BRAZILIAN ENERGY INTERLABORATORY PROGRAM APPLICATIVE

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Abstract: This paper describes the PCI Applicative structure and functionality developed by Eletrobras Eletronorte aiming at the management, control, operation and maintenance of the energy measurements, performed by the main calibration laboratories in Brazil, in the highest standard values of accuracy and precision. It also briefly describes the evolution stages of the Brazilian Energy Interlaboratory Comparison Program, nationally known as PCI. The main modules of the PCI Applicative are also described in a way that allows a comprehensive and interactive concept of the dynamics of the Intercomparison process carried out in Brazil.

Keywords: Interlaboratory, Brazilian, Eletrobras, Eletronorte, PCI Applicative

1. INTRODUCTION

Measurements, as it´s well known, make part of our daily life, in our homes, sports, electrical systems, offices, industries, hospitals, amusement, communication, aviation, navigation, researches, air space missions and others.

One of the key trusting factors in these measurements is how much accurately and precisely the calibration instruments are. It´s obvious that calibration in itself doesn´t guarantee that the dissemination of the standard quantities be maintained in highly accurate, precise and reliable metrological standards. One of a very well known techniques adopted to achieve those goals is the Interlaboratory Comparison.

 As Brazil, in the last twenty years, has been growing very strongly and fast, participating deeper and deeper in the global market and economy, measurements have been played a key role in the industry, agriculture, research and technological innovation. To keep pace with the national growth, test and calibration laboratories have been adopting and improving their methods, techniques, measurement and laboratory instrumentation. Great efforts have been taken to increase the number of laboratories to face the national demand..

The practice of Metrology worldwide and specifically in Brazil is a strategic tool in the global market scenery as well as a strong ally against technical barriers to trade. As the social, technological, industrial and economic growth of any nation can be measured by how deep the Metrology is adopted by the society, the Brazilian National Metrology Laboratory – INMETRO, has been responsible in such huge effort as maintaining, disseminating and accrediting the labs throughout Brazil in order to keep pace with the such a growth.

A group of 20 laboratories belonging to generation, transmission and power distribution companies as well as the main research institutes in Brazil make part of a Energy Interlaboratory Comparison Program which is managed by a technical coordinator who is responsible for the management as well as collecting the participants´ results of the measurements from each laboratory and performing all the mathematical and statistical calculations   in comparison to the reference´s measurements. As the numbers of tasks were becoming more and more extensive and complex, it was developed an applicative named PCI as a management tool which can be accessed   dynamically 24 hours a day through a site on the web.

2. HISTORY

Brazil is a country with an area of $8.525.000 \ km^2$ and $190.732.694$ inhabitants. The most populated areas are : southeast   42,1% , northeast 27,8%, south 14,4%, north 8,3% and central west 7,4% . As it can be seen in figures 1.1 and 1.2, the most important industrial areas are concentrated in the southeastern region. In the last 30 years the growth vector has been aimed to central and northern regions since those regions are very attractive in the field of a agriculture, cattle raising, hydraulic energy, fishing, mineral resources and other natural resources.

During the 70´s, the Brazilian Electrical System was mainly federal and state government owned. The Brazilian metrological system was insignificant, without a structured regulation as nowadays. A group of companies started to research the possibilities of improve an Interlaboratory Comparison based on the models adopted in Canada and United States. In 1974 that group wrote a preliminary recommendation for Intercomparison Program that could structure and rule and disseminate the Wh through the national interconnected system. The main goals of the recommendation were:

