in the conditions specified in 4.3 of EN 60204-32:2008. Where the cable length and cross section would cause voltage drops in excess of those allowed under EN 60204-32:2008, the selection of equipment shall be based on actual voltages.

When calculating the voltage drop, the position of the hoisting appliance in relation to its supply point shall be taken into account. The starting (I_D) and rated (I_N) currents of the motors operating simultaneously shall be taken into account.

NOTE 1 The rated current (I_N) cannot necessarily be considered to mean the nameplate current of the motor but the current drawn by the motor at full rated load.

For squirrel-cage induction motors I_D (starting current), refer to the motor's catalogue. In case the motor is controlled by an electronic drive (soft-starter, frequency converter etc.), the maximum current occurring during operation shall be considered as starting current, although the highest current does not necessarily occur when starting the motion.

NOTE 2 With direct starting of squirrel cage motors, I_D is typically five to ten times I_N . For slip-ring motors, I_D is typically two times I_N . With electronic drives, the starting current depends on the converter type and on its adjustments; with frequency converters in hoisting motions I_D is typically below two times I_N .

Where the crane-supply-switch is not readily accessible on the access way to the crane, the crane-disconnector and disconnectors for special circuits shall be capable of breaking the short circuit current of the associated circuits.

4.2.4 Protection against electric shock by direct contact

For each circuit or part of the electrical equipment, protection against electric shock by direct contact shall, whenever practicable, be provided by enclosures or insulation of live parts in accordance with EN 60204-32:2008.

Where these measures are not practicable,

- in electrical operating areas and enclosed electrical operating areas, protection by barriers in accordance with HD 60364-4-41:2017 may be provided;
- only in the case of conductor bars and conductor wires, protection by placing out of reach in accordance with EN 60204-32:2008 may be provided.

4.2.5 Control circuits and control functions

Where means for temporary suspension of safeguarding in accordance with EN 60204-32:2008, 9.2.4 is provided,

- the device for suspending shall be located inside an enclosure, access to which, requires special tools, or
- other means, not available for normal operation, e.g. a key-operated switch or password protection, shall be provided.

Suspension of safeguarding shall also limit the performance of the machine or have other means (e.g. automatic restoration of the safeguarding after power-off or a time delay) to avoid prolonged suspension.

Push-buttons and similar control devices that alternately initiate and stop an action, shall not be used for motion drives.

Cableless controls and control functions shall be in accordance with 9.2.7 of EN 60204-32:2008 and EN 62745:2017.

4.2.6 Operator interface and mounted control devices

Control devices and control stations and their operating positions shall be in accordance with EN 13557:2024.

The function of each control actuator shall be indicated on or adjacent to it.

The colours of push-buttons shall be in accordance with EN 60204-32:2008, 10.2 and colours to be used are as in the Table 1 unless otherwise stated in the instruction for use.

Table 1 — Colours of push buttons

Start/On	Green
Stop/Off	Black
Hold to Run	White
Reset	Blue
The stop button of a cableless control station	Red

Other functions	Yellow or grey
-----------------	----------------

4.2.7 Power driven motions

All powered motions shall be power driven at all times during normal operation.

4.2.8 Selection of motors

4.2.8.1 General

Motors for a crane motion shall be designed such that the motors have enough capacity:

- to perform the specified, consecutive working cycles without overheating;
- to start the motion with a specified acceleration;
- to maintain the specified speed of the motion.

Decisive duty features for sizing of crane motors are short-term factors such as the starting period of the motion or a single work cycle. Consequently, the basic crane duty parameters of EN 13001-1:2015 – the hoist load spectrum and total number of work cycles – are not relevant for sizing the motor as an electrical component. The average distance per work cycle of each motion in accordance with EN 13001-1:2015 shall be taken into account, when determining an appropriate rating type of the motor duty and thermal power rating requirement.

The following, related factors shall be taken into account together with the motor itself:

- features of the electrical drive system (rated current and voltage with resulting motor torque characteristics, speed regulation and type of braking);
- cyclic duration factor of the specified duty;
- number of cycles/hour;
- type of power feed;
- degree of protection (environment conditions);
- ambient temperature in the motor location;
- altitude of the operating site.

4.2.8.2 Loadings

4.2.8.2.1 General

The loads to be applied in 4.2.8.5 to 4.2.8.7 shall be in accordance with EN 13001-2:2021, setting all the dynamic factors $\phi_i = 1$ and the partial safety factors $\gamma_p = 1$. The hoisted load shall be applied with the value of the rated load, unless otherwise specified. The wind state for an outdoor crane shall be that specified for the crane and applied in calculation of wind forces in accordance with EN 13001-2:2021. Travel resistance shall be taken into account as an external load action.

