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Ball screws

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Machine Accessory Association (JMAA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 1192:1997** is replaced with this Standard.

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Ball screws

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 3408-1** published in 2006, the first edition of **ISO 3408-2** published in 1991 and the second edition of **ISO 3408-3** published in 2006 with some modifications of the technical contents. Types, qualities and measuring methods thereof conventionally specified in this Standard are remained, and materials, inspections and marking not specified in the corresponding International Standards are added.

The portions given sidelines or dotted underlines are the matters in which the contents of the corresponding International Standards have been modified. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies the ball screws.

NOTE : The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 3408-1:2006 *Ball screws—Part 1: Vocabulary and designation*

ISO 3408-2:1991 *Ball screws—Part 2: Nominal diameters and nominal leads—Metric series*

ISO 3408-3:2006 *Ball screws—Part 3: Acceptance conditions and acceptance tests* (overall evaluation: MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 1501 *Rolling bearings—Balls*

JIS B 7726 *Rockwell hardness test—Verification and calibration of testing machines*

JIS G 4051 *Carbon steels for machine structural use*

JIS K 2001 *Industrial liquid lubricants—ISO viscosity classification*

JIS Z 2245 *Rockwell hardness test—Test method*

JIS Z 8703 *Standard atmospheric conditions for testing*

3 Terms and definitions

For the purposes of this Standard, the following terms and definitions apply.

3.1 Terms and definitions for elements of ball screws

3.1.1 ball screw

3.1.1.1 ball screw

machine part in which the ball screw shaft and the ball nut actuate via balls, which is capable of converting the rotary motion to the linear motion and vice versa

3.1.1.2 positioning ball screw, type P

ball screw used for precision positioning which enables the indirect measurement of travel in axial direction from the angle of rotation and the lead, without backlash (preloaded)

NOTE : For the positioning ball screws, there are two types of C-series and Cp-series.

3.1.1.3 transport ball screw, type T

ball screw the travel of which can be measured by a separate measuring system independent of the angle of rotation and lead of the ball screw

NOTE : Usually Grade 7 and Grade 10 are used, but for special applications where high performance (smooth running) in torque variation is required, Grade 0 to Grade 5 may also be used.

3.1.1.4 single-start ball screw

ball screw in which the lead is equal to the pitch

3.1.1.5 multiple-start ball screw

ball screw in which the lead is an integer multiple of the pitch

3.1.2 ball screw shaft

cylindrical shaft on which one (or more) helical tracks are cut

3.1.3 ball nut

3.1.3.1 ball nut

ball nut body assembled with the ball recirculation system, end seals, and ball nut accessories

3.1.3.2 ball nut body

ball nut without ball recirculation system, end seals and ball nut accessories

3.1.3.3 ball recirculation system

mechanism for recirculation of balls

3.1.3.4 end seals

elements attached to the ball nut body such that foreign objects are inhibited from entering the ball nut and/or partial retention of the lubricant is provided

