INTERNATIONAL STANDARD

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Cranes — Design principles for loads and load combinations —

Part 2:
Mobile cranes

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

Partie 2: Grues mobiles

Reference number
ISO 8686-2:2004(E)

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Foreword

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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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8686-2 was prepared by Technical Committee ISO/TC 96, *Cranes*, Subcommittee SC 6, *Mobiles cranes*.

ISO 8686 consists of the following parts, under the general title *Cranes — Design principles for loads and load combinations*:

— *Part 1: General*

— *Part 2: Mobile cranes*

— *Part 3: Tower cranes*

— *Part 4: Jib cranes*

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

Cranes — Design principles for loads and load combinations —

Part 2: Mobile cranes

1 Scope

This part of ISO 8686 applies the principles set forth in ISO 8686-1 to mobile cranes, as defined in ISO 4306-2, and presents loads and load combinations appropriate for use in proof-of-competence calculations for the steel structures of mobile cranes.

This part of ISO 8686 is applicable to mobile cranes used for normal service and to mobile cranes used for duty cycle service.

NOTE Means for proof-of-competence testing will be addressed in another document.

2 Normative references

The following referenced documents are indispensable for the application 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 4302:1981, *Cranes — Wind load assessment*

ISO 4306-2, *Cranes — Vocabulary — Part 2: Mobile cranes*

ISO 4310:1981, *Cranes — Test code and procedures*

ISO 8686-1:1989, *Cranes — Design principles for loads and load combinations — Part 1: General*

ISO 10721-1, *Steel structures — Part 1: Materials and design*

ISO 10721-2, *Steel structures — Part 2: Fabrication and erection*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4306-2 and the following apply.

3.1
rated capacity
rated load
hoist medium load which includes the mass of lifting attachments

3.2
normal service
hook duties for which fatigue analysis of the steel load-supporting structure is not required, including occasional use for duty cycle work if duty cycle rating is no more than 80 % of normal service rating

3.3
duty cycle service
repetitive duties for which fatigue analysis of the steel load-supporting structure may be required

EXAMPLE Grab, dragline, magnet or comparable repetitive duty.

4 Choice of loads and load combinations

4.1 Basic considerations

Loads shall be combined with the intention of discovering maximum load effects on mobile crane components or members during operation, in accordance with the manufacturer's instructions, as simulated by elastostatic calculation. To achieve this, the following considerations govern preparation of proof-of-competence calculations.

a) The crane is taken in its most unfavorable attitude and configuration, while the loads are assumed to act in magnitude, position and direction causing unfavorable stresses at the critical points selected for evaluation on the basis of engineering considerations.

and

b) Conservatively, loads can be combined at the values defined in this part of ISO 8686 or, when appropriate, they can be combined with certain loads, adjusted by reduction factors for the probability of combined actions to more closely reflect loading conditions currently found in practice.

4.2 Simultaneous accelerations

The effect of one accelerating drive, e.g. slewing, luffing or telescoping, is assumed to act simultaneously with hoisting acceleration; only two drives are assumed to accelerate simultaneously in the absence of hoisting acceleration. However, no simultaneous accelerations shall be considered when specifically prohibited by the manufacturer for a particular configuration. No other accelerations are combined with travel unless specifically permitted in the manufacturer's instructions.

See Annex B for further information on simultaneous accelerations.

4.3 Side loading

Certain design features may have the effect of inducing side loading on booms. When those features are present in a design, they shall be included with all applicable load combinations for which calculations are performed, combined so as to maximize side loading. In addition to slewing and wind effects, features affecting side loading may include

a) reeving arrangements that cause the hoist line to deviate from the boom centreline, between the boom point sheave and the most extreme position on the hoisting drum, and

b) inclination of the boom foot due to deflection of the supporting crane structure.

4.4 Erection and dismantling

An evaluation shall be made for each step in the erection and dismantling processes, as appropriate to the crane type and configuration, and proof-of-competence calculations shall be carried out for each instance of significant member or component loading. Calculations shall utilize factors from Table 1 or Table 2 as given under Load combinations B.

