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Cranes — Classification —

Part 1: General

Appareils de levage à charge suspendue — Classification —

Partie 1: Généralités

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The committee responsible for this document is ISO/TC 96, *Cranes*, Subcommittee SC 10, *Design principles and requirements*.

This third edition of ISO 4301-1 constitutes a technical revision of ISO 4301-1:1986, which is provisionally retained as it specifies another approach to the classification of cranes that will continue to be used within the industry for some time. See also Annex B.

ISO 4301 consists of the following parts, under the general title *Cranes — Classification*:

— *Part 1: General*

— *Part 2: Mobile cranes*

— *Part 3: Tower cranes*

— *Part 4: Jib cranes*

— *Part 5: Overhead travelling and portal bridge cranes*

Introduction

Cranes play a part in the handling of materials by raising and moving loads the mass of which is within their rated capacity. However, there may be wide variations in their duty. The design of the crane has to take account of the duty in terms of conditions of service, in order to reach an appropriate level of safety and useful life which is in line with the purchaser's requirements.

Classification serves as a reference framework between purchaser and manufacturer, by which a particular appliance can be matched to the intended service. It also is the system used to provide a means of establishing rational bases for the design of structures and machinery.

Cranes — Classification —

Part 1:
General

1 Scope

This part of ISO 4301 establishes a general classification of cranes and mechanisms based on the service conditions, mainly expressed by the following:

— the total number of working cycles to be carried out during the specified design life of the crane;

— the load spectrum factor which represents the relative frequencies of loads to be handled;

— the average displacements.

2 Normative references

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

ISO 4306 (all parts), *Cranes — Vocabulary*

3 Definitions

For the purposes of this document, the terms and definitions given in ISO 4306 apply.

4 Symbols

The main symbols used in this document are given in Table 1.

Table 1 — Main symbols

Symbol	Description
A	Classes for group classification
C	Total number of working cycles
D	Classes for average displacement
K_p	Load spectrum factor
K_{cp}	Load effect spectrum factor of components
P [P]	Individual load magnitudes (load levels) of the crane [classes]
Q_p	Classes Q of load spectrum factors K_p
Q_{cp}	Classes Q of load effect spectrum factor K_{cp} of components
U	Classes of total numbers of working cycles C

5 Use of classification

5.1 General

Classification has two applications in practice (see 5.2 and 5.3), which although related can be regarded as separate objectives.

Determination of an appropriate life requires consideration of economic, technical and environmental factors, and should have regard to the influence of obsolescence.

5.2 Use of classification for commercial specification

The classification is applied by the purchaser and the manufacturer of a crane and/or load lifting attachments, between which agreement is necessary on the duty of the crane. The classification thus agreed is intended for contractual and technical reference purposes.

It is also used to specify the service conditions of cranes, load lifting attachments, or components which are designed for serial manufacture and allows such items to be selected in accordance with their intended use.

The specified classification shall be documented in the crane manuals.

5.3 Use of classification in the design

The second purpose of classification is to provide a basis for the designer to build up his analysis of the design and to verify that the crane or component is capable of achieving the intended life under the specified service conditions of the particular application.

As a person skilled in crane technology, the designer takes the specified service conditions, either provided by the purchaser or predetermined by the manufacturer (as is the case in the design of serial equipment), and incorporates them into the assumptions on which his analysis is based, having regard to all other factors which influence the proportioning of components.

Crane operation gives rise to stress or load histories in crane structures and components (e.g. wire ropes, slewing bearings, or wheels and rails). These histories may be classified for the particular component. The method of determining this classification is set out in the appropriate standards, e.g. for structures in ISO 20332.

6 Classification of crane duty for the crane as a whole

6.1 General

Crane duties are determined by the following parameters:

a) the total number of working cycles during the design life;

b) the relative frequencies of loads to be handled (load spectrum, state of loading);

c) the average displacements.

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 indicated instead of the class.

6.2 Total number of crane working cycles

For the purpose of classification, a crane working cycle is a sequence of movements which commences when the crane is ready to hoist the load and ends when the crane is ready to hoist the next load within the same task. A task, *r*, can be characterized by a specific combination of crane configuration and sequence of intended movements.

In certain specific tasks for which cranes are used, for example, bulk unloading by grab, the number of cycles can readily be derived from a knowledge of the total number of working hours and the number of operating cycles per hour. In other cases, for example, mobile cranes, the number is less easy to determine because the crane is used in a variety of duties and it becomes necessary to estimate suitable values on the basis of experience. The total number of working cycles, *C*, is the sum total of all working cycles during the design life of the crane.

