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Cranes — Wind load assessment

Appareils de levage à charge suspendue — Evaluation des charges dues au vent

ICS: 53.020.20

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 4302 was prepared by Technical Committee ISO/TC 96, *Cranes*, Subcommittee SC 10, *Design principles and requirements*.

This second edition cancels and replaces the first edition (ISO 4302:1981), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

Cranes — Wind load assessment

1 Scope and field of application

This International Standard relates to wind loads on cranes.

It establishes general methods for calculating wind loads as defined in ISO 8686-1 to be used in proofs of competence loads as defined in ISO 20332-1 for the structural and mechanical components of cranes as defined in ISO 4306-1.

It gives a simplified method of calculation and assumes that the wind can blow horizontally from any direction, that the wind blows at a constant velocity and that there is a static reaction to the Ioadings it applies to the crane structure. It includes built-in allowances for the effects of gusting (rapid changes in wind velocity) and for dynamic response.

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4306 all published parts, *Lifting appliances — Vocabulary*

ISO 8686 all parts, *Cranes — Design principles for loads and load combinations*

ISO 20332-1; *Cranes — Proof of competence of steel structure — Part 1: General*

3 Terms, Definitions, Symbols and Abbreviations

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

Table 1 — Main symbols

Symbol	Description
A	characteristic area
C_f	shape coefficient
D	diameter of a circular section
F	wind load
f_{rec}	recurrence interval factor
K	drag-coefficient of the terrain
K_d	factor related to the density of air
a_H	hook load wind factor
f_H	wind force due to the wind on the hook load
g	acceleration of free fall
m_H	mass of the gross or hoist load in kilograms
p	dynamic wind pressure
$q(z)$	equivalent static out-of-service wind pressure

Table 1 *(continued)*

Symbol	Description
R	recurrence interval
$v(z)$	equivalent static out-of-service wind velocity
$v(z)^*$	wind velocity component acting perpendicularly to the longitudinal axis of a member
$v_m(z)$	10 minutes mean storm wind velocity in the height z, in metres per second
v_{ref}	reference storm wind velocity
z	height above the surrounding ground level, in metres
ϕ_8	gust response factor
η_w	factor for the remaining hoist load in out of service condition
θ	angle of the wind ($\theta < 90°$) to the longitudinal axis or face
ρ	density of the air

4 Wind pressure

The dynamic wind pressure p is given by the formula

$$p = K_d \times v_s^2 \qquad (1)$$

where

K_d is a factor related to the density of air which for design purposes is assumed to be constant;

v_s is the wind speed, used as a basis of the calculation.

The Interntional System of Units (SI)[1)], when p is expressed in kilopascals (kPa) and v_s in metres per second (m/s):

$$p = 0{,}613 \times 10^{-3} \times v_s^2 \qquad (2)$$

5 In-service wind

5.1 General

This is the maximum wind that the crane is designed to withstand under operating conditions. The wind loading is assumed to be applied in the least favourable direction in combination with the appropriate service loads as defined in ISO 8686-1. In-service design wind speeds and corresponding pressures are given in Table 2. If the manufacturer uses in-service design wind values which differ from those in Table 2, the values used should be stated on the crane certificate.

1) A conversion chart covering v_s in knots, mile/h and m/s, and p in lbf/ft^2, Pa, and kgf/m^2 is given in Annex A.

5.2 Action of in-service wind on suspended load

On all cranes, the action of the wind on the load must be taken into account and the method by which this is done shall be clearly described. This may be accomplished by use of wind forces on load parameters of size and shape. The wind force on the load is calculated as a minimum as follows:

$$f_H = a_H \times m_H \times g \tag{3}$$

where

f_H is the wind force due to the wind on the hook load;

m_H is the mass of the hook load;

g is acceleration of free fall equal to 10 m/s^2.

a_H is the hook load wind factor

a_H = 0,015 for cranes of type a) in Table 2

a_H = 0,03 for cranes of type b) in Table 2

a_H = 0,06 for cranes of type c) in Table 2

Where a crane is designed to handle loads of specific size and shape only, the wind force on the suspended load shall be calculated for the appropriate dimensions and configuration.

