IS 14467 (1997): Cranes - Wind load assessment [MED 14: Cranes, Lifting Chains and Related Equipment]

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IS 14467 : 1997
ISO 4302 : 1981
(Reaffirmed 2003)

भारतीय मानक

क्रेन – वायु भार मूल्यांकन

Indian Standard

CRANES — WIND LOAD ASSESSMENT

ICS 53.020.20

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 1997

Price Group 3

Cranes, Lifting Chains and Its Related Equipment Sectional Committee, HMD 14

NATIONAL FOREWORD

This Indian Standard which is identical with ISO 4302 : 1981 'Cranes — Wind load assessment', issued by International Organization for Standardization (ISO), was adopted by the Bureau of Indian Standards on the recommendations of the Cranes, Lifting Chains and Its Related Equipment Sectional Committee, and approval of the Heavy Mechanical Engineering Division Council.

The text of ISO standard has been approved for publication as Indian Standard without deviations. Certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a full stop (.) as a decimal marker.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values(*revised*)'.

Indian Standard

CRANES — WIND LOAD ASSESSMENT

1 Scope and field of application

This International Standard relates to wind loads on cranes.

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 loadings 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.

A precise method for calculations of the loadings which arise due to the dynamic response of a crane and its load due to gusting will be given in a separate document.

2 Wind pressure

The dynamic wind pressure p is given by the formula

$$p = K v_s^2$$

where

K 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.

In SI units[1], when p is expressed in kilopascals (kPa) and v_s in metres per second (m/s) :

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

3 Design wind conditions

Two design wind conditions are taken into account in calculating wind loads on cranes.

3.1 In-service wind

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. In-service design wind speeds and corresponding pressures are given in table 1. If the manufacturer uses in-service design wind values which differ from those in table 1, the values used should be stated on the crane certificate.

3.1.1 Action of wind on suspended load

On all cranes, the actionof 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 :

a) a method of rated load reduction based upon wind velocity, load area and shape factor;

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 the annex.

b) a limitation of the in-service wind speed for loads exceeding a stipulated surface area;

c) 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 :

Cranes of type a) in table 1

$f = 0{,}015\ mg$ kN

Cranes of type b) in table 1

$f = 0{,}03\ mg$ kN

Cranes of type c) in table 1

$f = 0{,}06\ mg$ kN

where

f is the wind force due to the wind on the hook load, in kilonewtons;

m is the mass of the hook load, in tonnes;

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

3.2 Out-of-service wind

This is the maximum (storm) wind blowing from the least favourable direction that a crane is designed to withstand when in an out-of-service condition. The speed varies with the geographical location, and the degree of exposure to prevailing winds.

Out-of-service design wind velocities for use with this International Standard will be given in a further table to be produced when the requisite information becomes available. For the present, out-of-service design wind speeds should be taken from the appropriate national standards.

Mobile cranes with jibs not more than 30 m in length that can be readily lowered to the ground, low pivot cranes with telescoping jibs, and cranes with towers that are readily telescoped by means of self-contained mechanisms, only need to be designed for out-of-service wind in the lowered position. Operating instructions for such cranes shall include the requirement that jibs and/or towers are to be secured from wind exposure when not in service.

The operating instructions for cranes that require the installation of wind stabilizers, or other means not used during operation, in order to resist the specified out-of-service wind speed shall state the wind speed that the crane can safely sustain in its operating configuration; they shall also describe the provisions that must be followed in order that the crane may safely withstand the specified out-of-service wind.

4 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

$$F = Ap\,C_f$$

where

A is the effective frontal area of the part under consideration, in square metres, 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, in kilonewtons per square metre;

C_f is the force coefficient in the direction of the wind, for the part under consideration (see clause 5).

For calculating wind loadings for "out-of-service conditions", the wind pressure may be taken as constant for every 10 m vertical interval over the height of the crane. Alternatively the actual design wind pressure at any height may be calculated, or the design wind pressure at the top of the structure may be taken as constant over the entire height.

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

5 Force coefficients

5.1 Individual members, frames, etc.

Force coefficients for individual members, single lattice frames and machinery houses etc., are given in table 2. 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 table 2.

Force 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 ($D\,v_s < 6$ m^2/s and $D\,v_s > 6$ 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 force coefficients are applied to the corresponding frontal areas.

5.2 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 force coefficients. The force coefficients on the sheltered parts are multiplied by a shielding factor η given in table 3. Values of η vary with the solidity and spacing ratios as defined in table 3.

