

BS EN 15011:2011+A1:2014



BSI Standards Publication

Cranes — Bridge and gantry cranes

bsi.

...making excellence a habit.
AVA Documents™
Document Sharing Hub

National foreword

This British Standard is the UK implementation of EN 15011:2011+A1:2014. It supersedes BS EN 15011:2011, which is withdrawn.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/3/3, Bridge, gantry and slewing jib cranes.

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

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

© The British Standards Institution 2014. Published by BSI Standards Limited 2014

ISBN 978 0 580 81499 0

ICS 53.020.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2011.

Amendments/corrigenda issued since publication

Date	Text affected
30 April 2014	Implementation of CEN amendment A1:2014

English Version

Cranes - Bridge and gantry cranes

Appareils de levage à charge suspendue - Ponts roulants et
portiques

Krane - Brücken- und Portalkrane

This European Standard was approved by CEN on 18 December 2010 and includes Amendment 1 approved by CEN on 19 November 2013.

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.

This European Standard exists 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.

CEN members are the national standards bodies of 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 United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Contents

Page

Foreword.....	3
Introduction	4
1 Scope	5
2 Normative references	5
3 Terms and definitions	7
4 List of significant hazards	8
5 Safety requirements and/or protective measures	12
5.1 General.....	12
5.2 Requirements for strength and stability	13
5.3 Electrotechnical equipment.....	26
5.4 Non-electrotechnical equipment.....	28
5.5 Limiting and indicating devices	33
5.6 Man-machine interface.....	37
5.7 Equipment for warning.....	40
6 Verification of safety requirements and/or protective measures	41
6.1 General.....	41
6.2 Types of verification.....	41
6.3 Fitness for purpose testing	44
7 Information for use	46
7.1 General.....	46
7.2 Operator's manual	46
7.3 User's manual	46
7.4 Marking of rated capacities	48
Annex A (informative) Guidance for specifying the operating duty according to EN 13001-1	50
Annex B (informative) Guidance for specifying the classes P of average number of accelerations according to EN 13001-1	58
Annex C (informative) Calculation of dynamic coefficient $\phi_h(t)$	59
Annex D (normative) Loads caused by skewing	62
Annex E (informative) Local stresses in wheel supporting flanges	70
Annex F (normative) Noise test code.....	75
Annex G (informative) Actions on crane supporting structures induced by cranes	83
Annex H (informative) Selection of a suitable set of crane standards for a given application	85
Annex ZA (informative) Relationship between this European standard and the Essential Requirements of EU Directive 2006/42/EC	86
Bibliography	87

Foreword

This document (EN 15011:2011+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 August 2014, and conflicting national standards shall be withdrawn at the latest by August 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 15011:2011.

This document includes Amendment 1 approved by CEN on 2013-11-19.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**.

This document has been prepared under a 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.

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 has been prepared to be a harmonised standard to provide one means for bridge and gantry cranes to conform with the essential health and safety requirements of the Machinery Directive, as mentioned in Annex ZA.

As many of the hazards related to bridge and gantry cranes relate to their operating environment and use, it is assumed in the preparation of this European Standard that all the relevant information relating to the use and operating environment of the crane has been exchanged between the manufacturer and user (as recommended in ISO 9374, Parts 1 and 5), covering such issues as, for example:

- clearances;
- requirements concerning protection against hazardous environments;
- processed materials, such as potentially flammable or explosive material (e.g. coal, powder type materials).

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

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

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.

1 Scope

A1 This European Standard applies to bridge and gantry cranes able to travel by wheels on rails, runways or roadway surfaces, and to gantry cranes without wheels mounted in a stationary position. **A1**

This European Standard specifies requirements for all significant hazards, hazardous situations and events relevant to bridge and gantry cranes when used as intended and under conditions foreseen by the manufacturer (see Clause 4).

This European Standard does not include requirements for the lifting of persons.

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 European Standard.

This European Standard is applicable to bridge and gantry cranes manufactured after the date of its publication as an EN.

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.

EN 81-43, *Safety rules for the construction and installation of lifts — Special lifts for the transport of persons and goods - Part 43: Lifts for cranes*

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

EN 795, *Protection against falls from a height — Anchor devices — Requirements and testing*

EN 894-1, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 1: General principles for human interactions with displays and control actuators*

EN 894-2, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 2: Displays*

EN 953, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

A1 EN 1993-6 **A1**, *Eurocode 3 - Design of steel structures - Part 6: Crane supporting structures*

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

EN 12385-4, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications*

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

EN 12644-2, *Cranes — Information for use and testing — Part 2: Marking*

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

A1 EN 13001-2 **A1**, *Crane safety — General design — Part 2: Load **A1** actions **A1***

A1 EN 13001-3-1 **A1**, *Cranes — General Design — Part 3-1: Limit States and proof competence of steel structures*

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

EN 13135, *Cranes — Safety — Design — Requirements for equipment*

EN 13155, *Cranes — Safety — Non-fixed load lifting attachments*

EN 13157, *Cranes — Safety — Hand powered cranes*

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

EN 13586, *Cranes — Access*

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

EN 60204-11, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c. and not exceeding 36 kV (IEC 60204-11:2000)*

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

HD 60364-4-41, *Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock (IEC 60364-4-41:2005, mod.)*

EN 60825-1, *Safety of laser products — Part 1: Equipment classification and requirements (IEC 60825-1:2007)*

EN 60947-5-5, *Low-voltage switchgear and controlgear — Part 5-5: Control circuit devices and switching elements — Electrical emergency stop device with mechanical latching function (IEC 60947-5-5:1997)*

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

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

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

EN ISO 11202:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections (ISO 11202:2010)*

EN ISO 11203:2009, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level (ISO 11203:1995)*

EN ISO 11204:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying accurate environmental corrections (ISO 11204:2010)*

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

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

EN ISO 13732-1, *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 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)*

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

ISO 3864 (all parts), *Graphical symbols — Safety colours and safety signs*

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

ISO 7752-5, *Lifting appliances — Controls — Layout and characteristics — Part 5: Overhead travelling cranes and portal bridge cranes*

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

3 Terms and definitions

A1 For the purposes of this document, the terms and definitions given in EN ISO 12100, EN ISO 3744, EN ISO 11202, EN ISO 11203, EN ISO 11204 and the following apply. **A1**

3.1

bridge crane

A1 crane able to move along rails or runways having at least one primarily horizontal girder and equipped with at least one hoisting mechanism **A1**

NOTE Building structures, where hoists are mounted, are not regarded as bridge cranes.

