INTERCOMPARATION AS AN EXCELLENT TOOL FOR TESTING LABORATORY METHODS AND PRACTICE

Nermina ZAIMOVIĆ UZUNOVIĆ[1], Hazim BAŠIĆ[2], Almira SOFTIĆ[2]

1 Mechanical Engineering Faculty Zenica, B&H, nzaimovic@mf.unze.ba
2 Mechanical Engineering Faculty Sarajevo, B&H, basic@mef.unsa.ba, softic@mef.unsa.ba

Abstract:
Proficiency testing is an important way of meeting the requirements of ISO/IEC 17025 in the area of quality assurance of laboratory results. Laboratory for dimensional measuring technique on Mechanical Engineering Faculty participated in comparison of dial gauge and external micrometer. The key requirements of such comparisons are that the samples are same or similar, and also that the set of samples measured are appropriate to test and display similarities and differences in results. A proficiency testing 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. The main objective of a proficiency testing scheme is to help the participating laboratory to assess the accuracy of its test results. Regular participation in a proficiency testing scheme provides independent verification of measurement capability of a laboratory and shows a commitment to a maintenance and improvement of performance. Participants were three laboratories from Bosnia and Herzegovina and one pilot laboratory was from Norway. Included laboratories calibrated the instruments using their own procedures and issue their standard calibration certificates according to their accreditation scope. Circulation of testing instruments was from pilot laboratory to the participating laboratories one by one and again to the pilot laboratory for checking. The values compared were: f_{max} for external micrometer and f_e,f_{ges} and f_u for dial gauge.

Keywords: Laboratory, Proficiency testing, Intercomparison, Length measurement

1. INTRODUCTION

Proficiency testing involves a group of laboratories performing the same measurements on the same samples and comparing results. According to the standard ISO/IEC 17025:2005 a laboratory shall have the quality control procedures for monitoring the validity of test and calibration undertaken. It demonstrates to the public, customers, accreditation bodies, regulators, and management that procedures are under control and gives laboratory's staff confidence that the service which they provide will withstand scrutiny.

The basic purpose of proficiency testing is to assess performance of laboratories for their conduct of specific test, measurements or calibrations. Many laboratories operate in isolation from other laboratories and do not have ongoing opportunities to compare their data with others. Without such opportunities there are risks that a laboratory's data may have errors, biases or significant differences compared to similar laboratories, [1].

Proficiency testing provides an opportunity to undertake such comparisons and to have an independent appraisal of the laboratory's data compared to reference values (or other performance criteria) or to the performance of similar laboratories. The results from such participation provide laboratory managers with either a confirmation that the laboratory's performance is satisfactory or an alert that investigation of potential problems within the laboratory is required. If the proficiency testing program is an ongoing program, participation also provides laboratory management with continuous monitoring of the comparability of the laboratory's data and of its continuing effectiveness, or otherwise, in the relevant tests or measurements involved.

It is also mandated by accreditation bodies that laboratories participate in proficiency testing programs for all types of measurements undertaken in that laboratory, when suitable programs exist. The key requirements of such comparisons are that the samples are same or similar, and also that the set of samples measured are appropriate to test and display similarities and differences in results. Regular participation in a proficiency testing scheme provides independent verification of measurement capability of a laboratory and shows a commitment to a maintenance and improvement of performance, [2].

The typical format of proficiency testing programs issues a set of samples to each participant together with a set of instructions and any necessary background information. The participants then carry out the requested measurements in their normal manner and submit their measuring results. The results are then statistically handled to generate a report. Each participant is confidentially provided with a report to allow them to compare their performance with the other participants. The performance of individual laboratories will be known only by that particular laboratory and a limited number of management personnel. The handling of results is generally performed in a manner that compares each individual result with the consensus of the entire group, [3].

2. LABORATORIES AND INTERCOMPARATION PROCES

In this paper the results from a comparison of on calibration measurement results of a digital external micrometer and an analog dial gauge are presented.

Participants were three laboratories for Bosnia and Herzegovina and pilot laboratory was laboratory from Norway. One of laboratories was Laboratory for production measuring technique from Mechanical Engineering Faculty in Sarajevo (Lab C in paper). The laboratories calibrated the instruments using their own procedures and issue their standard calibration certificates according to their accreditation scope. The values to be compared were:

- External micrometer: Individual calibration points and parameters defined in the standard DIN 863: f_{max}.
- Dial gauge: Individual calibration points and parameters defined in the standard DIN 878: f_e, f_{ges} and f_u [6].

On Fig 1 and Fig 2 measuring instruments-manufacturer, range and resolution, used in process of circular intercomparation between participated laboratories are given. Reference values for calibration points on the scales are established as the mean value of two calibrations at the pilot laboratory, one before the circulation and one after.

Fig 1: Dial gauge, analogue: TESA, Switzerland
Range: 0.9 mm
Resolution: 10 µm

Fig 2: External Micrometer, digital: Mitutoyo, Japan
Range: (25÷ 50) mm
Resolution: 1 µm

Circulation of instruments was from pilot laboratory to the participating laboratories one by one and again to the pilot laboratory for checking.

