INTERNATIONAL STANDARD

ISO 3408-3

Second edition
2006-06-15

Ball screws —

Part 3: Acceptance conditions and acceptance tests

Vis à billes —

Partie 3: Conditions et essais de réception

Reference number
ISO 3408-3:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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.

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 3408-3 was prepared by Technical Committee ISO/TC 39, *Machine tools*.

This second edition cancels and replaces the first edition (ISO 3408-3:1992), which has been technically revised.

ISO 3408 consists of the following parts, under the general title *Ball screws*:

— *Part 1: Vocabulary and designation*

— *Part 2: Nominal diameters and nominal leads — Metric series*

— *Part 3: Acceptance conditions and acceptance tests*

— *Part 4: Static axial rigidity*

— *Part 5: Static and dynamic axial load ratings and operational lifetime*

Ball screws —

Part 3:
Acceptance conditions and acceptance tests

1 Scope

This part of ISO 3408 specifies the technical acceptance conditions for ball screws (see Figure 1) and, in particular, the respective permissible deviations for the acceptance tests.

NOTE The actual design need not necessarily correspond to that shown in Figure 1.

The respective tests required will be agreed upon between the manufacturer and user.

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 230-1:1996, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions*

ISO 286-2:1988, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*

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

3 Terms and definitions

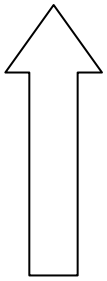
For the purposes of this document, the terms and definitions given in ISO 3408-1 apply.

4 Test conditions and permissible deviations

4.1 Classification

The tests are graded in six standard tolerance grades (see Table 1) in conformance with ISO 286-2:1988, Table 1.

Table 1 — Standard tolerance grades

Standard tolerance grade 0 Standard tolerance grade 1 Standard tolerance grade 3 Standard tolerance grade 5 Standard tolerance grade 7 Standard tolerance grade 10		Increasing requirements on accuracy and function

4.2 Geometrical tests

4.2.1 Tolerances

Tolerances on specified travel, e_p, for the useful travel, l_u (tests E 1.1 and E 1.2), are taken directly from ISO 286-2:1988, Table 1. Values of e_p for useful travel, l_u, of greater than or equal to 3 150 mm were calculated be linear extrapolation (see Table A.1).

Tolerances on travel variation, v_{up}, in micrometres, within useful travel l_u were evaluated using the following equations:

— Grade 0: $v_{up} = 0{,}0035 \cdot \bar{l}_u + 2{,}4$

— Grade 1: $v_{up} = 0{,}0045 \cdot \bar{l}_u + 4{,}6$

— Grade 3: $v_{up} = 0{,}009 \cdot \bar{l}_u + 9{,}2$

— Grade 5: $v_{up} = 0{,}018 \cdot \bar{l}_u + 18{,}4$

where $\bar{l}_u$ is the geometrical mean, in millimetres, of the extreme lengths of each step of measured travel given in Table A.1:

$$\bar{l}_u = \sqrt{l_{u\,max} \cdot l_{u\,min}}$$

Run-out tolerance and orientation tolerances were determined from experience.

4.2.2 Evaluation of the measuring diagrams

4.2.2.1 General

To evaluate the actual mean travel deviation within the useful travel, either a mathematical method — precise by its nature — or a graphical method — simple and quick and recommended as an approximation method suitable for everyday evaluation — may be used.

NOTE The travel variation, v_{ua}, resulting from the mathematical method may not be the minimum travel variation.

The graphical method gives the minimum travel variation.

4.2.2.2 Mathematical (least square) method

The actual mean travel deviation, e_a, is given by the formula

$$e_a = a + b_\gamma$$

with

$$a = \frac{\sum \gamma_i^2 \cdot \sum e_i - \sum \gamma_i \cdot \sum \gamma_i \cdot e_i}{n \cdot \sum \gamma_i^2 - \sum \gamma_i \cdot \sum \gamma_i}$$

and

$$b = \frac{n \cdot \sum \gamma_i \cdot e_i - \sum \gamma_i \cdot \sum e_i}{n \cdot \sum \gamma_i^2 - \sum \gamma_i \cdot \sum \gamma_i}$$

where

e_a is the actual mean travel deviation in relation to the specified or nominal travel, as appropriate;

γ is the angle of rotation (specified or nominal travel, as appropriate);

γ_i is the angle of rotation (specified or nominal travel, as appropriate) corresponding to the ith measuring point;

e_i is the travel deviation (or travel) in relation to the specified or nominal travel for the angel of rotation (or travel) corresponding to the i^{th} measuring point;

n is the number of measuring points.

