LABORATORY FOR PRODUCTION MEASUREMENT

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SOP 40

CALIBRATION OF STEP GAUGES

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Changes made

Change Nr.	Changed	Removed	Added
	Section	Section	Section
1.	9.2		
2.			
3.			

CONTENTS

1 INTRODUCTION

This procedure describes steps taken when calibrating step gauges by using a bidirectional 1D probe and a laser interferometer (*LI*).

In second part it describes steps taken when calibrating step gauges by using a 3D - Coordinate measuring machine (CMM).

1.1 General

Step gauges are material measures made of ceramic, steel, or other material, on which assigned quantity values are distances between the reference flat surface and *n* other parallel flat surfaces. Step gauges of dimensions up to 1500 mm are calibrated by using bidirectional Mahr 1320 probe and LI HP 5528 A on the Newport 2D stage. Step gauges of dimensions up to 1000 mm are calibrated by using CMM, when best measurement uncertainty is not required by customers.

2 MEASURING EQUIPMENT

• Two-coordinate measuring device	Newport 2D
• Bidirectional 1D probe	Mahr 1320
• Laser interferometer (*LI*)	HP 5528 A
• Temperature measurement system	JENAer Meßtechnik TEMP 14
• 3D - Coordinate measuring machine	Zeiss UMC 850

3 RECEIPT

After receiving the step gauge from a customer, it is visually checked for any damages on measurement surfaces (corrosion, scratches, wear) that could affect the measurement result. The type and the serial number of the step gauge is recorded, as well as the customer's data. Rules and instructions for receiving and identifying calibration objects in Chapter 12. 9 of the Quality manual shall be followed.

4 CLEANING

The step gauges (measurement surfaces) are cleaned with petroleum ether or petroleum and wiped afterwards using the tougher side of a chamois leather (or special synthetic cloth). Measurement surfaces should be shiny without spots.

5 TEMPERATURE STABILISATION

The step gauges are stabilized in the climatic chamber at 20 ˚C ± 0,1 ˚C for 24 hours or on the measuring table of CMM at 20 ˚C ± 1 ˚C for at least five hours.

6 CALIBRATION

6.1 Visual check

The step gauge is visually checked for any damages on measurement surfaces (e.g. corrosion, scratchers, wear), that could affect the measurement result.

The customer should be informed if the calibration cannot be carried out in a standard way due to some damages. The consent should be obtained from the customer if the standard calibration procedure should be changed due to some anomalies (eg. change of measurement points, increased uncertainty).

Any anomalies (damage, scratches, damage record...) should be recorded in the protocol of calibration and in the calibration certificate (in case it is issued).

6.2 Measurement procedure – LI/Newport

6.2.1 Fixing the step gauge

A step gauge is put on the measurement table base as described in the procedure in Appendix 1. It is supported at its Bessel points as shown in Figure 1.

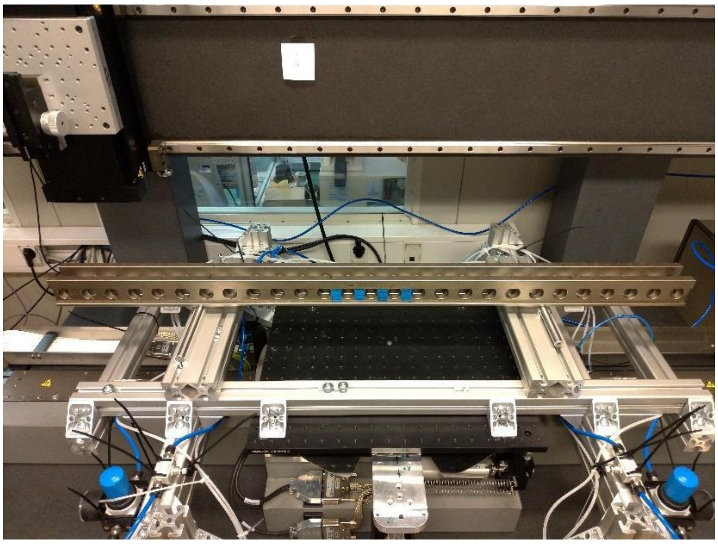

Figure 1: Fixture of a step gauge

6.2.2 Adjustment of the laser beam

Before measuring the step gauge, the laser beam shall be adjusted parallel to the axis of measurement. The laser beam is adjusted using a position sensing diode.

6.2.3 Adjustment of the step gauge

The step gauge shall also be adjusted parallel to the axis of measurement before calibration. This is done by using a dial gauge fixed on the vertical aluminium plate (in y and z axis) (Fig. 2). The maximum permissible difference between the dial gauge indications along x axis (in y and z axis) at 200 mm (worst case-shortest expected step gauge) is 30 μm.