The total number of crane working cycles during the design life of a crane can be separated into the numbers of working cycles corresponding to several typical tasks.

The total number of crane working cycles is related to the frequency of use (e.g. daily) and the intended life (in years) of the crane. For convenience, the range of the total number of crane working cycles has been divided into 10 classes of utilization in Table 2.

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

Class of utilization	Total number of crane working cycles, *C*
U_0	$C \leq 1{,}6 \times 10^4$
U_1	$1{,}6 \times 10^4 < C \leq 3{,}15 \times 10^4$
U_2	$3{,}15 \times 10^4 < C \leq 6{,}3 \times 10^4$
U_3	$6{,}3 \times 10^4 < C \leq 1{,}25 \times 10^5$
U_4	$1{,}25 \times 10^5 < C \leq 2{,}5 \times 10^5$
U_5	$2{,}5 \times 10^5 < C \leq 5 \times 10^5$
U_6	$5 \times 10^5 < C \leq 1 \times 10^6$
U_7	$1 \times 10^6 < C \leq 2 \times 10^6$
U_8	$2 \times 10^6 < C \leq 4 \times 10^6$
U_9	$4 \times 10^6 < C \leq 8 \times 10^6$

6.3 State of loading

The load spectrum factor, K_p, is one of the parameters used to specify the duty of the crane by describing the different net loads to be handled during the working movements. The load spectrum factor takes into account the number of times a load of a particular magnitude, in relation to the rated capacity of the crane, is lifted.

Six nominal values of load spectrum factor are listed in Table 3, each numerically representative of a corresponding nominal state of loading.

Where details of the numbers and masses of loads to be handled during the design life of the crane are not known, the selection of an appropriate nominal state of loading shall be agreed between the manufacturer and purchaser.

Alternatively, where precise details are available of the magnitudes of the loads and the number of times these will be handled during the design life of the crane, the load spectrum factor for a task may be calculated as follows.

The load spectrum factor, K_p, is given by Formula (1):

$$K_p = \sum \left[\frac{C_i}{C_T} \times \left(\frac{P_i}{P_{max}} \right)^m \right] \quad (1)$$

where

C_i represents the average number of load cycles which occur at the individual load levels, = C_1, C_2, C_3... C_n;

C_T is the total of all the individual load cycles at all load levels, = $\Sigma C_i = C_1 + C_2 + C_3 ... + C_n$;

P_i represents the individual load magnitudes (load levels), = P_1, P_2, P_3... P_n

P_{max} is the heaviest load (rated load for hoists) that may be handled by the crane or its mechanism;

m = 3.

Expanded, Formula (1) becomes:

$$K_p = \frac{C_1}{C_T} \times \left(\frac{P_1}{P_{max}} \right)^3 + \frac{C_2}{C_T} \times \left(\frac{P_2}{P_{max}} \right)^3 + \frac{C_3}{C_T} \times \left(\frac{P_3}{P_{max}} \right)^3 + \cdots + \frac{C_n}{C_T} \times \left(\frac{P_n}{P_{max}} \right)^3 \quad (2)$$

Where there are several tasks, r, a value K_p for all tasks is obtained from

$$K_p = \sum_r \frac{C_r}{C_{Tr}} \times K_{pr} \times \left(\frac{P_{max,r}}{P_{max}} \right)^3 \quad (3)$$

where the subscript, r, indicates the value for the respective task r.

The load spectrum factor for the crane is then established by matching the calculated load spectrum factor to the closest (higher) nominal value of K_p in Table 3.

Table 3 — Classes Q_p of load spectrum factors, K_p

State of loading	Load spectrum factor K_p	Remarks on the use of crane
Q_p0	$K_p \leq 0,031\ 3$	Cranes which hoist usually very light loads and the rated load very rarely
Q_p1	$0,031\ 3 < K_p \leq 0,062\ 5$	
Q_p2	$0,062\ 5 < K_p \leq 0,125$	Cranes which hoist the rated load occasionally and, normally, light loads
Q_p3	$0,125 < K_p \leq 0,25$	Cranes which hoist the rated load fairly frequently and, normally, moderate loads
Q_p4	$0,25 < K_p \leq 0,50$	Cranes which hoist the rated load frequently and, normally, heavy loads
Q_p5	$0,50 < K_p \leq 1,00$	Cranes which are regularly loaded close to the rated load
NOTE The classes Q_p differ from the classes Q of ISO 4301-1:1986.		