3.1.4 ball

3.1.4.1 load ball

ball which carries the load

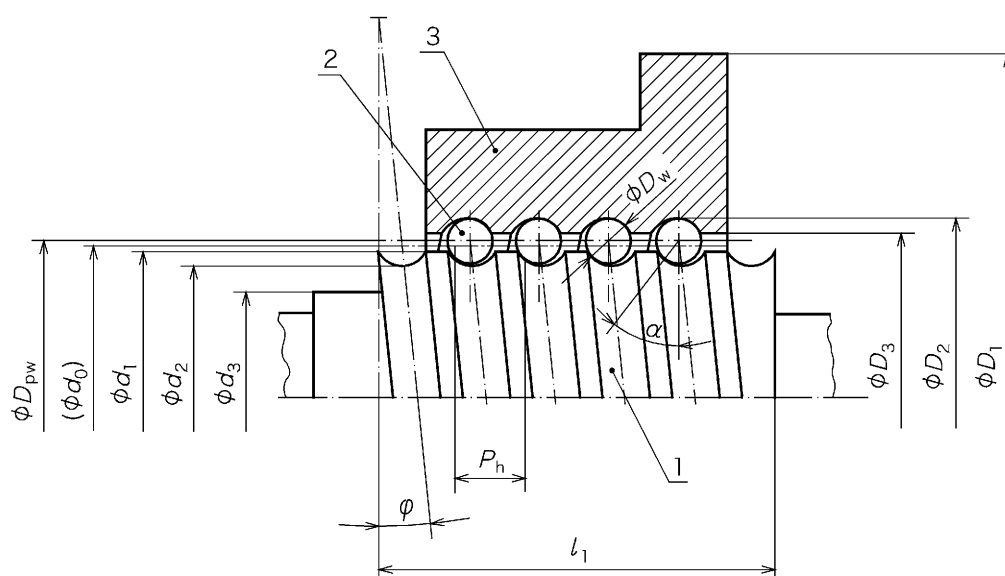
3.1.4.2 spacer ball

ball smaller than load ball, which does not carry the load but prevents the interference between load balls

3.2 Geometrical terms and definitions

3.2.1 Geometrical symbols relating to ball screw dimensions

Geometrical symbols relating to dimensions of ball screw shall be as given in figure 1.



- 1 : ball screw shaft
- 2 : ball
- 3 : ball nut
- d_0 : nominal diameter
- d_1 : ball screw shaft outer diameter
- d_2 : ball screw shaft root diameter
- d_3 : journal diameter
- D_1 : ball nut outer diameter
- D_2 : ball nut root diameter
- D_3 : ball nut internal diameter
- D_{pw} : pitch circle diameter
- D_w : ball diameter
- l_1 : thread length
- P_h : lead
- α : contact angle
- φ : lead angle

Figure 1 Geometrical symbols relating to dimensions of ball screw

3.2.2 Terms and definitions for ball screws

3.2.2.1 nominal diameter, d_0

ball screw shaft outer diameter of ball screw shaft without tolerance expressing the size of ball screw

In some cases, this is also expressed by the pitch circle diameter without tolerance.

3.2.2.2 pitch circle diameter, D_{pw}

diameter of cylinder containing the centres of balls which are in contact with the ball screw shaft and the ball nut body at the theoretical contact points (see figure 1 and figure 2)

3.2.2.3 ball track

space in which the ball screw shaft and the ball nut confront each other and the balls roll

The surface of ball track is called the ball track surface (see figure 2).