3.2

gantry crane

A1 crane able to travel by wheels on rails, runways or roadway surfaces, or crane without wheels mounted in a stationary position, having at least one primarily horizontal girder supported by at least one leg and equipped with at least one hoisting mechanism **A1**

NOTE Building structures, where hoists are mounted, are not regarded as gantry cranes.

3.3

rated capacity

m_{RC}

maximum net load (the sum of the payload and non-fixed load-lifting attachment) that the crane is designed to lift for a given crane configuration and load location during normal operation

3.4

hoist load

m_H

sum of the masses of the load equal to the rated capacity, the fixed lifting attachment and the hoist medium

3.5

hoist medium

part of the hoisting mechanism, either rope, belt or chain, by which the fixed load lifting attachment is suspended

3.6

underhung crane

bridge crane suspended from the lower flange of the crane track

3.7

direct acting rated capacity limiter

limiter acting directly in the chain of drive elements and limiting the transmitted force

NOTE Those limiters can be, for example, friction torque limiters, pressure limiting valves. Directing acting rated capacity limiters generally have no response delay.

3.8

indirect acting capacity limiter

limiter determining the transmitted force by measured signals and switching off the energy supply for the operation and, if required, triggering application of the brake torque

4 List of significant hazards

Table 1 of this clause contains all the significant hazards, hazardous situations and events, as far as they are dealt with in this European Standard, identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk.

Table 1 — List of significant hazards and associated requirements

No.	Hazard (as listed in EN 1050:1996)	Relevant clause(s) in this European Standard
1	Mechanical hazards	
1.1	Generated by machine parts or work pieces, e.g. by:	
1.1.2	relative location	5.6.2
1.1.3	mass and stability	5.2
1.1.4	mass and velocity	5.2, 5.3.6, 5.4.4, 5.6.1
1.1.5	inadequacy of mechanical strength	5.2
1.2	Accumulation of energy inside the machinery, e.g. by:	
1.2.2	fluids under pressure	5.4.1
1.3	Elementary forms of mechanical hazards	
1.3.1	Crushing	5.1, 5.6.2, 7.2
1.3.2	Shearing	5.6.2.4
1.3.3	Cutting or severing	
1.3.5	Drawing-in or trapping hazard - moving transmission parts	5.6.2.5, 5.6.2.6
1.3.6	Impact	5.5.3.1, 7.2
1.3.9	High pressure fluid injection or ejection hazard	7.3.3
2	Electrical hazards due to:	5.3
2.1	Contact of persons with live parts (direct contact)	5.3.2, 5.3.3

2.2	Contact of persons with parts which have become live under faulty conditions (indirect contact)	5.1
2.3	Approach to live parts under high voltage	5.3
2.4	Electrostatic phenomena	5.3.1
2.5	Thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short-circuits, overloads, etc.	5.1
3	Thermal hazards, resulting in:	
3.1	burns and scalds, by possible contact of persons with objects or materials with an extreme temperature, by flames, by radiation, etc.	5.4.8.1, 7.3.3
3.2	Hot or cold working environment	5.6.1
4	Hazards generated by noise, resulting in:	
4.1	Hearing losses	5.6.4
4.2	Interference with speech communication, signals	5.6.4, 7.3.1
5	Hazards generated by vibration	
5.2	Whole body vibration, particularly when combined with poor postures	5.2.2.6, 5.6.1
6	Radiation	
6.0	External radiation	See Introduction
6.5	Lasers	5.4.8.2
7	Processed materials and substances, used materials, fuels	
7.1	Hazards from contact with harmful fluids, gases, mists, fumes and dusts	5.4.8.4 See Introduction
7.2	Fire or explosion hazard	5.4.8.3 See Introduction
8	Neglected ergonomic principles in machine design, e.g. hazards from:	
8.1	Unhealthy postures or excessive efforts	5.6.1
8.2	Inadequate consideration of hand-arm or foot-leg anatomy	5.6.1
8.3	Neglected use of personal protection equipment	7.3.3
8.4	Inadequate local lighting	5.6.3
8.6	Human errors, human behaviour	5.5.2

8.7	Inadequate design, location or identification of manual controls	5.3.5, 5.6.1
8.8	Inadequate design or location of visual display units	5.7
10	Unexpected start-up, unexpected overrun/over speed (or any similar malfunction) from:	
10.1	Failure/disorder of control systems	5.3.4
10.3	External influences on electrical equipment	5.3.5.3, 5.4.2
10.4	Other external influences (gravity, wind, etc.)	5.3.5.3, 5.3.6, 5.4.2, 5.5.2.2, 5.5.4 b) and c)
10.5	Errors in the software	5.3.4, 5.3.5.3, 5.4.2
10.6	Errors made by the operator (due to mismatch of machinery with human characteristics and abilities, see No. 8.6)	5.3.5.3, 5.4.2
11	Impossibility of stopping the machine in the best possible conditions	5.4.4.1, 5.4.5.1, 5.5.2.2
13	Failure of the power supply	5.3, 5.4.2
14	Failure of the control circuit	5.3, 5.6.1, 5.4.2
16	Break-up during operation	5.2, 5.4.3.6.1, 7.3.3
16.1	Thermal effect on the crane	5.3
17	Falling or ejected object or fluid	5.4.1, 7.3.3
18	Loss of stability / overturning of machinery	5.2.3
19	Slip, trip and falling of persons (related to machinery)	5.6.2
20	Relating to the travelling function	
20.2	Movement without an operator at the driving position	5.3.5.3, 5.3.6, 5.6.1
20.4	Excessive speed of pedestrian controlled machinery	5.6.1
20.5	Excessive oscillations when moving	5.4.4.3, 5.5.4 e), 7.2
20.6	Insufficient ability of machinery to be slowed down, stopped and immobilized	5.4.3.6.1, 5.4.4, 5.5.2.2, 7.2
20.7	From derailment due to travelling	5.4.4.5
21	Linked to the work position (including driving station) on the machine	
21.1	Fall of persons during access to (or at/from) the work position	5.6.2
21.2	Exhaust gases / lack of oxygen at the work position	5.4.8.4.1