In order to determine whether or not a participating laboratory is proficient for a particular measurement discipline, an evaluation of the laboratory's performance must be conducted. While many methods of evaluation exist, the most commonly used method for determining the performance of an individual calibration laboratory is the normalized error (*En*) formula. For each measurement result, the normalized error, E_n, is calculated according to the formula:

$$E_n = \frac{x-X}{\sqrt{U_{lab}{}^2 - U_{ref}{}^2}} \tag{1}$$

Where:

x - participant's measurement result
X - assigned value of the artifact
E_n - normalized error
U_{lab} - uncertainty of the participant's measurement results
U_{ref} - uncertainty of the reference laboratory's assigned value.

When $|E_n|\leq 1$ the result is "satisfactory".
When $|E_n|>1$ the result receives an action signal, or "unsatisfactory" performance, [4, 5].

Measurement uncertainty is estimated with 95% confidence level. Reference values for calibration points on the scales are established as the mean value of two calibrations at the Pilot laboratory, one before the circulation and one after. If the normalized error is below 1, the measurement results between the lab and the pilot laboratory are in conformance.

3. INTERPRETATION OF MEASURING RESULTS

According to the report of intercomparation values for normalized error, E_n, are significantly below 1, except for one included lab for one instrument. This indicates that measuring results are within uncertainties quoted.

Reference values for calibration points on the scales are established as the mean value of two calibrations at the Pilot laboratory, one before the circulation and one after. If the normalized error is below 1, the measurement between the lab and the pilot laboratory are in conformance, at this level of measurement uncertainty, specified with 95% confidence. From the formula for E_n, it is easy to see that if the measurement uncertainty at the laboratory is estimated very high, it is easy to get a low value for E_n, [6]. That is reason why the contractor of intercomparation compared measurement results directly graphically, without uncertainty bars. When considering conformance to specification of a tolerance limit in DIN standards, contractor of intercomparation took the measurement uncertainty into account. Figure 3 shows measuring results of all participating laboratories together with pilot laboratory. The measurand to be compared for the external micrometer is error of indication, and the calculated parameter f_{max} as defined in DIN 863. Reference value for the parameter f_{max} for the external micrometer is calculated as a mean value of the calculated values from each calibration, P1 and P2. Measurement uncertainties for the reference values are stated as a 95% confidence interval for a calibration at the reference laboratory. For the sake of comparison of measurement results of the external micrometer, all results were set to 0 at reading 25 mm. For our laboratory (Lab C) one measuring point was midway between two reference points, see Fig 3.

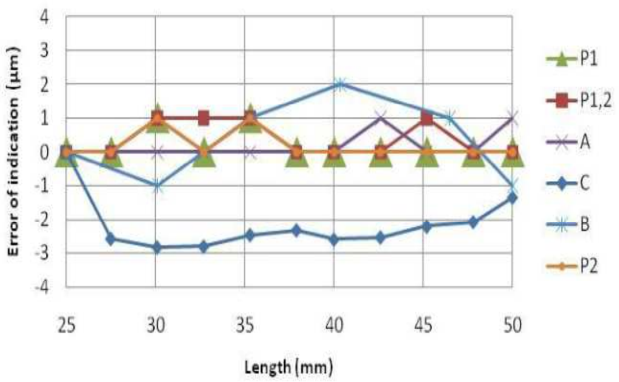

Fig 3: External micrometer, comparison of measurement of error of indication for each participant, A, B and C.

P1, P2 (overlapping results) are measurements at the pilot laboratory before and after circulation. P1,2 red curve, is calibration at pilot laboratory before circulation, but carried out by a different operator. P_{Ref}, the reference value for the comparison is established as the mean value of P1 and P2. Figure 3 indicates that there is some kind of bias effect not corrected for our laboratory which is named lab C. The resolution of the results are lower than 1 µm, because our calibration procedure on universal measuring machine was done. That was a signal to check and discuss our calibration procedure as well as method. Not using gauge blocks for calibration of the micrometer, but universal measuring machine, gives us bias effects due to incorrect measurement force.

In Table 1 measuring results and calculated values of E_n which all are below 1 are given.

The measurands to be compared for the dial gauge is error of indication, and calculated parameters f_{ges}, f_e and f_u as defined in DIN 878. Reference values for the parameters f_{ges}, f_e and f_u for the dial gauge are calculated as a mean value of the calculated values from each calibration, P1 and P2. P1 and P2 are measurements at the pilot laboratory before and after circulation. P_{Ref}, the reference value is mean value of P1 and P2. Measurement uncertainties for the reference values are stated with 95 % confidence interval for a calibration at the reference laboratory.

For the sake of comparison of measurement results of the dial gauge, all results were set to 0 at reading -0.45 mm. Figure 4 and Figure 5 shows comparison of error of indication (upward and downward) for each participant, A, B and C.