The adjustment shall be performed by following the next steps:

- Fix the step gauge on the measurement table and move it in the x-axis, while the dial gauge is fixed on the vertical aluminium plate,
- Measure the difference between the first and the last gauge block on the step gauge (in y and z axis) (Figure 2),

- If the difference between the first and the last "gauge block" on the step gauge (in y and z axes) is greater than 30 μm / 200 mm (or e. g. 150 μm / m), rotate or tilt the measurement table (Figure 3),
- repeat this step until the step gauge is properly aligned.

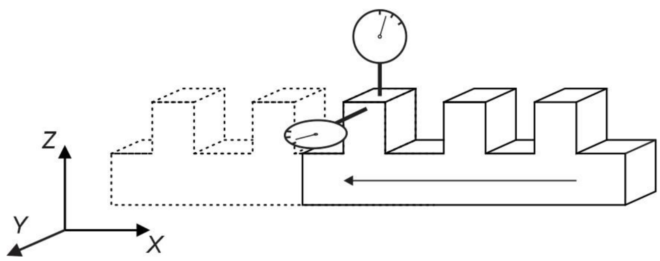

Figure 2: Alignment of the step gauge with the dial gauge parallel to the axis of measurement

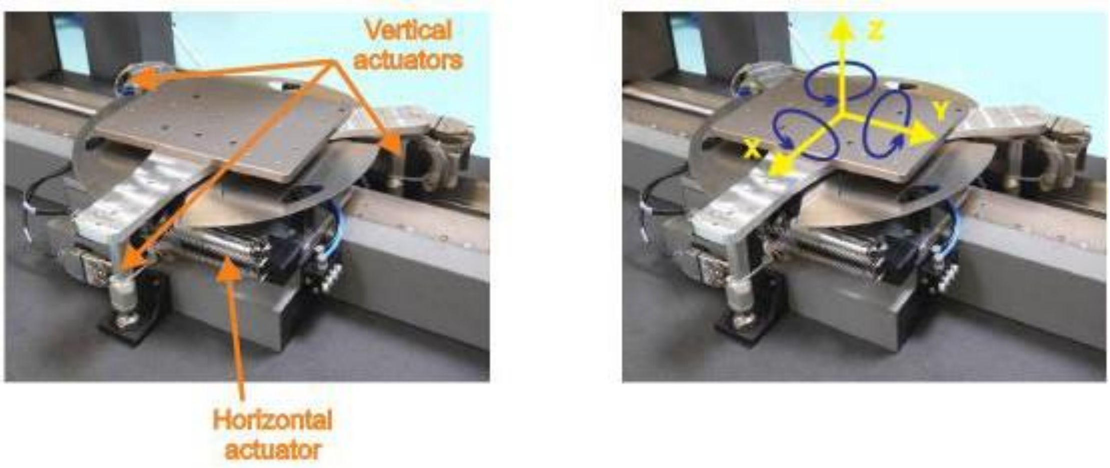

Figure 3: Adjusting the measurement table with actuators

6.2.4 Measurement

Basic measurement principle is shown in Figure 4. The measurement table with the step gauge is positioned along the measurement axis in such way, that the dead path (distance between *LI* interferometer and the retroreflector) is max. 10 mm. Move the measurement table into the measurement point – bidirectional probe should be moved onto zero point of the step gauge. It is necessary to lift the bidirectional probe in order to travel to the next probing point.