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, in newtons, are calculated from the following equations :

On the 1st frame :

$$F_1 = A\,p\,C_f$$

On the 2nd frame :

$$F_2 = \eta\,A\,p\,C_f$$

On the nth frame (where n is between 3 and 8) :

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

On the 9th and subsequent frames :

$$F_9 = \eta^8\,A\,p\,C_f$$

The total wind load, in newtons, is thus :

where there are up to 9 frames,

$$\underset{(n \leqslant 9)}{F_{\text{total}}} = [1 + \eta + \eta^2 + \eta^3 + \ldots + \eta^{(n-1)}]\,A\,p\,C_f$$

$$= A\,p\,C_f\left(\frac{1-\eta^n}{1-\eta}\right)$$

where there are more than 9 frames,

$$\underset{(n > 9)}{F_{\text{total}}} = [1 + \eta + \eta^2 + \eta^3 + \ldots + \eta^8 +$$

$$+ (n-9)\,\eta^8] \times A\,p\,C_f$$

$$= A\,p\,C_f\left[\left(\frac{1-\eta^9}{1-\eta}\right) + (n-9)\,\eta^8\right]$$

For design purposes the term η^x used in the above formula is taken as 0,10 whenever, numerically, it is less than 0,10.

5.3 Lattice towers

In calculating the "face-on" wind load on square towers, the solid area of the windward face is multiplied by the following overall force coefficients :

for towers composed of flat-sided sections : 1,7 $(1 + \eta)$

for towers composed of circular sections,

where $D\,v_s < 6$ m²/s : 1,2 $(1 + \eta)$

where $D\,v_s > 6$ m²/s : 1,4

The value of η is taken from table 3 for $a/b = 1$ according to the solidity ratio of the windward face.

The maximum wind load on a square tower occurs when the wind blows into a corner. It may be taken as 1,2 times for "face-on" load.

5.4 Parts inclined to the wind direction (individual members, frames, etc.)

Where the wind blows at an angle to the longitudinal axis of a member or to the surface of a frame, the force in the direction of the wind, F, in newtons, is obtained from the equation :

$$F = A\,p\,C_f \sin^2\theta$$

where

F, A, p and C_f are as defined in clause 4;

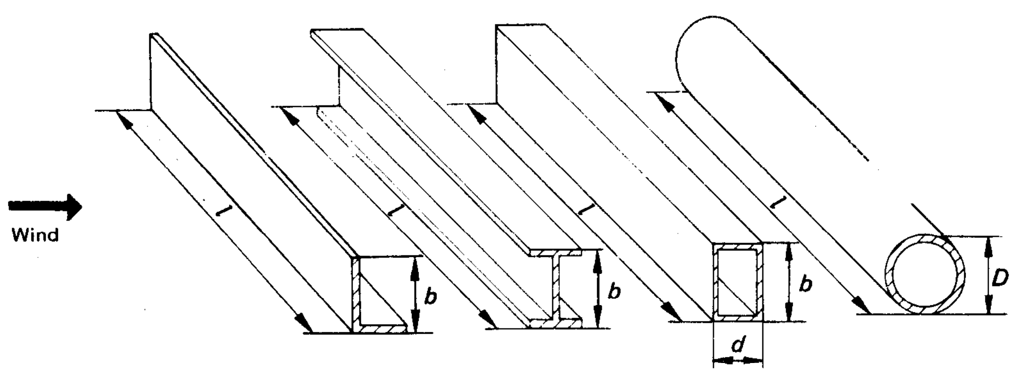
θ is the angle of the wind ($\theta < 90°$) to the longitudinal axis or face.

Table 1 — In-service design wind speeds and pressures

Type of crane	Wind speed m/s	Wind pressure 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

Table 2 — Force coefficients

Type	Description		Aerodynamic slenderness l/b or l/D					
			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 $D\,v_s < 6\ m^2/s$		0,75	0,80	0,90	0,95	1,0	1,1
	Circular sections $D\,v_s \geqslant 6\ m^2/s$		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 $\geqslant 2$	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 $D\,v_s < 6\ m^2/s$		1,2					
	Circular sections $D\,v_s \geqslant 6\ m^2/s$		0,8					
Machinery houses, etc.	Rectangular clad structures on ground or solid base (air flow beneath structure prevented)		1,1					



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

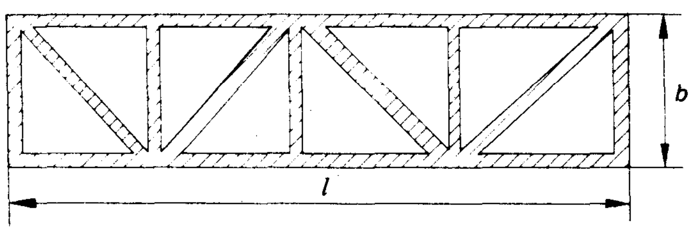
$$\text{Section ratio (for box sections)} = \frac{\text{breadth of section across wind front}}{\text{depth of section parallel to wind flow}} = \frac{b}{d}$$

