INTERNATIONAL STANDARD

# ISO 8686-3

Second edition
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# Cranes — Design principles for loads and load combinations —

## Part 3:
## Tower cranes

*Appareil de levage à charge suspendue — Principes de calcul des charges et des combinaisons de charges —*

*Partie 3: Grues à tour*



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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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This document was prepared by Technical Committee ISO/TC 96, *Cranes*, SC 7, *Tower cranes*.



Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This second edition cancels and replaces the first edition (ISO 8686-3:1998) and ISO 12485:1998 which have been technically revised.

The main changes compared to the previous edition are as follows:

— integration and rules for application of ISO 8686-1;

— integration of special rules regarding the calculation of wind loads on tower cranes in the out-of-service state;

— integration of rules regarding the calculation of rigid body stability in this document;

— integration of rules regarding the calculation of loads on crane support structure;

— integration of rules for the calculation of climbing systems;

— integration of rules for the calculation of mobile self-erecting tower cranes.

A list of all parts in the ISO 8686 series can be found on the ISO website.

# Cranes — Design principles for loads and load combinations —

# Part 3:
# Tower cranes

## 1 Scope

This document establishes the application of ISO 8686-1 to tower cranes for construction work as defined in ISO 4306-3, and gives specific requirements and values for factors to be used at the structural calculation.

Tower cranes for construction work are exclusively equipped with a hook as the load-handling device.

For tower cranes intended to be used for other purposes and/or with other load-handling devices, other values can be necessary according to the tower crane usage specification.

## 2 Normative references



The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.



ISO 4302, *Cranes — Wind load assessment*

ISO 4306-3, *Cranes — Vocabulary — Part 3: Tower cranes*

ISO 4310, *Cranes — Test code and procedures*

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

ISO 12488-1:2012, *Cranes — Tolerances for wheels and travel and traversing tracks — Part 1: General*

ISO 20332:2016, *Cranes — Proof of competence of steel structures*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-3 and ISO 8686-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

**3.1**
**balancing moment**
moment at which the balance of the lifted components of the crane is achieved before starting the climbing operation

**3.2**
**deviation moment**
amount by which the *balancing moment* (3.1) may deviate during a climbing sequence

## 4 Symbols and abbreviated terms

The symbols given in ISO 8686-1 and ISO 4302 shall apply.

## 5 General

The proof calculation — proof of strength and proof of stability — shall be performed in accordance with ISO 8686-1 and ISO 20332, together with the following provisions.

General principles of calculation are presented in ISO 8686-1:2012, Clause 5. Due to the general properties and usual design of tower cranes all calculations shall base on the assumption of a deformed system in a state of equilibrium (second order theory). Structural deformations may be neglected only if they result in a insignificant increase of the load effect.

Several of the following assumptions presuppose specific boundary conditions, which shall be adhered to or controlled by the user. It is therefore necessary that these boundary conditions are described along with the necessary measures in the operating instructions of the crane.

## 6 Loads

### 6.1 General

Design loads shall take into consideration the most unfavourable effects that can be expected during the life of the crane while it is operated and out of service, as well as during assembly, disassembly and transportation. In-service loads shall reflect unfavourable but realistic operating conditions and sequences of actions by the crane operator.



Loads, load combinations and parameters used in this document are considered to be deterministic.



These loads shall be defined and classified as regular loads (for load combinations A), occasional loads (for load combinations B) and exceptional loads (for load combinations C) according to ISO 8686-1:2012, Clause 6.

### 6.2 Loads and values for dynamic factors, $\phi_i$

Table 1 indicates loads that are generally relevant for tower cranes, and gives guidance on values for appropriate dynamic factors.

Alternatively, other values for dynamic factors may be used when determined by recognized theoretical analysis or a practical test.

In the case of a tower crane designed for a special use and/or with dedicated requirements, additional loads and relevant values of dynamic factors shall be considered and defined according to ISO 8686-1:2012, Clause 6.

