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A SEMI-AUTOMATION PROCEDURE FOR DIAL COMPARATORS CALIBRATION

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Abstract – In this article an improvement of a calibration process of measurement equipment in the field of dimensional metrology is presented. Devices under calibration process are dial comparators. The semi-automated process is focused on the acquisition and treatment of the calibration data. The aim of the semi-automated implementation is the improvement of the process performance for error minimization produced by human factors and a reduction of time.

We have implemented semi-automated process is as the operator experience and knowledge also brings quality to the calibration process itself.

Keywords: quality process, uncertainty, instrumentation controlled by computer.

1. INTRODUCTION

Calibration is an important issue to ensure that the instrument is performing correctly, and measures accurately the true value. When an instrument is calibrated, a Calibration Certificate is issued. To ensure the validity of each calibration, the reference equipment used is also calibrated and is traceable to a nationally recognized standard. The calibration certificate also contains the model, serial number, and date the instrument was calibrated, and who performed the calibration. Using a manufacturer certified facility ensures that proper procedures are followed when calibrating the instrument. This removes any uncertainty associated with the reliability and measurement accuracy of the instrument, and ensures the integrity of the measured record if it is ever called up as evidence in a court of law. Using unauthorized facilities may cause problems in court if the reference equipment is not traceable, or if the certification documents are incomplete.

ISO/IEC 17025 [1] is the main standard used by test and calibration laboratories.

Laboratories use ISO/IEC 17025 to implement a quality system aimed at improving their ability to consistently produce valid results. It is also the basis for accreditation from an Accreditation Body. Since the standard is about competence, accreditation is simply formal recognition of a demonstration of that competence[8],[9].

Laboratory of Metrology and Calibration (from now LMC), situated in the Technological Center of Vilanova i la Geltrú (from now CTVG) within Technical University of Catalonia (from now UPC), obtained the accreditation from the ISO 17025 [1] with the nº accreditation 152/LC375 for the ENAC entity [2].

The LMC is carrying out tasks of support and technological transfer to companies, in order to improve their quality [9]. The reason that motivated the accreditation process of the LMC in ISO 17025 standard, was the improvement of the LMC quality towards the companies. This accreditation gives an international dimension of quality to the laboratory that is necessary for certain companies, especially the companies having the ISO/TS 16949 [6] since this is one of the requirements for the external laboratory.

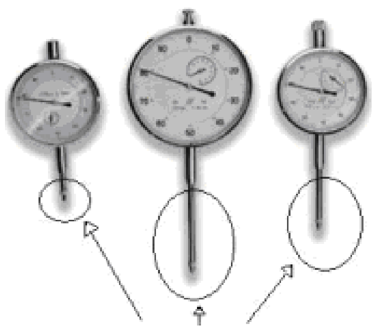

Fig. 1.Dial comparators. Devices under calibration

To assure quality in the product production process in a company, one of the most important factors is the need of a calibration planning in time for the measuring equipment. This assures that its equipment work in its range of acceptance. The range of acceptance is defined since anyone can mark the limits of acceptance of the measurement

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equipment taking into account (or correction) its error and the uncertainty. This is the information that certificate of calibration of an equipment offers.

An automated process of calibration has been developed for dial comparator equipment. The dial comparator is a mechanical device that indicates the variations of movement in an axis. The mobile part along the axis is remarked in Fig 1. Next section is describes the measurement equipment and the calibration process.

2. MEASUREMENT SYSTEM DESCRIPTION

In order to calibrate a dial comparator, the equipment used has a probe with a digital reader, and a chassis prepared for carrying out the comparison. Fig. 2 shows a brief description of the calibration equipment.

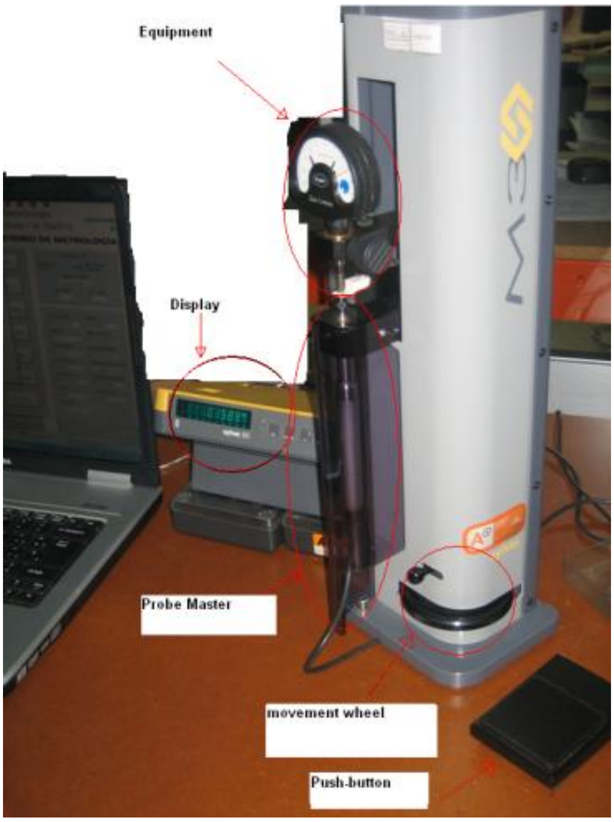


Fig. 2.Calibration Equipment

The digital reader (Fig. 2 display) has a RS-232 communication port that enables the data transfer to a computer.

