14th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2010, Mediterranean Cruise, 11-18 September 2010

THE IMPORTANCE OF INTERLABORATORY COMPARISON IN LENGTH MEASUREMENT AS A PREREQUISITE FOR RAISING THE ACCURACY OF MEASUREMENT AND DEVELOPMENT OF MEASUREMENT TRACEABILITY

Hazim Bašić
University of Sarajevo, Mechanical Engineering Faculty Sarajevo
Vilsonovo setaliste 9, 71 000 Sarajevo
Bosnia and Herzegovina

Almira Softić
University of Sarajevo, Mechanical Engineering Faculty Sarajevo
Vilsonovo setaliste 9, 71 000 Sarajevo
Bosnia and Herzegovina

ABSTRACT
In view of the ever-increasing globalisation of economy, the removal of technical barriers to trade has become a central political task. To establish the preconditions for free trade throughout world, the World Trade Organization adopted agreement encouraging the development of mutual recognition agreements and of international conformity assessment systems. Such agreements are based on mutual confidence and manifest the final result of a continuous and close cooperation programme essentially consisting of three major elements: the harmonization of accreditation criteria and operation procedures, a comprehensive programme of interlaboratory comparisons and peer assessments by an international team of experienced accreditation experts.
Gauge block calibration is one of the oldest high precision calibrations made in dimensional metrology. The most accurate measurements of gauge blocks have not changed appreciably in accuracy in the last 70 years. What was changed is the much more widespread necessity of such accuracy. Already, for many decades, the laboratory community has used interlaboratory studies as an external quality control.
Keywords: interlaboratory comparison, traceability, length measurement

1. INTRODUCTION

Interlaboratory studies serve several needs and aspects of the quality management of measuring measurements. They allow the validation of measuring methods, assessing the proficiency of individual laboratories, estimating measurement uncertainty and certifying reference materials in a wide range of application fields (ranging from industry, over environmental science to food analysis).
Gauge block calibration is one of the oldest high precision calibrations made in dimensional metrology [1, 5, 6]. Since their invention gauge blocks have been the major source of length standardization for industry. The most accurate measurements of gauge blocks have not changed appreciably in accuracy in the last 70 years. What was changed is the much more widespread necessity of such accuracy. Measurements, which previously could only be made with the equipment and expertize of national metrology laboratory, are routinely expected in private industrial laboratories. Already, for many decades, the laboratory community has used interlaboratory studies as an external quality control.

2. METROLOGY AND ACCREDITATION IN GLOBALISED ECONOMY

The world economic integration, known as Globalisation, has recently gained tremendous dynamism. Factors such as liberalisation of trade, rapid development of infrastructure in the fields of transport and communication, together with political integration movements accelerate this process. Metrology and accreditation play an important, yet often littleknown role in this process.

Measurement underpins a wide range of socio-economic activities, both domestic and international. Every day, thousands of chemical measurements support decisions on food safety, health and environmental protection. The global market, too, needs accurate and reliable measurements so that technical barriers to trade can be minimised. In all these sectors, the concept of "tested once, accepted everywhere" is increasingly important, and the need for reliable measurement results that can be compared across space and time has never been greater. Reliable measurements depend critically on competent staff, validated and tested methods, comprehensive quality systems, and traceability to appropriate measurement references. Recognition of these requirements is underscored by the increasing adoption of standards and measurement quality systems, such as laboratory accreditation against ISO 17025:2005.

At the national and international level, comparability between national measurement systems is being continually improved by intercomparison of measurement standards at the National Metrology Institute (NMI) level. A multilateral mutual recognition arrangement was signed in 1999 by the member nations of the Meter Convention in response to the need for an open, transparent and comprehensive scheme to give users reliable quantitative information on the comparability of national metrology systems. Individual measurement and testing laboratories play their part by careful use of appropriate measurement and reference standards for calibration and control of their measurement processes. In an increasingly regulated environment, however, laboratories are under greater pressure to demonstrate that their use of measurement and reference standards is indeed both appropriate and sufficient.

3. PROFICIENCY TESTING AND ITS SIGNIFICANCE

Interlaboratory studies, which are sometimes also called collaborative studies or trials or ring tests, are studies in which several laboratories analyse the same material(s). Depending on the focus of the study three main types can be distinguished:

1. *Collaborative trials or method-performance studies* assess the performance characteristics of a specific method. In the ISO 5725 guidelines [2] they are called *accuracy experiments* and consider the evaluation of the precision as well as the trueness from the interlaboratory trial. The ISO 5725-2 guideline [2] specifically describes *precision experiments* for the determination of the repeatability and the reproducibility. The second part of accuracy is trueness, which, in an interlaboratory context, measures the bias of the measurement method. ISO describes the *bias experiments* in ISO 5725-4 [2].

2. *Laboratory-performance or proficiency studies* focus on the laboratory with the aim to assess the proficiency of the individual laboratories. In such studies, sometimes called round-robin studies, test samples which are known or have been assigned, often from the interlaboratory experiment itself is analysed by a group of laboratories. The laboratories apply whatever method in use in their laboratory. Proficiency testing is an essential part of the accreditation of analytical laboratories. In contrast to collaborative trials, which are generally organised by one of the participating laboratories, proficiency tests that are planned a few times per year are managed by an external body.