Table 2 — In service design wind speeds v_s and pressures p

Type of crane	Wind speed v_s m/s	Wind pressure p kPa
a) Cranes that are easily secured against wind action, and are designed for operation in light winds only (for example cranes of low chassis height with booms that can be readily lowered to the ground)	14	0,125
b) All normal types of crane installed in the open	20	0,25
c) Transporter type unloaders which must continue to work in high winds	28,5	0,50

Other means of taking into account the action of wind on the load are a reduction of the rated load based upon wind velocity, load area and shape factor or a limitation of the in-service wind speed for loads exceeding a stipulated surface area.

5.3 Wind load calculations

For most complete and part structures, and individual members used in crane structures, the wind load, F, in kilonewtons, is calculated from the formula

$$F = A \times p \times C_f \tag{4}$$

where

A is the characteristic area, i.e. the effective frontal area of the part under consideration, i.e. the solid area projection on to a plane perpendicular to the wind direction;

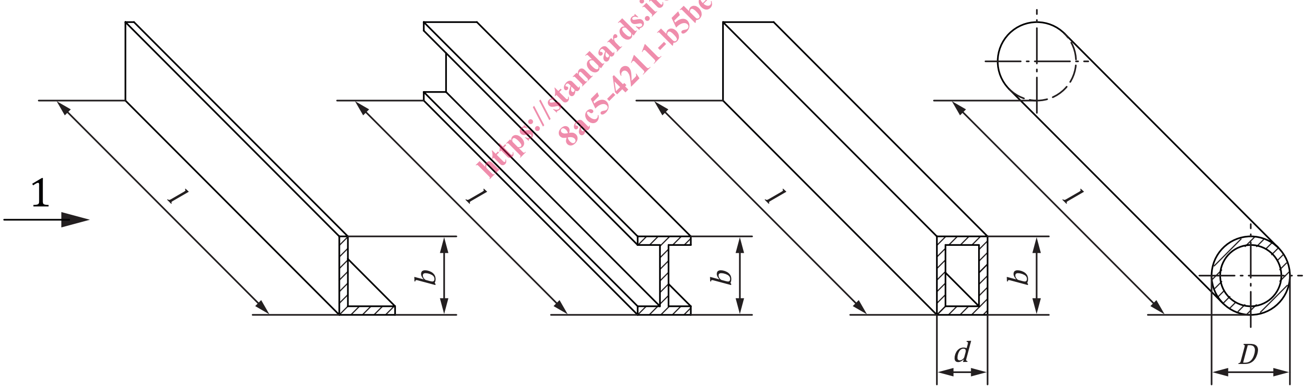
p is the wind pressure corresponding to appropriate design condition;

C_f is the shape coefficient in the direction of the wind, for the part under consideration (Table 3).

The total wind load on the structure is taken as the sum of the loads on its component parts.

Table 3 — Shape coefficients C_f per aerodynamic slenderness

Type	Description		Aerodynamic slenderness l/b or l/D (see Figure 1)					
			5	10	20	30	40	50
Individual members	Rolled sections, rectangles, hollow sections, flat plates		1,3	1,35	1,6	1,65	1,7	1,9
	Circular sections where $D \times v_s < 6\ m^2/s$		0,75	0,80	0,90	0,95	1,0	1,1
	$D \times v_s \geq 6\ m^2/s$		0,60	0,65	0,70	0,70	0,75	0,8
	Box sections over 350 mm square and 250 mm, 450 mm rectangular	b/d						
		≥ 2	1,55	1,75	1,95	2,1	2,2	
		1	1,40	1,55	1,75	1,85	1,9	
		0,5	1,0	1,2	1,3	1,35	1,4	
		0,25	0,8	0,9	0,9	1,0	1,0	
Single lattice frames	Flat sided sections		1,7					
	Circular sections where $D \times v_s < 6\ m^2/s$		1,2					
	$D \times v_s \geq 6\ m^2/s$		0,8					
Machinery houses, etc.	Rectangular clad structures an ground or solid base (air flow beneath structure prevented)		1,1					



$$\text{Aerodynamic slenderness} = \frac{\text{length of member}}{\text{breadth of section across wind front}} = \frac{l}{b} \text{ or } \frac{l}{D}$$

$$\text{Section ratio (for box sections)} = \frac{\text{breadth of section across wind front}}{\text{depth of section parallel to window flow}} = \frac{b}{d}$$

Key

1 Wind

Figure 1 — Aerodynamic slenderness and section ratio

5.4 Shape coefficients for individual members, frames, etc

Shape coefficients C_f for individual members, single lattice frames, and machinery houses etc., are given in Table 3. The values for individual members vary according to the aerodynamic slenderness and, in the case of large box sections, with the section ratio. Aerodynamic slenderness and section ratio are defined in Figure 1.