21.3	Fire (flammability of the cab, lack of extinguishing means)	5.4.8.3, 5.6.1
21.4	Mechanical hazards at the work position - contact with the wheels - fall of objects, penetration by object - contact of persons with machine parts or tools (pedestrian control)	5.6.2.5, 5.6.1
21.5	Insufficient visibility from the working position	5.6.1
21.6	Inadequate lighting	5.6.3
21.7	Inadequate seating	5.6.1
21.8	Noise at the driving position	5.6.4
21.9	Vibration at the driving position	5.6.1
21.10	Insufficient means of evacuation/emergency exit	5.6.2, 5.4.8.3
22	Due to the control system	5.6.1
22.1	Inadequate location of controls /control devices	5.6.1
22.2	Inadequate design of the actuation mode and/or action mode of controls	5.6.1
23	From handling the machine (lack of stability)	5.4.4.3
25	From/to third persons	
25.1	Unauthorized start-up/use	
25.2	Drift of a part away from its stopping position	5.4.5.2
25.3	Lack or inadequacy of visual or acoustic warning means	5.7
26	Insufficient instructions for the driver / operator	
26.1	Movement into prohibited area	5.5.3.1, 7.2
26.2	Tipping - Swinging	7.2
26.3	Collision: machines-machine	5.5.3.1, 5.5.3.3, 5.5.4 e), 7.2
26.4	Collision: machines-persons	5.5.3.1, 5.5.4 e), 7.2
26.5	Ground conditions	7.3.1
26.6	Supporting conditions	7.3.1
27	Mechanical hazards and events	
27.1	from load falls, collision, machine tipping caused by:	
27.1.1	lack of stability	5.2.3, 5.4.8.5
27.1.2	Uncontrolled loading - overloading – overturning moment exceeded	5.2.1.5, 5.2.1.6, 5.4.3.1 to 5.4.3.4, 5.4.8.5, 5.5.1, 5.5.2.1, 5.5.4 a)
27.1.3	Uncontrolled amplitude of movements	5.5.3.3, 7.2
27.1.4	Unexpected/unintended movement of loads	5.3.4, 5.4.1, 5.4.2, 5.4.3.1, 5.6, 7.2
27.1.5	Inadequate holding devices / accessories	5.4.1, 7.2

27.1.6	Collision of more than one machine	5.5.3.1, 5.5.3.3
27.1.7	Two-block of hook to hoist	5.4.3.1, 5.5.3.2
27.2	From access of persons to load support	7.2
27.3	From derailment	5.4.4.5, 5.4.4.6
27.4	From insufficient mechanical strength of parts Loss of mechanical strength, or inadequate mechanical strength	5.2, 5.4.3, 5.4.5.3, 5.4.6, 5.4.7, 7.3.3
27.5	From inadequate design of pulleys, drums	5.2, 5.4.1, 5.4.3.1
27.6	From inadequate selection/ integration into the machine of chains, ropes, lifting accessories	5.2, 5.4.1, 5.4.3.1, 5.4.3.6.2, 7.2
27.7	From lowering of the load by friction brake	5.4.1
27.8	From abnormal conditions of assembly / testing / use / maintenance	5.4.3.6.3, 5.5.4 d)
27.9	Load-person interference (impact by load)	5.6.1, 5.7, 7.2, 7.3.1
28	Electrical hazard	
28.1	from lightning	7.3.3
29	Hazards generated by neglecting ergonomic principles	
29.1	insufficient visibility from the driving position	5.6.1, 5.6.3

5 Safety requirements and/or protective measures

5.1 General

Bridge and gantry cranes shall comply with the safety requirements and/or protective measures of Clause 5. In addition, these cranes shall be designed according to the principles of **A1** EN ISO 12100 **A1** for relevant but not significant hazards, which are not dealt with by this European Standard.

Bridge and gantry cranes shall be in accordance with the following standards as amended by this European Standard:

- EN 13001-1, *Cranes — General design — Part 1: General principles and requirements*;
- EN 13001-2, *Cranes — General design — Part 2: Load **A1** actions **A1***;
- **A1** EN 13001-3-1 **A1**, *Cranes — General Design — Part 3-1: Limit States and proof competence of steel structures*;
- CEN/TS 13001-3-2, *Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems*;
- **A1** EN 13135, *Cranes — Safety — Design — Requirements for equipment*; **A1**
- EN 13155, *Cranes — Safety — Non-fixed load lifting attachments*;
- EN 13157, *Cranes — Safety — Hand powered cranes*;
- EN 13557, *Cranes — Controls and control stations*;

- EN 12077-2, *Cranes safety — Requirements for health and safety — Part 2: Limiting and indicating devices*;
- EN 13586, *Cranes — Access*;
- EN 12644-1, *Cranes — Information for use and testing — Part 1: Instructions*;
- EN 12644-2, *Cranes — Information for use and testing — Part 2: Marking*;
- EN 60204-32, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines* (IEC 60204-32:2008).

The requirements of this European Standard are not applicable to power driven hoist units, designed in accordance with EN 14492-2, and incorporated in a bridge and gantry cranes. These hoist units shall be selected accordance to the principles depicted within A.4.

5.2 Requirements for strength and stability

5.2.1 Load actions

5.2.1.1 Selection of service conditions

The service conditions that are selected and used as the basis of design, in accordance with EN 13001-1 and EN 13001-2, shall be specified in the technical file of the crane.

For cranes located outdoors, the recurrence period according to EN 13001-2 for out of service wind shall be not less than:

- 25 years for cranes located in coastal areas;
- 10 years for cranes located inland;
- 5 years for indoor cranes which may occasionally work and/or be parked outdoors.

NOTE Guidance for specifying the operation duty is given in Annex A. For information needed for the derivation of classification parameters see also ISO 9374-5.

5.2.1.2 Selection of loads and load combinations

The basic load combinations for the load calculation shall be selected in accordance with **A1** EN 13001-2 **A1**.

Where cranes work in atmospheres contaminated by process debris, such material accumulations deposited upon the upper surfaces of the crane shall be taken into account in the dead load computation.

5.2.1.3 Determination of dynamic factors

5.2.1.3.1 Hoisting and gravity effects acting on the mass of the crane

The masses of the crane shall be multiplied with factor $\phi_1 = 1 + \delta$ when calculating the stresses in load combinations in accordance with EN 13001-2.

A1 For masses with unfavourable gravitational load effect the factors shall be taken as $\delta = 0,10$ and $\phi_1 = 1,10$, and for masses with favourable gravitational load effect as $\delta = -0,05$ and $\phi_1 = 0,95$, unless other values are obtained by measurements or calculations. **A1**

5.2.1.3.2 Determination of factor ϕ_2

5.2.1.3.2.1 General principles

The hoist load shall be multiplied by factor ϕ_2 that represents the additional dynamic force applied on the crane, when the weight of a grounded load is transferred on the hoisting medium (ropes or chains).