4.5 Automatically initiated actions

When mobile cranes are furnished with controls or devices that cut out drives and apply brakes without an initiating action by the driver, or are furnished with brakes that automatically engage on loss of power or control function, calculations reflecting those effects shall be carried out under Emergency cut-out on row 11 of Table 1 or Table 2.

5 Loads from acceleration of crane drives

5.1 General

Mobile cranes are typically designed to accommodate a range of boom lengths and various extensions or front-end attachments. Therefore, some cranes may possess excess power in some configurations, power that crane drivers in practice will not fully utilize (in accordance with the manufacturer's instructions). Therefore, in proof-of-competence calculations, the change in drive force (ΔF) inducing either acceleration or deceleration may have to be chosen on the basis of a simulation of driver actions or tests rather than on drive or brake characteristics.

5.2 Slewing effects

In practice, slewing acceleration and deceleration rates can vary depending on the front-end attachment fitted, the operating radius, the control scheme employed, the crane driver's operating practices, and the characteristics of the slewing drive and braking mechanisms. For proof-of-competence calculations, the changes in drive forces ΔF causing slewing acceleration or deceleration which produce side loading can be taken as follows.

a) For cranes with stepped drive controls and for cranes wherein the driver does not have control over slewing acceleration or deceleration rates, ΔF shall be calculated from drive/brake characteristics.

b) For cranes with stepless continuously-variable drive controls, ΔF shall be calculated based either on

1) the highest forces which will occur during normal operation as described in the manufacturer's instructions, or

2) a simulation of driver actions or tests, or

3) drive/brake characteristics, but the resulting lateral force from slewing, referred to the boom tip, shall not be taken as less than 2 % of the rated load for latticed booms or 3 % for telescopic booms.

5.3 Hoisting effects

5.3.1 Inertial effects due to hoisting, except for hoisting an unrestrained grounded load (see ISO 8686-1:1989, 6.1.2.2), depend on the change in hoist drive force ΔF. The change in this force can be calculated from hoist drive or brake characteristics; or for hoist drives with stepless continuously-variable drive control, ΔF can be taken as follows:

$$\Delta F = \delta \times F$$

$$\delta = 0{,}167(v_h - 0{,}2) \qquad \text{for } 0{,}2 \leqslant v_h \leqslant 1{,}7$$

where

F is the rated load, in newtons;

v_h is the hoisting/lowering speed, in metres per second.

As given above, factor δ is for cranes in normal service. δ can also be determined from experience or by test.

5.3.2 No increase in δ is taken for hoisting or lowering speeds, v_h, greater than 1,7 m/s. When speeds are equal to or less than 0,2 m/s, δ is taken as 0.

5.3.3 For cranes in duty cycle service, δ is taken as twice the value for normal service, or alternatively, δ can be determined from experience or by test.

5.4 Application of changes in drive force, ΔF

5.4.1 ΔF values for hoisting are amplified by an appropriate dynamic amplification factor value ϕ_5 taken from Table 3 to make up the load for use on row 5 of Table 1 or Table 2.

5.4.2 ΔF values for drives other than hoisting are amplified by an appropriate dynamic amplification factor value ϕ_5 taken from Table 3, and the resulting inertial force shall comprise the load for use on row 4 of Table 1 or Table 2.

6 Proof-of-competence calculations for load-supporting structures

6.1 General

For proof-of-competence calculations, the crane manufacturer shall choose either the allowable stress method or the limit state method. Calculations by the allowable stress method shall be carried out in accordance with 6.2. Calculations by the limit state method shall be carried out in accordance with 6.3.

6.2 Allowable stress method

6.2.1 Table 1 gives loads and load combinations for the allowable stress method, together with applicable allowable stress coefficients γ_f and dynamic amplification factors ϕ_n. Table 3 gives values for the factors ϕ_n and other pertinent load information.

6.2.2 For members under axial compression, the allowable stress coefficients γ_f given in Table 1 are applicable only when used in conjunction with a column formula selected in accordance with Annex A.