4.2.2.3 Graphical method [see Figure 3 a) and b)]

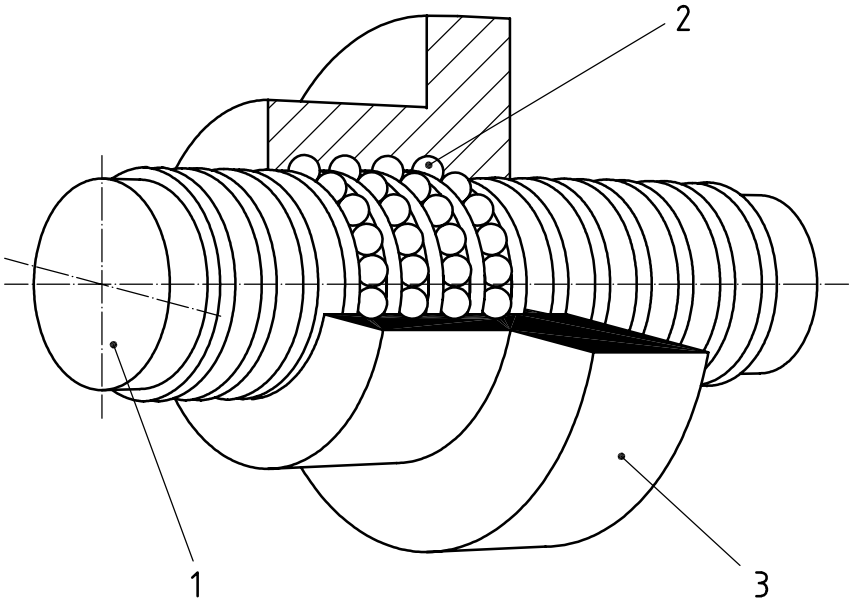
The evaluation of the actual mean travel deviation from the travel deviation diagram is carried out as follows:

a) draw the tangents to the actual travel deviation curve at two ore more upper peaks (l_1, l_2, ...) and repeat this procedure for the lower peaks (l_3, ...);

b) determine the largest respective deviations (e_1, e_2, e_3, ...) parallel to the ordinate, and select from these the smallest deviation (e_2 in the example);

c) draw a straight line through this point of minimum deviation that is parallel to the corresponding peak line (l'_2 parallel to l_2 in the example).

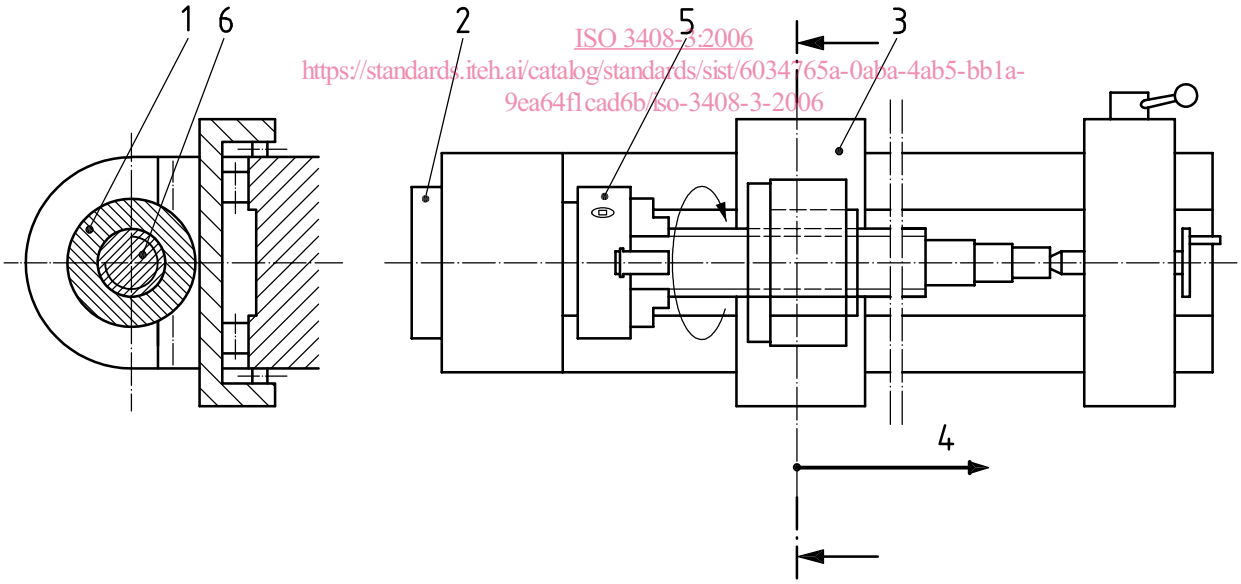
The actual mean travel deviation, e_a, is the centreline between these parallel lines (l_2 and l'_2). The bandwidth within the useful travel, v_{ua}, is the distance between these parallel lines, e_2, measured parallel to the ordinate.