When assuming the most extreme conditions, the hoisting medium is slack whilst the hoist mechanism reaches its maximum hoisting speed. In this condition the dynamic additional force is directly proportional to the hoisting speed, with a coefficient that depends upon the stiffness properties and mass distribution of the crane (β_2 in EN 13001-2). A1 A calculation model for the determination of the dynamic rope force history at the hoisting event is presented in Annex C. A1

In physical crane operation there are other factors that influence the actual dynamic effect, such as control systems, dampening and flexibility of other than main components (e.g. hoist slings, other lifting devices, load itself, crane foundation). These dependencies and determination of factor ϕ_2 are represented by hoisting classes in EN 13001-2.

When hoisting class is used it shall be selected according to 5.2.1.3.2.3.

The hoisting speed used for the determination of the dynamic coefficient shall reflect the actual use and possible exceptional events of the crane in a realistic way. Two events shall be considered as follows:

- crane in normal use where hoisting commences at a mechanism controlled speed from a slack rope condition – cases A and B as per EN 13001-2;
- exceptional case where hoisting commences at mechanism maximum speed from slack rope condition – case C as per EN 13001-2.

Guidance on selection of hoisting speeds is given in 5.2.1.3.2.4.

5.2.1.3.2.2 Calculation of the theoretical factor ϕ_{2t}

The theoretical dynamic factor ϕ_{2t} is used for the determination of the hoisting class as defined in EN 13001-2. It shall be estimated in one of the following ways:

- make a complete dynamic simulation taking into account the elastic, inertial and dampening properties. The maximum force in the hoisting medium during time of the first 3 s represents the hoist load multiplied by factor ϕ_{2t} ;
- where applicable, the rope force history $\phi_h(t)$ may be calculated in accordance with Annex C. $\phi_{2t} = \max\{\phi_h(t); t < 3 \text{ s}\}$. (A similar simulation can be used for a crane with a chain hoist.);
- use one of the simplified Equation (1).

a) for a crane with a rope hoist:

$$\phi_{2t} = 1 + \frac{2.8 \times v_{h,\max}}{0.45 + \left(\frac{R_r \times l_r}{1500 \times Z_a} \right)^{1/2}}$$

b) for a crane with a chain hoist:

$$\phi_{2t} = 1 + \frac{2.8 \times v_{h,\max}}{0.45 + \left(\frac{f_{uc} \times l_c}{150 \times Z_a} \right)^{1/2}} \quad (1)$$

where

- $v_{h,\max}$ is the maximum steady hoisting speed in metres per second;
- R_r is the rope grade according to EN 12385-4;
- f_{uc} is the ultimate strength of the chain steel in newtons per square millimetre;

l_r, l_c is the length of rope/chain fall in metres;
 Z_a is the actual coefficient of utilization of the rope/chain (total breaking force of the rope/chain reeving system / hoist load).

The length l_r / l_c shall be taken as the typical distance between the upper and lower rope sheaves / chain sprockets, when hoisting a grounded load. Where a loaded part, or all of the hoist media deviates from the vertical, the length of the rope/chain fall shall be adjusted to give the equivalent flexibility in vertical direction.

NOTE This simplified equation takes into account the rigidity and the masses of the crane parts and load and gives values which are approximately same as calculated according to Annex C.

5.2.1.3.2.3 Selection of hoisting class

The hoisting class shall be determined in accordance with Table 2.

Table 2 — Selection of hoisting class

Condition		Hoisting class
$\phi_{2t} \leq$	$1,07 + 0,24v_{h,max}$	HC1
$1,07 + 0,24v_{h,max} < \phi_{2t} \leq$	$1,12 + 0,41v_{h,max}$	HC2
$1,12 + 0,41v_{h,max} < \phi_{2t} \leq$	$1,17 + 0,58v_{h,max}$	HC3
$1,17 + 0,58v_{h,max} < \phi_{2t}$		HC4

5.2.1.3.2.4 Selection of the hoisting speed

The hoisting speed representing the normal use in load combinations A and B, and an exceptional occurrence in load combination C, shall be selected according to the hoist drive class, HD, provided by the system and in [\[A1\] EN 13001-2 \[A1\]](#).

5.2.1.3.2.5 Determination of ϕ_2 and hoisting class by testing

The dynamic factor ϕ_2 can also be determined by measurement from an equivalent crane. The values measured with different hoisting speeds shall be directly used in calculations, without reference to a hoisting class.

NOTE The dynamic increment of deflections found by measurement or dynamic simulation may include the dynamic effects from the mass of the crane including the trolley, see 5.2.1.3.1. The portion represented by the factor $\delta = 0,1$ could be removed from the evaluation of the final ϕ_2 to avoid it being considered twice in ϕ_1 and also in ϕ_2 .

5.2.1.3.3 Load caused by travelling on uneven surfaces

The dynamic actions on the crane by travelling, with or without hoist load, on roadway or on rail tracks shall be considered by the specific factor ϕ_4 .

For continuous rail tracks or welded rail tracks with finished ground joints without notches (steps or gaps) the specific factor $\phi_4 = 1$.

For roadways or rail tracks with notches (steps or gaps) the specific factor ϕ_4 shall be calculated according to [\[A1\] EN 13001-2 \[A1\]](#). For rubber tyred cranes the flexibility of the tyre shall be taken into account.

5.2.1.3.4 Loads caused by acceleration of drives

For crane drive motions, the change in load effect, ΔS , caused by acceleration or deceleration is presented by the following equation:

$$\Delta S = S_{(f)} - S_{(i)} \quad (2)$$

where

$S_{(f)}$ is the final load effect;

$S_{(i)}$ is the initial load effect.

NOTE 1 The change in load effects, ΔS , is caused by the change of drive force, ΔF , given by the equation:

$$\Delta F = F_{(f)} - F_{(i)}$$

where

$F_{(f)}$ is the final drive force;
and

$F_{(i)}$ is the initial drive force.

Loads induced in a crane by acceleration or deceleration caused by drive forces may be calculated using rigid body kinetic models. The load effect S shall be applied to the components exposed to the drive forces and where applicable to the crane and the hoist load as well. As a rigid body analysis does not directly reflect elastic effects, the load effect S shall be calculated by using an amplification factor ϕ_5 defined in [EN 13001-2](#) as follows:

$$S = S_{(i)} + \phi_p \cdot \phi_5 \cdot a \cdot m \quad (3)$$

where

$S_{(i)}$ is the initial load effect caused by $F_{(i)}$;

ϕ_5 is the amplification factor;

ϕ_p is the factor for effect of sequential positioning movements;

a is the acceleration or deceleration value;

m is the mass for which a applies.

