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)

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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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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	Increasing requirements on accuracy and function
Standard tolerance grade 1	
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 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

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

and

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

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)]

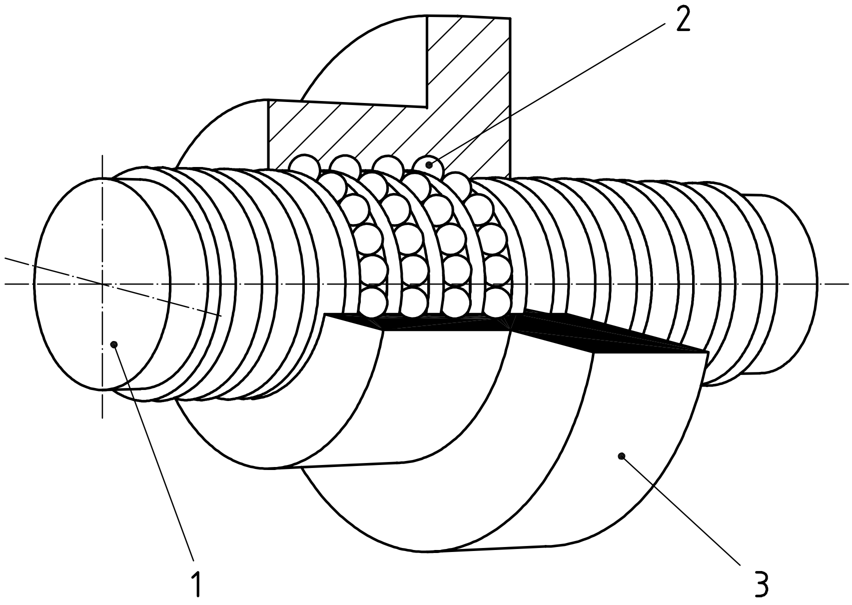
The evaluation of the actual mean travel deviation from the travel deviation diagram is carried out as follows:

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.



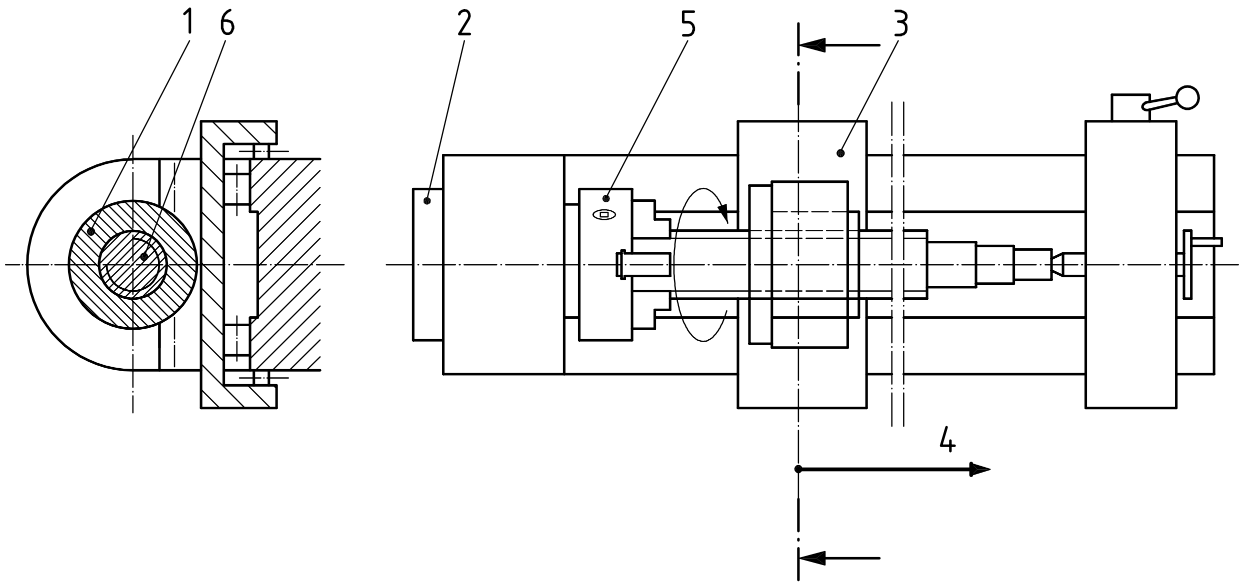
Key

1 ball screw shaft

2 ball

3 ball nut

Figure 1 — Ball screw



Key

1 ball nut

2 angular measuring instrument (permissible error = 10”)