6.4 Group classification

Having determined the class of utilization from Table 2 and the state of loading from Table 3, they can be combined into a single group classification for the crane as a whole. The group classification is determined from Table 4.

Table 4 — Classes A for group classification

Classes Q_p and load spectrum factor K_p		Classes U and total number of work cycles									
Class Q_p	Design value of load spectrum factor K_p	U_0 1,6 × 10^4	U_1 3,15 × 10^4	U_2 6,3 × 10^4	U_3 1,25 × 10^5	U_4 2,5 × 10^5	U_5 5,0 × 10^5	U_6 1,0 × 10^6	U_7 2,0 × 10^6	U_8 4,0 × 10^6	U_9 8,0 × 10^6
Q_p0	0,031 3	A03	A02	A01	A0	A1	A2	A3	A4	A5	A6
Q_p1	0,062 5	A02	A01	A0	A1	A2	A3	A4	A5	A6	A7
Q_p2	0,125 0	A01	A0	A1	A2	A3	A4	A5	A6	A7	A8
Q_p3	0,250 0	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9
Q_p4	0,500 0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Q_p5	1,000 0	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11

Where the Q_p and U classes are not specified and only the A class is given, the design calculations shall be based on the number of full load cycles, C_f, as given in the Table 5.

Table 5 — Design basis by classes

A-class	Design number of full load cycles, i.e. $K_p = 1$ C_f
A03	500
A02	1 000
A01	2 000
A0	4 000
A1	8 000
A2	16 000
A3	31 500
A4	63 000
A5	125 000
A6	250 000
A7	500 000
A8	1 000 000
A9	2 000 000
A10	4 000 000
A11	8 000 000

6.5 Average displacements

6.5.1 General

The fatigue design of detailed components requires the values of the stress histories to be determined.

For drive systems, there is a direct proportional relation between number of stress cycles and the displacement, between travel distance and rotation of wheels or shafts or between hook path and number of wire rope bendings.

The average linear or angular (e.g. slewing) displacement, $\bar{X}_r$, resulting in any drive serving between working spaces 1 and 2 during task *r* may be estimated by experience or is calculated by

$$\bar{X}_r = \frac{\sum_{j=1}^{n} n_{rj} \cdot x_{rj}}{\sum_{j=1}^{n} n_{rj}} - \frac{\sum_{i=1}^{m} n_{ri} \cdot x_{ri}}{\sum_{i=1}^{m} n_{ri}} \quad (4)$$

where

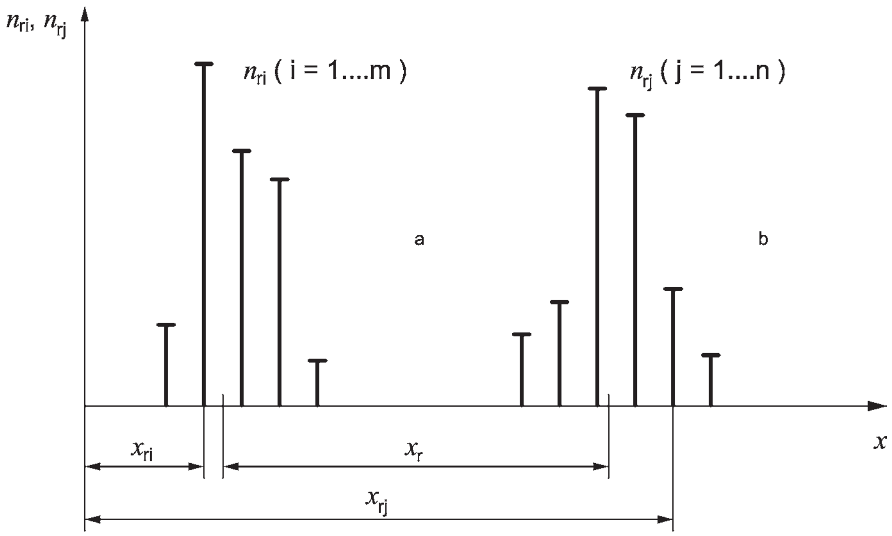
n_{ri} is the service frequency of positions i = 1...*m* in working space 1;

n_{rj} is the service frequency of positions j = 1...*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 1.



