

BS EN 13001-1:2015



BSI Standards Publication

# Cranes — General design

Part 1: General principles and requirements

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**National foreword**

This British Standard is the UK implementation of EN 13001-1:2015. It supersedes BS EN 13001-1:2004+A1:2009 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MHE/3/1, Crane design.

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

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ISBN 978 0 580 84410 2

ICS 53.020.20

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2015.

**Amendments issued since publication**

Date	Text affected
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EUROPEAN STANDARD

**EN 13001-1**

NORME EUROPÉENNE

EUROPÄISCHE NORM

April 2015

ICS 53.020.20

Supersedes EN 13001-1:2004+A1:2009

English Version

## Cranes - General design - Part 1: General principles and requirements

Appareils de levage à charge suspendue - Conception générale - Partie 1 : Principes généraux et prescriptions

Krane - Konstruktion allgemein - Teil 1: Allgemeine Prinzipien und Anforderungen

This European Standard was approved by CEN on 16 February 2015.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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

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## Foreword

This document (EN 13001-1:2015) 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of an identical text or by endorsement, at the latest by October 2015, and conflicting national standards shall be withdrawn at the latest by October 2015.

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 13001-1:2004+A1:2009.

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.

The major changes in this revision are in 4.2.7.2, 4.3.3 and 4.4.4. Annex B has been added.

This European Standard is one part of EN 13001. The parts are the following ones:

- *Part 1: General principles and requirements;*
- *Part 2: Load actions;*
- *Part 3-1: Limit States and proof competence of steel structure;*
- *Part 3-2: Limit states and proof of competence of wire ropes in reeving systems;*
- *Part 3-3: Limit states and proof of competence of wheel/rail contacts;*
- *Part 3-4: Limit states and proof of competence of machinery [currently at Enquiry stage];*
- *Part 3-5: Limit states and proof of competence of forged hooks [Technical Specification].*

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

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 harmonized standard to provide one means for the mechanical design and theoretical verification of cranes to conform to the essential health and safety requirements of the Machinery Directive, as amended. This standard also establishes interfaces between the user (purchaser) of the crane and the designer, as well as between the designer and the component manufacturer, in order to form a basis for selecting cranes and components.

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

The crane parts, components or machinery concerned and the extent to which hazards are covered are indicated in the scope of this 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

This European Standard specifies general principles and requirements to be used together with EN 13001-2 and the EN 13001-3 series of standards, and as such they specify conditions and requirements on design to prevent mechanical hazards of cranes, and a method of verification of those requirements.

NOTE Specific requirements for particular types of crane are given in the appropriate European Standard for the particular crane type.

The following is a list of significant hazardous situations and hazardous events that could result in risks to persons during normal use and foreseeable misuse. Clause 4 of this European Standard is necessary to reduce or eliminate the risks associated with the following hazards:

- a) instability of the crane or its parts (tilting);
- b) exceeding the limits of strength (yield, ultimate, fatigue);
- c) elastic instability of the crane or its parts (buckling, bulging);
- d) exceeding temperature limits of material or components;
- e) exceeding the deformation limits.

This European Standard is applicable to cranes which are manufactured after the date of approval by CEN of this standard and serves as reference base for the European Standards for particular crane types.

## 2 Normative references

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

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

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

ISO 2394, *General principles on reliability for structures*

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

## 3 Terms, definitions, symbols and abbreviations

### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010 and, for the definitions of loads, in ISO 4306-1:2007, Clause 6, and the following apply.

### 3.2 Symbols and abbreviations

The symbols and abbreviations used in this part of EN 13001 are given in Table 1.

**Table 1 — Symbols and abbreviations**

Symbols, abbreviations	Description
$adm\sigma$	Allowable (admissible) stress
$C$	Total number of working cycles
$C_i$	Number of working cycles where a load $i$ is handled
$C_r$	Number of working cycles of task $r$
$Dh0$ to $Dh9$	Classes of average linear displacement $\bar{X}_{lin}$ for hoisting
$Dt0$ to $Dt9$	Classes of average linear displacement $\bar{X}_{lin}$ for traversing (trolley)
$Dc0$ to $Dc9$	Classes of average linear displacement $\bar{X}_{lin}$ for travelling (crane)
$Da0$ to $Da5$	Classes of average angular displacement $\bar{X}_{ang}$
$f_i$	Characteristic loads including dynamic factors
$F_j$	Combined loads from load combination $j$ (limit state method)
$\bar{F}_j$	Combined loads from load combination $j$ (allowable stress method)
$k_m$	Stress spectrum factor, based on $m$ of detail under consideration
$kQ$	Load spectrum factor
$kQ_r$	Load spectrum factor for task $r$
$lim D$	Limit in damage calculation
$lim \sigma$	Limit design stress
$m$	Inverse slope of the $\log \sigma_a / \log N$ curve
$\hat{n}$	Total number of stress cycles
$n_{ij}$	Number of stress cycles of class $ij$
$n_{ij}^{(r)}$	Number of stress cycles of class $ij$ occurring each time task $r$ is carried out
$n_i, n_j$	Service frequency of position $i$ or $j$
$n(R$ or $\sigma_m)$	Number of stress cycles with stress amplitude $\sigma_a(R$ or $\sigma_m)$
$n_i(R$ or $\sigma_m)$	Number of stress cycles with amplitude $\sigma_{a,i}(R$ or $\sigma_m)$
$N$	Number of stress cycles to failure by fatigue
$N_D$	Number of cycles at reference point

Symbols, abbreviations	Description
$p$	Average number of accelerations
$P, P_0$ to $P_3$	Classes of average numbers of accelerations $p$
$Q_0$ to $Q_5$	Classes of load spectrum factors $kQ$
$Q$	Maximum value of $Q_r$ for all tasks $r$
$Q_i$	Magnitude of load $i$
$Q_r$	Maximum load for task $r$
$R_d$	Characteristic resistance of material, connection or component
$R$	Stress ratio
$s$	Stress history parameter
$S_{02}$ to $S_9$	Classes of stress history parameters $s$
$S_k$	Load effect in section $k$ of a member (limit state method)
$\bar{S}_k$	Load effect in section $k$ of a member (allowable stress method)
$U, U_0$ to $U_9$	Classes of total numbers of working cycles $C$
$x_{ri}, x_{rj}$	Displacement of the drive under consideration to serve position $i$ or $j$
$\bar{x}_r$	Average displacement during task $r$
$\bar{X}_{lin}, \bar{X}_{ang}$	Average linear or angular displacement
$\alpha, \alpha_1, \alpha_2$	Angles between horizontal line and lines of constant $N$ in the $\sigma_a - \sigma_m$ plane
$\alpha_r$	Relative number of working cycles for task $r$
$\gamma_f$	Overall safety factor
$\gamma_m$	Resistance coefficient
$\gamma_n$	Risk coefficient
$\gamma_p$	Partial safety factor
$\bar{\gamma}_p$	Reduced partial safety factor
$v$	Relative total number of stress cycles
$\sigma_a$	Stress amplitude
$\sigma_a(R), \hat{\sigma}_a(R)$	Stress amplitude, maximum stress amplitude for constant stress ratio $R$
$\sigma_a(\sigma_m), \hat{\sigma}_a(\sigma_m)$	Stress amplitude, maximum stress amplitude for constant mean stress $\sigma_m$
$\sigma_{a,i}$	Stress amplitude of range $i$

Symbols, abbreviations	Description
$\sigma_b$	Lower extreme value of stress cycle
$\sigma_1$	Design stress in element / (limit state method)
$\bar{\sigma}_1$	Design stress in element / (allowable stress method)
$\sigma_{11}$	Stresses in element / resulting from $S_k$ (limit state method)
$\bar{\sigma}_{11}$	Stresses in element / resulting from $\bar{S}_k$ (allowable stress method)
$\sigma_{21}$	Stresses in element / arising from local effects (limit state method)
$\bar{\sigma}_{21}$	Stresses in element / arising from local effects (allowable stress method)
$\sigma_m$	Mean stress
$\sigma_{m,j}$	Mean stress of range $j$
$\sigma_u$	Upper extreme value of stress cycle
$\phi_i$	Dynamic factors

## 4 Safety requirements and/or measures

### 4.1 General

Cranes shall conform to the safety requirements and/or measures of this clause. Hazards not covered in EN 13001 (all parts) may be covered by other general requirements for all types of cranes and/or by specific requirements for particular types of cranes, as given in the standards listed in Annex A. In addition, the machine shall be designed according to the principles of EN ISO 12100 for hazards relevant but not significant which are not dealt with by the above mentioned standards.

