BIPM Capacity Building & Knowledge Transfer Programme

2018 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	Calibration of Short Gauge Blocks by Mechanical Comparison
Description	Gauge blocks are fundamental artefacts for the dissemination of the length unit. Therefore, calibration of gauge blocks by mechanical comparison with the lowest possible uncertainty is of highest importance, especially for NMIs that do not have the capability to perform interferometric measurements.
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Motivation & Introduction

As a National Metrology Laboratory not performing interferometric gauge block calibration, the capability of performing Gauge block calibration by mechanical comparison with the lowest possible uncertainty is of highest importance for the Zambia Metrology Agency. This is because gauge blocks transfer traceability to less accurate gauge blocks and then to basic measurement devices (micrometers, calipers, dials, CMM etc.) used by a laboratory or industry.

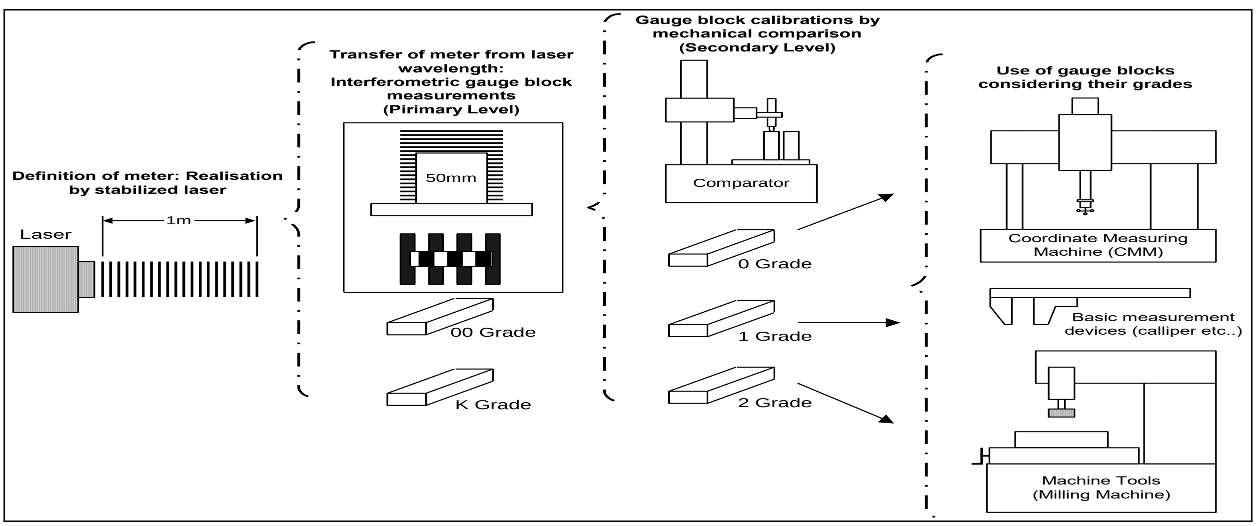


Figure 1: Hierarchical Chain of Traceability

Understanding the factors contributing to the measurement uncertainty provides the groundwork on which to reduce the uncertainty, to which the main contributors are identified as being the standard used, the measurement standard device and the temperature requirements. With the above in mind, it is important that:

- we calibrate our reference gauge blocks and mechanical comparators most accurately,
- we establish and gain confidence in our capabilities by taking part in international inter-comparisons,

With the ultimate goal being to publish CMCs for short gauge block calibration by mechanical comparison in the BIPM KCDB.

