INTERNATIONAL
STANDARD

ISO
3408-3

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Ball screws —

Part 3 :
Acceptance conditions and acceptance tests

Vis à billes —
Partie 3 : Conditions et essais de réception

Reference number
ISO 3408-3 : 1992 (E)

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.

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.

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

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: Ball screw axial rigidity*
- *Part 5: Distribution of static and dynamic loads and operational life*

Annex A forms an integral part of this part of ISO 3408.

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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 shall be agreed upon between the manufacturer and the user.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 2308. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3408 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 230-1 : 1986, *Acceptance 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 : 1991, *Ball screws — Part 1: Vocabulary and designation.*

3 Definitions

For the purposes of this part of ISO 3408, the definitions given in ISO 3408-1 apply.

4 Test conditions and permissible deviations

4.1 Classification

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

Table 1 — Standard tolerance grades

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

4.2 Geometrical tests

4.2.1 Tolerances

Tolerances on specified travel, e_p, for the useful travel, l_u (tests E1.1 and E1.2), 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 by linear extrapolation (see table A.1).

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

- Grade 1: $v_{up} = 0{,}004\,5\,\bar{l}_u + 4{,}6$
- Grade 3: $v_{up} = 0{,}009\,\bar{l}_u + 9{,}2$
- Grade 5: $v_{up} = 0{,}018\,\bar{l}_u + 18{,}4$

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:

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

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

4.2.2 Travel deviations

Depending on the type of ball screw considered [positioning (type P) or transport (type T) ball screw], the tests given in table 2 shall apply.

The basic measuring principle is illustrated in figure 2.

Table 2 — Travel deviation tests

Travel deviations per reference length	Type of ball screw P	Type of ball screw T
	Test	
Travel compensation c for useful travel l_u	Specified by user	$c = 0$
Tolerance on specified travel e_p	E1.1	E1.2
Permissible travel variation v_{up} within useful travel	E2	—
Permissible travel variation v_{300p} within 300 mm travel	E3	E3
Permissible travel variation $v_{2\pi p}$ within 2π rad	E4	—

Tests and tolerances refer to the ball nut body displacement 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 × 45°) per revolution or continuously within one thread (at the start, in the middle and at the end of useful travel), provided that this test has been the subject of a special agreement.

4.2.3 Evaluation of the measuring diagrams

To evaluate the actual mean travel deviation within the useful travel, one may use either a mathematical method, which is precise by its very nature, or a graphical method, which is simple and quick and is recommended as an approximation method suitable for everyday evaluations.

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.

4.2.3.1 Mathematical (least square) method

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

$$e_a = a + b\gamma$$

with

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

and

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

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 *i*th measuring point;

e_i is the travel deviation (or travel) in relation to the specified or nominal travel for the angle of rotation (or travel) corresponding to the *i*th measuring point;

n is the number of measuring points.

4.2.3.2 Graphical method [see figures 3a) and 3b)]

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 or 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 band width within the useful travel, v_{ua}, is the distance between these parallel lines, e_2, measured parallel to the ordinate.