- Service Standards Accuracies

- Wh control in the laboratories

- Wh error evaluation

- Provision of calibration services from the interconnected system energy meters

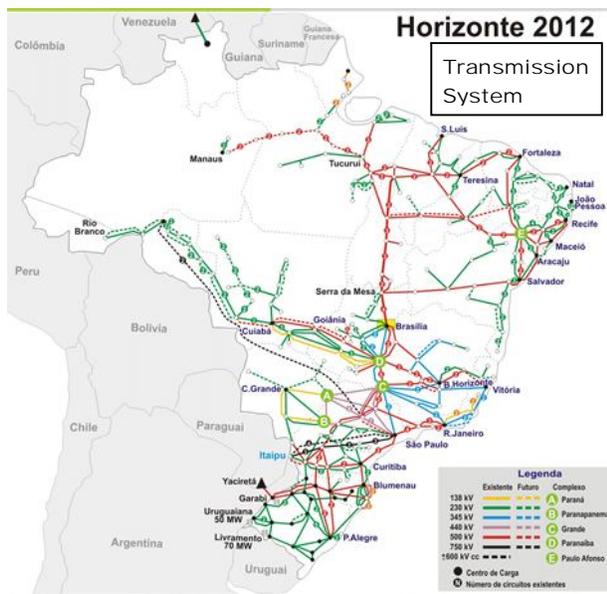Fig.1.1: Transmission and Hidraulic Resources

Fig.1.2: Transmission Network

The laboratories classification was only based on the measurement instruments capabilities. There weren´t technical procedures, proficiency programs, auditing programs or laboratories evaluation. Besides that, technical procedures weren´t taken into consideration. The very first circulating energy standards were induction type and Intercomparison took place twice a year.

The first three years of experience weren´t very conclusive, since frequent changes on the circulating energy standards occurred besides the inexistence of a reference standard. It should be emphasized that the uncertainty expressions methods weren´t taken in consideration since they weren´t acknowledged by the technicians of the participating laboratories.

It was evident that although there were significant differences among the results, the laboratories didn't know which path should be taken in order to overcome those difficulties. By 1978, new static circulating standards, with better accuracies and stabilities replaced the formers ones and only four laboratories participated in the Intercomparison.

Even though new standards were used , the divergences among the results were very high and one should conclude the process wasn´t synchronized and homogeneous. As the number of participants increased, better and clearer conclusions were expected to be achieved but the difficulties on how the results should be treated and interpreted still remained.

During the nineties the Brazilian Government decided to start up a privatization program which included the Generation, Transmission and Distribution sectors. Consequently the Interlaboratory Comparison structure was put aside since there wasn´t any concern of the private companies on maintaining or rearranging that structure.

But thanks to the efforts a group of metrologists the Interlaboratorial Comparison survived that abrupt change of directions. That group carried on a strategic plan which included the following decisions:

- The National Metrology Laboratory – INMETRO should be Invited to become a member as well as be the reference of the Interlaboratorial Comparison.
- The results would be compatibilized according the calculation of the normalized error En according to IEC

$$En = \frac{\left| lab.\,results - Ref\,results \right|}{\sqrt{u^2 lab + u^2 ref}} \qquad (1)$$

- The laboratories should estimate the measurement uncertainties according to ISO GUM 1993

- The points to be calibrated should be of compulsory and optional nature

In 2002, also as a result of the privatization process, the Intercomparison Members invited the National Grid Operator – ONS to become the institutional coordinator and as a result of that partnership, two new circulating standards were acquired to replace the older ones, which made possible the inclusion of additional members and points to be calibrated as well as contributed for a system with better accuracies and stability.

As a consequence of this growth it became harder and harder for the coordinator to manage all the steps of the

Intercomparison in an adequate way. So it was decided by members to implement an Application to fill up that gap.

3. PCI APPLICATIVE

As mentioned above, the organizations should steadily search the implementation of more efficient management tools, and here it´s highlighted the one which was introduced in Brazil to manage the National Circulating Electrical Intercomparison program named PCI Applicative. It is a tool that was developed by Eletrobras Eletronorte according to the participant´s suggestions and needs. That Applicative can be accessed by each participant according to a user name and log in. The Applicative includes a wide number of contents and only a few functions are able to be illustrated in this paper.

The Applicative main menu basically covers the following topics:

3.1. GENERAL INFORMATION

What is the PCI – In that section are described the Circulating Intercomparison importance, the traceability results to the Brazilian Reference Laboratory – INMETRO, the benefits for the participants and the strategic importance of electrical energy measurement   within the highest possible quality.