### 4.2 Proof calculation

#### 4.2.1 General principles

The objective of this calculation is to prove theoretically that a crane, taking into account the service conditions agreed between the user, designer and/or manufacturer, as well as the states during erection, dismantling and transport, has been designed in conformance to the safety requirements to prevent mechanical hazards.

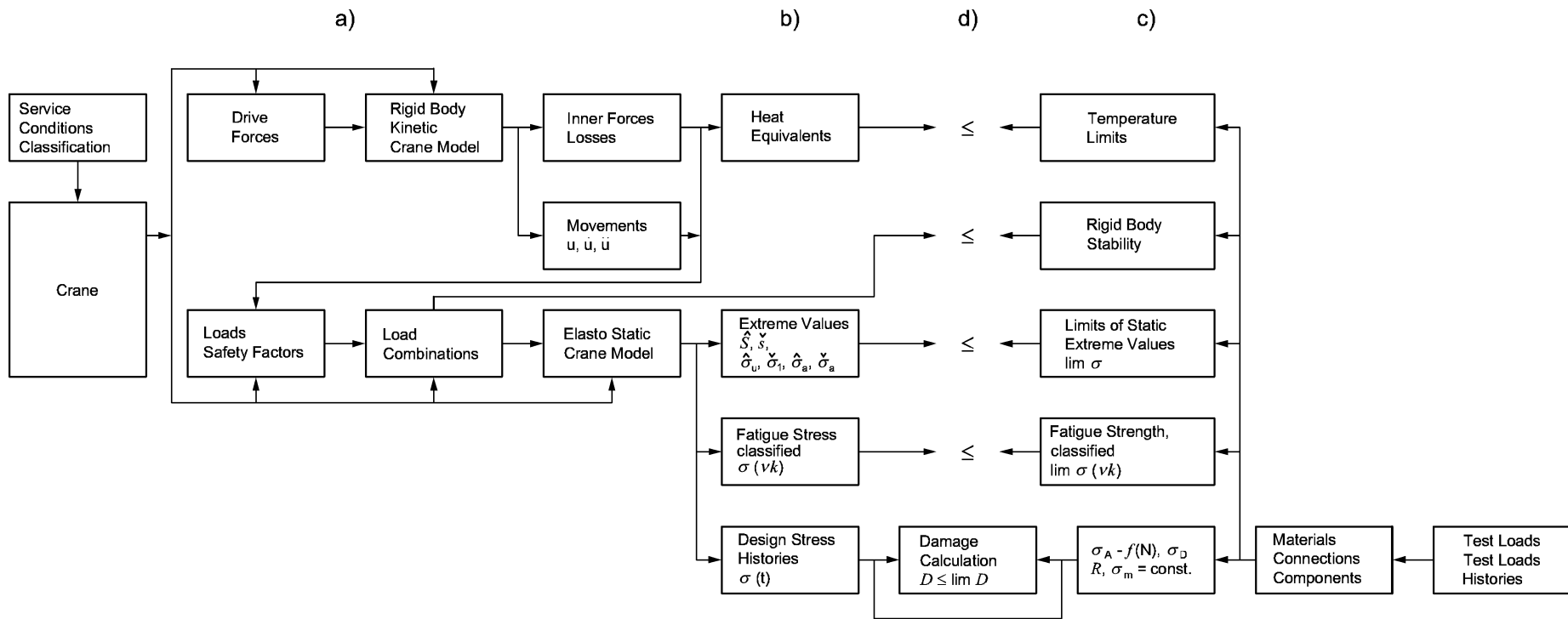
The proof of competence according to the EN 13001 series shall be carried out by using the general principles and methods appropriate for this purpose and corresponding with the recognized state of the art in crane design.

Alternatively, advanced and recognized theoretical or experimental methods may be used in general, provided that they conform to the principles of this standard.

Hazards can occur if extreme values of load effects or their histories exceed the corresponding limit states. To prevent these hazards with a margin of safety, it shall be shown that the calculated extreme values of load effects from all loads acting simultaneously on a crane and multiplied with an adequate partial safety coefficient, as well as the estimated histories of load effects, do not exceed their corresponding limit states at any critical point of the crane. For this purpose the limit state method, and where applicable the allowable stress method, is used in accordance with international and European design codes.

The analysis of load actions from individual events or representative use of a crane (representative load histories) is required to reflect realistic unfavourable operational conditions and sequences of actions of the crane.

Figure 1 illustrates the general layout of a proof calculation for cranes.



**Key**

- a) models of crane and loads
- b) load actions
- c) limit states
- d) proof

Figure 1 — Layout of the proof calculation

#### 4.2.2 Models of cranes and loads

For the calculation of the movements, inner forces (torques in gears, rope forces, etc.) and losses of the crane or its parts, rigid body kinetic models are used.

The loads acting on this model are the motor torques and/or brake torques, which shall balance any of the loads acting on the moved parts as losses, mass forces caused by gravity, movement of the crane or parts thereof, and wind forces.

From this rigid body kinetic model of the crane and the load models, any variation of displacement, speed, acceleration and/or inner forces as well as the corresponding instantaneous values of acceleration and/or inner forces can be derived.

These variations, if calculated in conformity with the agreed service conditions, are the base for estimating the histories of load effects (e.g. heat equivalents) and the stress histories. Since the variations and instantaneous values of accelerations and inner forces calculated by using a rigid body kinetic model only represent mean values of the real process, loads caused by sudden alterations of these mean values shall be amplified by dynamic factors  $\phi_i$  to estimate their real values (see EN 13001-2).

For cranes or crane configurations where all the loads from different drives acting simultaneously do not affect each other because they are acting at right angles to each other (i.e. orthogonal), load actions from drives can be considered independently. In cases where the loads from simultaneous actions of different drives affect each other (dependent, non-orthogonal), this shall be taken into account.

The calculation of nominal stresses in any mechanical and/or structural component of a crane or its parts can commonly be based on appropriate elasto-static models, built up by beam or more sophisticated elements, such as plane stress, plate or shell elements.

A nominal stress is a stress calculated in accordance with simple elastic strength of materials theory, excluding local stress concentration effects.

#### 4.2.3 Simulation of load actions

For the simulation of the time varying process of load actions on a crane or its parts, static equivalent loads from independent events occurring during the intended use of a crane shall be applied to elasto-static models, which correspond with the configuration and supporting conditions of the crane or its parts under consideration.

NOTE In this context the term "load" or "load action" means any action or circumstance, which causes load effects in the crane or its parts, for example: forces, intended and non-intended displacements and/or movements, temperature, wind pressure.

Static equivalent loads are given in EN 13001-2. These static equivalent loads are considered as deterministic actions, which have been adjusted in such a way that they represent load actions during the use of the crane from the actions or circumstances under consideration.

The limit state method (see 4.2.7.1) does take into account the probabilistic nature of the loads, whereas the allowable stress method (see 4.2.7.2) does not.

If a higher level of safety is required in some instance, a risk factor  $\gamma_n$  may be agreed upon and applied (see EN 13001-2).

#### 4.2.4 Load combinations and load effects

The loads shall be superimposed in such a way that the resulting load effects attain their instantaneous extreme values for the considered situation of use. Such superimpositions are called load combinations. Basic load combinations are given in EN 13001-2.

When establishing the load combinations, consideration shall be given to the use of the crane, taking into account its control systems, its normative instructions for use, and any other inherent conditions, where they relate to the specific aim of the proof of competence.

Magnitude, position and direction of all loads which act simultaneously in the sense of a load combination, shall be chosen in such a way that extreme load effects occur in the component or design detail under consideration. Consequently, in order to establish the extreme stresses in all the design critical points, several loading events or crane configurations shall be studied within the same load combination, e.g. different positions of a crab in a bridge or gantry crane.

The upper and lower extreme values of the load effects, in terms of inner forces or nominal stresses, shall be used for a static proof calculation to avoid the hazards described in the scope. In combination with the agreed service conditions and the kinematic properties of the crane or its parts, these values limit the histories of inner forces or nominal stresses for the proof of fatigue strength.

For the proof of fatigue strength, the number and magnitude of significant stress cycles shall be specified.

#### **4.2.5 Limit states**

For the purposes of this standard limit states are states of the crane, its components or materials which, if exceeded, can result in the loss of the operational characteristics of the crane. There is a distinction between ultimate limit states and serviceability limit states as follows:

a) Ultimate limit states, given by:

- 1) plastic deformations from the effect of nominal stresses or sliding of frictional connections;
- 2) failure of components or connections (e.g. static failure, failure by fatigue or formation of critical cracks);
- 3) elastic instability of the crane or its parts (e.g. buckling, bulging);
- 4) rigid body instability of the crane or its parts (e.g. tilting, shifting).

b) Serviceability limit states, examples of which are:

- 1) deformations which impair the intended utilization of the crane (e.g. function of moving components, clearances of parts);
- 2) vibrations that cause damage to the crane driver or cause damage to the crane structure or restrict the ability to operate;
- 3) exceeding temperature limits (e.g. overheating of motors and brakes).