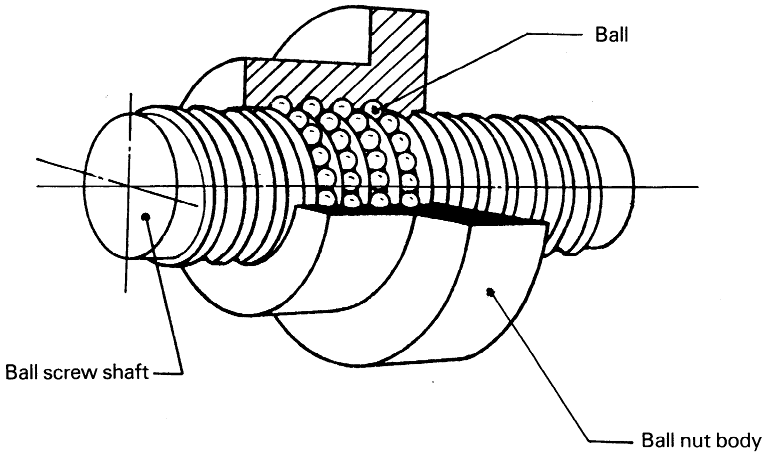


Figure 1 — Ball screw

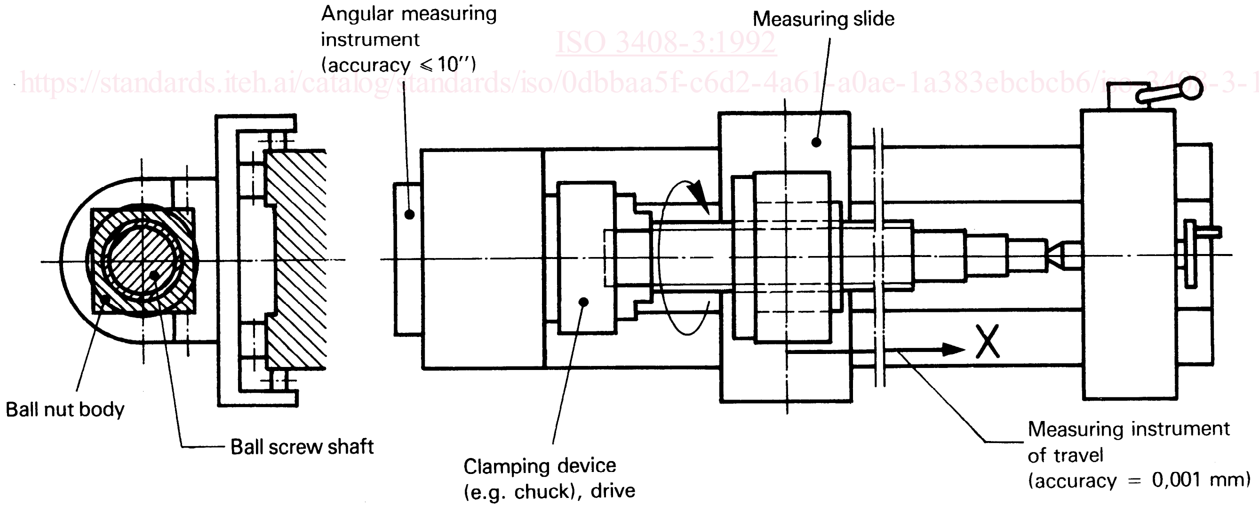
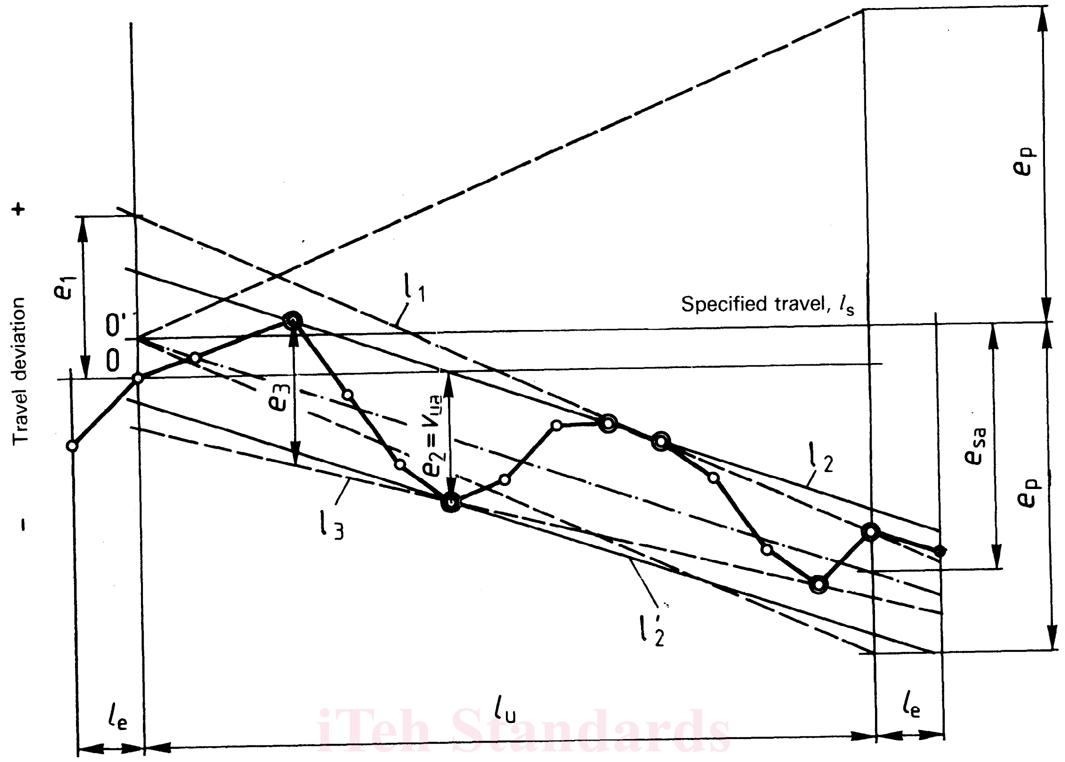
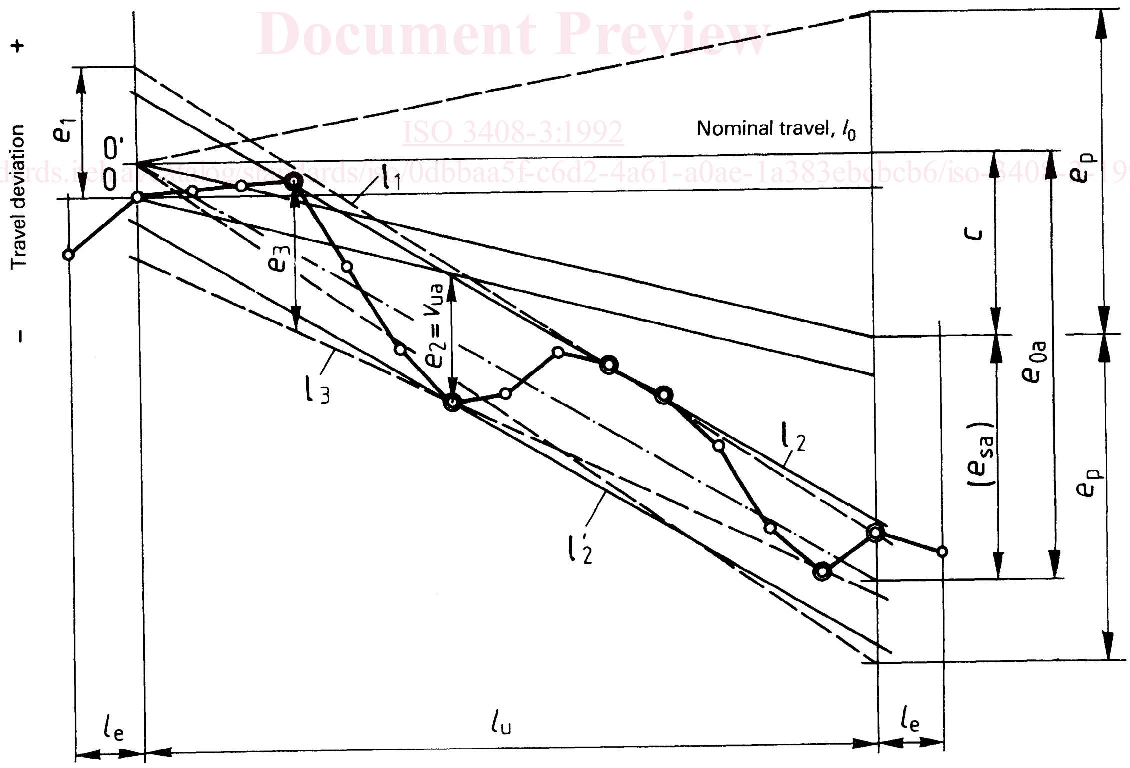