In transforming the load actions to a motor torque, the internal efficiency (friction) of the mechanical system shall be taken into account.

For the thermal capacity calculation in 4.2.8.7, the load combinations A of EN 13001-2:2021 shall be applied, with the addition of in-service wind force during controlled movement in accordance with EN 13001-2:2021 into each load combination.

For the torque calculations in 4.2.8.5 and 4.2.8.6, the load combinations B of EN 13001-2:2021 shall be applied, applying the in-service wind force required for starting drive forces in accordance with EN 13001-2:2021.

4.2.8.2.2 Travel resistance

The total travel resistance due to rolling resistance and bearing friction in cases, where a wheel is running on a flat surface, shall be calculated by multiplying the wheel force perpendicular to the running surface by a rolling friction factor.

Values given in the Table 2 shall be used for the rolling friction factors for a steel wheel equipped with roller bearings.

Table 2 — Rolling friction factors for steel-steel contact

Wheel construction	Wheel diameter D_w [mm]								
	50	80	100	125	160	250	320	400	630 and larger
Flanged wheels	0,013	0,011	0,01	0,009	0,008	0,006 5	0,006	0,005 5	0,005
Flangeless wheels	0,011	0,009 5	0,008 5	0,007 5	0,007	0,005 5	0,005 2	0,005	0,004 5
Friction factors for intermediate values of D_w may be derived by interpolation.									
NOTE Wheel diameters less than 50 mm are not dealt with.									

4.2.8.2.3 Wheel friction

The friction factor, see Table 3, for a rail/wheel contact to calculate the traction and braking capacity of a drive mechanism shall be determined, taking into account the ambient conditions and the provisions for cleaning of the rail.

Table 3 — Friction factors

Wheel type	Steel wheels and steel rails				Rubber tyres
Rail condition	Indoor crane, clean environment	Indoor crane, contaminated environment	Outdoor crane, rail clean of ice, oil, loose dirt etc.	Outdoor crane, contaminated environment	Prepared ground surfaces
Friction factor	0,18	0,14	0,14	0,1	0,20

4.2.8.3 Multiple motors for a motion

In cases where two or more motors drive the same motion, the following shall be considered:

- synchronisation of the mechanisms, if required due to the needs of the application;
- division of external load actions to the motors, taking into account properties and geometric proportions of the mechanical configuration;

- effect on motors, limiting their capabilities to develop torque, e.g. due to slippage of driven wheels or due to current limit of a single or multiple drive system(s) supplying the motors.

4.2.8.4 Mechanical strength

The proof of mechanical strength of the motor components shall be done in accordance with the general principles specified for mechanical components. The rated load shall only be applied in the calculations, without consideration to variation of actual hoisted loads. Dynamic impacts in motor torque, e.g. due to change of direction of the torque, shall be taken into account.

Mechanical strength of the motor shafts and shaft gears, which are subject to metal fatigue under cyclic loading due to motor rotation, shall be designed for a fatigue limit under maximum torque.

The bearing housings of hoist motors shall be designed such that in case of failure of rolling elements of a bearing, the capability to hold the torque is not lost.

A motor and its possible overspeed protection shall be selected so that the maximum safe operating speed of the motor will not be exceeded under any foreseen conditions.

NOTE See EN 60034-1:2010, 9.6.

4.2.8.5 Torque requirement for vertical movements

4.2.8.5.1 General

In addition to primary hoisting of the load, this clause shall also be applied to combined vertical and horizontal movement of hoist load or dead weight of a crane part, where the slope of the path of the moved mass is 5 % or steeper in relation to horizontal level.

4.2.8.5.2 Determination of required torque

The maximum torque at the motor shaft ($M_{\max}$) shall be calculated by transforming the external load actions determined in 4.2.8.2 to a torque at the motor shaft, applying the maximum values of load actions. The load action due to acceleration of the motion may be omitted. The configuration of the mechanical transmission and efficiency (friction) of the transmission shall be taken into account.