Key

1 ball screw shaft
2 ball
3 ball nut

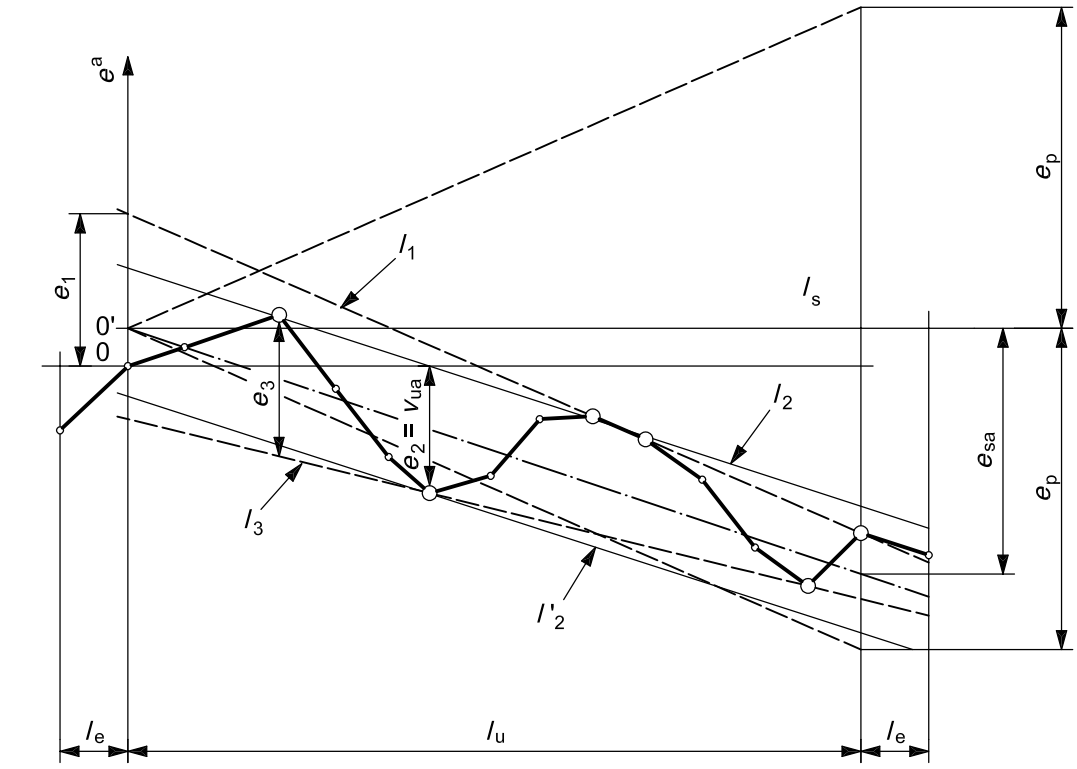
Figure 1 — Ball screw



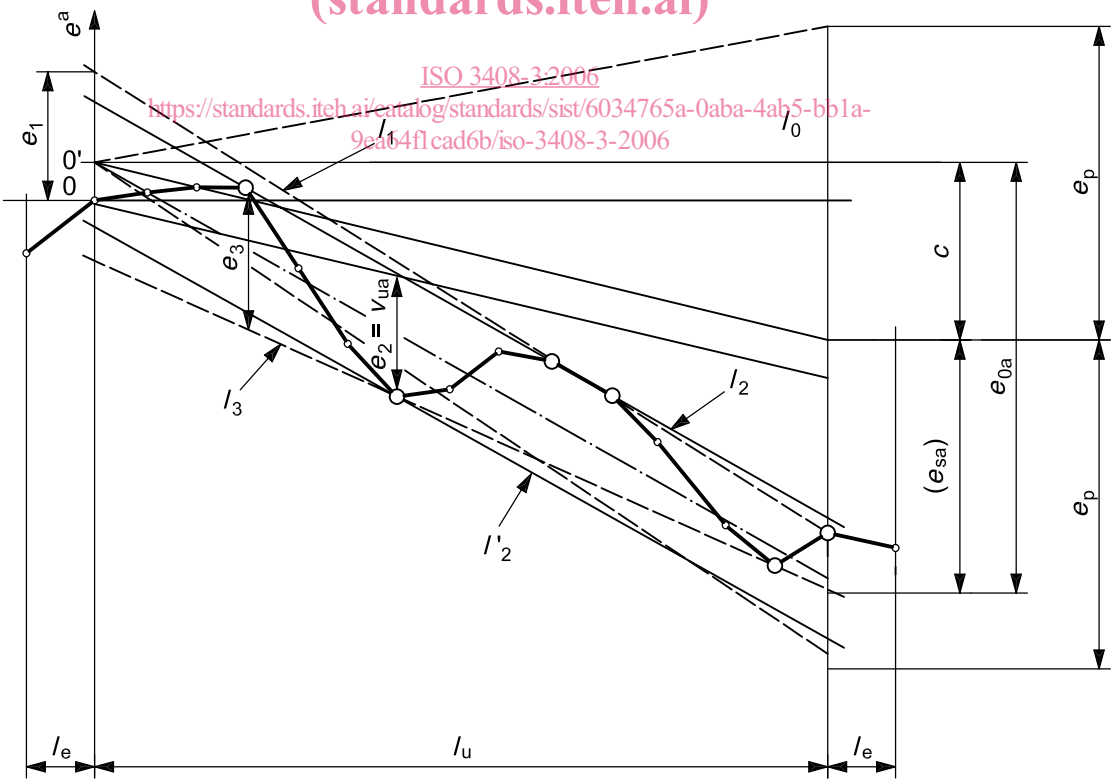
Key

1 ball nut
2 angular measuring instrument (permissible error = 10”)
3 measuring slide
4 travel measuring instrument (permissible error = 1 µm)
5 clamping device (e.g. chuck), drive
6 ball screw shaft

Figure 2 — Basic measuring principle



a) **Deviation e_{sa} related to specified travel l_s**



b) **Deviation e_{0a} related to nominal travel l_0**

NOTE For the excess travel, see Table A.3.

[a] Travel deviation.

Figure 3 — Determination of the actual mean travel deviation, e_{sa} or e_{0a}

5 Acceptance tests

5.1 General

The typical tolerance grades for positioning and transport ball screws are given in Table 2.

Table 2 — Typical tolerance grades for positioning and transport ball screws

Type of ball screw	Standard tolerance grade
Positioning	0 – 1 – 3 – 5
Transport	0 – 1 – 3 – 5 – 7 – 10

The test according to Table 3 shall apply, depending on the type of ball screw considered [positioning (type P) or transport (type T) ball screw].

The basic measuring principle is illustrated in Figure 2.

Table 3 — Travel deviation tests

Travel deviations per reference length	Type of ball screw	
	Positioning	Transport
	Test	
Travel compensation c for useful travel l_u	Specified by user	C = 0
Tolerance on specified travel e_p	E 1.1	E 1.2
Permissible travel variation v_{up} within useful travel	E 2	—
Permissible travel variation v_{300p} within 300 mm travel	E 3	E 3
Permissible travel variation $v_{2\pi p}$ within 2π rad	E 4	—

Tests and tolerances to the ball nut displacement are relative to the ball screw shaft.