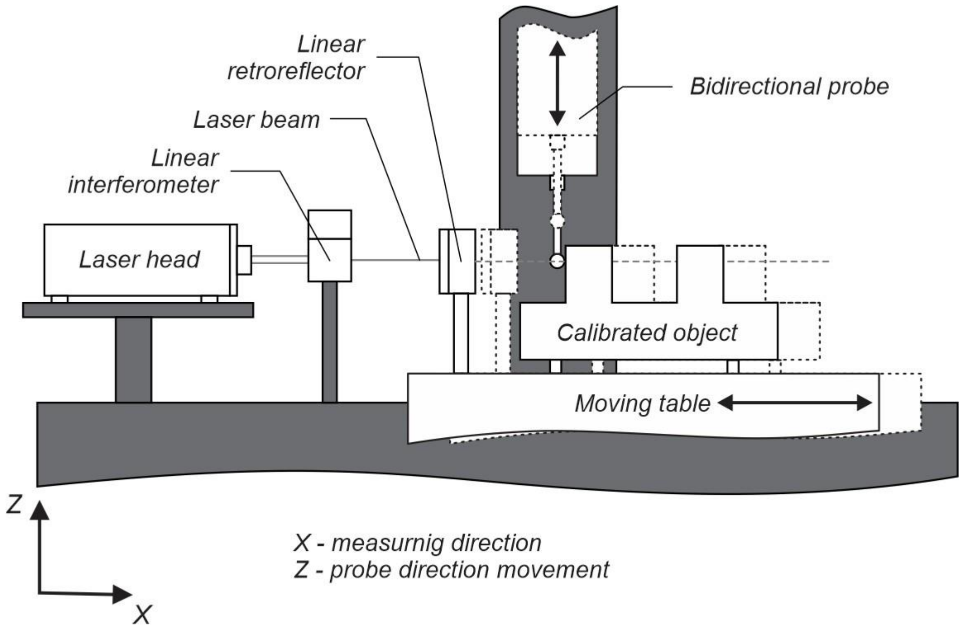

Figure 4: Measurement set-up

- By clicking the button “Začetek meritve” the measuring procedure starts. The *.csv file with nominal data probing points shall be loaded.
- Induction probe moves up.
- The step gauge is moved in such way that the induction probe is positioned 0,5 mm before nominal position of the measurement point. The induction probe is then lowered.
- The step gauge moves toward the induction probe in 50 µm increments until they are in contact. The *LI* value and the bidirectional value, as well as the temperature readings of all temperature sensors, are stored.
- The step gauge moves backwards (for approx. 1 mm) in order to release the bidirectional probe (to prevent a damage).
- The bidirectional probe moves up (in z direction) and the step gauge returns to zero point where the probe is lowered and both, the probe and LI, are reset.
- The described sequence repeats for the next measurement point.
- This procedure is repeated until the last measurement point. Each point is measured 20 times.
- After the measurement is finished, all data are saved into the *.xlsx file.

6.2.5 Correction of the measurement result

<u>Correction of the thermal expansion</u>

Temperature is measured on the step gauge using eight contact sensors TEMP 14. Contact sensors shall be placed on top of the step gauge in even intervals and fixed on the step gauge using rubber bands.

<u>Correction of the Abbe error</u>

Error caused by the pitch and yaw were measured with a *LI* and the greatest Abbe errors were evaluated in advance and are considered in the measurement uncertainty evaluation.

<u>Correction of the LI indication</u>

The results of the specific items must be corrected for the value represented by systematic deviations of parameters (temperature, pressure). This correction is carried out on-line in the *LI* program.

6.3 Measurement procedure – CMM

When best measurement uncertainty (CMC) is not required by customers, we can calibrate step gauges simply and faster by using a 3D - Coordinate measuring machine (CMM). We can measure distances up to 1000 mm.

The step gauge is put on a proper flat base and fixed by using fixing elements on the working surface in the way that main probing direction is parallel with the Y-axis of the CMM. Before the measurement, the measuring surfaces are carefully cleaned with petroleum ether.

Measuring quantity is a distance between the central points of the measured surfaces. The nominal zero surface is probed and set as an origin (zero primary base alignment), and then the perpendicular distance into the center point of the second plane is measured. The central point of the plane is determined by probing and in Calypso software. The probe is driven in -Y direction to the probing points. All external and equidirectional distances (Fig. 5) are measured. The whole procedure is repeated three times. The measurement results for each distance between two surfaces are calculated as the mean values by the CMM program (Calypso).