**Table 1 — Loads and guidance on values for dynamic factors, $\phi_i$, for tower cranes**

| Line number $i$ | Loads | Dyn. factors $\phi_i$ | Definitions and guidance on values for dynamic factors, $\phi_i$, and load determination |
|---|---|---|---|
| **Regular loads** | | | |
| 1 | Hoisting and gravity effects acting on the mass of the crane | $\phi_1$ | $\phi_1$ shall be considered according to ISO 8686-1.<br>The value $a$ defined for tower cranes is: $a$ = 0,05. |
| 2 | Inertial and gravity effects by hoisting an unrestrained grounded load | $\phi_2$ | $\phi_2$ shall be considered according to ISO 8686-1.<br>Hoisting class HC1 is defined for tower cranes.<br>For load combinations A1 and B1: $\phi_{2,max}$ = 1,3.<br>For load combination C1: $\phi_2$ without limitation.<br>Due to the nature of tower cranes, only the hoist drive classes HD1 or HD4 shall be used. The classes HD2, HD3 and HD5 are not allowed to be used. |
| 3 | Inertial and gravity effects by sudden release of a part of the hoist load | $\phi_3$ | Not applicable for tower cranes. |
| 4 | Loads caused by travelling on uneven surface | $\phi_4$ | The railway tolerances for a tower crane rail track shall be specified according to ISO 12488-1:2012, Class 2. With this condition, this load action does not need to be considered.<br>In case of different condition, the load action shall be considered according to ISO 8686-1. |
| 5 | Loads caused by acceleration of drives | $\phi_5$ | $\phi_5$ shall be considered according to ISO 8686-1.<br>Usual values of the dynamic coefficient $\phi_5$ for tower cranes are:<br>— $\phi_5$ = 1,0 for centrifugal forces;<br>— $\phi_5$ = 1,5 for drive forces for all typical drives of tower cranes (with no backlash or in case where existing backlash does not affect the dynamic forces and with smooth change of forces). |
| 6 | Loads determined by displacements (or rotations) | — | The erection tolerances for the supporting structure for a tower crane shall comply with the requirements given in 7.6, item (i). Under this condition, this load action does not need to be considered.<br>In case of different condition, the load action shall be considered according to ISO 8686-1. |
| **Occasional loads** | | | |
| 7 | Loads due to in-service wind | — | The minimum in-service wind pressure that shall be considered is $q_{(3)}$ = 250 Pa (wind speed $v_{(3)}$ = 20 m/s).<br>In case a special load chart is additionally provided for the tower crane, the minimum in-service wind pressure that shall be considered for this special load chart is $q_{(3)}$ = 125 Pa (wind speed $v_{(3)}$ = 14,1 m/s). |
| 8 | Loads due to snow and ice | — | This load shall be considered only on special request from a user. |
| 9 | Loads due to temperature variation | — | Not applicable for tower cranes. |