A pitch-to-pitch measurement may be carried out using a measuring ball by touching the ball track of a non-rotating ball screw shaft. For the measuring intervals, see Table A.2.

The travel variation $v_{2\pi}$ within 2π rad is determined over nine measurements ($8 \times 45°$) per revolution, or continuously within one thread (at the start, in the middle and at the end of useful travel), provided that this has been the subject of special agreement.

5.2 Travel deviation and variation

Object: Positioning ball screw **E 1.1**

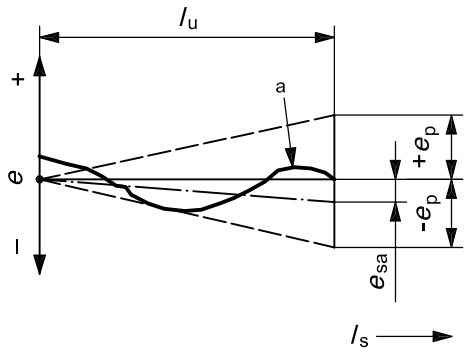
Checking of the mean travel deviations, e_{sa} and e_{0a}, within the useful travel, l_u:

a) for the specified travel, l_s;

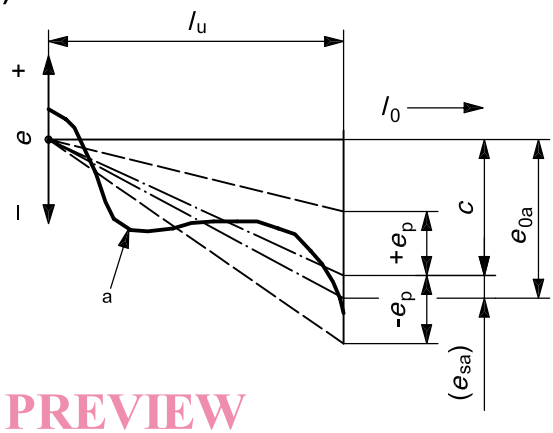
b) for the nominal travel, l_0.

Diagram

a)



b)



[a] Actual travel deviation.

Permissible deviations

Useful travel l_u mm		Tolerance on specified travel e_p µm					
		Standard tolerance grade					
>	⩽	0	1	3	5	7	10
0	315	4	6	12	23	—	—
315	400	5	7	13	25	—	—
400	500	6	8	15	27	—	—
500	630	6	9	16	32	—	—
630	800	7	10	18	36	—	—
800	1 000	8	11	21	40	—	—
1 000	1 250	9	13	24	47	—	—
1 250	1 600	11	15	29	55	—	—
1 600	2 000	—	18	35	65	—	—
2 000	2 500	—	22	41	78	—	—
2 500	3 150	—	26	50	96	—	—
3 150	4 000	—	32	62	115	—	—
4 000	5 000	—	—	76	140	—	—
5 000	6 300	—	—	—	170	—	—

Observations and remarks

a)

e_{sa} = _____ µm

b)

The travel compensation c shall be specified by the user

c = _____

e_{0a} = _____ µm

Measuring instruments

See Figure 2.

Test instructions

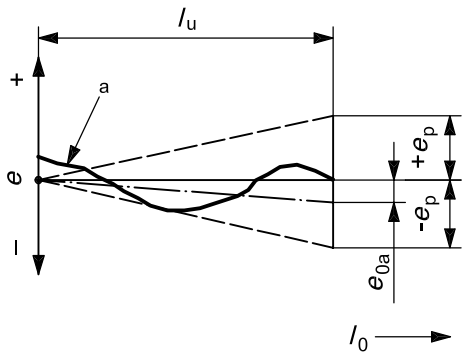
See Figure 2.

Object: Transport ball screw

E 1.2

Checking of the mean travel deviation e_{0a}, within the useful travel, l_u:

Diagram



a Actual travel deviation.

Permissible deviations

Tolerance on specified travel e_p µm						
Standard tolerance grade						
0	1	3	5	7	10	
$e_p = \pm \frac{l_u}{300} \cdot v_{300p}$						

Observations and remarks

e_{0a} = _____ µm

Measuring instruments

See Figure 2.

Test instructions

See Figure 2.