Research

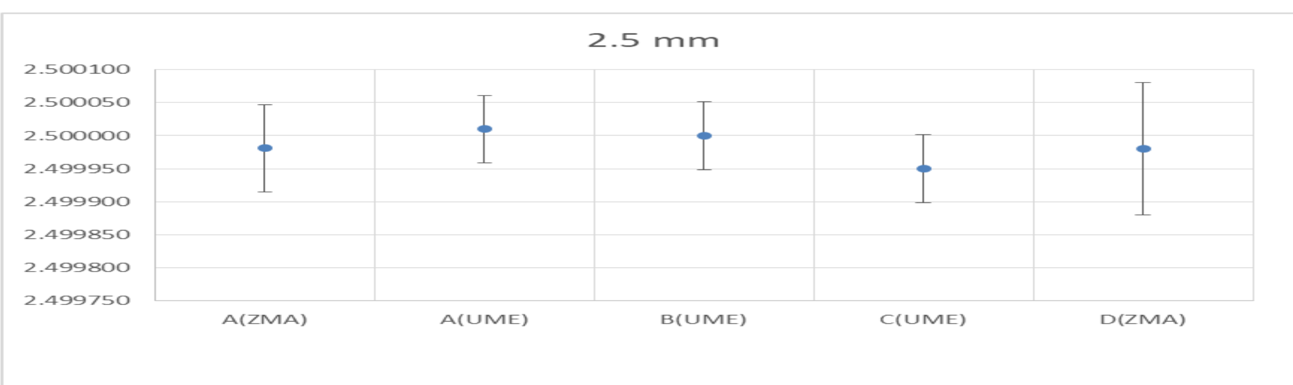
1. LITERATURE REVIEW
   We studied the standards such as ASME B89.1.9-2002/ ISO 3650-GPS-length standards-gauge blocks and EURAMET cg-2; Calibration of gauge block comparator and other UME training documents. These helped to identify and give an understanding of the required measurement parameters such as wringing, central length, variation in length and thus give classification. Sources of measurement uncertainty were evaluated based on basic principles. This included studying the various contributors and how they affected the overall uncertainty as each was varied in the uncertainty budget. An example was the difference in temperature between the reference gauge block and the test gauge blocks. A large difference in temperature between the two lead to an increase in the measurement uncertainty, leading to the conclusion that it was better to have the two be at the same temperature before calibration, which was easier to achieve with gauge blocks composed of like material.

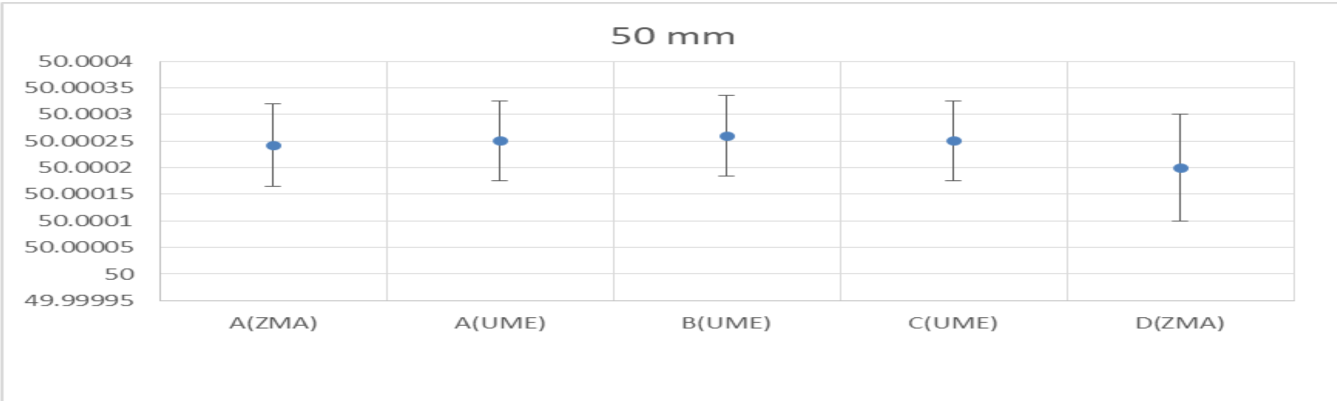
2. PRACTICALS
   The time spent in the laboratory included learning how to
   - Clean and inspect the gauge blocks for scratches, burs and rust and then apply the appropriate process for removing rust and burs.
   - Check the parameters such as wringing and flatness with the use of an optical flat.
   - Clean and calibrate the mechanical gauge block comparator
   - Service the comparator, including the checking and changing of probes.