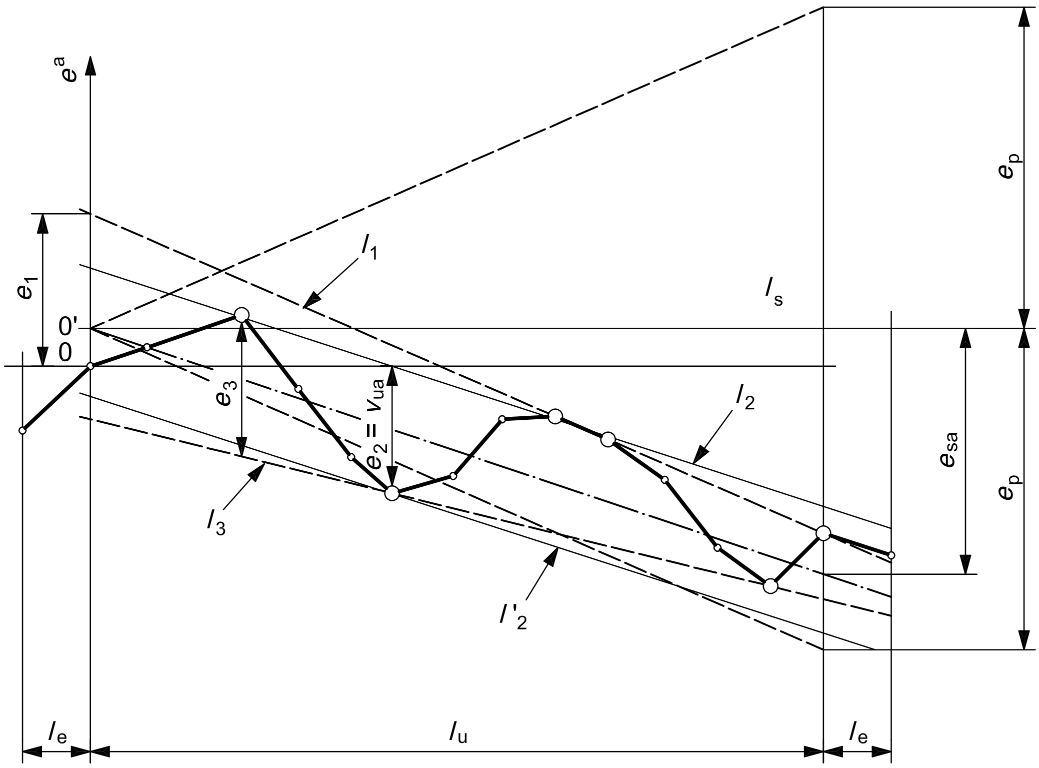
3 measuring slide

4 travel measuring instrument (permissible error = 1 µm)

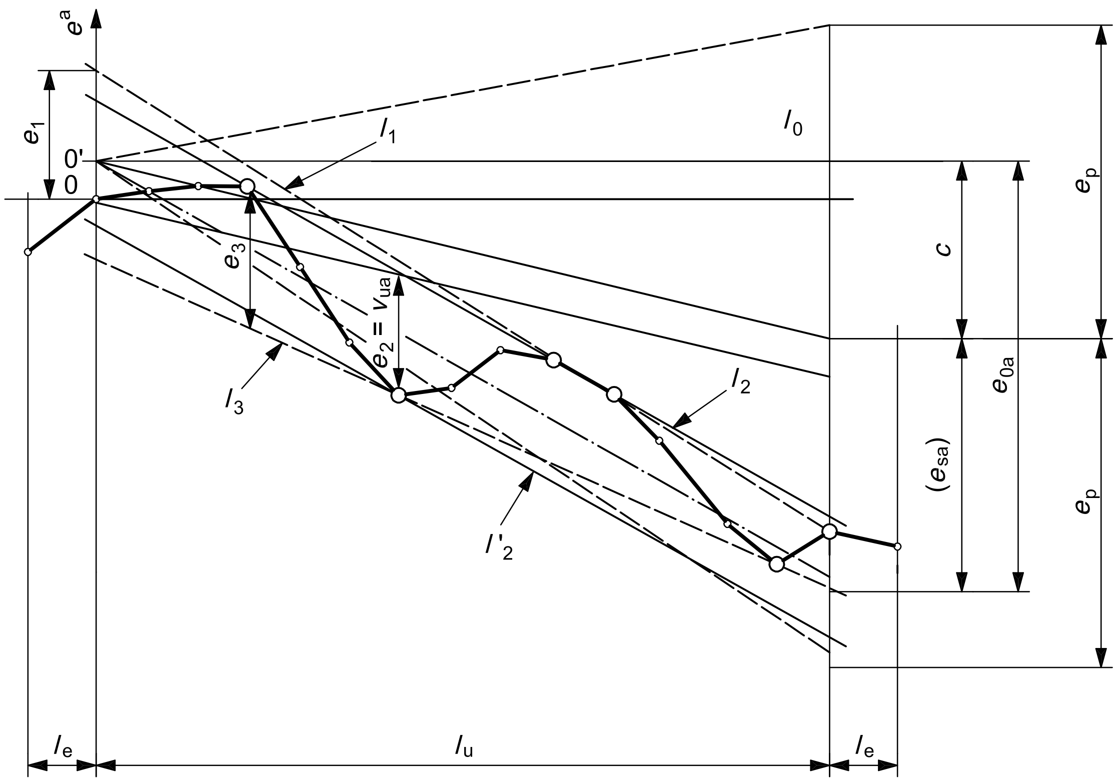
5 clamping device (e.g. chuck), drive

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

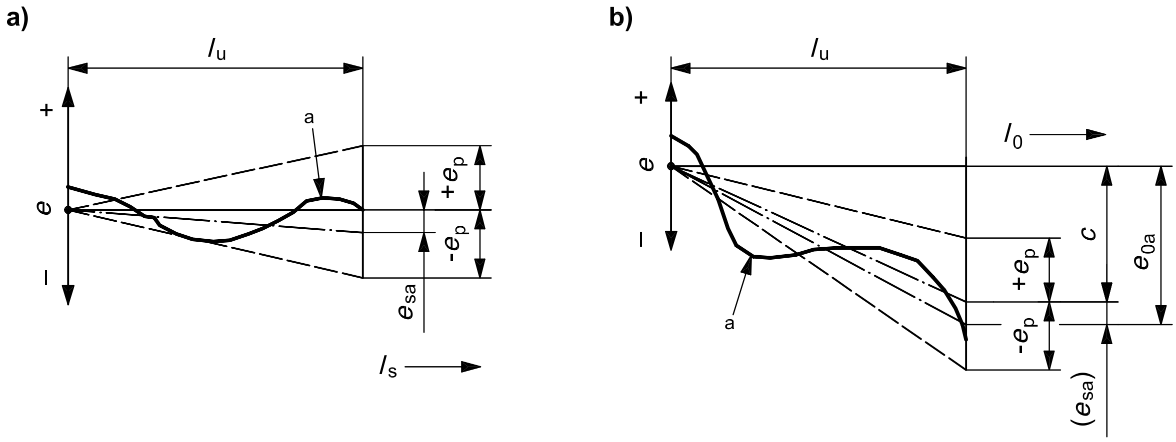
E 1.1

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] 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