History – A brief description of the Circulating Intercomparison evolution in Brazil as well as the outstanding events since the very beginning of the PCI in 1973.

Participants – A List of laboratories that are enrolled in the National Circulating Electrical Intercomparison.

Today there are twenty laboratories participating in the Program besides the National Laboratory- INMETRO.

3.2. MEMBERS DATA

General Information: According to cycle and in figure 2, one can find the following data: federal and state identification, participating member list with all the key information such as: company´s identification, technical responsible, address, e-mails, phone numbers etc as it can be seen. Also, all the technical data of standards used in the Intercomparison are detailed, such as: manufacturer, number of phases, serial number, calibration data and accuracy.

It´s possible for each member to find out the addresses to where the standards should be shipped in as illustrated in figure 2.
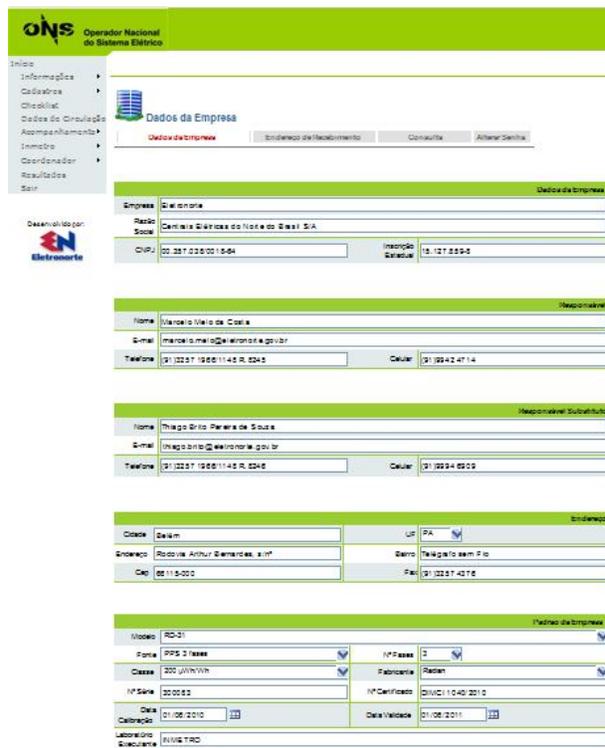

Fig.2: Participants Data

In figure 3 it´s shown how one member can access all the other members´ personal data, addresses, e-mails, phone numbers as well all technical data of the reference standard used on the calibration procedures.

Fig.3: Members consulting

Each member can change his own log in and password as shown below in figure 4.

Fig.4: Members Log In

Measurement Records – The measurements` results of each Intercomparison member can be accessed such as: measured values, errors and uncertainties from each year, as well as the standards used for the measurements, load conditions, calibrated pints, angle phases, (figures 5.1 and 5.2).
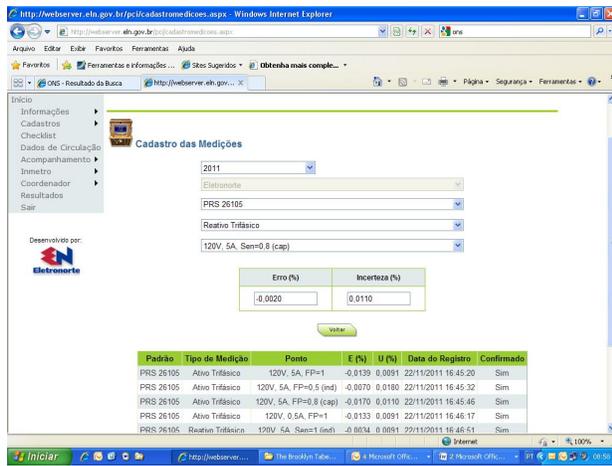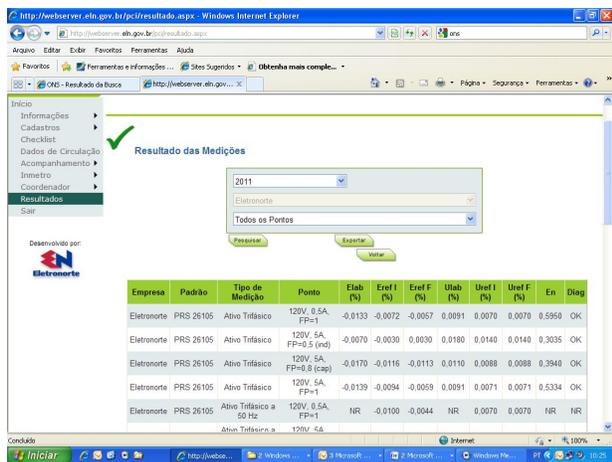

