LOCATION OF INTERNAL FAULTS IN ELECTRICAL EQUIPMENT USING DIGITAL X-RAY TECHNOLOGY

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Abstract: This paper presents a new test methodology, based on digital X-ray technology, to observe the inside of several electrical equipments without the need of damaging it and shows internal faults making easy to take a decision about the necessity of replacing.

Introduction: The problems that have been observed in some Brazilian Electrical Utilities, regarding to polymeric insulators are associated to the production process. In the case of suspension type insulators the problem is mainly related to their interfaces and for distribution networks the problem is with pin insulators that presented internal bubbles, only detected in the destruction of the insulators.

Besides the tests presented in IEC-61109 standard, partial discharge test and supersonic wave test were made, on samples taken from the production line in order to detect internal defects. The same samples were submitted to digital X-ray technology and, finally, the insulators were cut to verify the dimensions of the internal faults when there were any.

The necessity to detect internal faults using portable equipment is of great interest for manufacturers and users and face the results obtained, this methodology was applied in several materials like electrical fittings, connectors and cables.

This paper also shows the tests made on a energized line of 230 kV.

Results: The initial tests were made with 15 kV polymeric pin insulators selected in COELBA storehouse. Some samples are from the same manufacturers whose insulators had presented mechanical problems when installed in distribution lines.

The insulators were submitted to several dielectric tests (see Table 1). After that the insulators were X-rayed with the goal of confirming the test results. At last, the insulators were cut to verify the dimensions of the internal faults.

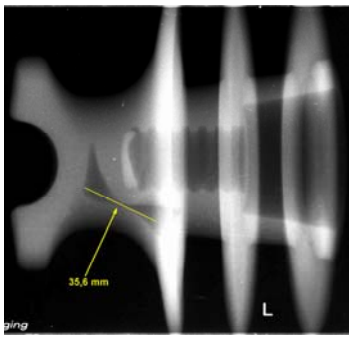
TABLE 1: DIELECTRIC TESTS RESULTS

Manufacturer	Sample	Test	
		Power frequency	Puncture
A	1	84,6 kV	Withstand
	2	55,5 kV	-
B	1	73,6 kV	Withstand
C	1	86,8 kV	Withstand

Note: The sample A-2 failed during the power frequency test.

The photos obtained with the digital X-Ray technology of the insulators after the dielectric tests and also the insulators after being cut with electrical saw to verify the internal failures presented by X-Ray technology.can be seen in Figures 1 to 4.

X-Ray images



Insulator after cutting

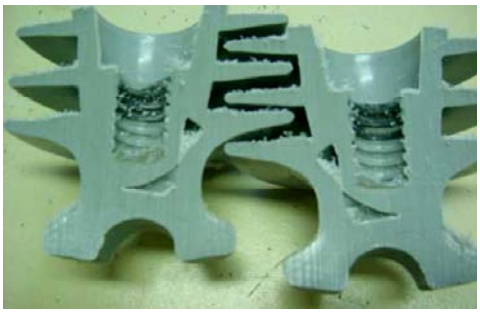
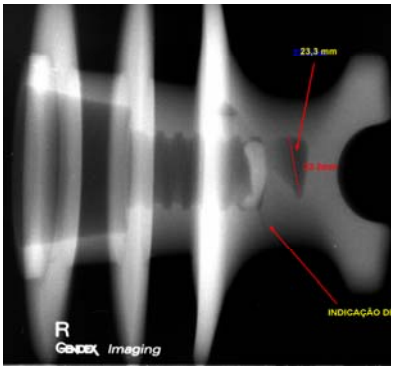


Figure 1 : Insulator A-1



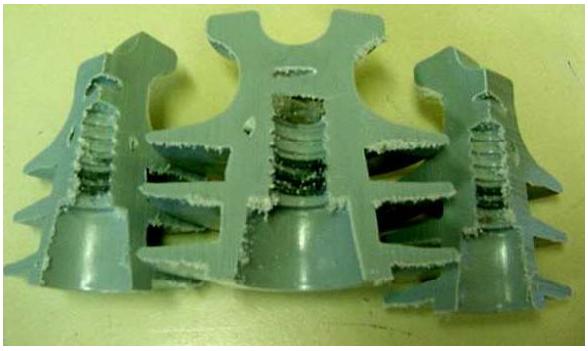
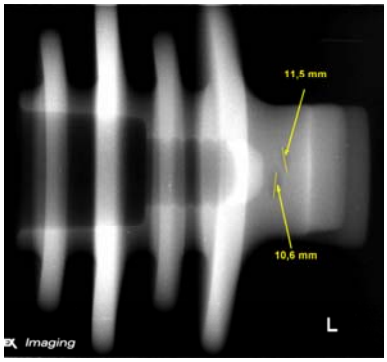


Figure 2 : Insulator A-2

X-Ray images



Insulator after cutting

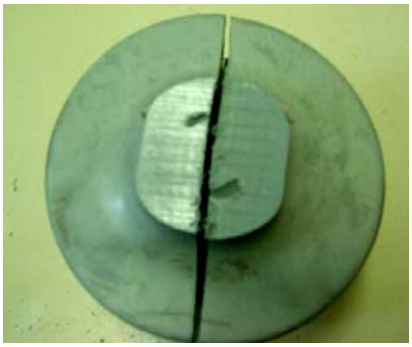
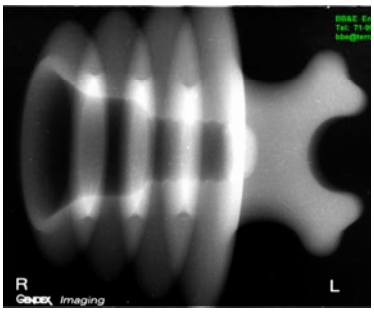