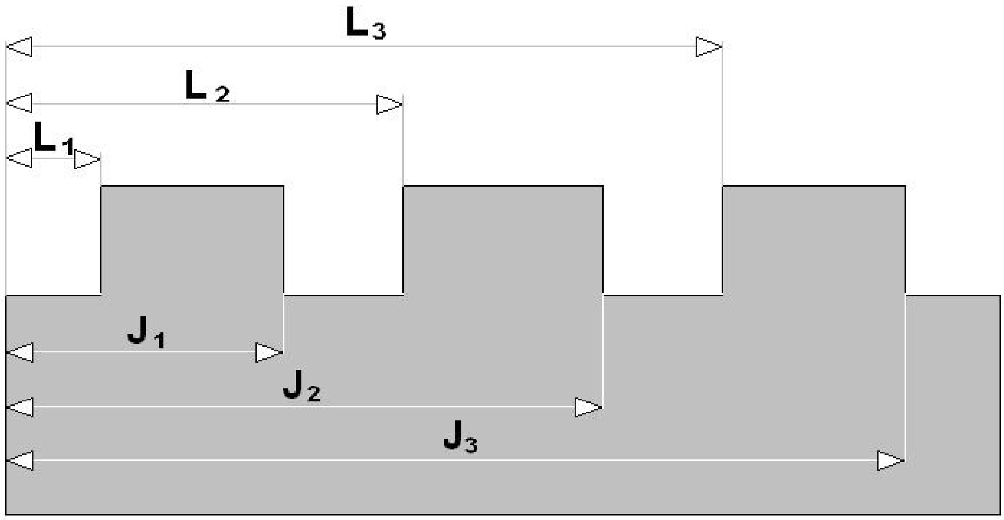

Figure 5: Measured quantities on a step gauge

6.4 Evaluation of the calibration results

Test calibration results are written into the EXCEL file, which evaluates them. The programme is stored in the file (\\Fsltm5\ltm\2-Laboratorijski dnevnik\KALIB-2stran-"artist name"\KALIB-2stran.xls).

On CMM calibration, the measurement results are calculated by the CMM program (Calypso) and stored in the protocol ZEISS CALYPSO. The calibration result is the mean value of 3 measurements (calculated in the ZEISS protocol). Measured (calculated) values are entered directly into the calibration certificate template.

7 DOCUMENTATION

Newport/LI:

The calibration record is produced by using a template » Predloga_zapis-SOP 40.xlsx«, which is stored in the folder »4-Sistem kakovosti/SOP/SOP 40-Stopnicasta merila«. The record is sored into a relevant sub-folder (SOP 40/Zapisi, relevant year) of the folder »3-Zapisi in certifikati«. Instruction for storing records in Quality manual (Ch. 6.2) shall be followed. The second page of the calibration certificate is created by using a template »Predloga_2stran-SOP 40.docx«, which is stored in the folder »4-Sistem kakovosti/SOP/SOP 40-Stopnicasta merila«. The calibration certificate is created and archived in accordance with instructions in the Quality Manual (Ch. 6.1).

CMM:

The calibration record (original ZEISS CALYPSO protocol) is stored into a relevant sub-folder (SOP 40/Zapisi, relevant year) of the folder »3-Zapisi in certifikati«. Instruction for storing records in Quality manual (Ch. 6.2) shall be followed. The second page of the calibration certificate is created by using a template »Predloga_2stran-SOP40.dotx«, which is stored in the folder »4-Sistem kakovosti/SOP/SOP 40-Stopnicasta merila «. The calibration certificate is created and archived in accordance with instructions in the Quality Manual (Ch. 6.1).

8 PROTECTION

Step gauges made of steel are protected with special oil for gauge blocks. No special protection is required for ceramic step gauges.

9 MEASUREMENT UNCERTAINTY – LI/Newport

9.1 Mathematical model of measurement

Measured distance between the step gauge surfaces is the sum of the of the laser interferometer indication and the bi-directional induction probe indication.

Distance between surfaces L_{cal} (calibration result) for unidirectional probing is given by:

$$L_{cal} = (L_{LI} + L_T - L_{ref}) \cdot (1 - \alpha_m \cdot \theta_m) - e_{tcm} + e_{cos} + e_{mp} + e_a + e_{ms} \quad (1)$$

Distance between surfaces L_{cal} (calibration result) for bidirectional probing is given by:

$$L_{cal} = (L_{LI} + L_T - d_k - L_{ref}) \cdot (1 - \alpha_m \cdot \theta_m) - e_{tcm} + e_{cos} + e_{mp} + e_a + e_{ms} \quad (2)$$

where:

L_{cal} – distance between surfaces (calibration result) at 20 °C
L_{LI} – compensated length shown by the LI in the measurement point
L_T – bi-directional probe indication in the measurement point
d_k – sphere diameter of the bi-directional probe
L_{ref} – sum of the LI and the bi-directional probe indications in the reference (zero) position (assumed value is 0; reset),
α_m – linear temperature expansion coefficient of the step gauge,
θ_m – temperature deviation of the step gauge from 20 °C
e_{tcm} – error of the thermal expansion calculation (compensation formula)
e_{cos} – cosine error (assumed to be 0)
e_{ms} – dead path error
e_a – error due to the table tilt and rotation (Abbe error)
e_{ms} – random error due to non-compensated mechanical influences (repeatability)

9.2 Standard uncertainties of the estimations of the input values and combined standard uncertainty of measurement

Equation for combined uncertainty calculation for bidirectional probing ("worst case") is calculated by the following equation:

$$u_c^2(e) = c_{LLI}^2u^2(L_{LI}) + c_{LT}^2u^2(L_T)\,) + c_{dk}^2u^2(d_k) + c_{Lref}^2u^2(L_{ref}) + c_{\alpha m}^2u^2(\alpha_m) + \\ + c_{\theta m}^2u^2(\theta_m) + c_{etcm}^2u^2(e_{tcm}) + c_{ecos}^2u^2(e_{cos}) + c_{emp}^2u^2(e_{mp}) + c_{ea}^2u^2(e_a) + \\ c_{ems}^2u^2(e_{ms}) \quad (3)$$

where c_i are partial derivatives of the function (3):