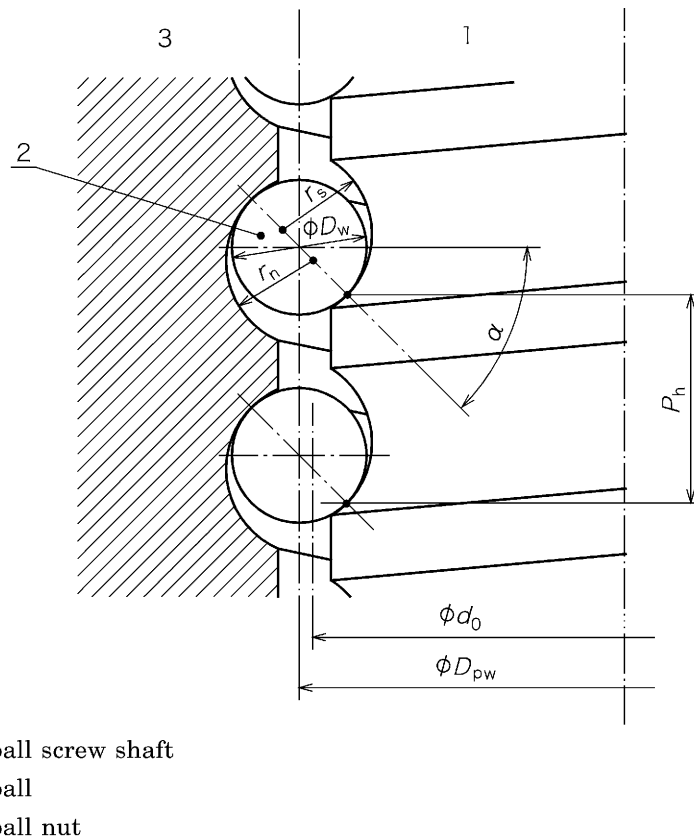


Figure 2 Ball track

3.2.2.4 grooves

3.2.2.4.1 gothic groove, ogival groove

groove whose normal cross-section is in the form of gothic arch

3.2.2.4.2 round groove

groove whose normal cross-section is in the form of arc of a circle

3.2.2.5 conformity, f_{rs}, f_{rn}

ratio of the groove radius of ball screw shaft r_s or of the groove radius of ball nut body r_n to the ball diameter D_w (see figure 2)

$$f_{rs} = r_s/D_w \quad \text{or} \quad f_{rn} = r_n/D_w$$

where, subscript s : ball screw shaft

subscript n : ball nut

3.2.2.6 contact angle, α

angle between a line perpendicular to axis which is passing through the centre of ball and the line connecting the centre of ball and the contact point (see figure 2)

3.2.2.7 backlash, axial play, s_a

free axial displacement between the ball nut body and the ball screw shaft when there is no rotation between two components

3.2.2.8 radial play, s_r

free radial displacement between the ball nut body and the ball screw shaft when there is no rotation between two components

3.2.2.9 travel, l

travel in axial direction when rotated arbitrary number of revolutions according to the lead

3.2.2.9.1 nominal lead, P_{h0}

lead without tolerance used to indicate the size of ball screw

3.2.2.9.2 specified lead, P_{hs}

lead given some amount of correction to the nominal lead in order to compensate the deformation generated due to the temperature rise or the load

In the case of transport ball screws, in general, it is same as the nominal lead.

3.2.2.9.3 lead, P_h

relative travel in axial direction between the actual ball screw shaft and the ball nut in respect to the revolution of 2π rad (or one revolution)

3.2.2.9.4 nominal travel, l_0

travel in axial direction when rotated arbitrary number of revolutions according to the nominal lead [① in figure 3 a)]

3.2.2.9.5 specified travel, l_s

travel in axial direction when rotated arbitrary number of revolutions according to the specified lead [② in figure 3 a)]

3.2.2.9.6 actual travel, l_a

actual travel of ball nut in axial direction in respect to an arbitrary angle of rotation of ball screw shaft, which is obtained in accordance with **8.2 b)** [③ in figure 3 a)]

3.2.2.9.7 actual mean travel, l_m

straight line which represents the tendency of actual travel

It is obtained by the least square method or a simple and appropriate approximation method from the curve indicating the valid travel of ball nut (actual travel in respect to the useful travel of ball screw shaft [④ in figure 3 a)]).

NOTE : The method to obtain the actual mean travel line by the approximation method is shown in figure 3 b). Draw one or several tangents passing through at least two upper side apexes of the actual travel curve [② ③ of figure 3 b)], and carry out this measure also for the lower side apexes [④ of figure 3 b)]. Next, draw straight lines including all of the actual travel curves in parallel to respective tangents [②' ③' ④' of figure 3 b)], determine the respective variation widths in parallel to the ordinate [⑤ ⑥ ⑦ of figure 3 b)], and after that of the smallest is determined [⑧ of figure 3 b)], draw a parallel straight line at equal distance from the determined two parallel straight lines of upper side and lower side [⑨ of figure 3 b)], and take this as the actual mean travel line.

3.2.2.9.8 useful travel, l_u

thread length of ball screw shaft which specifies the tolerance on travel of the ball screw in axial direction [⑩ in figure 3 a)]

3.2.2.10 travel compensation and tolerance on specified travel

3.2.2.10.1 travel compensation, c

difference between the specified travel and the nominal travel within the valid travel [⑪ in figure 3 a)]

3.2.2.10.2 tolerance on specified travel, e_p

difference between the actual mean travel and the specified travel corresponding to the valid travel of ball nut or the useful travel of ball screw shaft [⑫ in figure 3 a)]

3.2.2.11 travel variation, v

maximum width of the actual travel curve between the two straight lines put in parallel to the actual mean travel line

The following three items shall be specified.

