INTERNATIONAL STANDARD

ISO 16881-1

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Cranes — Design calculation for rail wheels and associated trolley track supporting structure —

Part 1:
General

Appareils de levage à charge suspendue — Calcul de conception des galets et de la structure de support du chariot de roulement —

Partie 1: Généralités

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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.

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 16881-1 was prepared by Technical Committee ISO/TC 96, *Cranes*, Subcommittee SC 9, *Bridge and gantry cranes*.

ISO 16881 consists of the following parts, under the general title *Cranes — Design calculation for rail wheels and associated trolley track supporting structure*:

— *Part 1: General*

The following parts are under preparation:

— *Part 2: Mobile cranes*

— *Part 3: Tower cranes*

— *Part 4: Jib cranes*

— *Part 5: Bridge and gantry cranes*

Introduction

This part of ISO 16881 establishes requirements and gives guidance and design rules that reflect the present state of the art in the field of crane machine design. The rules given represent good design practice that will ensure fulfilment of essential safety requirements and adequate service life of components. Deviation from these rules normally could lead to increased risks or reduction of service life, but it is acknowledged that new technical innovations, materials, etc. may enable new solutions that result in equal or improved safety and durability.

Cranes — Design calculation for rail wheels and associated trolley track supporting structure —

Part 1: **General**

1 Scope

This part of ISO 16881 gives the requirements for the selection of the size for iron or steel wheels and presents the formulae for the local stresses in crane structures due to the effects of the wheel loads.

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 4301-1, *Cranes and lifting appliances — Classification — Part 1: General*

ISO 4306-1, *Cranes — Vocabulary — Part 1: General*

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

ISO 8686-2, *Cranes — Design principles for loads and load combinations — Part 2: Mobile cranes*

ISO 8686-3, *Cranes — Design principles for loads and load combinations — Part 3: Tower cranes*

ISO 8686-4, *Cranes — Design principles for loads and load combinations — Part 4: Jib cranes*

ISO 8686-5, *Cranes — Design principles for loads and load combinations — Part 5: Overhead travelling and portal bridge cranes*

3 Terms and definitions

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

4 Requirements

4.1 Selection of rail wheels

4.1.1 Rail wheel size

To determine the size of a rail wheel, the following checks shall be made:

a) verify that the wheel is capable of withstanding the maximum load to which it will be subjected;

b) verify that the wheel will allow the appliance to perform its normal duty without abnormal wear.

These verifications are made by means of the following two equations:

$$\frac{P_{\text{max}}}{b \cdot D} \leqslant 1{,}9 P_{\text{L}} \quad (1)$$

$$\frac{P_{\text{mean}}}{b \cdot D} \leqslant P_{\text{L}} \cdot c_1 \cdot c_2 \quad (2)$$

where

D is the wheel diameter, in millimetres;

b is the useful width of the rail, in millimetres;

P_{L} is a limiting pressure dependent upon the metal used for the wheel, in newtons per square millimetre (N/mm^2), see Table 1;

c_1 is a coefficient depending on the speed of rotation of the wheel, see Table 2;

c_2 is a coefficient depending on the group of the mechanism, see Table 3;

P_{max} is the maximum load on the wheel resulting from load combinations A, B or C, including consideration of both dynamic and static test loadings (load combinations are defined in ISO 8686-1 to ISO 8686-5);

P_{mean} is the higher mean load value resulting from Equation (3) when considering both load combinations A and B.

The mean wheel load takes into account variations of the wheel loading, including, where applicable, positional changes of the handled load in relation to the supporting wheels during a working cycle. Equation (3) gives an approximate value of the resultant cubic mean loading.

When the work process is well known, the cubic mean load can be calculated more accurately using the wheel loads resulting from the actual positions of the handled load. In this calculation, the maximum lifted load shall be used, coefficient c_2 taking into account the variation of the load.

4.1.2 Determining the mean load

In order to determine the mean loads, the procedure is to consider the maximum and minimum loads withstood by the wheel in the loading cases considered, i.e. with the appliance in normal duty but omitting the dynamic coefficients ϕ when determining P_{mean}. The values of P_{mean} are determined by the Equation (3) in the load combinations A and B.

$$P_{\text{mean}} = \frac{P_{\text{min,A,B}} + 2P_{\text{max,A,B}}}{3} \quad (3)$$

4.1.3 Determining the useful rail width b

For rails having a flat or slightly convex bearing surface, of total width, l, with rounded corners of radius, r, at each side (see Figure 1), the useful width, b, shall be calculated using Equation (4):

$$b = l - 2r \quad (4)$$

For rails or wheels with a slightly convex bearing surface, the limiting pressure P_{L} may be increased by 10 %. This allows for the improved contact of a rail to the rolling motion of the wheel.

In the case of a flat, tapered or convex wheel running on the bottom flange of a beam, the useful width is calculated by Equation (5):

$$b = w - r \tag{5}$$

where the wheel tread of width, w, and the corner radius r are to be taken according to Figure 2. The wheel diameter, D, shall be taken as the mean diameter on the projected width ($w - r$).