The factor ϕ_5 shall be taken from Tables 3 and 4 unless more accurate factors are available from elastic model calculations or measurements. The factor ϕ_p shall be taken from Table 5.

Where the force S is limited by friction or by the nature of the drive mechanism, this frictional force shall be used instead of calculated force S .

Table 3 — Factor ϕ_5 for travel, traverse and slewing mechanism

A1

Drive type	Factor ϕ_5	
	Typical backlash for gearbox	Considerable backlash, e.g. open gears
Stepless speed control	1,2	1,5
Multi step speed control	1,6	2,0
Two step speed control	1,8	2,2
Single step speed control	2,0	2,4

A1

Table 4 — Factor ϕ_5 for hoist mechanism

A1

Drive type	Factor ϕ_5 lifting	Factor ϕ_5 lowering
Stepless speed control	1,05	1,10
Multi step speed control	1,15	1,20
Two step speed control	1,20	1,35
Single step speed control	1,20	1,30

A1

NOTE 2 Factors in Tables 3 and 4 take account for switching on/off the speed and speed change.

Table 5 — Factor ϕ_P

Class of load positioning in accordance with EN 13001-1	ϕ_P
P ₀ and P ₁	1,0
P ₂	1,15
P ₃	1,3

NOTE 3 Positioning movements may increase the total load effects, when made in non-optimal manner. This is taken into account by factor ϕ_P dependent upon the class P. Guidance for determining the class P is given in Annex B.

5.2.1.4 Loads caused by skewing

5.2.1.4.1 General

Skewing forces for top running cranes and trolleys shall be calculated in accordance with 5.2.1.4.2 to 5.2.1.4.4 and Annex D, which provide simplified methods for calculating the forces generated when considering both RIGID and FLEXIBLE crane structures. Skewing forces for underhung cranes shall be calculated in accordance with 5.2.1.4.5.

[A1] In general the skewing forces shall be addressed to load combination B. Where the crane is provided with continuously active anti-skew devices, the forces, without the benefit of anti-skew devices (e.g. failure of the device), shall be addressed to load combination C. **[A1]**

NOTE 1 The method given in **[A1]** EN 13001-2 **[A1]** is applicable to rigid structures. Bridge and gantry cranes can possess both rigid and flexible characteristics; therefore, a more general method is required as given here. With this method also flexible structures, uneven number of wheels, unequally distributed wheel loads as well as different types of guide means and anti-skewing devices can be considered.

NOTE 2 Forces arising from skewing are generated when the resultant direction of rolling movement of the travelling crane no longer coincides with the direction of the runway rail, and when the front positive guiding means come into contact with the rail. This is caused by tolerances and inaccuracies, which arise in the manufacture of the crane (bores of track wheels) and that of the runway's rail (bends, kinks). The values and distribution of these forces depend chiefly upon the clearances between the runway rail and the wheel flanges or guide rollers and the latter's location, also on the number, arrangement, bearing arrangement and rotational speed synchronisation of the track wheels and structural flexibility.

NOTE 3 The use of anti-skew devices with travel motions reduces the guiding forces between the rail and guiding means. It also reduces the lateral slip forces of the wheels, but some lateral slip remains due to wheel alignment tolerances and lateral deformations of structures, which effect should be considered.

5.2.1.4.2 Skew angle

The skew angle shall be calculated as follows:

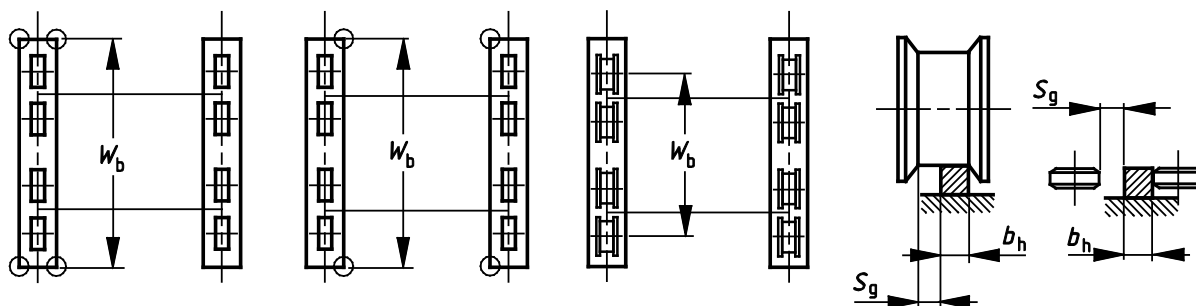


Figure 1 — Parameters of skew angle

The total skew angle to be considered in design is

$$\alpha = \alpha_g + \alpha_w + \alpha_t$$

where

- α is the skew angle to be considered in design;
- α_g is the skew component S_g/w_b ;
- α_w is the component due to wear - rail and wheel flange/guide roller;
- α_t is the component due to alignment tolerances of rail/wheel.

The values for skew angles shall be determined according to Table 6.

Table 6 — Skew angle computation

Ⓐ1

Skew component	Skew angle resulting from	Flanged wheels	Guide rollers
α_g	Track clearance	$\alpha_g = s_{g\min} / W_b$ when $s_g \leq \frac{4}{3} s_{g\min}$ $\alpha_g = 0,75 \cdot s_g / W_b$ when $s_g > \frac{4}{3} s_{g\min}$	
	Crane travelling; Recommended minimum track clearances	$s_{g\min} = 10 \text{ mm}$	$s_{g\min} = 5 \text{ mm}$
	Trolley traversing; Recommended minimum track clearances	$s_{g\min} = 4 \text{ mm}$	$s_{g\min} = 2 \text{ mm}$
α_t	Tolerances (wheel alignment and straightness of the rail)	$\alpha_t = 0,001 \text{ rad}$	
α_w	Wear of wheel flanges/rollers and rails	$\alpha_w = 0,10 \cdot b_h / W_b$	$\alpha_w = 0,03 \cdot b_h / W_b$

Ⓐ1

The skew angle shall be $\alpha \leq 0,015 \text{ rad}$ in order to achieve good travel behaviour of the crane or the trolley.

NOTE For larger track clearances the skew angle is reduced to 75 % because bridge and gantry cranes and their trolleys use the full track clearance only rarely. Usually only the forward guide means is in contact with the rail.

5.2.1.4.3 Friction slip relationship

The following simplified empirical relationship shall be used to calculate the friction coefficient for longitudinal and lateral slip:

$$\mu_f = \mu_0 (1 - e^{-250\sigma}) \quad (4)$$

where

μ_f is the slip coefficient;

Ⓐ1 μ_0 is the friction factor:

$\mu_0 = 0,3$ for cleaned rails;

$\mu_0 = 0,2$ for non-cleaned rails in usual environment; Ⓐ1

e is the base of natural logarithms, 2,718;

σ is the slip factor.

