INSTITUTO DE PESQUISAS TECNOLÓGICAS

COMUNICAÇÃO TÉCNICA

Nº 178736

Development and validatin of a disruptive discharge simulator for use in proficiency testing activities

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Palestra apresentada no CONGRESSO INTERNACIONAL DE METROLOGIA ELÉTRICA, 2023, Itaipava. ***Pôster...*** *1 slide .*

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Development and validation of a disruptive discharge simulator for use in proficiency testing activities

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ABSTRACT

The present work aims to develop an artifact to enable the comparison of results in a dielectric strength proficiency test.

1. INTRODUCTION

The insulation resistance testing (IR) purpose to verify the quality of a product regarding electrical insulation. The importance of the test is primarily to prevent a possible accident to patient and professional responsible who may be near or in contact with a supposedly insulating surface, due to the risk of electric shock.

Several different techniques determine the performance of the insulation resistance testing, combined with other tests as a necessary part of evaluating the electrical safety of a product. For example, the Brazilian Health Regulatory Agency (Anvisa), by Normative Instruction 116 of 12.21.2021 [3], determines the use of IEC 60601-1:2005 (Medical electrical equipment Part 1: General requirements for basic safety and essential performance) for the conformity certification of equipment under the Agency's regime (Figure 1).

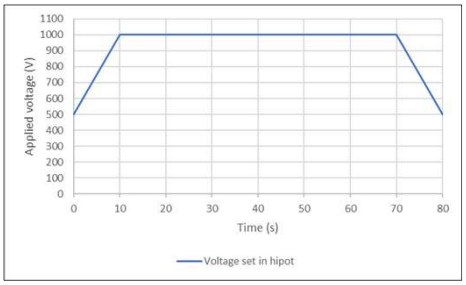

Fig. 1. Ramp-up and ramp-down for the dielectric strength test, according to the IEC 60601-1:2005.

2. METHODOLOGY

Firstly, it was necessary to develop an artifact that could offer a quantitative comparison of the results declared by participants in a proficiency test in dielectric strength without affecting the electrical characteristics of the device, meeting the stability criteria necessary for a proficiency testing program.

The developed device (figure 2) consists of a vitrified wire resistor of 5 kΩ/200 W and a 680 V varistor.

Fig. 2. Disruptive discharge simulator developed.

The developed device was validated through calibration, standards used are previously calibrated by a laboratory accredited by Cgcre. The calibration curve was raised, obtained by linear regression in the range between 80 mA and 100 mA. The equations used for linear regression and the uncertainty (S), according to equation 1.

$$S = \frac{\sqrt{\sum_{i=1}^{n} \Delta E_i^2}}{n-2} \qquad (1)$$

Where,

ΔEi corresponds to the difference between the measured voltage values and the values obtained through the regression curve adjustment.

3. PROFICIENCY TESTING ACTIVITIES

The organized proficiency testing activity in dielectric strength consisted of an interlaboratory comparison between the Electrical Metrology Laboratory and the End-Use Laboratory and Energy Management Laboratory, both located at IPT, considering that the high voltage applicator was configured as follows.

- Minimum voltage (initial) = 0 V
- Maximum applied voltage = 1000 V (60 Hz)
- Ramp-up time = 10 s
- Breakdown electrical current = 95 mA

The evaluation of the breakdown voltage measured by the participants was performed based on the Normalized Error (2).

$$En = \left| \frac{V_D - V_{LAB\_X}}{(U_D^2 + U_{LAB\_X}^2)^{1/2}} \right| \qquad (2)$$

Where:

VD: Designated value;
VLAB_X: Value obtained by participating laboratory;
UD: Uncertainty of designated value;
ULAB_X: Expanded uncertainty of measurement of value obtained by participating laboratory;

If Normalized Error ≤ 1, then the result is considered satisfactory and;
If Normalized Error > 1, then the result is considered unsatisfactory.

4. RESULTS

The table 1 below presents the results obtained from the calibration curve (angular coefficient (b) and linear coefficient (a)).

TABLE 1. Results obtained from the initial and final calibration curves

Descrição	Value
Linear coefficient (a)	41,98 V
Angular coefficient (b)	5,4 V/mA
Standard uncertainty of initial curve	0,96 V
Standard uncertainty of final curve	3,2 V

The results declared by End-Use and Energy Management Laboratory – LGE are presented in Table 2.

Table 2. Analysis of the results obtained in the interlaboratory comparison through the Normalized Error.

LGE current (mA)	V_{LGE} (V)	U_{LGE} (V)	V_D (V)	U_D (V)	Normalized Error
95,17	570,0	28,5	556,3	4,2	0,48

5. CONCLUSION

Due to the scarcity of proficiency testing programs in dielectric strength, which could offer quantitative results and thus provide a more appropriate analysis between participating laboratories, a device called as disruptive discharge simulator was developed. This device obtained satisfactory results regarding stability and was used as an artifact in an interlaboratory comparison program. For the comparison, a protocol was defined, and the program was run. From the presented program results, it was possible to quantitatively evaluate the participating laboratory based on Normalized Error.