Figure 3 : Insulator B



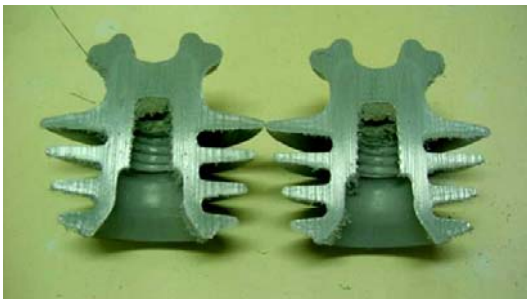
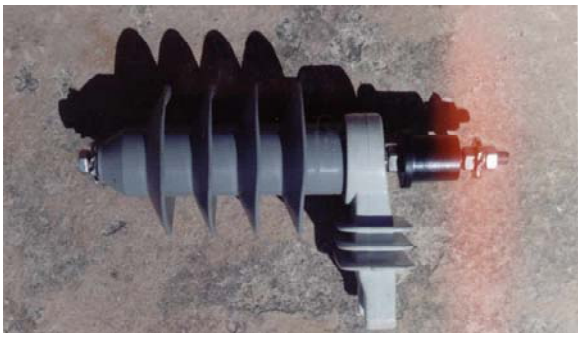


Figure 4 : Insulator C

Facing the good results obtained with the pin insulators, the authors decided to verify the possibility to apply the digital X-Ray technology in others equipments like underground cable joints, polymeric insulators, lightning arrester and circuit breaker, when de-energized. The results can be seen on Figures 5 and 6.

Object under test



X-ray images

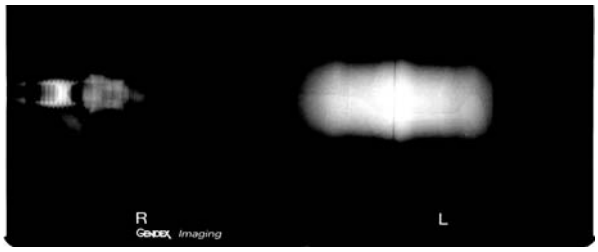


Figure 5 : 12 kV polymeric lightning arrester

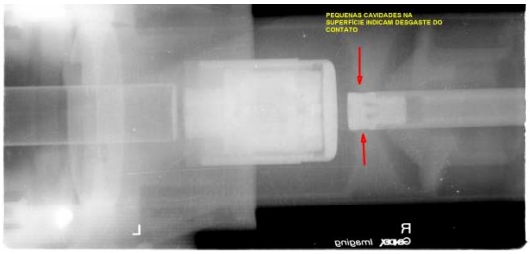



Figure 6 : 15 kV oil circuit-breaker

The advantage of the use of digital X-Ray technology can be greater if there is possible to apply this technology to energized equipments. The greater doubts were the insulation of the lead box, that is used to protect the persons against the effects of the radioactive particle, and the effect of the energized line electric field on the imaging plates used to capture the projection of the image of an object under test.

Several tests were made and the results obtained on an energized 230 kV line can be seen on Figures 7 and 8.

Figure 7 : Test arrangement on a 230 kV energized line

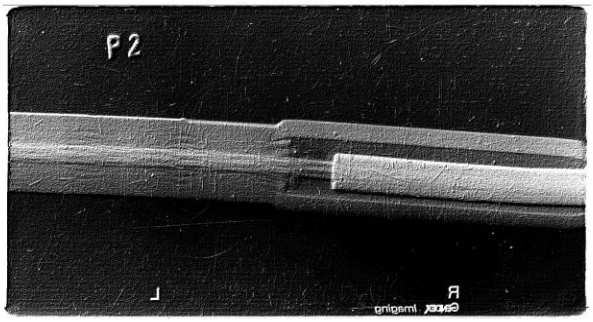


Figure 8 : X-ray image of a line joint

Discussion: This technology introduces the possibility of applying image processing procedures to the results obtained with the projection of an object image over the imaging plates (phosphoric screen). It replaces the use of radiograph film and can be used in all type of solid materials, metallic or not.

This technology uses ionized radiation (gamma ray or X-ray) to stimulate the phosphorus atoms to throw out signals that are picked up by laser reader and then processed by a software that presents the radiographic images. It must be emphasized that this technology needs only 10% of the radiation necessary to make a usual radiograph and can be done in any place without any complex human protection structure.

Conclusions: The great results obtained with the application of X-Ray technology to several equipments were enlarged with the results on an energized line. Several studies will be made to verify the use of this technology to energized substation equipment. A new test engineer must be trained in to develop the capacity to interpret the images and associate them to future problems for the equipment under investigation.

The portability and the feasibility of the digital X-Ray equipment are the main advantages of this technology because it makes easy the task of analyze internally an electrical equipment converting into a valuable tool to reducing the maintenance costs.

References:

[1] IEC 60437, Radio interference test on high-voltage insulators, 1997.

[2] IEC 270, Partial discharge measurements, 1981.

[3] IEC 61109, Composite insulators for systems with nominal voltage greater than 1000 V, 1992

[4] IEC 61211, Insulator of ceramic material or glass for nominal voltage above 1000 V - Puncture Test,. 1994.