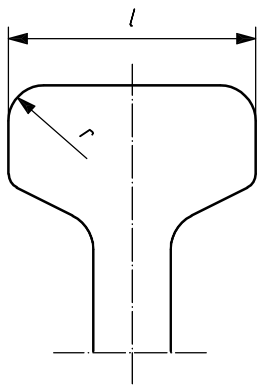

Figure 1 — Rail dimensions

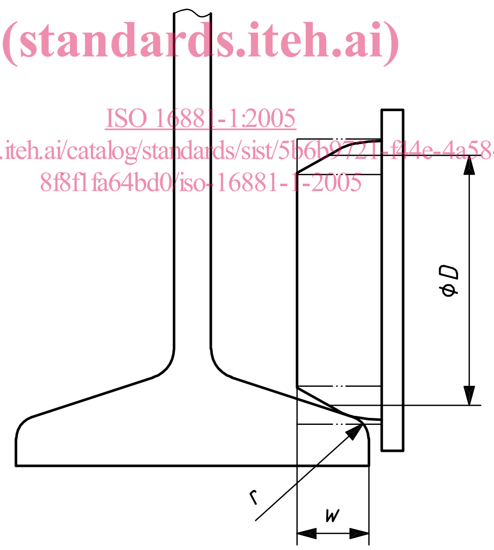

Figure 2 — Dimensions of flange running wheel

4.1.4 Determining limiting pressure P_L

The value of P_L is given in Table 1 as a function of the ultimate strength of the metal of which the rail wheel is made.

Table 1 — Values of P_L

Ultimate strength of metal used for rail wheel f_u N/mm^2	P_L N/mm^2	Minimum ultimate strength for rail N/mm^2
> 500	5,00	350
> 600	5,60	350
> 700	6,50	510
> 800	7,20	510
> 900	7,80	600
> 1 000	8,50	700

The qualities of metal correspond to cast, forged or rolled steels, and spheroidal graphite cast iron.

The hardening of the wheel tread at the depth of 0,01D may be taken into account when selecting the value of P_L.

In the case of rail wheels with tyres, consideration must obviously be given to the quality of the tyre, which shall be sufficiently thick not to roll itself out.

4.1.5 Determining coefficient c_1

The values of c_1 depend on the speed of rotation of the wheel and are given in Table 2.

Table 2 — Values of c_1

Wheel rotation speed r/min	c_1	Wheel rotation speed r/min	c_1	Wheel rotation speed r/min	c_1
200	0,66	50	0,94	16	1,09
160	0,72	45	0,96	14	1,10
125	0,77	40	0,97	12,5	1,11
112	0,79	35,5	0,99	11,2	1,12
100	0,82	31,5	1	10	1,13
90	0,84	28	1,02	8	1,14
80	0,87	25	1,03	6,3	1,15
71	0,89	22,4	1,04	5	1,16
63	0,91	20	1,06		
56	0,92	18	1,07		

4.1.6 Determining coefficient c_2

Coefficient c_2 depends on the group classification of the mechanism and is given in Table 3.

Table 3 — Values of c_2

Group classification of mechanism	c_2
M1 et M2	1,25
M3 et M4	1,12
M5	1,00
M6	0,90
M7 et M8	0,80

The formulae apply only to wheels whose diameters do not exceed 1,25 m. For larger diameters, experience shows that the permissible pressures between the rail and the wheel must be lowered. The use of wheels of greater diameter is not recommended.

NOTE The wheel selection method presented here is based on FEM 1.001-1988, Booklet 4, as revised in Booklet 9 in 1998. This method is based on the group classification of mechanisms (classes M1 to M8) that is equal to the classification of ISO 4301-1.

4.2 Determination of the class of mechanism of the travel wheel

The determination of the mechanism class (according to ISO 4301-1) of the rail wheel is made in general terms as follows.

a) The number of working cycles, C, is taken as the specified value or the upper limit of the given U-class.

b) The average displacement of the travel motion, x_m, is specified according to intended use.

c) The wheel load spectrum class number, L_i, shall be taken as specified or to be calculated from a given spectrum or description of work cycles.

d) Total travel distance is $L = 2Cx_m$.

e) Running time $T = L/v_t$, where v_t is the normal travel speed of the motion (usually, the maximum speed).

f) Operation time class number is calculated as $T_j = 1 + \text{Int}\,[\log (T/200{,}01\text{ h})/\log (2)]$.

EXAMPLE 1 $T = 3\,200$, $T_j = 1 + \text{Int}\,[\log (3\,200/200{,}01)/0{,}693\,147] = 1 + \text{Int}\,(3{,}999\,9) = 4$; $\Rightarrow$ classe T_4.

EXAMPLE 2 $T = 3\,201$, $T_j = 1 + \text{Int}\,[\log (3\,201/200{,}01)/0{,}693\,147] = 1 + \text{Int}\,(4{,}000\,4) = 5$; $\Rightarrow$ classe T_5.

g) The mechanism class number is calculated as $m_m = L_i + T_j - 2$.

T_j, L_i, and m_m shall be understood as integer numbers, e.g. 5, or as the corresponding symbol, T_5 .

4.3 Determination of local stresses due to wheel loads

The local stresses due to the wheel forces of a crab or a crane may be determined according to Annexes A and B.

When the permissible stress method is used, the local stresses according to Annexes A and B, combined with the global stresses due to the rated loads, shall not exceed the permissible stresses.

When the limit state method is used, the local stresses shall be calculated with the loads multiplied by the relevant partial load factors, γ_p. These stresses, combined with the global stresses, shall not exceed the yield stress divided by the material factor, γ_m.

Factors γ_p and γ_m shall be taken according to the relevant part(s) of ISO 8686.