Key

a working space 1

b working space 2

Figure 1 — Service frequencies n_{ri} and n_{rj} 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 total displacement, $\bar{X}$, shall be calculated from the average displacements, $\bar{X}_r$, for all tasks *r*, and the corresponding number of working cycles, C_r, as follows:

$$\bar{X} = 2 \times \sum_r \left(\bar{X}_r \cdot C_r \right) \quad (5)$$

Formula (5) can be used as the total 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, 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.

Examples of average displacements of overhead travelling cranes are shown in Annex A.

6.5.2 Average linear displacements

Average linear displacements for hoisting, traversing and travelling have been divided into 10 classes in Table 6.

For unambiguous use of the classes D, the symbols are used with an additional designation for specific motions.

Table 6 — Symbols for classes D of average linear displacements and design values, X_{lin}

Designation of classes for average displacements			Range of average hoisting displacement $\bar{X}_{lin}$ m	Design value of average displacement m
Hoisting	Traversing (trolley)	Travelling (crane)		
D_h0	D_t0	D_c0	$\bar{X}_{lin} \leq 0{,}63$	0,63
D_h1	D_t1	D_c1	$0{,}63 < \bar{X}_{lin} \leq 1{,}25$	1,25
D_h2	D_t2	D_c2	$1{,}25 < \bar{X}_{lin} \leq 2{,}5$	2,5
D_h3	D_t3	D_c3	$2{,}5 < \bar{X}_{lin} \leq 5$	5
D_h4	D_t4	D_c4	$5 < \bar{X}_{lin} \leq 10$	10
D_h5	D_t5	D_c5	$10 < \bar{X}_{lin} \leq 20$	20
D_h6	Dt6	D_c6	$20 < \bar{X}_{lin} \leq 40$	40
D_h7	D_t7	D_c7	$40 < \bar{X}_{lin} \leq 80$	80
D_h8	D_t8	D_c8	$80 < \bar{X}_{lin} \leq 160$	160
D_h9	D_t9	D_c9	$160 < \bar{X}_{lin} \leq 320$	320

6.5.3 Average angular displacements

Average angular displacements have been divided into six classes in Table 7.

Table 7 — Classes D_a of average angular displacement, $\bar{X}_{ang}$

Class	Average angular displacement $\bar{X}_{ang}$
D_a0	$\bar{X}_{ang} \leq 11{,}75°$
D_a1	$11{,}75° < \bar{X}_{ang} \leq 22{,}5°$
D_a2	$22{,}5° < \bar{X}_{ang} \leq 45°$
D_a3	$45° < \bar{X}_{ang} \leq 90°$
D_a4	$90° < \bar{X}_{ang}\ 180°$
D_a5	$180° < \bar{X}_{ang}\ 360°$

7 Classification of components and mechanisms

7.1 General

Typical components for which classification may be applied are serial hoists or drives for travelling, traversing, or boom hoisting. The classification may be different for individual components in a particular crane.

Component duties are determined by the following parameters:

a) the total number of component working cycles of the component during the design life;

b) the relative frequencies of loads to be handled (load spectrum, state of loading);

c) the average displacements;

d) the average number of accelerations per movement (e.g. positioning).

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 indicated instead of the class.

7.2 Total number of component working cycles

The total number of component working cycles may be derived from the working cycles of the crane.

There are component working cycles that occur less frequently than the working cycles of the crane, such as the following:

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, either by a value or as a portion or percentage of the total number of working cycles.

For convenience the classes of utilization given in Table 2 shall be used for components.

7.3 State of loading

The load effect spectrum factor K_{cp} is one of the parameters used to specify the duty of the crane components. It is determined individually for each component and it describes the variation of the load effects (stresses) in the component during the component working cycles.

For hoist drives, it describes the variable loadings of the hoist drive during the working movements.

For travelling or traversing drives, it describes the different transported masses, payload and dead weights.

The load spectrum factor characterizes the number of times a load effect of a particular magnitude occurs in relation to the maximum load effect in the component.

The provisions of 6.3 shall be applied accordingly, using K_{cp}, instead of load spectrum factor K_p, and classes Q_{cp} instead of Q_p.

7.4 Group classification

Having determined the class of utilization from Table 2 and the state of loading from Table 3, they can be combined into a single group classification for the crane component. The group classification is determined from Table 4, using the designation A_c instead of A.

7.5 Average displacements

The provisions of 6.4 may be applied for crane components accordingly.

