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Machine tools — Ball splines —

Part 2: Dynamic and static load ratings and rating life

Machines-outils — Guidages cannelés à billes —

Partie 2: Charges dynamiques et statiques de base et durée de vie de base

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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 23848-2 was prepared by Technical Committee ISO/TC 39, *Machine tools*.

ISO 23848 consists of the following parts, under the general title *Machine tools — Ball splines*:

— *Part 1: General characteristics and requirements*

— *Part 2: Dynamic and static load ratings and rating life*

Introduction

The ball spline is a power transmission component based on recirculating balls, which is designed to translate axially while transmitting torque by an anti-friction means. The ball spline is selected for its smooth operation, high-speed capability, low friction and high radial and high torsional load capacity. This part of ISO 23848 specifies and standardizes the basic dynamic load rating and torque rating, the basic static load rating and torque rating and the 90 % rating life for ball splines of type AI, type AII and type R.

Machine tools — Ball splines —

Part 2:
Dynamic and static load ratings and rating life

1 Scope

This part of ISO 23848 specifies the calculation method of basic dynamic load rating, basic static load rating and basic rating life prediction for the design and use of ball splines of type AI, type AII and type R. It also establishes the basic static and dynamic torque ratings for these ball splines.

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 23848-1, *Machine tools — Ball splines — Part 1: Characteristics, shapes, and dimensions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23848-1 and the following apply.

3.1
basic dynamic load rating
C
constant stationary radial load, having direction and magnitude which do not vary with time and which a ball spline assembly theoretically endures for a basic rating life of 50 km

3.2
basic dynamic torque rating
C_T
constant torque, having direction and magnitude which do not vary with time and which a ball spline assembly theoretically endures for a basic rating life of 50 km

3.3
basic rating life
L_{10}
fatigue life that of a group of ball splines have a 90 % probability of enduring

3.4
basic static load rating
C_0
static radial load which corresponds to a calculated Hertzian contact stress at the centre of the contacting surfaces of the maximum ball load position

See Table 1.

Table 1 — Maximum contact stress, σ_{max}, corresponds to basic static load rating

r_g/D_w	$\leqslant$ 0,52	0,53	0,54	0,55	0,56	0,57	0,58	0,59	$\geqslant$ 0,6
σ_{max} MPa	4 200	4 250	4 300	4 350	4 400	4 450	4 500	4 550	4 600

3.5
basic static torque rating
C_{0T}
static torque which corresponds to a calculated Hertzian contact stress at the centre of the contacting surfaces of the maximum ball load position, as shown in Table 1

3.6
dynamic equivalent load
P
constant radial load under the influence of which a ball spline has the same life as it attains under the actual applied load conditions

3.7
dynamic equivalent torque
T
constant torque under which a ball spline has the same life as it attains under the actual applied torque conditions

3.8
life
total running distance of a ball spline before the first evidence of rolling contact fatigue failure or flaking occurs at the raceways of either the spline outer race, the spline shaft or the re-circulating balls

3.9
static equivalent load
P_0
static radial load which causes the same constant stress at the centre of the contacting surfaces as occurs under the actual applied load conditions

3.10
static equivalent torque
T_0
static torque which causes the same constant stress at the centre of the contacting surfaces as occurs under the actual applied torque conditions

3.11
reliability
R
probability that the ball spline assembly will not fail by rolling contact fatigue under a specified load and/or torque