#### **4.2.6 Proof of competence**

The limit states applicable to the combination of material selection, manufacturing techniques and the specified service conditions shall be stated in the proof of competence.

For the verification that the ultimate limit states are not exceeded, the following proofs shall be established:

a) proof of strength of members, connections and components:

- 1) under static and quasi-static loading;
- 2) under cyclic loading (fatigue);

- b) proof of elastic stability of the crane and its parts;
- c) proof of crane stability.

For the verification that the serviceability limit states are not exceeded, the following aspects shall be considered, and a proof be established where appropriate:

- d) proof of deformation;
- e) vibration;
- f) thermal performance.

#### 4.2.7 Methods for the proof of competence

##### 4.2.7.1 Limit state method

For a general description of the limit state method, see ISO 2394. For all crane systems, the limit state method is applicable without any restriction.

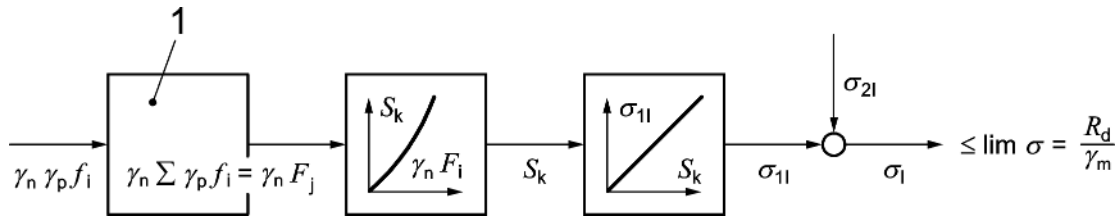
Individual characteristic loads  $f_i$  shall be calculated and amplified where necessary using the factors  $\phi_i$ , multiplied by the appropriate partial safety factors  $\gamma_p$  or reduced partial safety factors  $\bar{\gamma}_p$  and combined into  $F_j$  according to the load combination under consideration. When agreed upon  $F_j$  shall also be multiplied by an appropriate risk coefficient  $\gamma_n$ . The result  $\gamma_n \cdot F_j$  shall be used to determine the resulting load effects  $S_k$ , i.e. the inner forces in structural or mechanical components or the forces in articulations and supports.

For proof that yielding and elastic instability will not occur, the nominal design stresses  $\sigma_{11}$  due to the action of the loads on a particular component are calculated and combined with any stresses  $\sigma_{21}$  resulting from local effects, calculated using the appropriate partial safety factors  $\gamma_p$  and where agreed upon the risk coefficient  $\gamma_n$ .

The resulting design stress  $\sigma_1$  shall be compared with the limit design stress  $\lim \sigma$ . It is derived from the specific strength or characteristic resistance  $R_d$  of material, connection or component with at least 95 % probability of survival, divided by the resistance coefficient  $\gamma_m = 1,10$ .

For the proof of crane stability it shall be shown that under the combined action of the loads multiplied by their partial safety factors no rigid body movement occurs. All supports, where given limits are exceeded, i.e. wheel/rail under tension or rope under compression, shall be neglected. This means that in the sense of the elasto-static model, the corresponding restraints shall be set "inactive". The remaining positive and/or frictional support forces shall be sufficient to ensure the crane stability.

A flow chart illustrating the limit state method for the proof calculation based on stresses is shown in Figure 2. For the proof based on forces, moments, deflections the limit state method shall be applied by analogy.



**Key**

- 1 see EN 13001-2
- $f_i$  characteristic load  $i$  on the element component including dynamic factors
- $F_j$  combined load from load combination
- $S_k$  load effects in section  $k$  of members or supporting parts, such as inner forces and moments, resulting from load combination  $F_j$
- $\sigma_{1l}$  stresses in the particular element  $l$  as a result of load effects  $S_k$
- $\sigma_{2l}$  stresses in the particular element  $l$  arising from local effects
- $\sigma_l$  resulting design stress in the particular element  $l$
- $R_d$  specified strength or characteristic resistance of the material, particular element or connection, such as the stress corresponding to the yield point, limit of elastic stability or fatigue strength (limit states)
- $\lim \sigma$  limit design stress
- $\gamma_p$  partial safety factors applied to individual loads according to the load combination under consideration
- $\gamma_n$  risk coefficient, where applicable
- $\gamma_m$  resistance coefficient

**Figure 2 — Flow chart of the limit state method**

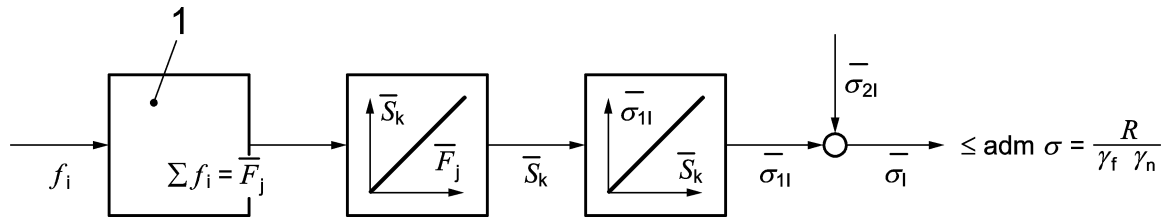
**4.2.7.2 Allowable stress method**

For cranes or portions of cranes where all masses act only unfavourable (see EN 13001-2) and with a linear relationship between load actions and load effects, the allowable stress method is applicable for the proof of competence calculation. The allowable stress method is a special case of the limit state method, where the partial safety factors are given the same value, which combined with the resistance coefficient, forms an overall safety factor  $\gamma_f$ . Because of its special character, the allowable stress method is only reliable in specific cases.

Individual specified loads  $f_i$  shall be calculated and amplified where necessary using the factors  $\phi_i$  and shall be combined according to the load combinations under consideration. The combined load  $\overline{F}_j$  shall be used to determine the resulting load effects  $\overline{S}_k$ , i.e. the inner forces in structural and mechanical components or the forces in articulations and supports.

For proof that yielding and elastic instability do not occur, the nominal stress  $\overline{\sigma}_{1l}$  due to the action of the load effects on a particular element or component shall be calculated and combined with any stresses  $\overline{\sigma}_{2l}$  resulting from local effects. The resulting stress  $\overline{\sigma}_l$  shall be compared with the allowable stress  $\text{adm } \sigma$ . It is derived from the specific strength or characteristic resistance  $R_d$  of material, connection or component with at least 95 % probability of survival divided by the overall safety factor  $\gamma_f$  and where applicable the risk coefficient  $\gamma_n$ .

A flow chart illustrating the allowable stress method is shown in Figure 3.



**Key**

- 1 see EN 13001-2
- $f_i$  characteristic load  $i$  on the element or component including dynamic factors
- $\bar{F}_j$  combined load from load combination  $j$
- $\bar{S}_k$  load effects in section  $k$  of members or supporting parts, such as inner forces and moments resulting from load combination  $\bar{F}_j$
- $\bar{\sigma}_{11}$  stresses in the particular element  $l$  as result of load effects  $\bar{S}_k$
- $\bar{\sigma}_{21}$  stresses in the particular element  $l$  arising from local effects
- $\bar{\sigma}_l$  resulting stress in the particular element  $l$
- $R_d$  specified strength or characteristic resistance of the material, particular element or connection, such as the stress corresponding to the yield point, limit of elastic stability or fatigue strength (limit states)
- adm  $\sigma$  allowable (admissible) stress
- $\gamma_f$  overall safety factors applied to the specified strength according to the load combination under consideration
- $\gamma_n$  risk coefficient, where applicable

**Figure 3 — Flow chart of the allowable stress method**

**4.3 Classification**

**4.3.1 General**

The classification is used to determine and agree the usage of cranes and/or load lifting attachments which are designed and manufactured individually. It is also used to specify the usage of cranes and/or load lifting attachments which are designed for serial manufacture, and allows such items to be selected in accordance with their intended use. Classification is independent of the type of crane and the way it is operated.

The service conditions are determined by the following parameters:

- a) the total number of working cycles during the specified design life;
- b) the average distances;
- c) the relative frequencies of loads to be handled (load spectra);
- d) the average number of accelerations per movement.

When the classified ranges of parameters are used, the design shall be based on the maximum values of the parameters within the specified classes. Use of an intermediate value for a parameter is permissible, but in that case this design value shall be determined and marked instead of the class.