**Table 1** *(continued)*

| Line number $i$ | Loads | Dyn. factors $\phi_i$ | Definitions and guidance on values for dynamic factors, $\phi_i$, and load determination |
|---|---|---|---|
| 10 | Loads caused by skewing | — | Skewing forces are insignificant and do not need to be considered when the ratio of the wheel base divided by the track width of the undercarriage is 1 or greater.<br>In case of different conditions, the load action shall be considered according to ISO 8686-1. |
| **Exceptional loads** | | | |
| 11 | Loads caused by hoisting a grounded load at maximum hoisting speed | $\phi_2$ | Refer to line 2 of Table 1. |
| 12 | Loads due to out-of-service wind | — | Refer to 6.3. |
| 13 | Test loads | $\phi_6$ | The values of test loads shall be in accordance with ISO 4310.<br>The minimum wind pressure that shall be considered for test loads is $q_{(3)}$ = 40 Pa (wind speed $v_{(3)}$ = 8 m/s). |
| 14 | Loads due to buffer forces | $\phi_7$ | A verification of the energy absorption capacity of the buffers and the effect of the buffer forces on the tower crane structure may be disregarded, on condition that the crane travelling speed does not exceed 40 m/min and at least 2 limit switches are installed in each driving direction in addition to buffer stops.<br>In case of different conditions, the load action shall be considered according to ISO 8686-1. |
| 15 | Loads due to tilting forces | — | Not applicable to tower cranes. |
| 16 | Loads due to unintentional loss of hoist load | $\phi_9$ | According to ISO 8686-1.<br>For tower cranes, this load case refers to hoist rope rupture or accidental drop of hoist load.<br>$\phi_9$ = −0,3 shall be used for the proof of strength and the proof of rigid body stability. Alternatively, this load may be evaluated by calculation on a dynamic model analysis or by a practical test. |
| 17 | Loads caused by Emergency Off | — | This load can be determined by calculation on a dynamic model analysis or by a practical test. |
| 18 | Loads caused by anticipated failure of mechanism or components | — | This load can be determined by calculation on a dynamic model analysis or by a practical test. |
| 19 | Loads due to external excitation of the crane foundation | — | To be considered only on special request from a third party. |
| 20 | Loads caused by erection, dismantling and transport | — | Refer to 6.4. |
| 21 | Loads on means provided for access | — | Refer to 6.5 |



## 6.3 Loads due to out-of-service wind

### 6.3.1 General

Loads due to out-of-service wind shall be considered according to ISO 8686-1 and ISO 4302.

Tower cranes are typically designed to slew freely in the out-of-service state and to show a good weathervaning behaviour thereby.

Nevertheless, in order to cover a delayed slewing of the cranes in the prevailing wind direction or generally to take into account particularly turbulent construction sites, additional safety load cases in the out-of-service state shall be considered. These additional empirical load cases relate primarily to an extension of the proof of rigid body stability. However, in order not to create a gap in the proof verification, at least the substructure and the crane tower shall be verified by a proof of strength regarding these load actions.

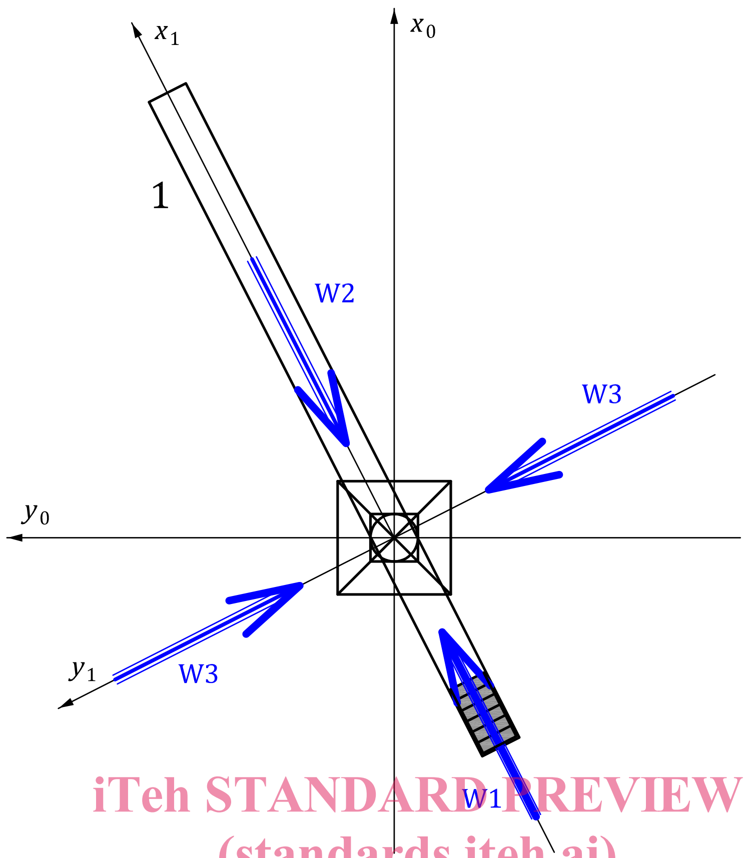
Hence, wind loads due to out-of-service wind for tower cranes are split-up in three different wind load assumptions, depending on the wind direction acting on the crane (see Figure 1), with the requirement of a free slewing upper works. These loads are converted into three load combinations: C2.1, C2.2 and C2.3 according to Tables 4 and 5.