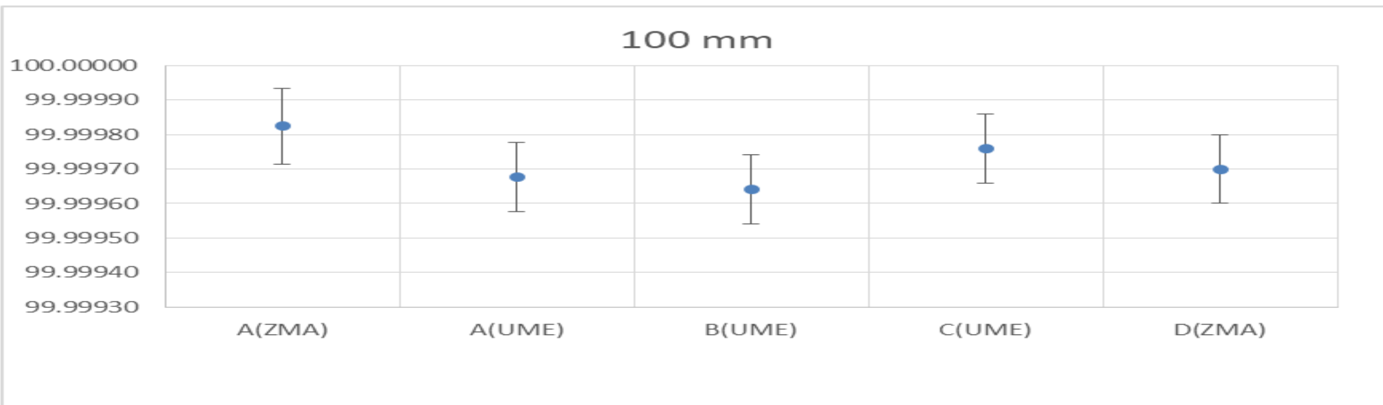
3. INTER-COMPARISONS
   With our reference gauge blocks and reference measurement device calibrated, the best way to test our methods and measurement devices was to carry out a trial inter-comparison amongst ourselves. For this exercise I had 3 gauge blocks of 2.5 mm, 50 mm and 100 mm, which had been calibrated by the Zambia Metrology Agency Dimensional Laboratory. We first measured the gauge blocks by interferometry to use as a reference value. The gauge block calibrations were then carried out on the UME comparator with UME reference standards with 3 participants and then repeated on the ZMA Mahr comparator with ZMA reference standards. The results obtained were then compared using the E_n value.

Results

The inter-comparison carried out was not official and so does not reflect each laboratory's capabilities. It was a way to help check our methods and comparator device**.** The results obtained from the measurements are illustrated in the following three graphs.







The results were evaluated using the E_n value criteria. Where the values were acceptable if $-1 \leq E_n \geq 1$. From the criteria used all the participants' measurement results were acceptable.

Conclusions and Future Work

Based on the comparison results obtained we can say that our measurement device and techniques are fit for use. It was learnt that minimizing the variations (say from 20 ± 1 to 20 ± 0.3) in environmental temperature reduced the measurement uncertainty. The small margin also allowed for small differences between the standard and test gauge blocks. For the longer gauge blocks (50, 75,100) mm, it was observed that without allowing for stabilization, the readings obtained both during gauge block calibration and comparator calibration had large standard deviations contributing greatly to the measurement uncertainty.

With the above outcome we now look forward to successfully taking part in supplementary gauge block inter comparisons and submitting our CMC's for review towards achieving our goal of publishing our CMC value in the BIPM KCDB.

We also look forward to extending the knowledge acquired towards improving and expanding this capability to include the calibration of long gauge blocks.

Acknowledgements

I would like to thank the BIPM Capacity Building & Knowledge Transfer Programme for having provided this opportunity to learn from experienced Metrologist such as Dr. Tanfer Yandayan and Sibel Asli Akgöz, who despite their busy schedules spared their time to teach me and for their questions and answers towards helping me understand further. I also wish to give thanks to Mr. Tamer Çetin for his help and guidance in the laboratory, and to all the UME team for making my stay comfortable and to the Zambia Metrology Agency team for their support in undertaking this project.