BIPM Capacity Building & Knowledge Transfer Programme

2023 BIPM - TÜBİTAK UME Project Placement – Cycle 6

REPORT

Project Name:	«Calibration of gauge blocks by interferometer and mechanical comparison»
Description:	The purpose of the project is to acquire theoretical knowledge and practical experience in carrying out calibration of gauge blocks of 3 and 4 categories (1, 2, 3, 4, 5 accuracy class) using the comparison method. The relevance of the project is the upcoming acquisition of a comparator for calibration of gauge blocks.
Author, NMI:	Andryuchshenko Yekaterina, the branch for the city of Almaty and Almaty region of RSE "KazStandart", Kazakhstan
Mentor at TÜBİTAK UME:	Muharrem Aşar, Dimensional laboratory, TÜBİTAK-UME, Turkey
Date:	02 October 2023 - 27 October 2023

Motivation & Introduction

Currently, the branch in Almaty and Almaty region of RSE "KazStandart" has a State secondary standard of a unit of length in the range from 0.1 to 200 mm (Kesters interferometer) on which 1 and 2 category (00, 0 accuracy class, according to GOST 9038-90 «Gauge blocks. Specifications») of gauge blocks are calibrated.

The relevance of the project is the upcoming acquisition of a comparator for calibration of gauge blocks 3 and 4 categories (1, 2, 3, 4, 5 accuracy class, according to GOST 9038-90) by comparison method.

The purpose of the project is to acquire theoretical knowledge and practical experience in carrying out calibration of gauge blocks by comparison.

The work that was planned to be carried out as part of the research:

– to get practical experience in calibrating measuring gauge blocks by mechanical comparison using a comparator;

– to identify factors affecting the accuracy of the measurement results and contributing to the uncertainty of the measurement result in order to eliminate them and reduce the inaccuracies introduced;

– to determine corrections that are taken into account when processing measurement results;

– to practice the skills of processing measurement results and calculating the uncertainty of the measurement result when calibrating gauge blocks;

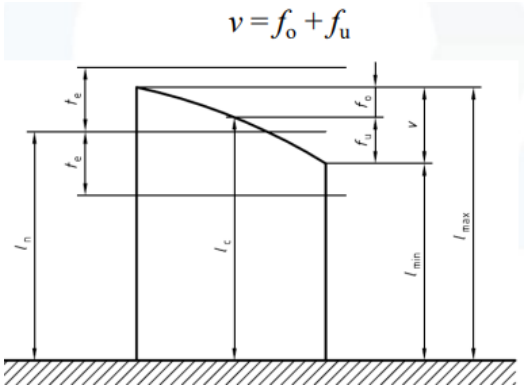
– to consider the comparator calibration procedure;
– to consider the procedures for periodic comparator research carried out in the period between calibrations.

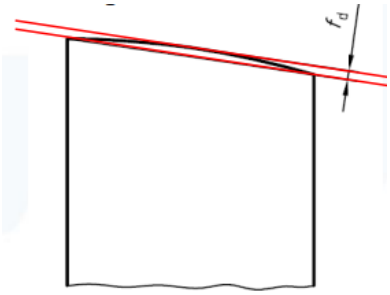
Research

As a result of the study, the following work was performed:

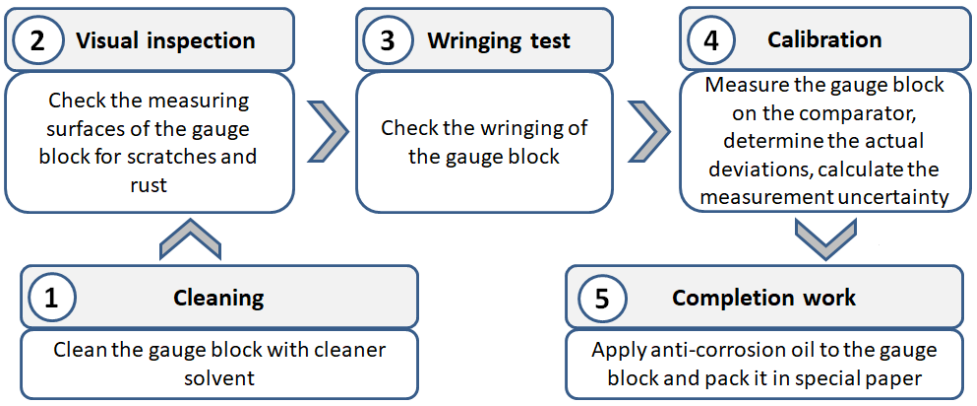
1. The main standardized parameters of gauge blocks are considered