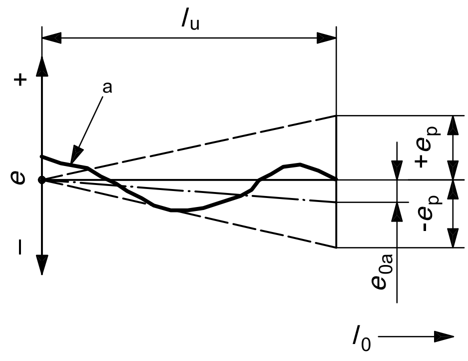
See Figure 2.

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

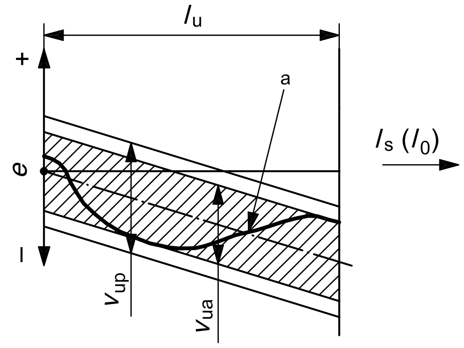
See Figure 2.

Object: Positioning ball screw

E 2

Checking of the travel variation v_u within the useful travel, l_u:

Diagram



[a] Actual travel deviation.

Permissible deviations

Useful travel l_u mm		Travel variation v_{up} µm					
		Standard tolerance grade					
>	⩽	0	1	3	5	7	10
0	315	3,5	6	12	23	—	—
315	400	3,5	6	12	25	—	—
400	500	4	7	13	26	—	—
500	630	4	7	14	29	—	—
630	800	5	8	16	31	—	—
800	1 000	6	9	17	34	—	—
1 000	1 250	6	10	19	39	—	—
1 250	1 600	7	11	22	44	—	—
1 600	2 000	—	13	25	51	—	—
2 000	2 500	—	15	29	59	—	—
2 500	3 150	—	17	34	69	—	—
3 150	4 000	—	21	41	82	—	—
4 000	5 000	—	—	49	99	—	—
5 000	6 300	—	—	—	119	—	—

Observations and remarks

v_{ua} = ________ µm

Measuring instruments

See Figure 2.

Test instructions

See Figure 2.

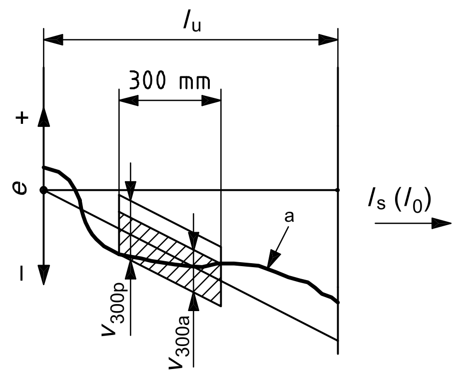
v_{ua} is the smallest distance, measured parallel to the ordinate, between two lines parallel to the mean travel that envelop the actual travel deviation over the useful travel l_u.

Object: Positioning or transport ball screw

E 3

Checking of the travel variation v_{300} within an axial travel of 300 mm:

Diagram



[a] Actual travel deviation.

Permissible deviations

Standard tolerance grade					
0	1	3	5	7	10
v_{300p} µm					
3,5	6	12	23	52[a]	210[a]

[a] Only for transport ball screws.

Observations and remarks

$v_{300a\ max}$ = ________ µm

Measuring instruments

See Figure 2.

Test instructions

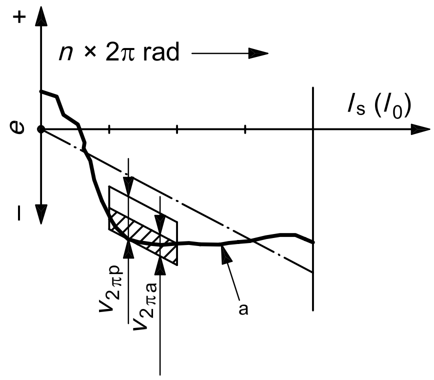
See Figure 2.

v_{300a} is the smallest distance, measured parallel to the ordinate, found when a template is moved along the actual travel deviation and parallel to the mean travel, which contains the actual travel deviation over any 300 mm length along the useful travel.

Object: Positioning ball screw | **E 4**

Checking of the travel variation $v_{2\pi p}$ within 2π rad:

Diagram



[a] Actual travel deviation.

Permissible deviations

Standard tolerance grade					
0	1	3	5	7	10
$v_{2\pi p}$ µm					
3	4	6	8	—	—

Observations and remarks

$v_{2\pi a\ max}$ = ________ µm

Measuring instruments

See Figure 2.

Test instructions

See Figure 2.