Figure 2 — Basic measuring principle



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



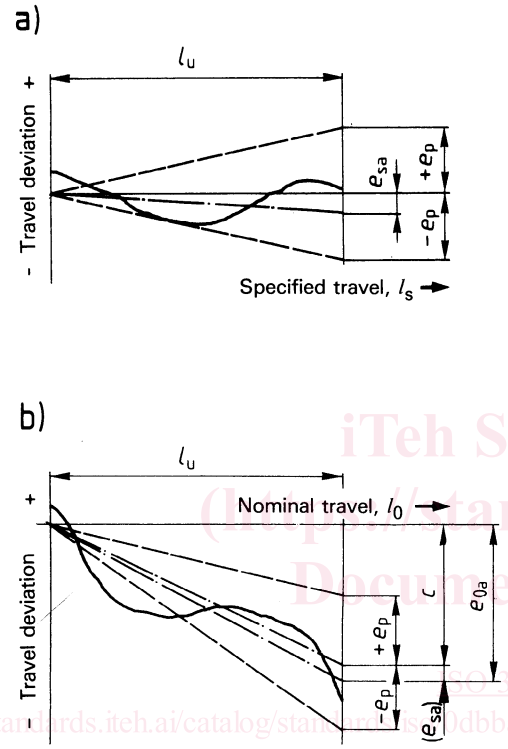
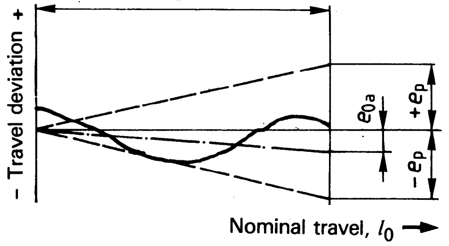
b) **Deviation, e_{0a}, related to the nominal travel, l_0**

NOTE — For the excess travel, see table A.3.