We considered the parameters of the gauge block that need to be checked during calibration:
– deviation of the length at central point from nominal length: e = l – ln
– deviation from flatness: fd
– variation in length: v = fo + fu
– wringing.
We considered tolerances of the parameter according to ISO 3650: 1998 «Geometrical Product Specifications (GPS) - Length standards - Gauge blocks».





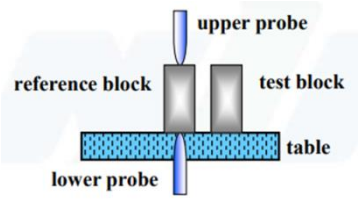
2. The stages of calibration of gauge blocks are considered



3. Gauge blocks were measured using a comparator and the uncertainty of the measurement result was calculated

We practiced to calibrate gauge blocks using a comparator TESA, found deviation of the length at the central point from the nominal length and variation in length of the tested gauge block by comparison with the reference gauge block.

We also looked at the factors that influence the measurement result and how uncertainty is calculated.



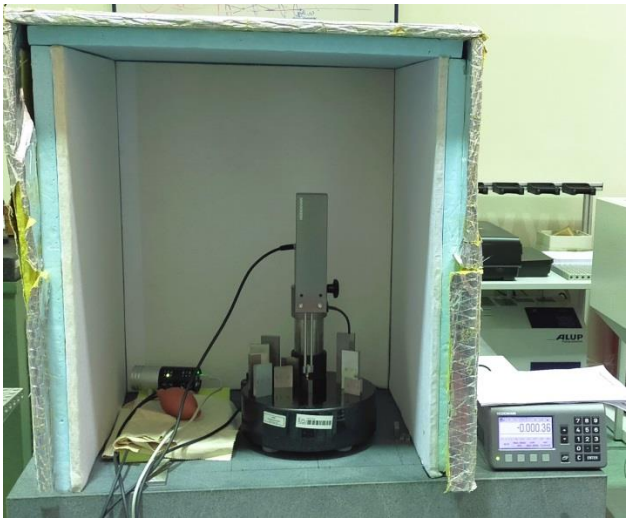
Gauge block comparator
with double probes

4. The dependence of the length of the gauge block on temperature has been researched

We researched in practice the factor that affects the accuracy of measuring the length of the gauge block and the uncertainty of the measurement result – temperature.

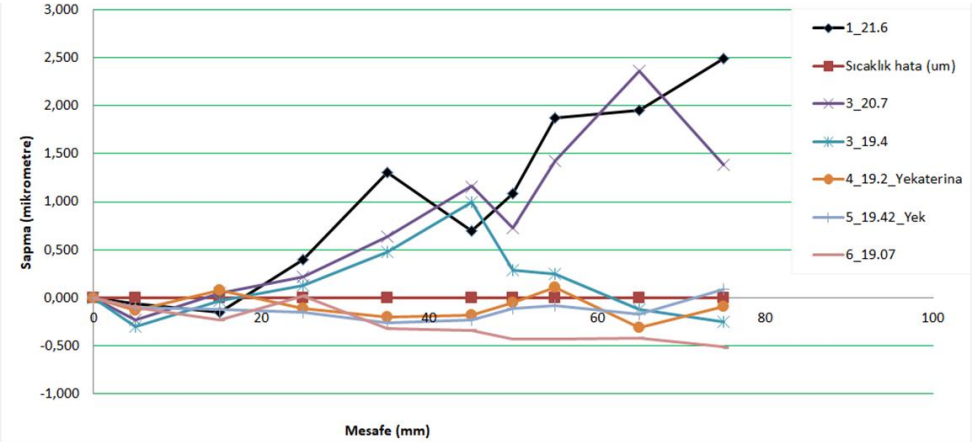
Since when the temperature changes, the length of the gauge block also changes (decreases or increases). It depends on the coefficient of thermal expansion (CTE) α of the material from which the block is made.