In order to be able to develop the necessary torque for lifting the rated load, for compensating for variations in the mains voltage and frequency and for compensating for variations in the motor characteristics, the torque developed by the motor shall satisfy the following condition:

$$\frac{M_D}{M_{\max}} \geq k_V \quad (1)$$

where

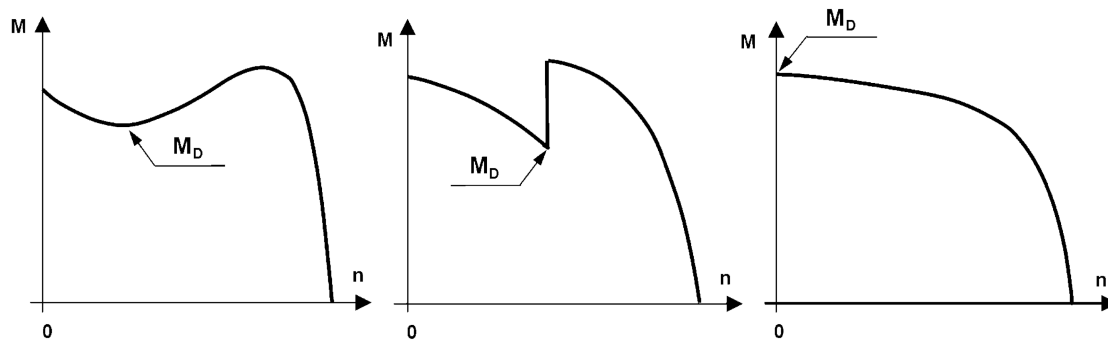
M_D is the design motor torque taken as the minimum torque developed by the motor and the drive system together during the starting period of the motion; see the Figure 1. The combined behaviour of the drive system and the motor shall be taken into account, when determining the torque.

For inverter drives with squirrel cage motors, M_N may be based upon the break-down torque (pull-out torque) of a motor, taking into account the characteristics of the drive system.

$M_{\max}$ is the maximum torque at the motor shaft resisting the movement;

k_V is the required safety factor in accordance with the Table 4.

Where the drive system characteristics vary by the value of hoisted loads (e.g. smaller loads at higher speeds with field weakening systems), the proof of the motor torque requirement shall be done, in addition to the rated load, also with any other hoisted load/motor torque combination, which is relevant to the safety and performance of hoist drive. In such cases, the torques M_D and M_{max} in Formula (1) shall be taken as those relevant for these conditions.



Key

- M motor torque
- M_D design motor torque
- n rotation speed of the motor

Figure 1 — Determination of torque M_D for different types of torque curves

Table 4 — Safety factors k_v for vertical motions

Type of motor and drive	Squirrel cage motors with direct starting and drive	Slip ring motors	DC motors and drives	Squirrel cage motors with inverter drives
Safety factor k_v	1,6	1,5	1,3	1,3

4.2.8.6 Torque requirement for horizontal motions

4.2.8.6.1 General

This clause shall be applied in cases, where the slope of the path of the moved mass is less than 5 % in relation to horizontal level. This clause covers trolley traversing, crane travelling, slewing and level luffing movements.

The maximum external load actions – including the acceleration of the movement – with the magnitude they resist the motion shall be transformed to a torque at the motor shaft, taking into account the configuration of the mechanical transmission and efficiency (friction) of the transmission.

For movements driven through friction between driving wheels and a runway, the values of individual wheel loads and the limitation of transmissible torque due to friction shall be taken into account.

4.2.8.6.2 Determination of required torque

Account shall be taken of the sum of forces resisting the movement resulting from the dead weight, the hoisted load and operating conditions such as:

- deformation of the running surface;
- friction of the wheels on straight sections and in curves;
- wind forces;
- gradients in the track;
- necessary force to move the power supply system.

In order to guarantee the starting of the motion to the intended direction, at a specified acceleration and under specified wind conditions, the sum torque developed by the motors shall satisfy the conditions of Formulae (2) and (3).

For reaching the specified acceleration in average wind conditions, the drive system shall satisfy the requirement of the Formula (2).

$$\frac{M_D}{M_{tr} + M_{acc} + M_{W3} + M_{inc}} \geq k_H \quad (2)$$

For reaching a specified acceleration in the maximum wind conditions, the drive system shall satisfy the requirement of the Formula (3).

$$\frac{M_D}{M_{tr} + 0,5 \times M_{acc} + M_{W2} + M_{inc}} \geq k_H \quad (3)$$

where in Formulae (2) and (3)

- M_D is the sum of the design motor torques, taken into account the minimum torque developed by the motor and the drive system together during the starting period of the motion; see Figure 1. The combined behaviour of the drive system and the motor shall be taken into account, when determining the torques;
- M_{tr} is the torque at the motor shaft due travel resistance;
- M_{acc} is the torque at the motor shaft due to acceleration. Inertia of each component in the system, including the rotating parts of the motor, shall be taken into account.
In cases where the acceleration is not specified, acceleration time of 5 s shall be used in calculation of M_{acc} .
- M_{W2} is the torque at the motor shaft due to wind force required for starting drive forces; wind effect level W2 in accordance with EN 13001-2:2021, 4.2.3.1;
- M_{W3} is the torque at the motor shaft due to wind force during steady movement; wind effect level W3 in accordance with EN 13001-2:2021, 4.2.3.1;
- M_{inc} is the torque at the motor shaft due to inclination of the path of moved masses;
- k_H is the safety factor for horizontal motions; $k_H = 1,1$ for all types of drive systems.