3. The objective of *material-certification studies* is to provide (certified) reference materials. A group selected laboratories analyses, preferably with different methods, a material to determine the most probable value of the concentration of a certain analyte with the smallest uncertainty possible.

ISO 5725-1 defines repeatability as “the precision under repeatability conditions” [3].. This means “conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time”. Short intervals of time mean that the measurements are carried out without recalibration of the instrument, unless the recalibration is an inherent part of the method. Theword “independent” means that all steps of the method must be carried out for each replicate measurement.

The repeatability can be described by the repeatability standard deviation s_r. Another measure is the repeatability limit, r. This is defined by ISO as “the value less than or equal to which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 95%”. It can be shown that

$$r = 2.8 s_r \quad (1)$$

The repeatability variance and relative repeatability standard deviation are written as $s^2 r$ and RSDr, respectively.

Reproducibility is defined by ISO as the “precision under reproducibility conditions” [3].. The latter are “conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment”. It follows that the reproducibility of a method is necessarily obtained from a collaborative precision study.

The reproducibility limit R is defined by ISO as “the value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of 95%”. It is obtained as

$$R = 2.8 s_R \quad (2)$$

Notice that the GUM [4, 5] defines reproducibility as “the closeness of agreement between the results of measurements of the same measurand carried out under changed conditions of measurement”. The Guide continues to specify that the changed conditions may include different principles or methods of measurement, different observers, different measuring instruments, different locations, different conditions of use or different periods of time and a note specifies that “a valid statement of reproducibility requires specification of the conditions changed”. Reproducibility is then no longer linked to a specific method and therefore, in a GUM context, an interlaboratory study as described in this article measures reproducibility in a measurement set up in which all possible conditions change except the method applied.

Proficiency testing is a method of checking laboratory testing performance by means of an inter-laboratory test. Participation in PT schemes provides laboratories with an objective of assessing and demonstrating the reliability of data they are producing. Besides these, it is also mandatory for all accredited and applicant (for accreditation) laboratories to participate successfully in a proficiency testing program in their respective scope of testing. Interlaboratory comparisons are widely used for a number of purposes and are being increasingly used internationally.

A Proficiency Testing (PT) scheme is a system for objectively evaluating laboratory results by external means, and includes regular comparison of a laboratory's results at intervals with those of other laboratories. This is achieved by regularly distributing homogeneous test samples to participating laboratories for analysis and reporting of the data. The main objective of a PT scheme is to help the participating laboratory to assess the accuracy of its test results.

Proficiency testing techniques vary, depending on the nature of the item or material under test, test method in use and the number of testing laboratories participating. They possess the common feature of comparison of test results obtained by one testing laboratory with those obtained by other testing

laboratories. In some programs, one of the participating laboratories may be controlling and coordinating.

The purpose of inter-laboratory tests include:

- This type of test is used to determine the competency of an individual laboratory for specific tests (as per the requirement of the accreditation body).
- Inter-laboratory tests are effective in checking the consistency or comparing the competency of personnel involved in testing.
- This technique also provides confidence in the calibration of instruments.
- It helps in ensuring the uniformity of test methods employed in different laboratories.
- Interlaboratory tests are conducted to achieve confidence in testing.

The benefits to the participating laboratory include:

- Provides reliability of data produced by the laboratory.
- Supplements the laboratories' own internal quality control checks, like calibration or tracebility of reference standard.
- Acts as a tool for validation of test method.
- Results of a proficiency testing program can be used for determination of measurement of uncertainty of a test method.
- Analysis and interpretation of PT test results helps in achieving uniformity of test results across the different laboratories.

4. CONCLUSION

Proficiency testing is gaining increasing importance as a quality assurance tool for laboratories. The performance of laboratories in proficiency testing schemes is also being increasingly used, particularly by accreditation bodies, as a measure of the competence and quality of laboratories. It is important for laboratories to have comprehensive information on the scope and availability of proficiency testing schemes in the areas in which they work. This will enable them to make appropriate decisions about in which scheme they should participate. Laboratories, therefore, need to develop a good working understanding of proficiency testing, what the objectives of proficiency testing are, and how the data from proficiency testing schemes should be evaluated and used. This is important not only for laboratory staff and management within laboratories, but also for those who use their results, including accreditation bodies and the laboratory's customers.

5. REFERENCES

[1] Dorion T., Beers J.: *The Gauge Block Handbook*, NIST Monograph 180, Dimensional Metrology Group, Precision Engineering Division, National Institute of Standards and Technology, 2005.

[2] *Accuracy (trueness and precision) of measurement methods andresults—parts 1–6* (ISO 5725), International Organisation for Standardization (ISO), Geneva, 1994.

[3] *Statistical methods for use in proficiency testing by interlaboratory comparisons(ISO 13528),* International Organisation for Standardization (ISO),Geneva, 2005.

[4] EA document *EA-4/02 Expression of the Uncertainty of Measurement in Calibration*, European cooperation for Accreditation, 1999.

[5] http://www.itl.nist.gov/div898/handbook/mpc/section3/mpc342.htm

[6] Softic A., Basic H., Sinisa T.: Some aspect of measurement uncertainty calculation in gauges block calibration, 12th International Research/Expert Conference 'Trends in the Development of Machinery and Associated Technology', TMT 2008, Istanbul, Turkey, 26-30 August, 2008.