The studies were carried out using a length meter Heidenhain with one probe and gauge blocks with nominal lengths of 25, 30, 40, 50, 60, 70, 75, 80, 90, 100 mm.



During measurements, the temperature in the laboratory was maintained at 19.07℃, 19.20℃, 19.40℃, 19.42℃, 20.70℃, 21.60℃

This graph shows that the measured gauge block lengths increase or decrease due to the fact that the temperature deviates from standard conditions of 20℃(center line 0,000).



Therefore, when calibrating gauge blocks, it is important to maintain a standard temperature 20℃in the laboratory, and also take into account the temperature deviation from 20℃when calculating the deviation of the gauge block and calculating measurement uncertainty.

Length of the gauge block at standard conditions (20℃):

$$L_{20} = L_R + L \cdot [\, \alpha_R \cdot (\, t_R - 20℃) - \alpha_T \cdot (\, t_T - 20℃) \,] + D,$$

- L_{20} - length of test gauge block at 20℃;
- L_R - length of reference gauge block at 20℃(from its certificate);
- L - nominal length of gauge block;
- α_R - thermal expansion coefficient (CTE) of reference gauge block;
- t_R - calibration temperature of reference gauge block;
- α_T - thermal expansion coefficient (CTE) of test gauge block;
- t_T - calibration temperature of test gauge block;
- D - indicator value of comparator (the difference in length between reference and test gauge blocks).

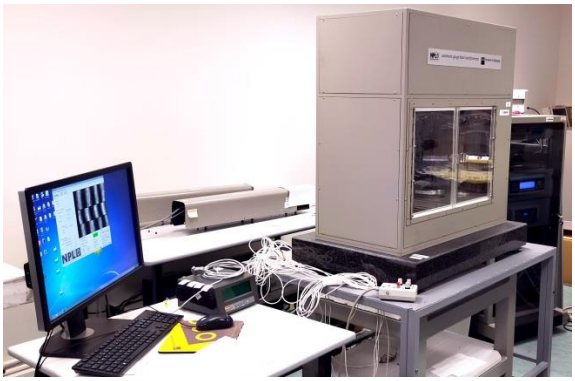
5. The procedure for calibrating the gauge block comparator is considered

We reviewed the procedure EURAMET cg-2 «Calibration of gauge block comparators» and got acquainted with the reference equipment needed to calibrate the comparator. We calibrated the comparator TESA and calculated the measurement results from given forms in EURAMET cg-2.

We also looked at the factors that influence the measurement result and how uncertainty is calculated.

6. Got acquainted with the gauge block interferometer

An automatic gauge block interferometer NPL was considered. The composition of the interferometer, its purpose, operating principle were reviewed. Calibration of the gauge blocks and work with the software were demonstrated.



Conclusions and Future Work

As a result of the research, theoretical knowledge and practical experience were obtained that are necessary to expand the field of activity of the calibration laboratory of the branch with a new type of work (calibration of gauge blocks 3 and 4 category).

And also got knowledge to:

1. to develop the necessary documented procedures:
   - procedure of calibration of gauge blocks by a comparator;
   - procedure of comparator calibration;
2. to make a budget uncertainty of measurement results.

Acknowledgements

I would like to thank BIPM and TÜBİTAK UME for organizing this program and for the opportunity to gain the necessary knowledge and practical experience.

I would like to thank Muharrem Aşar, Sibel Asli Akgöz, Tanfer Yandayan, as well as all the specialists of the dimensional laboratory for the acquired knowledge and experience, for very detailed and at the same time using simple words explanations on working with the standard, for answering all my questions, for the opportunity to take part in temperature dependence researches, for the detailed explanation of the uncertainty calculation and as well as for additional advice on standards that were not part of this project.