- v_u : that corresponding to valid travel of ball nut or useful travel of ball screw shaft [⑬ in figure 3 a)]
- v_{300} : that corresponding to arbitrary 300 mm taken within useful travel of ball screw shaft [⑭ in figure 3 a)]
- $v_{2\pi}$: that corresponding to arbitrary one revolution (2π rad) within useful travel of ball screw shaft [⑮ in figure 3 a)]

3.3 Terms and definitions of life, load, speed, etc.

3.3.1 life, L

for individual ball screw, number of revolutions of ball screw shaft against the ball nut body before the first evidence of fatigue develops on the ball screw shaft, or either of the grooves or the rolling elements of the ball nut body

3.3.2 basic rating life, L_{10}

life achieving to 3.3.1 with a 90 % probability for individual ball screw or group of identical ball screws operating under the same conditions

3.3.3 basic dynamic axial load rating, C_a

constant centric axial load that a ball screw can theoretically endure for the basic rating life of one million revolutions

3.3.4 basic static axial load rating, C_{0a}

static centric axial load that the total permanent deformation of ball and ball track at contact point of the largest load between the ball and the ball track corresponds to 0.000 1 times the ball diameter

3.3.5 preload, F_{pr}

force acting on the ball screw inside by assembling a group of over size balls or using a pair of ball nuts being displaced in axial direction to each other, in order to attempt the decrease of backlash or the increase of rigidity of the ball screw

NOTE : The ball nut subjected to the above is called the preloaded ball nut.

3.3.6 dynamic drag torque, T_p

dynamic torque required to rotate the ball nut relative to the ball screw shaft, or vice versa in the absence of an external load and the end seals on the preloaded ball screw

3.3.7 total dynamic drag torque, T_t

dynamic torque required to rotate the ball nut relative to the ball screw shaft, or vice versa in the absence of an external load but with the end seals on the preloaded ball screw

3.3.8 basic torque, T_{p0}

dynamic drag torque established as the target [① in figure 4]

3.3.9 fluctuation value of basic torque, ΔT_{p0}

fluctuation value of dynamic drag torque established as the target

Positive and negative in respect to the basic torque may be taken [② in figure 4]

3.3.10 fluctuation rate of basic torque

rate of basic torque T_{p0} to the fluctuation value of basic torque ΔT_{p0}

3.3.11 actual torque curve

dynamic torque curve measured and recorded on the actual preloaded ball screws [③ in figure 4]

3.3.12 mean actual torque, T_{pa}

arithmetic mean value of the maximum value and the minimum value of the actual torque curve except the starting torque, when measured allowing the ball nut to behave reciprocating motion on the useful travel [④ in figure 4]

3.3.13 fluctuation value of actual torque, ΔT_{pa}

maximum fluctuation value of actual torque curve except the starting torque, when measured allowing the ball nut to behave reciprocating motion on the useful travel

Positive and negative may be taken in respect to the mean actual torque [⑤ in figure 4]