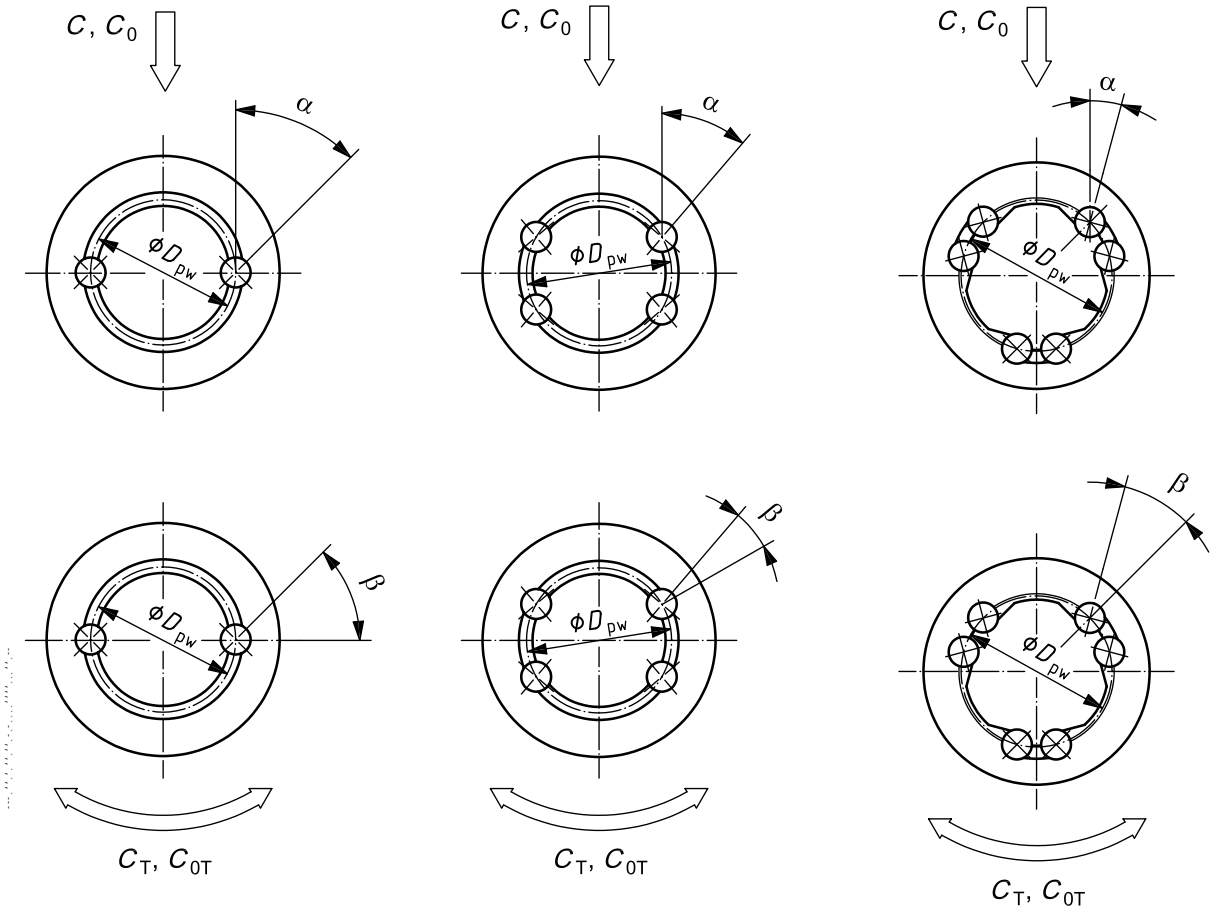
NOTE This term is the same as the probability of survival.

4 Symbols

Symbol	Description	Unit
b_m	Rating factor for contemporary used high quality hardened steel and product quality	—
C	Basic dynamic load rating	N
C_T	Basic dynamic torque rating	Nm
C_0	Basic static load rating	N
C_{0T}	Basic static torque rating	Nm
D_{pw}	Ball pitch circle diameter	mm
D_w	Ball diameter	mm
f_c	Factor determined by geometrical shape, working accuracy and material for each part of ball spline	—
f_0	Factor determined by geometrical shape and working stress for each part of ball spline	—
i	Number of spline grooves	—
i_t	Number of spline grooves applied to calculation of load rating	—
k_i	Ball row arrangement factor applied to calculation of dynamic load rating	—
k_{0i}	Ball row arrangement factor applied to calculation of static load rating	—
L_{10}	Basic rating life with 90 % reliability	50 km
l_t	Outer race spline groove length applied to calculation of load rating	mm
P	Dynamic equivalent load	N
P_0	Static equivalent load	N
R	Reliability	—
r_g	Spline groove radius	mm
T	Dynamic equivalent torque	Nm
T_0	Static equivalent torque	Nm
Z_t	Number of effective balls for one spline groove applied to calculation of load rating	—
α	Contact angle for radial load	°
β	Contact angle for torque direction	°
λ	Adjustment factor for dynamic load rating and torque rating	—
σ_{max}	Maximum contact stress	MPa

5 Type AI and type AII (angular type)

The load ratings, torque ratings and contact angles corresponding to the applied radial load and torque for the three types of ball spline are shown in Figure 1. The load and torque ratings are defined in 5.1 to 5.4.



a) Type AI b) Type AII

Figure 1 — Load ratings, torque ratings and contact angles for ball splines of type AI and AII

5.1 Basic dynamic load rating

The basic dynamic load rating, C, is found using Equations (1) and (2):

$$C = b_{\mathrm{m}} \times f_{\mathrm{c}} \times l_{\mathrm{t}}^{1/30} \times i_{\mathrm{t}}^{0,7} \times Z_{\mathrm{t}}^{2/3} \times D_{\mathrm{w}}^{2,1} \times \cos\alpha \tag{1}$$

$$f_{\mathrm{c}} = \lambda \times 30,9 \times \left(\frac{2 \times r_{\mathrm{g}}}{2 \times r_{\mathrm{g}} - D_{\mathrm{w}}} \right)^{0,41} \tag{2}$$

where

$b_{\mathrm{m}} = 1,3$;

$\lambda = 0,9$.