$c_{LLI} = \partial f/\partial L_{LI} = 1 - \alpha_m \cdot \theta_m \approx 1$; if $\theta_{mmax} = \pm 0{,}1°C$
$c_{LT} = \partial f/\partial L_T = 1 - \alpha_m \cdot \theta_m \approx 1$; if $\theta_{mmax} = \pm 0{,}1°C$
$c_{dk} = \partial f/\partial d_k = 1 - \alpha_m \cdot \theta_m \approx 1$; if $\theta_{mmax} = \pm 0{,}1°C$
$c_{Lref} = \partial f/\partial L_{Lref} = -1-\alpha_m \cdot \theta_m \approx -1$; if $\theta_{mmax} = \pm 0{,}1°C$
$c_{\alpha m} = \partial f/\partial \alpha_m = \theta_m \cdot (L_{LI} + L_T - d_k - L_{ref}) \approx \theta_m \cdot L$; *L is nominal length of calibration*
$c_{\theta m} = \partial f/\partial \theta_m = \alpha_m \cdot (L_{LI} + L_T - d_k - L_{ref}) \approx \alpha_m \cdot L$
$c_{etcm} = \partial f/\partial \delta e_{tcm} = -1$
$c_{ecos} = \partial f/\partial \delta e_{cos} = 1$
$c_{emp} = \partial f/\partial \delta e_{mp} = 1$
$c_{ea} = \partial f/\partial e_a = 1$
$c_{ems} = \partial f/\partial e_{ms} = 1$

Standard uncertainty of the input quantities is calculated (estimated) for the used machine, methods and procedures.

a) *Uncertainty of the LI measurement in the measurement point $u(L_{LI})$*

Maximum LI uncertainty is:

$u(L_{LI}) = 10\ \text{nm} + 2 \cdot 10^{-7} \cdot L$

(calculated in: LTM_lab\4-Sistem kakovosti\Zapisi\Negotovost\Izračuni)

b) *Uncertainty of the bi-directional probe indication from zero point $u(L_T)$*

Determined from the probe characterization (systematic deviation, linearity, repeatability). In this chapter only systematic deviation and linearity are taken into consideration.

Repeatability is taken into consideration in chapter k (random error) together with repeatability of the zero point positioning (deviations due to non-flat measurement surface)

Probe characterization was done by moving a gauge block into the probe to 10 different measurement point from 10 to 100 µm. At each measurement point, probe measurement was sampled and compared to the LI measurement in the same measurement point. Gauge block was moved away from the probe between each measurement point in order to release the measurement probe.

Four sets of measurements were done with 80 measurements for each measurement point in each set. Two sets were performed in positive probe direction and two in negative. Each of the two sets in the same direction were done with a different random arrangement of measurement points.

Evaluated probe indication standard uncertainty is:

$u(L_T) = 20$ nm

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c) *Uncertainty of the probe sphere diameter $u(d_k)$*

Sphere diameter of the bi-directional probe was evaluated by means of measuring two gauge blocks of known dimensions. Gauge blocks of nominal dimensions 20 mm and 30 mm were used.

During the experiment, 16 sets of 100 measurements were made. 9 sets were performed on 200 mm gauge block and 7 sets on 30 mm gauge block.

For each measurement set, average diameter of the sphere was calculated. From these averages, the average diameter of all sets was calculated as well as the standard deviation. Standard deviation of all sets was 27 nm. On the basis of this experiment, the standard uncertainty of the probe sphere was determined as

$u(d_k) = 30$ nm.

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d) *Uncertainty of the reference (zero) position $u(L_{ref})$*

In the reference position, laser interferometer and bi-directional probe were reset (set to value 0). Measurement uncertainty depends on the stability of the zero point of both systems. Stability of the zero point was estimated based on observing the LI and the bi-directional probe displays in the interval of 4 min. Based on the observation, it was determined that the sum of both values varies for around 10 nm/min. Since the maximum time from resetting the LI and the bi-directional probe to the measurement performed in a measurement point is 3 min, standard measurement uncertainty is:

$$(L_{refLI}) = 10 \cdot 3/\sqrt{3} = 17{,}3 \text{ nm}$$

e) Uncertainty of the step gauge thermal expansion $u(\alpha_m)$

Since most step gauge bodies are made of steel, we can assume an interval around the average value $\alpha = 11 \cdot 10^{-6}$ °C^{-1} with limits of $\pm 1 \cdot 10^{-6}$ °C^{-1}.