NOTE The slip factor is the ratio of the slip distance – transverse and/or longitudinal – to the corresponding travel distance. For the transverse slip the slip factor is equal to the instantaneous total skewing angle (α or $\alpha + \Delta\alpha$). See D.3.2.

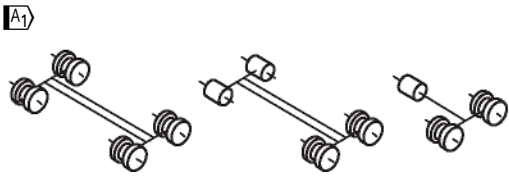
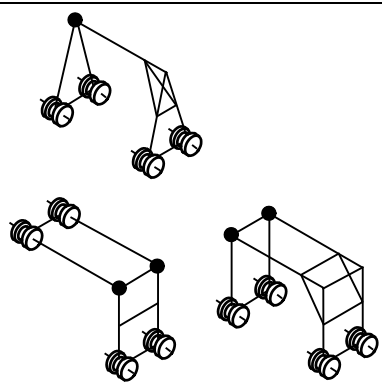
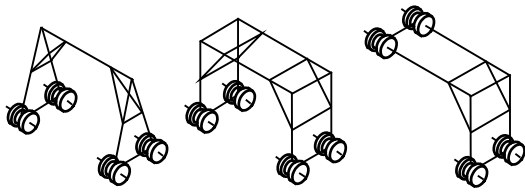
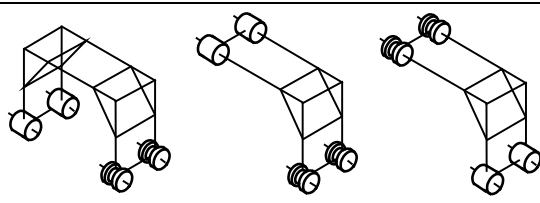
Ⓐ1 deleted text Ⓐ1

5.2.1.4.4 Selection of calculation methods

Either of two simplified calculation methods shall be used: either a RIGID or FLEXIBLE method. The RIGID method assumes the structures of the crane and the runway to be rigid. The FLEXIBLE method assumes the structure to be flexible. In cases of doubt the FLEXIBLE method should be utilised.

Calculation models to be adopted relative to the crane/trolley structural configuration are listed within Table 7.

Table 7 — Calculation models of bridge and gantry cranes

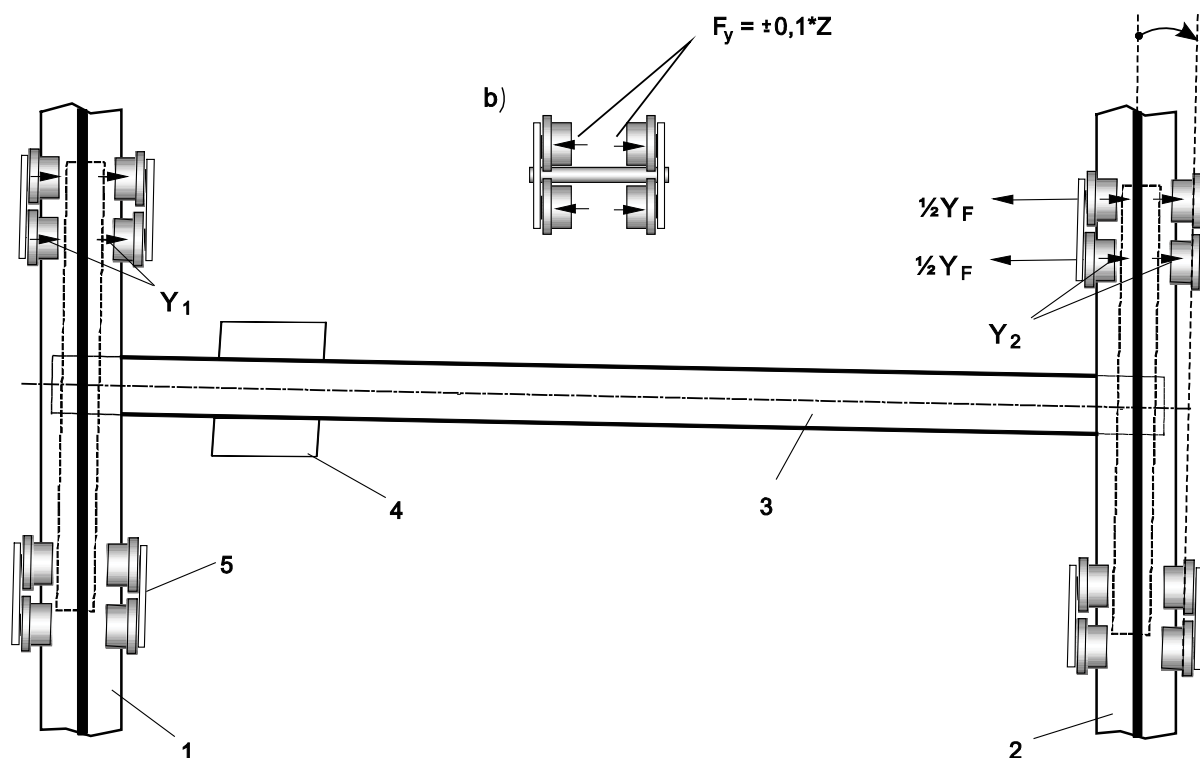
Type	Structural configuration	Applicable method for calculation of loads due to skewing:
A	 Bridge crane, trolley. Even, horizontal, almost stiff. Guide means on one or both end carriages. A1	Method RIGID
B	 Crane with articulation, respectively crane with flexible support (● = articulation about an axis parallel with crane track). Guide means on both end carriages.	Each end carriage shall be calculated separately with the method RIGID. Concerning the skewing forces the crane divides into two almost independent, individually guided carriages.
C	 Crane without articulation. Guide means on both end carriages.	Method RIGID.
D	 Crane without articulation. Guide means on only one end carriage.	The method depends on the flexibility of the structure. The decision is made by the result of the method RIGID. Procedure: a) Calculate the skewing forces with the method RIGID;

	b) Supply a fixed support for the end carriage with guide means. Supply a floating support for the unguided end carriage (see Figure D.2c)). Apply the forces calculated with method RIGID to the floating end carriage. The originally parallel end carriages receive an angle position $\Delta\alpha$ to each other. Calculate $\mu_f(\alpha + \Delta\alpha)$ according to 5.2.1.4.3; c) If $\mu_f(\alpha + \Delta\alpha) / \mu_f(\alpha) > 1,15$ then the skewing forces have to be calculated with the method FLEXIBLE. Otherwise the calculation with the method RIGID is sufficient. E.g.: $\mu_f(\alpha + \Delta\alpha) = \mu_0 \left(1 - e^{(-250(\alpha + \Delta\alpha))} \right) \text{ and } \mu_f(\alpha) = \mu_0 \left(1 - e^{(-250\alpha)} \right) .$
--	---

