Study of Intermediate Checking of the Calibration for Electrometers with Capacitors

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Abstract. In this article we will show the performance of electrometers when the current source came from a capacitor. This device is called "capacitance current source". We use a QuadTech capacitor of 1000 pF and a voltage of 1V. The performance of the electrometers was very different. One of the electrometers was tested with the "earth button" on at the FLUKE 5500A calibrator; and your performance was better. The measurements were made manually. It is possible that, with the automation of measurements, the performance of electrometers, for the intermediate checking of calibration, will reach a value not yet seen in this study.

1 Introduction

The National Metrology Laboratory of Ionizing Radiation (LNMRI) is located at the Institute of Radiation Protection and Dosimetry (IRD) and has responsibilities as a National Laboratory by designation of the National Institute of Metrology, Standardization and Industrial Quality (Inmetro). In the R&D context, LNMRI/ IRD develop primary standardization techniques in the areas of Radiodiagnosis, Radioprotection and Radiotherapy. In addition, it provides metrological traceability to the measurements of radiation doses received by patients undergoing radiological examinations and cancer treatments. It also contributes to the correct dose monitoring of workers in the nuclear industry and radioactive facilities, which are called OEP (Occupationally Exposed Person). For this reason, it is so important to guarantee the accuracy of measurements in these areas of application of ionizing radiation. Dosimeters are instruments built by two devices: an ion chamber and an electrometer. The first device converts the received ionizing radiation dose to electrical current (ionization current), and the second device measures the electrical charge from the chamber. LNMRI/ IRD periodically sends its standards to the International Reference Laboratories, PTB-Germany and BIPM-France.

However, after the automatization of procedures, the International Laboratories started calibrating only the ion chambers. The calibration of electrometers, associated with the National Standards, became the responsibility of the LNMRI/ IRD. [1]

There aren't laboratories in the country that calibrate electrometers at small values of electric current: 10^{-12} A. The calibration of electrometers abroad, as is currently done, represents a high cost, in addition to presenting administrative, operational and customs difficulties.

As already presented in [2] and [3], the LNMRI/ IRD started the implementation of the intermediary check of calibration [4], to guarantee that the calibration factor of a given instrument has validity for a longer time and, therefore, such an instrument could continue to be used in the laboratory routines of the LNMRI/ IRD.

The system applied to the intermediary checking was intended to monitor the drift of a measurement standard in the period between two calibrations, that is, to assess whether the characteristics of said standard have not changed significantly since the last calibration and, consequently, if the calibration certificates values remain valid. Intermediary check is an essential procedure to ensure metrological consistency [4].

At the article [5], is analyzed the interference of the application or not of the REL function in the performance of the electrometers, during the Intermediate Check. It shows that this function, widely used during the measurement, also affected the performance of the electrometers submitted to the test.

In the article [6], we compared the performance of electrometers when we used two methods of

generating electric current for the intermediate Checking, namely: 1) method where the current source is generated by the FLUKE 5500A calibrator [7], also known as Ohm's method and 2) method where the current source is generated a well-type chamber of the brand STANDARD IMAGING and model HDR 1000 Plus with the test radiation source of ^{226}Ra. This source is part of the first National Standard for measuring X-ray beams, kept at the LNMRI-IRD.

In this article, we will deal with the third source of current generation available in the LNMRI-IRD, which is the source generated by a capacitor, that is, the method where the current source is generated by capacitance.

2. Materials and Methods

To compose the circuit for obtaining the Intermediate Checking, we used a Reference Standard Capacitor QuadTech of 1000 pF, connected to a FLUKE 5500A calibrator [7] with the voltage set at 1 V and three KEITHLEY electrometers, model 6517 [8].

2.1. Measurements

Obtaining the reading of each electrometer used was done manually. Eighteen electrical charge measurements were recorded with fifteen group of measurements each. From each group of fifteen measurements, ten data measurements were used, in sequence, and these sets of ten measurements were registered, in sequence, only from the beginning or from the end of the data group of fifteen measurements; in order to have guaranteed the best practice in metrology. The electrometers used were series #885222, #1211856 and #0824993. For electrometer #885222, we also performed measurements with the FLUKE 5500A calibrator [7] with the button earth set on. We did not carry out measurements with the other electrometers with the button earth set on due to availability problems. Measurements were performed at a temperature of 20^{o} C. Each of the 15 measurements for each electrometer was performed on eighteen different days.

2.2. Result analysis criteria

The measurements were divided in 10 (ten) groups of range of standard deviation. The intervals of the ranges were decided with the base of the results observed at the laboratory by practice.

3. Results

At the table 1 are showed the results obtained from the performance of the three electrometers available at the LNMRI-IRD for the study of the Intermediate Checking of calibration. We can see that the #1211856 electrometer has shown better results, once the measurements have been concentrated in the smaller five ranges.

At the Table 2, is shown the result obtained for the performance of the electrometer #885222, when the voltage generator FLUKE 5500A calibrator was with the earth button activate. It was clear, based in the greater concentration of the results in the range 0,0 – 0,5 % of standard deviation, the good influence of the function “earth”.