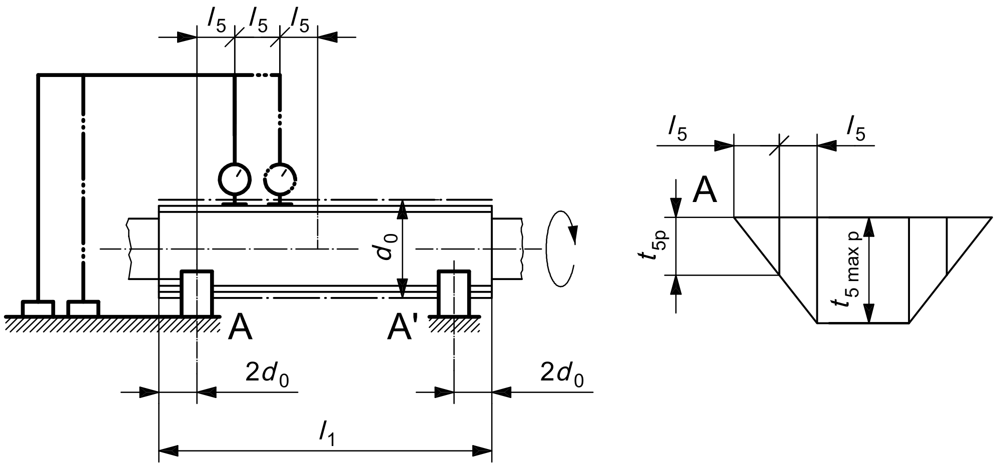
$v_{2\pi a}$ is the smallest distance, measured parallel to the ordinate, found when a template is moved along the actual travel deviation and parallel to the mean travel, which contains the actual travel deviation over any distance corresponding to one revolution, i.e. 2π rad along the useful travel.

5.3 Run-out and location tolerances

Object: Transport or positioning ball screw — **E 5**

Measurement of radial run-out, t_5, of ball screw shaft outer diameter for ascertaining straightness related to AA′ per length l_5:

Diagram



Permissible deviations

Nominal diameter d_0 mm		l_5 mm	Standard tolerance grade					
			0	1	3	5	7	10
>	⩽		l_{5p}, µm, for l_5					
6	12	80						
12	25	160						
25	50	315	16	20	25	32	40	80
50	100	630						
100	200	1 250						
l_1/d_0			$l_{5max\ p}$, µm, for $l_1 > 4l_5$					
>	⩽							
—	40		32	40	50	64	80	160
40	60		48	60	75	96	120	240
60	80		80	100	125	160	200	400
80	100		128	160	200	256	320	640

Observations and remarks

t_{5a} = ________ µm

$t_{5max\ a}$ = _________ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.612.2

Place ball screw in identical V-blocks at points A and A′.

Set dial gauge with measuring shoe at the distance l_5 perpendicular to the cylindrical surface.

Rotate the ball screw slowly while recording the changes in the measurements at specified measuring intervals.

NOTE 1 Optionally, measurement by supporting the ball screw shaft at both centres can be used by agreement.

NOTE 2 If $l_1 < 2l_5$ take the measurement at $l_1/2$.

Object: Positioning or transport ball screw

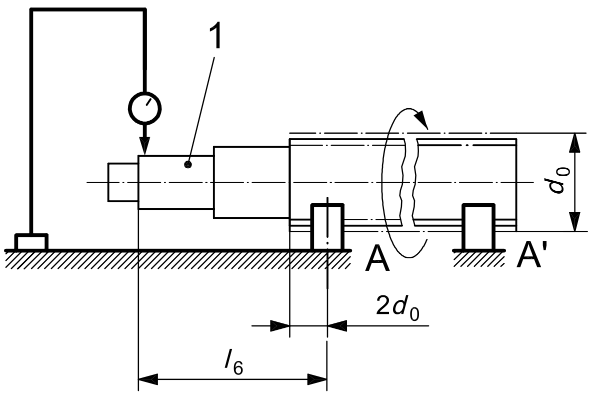
E 6.1

Measurement of redial runout, $t_{6.1}$, of bearing seat related to AA′, per unit length l:

For $l_6 \leqslant l$ (l see table)

For $l_6 > l$ to be valid $t_{6.1a} \leqslant t_{6.1p} \frac{l_6}{l}$

Diagram



Key

1 bearing seat

Permissible deviations

Nominal diameter d_0 mm		l mm	Standard tolerance grade				
			1	3	5	7	10
>	⩽		$t_{6.1p}$, µm, for l				
6	20	80	10	12	20	40	63
20	50	125	12	16	25	50	80
50	125	200	16	20	32	63	100
125	200	315	—	25	40	80	125

Observations and remarks

Diameter	$t_{6.1a}$
______ mm	_____ µm
______ mm	_____ µm
______ mm	_____ µm
______ mm	_____ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.612.2

Place ball screw in identical V-blocks at points A and A′.

Place the dial gauge at the distance l_6 perpendicular to the cylindrical surface.

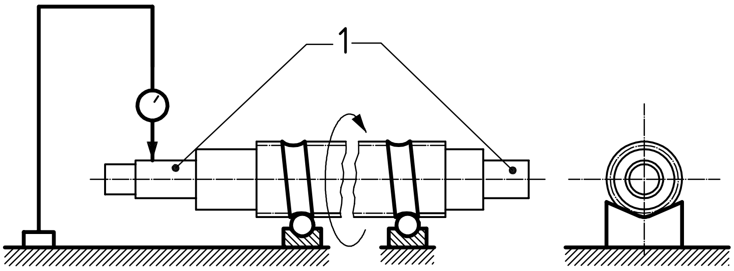
Rotate the ball screw slowly and record the dial gauge readings.