NOTE Examples for the application or simplified use of the parameters (classification) are shown in the EN 13001-3 series (see Bibliography) and the European Standards for specific crane types.

#### 4.3.2 Total numbers of working cycles

For the purpose of classification, a working cycle is a sequence of movements which commences when the crane is ready to hoist the payload, and ends when the crane is ready to hoist the next payload.

The range of total numbers of working cycles  $C$  is classified in Table 2.

**Table 2 — Classes  $U$  of total numbers of working cycles  $C$**

Class	Total number of working cycles
$U_0$	$C \leq 1,60 \times 10^4$
$U_1$	$1,60 \times 10^4 < C \leq 3,15 \times 10^4$
$U_2$	$3,15 \times 10^4 < C \leq 6,30 \times 10^4$
$U_3$	$6,30 \times 10^4 < C \leq 1,25 \times 10^5$
$U_4$	$1,25 \times 10^5 < C \leq 2,50 \times 10^5$
$U_5$	$2,50 \times 10^5 < C \leq 5,00 \times 10^5$
$U_6$	$5,00 \times 10^5 < C \leq 1,00 \times 10^6$
$U_7$	$1,00 \times 10^6 < C \leq 2,00 \times 10^6$
$U_8$	$2,00 \times 10^6 < C \leq 4,00 \times 10^6$
$U_9$	$4,00 \times 10^6 < C \leq 8,00 \times 10^6$

There are operations that occur less frequently than the working cycles but which shall be taken into account in the proof of fatigue strength, such as:

- a) raising/lowering the boom of a ship unloader;
- b) erection/dismantling of a mobile or tower crane;
- c) movement of a harbour crane from one working position to another.

The total number of such operations during the design life shall be specified.

The total number of working cycles of a crane during its design life can be divided into groups of working cycles. Each group corresponds to one of typical tasks performed by the crane. A task can be characterized by a specific combination of crane configuration and sequence of intended movements.

The relative number of working cycles  $\alpha_r$  for a task  $r$  is given by the expression:

$$\alpha_r = C_r / C \tag{1}$$

where

- $C$  is the total number of working cycles during the design life of the crane;
- $C_r$  is the number of working cycles of task  $r$ .

### 4.3.3 Average linear or angular displacements

The average displacement  $\bar{X}$  may be estimated by experience or calculated from the average linear or angular (e.g. slewing) displacements  $\bar{X}_r$  as follows:

$$\bar{X} = \sum_r (\alpha_r \cdot \bar{X}_r) \quad (2)$$

where

$\alpha_r$  is the relative number of working cycles for a task  $r$ .

The average displacement  $\bar{X}_r$  resulting in any drive serving between working spaces 1 and 2 during a task  $r$  may be estimated by experience or is calculated by:

$$\bar{X}_r = \frac{\sum_{j=1}^n n_{rj} \cdot x_{rj}}{\sum_{j=1}^n n_{rj}} - \frac{\sum_{i=1}^m n_{ri} \cdot x_{ri}}{\sum_{i=1}^m n_{ri}} \quad (3)$$

where

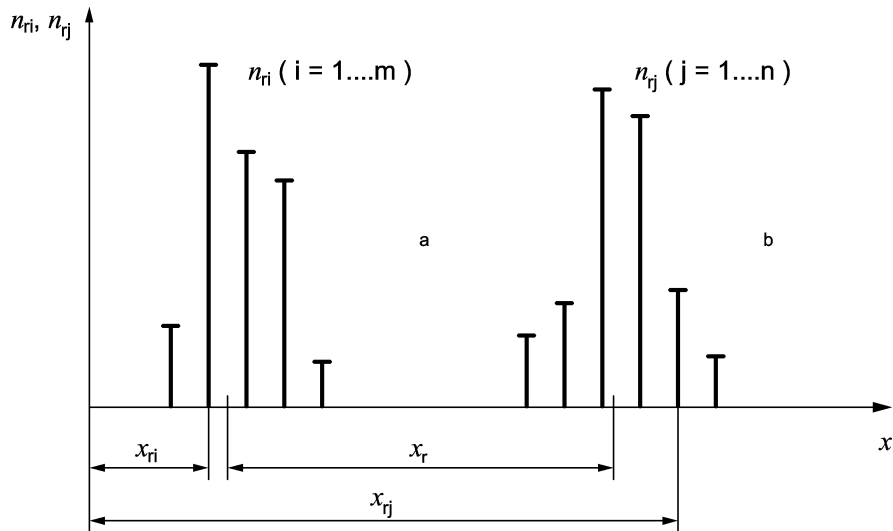
$n_{ri}$  is the service frequency of positions  $i = 1 \dots m$  in working space 1;

$n_{rj}$  is the service frequency of positions  $j = 1 \dots n$  in working space 2;

$x_{ri}$  is the coordinate of the drive under consideration to serve position  $i$ ;

$x_{rj}$  is the coordinate of the drive under consideration to serve position  $j$ .

The above given parameters are illustrated in Figure 4.



**Key**

- a working space 1
- b working space 2

**Figure 4 — Service frequencies  $n_{ri}$  and during task  $r$  in the working spaces 1 and 2, average linear displacement in the direction of movement of the drive under consideration**

Working movements within one working space shall be considered as a separate task.

The average displacement  $\bar{X}$  should be estimated from the average displacements  $\bar{x}_r$  for all tasks  $r$  and the corresponding relative number of working cycles  $\alpha_r$  as follows:

$$\bar{X} = \sum_r (\alpha_r \cdot \bar{x}_r) \tag{4}$$

Formula (4) can be used as the average displacement of the drive for the estimation of the number of revolutions or cycles of any component, where the displacements are about the same at all levels of loading. If there are significant differences in the displacements with different load levels, e.g. short displacements under high loads and longer displacements under low loads, this should be taken into account in the estimation of the stress spectrum factor of the relevant components.

The average linear (index lin) or angular (index ang) displacement  $\bar{X}$  is classified in Table 3.

Table 3 — Symbols for classes *D* of average displacement  $\bar{X}$

Linear displacement			Angular displacement		
Classes			Range of average displacement $\bar{X}_{lin}$ [m]	Class	Range of average displacement $\bar{X}_{ang}$ [rad]
Hoisting	Traversing (Trolley)	Travelling (Crane)			
<i>Dh0</i>	<i>Dt0</i>	<i>Dc0</i>	$\bar{X}_{lin} \leq 0,63$	<i>Da0</i>	$\bar{X}_{ang} \leq \frac{\pi}{16}$
<i>Dh1</i>	<i>Dt1</i>	<i>Dc1</i>	$0,63 < \bar{X}_{lin} \leq 1,25$	<i>Da1</i>	$\frac{\pi}{16} < \bar{X}_{ang} \leq \frac{\pi}{8}$
<i>Dh2</i>	<i>Dt2</i>	<i>Dc2</i>	$1,25 < \bar{X}_{lin} \leq 2,5$	<i>Da2</i>	$\frac{\pi}{8} < \bar{X}_{ang} \leq \frac{\pi}{4}$
<i>Dh3</i>	<i>Dt3</i>	<i>Dc3</i>	$2,5 < \bar{X}_{lin} \leq 5$	<i>Da3</i>	$\frac{\pi}{4} < \bar{X}_{ang} \leq \frac{\pi}{2}$
<i>Dh4</i>	<i>Dt4</i>	<i>Dc4</i>	$5 < \bar{X}_{lin} \leq 10$	<i>Da4</i>	$\frac{\pi}{2} < \bar{X}_{ang} \leq \pi$
<i>Dh5</i>	<i>Dt5</i>	<i>Dc5</i>	$10 < \bar{X}_{lin} \leq 20$	<i>Da5</i>	$\pi < \bar{X}_{ang} \leq 2\pi$
<i>Dh6</i>	<i>Dt6</i>	<i>Dc6</i>	$20 < \bar{X}_{lin} \leq 40$		
<i>Dh7</i>	<i>Dt7</i>	<i>Dc7</i>	$40 < \bar{X}_{lin} \leq 80$		
<i>Dh8</i>	<i>Dt8</i>	<i>Dc8</i>	$80 < \bar{X}_{lin} \leq 160$		
<i>Dh9</i>	<i>Dt9</i>	<i>Dc9</i>	$160 < \bar{X}_{lin} \leq 320$		

#### 4.3.4 Frequencies of loads

The load spectrum factor  $kQ$  is one of the parameters to specify the service conditions of the crane by describing the different net loads to be handled during the working movements; it also describes the variable loadings of the hoist drive during the working movements and shall be taken into account in the proof calculation.