5.2.1.4.5 Skewing forces for underhung cranes

The skewing forces of the underhung cranes, having rigid structure and running on the bottom flanges of rigidly fixed runway beams, shall be calculated with the same principles as the top running cranes. See D.2. However, the guiding force Y_F may be divided on two wheel flanges of a leading bogie. The minor lateral forces of the trailing bogies may be ignored. Figure 2 represents an example of the structures and one possible set of the most critical skewing force combinations.

For configurations where either a runway beam (or both of them) or the bogies on one of the runways, can float laterally, the lateral forces Y_1 and Y_2 are balanced by separate guiding forces Y_F on both leading bogies. In these cases the guiding forces $\frac{1}{2}Y_F$ shall be taken conventionally as 20 % of the maximum static vertical force Z of the wheel. Y_1 and Y_2 , frictional forces are then 10 % of the vertical wheel force of each wheel. The guiding forces, Y_F , and frictional forces, Y , balance each other separately on both runways, forming internal force systems within the bogies (element b) in Figure 2), and also local internal force systems within the bottom runway flanges. These forces balanced locally do not impose external forces on the crane structure.



Key

- 1 bottom flange and cut web of runway beam No. 1
- 2 bottom flange and cut web of runway beam No. 2
- 3 crane girder; end carriage beams under the runways not shown
- 4 hoist trolley with load
- 5 4-wheel bogies at each corner of the crane
- Y_1 transverse frictional skewing forces applied between the wheels and the top surface of the bottom flange of the runway 1
- Y_2 transverse frictional skewing forces applied between the wheels and the top surface of the bottom flange of the runway 2
- Y_F guiding force applied to the wheel flanges of the guiding bogie
- F_y minimum transverse forces to be also considered in bogie design as shown in element b)
- Z maximum dynamic wheel force in vertical direction

Figure 2 — Skewing forces of underhung crane

Besides the skewing, the lateral forces on the bogies of the underhung cranes are created also by acceleration of the crane loaded asymmetrically and by acceleration of the hoist trolley and load. These forces shall be considered according to 5.2.1.3.4.

5.2.1.5 Overload condition

5.2.1.5.1 Cranes with direct acting lifting force limiter

The maximum force, $F_{max.L}$, which is applied to the crane when the direct acting lifting force limiter operates, shall be calculated as follows:

$$F_{\max L} = \phi_{DAL} \cdot m_H \cdot g \quad (5)$$

where

$F_{\max L}$	is the maximum force in newtons;
ϕ_{DAL}	is the force-limit factor for direct acting lifting force limiters [-];
m_H	is the mass of the hoist load in kilograms;
g	is the gravity constant 9,81 m/s ² .

For hydraulic systems, the factor ϕ_{DAL} shall be less than or equal to 1,4, with friction torque limiters or pneumatic systems this factor shall be less than, or equal to 1,6.

[A1] The force $F_{\max L}$ shall be assigned to the corresponding load and stability combinations C of EN 13001-2. **[A1]**

5.2.1.5.2 Cranes with indirect acting lifting force limiter

The maximum force, $F_{\max L}$, which is applied to the crane, resulting from the operation of the indirect acting lifting force limiter in an overload, stall load and if relevant, in a snag load case, shall be calculated as follows:

$$F_{\max L} = \phi_{IAL} \cdot m_H \cdot g \quad (6)$$

where

$F_{\max L}$	is the maximum force in newtons;
ϕ_{IAL}	is the load factor for maximum force [-];
m_H	is the mass of the hoist load in kilograms;
g	is the gravity constant 9,81 m/s ² .

The $F_{\max L}$ represents the final load in the hoist system after the triggering has operated and the hoist motion is brought to rest. It shall be calculated with due consideration to stiffness of the hoist mechanism and structures as a whole, properties of stall load protection system, properties of the hoist drive system and functioning of the indirect acting limiter, see 5.5.1.2. **[A1]** Guidance of a calculation method is given in the corresponding annex of EN 13001-2. **[A1]**

[A1] The force $F_{\max L}$ shall be assigned to the corresponding load and stability combinations C of EN 13001-2. **[A1]**

5.2.1.6 Test loads

The overload test loads to be taken into account in calculation shall be in accordance with 6.3.2.

5.2.1.7 Design basis for multi point lifting in cases where the lifting forces are not equalized

For cranes, which are equipped with two or more lifting points for lifting a single load, e.g. container lifting frame, the loading on an individual lifting point will depend upon the position of the load centre of gravity with respect to the lifting points. Location of centres of gravities with relevant loads shall be specified in the technical file and in the operating instructions.

In force calculations both the case of a mid-air load suspension and that of a load being grounded, possibly in an inclined position or on an inclined plane, shall be considered. The forces from the latter case (inclined grounding) shall be addressed to one of the load combinations A, B or C based upon its frequency of occurrence.

The proof of static strength for the lifting points shall be based upon the maximum force resulting from the hoist load and maximum load eccentricity. The maximum force possible in each lifting point shall be considered as a regular load in all relevant load combinations A, B and C according to EN 13001-2. Due consideration shall be given to the effect of horizontal load actions on the forces in the lifting points.

The proof of fatigue strength shall take into account the whole range of centre of gravity locations, the frequency of occurrence of these locations and distribution of load values. The resulting fatigue loading shall be expressed by a series of $\{A_1\}$ forces $\{A_1\}$ on the lifting points and their respective frequencies of occurrence. Horizontal load actions and inclined grounding shall be considered in case they appear in load combination A.

5.2.1.8 Conditions of use of permissible stress method and limit state method

Selection of allowable stress method or limit state method shall be made in accordance with EN 13001-1 and EN 13001-2.

5.2.2 Limit states and proof of competence

5.2.2.1 Limit states and proof of competence of structural members

The limit states and proof of competence of structural members and connections shall be determined in accordance with $\{A_1\}$ EN 13001-3-1 $\{A_1\}$.