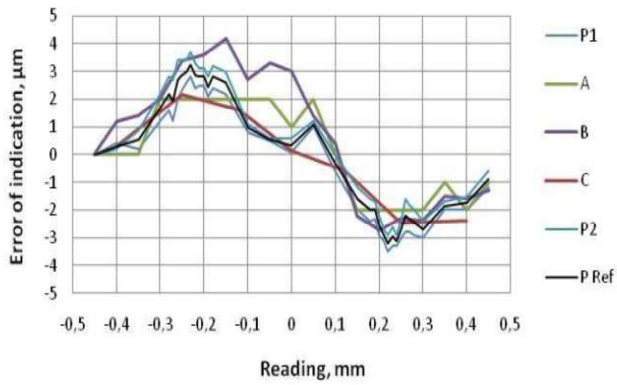

Fig 4: Dial gauge, comparison of error of indication (upward) for each participant, A, B and C.

To check if the instrument under calibration is conforming tolerances (ISO, DIN, etc) it is mandatory to have low measurement uncertainty compared to the tolerance. The measurement result expanded with the measurement uncertainty needs to be lower than the tolerance specified in order to make statement that with 95% confidence the instrument is conforming to specifications.

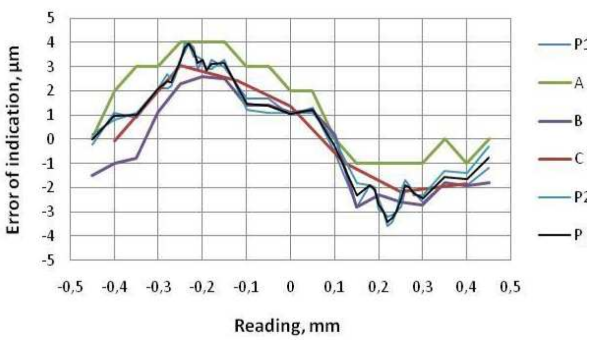

Fig 5: Dial gauge, comparison of error of indication (downward) for participated laboratory, A, B and C.

Table 1: Comparison of reported parameters f_{ges}, f_e, f_u.

	Ref			A			B			C		
	f_{ges}	f_e	f_u	f_{ges}	f_e	f_u	f_{ges}	f_e	f_u	f_{ges}	f_e	f_u
Parameter, µm	7,4	6,5	1,4	6,0	4,0	3,0	7,0	6,9	2,2	7,5	6,8	2,7
U(95%)	0,7	0,7	0,7	5,8	5,8	5,6	5,6	5,6	5,6	7	7	7
E_n				0,24	0,43	0,27	0,07	0,07	0,14	0,01	0,04	0,018

CONCLUSION

Proficiency testing has an increasing importance as a quality assurance tool for 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, [7]. One unsatisfactory result in any round does not make laboratory poor, neither does achievement of 100% satisfactory results in any round make a laboratory necessarily good. Maybe, not using gauge blocks for calibration of the micrometer, but for example a length measuring instrument with higher resolution, might give bias effects due to incorrect measurement force. All above mentioned show how valuable information can be obtained by interlaboratory comparisons. It is important that laboratories give to its customers the right information regarding the accuracy of the results of their calibration standards and instruments. Intercomparison of measurements results are one of the main ways of proving realistic estimates of measurement uncertainty. Without participation in the intercomparation processes, such sources of error could remain undetected and the laboratory would not have been able to undertake appropriate corrective actions. Laboratory response to the unsatisfactory result will give more information about itself than the unsatisfactory result, [8]. The basic principle of the laboratory work must be – compare our measuring results and find out where we are in the world of metrology, [9]. The experience of each laboratory, which confers intercomparisons, it can not replace modern equipment and other assumptions. Therefore, collaboration between the laboratories is necessary for solving common issues and dilemmas that challenge the results of intercomparison, [10].

REFERENCES

[1] Basic H., Softic A.,: The importance of interlaboratory comparison in length measurement as a prerequisite for raising the accuracy of measurement and development of measurement traceability, 14th International Research/Expert Conference ‘Trends in the Development of Machinery and Associated Technology’, TMT 2010, Mediterranean Cruise, 11-18 September, 2010.

[2] ILAC-G22 ILAC Use of Proficiency Testing as a tool for Accreditation in Testing, ILAC, 2004.

[3] EA-2/10 EA Policy for Participation in National and International Proficiency Testing Activities, European Co-operation for Accreditation, 2001.

[4] Standard BAS ISO/IEC 17043:2010 Conformity assessment-General requirements for proficiency testing First edition, 2010.

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

[6] Pajkic B.,: Medulaboratorijska saradnja-Primjeri interkomparacije rezultata mjerenja etalona duzine, Kongres metrologa 2011, Kladovo, Oktobar, 2011.

[7] Karlsson H.: Comparison of dial gauge and external micrometer, Report on results, Justervesenet, Norway, May 2011.

[8] Hellenic Accreditation System S.A. PT policy: ESYD Policy relevant to proficiency testing schemes and interlaboratory comparisons, ESYD PDI/02/01/02-09-2011.

[9] Santovac, D., Redžepović, A., Bogojević, K., Značaj PT šema, *Akreditaciono telo Srbije, Bilten*, God. **1**, (**2**), Beograd, 2011.

[10] Stein, P.: “Calibration Buyers, Beware”: What to look for when considering a commercial calibration laboratory", American Society for Quality's, Quality Progress magazine, 2000.