Fig.5.1: Measurement Records

Fig.5.2: Measurement Records

3.3. CHECKLIST – Each member can follow up the circulating standards such as the shipment date, origin, date they were received as well as the standards´ conditions as found and as left by the former member (figure 6).

As the Intercomparison Standards are shipped in and out throughout the 20 laboratories in Brazil, sometimes some damages may occur as well as losses damages of the accessories or components. So, immediate actions by the coordinator or any participant are possible and such occurrences are registered by the receiver participant.
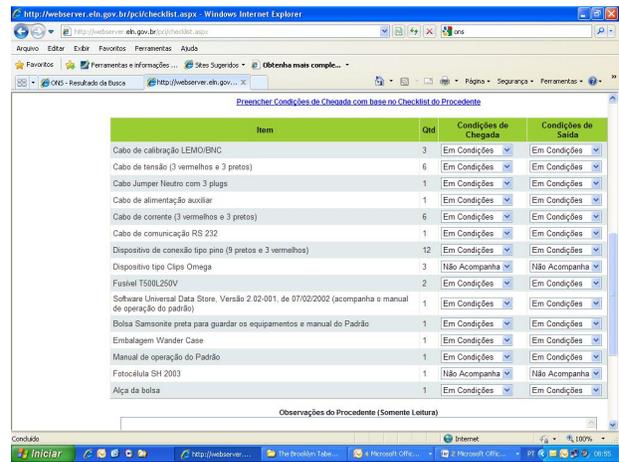

Fig.6: Checklist

3.4. CIRCULATION DATA – at this menu we find the information over, shipment data, laboratory origin and addressee, identification of transportation company, transportation document number and arrival date.

3.5. FOLLOW–UP – An instant view of the Intercomparison status can be obtained through:

Circulation Map – the members can identify in which lab the circulating standards are as well as pinpoint on the map all the laboratories that already have performed the measurements (Fig.7: Circulating Map).
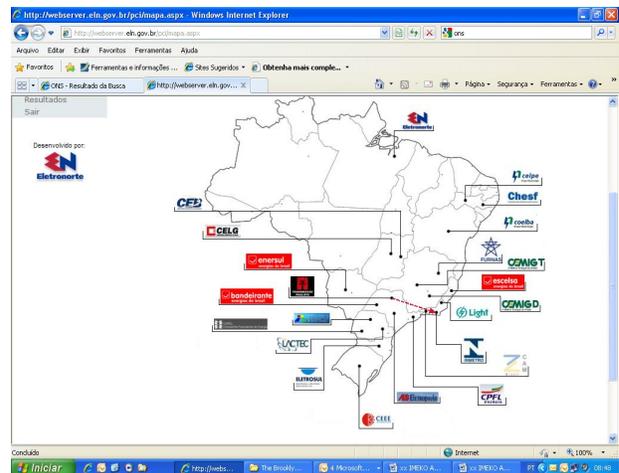