The load spectrum factor  $kQ_r$  for each task *r* (with discrete distribution of loads) is determined from

$$kQ_r = \sum_i \frac{C_i}{C_r} \cdot \left( \frac{Q_i}{Q_r} \right)^3 \quad (5)$$

where

$C_i$  is the number of working cycles where a net load *i* of magnitude  $Q_i$  is handled for task *r*;

$C_r$  is the number of working cycles of task *r*;

$Q_i$  is the magnitude of load *i*;

$Q_r$  is the maximum net load for task  $r$ .

The term  $C_i/C_r$  gives the relative number of working cycles. The relative load is given by  $Q_i/Q_r$ .

For the calculation of  $kQ_r$  with continuous distributions of loads see Annex B.

Where there is more than one task, a value of  $kQ$  for all tasks is obtained from:

$$kQ = \sum_r \frac{C_r}{C} \cdot kQ_r \cdot \left( \frac{Q_r}{Q} \right)^3 \quad (6)$$

where

$Q$  is the maximum value of  $Q_r$  for all tasks.

Where details concerning the numbers of working cycles and the masses of the particular net loads to be handled are not known, an appropriate relative frequency shall be agreed between the user, manufacturer and designer for each task  $r$ .

Table 4 shows the classes  $Q$  of load spectrum factors  $kQ$ .

**Table 4 — Classes  $Q$  of load spectrum factors  $kQ$**

Class	Load spectrum factors
$Q_0$	$kQ \leq 0,0313$
$Q_1$	$0,0313 < kQ \leq 0,0625$
$Q_2$	$0,0625 < kQ \leq 0,1250$
$Q_3$	$0,1250 < kQ \leq 0,2500$
$Q_4$	$0,2500 < kQ \leq 0,5000$
$Q_5$	$0,5000 < kQ \leq 1,0000$

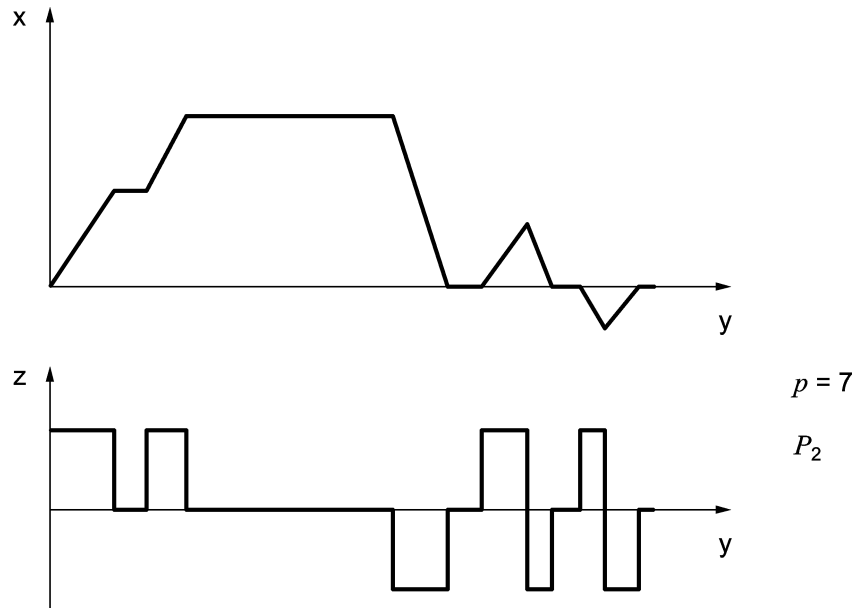
Where, from the classification process, only a single load spectrum factor is used to describe the loads to be handled, it is necessary to deduce the relative frequencies that produce most fatigue damage in the location under consideration. This is because for the same load spectrum factor, different frequencies of the net loads can produce different fatigue effects at a particular location.

#### 4.3.5 Positioning of loads

The number of intended and additional accelerations of any drive to reach the intended position of the load shall be taken into account in the proof of competence. This may be done by using average number of accelerations  $p$  classified in Table 5 and illustrated in Figure 5.

**Table 5 — Classes  $P$  of average number of accelerations  $p$**

Class	Average number of accelerations
$P_0$	$P = 2$
$P_1$	$2 < P \leq 4$
$P_2$	$4 < P \leq 8$
$P_3$	$8 < p$



**Key**

- x speed
- y time
- z acceleration.

**Figure 5 — Example for class P**

**4.4 Stress histories**

**4.4.1 General**

For the proof of fatigue strength of mechanical or structural components of a crane selected for the proof calculation, the stress histories arising from the specified service conditions shall be determined.

The stress history is a numerical presentation of all stress variations that are significant for fatigue. Using the established rules of metal fatigue the large number of variable magnitude stress cycles are condensed to one or two parameters.

Stress histories may be determined by tests or estimated from elasto-kinetic or rigid body-kinetic simulations.

For the proof of fatigue strength, occasional and exceptional loads are usually neglected. In some applications the effect of occasional loads can occur regularly. The stress histories from these occasional loads may be estimated in the same way as those from the regular ones and shall be taken into account for the fatigue assessment.

For the proof of fatigue strength, loads are multiplied by the dynamic factor  $\phi_i$  in accordance with EN 13001-2, whilst all partial safety factors  $\gamma_p$  are set to 1.

Those stress histories which are not proportional (such as in the top chord of a girder from the beam's theory and the local effects from the wheel loads or the stresses from bending and torsion shear in a gear shaft) may be determined independently. The fatigue assessment of the combined effect of such histories - interaction - is based on the action of the independent ones.

Stress histories shall be represented in terms of maximum stress amplitudes and:

- a) frequencies of stress amplitudes and mean stresses;

or

b) densities of stress amplitudes and mean stresses and the total number of stress cycles.

In the following clauses only a) is dealt with.

#### 4.4.2 Frequencies of stress cycles

For the proof of fatigue strength any stress histories shall be described by two-parameter frequencies related to stress cycles and mean stresses by using methods such as the hysteresis counting method (“rainflow counting”).

Each of the stress cycles is sufficiently described by its upper and lower extreme value from which the value of the stress amplitude and mean stress may be determined as follows:

$$\sigma_a = (\sigma_u - \sigma_b) / 2 \tag{7}$$

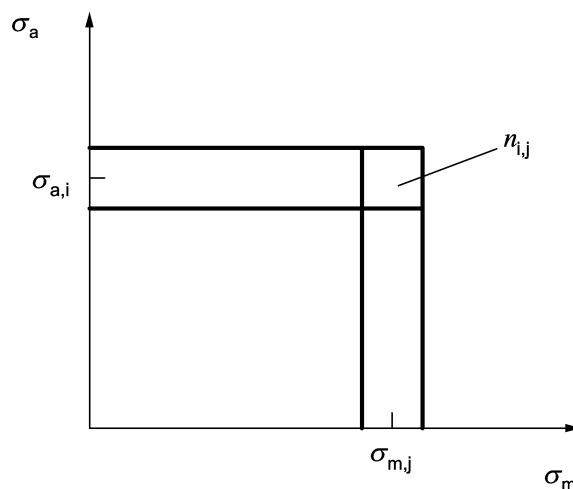
$$\sigma_m = (\sigma_u + \sigma_b) / 2 \tag{8}$$

where

- $\sigma_u$  is the upper extreme value of a stress cycle;
- $\sigma_b$  is the lower extreme value of a stress cycle;
- $\sigma_a$  is the stress amplitude;
- $\sigma_m$  is the mean stress.

All identified stress cycles are classified for statistical presentation. For this purpose each stress cycle whose amplitude is in the range  $i$  and whose mean stress is in the range  $j$  falls within the class of stress cycles  $ij$ . The number of stress cycles of class  $ij$  (frequency) is  $n_{ij}$ .

Frequencies of the amplitudes of normal stresses shall be determined for positive and negative mean stresses, the frequencies of the amplitudes of shear stresses need only to be determined for positive mean stresses. The above given two-parameter presentation of stress histories is shown in Figure 6.



**Figure 6 — Two-parameter representation of stress cycles**

The number of stress cycles of class  $ij$  and the total number of stress cycles occurring during the design life of the crane may be calculated by the following expressions:

$$n_{ij} = \sum_r \alpha_r \cdot C \cdot n_{ij}^{(r)} \quad (9)$$

$$\hat{n} = \sum_i \cdot \sum_j n_{ij} \quad (10)$$

where

- $n_{ij}$  is the number of stress cycles of class ij;
- $n_{ij}^{(r)}$  is the number of stress cycles of class ij occurring each time task r is carried out;
- $\alpha_r$  is the relative number of working cycles for each task r;
- $C$  is the total number of working cycles;
- $\hat{n}$  is the total number of stress cycles.