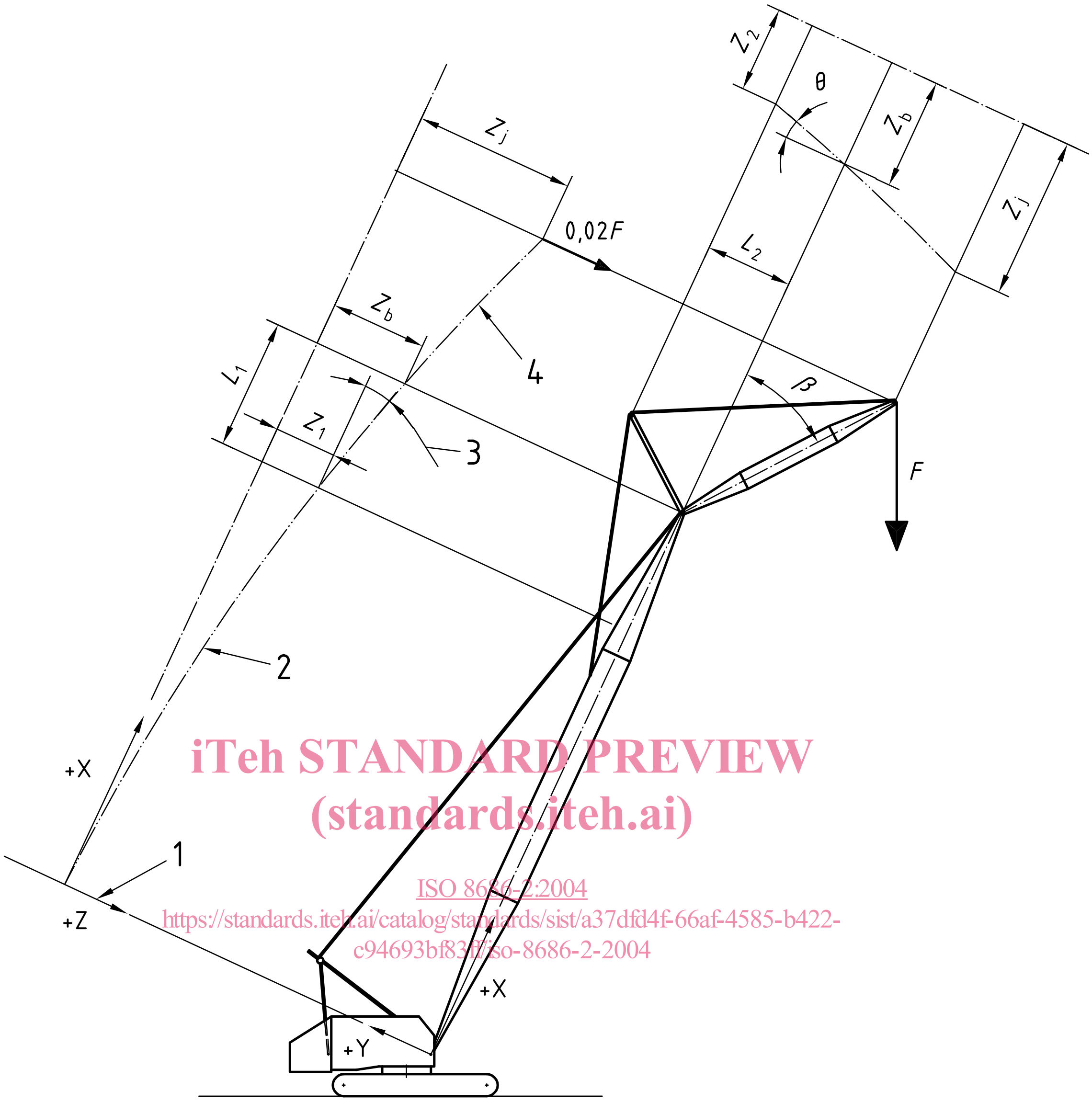
6.3 Limit state method

6.3.1 Table 2 gives loads and load combinations for the limit state method, together with applicable partial load factors γ_p and dynamic amplification factors ϕ_n. Table 3 gives values for the factors ϕ_n and other pertinent load information. The resistance coefficient γ_m shall be taken as 1,1 for all load combinations. This coefficient shall be divided into the limit strength to reflect statistical variations in material strength and local imperfections.