Fig.7: Circulation Map

Calendar – An annual timetable (figure 8) with the scheduled and updated periods for each laboratory can be monitored at any moment allowing the Coordinator to take the due decisions in case of delays or technical problems with the standards.
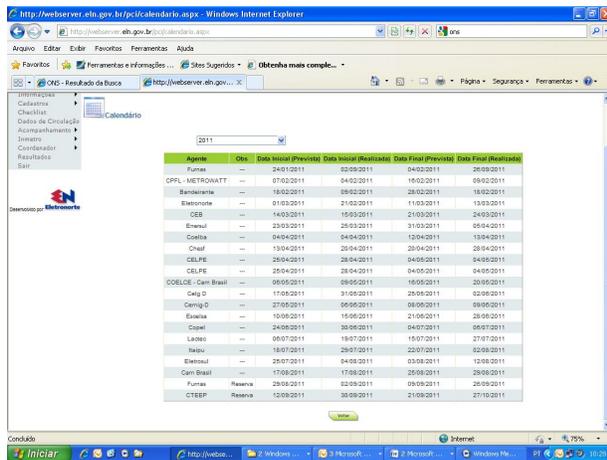
Fig.8: Calendar

Fig.9: Final Results

3.6. INMETRO – As the reference Laboratory, the Comparison starts and ends up at the National Laboratory - INMETRO, its reprentative fills up the information :

Standards Data – The main characteristics of the Standards used by INMETRO are at the participants´ consulting

Standards' accessories – All items used by INMETRO are listed and shipped to the first laboratory according to the calendar table .

Reference measurements – Here are the estimated INMETRO error and uncertainties with which participants` results will be compared.

3.7. COORDINATOR – That item is only accessed by the coordinator which is elected for a two year term. He can fill up and update the yearly calendar, include new participants and the standards, cycles, types of power sources and measurements as well as the points to be calibrated in each cycle. He also is responsible for any Applicative updating of the standards data used by each laboratory.

3.8. RESULTS - As the circulation reaches the last participant, all the results (figures 9.1 and 9.2) are compiled and are presented at the Annual Meeting usually in November where the results are submitted to an evaluation by the group. In case of any non conformity, the reprentative member explains his attempt in solving it as well as reviewing his procedures during an specific length of time. Each user can access the results of each cycle for a specific calibration point as well as export the data to excel or other applicative.
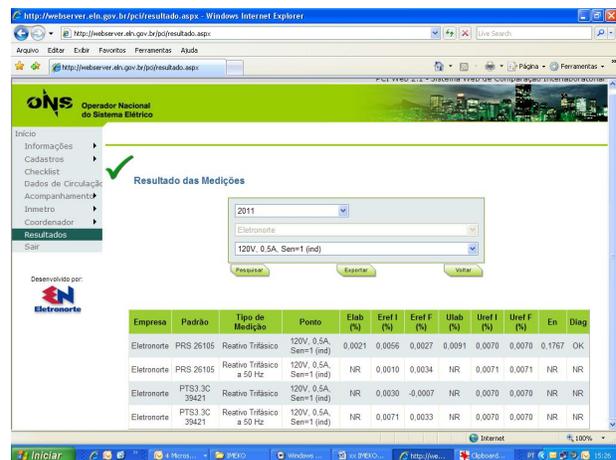
4. PCI APPLICATIVE MANAGEMENT

In order to guide, rule and manage the Interlaboratory Comparison Program each member uses the Procedure Manual, written and updated by the coordinator according to the participants´ suggestions.

Besides the annual meeting held once a year, extraordinary meetings occur in case of deep changes in the Program such as uncertainty estimation expression or any other institutional matter.

As any activity, it´s needless to say that any tools or management techniques or methodologies are successful only and if only there´s a dynamic action of the coordinator as the responsible by the course of the Intercomparison according to the following duties:

- Updating the applicative in a structural way according to participants´ needs or demand that are presented during the annual meeting at the ends of the year
- Accessing the participants information in the Applicative in order to detect any failure in fulfilling the scheduled or any other problem of technical or administrative nature
- Feed in the Applicative with INMETRO data in order that each participant be able to estimate the normalized error - EN
- Feed in new participant and new auxiliary tables.
- Rearrange the Intercomparison Calendar in case of impairment by any Participant in fulfilling the calibration schedule.

- Inform the final results which are submitted to analysis during the general Annual meeting
- Enforce actions to solve non conformities with the support of all participants whenever En $\geq$ 1 are detected.

5. REFERENCES

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