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Cranes — Wind load assessment

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

Reference number
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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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 4302:1981), which has been technically revised. All clauses have been technically revised to be aligned with ISO 20332, in combination with ISO 8686-1, and the informative Annex A, "Wind maps", has been added.

Cranes — Wind load assessment

1 Scope

This International Standard specifies the assessment of wind loads on cranes.

It establishes general methods for calculating wind loads (for in-service and out-of-service conditions), which are included in the load combinations stated in ISO 8686-1 and used for proofs of competence such as those given in ISO 20332 for the structural components of cranes.

It provides a simplified method of calculation and assumes that

— the wind may blow horizontally from any direction,

— the wind blows at a constant speed,

— there is a static reaction to the wind load applied to the crane structure.

It includes built-in allowances for the effects of gusting (fluctuation in wind speed) and for dynamic response.

It gives guidance on when to secure the crane for out-of-service conditions.

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

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the following terms and definitions apply. The main symbols are given in Table 1.

3.1
in-service wind
maximum wind that the crane is designed to withstand under operating conditions

3.2
out-of-service wind
maximum (storm) wind blowing from the least favourable direction that a crane is designed to withstand when in an out-of-service condition

Table 1 — Main symbols

Symbol	Description
A	Characteristic area
A_H	Wind area of the suspended load
C_f, c_H	Shape coefficients
D	Diameter of a circular section
F	Wind load
f_{rec}	Recurrence interval factor
K	Terrain-roughness-coefficient
F_H	Wind load due to the wind on the hoist load
m_H	Mass of the gross or hoist load in kilograms
p	In-service wind pressure
$q(z)$	Equivalent static out-of-service wind pressure at height z
R	Recurrence interval
v_g	3 s gust amplitude
v_s	Wind speed, used as a basis of the calculation
v_s*	Wind speed component acting perpendicularly to the longitudinal axis or surface of a member
$v(z)$	Equivalent static out-of-service wind speed at the height z
$v(z)$*	Wind speed component acting perpendicularly to the longitudinal axis of a member at height z
$v_m(z)$	10 min mean storm wind speed at height z, in metres per second
v_{ref}	Reference storm wind speed
z	Height above the surrounding ground level, in metres
Φ_8	Gust response factor
θ	Angle of the wind direction to the longitudinal axis or face ($\theta < 90°$)
η	Shielding factor
η_W	Factor for the remaining hoist load in out-of-service condition
ρ	Density of the air

4 Wind pressure

The wind pressure, p, is given by the formula

$$p = 0{,}5 \times \rho \times v_s^2 \tag{1}$$

where

ρ is the density of air which, for design purposes, is assumed to be constant ρ = 1,225 kg/m^3;

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

When using the international system of units (SI), where p is expressed in N/m^2 and v_s in metres per second (m/s), the following applies:

$$p = 0{,}625 \times v_s^2 \tag{2}$$

5 In-service wind

5.1 General

The wind loading shall be applied in the least favourable direction in combination with the appropriate loads as defined in ISO 8686-1:2012, load combinations B and C.

In-service design wind speeds and corresponding pressures shall be either selected based on Table 2 or specified based on the crane configuration, application and the wind conditions. The in-service design wind speed shall be documented in the operating manual of the crane.

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

Type of crane or application	Design wind speed v_s m/s	Design wind pressure p N/m²
Cranes that are easily secured against wind action and which are designed for operation in light winds only (e.g. cranes of low chassis height with booms that can be readily lowered to the ground)	14	125
All normal types of crane installed in the open	20	250
Cranes in process applications, where a crane must continue to work in high winds	28,5	500

The wind speed shall be measured at the highest point of the crane. The in-service design wind speed in Table 2 is based on the premise that the crane can be fully secured in an out-of-service configuration before the design wind speed is exceeded. As the means for this securing vary by crane type and configuration, the time allowance (e.g. locking devices at special locations of the crane runway, hand-operated or automatic rail clamps) shall take this into account by a lower level of wind speed chosen to start the securing. Wind speeds for the use of different crane configurations and for the starting of securing shall be specified.

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 loads on load parameters of size and shape. The wind load F_H on the load shall be calculated as a minimum as follows:

$$F_H = c_H \times A_H \times p \qquad (3)$$

where

F_H is the wind load on the suspended load *in the direction of the wind*;

c_H is the shape coefficient of the suspended load;

A_H is the wind area of the hoist load;

p is the wind pressure corresponding to appropriate design condition.

In the absence of detailed information on the load it shall be assumed that $c_H = 2{,}4$ and $A_H = 0{,}000\,5 \times m_H$, where A_H is expressed in square metres (m²) and m_H is the mass of the hoist load in kilograms (kg).

Additionally, the effects of wind actions on the load may be limited by

— a reduction of the rated load based upon wind speed, load area and shape factor,

— a limitation of the in-service wind speed for loads exceeding a stipulated surface area.

5.3 Wind load calculations

For crane structures or individual members used in crane structures the wind load, F, in the direction of the wind, is calculated from the formula:

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

where

- F is the wind load acting perpendicularly to the longitudinal axis of the member (see 5.6)
- A is the characteristic area, i.e. the projection of the solid area of the member 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 for the member under consideration, with reference to the wind direction and the characteristic area (see 5.4). Values shall be either those given in Table 3 or those derived by recognized theoretical or experimental methods (e.g. wind tunnel or full scale tests), or other recognized sources.