The proof of stability and the proof of strength shall be made with the following load combinations:

— C2.1: crane in out-of-service conditions, considering out-of-service wind from rear;

— C2.2: crane in out-of-service conditions, considering out-of-service wind from front; and

— C2.3: crane in out-of-service conditions, considering out-of-service wind from side.






**Key**

- $(x_0, y_0)$ coordinate system defined in a horizontal plane at ground level, linked to the stationary crane part of the crane, $x_0$ is conventionally defined parallel to the most unfavourable tilting axis (index 0)
- $(x_1, y_1)$ coordinate system defined in a horizontal plane at the level of the slewing ring, linked to the slewing part of the crane, $x_1$ is conventionally defined parallel to the jib axis of the crane (index 1)
- 1 jib direction
- W1 wind from rear
- W2 wind from front
- W3 wind from side

**Figure 1 — Figure illustrating the wind directions “wind from rear", "wind from front" and "wind from side”**

If the tower crane is not slewing freely out-of-service, the wind load action “wind from rear” according to 6.3.2 shall be applied from all sides. The additional wind loads given in 6.3.3 and 6.3.4 may be ignored in that case.

For a crane that possesses innate means to be readily removed from exposure to storm winds (e.g. a mobile self-erecting tower crane), loads due to out-of-service wind may be disregarded or reduced, as appropriate.

### 6.3.2 Loads due to out-of-service wind from rear

The out-of-service wind loads from rear are assumed to act on a member of a tower crane or on the hoist load remaining suspended at the crane and are calculated using Formula (1):

$$F = K_s * q(z) * C_f * A \tag{1}$$

where

$F$ is the wind load as defined in ISO 4302:2016, 6.2;

$K_s$ is the structural factor, where, due to the size and structure of tower cranes, the structural factor $K_s$ takes into account the effect on wind actions from the non-simultaneous occurrence of peak wind pressures on the surface, such that

$K_s$ is set to 0,95 for tower cranes,

$K_s$ is only allowed to be used at load combination C2.1;

$q(z)$ is the wind pressure as defined in ISO 4302:2016, 6.2;

$C_f$ is the aerodynamic coefficient as defined in ISO 4302:2016, 6.2;

$A$ is the characteristic area as defined in ISO 4302:2016, 6.2.

The reference wind speed and recurrence period shall conform to the following minimum requirements:

— reference wind speed, $v_{ref}$ = 28 m/s;

— recurrence period, $R$ = 25 years.

Higher reference wind speeds and recurrence periods shall be applied when required by the local wind conditions and duration of exposure.



For specific applications or jobsite conditions (special cranes such as very high cranes, cranes tied to a building, jobsites with special wind effects, etc.), parameters different from those listed above based on more accurate wind load evaluation methods may be used.



### 6.3.3 Loads due to out-of-service wind from front

The wind load action for out-of-service wind from front as described in 6.3.1 shall be considered according to Formula (2):

$$F = q_{(3)} * C_f * A \quad (2)$$

where

$F$ is the calculated wind load;

$q_{(3)}$ is an empirically defined uniform wind pressure with 710 Pa; This wind pressure shall be applied constant over the height of the crane;

$C_f * A$ is the effective aerodynamic area ($C_f * A$) for an approaching flow from front. Simplified, the effective wind area for a flow from rear, as calculated in 6.3.2, can be used for this load action also.

### 6.3.4 Loads due to out-of-service wind from side

The wind load action for out-of-service wind from side as described in 6.3.1 shall be considered according Formula (3):

$$F = q_{(3)} * C_f * A \quad (3)$$

where