Shape coefficients obtained by wind tunnel or full scale tests may also be used.

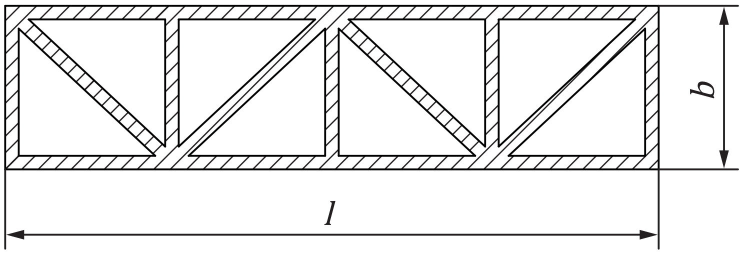
Where a frame is made up of flat-sided and circular sections, or of circular sections in both flow regimes ($D \times v_s < 6$ m^2/s and $D \times v_s \geq 6$ m^2/s, where D is the diameter of a circular section, in metres, and v_s is the design wind speed, in metres per second) the appropriate shape coefficients are applied to the corresponding frontal areas.

5.5 Shielding factors — Multiple frames or members

Where parallel frames or members are positioned so that shielding takes place, the wind force on the windward frame or member and on the unsheltered parts of those behind it are calculated using the appropriate shape coefficients. The shape coefficients on the sheltered parts are multiplied by a shielding factor η given in Table 4. Values of η vary with the solidity and spacing ratios as defined in Figure 2.

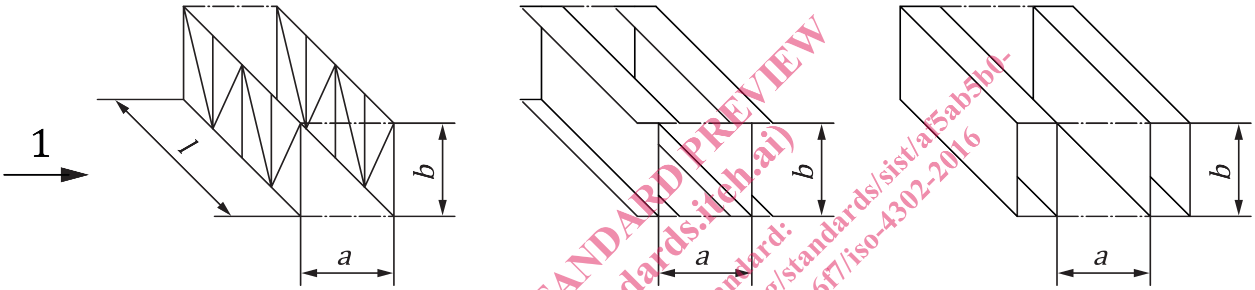
Table 4 — Shielding factors (η)

Spacing ratio	Solidity ratio A/A_e (see Figure 2)					
a/b	0,1	0,2	0,3	0,4	0,5	≥ 0,6
0,5	0,75	0,4	0,32	0,21	0,15	0,1
1,0	0,92	0,75	0,59	0,43	0,25	0,1
2,0	0,95	0,8	0,63	0,5	0,33	0,2
4,0	1	0,88	0,76	0,66	0,55	0,45
5,0	1	0,95	0,88	0,81	0,75	0,68
6,0	1	1	1	1	1	1



$$\text{Solidity ratio } \frac{A}{A_e} = \frac{\text{area of solid parts (shown shaded)}}{\text{enclosed area}} = \frac{\sum A_{\text{members}}}{b \times l}$$

a) Solidity ratio



$$\text{Spacing ratio} = \frac{\text{distance between facing sides}}{\text{breadth of member across wind front}} = \frac{a}{b}$$

b) Spacing ratio

Key

1 Wind

Figure 2 — Solidity ratio and spacing ratio

Where there are a number of identical frames or members spaced equidistantly behind each other in such a way that each frame shields those behind it, it is accepted that the shielding effect increases up to the ninth frame and remains constant thereafter. The wind loads, are calculated from the following equations:

On the first nine frames:

$$F_n = \eta^{(n-1)} \times A \times p \times C_f \tag{5}$$

where

F_n is the wind load on the n-th frame

η is the shielding factor

A, p, C_f are as defined in Formula (4)