Object: Positioning or transport ball screw

E 6.2

Measurement of radial runout, $t_{6.2}$, of bearing seat related to the centreline of the screw part:

Diagram



Key

1 bearing seat

Permissible deviations

Nominal diameter d_0 mm		Standard tolerance grade				
		0	1	3	5	—
>	⩽	$t_{6.2p}$, µm				
—	8	3	5	8	10	—
8	12	4	5	8	11	
12	20	4	6	9	12	
20	32	5	7	10	13	
32	50	6	8	12	15	
50	80	7	9	13	17	
80	125	—	10	15	20	

Observations and remarks

$t_{6.2a}$ = _________ µm

Measuring instruments

Dial gauge and V-blocks (assembled nut or jig for exclusive use)

Test instructions Reference to test code ISO 230-1:1996, 5.612.2

Support a screw shaft at near both ends of threaded part, using the plural number of balls of the same size as the balls used.

Place the dial gauge at the outside diameter of the ball bearing seat of the screw shaft.

Rotate the screw shaft one revolution and record the dial gauge readings.

NOTE This test can be used on an agreement between user and manufacturer. If used, it replaces test E 6.1.

Object: Positioning or transport ball screw

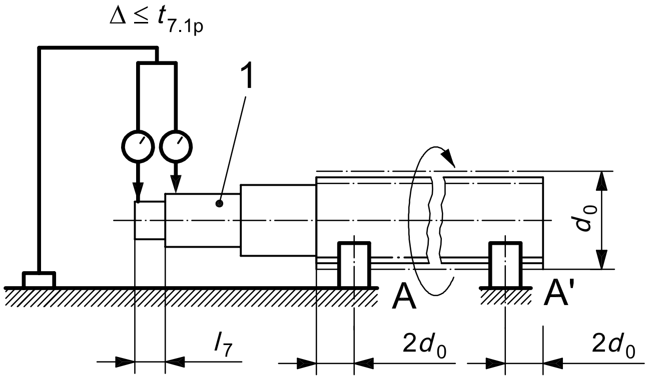
E 7.1

Measurement of radial run-out, $t_{7.1}$, of journal diameter related to the bearing seat by determining the difference:

for $l_7 \leqslant l$ (l see table)

for $l_7 > l$ to be valid $t_{7.1a} \leqslant t_{7.1p} \frac{l_7}{l}$

Diagram



Key

1 bearing seat

Permissible deviations

Nominal diameter d_0 mm		l mm	Standard tolerance grade				
			1	3	5	7	10
>	⩽		$t_{7.1p}$, µm, for l				
6	20	80	5	6	8	12	16
20	50	125	6	8	10	16	20
50	125	200	8	10	12	20	25
125	200	315	—	12	16	25	32

Observations and remarks

Diameter $t_{7.1a}$

_____ mm _____ µm

_____ mm _____ µm

_____ mm _____ µm

_____ mm _____ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.612.2

Place ball screw in identical V-blocks at points A and A′.

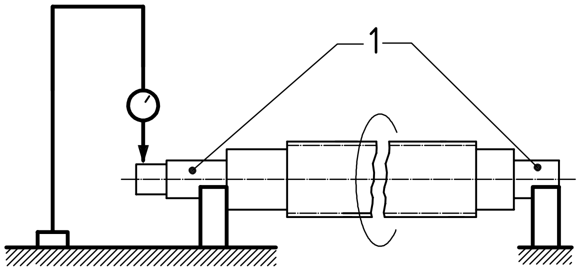
Place the dial gauge at the distance l_7 perpendicular to the cylindrical surface.

Rotate the ball screw slowly and record the dial gauge readings.

Object: Positioning or transport ball screw **E 7.2**

Measurement of radial run-out, $t_{7.2}$, of the journal diameter related to the centreline of the bearing seat:

Diagram



Key

1 bearing seat

Permissible deviations

Nominal diameter d_0 mm		Standard tolerance grade				
		0	1	3	5	—
>	⩽	$t_{7.2p}$, µm				
—	8	3	5	8	10	
8	12	4	5	8	11	
12	20	4	6	9	12	
20	32	5	7	10	13	—
32	50	6	8	12	15	
50	80	7	9	13	17	
80	125	—	10	15	20	

Observations and remarks

$t_{7.2a}$ = ____________ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.612.2

Support a screw shaft at its supporting bearing seats horizontally using V-blocks.

Put the dial gauge at the outside diameter of the journals.

Rotate the screw shaft one revolution and record the dial gauge readings.

NOTE 1 This test can be used on an agreement between user and manufacturer. If used, it replaces test E 7.1.

Object: Positioning or transport ball screw

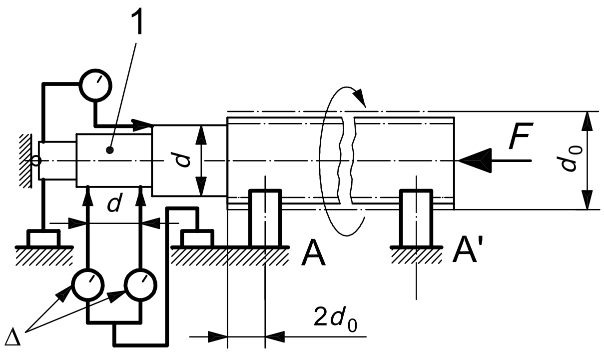
E 8.1

Measurement of axial run-out, $t_{8.1}$, of shaft (bearing) faces related to AA′:

Diagram

$t_{8.1a} \leqslant t_{8.1p} - |\Delta|$

where Δ is the deviation of straightness.