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

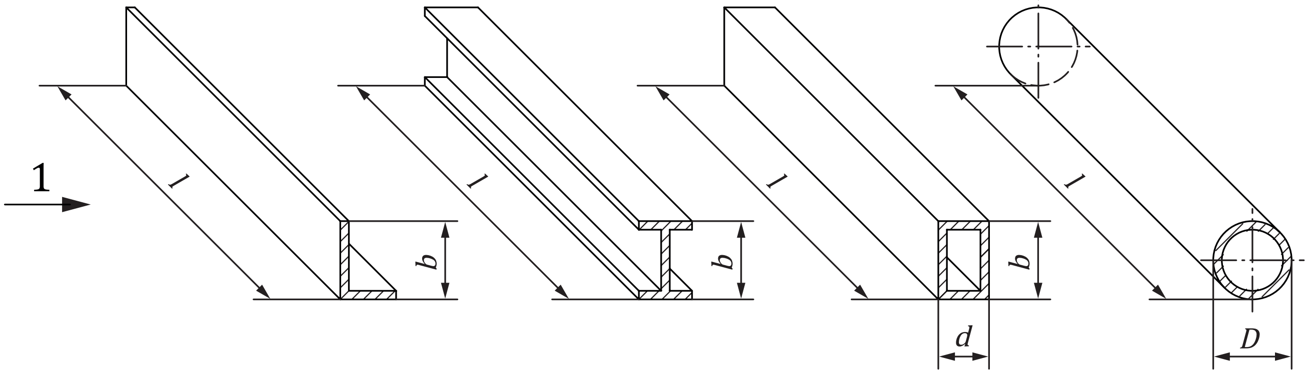
5.4 Shape coefficients for individual members, frames, etc

Shape coefficients, C_f, for individual members, single lattice frames, and machinery houses, etc. 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.

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, with D the diameter of a circular section in metres, and v_s the design wind speed in metres per second, the appropriate shape coefficients are applied to the corresponding frontal areas.

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
	Circular sections where $D \times v_s \geq 6$ 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					
	Circular sections where $D \times v_s \geq 6$ m^2/s		0,8					
Machinery houses, etc.	Rectangular clad structures on ground or solid base (air flow beneath structure prevented)		1,1					



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

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

Key

1 wind direction

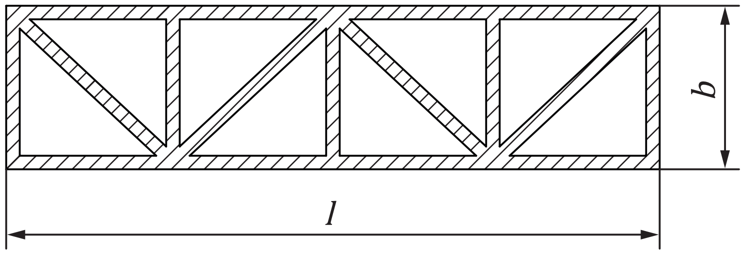
Figure 1 — Aerodynamic slenderness and section ratio

5.5 Shielding factors — Multiple frames or members

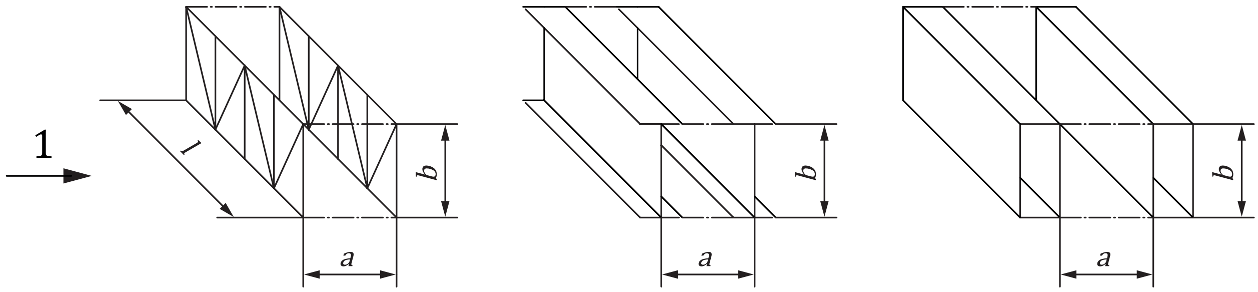
Where parallel frames or members are positioned so that shielding takes place, the wind load on the windward frame or member and on the unsheltered parts of those behind it are calculated using the appropriate shape coefficients. The shape coefficients on the sheltered parts are multiplied by a shielding 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 a/b	**Solidity ratio** (see Figure 2) A/A_e					
	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



a) Solidity ratio



b) Spacing ratio

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

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

Key

1 wind direction

Figure 2 — Solidity ratio and spacing ratio

Where there are a number of identical frames or members spaced equidistantly behind one another 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 Formulae (5) and (6).

On the first eight frames:

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

where