4.2.8.7 Thermal capacity requirement

4.2.8.7.1 Cyclic duration factor

Intensity of the motor duty is described through a cyclic duration factor ED. This factor is specified for periodic intermittent motor duty calculated as follows:

$$ED = 100 \times \frac{t_R}{t_R + t_O} \quad (4)$$

where

ED is cyclic duration factor, in %;

t_R is the running time of the motor within a 10 min period;

t_O is the idle time of the motor within a 10 min period.

The factor is used for thermal power rating of motors in S3-type intermittent duty.

4.2.8.7.2 Mean equivalent torque and power

The mean equivalent power is a power comparable to the thermal capacity of a motor. The power is derived through motor torques due to external loadings. The mean equivalent torque shall be determined as a function of the affecting torques during the working cycles.

When arranging a work cycle into different phases such as acceleration, deceleration and steady movement, the number of which is n , the mean equivalent torque shall be calculated using the following formula:

$$M_{med} = \sqrt{\frac{M_1^2 \cdot t_1 + M_2^2 \cdot t_2 + \dots + M_n^2 \cdot t_n}{t_1 + t_2 + \dots + t_n}} \quad (5)$$

where

M_{med} is the mean equivalent torque;

$M_1, M_2, \dots, M_n$ are the motor torques affecting in different phases of a work cycle. All relevant load actions described in the above clauses shall be taken into account, including acceleration and wind force during controlled movement;

$t_1, t_2, \dots, t_n$ are the duration times of the torques affecting at the motor shaft within a work cycle; idle times, when the motor speed and torque both are zero, are not taken into account.

If the crane can perform several work cycles in a 10 min period, a variety of hoist loads shall be taken into account so that the mean equivalent torque is calculated over a total period of approximately 10 min.

If an average work cycle takes 10 min or longer – including the idle times – the torques shall be calculated applying the rated load only, without consideration of variety in magnitude of loads.

For the calculation of the torques in Formula (5), the true characteristics of work cycles shall be taken into account with consideration of the following:

- loaded and unloaded phases of a work cycle;
- lifting and lowering of the load;
- acceleration and deceleration loadings;
- mechanical efficiency, both increasing and decreasing the motor torque;
- wind loading in accordance with 4.2.8.2.1, both head wind and tail wind.

The mean equivalent power shall be calculated using the formula:

$$P_{\text{med}} = M_{\text{med}} \times \omega = M_{\text{med}} \times \frac{2 \cdot \pi \cdot n}{60} \quad (6)$$

where

- M_{med} is the mean equivalent torque, [Nm];
- ω is the nominal angular speed of motor, [1/s];
- n is the nominal rotational speed of motor given in rotations/min.

4.2.8.7.3 Motor power requirement in general

With the exception of 4.2.8.7.4, the thermal power rating of the motor shall meet the following requirement:

$$k \times P_{\text{mot}} \geq P_{\text{med}} \quad (7)$$

where

- P_{med} is the mean equivalent power calculated for the specified work cycles;
- P_{mot} is the rated power of the motor in a standardized duty class S1, S2 or S3, applicable for the work cycles used in calculating M_{med} and P_{med} ; specified for ambient temperature 40 °C and altitude 1 000 m above sea level;
- k is the power correction factor to take into account decreased cooling speed of motors in high ambient temperatures and high altitudes. In cases where no other data are available, k shall be taken in accordance with 4.2.8.7.6. The motor manufacturer may specify the motor rated power for any specific ambient temperature and altitude, in which cases this power shall be used as P_{mot} with $k = 1$. In all cases it shall apply that $k \leq 1$.

P_{mot} may be taken in accordance with S3-duty in cases where the motion is intermittent and repeated in periods of 10 min or shorter during an average work cycle. The power P_{mot} shall be that related to a cyclic duration factor ED fitting closest to the actual, average work cycle.

P_{mot} may be taken in accordance with S2-duty in cases where the motion is continuous for a considerable period of time, typically up to 1 h, and in between the work cycles the motion is in rest for a long period of time, for a minimum of several hours.

P_{mot} may be taken in accordance with S1-duty for any type of use, except what is given in 4.2.8.7.4.