This equipment has a great variety of ranges (50mm, 10mm, 5mm, 3mm, 0,8mm, for example) for measuring and a great variety of resolutions (0,1mm, 0,01mm, 0,001mm, 0,0005mm, for example). The use of this equipment is very diverse as detecting height variations in a production line, detecting vibrations or direct measurement of pieces, etc. This equipment is mainly used in mechanical implementation and automation sector.

3. ACQUISITIONS AND PROCESSING SYSTEM

A RS-232 to USB interface is used to connect the calibration equipment to a laptop computer. Graphical programming language, LabVIEW [3], is used to develop the communication and application software. This language programming has 2 panels, the front Panel in order to design the user interface and the block diagram for the graphical source code. For carrying out the communication correctly the characteristics of the protocol defined by the manufacturer, have to be analyzed. Once we recognize all the functions necessary to receive data from the calibration equipment, we are ready to carry out the application software.

In our case we have to automate an internal procedure IC-05. This procedure fulfills the ISO 17025[1] and it has been audited by ENAC [2], where the method and calculations of the uncertainty are specified, according to EA-4/02 [4] and the CEA-ENAC-LC/02 [5]. To have a guide we detail that the process of calibration is divided into two phases:

Phase 1:

- Definition of the initial point.
- Moving the axis until the end of the itinerary.
- Moving the axis until the initial point.
- In this process 11 upward readings and 11 downward readings are taken.

Phase 2:

The repetition of the equipment is estimated in 2 points. The choice of the points would not be arbitrary. 1 point is the full stop of the itinerary, and the other point is the initial point.

Application software takes into account these two process phase's related follows.

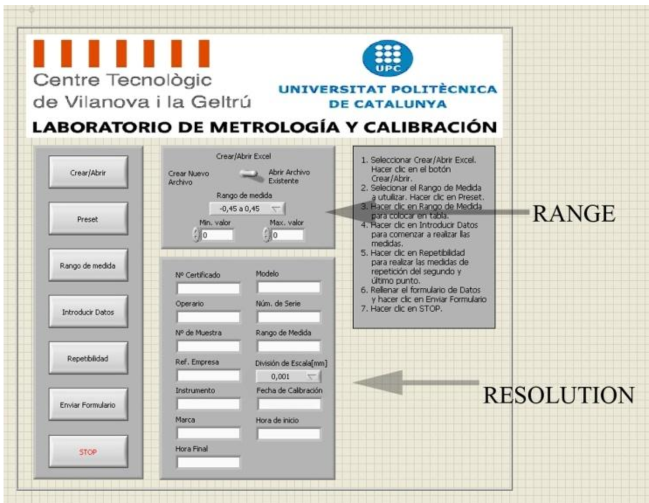
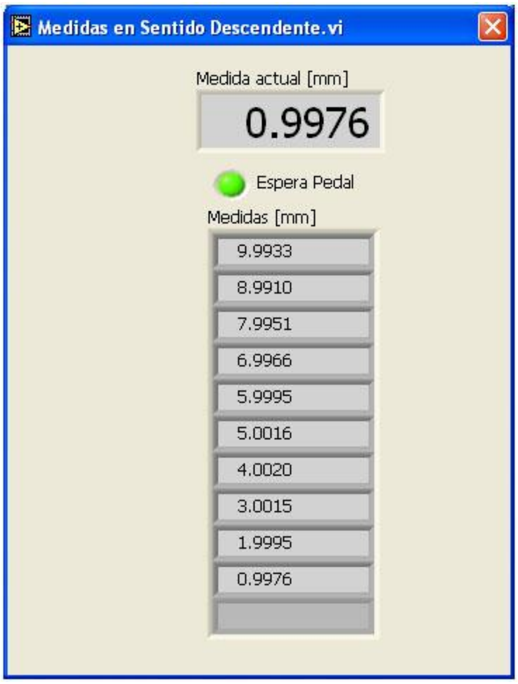


Fig. 3.Front Panel Interface. Range and Resolution Configuration

Phase 1. The application software requests the range and resolution of the equipment under test (Fig. 3.). Then, the dial in the equipment has to include master as figure 2 shows. Now calibration process starts. Initially an Excel file is opened where all the data coming from the calibration instruments will be stored. This excel file includes the certificate of calibration.

Every time the calibration equipment push-button is pushed the application receives a measurement that is displayed and stored as in Fig. 4. This way we can change the direction along the axis. Both data are displayed in a front panel shown in Fig. 4.



Phase 2. In this phase the software indicates the points of repetition, and displayed.

Fig. 5.Front Panel Interface with calibration points

Next it will carry out the lay in the initial point, depending on the assigned range on the display. Fig. 5. shows the points chosen by the calibration.