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

5 Acceptance tests

5.1 Travel deviation and variation

Test	Diagram	Object	Measuring instruments
E1.1		Checking of mean travel deviation, *e*, for useful travel, l_u a) for the specified travel, l_s b) for the nominal travel, l_0	See figure 2
E1.2		Checking of mean travel deviation, *e*, for useful travel, l_u	See figure 2

<table>
<tr><th></th><th>Test instruction</th><th>Permissible deviations</th><th>Observations and remarks</th></tr>
<tr><td></td><td>See figure 2</td><td>

Positioning ball screws

<table>
<tr><th colspan="2">l_u
mm</th><th colspan="5">Standard tolerance grade</th></tr>
<tr><th rowspan="2">above</th><th rowspan="2">up to and including</th><th>1</th><th>3</th><th>5</th><th>7</th><th>10</th></tr>
<tr><th colspan="5">e_p
µm</th></tr>
<tr><td></td><td>315</td><td>6</td><td>12</td><td>23</td><td>—</td><td>—</td></tr>
<tr><td>315</td><td>400</td><td>7</td><td>13</td><td>25</td><td>—</td><td>—</td></tr>
<tr><td>400</td><td>500</td><td>8</td><td>15</td><td>27</td><td>—</td><td>—</td></tr>
<tr><td>500</td><td>630</td><td>9</td><td>16</td><td>32</td><td>—</td><td>—</td></tr>
<tr><td>630</td><td>800</td><td>10</td><td>18</td><td>36</td><td>—</td><td>—</td></tr>
<tr><td>800</td><td>1 000</td><td>11</td><td>21</td><td>40</td><td>—</td><td>—</td></tr>
<tr><td>1 000</td><td>1 250</td><td>13</td><td>24</td><td>47</td><td>—</td><td>—</td></tr>
<tr><td>1 250</td><td>1 600</td><td>15</td><td>29</td><td>55</td><td>—</td><td>—</td></tr>
<tr><td>1 600</td><td>2 000</td><td>18</td><td>35</td><td>65</td><td>—</td><td>—</td></tr>
<tr><td>2 000</td><td>2 500</td><td>22</td><td>41</td><td>78</td><td>—</td><td>—</td></tr>
<tr><td>2 500</td><td>3 150</td><td>26</td><td>50</td><td>96</td><td>—</td><td>—</td></tr>
<tr><td>3 150</td><td>4 000</td><td>32</td><td>62</td><td>115</td><td>—</td><td>—</td></tr>
<tr><td>4 000</td><td>5 000</td><td>—</td><td>76</td><td>140</td><td>—</td><td>—</td></tr>
<tr><td>5 000</td><td>6 300</td><td>—</td><td>—</td><td>170</td><td>—</td><td>—</td></tr>
</table>

</td><td>

a)

e_{sa} = ... µm

b)

c shall be specified by user

c = ...

e_{0a} = ... µm

</td></tr>
<tr><td></td><td>See figure 2</td><td>

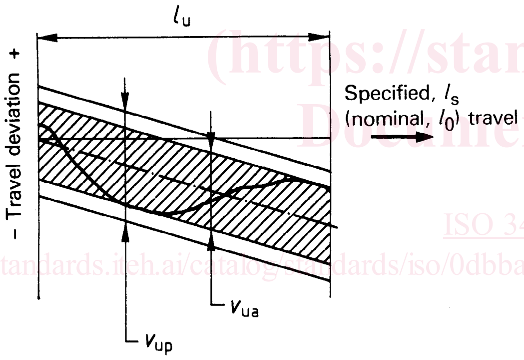
Transport ball screws

<table>
<tr><th colspan="5">Standard tolerance grade</th></tr>
<tr><th>1</th><th>3</th><th>5</th><th>7</th><th>10</th></tr>
<tr><td colspan="5">$c = 0$</td></tr>
<tr><td colspan="5">$e_p = 2 \frac{l_u}{300} v_{300p}$</td></tr>
<tr><td colspan="5">v_{300p}, see test E3</td></tr>
</table>

</td><td>

e_{0a} = ... µm

</td></tr>
</table>

Test	Diagram	Object	Measuring instruments
E2		Checking of travel variation, v_u, within useful travel, l_u	See figure 2