Standard uncertainty at assumed rectangular distribution is:

$$(\alpha_m) = (1 \cdot 10^{-6}\,°C^{-1})/\sqrt{3} = 0{,}58 \cdot 10^{-6}\,°C^{-1}$$

f) Uncertainty of the temperature deviation $u(\theta_m)$

Step gauge temperature is measured with eight material probes during the calibration. Thermal expansion is compensated in real time according to the established nonlinear model [2]. Uncertainty of the temperature deviation is determined by the uncertainty of the temperature measurement (probes uncertainty – from certificate) and is:

$$u(\theta_m) = 7{,}5 \text{ mK}$$

g) Uncertainty due to the thermal expansion calculation $u(e_{tmc})$

Thermal expansion compensation is calculated from the nonlinear model [2]. Nonlinear model is based on simulation results, which are not a perfect representation of reality, therefore same uncertainty exists in the model. This uncertainty was estimated by comparing model results to experimental measurement results and has been estimated as:

$$u(e_{tmc}) = 3 \cdot 10^{-8} \cdot L$$

h) Uncertainty due to cosine errors $u(e_{cos})$

Two cosine errors are present:

- Error due to misalignment of the laser beam (in xz and xy planes)
- Error doe to misalignment of the step gauge (in xz and xy planes)

Alignment of the laser beam can be done within ±0,1 mm of deviation from the target center at the length of 1 m. Therefore, interval of cosine error for single plane is:

$$e_{cosLI} = \pm 5 \cdot 10^{-9} \cdot L\ .$$

Alignment of the step gauge can be done within ±30 µm from the direction of movement (alignment process is given in Chapter 6.2.3). If the shortest step gauge to be calibrated using this procedure is 200 mm, than the worst case angle φ is:

$$\text{tg}\ \varphi = 30\ \mu\text{m} / 200\ \text{mm};$$
$$\varphi = 0{,}0086°$$

Cosine error in single plane is therefore:

$e_{\cos SG1} = L\,(1 - \cos\varphi) = 1{,}1 \cdot 10^{-8} \cdot L$

Combined cosine error of the step gauge alignment in space (2 ortogonal planes) is then:

$e_{\cos SG} = L\,(1 - \cos\varphi) = 2{,}2 \cdot 10^{-8} \cdot L$

It is obvious that the cosine error of the LI beam is negligible in comparison to the one of the step gauge. Therefore, the total standard uncertainty due to the cosine error is:

$$(e_{cs}) = (2{,}2 \cdot 10^{-8} \cdot L\,)/\sqrt{3} = 1{,}3 \cdot 10^{-8} \cdot L$$

i) Uncertainty due to dead path u(e_{mp})

Measurement setup is done is such a way, that maximum dead path is 10 mm.
According to Edlen equation, error of 1µm/m is caused by:

- Temperature change of 1 °C or
- Pressure change of 3,3 hPa (2,5 mm Hg) or
- Humidity change 80 %.

In the used climate chamber, maximum deviation of conditions are:

- ΔT = 0,3 °C
- Δp = 5 hPa
- ΔH = 10 %

This can cause a maximum error (zero point drift) of ($\sqrt{3^2 + 15^2 + 1{,}2^2} = 15{,}3$ nm)
Standard uncertainty assuming rectangular distribution therefore is:

$u(e_{mp})$ = 8,9 nm

j) Uncertainty due to Abbe error u(e_a)

Abbe error is caused by different tilt of measurement table along the measurement path (x axis). Tilt angles were measured by LI and the following values of Abbe errors were obtained:

- for pitch (Fig. 9), the maximum difference in angle was 7 µm/m at the length of 500 mm (measured with *LI*). Maximum deviation of *LI* reflector in z axis is 2 mm (*calculated in: \\Fsltm5\ltm\4-Sistem kakovosti\SOP\Kalibracije\SOP 21-Črtna merila\Meritve - negotovost/ Meritve-Abbe-Newport.xlsx*

  Expected error interval:

  $$I = 7\ \text{nm/mm} \cdot 2\ \text{mm} = 14\ \text{nm}$$

  Standard uncertainty at rectangular distribution is:

  $$u(e_a) = 8\ \text{nm}$$

- for yaw (Fig. 10), the maximum difference in angle is 10 µm/at the length of 500 mm (measured with *LI*). Maximum deviation of *LI* reflector in axis x is 2 mm (*calculated in: \\Fsltm5\ltm\4-Sistem kakovosti\SOP\Kalibracije\SOP 21-Črtna merila\Meritve - negotovost/ Meritve-Abbe-Newport.xlsx*