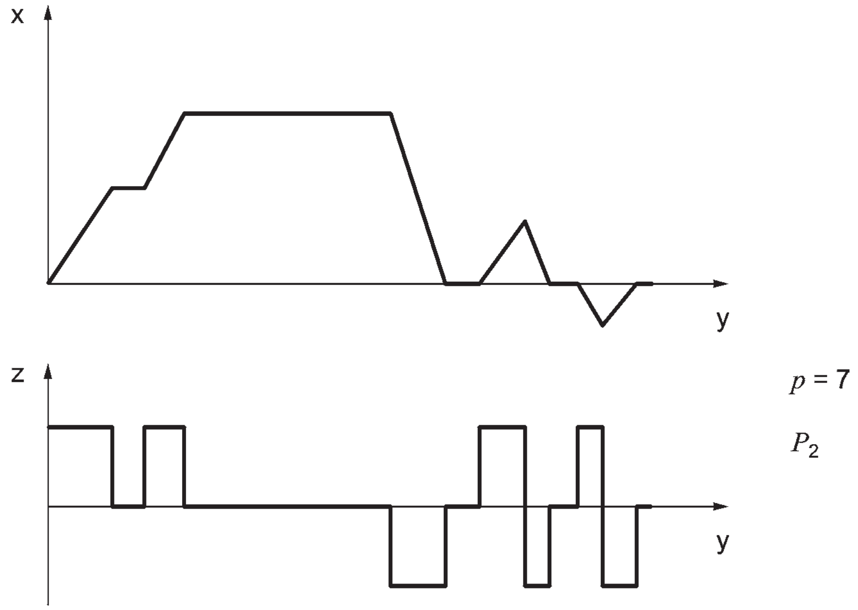
7.6 Accelerations per movement

The number of intended or expected accelerations of any drive to reach the intended position of the load is one of the parameters of the service conditions of a crane component. ISO 8686-1:2012, 6.1.4 takes these accelerations into account.

The average number of accelerations, p, of the drive under consideration has been divided into four classes in Table 8 and illustrated in Figure 2.

Table 8 — Classes P of average number of accelerations, *p*

Class	Average number of accelerations, p
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 2 — Example of class P

7.7 Stress histories

The stress history is a numerical presentation of all stress variations that are significant for fatigue. Rope force histories or wheel contact histories are analogous values.

Those histories are expressed in history parameters, *s*. The methods of determining this parameter are set out in the appropriate standards, e.g. for structures in ISO 20332.

Those histories are expressed in history parameters, *s*, and classified in 12 classes S. Class S7 indicates cycles with full load and the number of cycles equals the number of cycles at the reference point, 2×10^6 for steel structures. For detailed information, see ISO 20332:2016, 6.3.

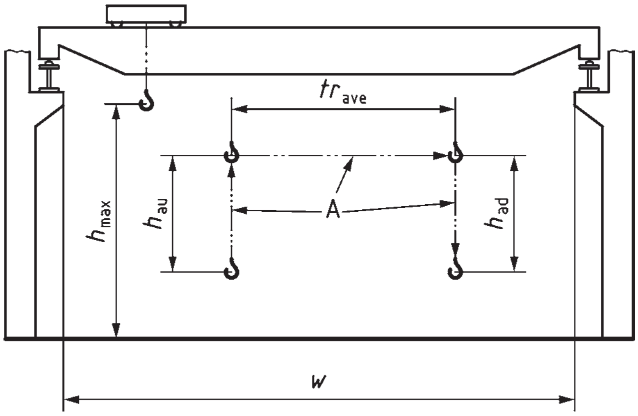
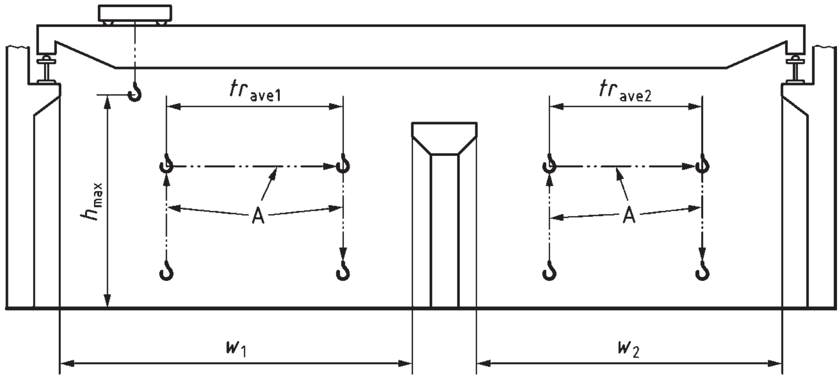
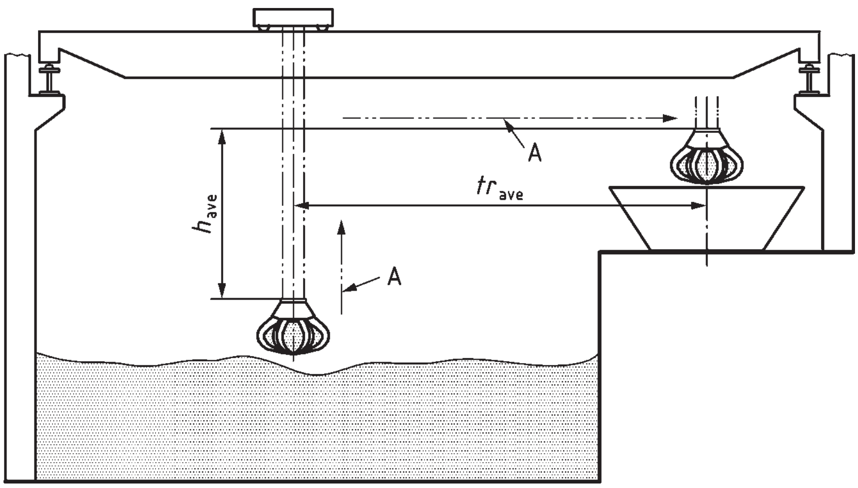
For fatigue assessment, it is necessary to deduce the stress histories in the location under consideration. When, from the classification process, only a single load spectrum factor is used to describe the loads to be handled, the relative frequencies that produce most fatigue damage shall be deduced.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