5.2.2.2 Limit states of mechanical components

Proof of competence of ropes in rope drives shall be in accordance with CEN/TS 13001-3-2.

NOTE A European Standard for the selection of rail wheels is under preparation. While the appropriate standard is not available, the rail wheels and rails may be selected in accordance with ISO 16881-1. Other methods that are based on experimental knowledge on the wear of the used materials and which give comparable life of the wheels can be used.

For other components the load effects and required life (number of cycles) shall be derived from the service and load conditions specified in 5.2.1 and they shall not exceed the limit states specified by the component manufacturer.

5.2.2.3 Local stresses from wheel loads

$\{A_1\}$ Trolley wheels generally transmit vertical and horizontal wheel loads. The effects of these wheel loads on the supporting structure shall be taken into account in combination with global stresses.

Distribution of wheel loads of a crane or a trolley shall not be considered equalised unless equalising is ensured by appropriate arrangements (e.g. pinned bogies, balancers, flexibility of structures).

Stresses in the web under the rail, resulting from vertical wheel loads, shall be calculated in conformance with EN 13001-3-1. When passing over girder cuts (e.g. from main girder to cantilever), the effective distribution length is halved, which shall be taken into account in the calculation.

NOTE Annex E presents one permissible method to determine the stresses in the case of cranes with the trolley travelling on the lower flange of the girder.

The local stress due to the wheel load shall be combined with the global normal and shear stresses for the determination of the equivalent stress in accordance with the principles given in EN 13001-3-1.

For fatigue assessment in accordance with EN 13001-3-1

- the total number of wheel overruns at the mostly loaded position shall be taken into account;
- For top-running trolleys, where the weld joint of flange/web is subjected only to transverse compressive stresses, the weld may be regarded as a fail-safe component, when selecting the specific resistant factor Y_{mf} ;

- For under hung hoists travelling on the bottom flange of a girder, the weld shall be regarded as a non fail-safe component, when selecting the specific resistant factor γ_{mf} . 

5.2.2.4 Proof of strength of lifting points

Lifting points (holes and lugs) used for erection and maintenance purposes shall be calculated by either:

- using theory of plasticity with a minimum factor of 4 and welds to structures with a minimum factor of 5 against ultimate strength of steel. To justify the use of this theory, the percentage elongation after fracture of the materials shall be at least 15 %; or
- using the theory of elasticity.

5.2.2.5 Elastic deformation

The elastic deformations of the crane structure shall not have a detrimental influence on the function of the crane.

NOTE Information and guide values for the specification of crane girders are given in ISO 22986.

5.2.2.6 Vibration frequencies of crane girders

Recommended natural frequencies of structural vibrations are given in ISO 22986. Where frequencies are lower, consideration shall be given to the effect of additional fatigue on the structure and to load control. Consideration shall also be given to minimize the amplitude and duration of vibrations e.g. by using stepless controls.

NOTE See also 5.6.1 concerning cabins.

5.2.3 Stability

5.2.3.1 General requirements

A crane is considered to be stable, when the overturning moment calculated with specified loads and factors is smaller than the stabilising moment about any tipping axis.

The partial safety factors for the proof of stability of the crane shall be taken from EN 13001-2.

5.2.3.2 Gantry crane configurations

A basic crane configuration assumes a fixed legged crane standing on four or more corners.

For other crane configurations an additional risk coefficient γ_n shall be applied for all non-favourable loads of  EN 13001-2  based upon the leg configuration of a crane as follows:

- cranes supported on three corners $\gamma_n = 1,10$;
- cranes supported by a hinged leg in one or more of the corners:
 - hinged leg corner lifting up $\gamma_n = 1,10$;
 - fixed leg corner lifting up $\gamma_n = 1,22$.

Cases b_1) and b_2) can appear on the same crane, see Figure 3.

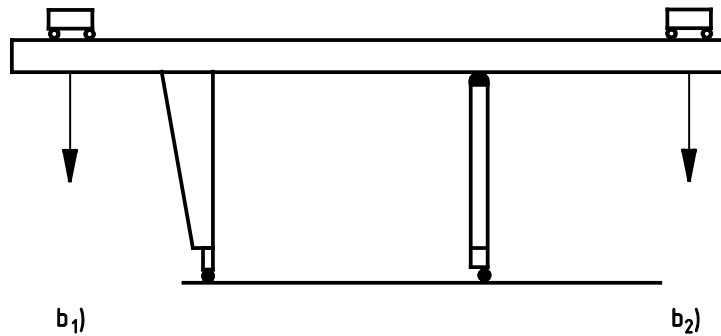


Figure 3 — Typical gantry crane configuration with cantilevers

5.2.3.3 Design of tie-downs

Where the stability of the crane does not conform to 5.2.3.1 and 5.2.3.2 in out-of service wind conditions, it shall be equipped with tie-downs. The tie-downs shall be designed with the partial load factors in accordance with the EN 13001-2 and the relevant risk factors in accordance with 5.2.3.2.

[A1] The additional risk coefficient factors for design of tie-downs and their fastening points shall be taken as follows:

- for steel sections $\gamma_n = 1,20$;
- for wire ropes and chains $\gamma_n = 1,60$. **[A1]**

5.2.3.4 Stability of rubber tyred gantry crane (RTG)

Rubber tyred gantry cranes shall remain stable when they experience an immediate tyre deflation whilst travelling at maximum speed down a maximum incline in both the loaded and unloaded conditions.

5.3 Electrotechnical equipment

5.3.1 Physical environment and operating conditions

When the physical environment or the operating conditions are outside those specified in EN 60204-32:2008, 4.4 the specification of the electrical equipment shall be amended accordingly. Attention should be given to wind chill effects and solar heat gain.

5.3.2 Electrical supply

High voltage equipment (exceeding 1 kV AC or 1,5 kV DC) shall comply with EN 60204-11. All references to EN 60204-1 in EN 60204-11 shall be considered as references to the respective clauses in EN 60204-32.

Where a collector system is used for the incoming supply and it cannot be totally enclosed to prevent danger to personnel and damage by the operation of the crane or associated activities, the provisions of EN 60204-32:2008, 12.7.1 shall apply.

5.3.3 Protection against electric shock by direct contact

[A1] Protection against electric shock by direct contact shall comply with EN 60204-32:2008, 6.2 with the following limitations:

- protection by barriers in accordance with HD 60364-4-41 is only acceptable in areas restricted to electrically skilled persons;
- protection by placing out of reach in accordance with EN 60204-32:2008, 6.2.6 is acceptable only in the case of conductor bars. **[A1]**