Table 1. Performance of electrometers

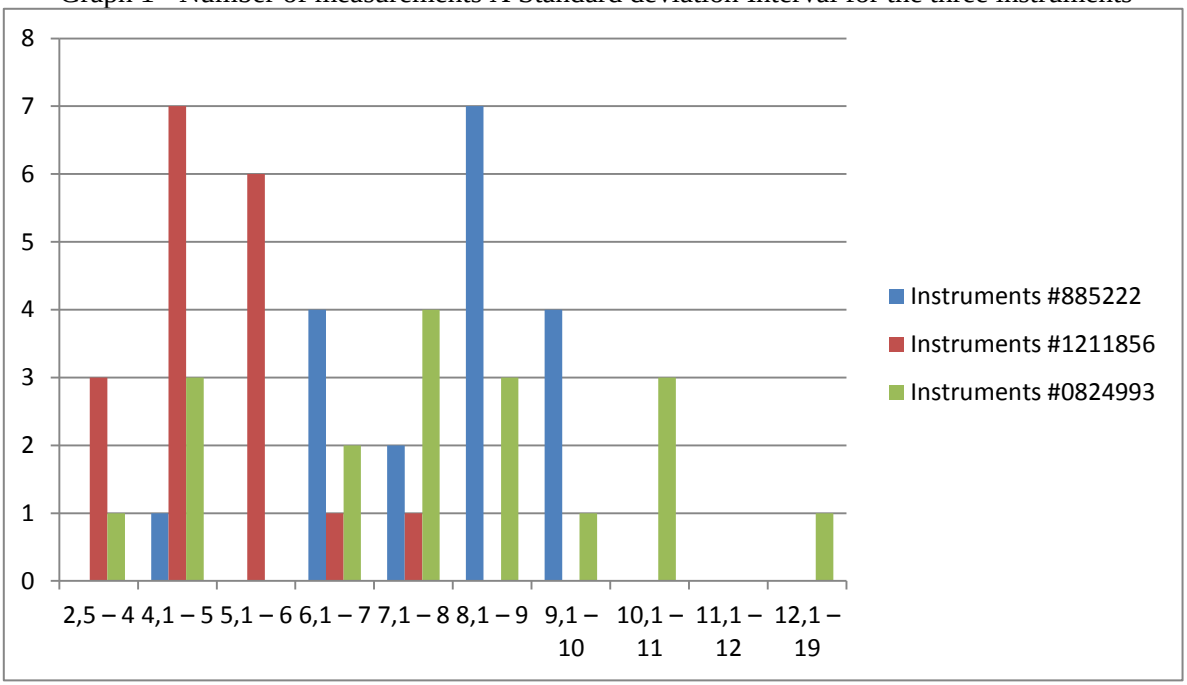
Standard Deviation [%]	*Instrumentes*		
	#885222	*#1211856*	*#0824993*
2,5 – 4		3	1
4,1 – 5	1	7	3
5,1 – 6		6	
6,1 – 7	4	1	2
7,1 – 8	2	1	4
8,1 – 9	7		3
9,1 – 10	4		1
10,1 – 11			3
11,1 – 12			
12,1 – 19			1
TOTAL	18	18	18

Table 2. Performance of the serial electrometer #885222 with the earth button on.

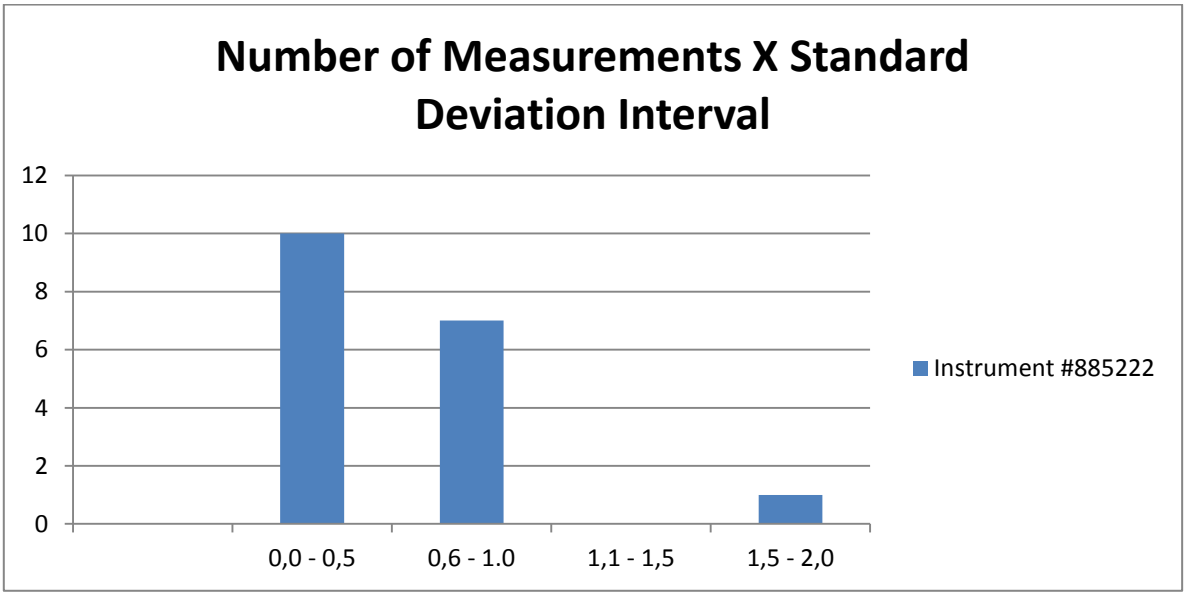
Standard Deviation [%]	*#885222*
0,0 - 0,5	10
0,6 - 1.0	7
1,1 - 1,5	
1,5 - 2,0	1
TOTAL	18

The result can also be visualized through the graph Number of measurements X Standard Deviation

Graph 1 - Number of measurements X Standard deviation Interval for the three instruments



Graph 2 - Number of Measurements X Standard Deviation for instrument #885222



4.Conclusion

We can conclude, from Table 1, that the electrometer #1211856 has shown the best performance.

An observation of the Table 2 we can conclude that the function “earth” has strongly impact for de performance of the electrometers, which indicates that this method is very promising in the study of intermediate checking of the calibration.

Unfortunately, the theme of intermediate checking of calibration for electrometers is not a common activity at the labs; that’s why we cannot present the results for comparison.

5. References

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