Key

1 bearing seat

Permissible deviations

Nominal diameter d_0 mm		Standard tolerance grade				
		1	3	5	7	10
>	⩽	$t_{8.1p}$, µm				
6	63	3	4	5	6	10
63	125	4	5	6	8	12
125	200	—	6	8	10	16

Observations and remarks

Diameter $t_{8.1a}$

_____ mm _____ µm

_____ mm _____ µm

_____ mm _____ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.632

Place ball screw at points A and A′ on V-blocks.

Secure the ball screw shaft in the axial direction against movement (e.g. by placing a ball between the centres of the ball screw shaft and the mounting surface).

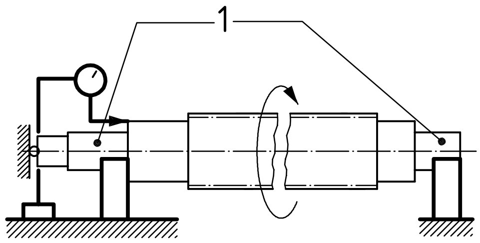
Place the dial gauge perpendicular to the end face of the journal and to the cylindrical surface of the corresponding diameter.

Rotate the screw shaft one revolution and record the dial gauge readings.

Object: Positioning or transport ball screw | **E 8.2**

Measurement of axial run-out, $t_{8.2}$, of the shaft faces related to the centreline of the screw shaft:

Diagram



Key

1 bearing seat

Permissible deviations

Nominal diameter d_0 mm		Standard tolerance grade				
		0	1	3	5	—
>	⩽	$t_{8.2p}$, µm				
—	8	2	3	4	5	—
8	12	2	3	4	5	
12	20	2	3	4	5	
20	32	2	3	4	5	
32	50	2	3	4	5	
50	80	3	4	5	7	
80	125	—	4	6	8	

Observations and remarks

$t_{8.2a}$ = ____________ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.632

Support a screw shaft horizontally by the V-blocks at the supporting bearing seats while butting one end of the screw shaft to the fixed face.

Place the dial gauge at its supporting bearing seat end face.

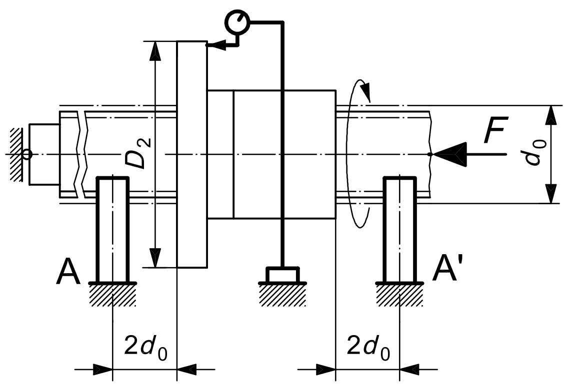
Rotate the screw shaft one revolution and record the dial gauge readings.

NOTE 1 This test can be used by agreement between user and manufacturer. If used, it replaces test E 8.1.

Object: Positioning or transport ball screw **E 9**

Measurement of axial run-out, t_9, of ball nut location face related to AA′ (for preloaded ball nuts only):

Diagram



Permissible deviations

Flange diameter D_2 mm		Standard tolerance grade					
		0	1	3	5	7	10
>	⩽	t_{9p}, µm					
16	32	8	10	12	16	20	—
32	63	10	12	16	20	25	—
63	125	12	16	20	25	32	—
126	250	16	20	25	32	40	—
250	500	—	—	32	40	50	—

Observations and remarks

$t_{9a\ max}$ = ____________ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.632

System preloaded. Place the ball screw on V-blocks at points A and A′.

Secure the ball screw shaft in the axial direction against movement (e.g. by placing a ball between the centres of the ball screw shaft and the mounting surface).

Place the dial gauge perpendicular to the flange face at the outer rim of the inspection diameter D_2.

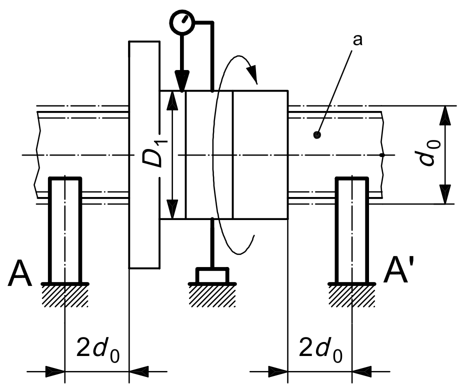
Secure the ball nut against rotation on the ball screw shaft.

Rotate the ball screw shaft and record the dial gauge readings.

Object: Positioning or transport ball screw **E 10**

Measurement of radial run-out, t_{10}, of ball nut location diameter related to AA′ (for preloaded and rotating ball nuts only):

Diagram



[a] Fixed.

Permissible deviations

Ball nut body outer diameter D_1 mm		Standard tolerance grade					
		0	1	3	5	7	10
>	⩽	t_{10p}, µm					
16	32	8	10	12	16	20	—
32	63	10	12	16	20	25	
63	125	12	16	20	25	32	
125	250	16	20	25	32	40	
250	500	—	—	32	40	50	

Observations and remarks

$t_{10a\ max}$ = ____________ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.612.2

System preloaded. Place the ball screw on V-blocks at points A and A'.