#### 4.4.3 Transformation of the identified stress cycles into cycles with constant mean stress or constant stress ratio

Fatigue strengths are usually presented for constant mean stresses  $\sigma_m$  (usually  $\sigma_m = 0$ ) or constant stress ratio  $R = \sigma_l / \sigma_u$  (usually  $R = -1$  or  $0$ ).

Therefore it is necessary to transform the two-parameter frequencies of stress cycles into one-parameter frequencies for constant mean stress or constant stress ratio.

The transformed stress amplitudes are calculated as follows (see Figure 8):

$$\sigma_a(R) = \frac{\sigma_{a,i} - tg\alpha \cdot \sigma_{m,j}}{1 - tg\alpha \cdot \frac{1+R}{1-R}} \quad (11)$$

$$\sigma_a(\sigma_m) = \sigma_{a,i} - tg\alpha \cdot (\sigma_{m,j} - \sigma_m) \quad (12)$$

where

$$tg\alpha = tg\alpha_1 = \frac{\sigma_a(R=-1)}{\sigma_a(R=0)} - 1 \quad \text{for } \sigma_{m,j} \geq 0 \text{ and } \sigma_m \geq 0 \quad (13)$$

$$tg\alpha = tg\alpha_2 = 1 - \frac{\sigma_a(R=-1)}{\sigma_a(R=\infty)} \quad \text{for } \sigma_{m,j} < 0 \text{ and } \sigma_m < 0 \quad (14)$$

where

- $\sigma_{a,i}$  is the stress amplitude of range  $i$  resulting from "rainflow counting" (see Figure 6);
- $\sigma_{m,j}$  is the mean stress of range  $j$  resulting from "rainflow counting" (see Figure 6);
- $\sigma_a(R)$  is the transformed stress amplitude for constant stress ratio;
- $\sigma_a(\sigma_m)$  is the transformed stress amplitude for constant mean stress;
- $R$  is the constant stress ratio selected for one-parameter classification of stress cycles;
- $\sigma_m$  is the constant mean stress selected for one-parameter classification of stress cycles;

$\alpha_1, \alpha_2$  are the angles between the horizontal line and lines of constant  $N$  in the  $\sigma_a - \sigma_m$  - plane (see Figure 7 and 8);

NOTE If the mean stress  $\sigma_m$  is assumed not to be significant (e.g. for welded connections without stress relieving), it is set  $\alpha_1 = \alpha_2 = 0$ .

$\alpha_1, \alpha_2$  are the angles between the horizontal line and the lines of constant  $N$  in the  $\sigma_a - \sigma_m$  - plane (see Figure 8), positive counting counter clockwise;

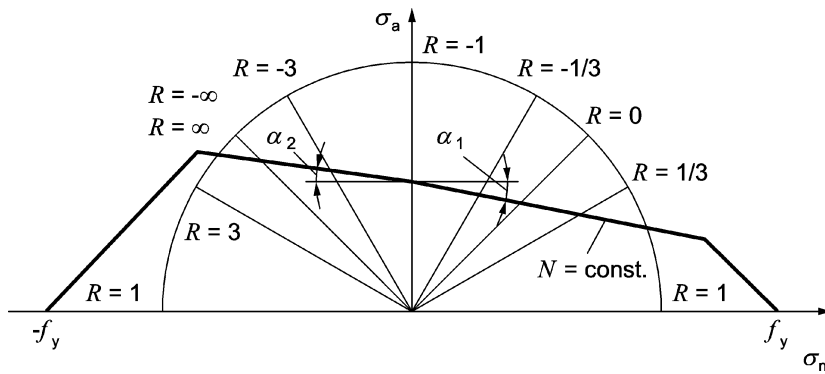
$N$  is the number of stress cycles to failure by fatigue for the stress cycle described by  $\sigma_{a,i}$  and  $\sigma_{m,j}$ ;

$\sigma_a (R = -1)$ ,

$\sigma_a (R = 0)$ ,

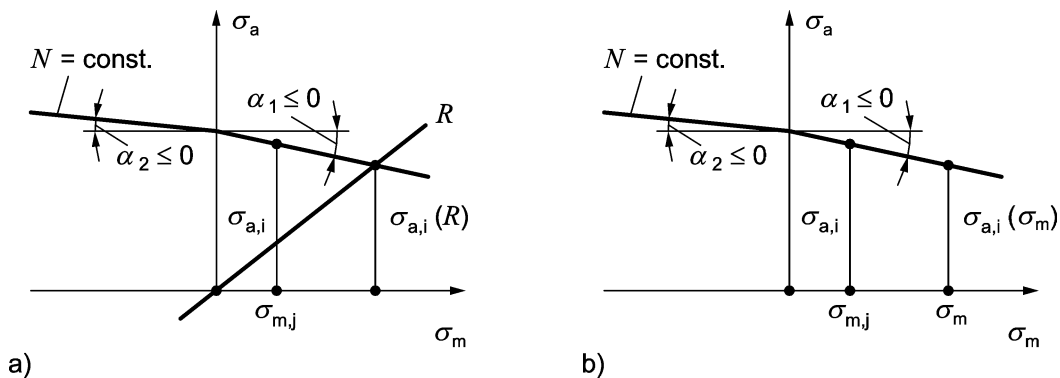
$\sigma_a (R = \infty)$  are the stress amplitudes, in dependence on the specified stress ratio  $R$  and number of cycles  $N$ , for which failure by fatigue occurs.

The relationship between stress amplitudes to failure by fatigue and mean stress or stress ratio for the component under consideration for fatigue assessment is shown in Figure 7.



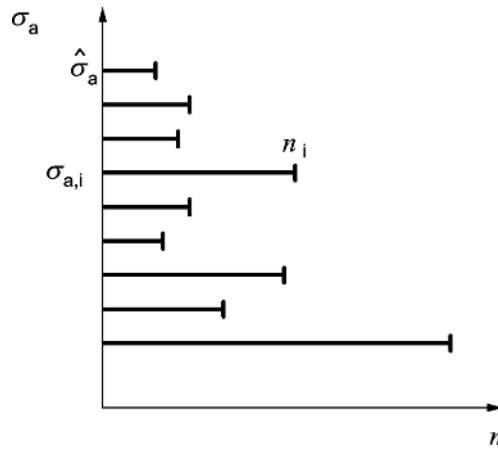
**Figure 7 —  $\sigma_a - \sigma_m$  - plane of the component under consideration for the proof of fatigue strength (simplified Haigh-Diagram)**

The transformation of stress cycles, given by the above formulae, is illustrated in Figure 8.



**Figure 8 — Transformation of stress cycles a) for constant stress ratio, and b) for constant mean stress**

The transformation yields in one-parameter frequencies of stress amplitudes referred to constant stress ratio or constant mean stress. Figure 9 shows an example for one-parameter representation of stress histories of discreet distribution. Annex B shows the mathematical formulae for continuous distributions.



**Key**

- $\hat{\sigma}_a$  is the maximum stress amplitude
- $\sigma_{a,i}$  is the stress amplitude of range  $i$  resulting from “rainflow counting”
- $n_i$  is the number of stress cycles with stress amplitude of class  $i$

**Figure 9 — One parameter representation of stress histories (frequencies of stress amplitudes referred to constant stress ratio or constant mean stress)**

**4.4.4 Classification of stress histories**

For classification of stress histories the stress history parameter  $s$  may be calculated as follows, based on a one-parameter presentation of stress histories during the design life of the crane:

$$s = v \cdot k_m \tag{15}$$

where

$$k_m = \sum_i \left[ \frac{\sigma_{a,i}}{\hat{\sigma}_a} \right]^m \cdot \frac{n_i}{\hat{n}} \tag{16}$$

$$v = \hat{n} / N_D \tag{17}$$

where

- $v$  is the relative total number of stress cycles;
- $k_m$  is the stress spectrum factor based on  $m$  of detail under consideration;
- $\sigma_{a,i}$  is the stress amplitude of range  $i$  for constant stress ratio  $R$  or constant mean stress  $\sigma_m$  (see Figure 9);
- $\hat{\sigma}_a$  is the maximum stress amplitude for constant stress ratio  $R$  or constant mean stress  $\sigma_m$  (see Figure 9);

