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THE ART OF CALIBRATION

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Abstract: Calibration of measuring instruments is one of the fundamental metrological activities. Calibration is a specific art of measurement, which requires a lot of theoretical knowledge on the measurement, technical and metrological parameters of the instrument under Calibration, as well as the other ability to make the calibration procedure in a suitable and right way. Without the properly calibrated measuring instrument no measurement could be declared as correct and traceable to the national or international standard.

In this paper, we will explain the basic requirements and practical principles, which have to contribute to obtain correct and reliable calibration results.

Keywords: Calibration, calibration procedure, evaluation of calibration results

1   INTRODUCTION

The term "calibration" originates in the 18th century and was connected with the massive production of fire-arms [1]. Further development of measuring instruments led to the more expanded approach of this term and the valid definition of the calibration [2] includes essential elements of this phenomenon.

In the modern metrology, the calibration of working measuring instruments plays an important role. Especially, for the accreditation process of calibration laboratories, it is destinated to the acceptability of any laboratory, its calibration results and for the reliable interpretation of its calibration certificates.

2   WHAT IS THE ESSENCE OF CALIBRATION?

The definition of calibration in [2] is not fully clear and understandable for many metrologists in the practice. If we wish well comprehend the essence of calibration, we need the deeper analysis of the definition's text. By the other words, the calibration might be interpreted as the determination of measuring instrument's errors in its whole measuring range.

Calibration gives the user of a measuring instrument a set of data (errors, or corrections), which may lead to the better using this instrument in the practical application.

Calibration is very important for the statement of traceability [4]. Without the unbroken chain of calibration (beginning from the primary standard) it could not be assured the reliable and correct result of any measurement. Furthermore, the verification of measuring instruments [2] requires, as the first step of the verification procedure, the calibration of the measuring instrument. Unfortunately, in the practice a misunderstanding often happens.

3   WHAT ARE THE BASIC ELEMENTS OF CALIBRATION?

If we consider the calibration of measuring instrument as a process, we should analyse this process as a of many elements [5]. These basic elements are as follows:

a) choice of a measurement standard,
b) determination of a calibration step,
c) number of calibration runs (repeated measurements),
d) evaluation of calibration results,
e) presentation of calibration results.

All these elements should be taken into consideration by creating of calibration producer for the specified measuring instrument. As it has been explained in [5], the calibration is a rather complex issue and requires the good knowledge in the field of physics, instrumentation, mathematical methods of data evaluation and certainly, experienced and well trained personnel.

The choice of a measurement standard should be always based on the requirement of measuring instrument user, in connection with the final uncertainty values for calibration results. That means, as a general rule, the uncertainty of the values, represented by the measurement standard, should be in the range of 0.1 to 0.3 of values, required for calibration by the user of measuring instrument.

Sufficient determination (choice) of calibration step (or the number and location of calibration points) often requires special experiments [3]. It is a common practice, that the calibration points are equidistant position through the measuring range, however by many measuring instruments this may cause additional errors [6]. By our experience, the calibration step, based on 7 to 10 calibration points will be sufficient for the majority of the calibrated measuring instruments. If the user of measuring instrument has any special requirements concerning the calibration step, the calibration laboratory should to accommodate his demand.

The number of calibration runs is crucial for reliable calibration results and it must be determined with respect to the user's requirements, concerning the uncertainty of the calibration. Repeated calibration measurements influence the value of the A type uncertainty u_A. As a rule, the u_A should be lower as the second component of a combined standard uncertainty u_B. Before the planning of calibration procedure, the analysis of this calibration element should be performed.

Evaluation of calibration data consists of the calculation of final errors (or corrections) and uncertainties. It is of a great importance, by the components (partial uncertainty elements),they will create the final uncertainty value u_c

As the last element of calibration, the presentation of calibration results should be performed with special care [3]. There are three possibilities, how to present (in Calibration certificate) calibration results. Firstly, the results can be displayed in a table form, secondly as a graphical presentation of the error or correction curve and, thirdly, as a mathematical explanation of calibration results in the form of experimental equation [3]. All these methods of presentation of calibration results might be considered as suitable. Certainly, the calibration laboratory should prefer the presentation form, required by the user of calibrated measuring instrument.

4   HOW TO DESIGN A CALIBRATION PROCEDURE?

Any calibration laboratory, which is involved in the accreditation process, should have the documented methods of calibration for various measuring instruments. By the other words, for any relevant type of measuring instrument the calibration procedure must be defined and described in a special document (named as the "Calibration procedure"), which is an integral part or the documentation for the laboratory quality system.

By the designing the calibration procedure it must be respected all the elements of the calibration (as mentioned in the Chapter 3) and , if needed, other specific technical, metrological and processing parameters, relating to the measuring instrument.

No doubt, the designing of calibration procedure is a process, that requires a lot of knowledge, experience and a good ability to write a text, understandable for laboratory staff, as well as for the user of measuring instrument.

5   THE PROBLEM OF RE-CALIBRATION INTERVAL

A re-calibration interval is a period between two successive calibrations. This interval is not defined in the calibration certificate, however, its of a great importance.

If we consider, that the calibration is done a calibration laboratory with nearly ideal environmental conditions (humidity control, temperature stability, absence of vibrations, etc.), the results of calibration are valid only fore these conditions. But, the calibrations measuring instrument is mostly used in other conditions and therefore the results of calibration might have only the limited validity.

The need of a re-calibration is indisputable, but the re-calibration interval might not be determined by the calibration laboratory. In this case, the user's experience is crucial, e.g. the measuring conditions should be re-calibration more frequently,
For the suitable solution of this problem, the recommendations for re-calibration intervals are in the guide [7] explained.

6   CONCLUSION

Calibration is a special art of measurement, that requires a lot of theoretical knowledge, practical experience, skills and ability to write the sufficient calibration documents. The importance of calibration [8] and fundamental principles described in this paper, should be inspirative for all the persons, dealing active in the calibration laboratories.

REFERENCES

[1] C.F. DIETRICH, Uncertainty, Calibration and probability 2nd ed., Adam Hilger, Bristol/Philadelphia/ New York, 1991, XVI + 535 p.

[2] International Vocabulary of Basic and General Terms in Metrology, 2nd ed., ISO, Geneva 1993, 59p.

[3] P. Farar, I. Brezina, Traceability and Calibration - the primary requirement of accurate measurements, in: F. Torres, J.J. Aguilar, M.A. Lope (eds.), ISMQC' 95, (Zaragoza), 1995, p. 38-45

[4] P. Farar, I. Brezina, Traceability and Calibration, in: Proceedings of the XIV. IMEKO World Congress, Vol, V, Tampere 1997, p. 161-163

[5] I. Brezina, P. Farar, Calibration of measuring instruments - the key issue of the laboratory quality management, Menadzment totalnim kvalitetom (Beograd), 24, (3-4), 1996, p. 32-36

[6] G. Betta, M. Dell'Isola, Optimum Choice of Measurement Points for Sensor Calibration, Measurement, 17, (2) 1996, p. 115-125

[7] International Document No. 10: Guidelines for the Re-calibration Intervals of Measuring Equipments Used in Testing Laboratories, OIML Paris, 1994

[8] The importance of calibration, Lab Products International, 13, (5), 1999, p. 18

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