Place the dial gauge perpendicular to the cylindrical surface of ball nut location diameter D_1.

Secure the ball screw shaft.

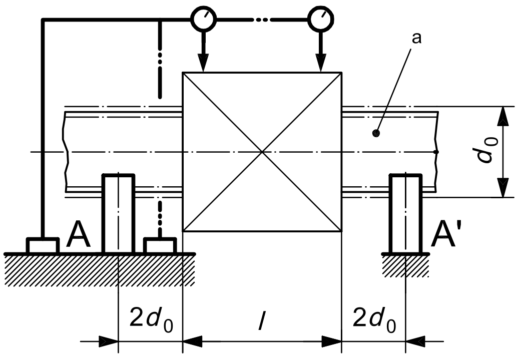
Rotate the ball nut body slowly. Record the dial gauge readings.

Object: Positioning or transport ball screw

E 11

Deviation of parallelism, t_{11}, of rectangular ball nut related to AA′ (for preloaded ball nuts only):

Diagram



[a] Fixed.

Permissible deviations

Standard tolerance grade					
0	1	3	5	7	10
t_{11p}, µm, for each 100 mm (cumulative)					
14	16	20	25	32	—

Observations and remarks

t_{11a} = ____________ µm

Measuring instruments

Dial gauge and V-blocks

Test instructions Reference to test code ISO 230-1:1996, 5.412.2

System preloaded.

Place ball screw on V-blocks at points A and A′.

Place the dial gauge perpendicular to the inspection surface and probe along the specified inspection length l.

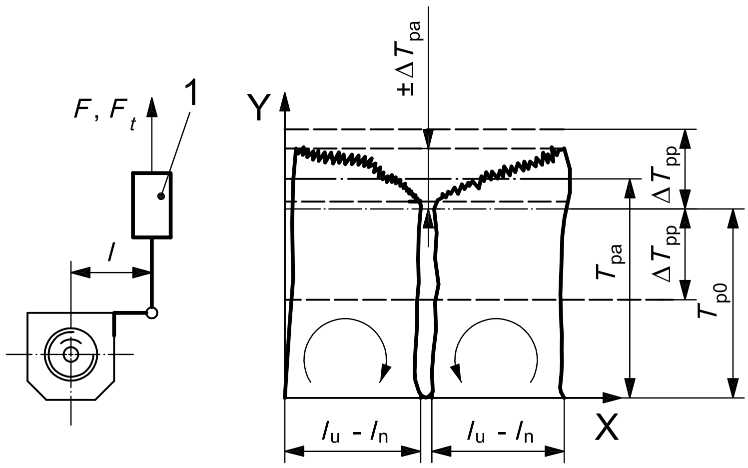
Record the dial gauge readings.

5.4 Functional tests

Object: Positioning or transport ball screw **E 12**

Measurement of dynamic preload drag torque, ΔT_p:

Diagram



$T_p = F \times l$ without end seals

$T_t = F_t \times l$ with end seals

l_n = ball nut length

Key

X travel

Y dynamic preload drag torque

1 force indicator

Permissible deviations

T_{p0} Nm		Standard tolerance grade					
		0	1	3	5	7	10
>	⩽	ΔT_{pp},% of T_{p0}, for $l_u / d_0 \leqslant 40$; $l_u \leqslant 4\,000$ mm					
0,2	0,4	30	35	40	50	—	—
0,4	0,6	25	30	35	40	—	—
0,6	1,0	20	25	30	35	40	—
1,0	2,5	15	20	25	30	35	—
2,5	6,3	10	15	20	25	30	—
6,3	10	—	—	15	20	30	—
>	⩽	ΔT_{pp},% of T_{p0}, for $40 < l_u / d_0 \leqslant 60$; $l_u \leqslant 4\,000$ mm					
0,2	0,4	40	40	50	60	—	—
0,4	0,6	35	35	40	45	—	—
0,6	1,0	30	30	35	40	45	—
1,0	2,5	25	25	30	35	40	—
2,5	6,3	20	20	25	30	35	—
6,3	10	—	—	20	25	35	—
>	⩽	ΔT_{pp},% of T_{p0}; $l_u > 4\,000$ mm					
—	0,6	Not specified					
0,6	1,0	—	—	40	45	50	—
1,0	2,5	—	—	35	40	45	—
2,5	6,3	—	—	30	35	40	—
6,3	10	—	—	25	30	35	—

Observations and remarks

Without end seals

l = ______________ m

F = _____________ N

T_{pa} = ___________ Nm

ΔT_{pa} = ± ________ Nm

≈ ± ________ % of T_{p0}

With end seals

F_t = _____________ N

T_{ta} = ____________ Nm

ΔT_{ta} = ± ___________ Nm

≈ ± ________ % of T_{p0}

Measuring instruments

Test bench with recorder for force value measured.

Test instructions

System preloaded (with or without end seals).

For the recording of the radial preload force, couple the ball nut body to a load cell at the distance l from the axis of rotation.

Take recordings of the force indicator at a rotational speed 100 min^{-1} in both directions of rotation [a].