6.3.2 For members under axial compression, the resistance coefficient γ_m and the partial load factors γ_p given in Table 2 are applicable only when used in conjunction with a column formula selected in accordance with Annex A.

7 Side-load deflection of latticed booms

7.1 Lateral deflection of wire-rope-supported latticed booms and fly jibs are a measure of elastic stability, as these members are primarily loaded in compression. Excessive side deflections can induce elastic instability. Therefore, all wire-rope-supported latticed booms and fly jibs shall be limited to deflections not exceeding 2 % of their effective length when subjected to rated load together with side loading of 2 % of rated load. Deflection limits may be verified by calculation or by test. Deflection limitations apply only to mobile cranes with latticed booms and fly jibs mounted on latticed booms.



Key

1 boom foot centreline

2 boom centreline

3 slope Z'

4 jib centreline

F rated load

Figure 1 — Terms and symbols related to deflection measurement — Lattice jib with fly jib

7.2 For a single fly jib mounted on a jib, the following relationship is given (Figure 1):

$$Z_j \leqslant 0{,}02\,L_j + Z_b + Z'\,(L_j \cos\beta) + \theta\,(L_j \sin\beta)$$

where the following values are calculated (or measured):

Z_j is the fly jib tip deflection;

Z_b is the latticed jib tip deflection;

Z_1 is the latticed jib deflection at a distance L_1 down from the jib tip;

Z_2 is the fly jib strut deflection at the tip;

and the following values are calculated:

Z' (slope) = $(Z_b - Z_1) / L_1$

$\theta = (Z_b - Z_2) / L_2$

If slope Z' and torsion θ are not calculated, the last two terms of the equation for Z_j may be deleted.

Table 1 — Loads and load combinations — Mobile cranes — Allowable stress method

Categories of loads	List of loads			Load combinations A: Allow. stress coef. γ_f	A1	A2	A3	A4	Load combinations B: Allow. stress coef. γ_f	B1	B2	B3	B4	Load combinations C: Allow. stress coef. γ_f	C1	C2	C3	C4	Row
Regular (6.1)	Gravity, acceleration and impacts	1. Mass of the crane		1,48	ϕ_1	ϕ_1	1	—	1,34	ϕ_1	ϕ_1	1	—	1,22	ϕ_1	1	ϕ_1	1	**1**
		2. Mass of the rated load			ϕ_2	ϕ_3	1	—		ϕ_2	ϕ_3	1	—		—	η	—	1	**2**
		3. Mass of the crane and rated load traveling on an uneven surface			—	—	—	ϕ_4		—	—	—	ϕ_4		—	—	—	—	**3**
	Acceleration from drives	4. Masses of the crane and rated load	Other than hoist drive		ϕ_5	ϕ_5	1	—		ϕ_5	ϕ_5	1	—		—	—	ϕ_5	—	**4**
			Hoist drive		—	—	ϕ_5	—		—	—	ϕ_5	—		—	—	—	—	**5**
Occasional (6.2)	Effects of climate	1. In-service wind			—	—	—	—		1	1	1	1		—	—	1	—	**6**
		2. Snow and ice			—	—	—	—		1	1	1	1		—	—	—	—	**7**
Exceptional (6.3)	1. Hoisting a grounded load				—	—	—	—		—	—	—	—		ϕ_2	—	—	—	**8**
	2. Out-of-service wind				—	—	—	—		—	—	—	—		—	1	—	—	**9**
	3. Test loads				—	—	—	—		—	—	—	—		—	—	ϕ_6	—	**10**
	4. Emergency cut-out				—	—	—	—		—	—	—	—		—	—	—	ϕ_5	**11**

NOTE 1 Under load combination C2, η allows for the mass of the hook block or overhaul ball remaining suspended when the crane is out of service. $\eta m = (m - \Delta m)$, see ISO 8686-1:1989, 6.3.1.

NOTE 2 The subclauses 6.1, 6.2 and 6.3 referenced in the first column, Categories of loads, are taken from ISO 8686-1:1989.

NOTE 3 See Table 3 for factors ϕ_n.

NOTE 4 See Table C.1 for descriptions of the load combinations.

NOTE 5 Additional load cases may need to be calculated. See 4.4.