Expected error interval:

$$I = 10 \text{ nm/m} \cdot 2 \text{ mm} = 20 \text{ nm}$$

Standard uncertainty at rectangular distribution is:

$$u(e_a) = 11{,}5 \text{ nm}$$

Total standard uncertainty due to Abbe error $u(e_a)$ is

$$u(e_a) = \sqrt{u_{zy}^2(e_a) + u_{xy}^2(e_a)} = 13 \text{ nm} \quad .14$$

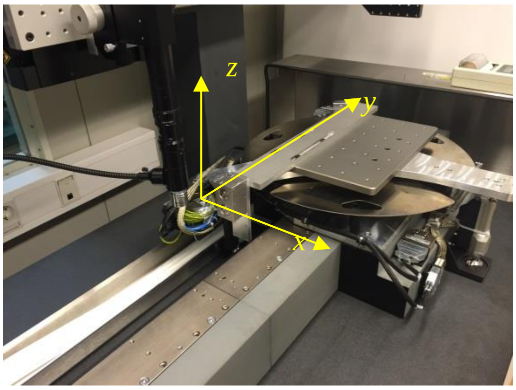

Figure 5: Abbe error for pitch

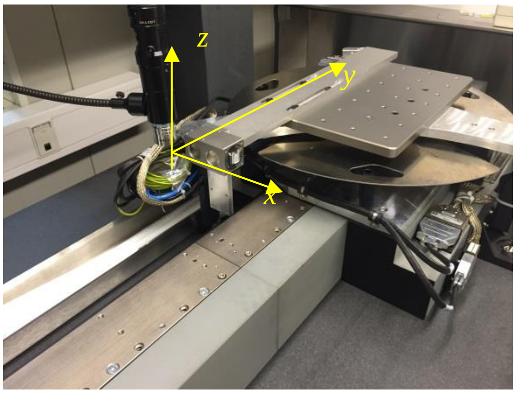

Figure 6: Abbe error for yaw

k) Uncertainty due to random error u(e$_{ms}$)

Random errors mostly caused by repeatability of the probe and error when the probe moves into measurement position (both x and z axis). Random errors are partially eliminated by repeating measurement in each measurement point 20 times (see procedure). Standard uncertainty of the calculated average value of all 20 measurements is calculated as:

$$(e_{ms}) = \frac{s}{\sqrt{20}}$$

This contribution is calculated individually for each measurement point. (calculated in the excel file:

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CMC was determined experimentally using a gauge block (representing the surface of an »ideal« step gauge). Experiments were made in four series with 80 measurements in each series. Experimental standard deviation was in the worst case scenario 50 nm. Considering the 20 measurements made in each measurement point in the actual step gauge calibration, standard uncertainty is:

$$(e_{ms}) = \frac{50}{\sqrt{20}} = 11 \text{ nm}$$

Table 1: Uncertainty budget

Quantity X_i	Estimated value	Standard uncertainty	Distribution	Sensitivity coefficient	Uncertainty contribution
L_{LI}	L	$10\ \text{nm} + 2\cdot10^{-7}\cdot L$	normal	1	$10\ \text{nm} + 2\cdot10^{-7}\cdot L$
L_T	<100 nm	20 nm	normal	1	20 nm
d_k	3 mm	30 nm		1	30 nm
L_{ref}	0 mm	17,3nm	normal	-1	17,3 nm
α_m	$11\cdot10^{-6}$ °C^{-1}	$0{,}58\cdot10^{-6}$ °C^{-1}	rectangular	0,1 °C·L	$6\cdot10^{-8}\cdot L$
θ_m	0°C	0,0075 °C	normal	$11\cdot10^{-6}$ °C$^{-1}\cdot L$	$8{,}3\cdot10^{-8}\cdot L$
e_{tcm}	0	$3\cdot10^{-8}\cdot L$	rectangular	-1	$3\cdot10^{-8}\cdot L$
e_{cos}	0	$1{,}3\cdot10^{-8}\cdot L$	rectangular	1	$1{,}3\cdot10^{-8}\cdot L$
e_{mp}	0	9 nm	rectangular	1	9 nm
e_a	0	13 nm	rectangular	1	14 nm
e_{ms}	0	11 nm	normal	1	11 nm
				Total:	$\sqrt{(46\ \text{nm})^2 + (2{,}35\cdot10^{-7}\cdot L)^2}$

Total combined uncertainty of estimated input quantities at best measurement conditions is expressed with the following equation (calculated from table 1):

$u = 46\ \text{nm} + 2{,}35\cdot10^{-7}\cdot L$

9.3 Expanded uncertainty

For expanded uncertainty calculation factor of $k = 2$ is used in accordance with EAL guidelines. The value is rounded up to:

$$U = \sqrt{(0{,}1\ \mu\text{m})^2 + (0{,}5\cdot10^{-6}\cdot L)^2}$$

10 MEASUREMENT UNCERTAINTY – CMM

Coordinate measuring machine is used in the range, defined by the manufacturer. Therefore, we apply uncertainty specified by the producer and verified with periodical verification tests.