5.2 Basic static load rating

The basic static load rating, C_0, is found using Equation (3):

$$C_0 = f_0 \times i_t \times Z_t \times D_w^2 \times \cos\alpha \tag{3}$$

5.3 Basic dynamic torque rating

The basic dynamic torque rating, C_T, is found using Equations (4) and (5):

$$C_T = \frac{\frac{D_{pw}}{2} \times b_m \times f_c \times l_t^{1/30} \times i_t^{0,7} \times Z_t^{2/3} \times D_w^{2,1} \times \sin\beta}{1000} \tag{4}$$

$$f_c = \lambda \times 30,9 \times \left(\frac{2 \times r_g}{2 \times r_g - D_w} \right)^{0,41} \tag{5}$$

where

$b_m = 1,3$;

$\lambda = 0,9$.

5.4 Basic static torque rating

The basic static torque rating, C_{0T}, is found using Equation (6):

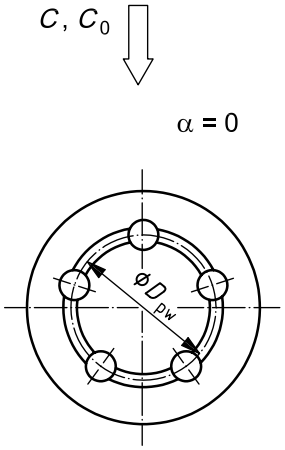
$$C_{0T} = \frac{\frac{D_{pw}}{2} \times f_0 \times i_t \times Z_t \times D_w^2 \times \sin\beta}{1000} \tag{6}$$

Table 2 — f_c factor and f_0 factor

r_g/D_w	0,52	0,53	0,54	0,55	0,56	0,57	0,58	0,59	0,6
f_c	105,8	90,3	80,8	74,3	69,5	65,7	62,7	60,1	58,0
f_0	94,6	76,3	66,1	59,5	54,9	51,5	49,0	47,1	45,6

6 Type R (radial type)

The load ratings corresponding to the applied radial load and torque are shown in Figure 2 for the radial type (type R) ball spline. The load ratings are defined in 6.1 and 6.2.



NOTE Without definition for C_T and C_{0T}.

Figure 2 — Load ratings and contact angles for ball splines of type R

6.1 Basic dynamic load rating

The basic dynamic load rating, C, is found using Equations (7) and (8):

$$C = b_m \times f_c \times k_i \times l_t^{1/30} \times Z_t^{2/3} \times D_w^{2,1} \tag{7}$$

$$f_c = \lambda \times 30,9 \times \left(\frac{2 \times r_g}{2 \times r_g - D_w} \right)^{0,41} \tag{8}$$

where

$b_m = 1,3$;

$\lambda = 0,9$.

6.2 Basic static load rating

The basic static load rating, C_0, is found using Equation (9):

$$C_0 = f_0 \times k_{0i} \times Z_t \times D_w^2 \tag{9}$$

Table 3 — k_i factor and k_{0i} factor

i	3	4	5	6	7	8	9	10
k_i	1	1	1,104	1,329	1,531	1,681	1,807	1,948
k_{0i}	1	1	1,106	1,354	1,614	1,841	2,052	2,284

7 Rating life

The basic rating life, L_{10}, for applied radial load is given as Equation (10):

$$L_{10} = \left(\frac{C}{P} \right)^3 \tag{10}$$

The basic rating life, L_{10}, for applied torque is given as Equation (11):

$$L_{10} = \left(\frac{C_\mathrm{T}}{T} \right)^3 \tag{11}$$

Bibliography

[1] ISO 14728-1, *Rolling bearings — Linear motion rolling bearings — Part 1: Dynamic load ratings and rating life*

[2] ISO 14728-2, *Rolling bearings — Linear motion rolling bearings — Part 2: Static load ratings*

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