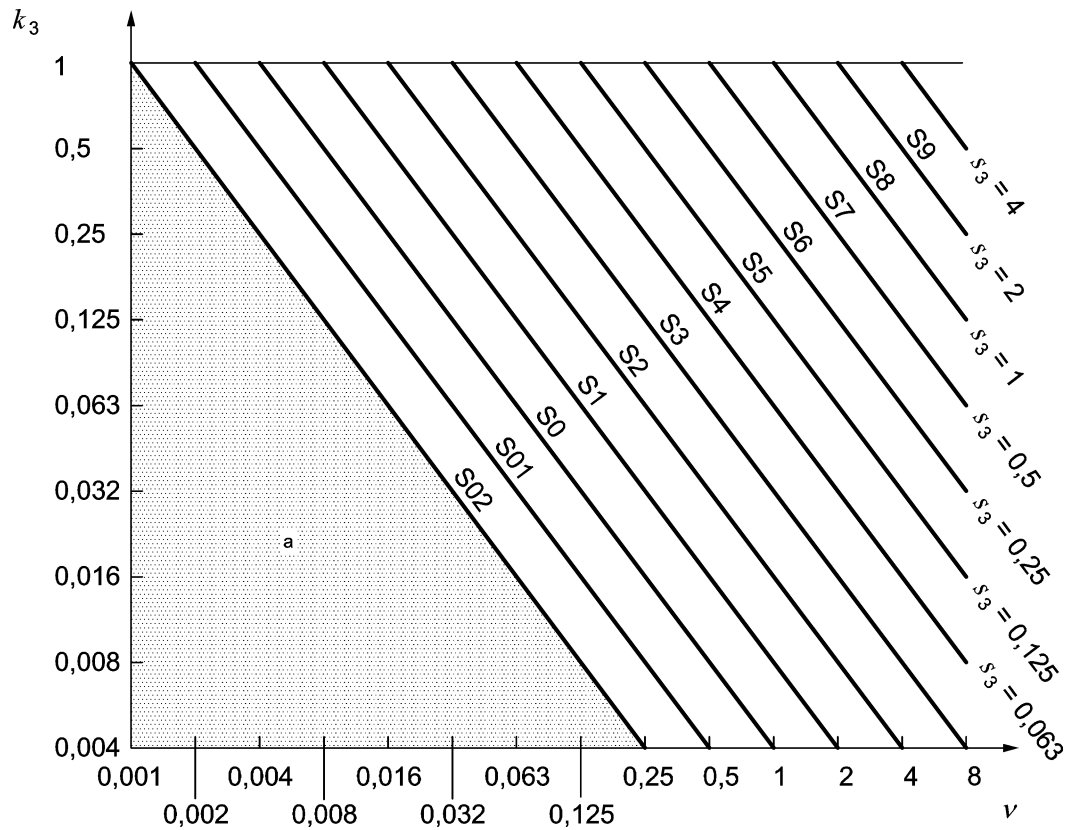
- $n_i$  is the number of stress cycles with stress amplitude of range  $i$  (see Figure 9);
- $\hat{n} = \sum_i n_i$  is the total number of stress cycles during the design life of the crane;
- $N_D = 2 \cdot 10^6$  is the number of cycles at the reference point;
- $m$  is the inverse slope of the  $\log \sigma_a / \log N$ -curve of the component under consideration.

The stress spectrum factor  $k_m$  according to Formula (16) assumes a discreet distribution of stress amplitude ranges. The use of continuous distributions for the calculation of  $k_m$  is shown in B.2.

The classification of stress histories by classes  $S$  of the stress history parameters  $s$ , when evaluated for  $m = 3$ , is given in Table 6 and illustrated in Figure 10.

**Table 6 — Classes  $S$  of stress history parameter  $s$**

<b>Class</b>	<b>Stress history parameter</b>
$S_{02}$	$s \leq 0,002$
$S_{01}$	$0,002 < s \leq 0,004$
$S_0$	$0,004 < s \leq 0,008$
$S_1$	$0,008 < s \leq 0,016$
$S_2$	$0,016 < s \leq 0,032$
$S_3$	$0,032 < s \leq 0,063$
$S_4$	$0,063 < s \leq 0,125$
$S_5$	$0,125 < s \leq 0,250$
$S_6$	$0,250 < s \leq 0,500$
$S_7$	$0,500 < s \leq 1,000$
$S_8$	$1,000 < s \leq 2,000$
$S_9$	$2,000 < s \leq 4,000$



**Key**

a fatigue assessment not required

**Figure 10 — Illustration of the classification of stress history parameter  $s$  for  $m = 3$**

A given stress history falls into specific class  $S$ , independent of the slope  $m$  of the relevant  $\log \sigma_a / \log N$ -curve. Due to the logarithmic scale for  $k$  and  $v$ , the diagonal lines (class limits) represent lines for  $s = \text{constant}$ .

For the proof of fatigue strength of components the stress histories acting on them may also be directly specified, considering the service conditions, by selecting a class  $S$  according to Table 6.

Stress histories characterized by the same value of  $s$  may be assumed to be equivalent in respect to the damage in similar materials, details or components.

## Annex A (informative)

### Selection of a suitable set of crane standards for a given application

Is there a product standard in the following list that suits the application?	
EN 13000	<i>Cranes — Mobile cranes</i>
EN 14439	<i>Cranes — Tower cranes</i>
EN 14985	<i>Cranes — Slewing jib cranes</i>
EN 15011	<i>Cranes — Bridge and gantry cranes</i>
EN 13852-1	<i>Cranes — Offshore cranes — Part 1: General purpose offshore cranes</i>
EN 13852-2	<i>Cranes — Offshore cranes — Part 2: Floating cranes</i>
EN 14492-1	<i>Cranes — Power driven winches and hoists — Part 1: Power driven winches</i>
EN 14492-2	<i>Cranes — Power driven winches and hoists — Part 2: Power driven hoists</i>
EN 12999	<i>Cranes — Loader cranes</i>
EN 13157	<i>Cranes — Safety — Hand powered cranes</i>
EN 13155	<i>Cranes — Safety — Non-fixed load lifting attachments</i>
EN 14238	<i>Cranes — Manually controlled load manipulating devices</i>
EN 15056	<i>Cranes — Requirements for container handling spreaders</i>

	YES	NO
Use it directly, plus the standards that are referred to		

Use the following:	
EN 13001-1	<i>Cranes — General design — Part 1: General principles and requirements</i>
EN 13001-2	<i>Crane safety — General design — Part 2: Load actions</i>
EN 13001-3-1	<i>Cranes — General Design — Part 3-1: Limit States and proof of competence of steel structure</i>
EN 13001-3-2	<i>Cranes — General design — Part 3-2: Limit states and proof of competence of wire ropes in reeving systems</i>
EN 13001-3-3	<i>Cranes — General design — Part 3-3: Limit states and proof of competence of wheel/rail contacts</i>
CEN/TS 13001-3-5	<i>Cranes — General design — Part 3-5: Limit states and proof of competence of forged hooks</i>
EN 13135	<i>Cranes — Safety — Design — Requirements for equipment</i>
EN 13557	<i>Cranes — Controls and control stations</i>

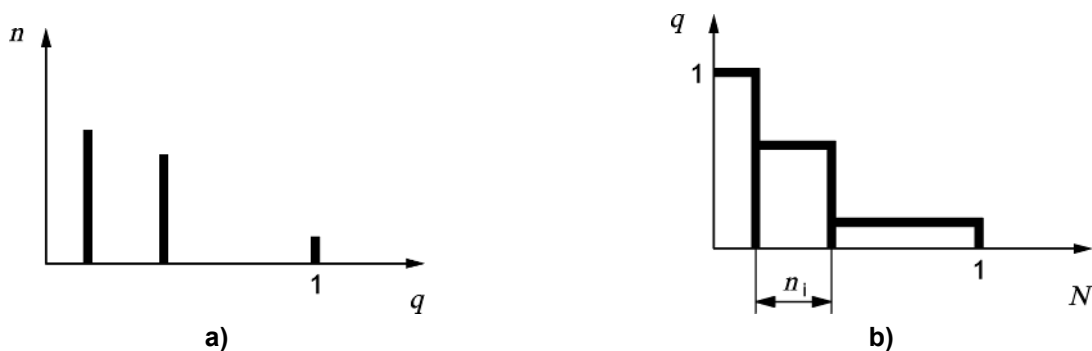
EN 12077-2	<i>Cranes safety — Requirements for health and safety — Part 2: Limiting and indicating devices</i>
EN 13586	<i>Cranes — Access</i>
EN 14502-1	<i>Cranes — Equipment for the lifting of persons — Part 1: Suspended baskets</i>
EN 14502-2	<i>Cranes — Equipment for the lifting of persons — Part 2: Elevating control stations</i>
EN 12644-1	<i>Cranes — Information for use and testing — Part 1: Instructions</i>
EN 12644-2	<i>Cranes — Information for use and testing — Part 2: Marking</i>

## Annex B (informative)

### Discreet and continuous distributions

#### B.1 General

The presentation of distributions with discrete values (cycles and amplitudes) can be shown as spectrum or as accumulated spectrum. Figure B.1 illustrates both presentations for discrete distributions.