Annex A
(informative)

Examples for average displacements

See Table A.1.

Table A.1 — Guidance on determining average displacements

No.	Average displacements	Description of work process
1	By definition: $h_{ave} = h_{au} + h_{ad}$ The following estimations may be used: $h_{au} = h_{ad} = 0{,}5 \times h_{max}$ $tr_{ave} = 0{,}5 \times w$	 General workshop application; no systematic, pre-determined process
2	Average hoist displacements as in item 1. Operation is not between the two working spaces, but within a working space, whereby it applies that: $tr_{ave1} = 0{,}5 \times w_1$ and $tr_{ave2} = 0{,}5 \times w_2$	 General workshop application; hoist is serving two separate working spaces
3	Average displacements are determined from the average process condition, in the application shown in the figure, movement from the middle of the hold to the hopper.	 Process application

h_{max}, w, w_1, w_2 are the maximum working ranges of movements

h_{ave}, h_{au}, h_{ad}, tr_{ave}, tr_{ave1}, tr_{ave2} are the average displacements

A is the direction of movement with net load, i.e. the laden part of a work cycle.

Annex B
(informative)

Guidance for the conversion of M-classes

ISO 4301-1:1986 contained M-classes for the group classification of mechanisms as a whole.

For full load cycles (i.e. K_{cp} = 1) the M-classes correspond to the total duration of use, T_f, according to Table B.1.

Table B.1 — Total duration of use T_f for full load cycles

M-class	Total duration of full load cycles T_f h
M1	100
M2	200
M3	400
M4	800
M5	1 600
M6	3 200
M7	6 300
M8	12 500

For a given M-class, the respective A_c-class (see 7.4) can be determined by means of the average duration, t_{av}, of a cycle, which can be calculated by

$$t_{av} = \frac{2 \times X_{av}}{v_{av}} \tag{B.1}$$

where

X_{av} is the average displacement;

v_{av} is the average speed.

The design number of full load cycles, C_f, can be calculated by

$$C_f = \frac{T_f}{t_{av}} \tag{B.2}$$

and the respective A_c-class can be found with Table 5.

EXAMPLE Hoist classified according to ISO 4301-1:1986 in class M5, average hoisting displacement X_{av} = 5 m and average hoisting speed v_{av} = 4 m/min.

$$t_{av} = \frac{2 \times X_{av}}{v_{av}} = \frac{2 \times 5}{4} = 2{,}5\left[\text{min}\right] = 0{,}041\ 66\left[h\right]$$

$$C_f = \frac{T_f\left(M5\right)}{t_{av}} = \frac{1\ 600}{0{,}041\ 66} = 38\ 400$$

and from Table 5 follows: Class A_c4.

Bibliography

[1] ISO 8686-1:2012, *Cranes — Design principles for loads and load combinations — Part 1: General*

[2] ISO 20332:2008, *Cranes — Proof of competence of steel structures*

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