3.3.14 fluctuation rate of actual torque

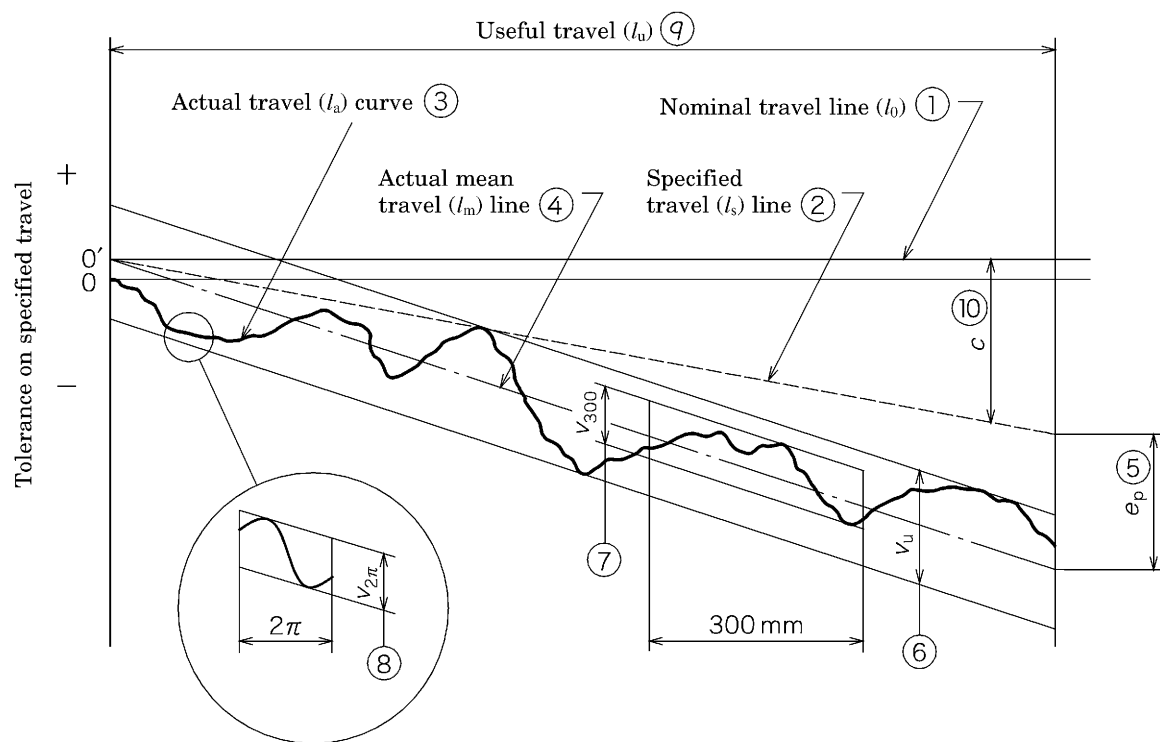
rate of fluctuation value of actual torque ΔT_{pa} to the mean actual torque T_{pa}

3.3.15 axial rigidity, stiffness, spring rate, R

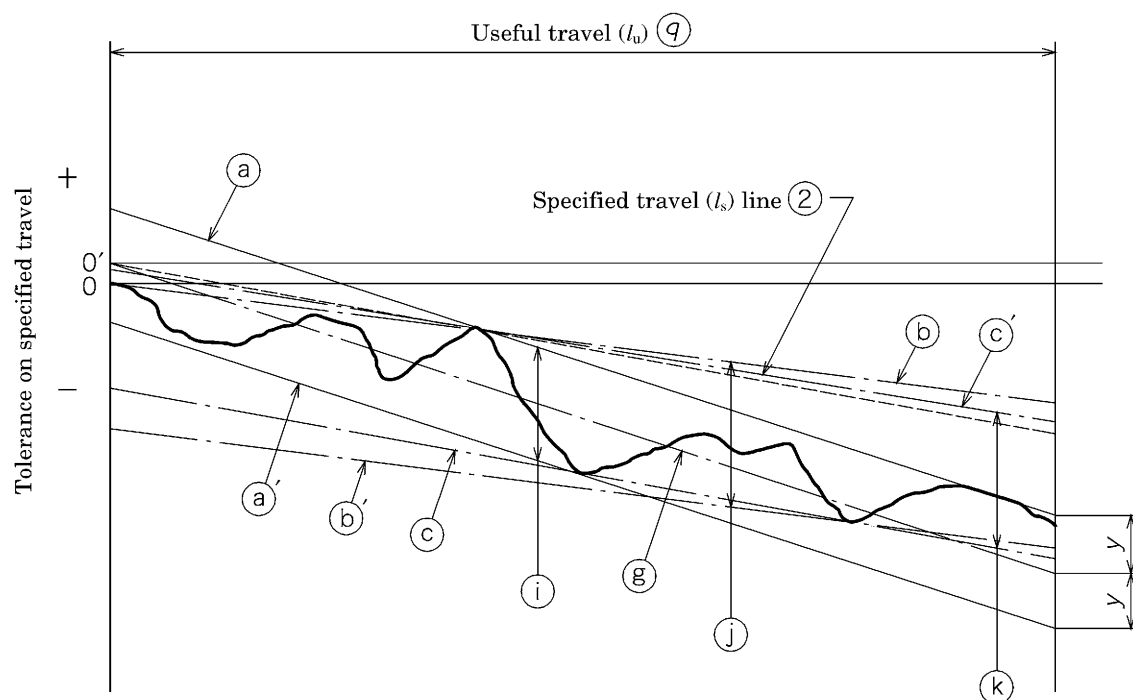
load per unit of deflection to the deflection in axial direction