$U_{\mathrm{KMN}} = A + B$

$A = 2a$

$$a = \sqrt{\left(\frac{2{,}1}{2}\right)^2 + s^2}$$

where:

s - standard deviation of 15 measurements

Expanded best measurement capability in one axis in a temperature range from 18 °C to 20°C is:

$$U_{\mathrm{KMN}} = 2{,}1\ \mu\mathrm{m} + 3{,}3 \cdot 10^{-6} \cdot L$$

11 TRACEABILITY

Measurement equipment used for calibration:

- Newport 2D - no calibration necessary (only used as a base)
- Bidirectional Mahr probe 1320 – calibrated internally
- Laser interferometer (*LI*) - calibrated internally (sensors calibrated in Slovenian national laboratories for temperature and pressure)
- TEMP 14 - calibrated in an accredited or national European laboratory
- 3D CMM Zeiss UMC 850 – calibrated internally

12 LITERATURE

[1] Laser Beam Alignment for Cosine Error. LTM Procedure

[2] Šafarič J., Dolšak B., Klobučar R., Ačko B., Analysis of thermal contribution to the measurement uncertainty in step gauge calibration. Precision Engineering 2020; 66. https://doi.org/10.1016/j.precisioneng.2020.06.012

[3] SOP 29, SOP 30, SOP 31 LTM Procedures

APPENDIX 1

INSTRUCTIONS FOR FIXING THE STEP GAUGE ON THE SUPPORTING MECHANISM

1. Supporting points of the step gauge

Fix the movable supports in the calculated positions.

Example:

Distance between the support points is 600 mm.

Length of the supporting mechanism is 990 mm.

Distance between the front surface of the movable support and the rod Φ14 mm is 20 mm.

Move the movable supports in the following position against to the left and the right end of the supporting mechanism:

Position = (990 - 600) / 2 - 20

2. Setting the temporary supports

Set the NEWPORT movable table into the middle position in z axis.

Set the temporary supports of dimensions (50 x 70 x 190) mm on the NEWPORT granite plate.

To the left and to the right of the table centre 290 mm (longitudinally), to the front and to the back of the table centre 155 mm (transversely).

3. Setting the supporting mechanism on the temporary supports

Lean the supporting mechanism on the temporary supports. Pressure regulators shall be on the front side.

Manually pull the pneumatic cylinders in their maximum position (down).

Attach the air pipe.

4. Calculating the air pressure

Determine the step gauge weight. Calculate the additional pressure as 0,031 bar per 1kg of the step gauge weight.

Set the lifting cylinders pressure on the right regulator to (additional pressure + base pressure 1 bar + spare pressure 0,5 bar).

Set the left regulator pressure (for air slide bearings) to 2,5 bar.

Turn on the air on the valve.

5. Initial fixing of the supporting mechanism on the table

Lift the supporting mechanism on one side and remove the temporary supports. Lay the slide bearings on the table.

Repeat the same procedure on the other side.

Check the function of the slide bearings (by rotating each bearing).

Fix the supporting mechanism on the movable table with two screws M6x70.

6. Setting the step gauge

Lay the step gauge on the slide supports in such way that it lies in the middle of the supporting mechanism in longitudinal as well as in transversal direction.

Get sure that the step gauge lies on the rods Φ14 mm.

Adjust the step gauge leaning with pin screws M6.

Fix the step gauge with clamps.

7. Final fixing of the supporting mechanism on the table

Lower the air pressure of the lifting cylinders for the spare pressure (0,5 bar) and check that the supporting mechanism leans on the movable table.

Change the screws M6x70 with four screws M6x15, which centre the supporting mechanism on the table.

8. Measurement

Perform the measurement.

9. Removing the step gauge

Unscrew the screws M6x15.

Raise the air pressure of the lifting cylinders for the spare pressure.

Fix the supporting mechanism on the movable table with two screws M6x70.

Unscrew and remove the clamps.

Remove the step gauge.

10. Removing the supporting mechanism

Remove the screws M6x70.

Lean the supporting mechanism on the temporary supports.

Turn off the air flow on the valve.

Unplug the air pipe.

Store the supporting mechanism in such position that the air bearings are not under load.