Data is introduced by moving the mechanical support, through the moving wheel (Fig. 2.), to the nominal value monitored on the equipment display. Measurements are displayed as in Fig. 4.

Once the repetition of the 2 points is finished. The program will save all data in the Excel file. Calculations of all the necessary data for carrying out the certificate, the file only has to be stored and the calibration certificate is generated.

4 RESULTS

As a result we can see in figure 6 data exported from LabVIEW application software to the excel file used to elaborate the calibration certificate. The final result is a calibration certificate of the equipment.

DATOS

Punto de calibración (mm)	u_{pi}(μm)	Sentido ascendente (mm)		
		$1_{patrón}$	$1_{compara}$	Ci (μm)
-0,05	0,425	-0,0500	-0,05	0
-0,04	0,425	-0,0399	-0,04	0,1
-0,03	0,425	-0,0295	-0,03	0,5
-0,02	0,425	-0,0192	-0,02	0,8
-0,01	0,425	-0,0093	-0,01	0,7
0	0,425	0,0007	0	0,7
0,01	0,425	0,0106	0,01	0,6
0,02	0,425	0,0204	0,02	0,4
0,03	0,425	0,0305	0,03	0,5
0,04	0,425	0,0408	0,04	0,8
0,05	0,425	0,0510	0,05	1

Punto de calibración (mm)	u_{pi}(μm)	Sentido descendente (mm)		
		$1_{patrón}$	$1_{compara}$	Ci (μm)
0,05	0,425	0,0507	0,05	0,7
0,04	0,425	0,0404	0,04	0,4
0,03	0,425	0,0303	0,03	0,3
0,02	0,425	0,0200	0,02	0
0,01	0,425	0,0101	0,01	0,1
0	0,425	0,0002	0	0,2
-0,01	0,425	-0,0096	-0,01	0,4
-0,02	0,425	-0,0197	-0,02	0,3
-0,03	0,425	-0,0298	-0,03	0,2
-0,04	0,425	-0,0401	-0,04	-0,1
-0,05	0	-0,0504	-0,05	-0,4

Medida de la repetibilidad

Patrón (mm)	Comp. (mm)	C_2 (μm)
-0,0397	-0,040	0,3
-0,0397	-0,040	0,3
-0,0397	-0,040	0,3
-0,0401	-0,040	-0,1
-0,0401	-0,040	-0,1
-0,0400	-0,040	0

Patrón (mm)	Comp. (mm)	C_{11} (μm)
0,0509	0,050	0,9
0,0509	0,050	0,9
0,0510	0,050	1
0,0507	0,050	0,7
0,0507	0,050	0,7
0,0507	0,050	0,7

Fig. 6.Calibration data for the calibration certificate

The uncertainly contributions are: the repeatability, device scale, master uncertainly, temperature variation. The uncertainty is then calculated with a fixed factor k though t-student distribution. The confidence level is 95 %. To calculate the degrees of freedom Welch-Satterthwaite equation (1).

$$\vartheta_{eff} = \frac{u^4}{\frac{u_S^4}{\vartheta_S}} \qquad (1)$$

Where $\vartheta_S = n - 1$ and n is the measurement number. Then the factor k is taken from Table 1:

Table 1. Relation between ϑ_{eff} and k factor.

ϑ_{eff}	4	5	6	10	20	50	≥100
k	2,87	2,65	2,52	2,28	2,13	2,05	2,00

The expanded uncertainly is calculated use (2):

$$U = k \cdot u = k \cdot \sqrt{u_S^2 + u_E^2 + u_M^2 + u_T^2} \qquad (2)$$

The owner of the device (Dial comparators in this case), indicates the uncertainty needed for their measurements according to their company specifications. One of the calculations that our customers can carry out are expressed by (3), where U_{USO} is the uncertainty of the equipment. *U v*alue reflects the uncertainty of the equipment without taking into account its errors.

$$U_{USO} = U + |Error| \tag{3}$$

Acceptance range according to the rule UNE-EN 30012 [7] is represented by expression (4):

$$3 < \frac{T}{2 \cdot U_{USO}} < 10 \tag{4}$$

Where T represents the tolerance of the manufacturer of the product, given by the difference between the upper limit and the lower limit.

5 CONCLUSIONS

As we have verified, carrying out the semi-automated process, the person who carries out the calibration does not have to export manually 22 data values in phase 1 and 10 data in phase 2. Also we emphasize the improvement in the time of calibration. The time to realize a calibration before the application software was developed was 30 minutes for each device under calibration. Nowadays with the application software the calibration time is 10 minutes. This way we minimize the human errors in the data acquisition as well as calibration certificate generation where data has to be included in the computer.

It is also necessary to highlight how the program only carries out the acquisition and stores the data in an Excel file where two very important factors are guaranteed:

- If we carry out any modification of the calculation process, it will not affect the application.

- Impartiality in the data acquisition.

Therefore we have an improvement in the efficiency of the process as well as an improvement in the quality of work of the workers.

6. ACKNOWLEDGMENTS

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