4.2.8.7.4 S1-rated squirrel cage motors with direct starting

For calculation of thermal capacity of S1-rated squirrel cage motors with direct starting and in intermittent duty, high starting currents and consequent thermal impact shall be taken into consideration.

4.2.8.7.5 Motor requirements in driving to stowage position

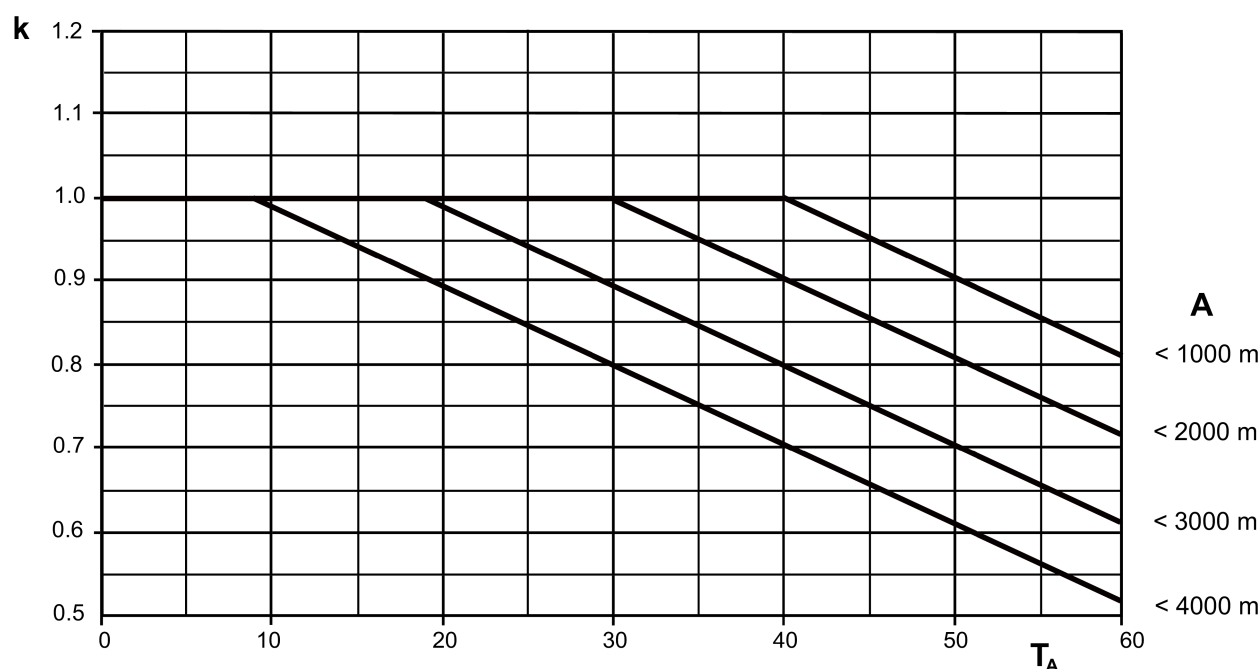
In out-door cranes, which have only a limited number of stowage positions, the travelling drive system shall be capable of moving the crane from any working position to the nearest available stowage position. The following requirements in selection of motors apply:

- the safety factor used with the Formula (3) is $k_H = 1,3$;
- the wind load applied with the Formula (3) is the in-service wind force required for starting drive forces;

- the motor power rating for Formula (6) shall be taken in accordance with S2-duty and duration comparable with the travelling time to the stowage position.

4.2.8.7.6 Power correction for ambient temperature and altitude

For the motor selection, the rated power of the motor P_{mot} shall be corrected as a function of altitude if this exceeds 1 000 m and the ambient temperature if this exceeds 40 °C. The correction factor k shall be taken from the Figure 2, unless other values are specified in the motor's instructions.



Key

- T_A ambient temperature (°C)
 k power correction factor
 A altitude above sea level

Figure 2 — Power correction factor k as function of ambient temperature and altitude

NOTE Figure 2 is based upon EN 60034-1 with motor insulation class F and integrated cooling in the motor. For other insulation and cooling arrangements, an applicable value can be received from the motor manufacturer.

4.2.8.7.7 Power conversion for low ED-factors in S3-duty

For intermittent duty of type S3 in cases where the thermal power of a motor is not given below ED-factor 40 %, the thermal motor power greater than those in Table 5 for lower ED-factors shall not be used for design.

Table 5 — Power conversion for low ED-factors

ED-factor	40 %	25 %	15 %	10 %
Thermal power, S3 duty	P_{40}	$1,10 \times P_{40}$	$1,16 \times P_{40}$	$1,20 \times P_{40}$