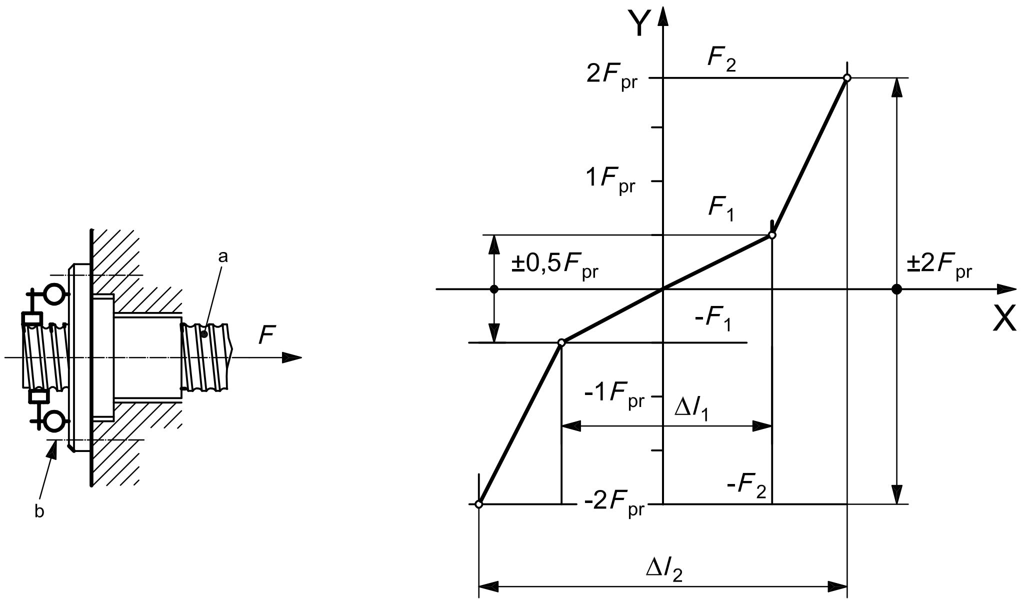
For lubrication, use a lubricant of ISO viscosity grade 100 [a].

[a] Other rotational speeds, lubricants and measuring instruments may be used by agreement between the user and the manufacturer.

Object: Positioning or transport ball screw — **E 13**

Measurement of axial rigidity, R_{nu}:

Diagram



Key

X elastic deformation, Δl

Y load, F

[a] Fixed against rotation.

[b] Axially fixed.

Permissible deviations	**Observations and remarks**
Not specified	F_{pr} = ____________ N F_1 = ____________ N F_2 = ____________ N Δl_1 = _____________ µm Δl_2 = _____________ µm R_{nu1} = ___________ N/µm R_{nu2} = ___________ N/µm

Measuring instruments

Dial gauges and load cell.

Test instructions

Fix the preloaded ball nut axially in both directions and secure the ball screw shaft against rotation.

Place the dial gauge supports on the ball screw shaft and touch the measuring stylus against the face of the ball nut body, as near as possible and as parallel as possible to the ball screw shaft axis.

Apply the axial load $F_1 = 0,5F_{pr}$ or $F_2 = 2F_{pr}$ to the ball screw shaft in tension and in compression.

F_{pr} is the preload and Δl_1 or Δl_2 are the elastic deformations (reversal range) caused by the axial test loads $\pm F_1$ and $\pm F_2$ respectively.

Rigidity in the ranges $\pm F_1$: $$R_{nu1} = \frac{2 \cdot F_1}{\Delta l_1} = \frac{F_{pr}}{\Delta l_1}$$

Rigidity in the range $+F_1$ to $+F_2$ and $-F_1$ to $-F_2$: $$R_{nu2} = \frac{2 \cdot (F_2 - F_1)}{\Delta l_2 - \Delta l_1} = \frac{3 \cdot F_{pr}}{\Delta l_2 - \Delta l_1}$$

Other test loads F may be used by agreement between the user and the manufacturer.

Annex A
(normative)

Complementary tables

Table A.1 — Tolerance values on specified travel, e_p, for a band width per 300 mm (v_{300}) and for a mean travel deviation, e, and for the standard tolerance grades according to ISO 286-2:1988

Measured travel mm		Standard tolerance grade					
		0	1	3	5	7	10
>	⩽	Tolerance on specified travel, e_p µm					
—	315	4	6	12	23	52	210
315	400	5	7	13	25	57	230
400	500	6	8	15	27	63	250
500	630	6[a]	9	16	32	70	280
630	800	7[a]	10	18	36	80	320
800	1 000	8[a]	11	21	40	90	360
1 000	1 250	9[a]	13	24	47	105	420
1 250	1 600	11[a]	15	29	55	125	500
1 600	2 000	13[a]	18	35	65	150	600
2 000	2 500	15[a]	22	41	78	175	700
2 500	3 150	18[a]	26	50	96	210	860
3 150	4 000		32 [a]	62 [a]	115 [a]	260 [a]	1 050 [a]
4 000	5 000		39 [a]	76 [a]	140 [a]	320 [a]	1 300 [a]
5 000	6 300		48 [a]	92 [a]	170 [a]	390 [a]	1 550 [a]

[a] These values were calculated by linear extrapolation from the IT values in accordance with ISO 286-2 for sizes above 500 mm and less than or equal to 3 150 mm.

Table A.2 — Minimum number of measurements over 300 mm (measuring intervals)

Lead P_h mm	Specified tolerance grade					
	0	1	3	5	7	10
	Minimum number of measurements					
2,5	20	15	10	6	3	1
5	20	15	10	6	3	1
10	15	10	5	3	1	1
20	6	5	4	3	1	1
40	—	—	2	1	1	1

Table A.3 — Maximum excess travel

Dimensions in millimetres

Lead, P_h	2,5	5	10	20	40
Maximum excess travel, l_{max}	10	20	40	60	100

ICS 25.060.99

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