3.3.16 critical speed, n_{cr}

rotational speed of the ball nut or the ball screw shaft that produces resonant vibrations of the ball screw



a) Travel



b) Actual mean travel

Figure 3 Diagram for explanation of definitions of terms (I)

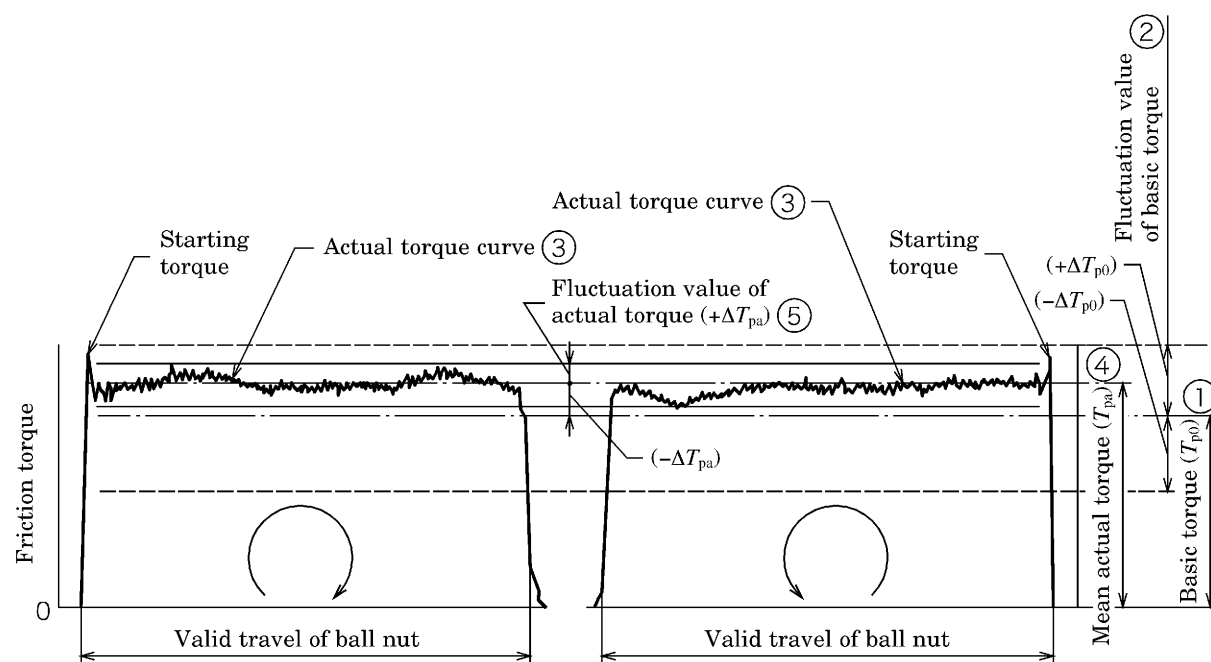


Figure 4 Diagram for explanation of definitions of terms (II)

4 Types and grades

The types of the ball screws shall be C-series and Cp-series for positioning, and Ct-series for transport. The types and grades shall be as given in table 1.

Table 1 Types and grades

Type	Symbol of series	Grade
For positioning	C	0, 1, 3, 5
	Cp	0, 1, 3, 5
For transport	Ct	0, 1, 3, 5, 7, 10

5 Combination of nominal diameter and nominal lead

The combination of nominal diameter and nominal lead of ball screws shall be as given in table 2.

The boldfaced numerical values are the combinations recommended.