Figure 1 — Aerodynamic slenderness and section ratio

Table 3 — Shielding factors (η)

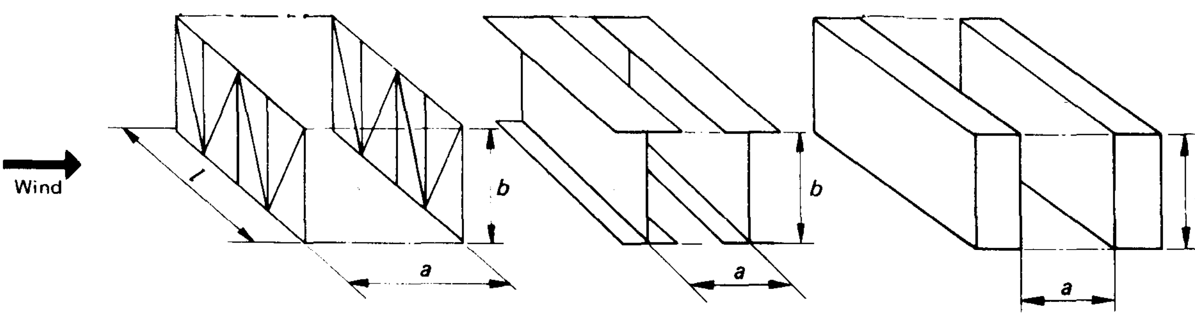
Spacing ratio a/b	Solidity ratio A/A_e					
	0,1	0,2	0,3	0,4	0,5	⩾ 0,6
0,5	0,75	0,4	0,32	0,21	0,15	0,1
1,0	0,92	0,75	0,59	0,43	0,25	0,1
2,0	0,95	0,8	0,63	0,5	0,33	0,2
4,0	1	0,88	0,76	0,66	0,55	0,45
5,0	1	0,95	0,88	0,81	0,75	0,68
6,0	1	1	1	1	1	1

a) Solidity ratio



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

b) Spacing ratio

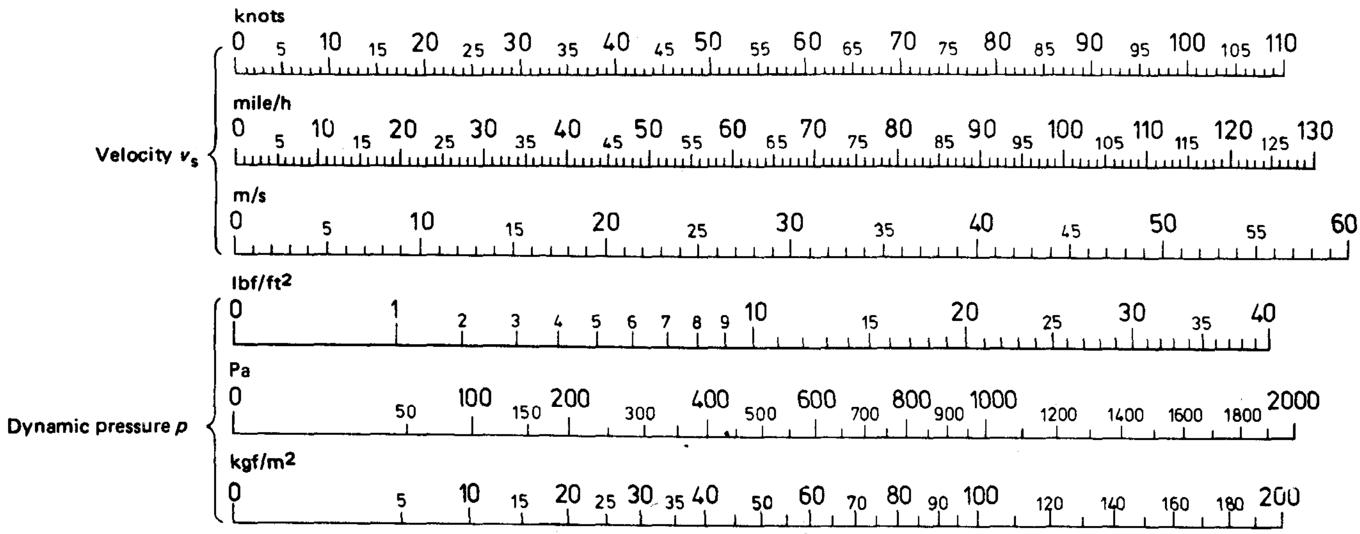


$$\text{Spacing ratio} = \frac{\text{distance between facing sides}}{\text{breadth of member across wind front}} = \frac{a}{b}$$

Figure 2 — Solidity ratio and spacing ratio

Annex

Conversion chart for wind speed and pressure



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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'

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