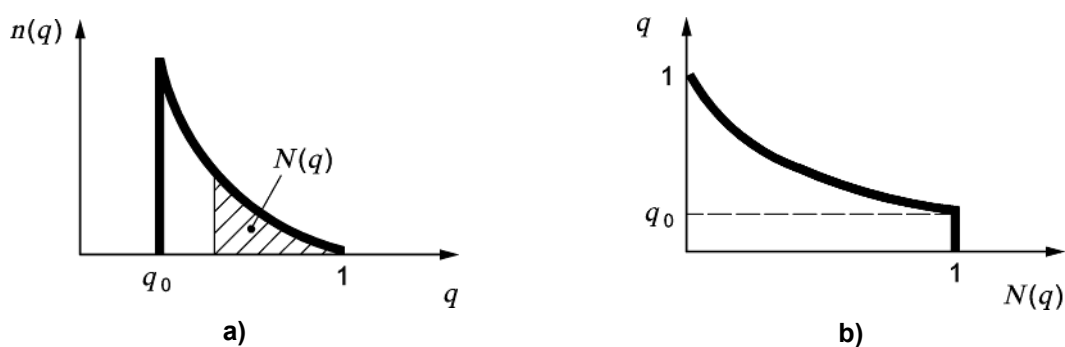


**Key**

- a) spectrum, where  $n$  is the relative number of cycles with amplitude  $q$ :  $\sum n = 1$
- b) accumulated spectrum

**Figure B.1 — Discreet distributions**

The presentation of distributions given by continuous functions can be shown as density function or as accumulated density function. Figure B.2 illustrates both presentations for distributions given by continuous functions.



**Figure B.2 — Continuous distributions**

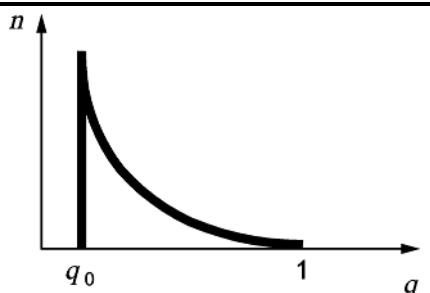
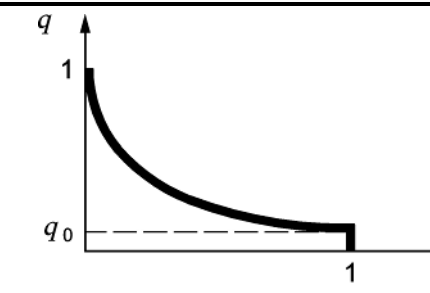
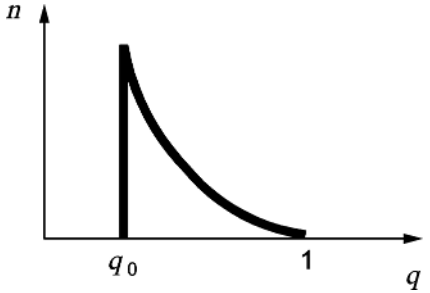
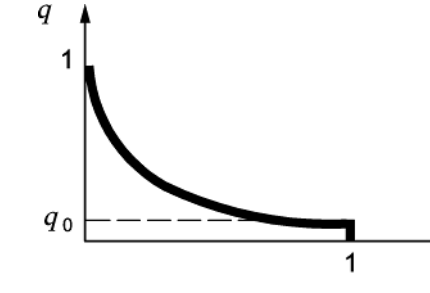
NOTE Whereas  $n(q)$  gives the relative number of cycles with amplitude  $q$ , the accumulated value of  $N(q)$  gives the number of cycles with amplitudes greater than  $q$ .

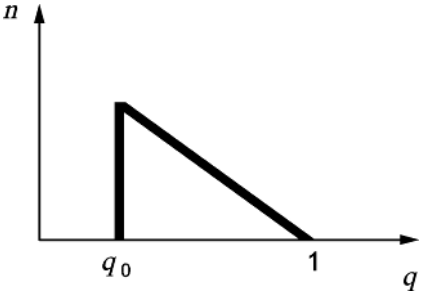
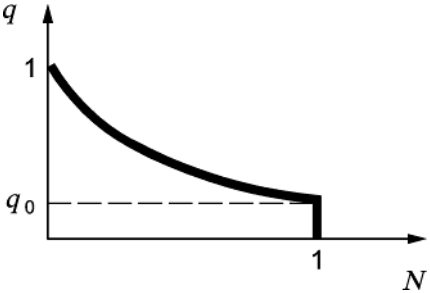
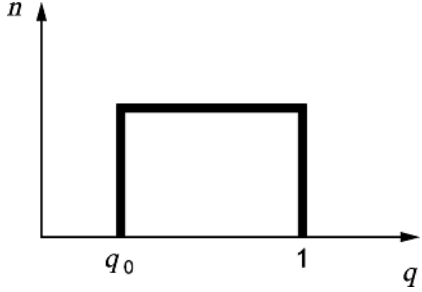
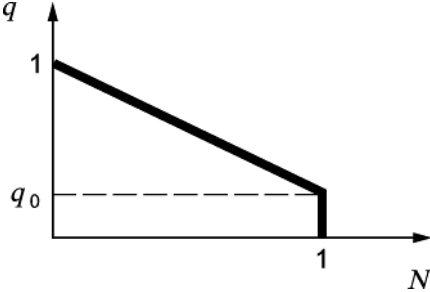
#### B.2 Application of continuous distributions

The stress spectrum factor  $k_m$  can be calculated from the density function or from the accumulated density by

$$k_m = \int_{q_0}^1 q^m \cdot n \cdot dq = \int_0^1 q^m \cdot dN$$

Table B.1 — Examples of  $k_m$  from density and accumulated density functions

Density Function	Accumulated Density Function
 $n = 4 \cdot \frac{(1-q)^3}{(1-q_0)^4}$ $k_{(m)} = \frac{4}{(1-q_0)^4} \cdot \left[ \frac{1-q_0^{m+1}}{m+1} - 3 \cdot \frac{1-q_0^{m+2}}{m+2} + 3 \cdot \frac{1-q_0^{m+3}}{m+3} - \frac{1-q_0^{m+4}}{m+4} \right];$ <p>For <math>m = 3</math> and <math>q_0 = 0,022\ 55</math> follows <math>k_{(3)} = 0,031\ 3</math> respective class <math>Q_0</math> For <math>m = 3</math> and <math>q_0 = 0,182\ 80</math> follows <math>k_{(3)} = 0,062\ 5</math> respective class <math>Q_1</math></p>	 $N_{(q)} = \left( \frac{1-q}{1-q_0} \right)^4 \text{ or } q_{(N)} = 1 - (1-q_0) \cdot \sqrt[4]{N}$
 $n = 3 \cdot \frac{(1-q)^2}{(1-q_0)^3}$ $k_{(m)} = \frac{3}{(1-q_0)^3} \cdot \left[ \frac{1-q_0^{m+1}}{m+1} - 2 \cdot \frac{1-q_0^{m+2}}{m+2} + \frac{1-q_0^{m+3}}{m+3} \right];$ <p>For <math>m = 3</math> and <math>q_0 = 0,276\ 55</math> follows <math>k_{(3)} = 0,125</math> respective class <math>Q_2</math></p>	 $N_{(q)} = \left( \frac{1-q}{1-q_0} \right)^3 \text{ or } q_{(N)} = 1 - (1-q_0) \cdot \sqrt[3]{N}$

 $n = 2 \cdot \frac{1-q}{(1-q_0)^2}$	 $N_{(q)} = \left( \frac{1-q}{1-q_0} \right)^2 \text{ or } q_{(N)} = 1 - (1-q_0) \cdot \sqrt{N}$ $k_{(m)} = \frac{2}{(1-q_0)^2} \cdot \left[ \frac{1-q_0^{m+1}}{m+1} - \frac{1-q_0^{m+2}}{m+2} \right];$ <p>For <math>m = 3</math> and <math>q_0 = 0,394\ 26</math> follows <math>k_{(3)} = 0,25</math> respective class <math>Q_3</math></p>
<p><b>Density Function</b></p>	<p><b>Accumulated Density Function</b></p>
 $n = \frac{1}{1-q_0}$	 $N_{(q)} = \frac{1-q}{1-q_0} \text{ or } q_{(N)} = 1 - (1-q_0) \cdot N$ $k_{(m)} = \frac{1}{1-q_0} \cdot \frac{1-q_0^{m+1}}{m+1};$ <p>For <math>m = 3</math> and <math>q_0 = 0,543\ 70</math> follows <math>k_{(3)} = 0,5</math> respective class <math>Q_4</math></p>

## **Annex ZA** (informative)

### **Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC**

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive Machinery 2006/42/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

**WARNING** — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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