2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: 978-85-99141-02-1

IMPROVEMENT OF GAMMA CALIBRATION PROCEDURES WITH COMMERCIAL MANAGEMENT SOFTWARE

Rodrigo F. Lucena, Maria da Penha A. Potiens, Gelson P. Santos and Vitor Vivolo

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
rodrigoifusp@yahoo.com.br
mppalbu@ipen.br
gpsantos@ipen.br
vivolo@ipen.br

ABSTRACT

In this work, the gamma calibration procedure of the Instruments Calibration Laboratory (LCI) of the IPEN-CNEN/SP was improved with the use of the commercial management software Autolab™ from Automa Company. That software was adapted for our specific use in the calibration procedures. The evaluation of the uncertainties in gamma calibration protocol was improved by the LCI staff and yet the all worksheets and final calibration report lay-out was developed in commercial software like Excell™ and Word™ from Microsft™.

1. INTRODUCTION

The Instruments Calibration Laboratory (LCI) of the IPEN-CNEN/SP calibrates, portable survey meters, ionization chambers, performs irradiation of personal dosimeters (TLD) and calibration of instruments used in dosimetry [1-6] since 1980. These instruments are used in radiation protection, diagnostic radiology and therapy procedures. The costumers of the LCI are hospitals, industries, clinics, universities and others in Brazil and some South America countries. The LCI is a calibration laboratory inside the Radiation Metrology Center (CMR) of the IPEN. In the last years, the number of portable survey meters calibrated for the Instruments Calibration Laboratory (LCI) of the IPEN-CNEN/SP was increased continuously; in 2006, about 1,600 equipments were calibrated. An optimization of the gamma calibration protocols was necessary to attend the new service demand.

The LCI has special reference systems for calibration and dosimetry in radiation protection, diagnostic radiology and radiotherapy levels. To the establishment of the radiation qualities beams for the calibration of the portable survey meters (such as Geiger-Müller, scintillators, ionization chambers and semiconductors) and instruments used in dosimetry, the LCI uses as a reference a secondary standard spherical ionization chamber connected to an electrometer, and the gamma irradiator system has Cs-137, Co-60, Ra-226 and Am-241 radioactive sources.

The whole calibration procedure has many steps such as administrative steps (management of the calibration schedule and pricing, final report printing and safety copy, archive in paper of the whole forms used in the calibration process, etc.), and technical steps (calibration set-ups and procedures, environmental condition control, reference system measurements, uncertainties evaluation, fill out calibration worksheets, etc.). Considering the difficult in upgrading the set-ups and staff of the LCI, an improvement of the whole calibration process is very helpful. When one thinks in improve a process the first idea is change parts or cut steps in the process but, when it is not possible to cut steps of the process it is necessary to verify what it is possible to change in each step to improve the process. The second very good idea is to modify the speed of the whole process doing the steps and the whole process very fast. In that case, the study of a special commercial software to the management of the whole calibration process with advantages in the regular calibration process is desirable in order to improve the quality and speedy in the whole process, transfering safely the calibration data, clients information and back-up of the all steps during the calibration procedures. That specific software would solve the difficulties coming with the increased calibration demand in the LCI.

Then, the objective of this work was study the whole calibration process (step by step) of the gamma portable survey meters adapting the commercial software to improve the whole calibration procedures of the LCI.

2. MATERIALS AND METHODS

For the study of the whole calibration procedures were used a commercial software for manager the calibration procedures including calculation routines (Autolab^{TM}) [7]; the gamma irradiator system from manufacturer STS Steuerungstechnik & Strahlenschutz GmbH, Germany, with Co-60 (18,0 GBq), Cs-137 (651 GBq), Am-241 (7,3 GBq) and Ra-226 (0,4 GBq) radioactive sources, the reference date of the sources is December 2005. The gamma radiation qualities established follow the recommendations of the Standard ISO 4037-1[8], radioprotection level. For dosimetry of the gamma calibration system was used a reference system with PTW 32002, ionization chamber (1.000 cm^3) connected to a PTW electrometer, model UNIDOS, check-source of the Sr-90, and others instruments such as, thermometer, barometer, hygrometer, etc.

The calibration procedures review was made and included all steps: management of the calibration schedule and pricing; storage of the equipments; calibration set-ups; environmental conditions control; reference system measurements; uncertainties evaluation and calibration report.

The chosen commercial software was Autolab^{TM} from Automa Company. Its structure allows the use of the modules such as: calibration schedule, quotation service, calibration data sheets, uncertainties evaluation, automatic writing of the calibration report, data base of the equipments models and calibration protocols, etc. However, that software was developed for use in electrical measurements and not specific for radiation measurements, then it was necessary an adaptation in that modules. The evaluation of the uncertainties in gamma calibration protocol was improved as recommended for ISOGUM [9], the worksheets developed in the commercial software Excell^{TM} received a new lay-out, and the final calibration reports received a new design with essential information for the clients [10].

3. RESULTS

As the initial step of the calibration procedures review was made the inventory of the instruments calibrated for LCI in the last five years, and the results show that were tested about 500 different models (80 % with operational manuals); 17,7 % from Brazilian manufactures and 82,3 % from others countries. One inventory and re-organization of operate and service manuals archive was made to help in the inventory of those instruments (their location, identify tag, number of copies, etc.). The Table 1 shows the 20 models of equipments most calibrated for LCI in 2006 from a total of the 200 calibrated models, ordered by the percentage (%) of each kind of equipment calibrated.

Table 1. Numerical results of the instruments calibrated for the LCI in 2006

Manufacturer	Model	Manual status (Yes/No)	Number of instruments calibrated in 2006 (units)	In percentage of the total instruments calibrated (%)
Ludlum	3	Y	59	6,06
MRA -Nacional	G1Plus	N	29	2,98
Victoreen/Inovision	190	Y	29	2,98
Arrow-Tech	138S	N	26	2,67
Automess	6150AD	Y	25	2,57
Dosimeter	862	Y	24	2,46
Radcal	9015	Y	23	2,36
Victoreen/Inovision	290	Y	21	2,16
Victoreen/Inovision	856-1	N	21	2,16
MRA -Nacional	G1E	N	19	1,95
COPESP -Nacional	002MR	N	17	1,74
Radcal	9010	Y	17	1,74
Victoreen/Inovision	451P	Y	17	1,74
Graetz	X5 DE	Y	16	1,64
Radcal	2025	Y	16	1,64
Victoreen/Inovision	450P	Y	16	1,64
SE International	Radiation Alert Monitor 4	Y	15	1,54
Capintec	CRC-15R	Y	14	1,44
PTW Freiburg	Unidose	Y	14	1,44
Nacional - Prólogo	PSN 7013	Y	13	1,33

For the evaluation of the uncertainties in gamma calibration protocol all uncertainties factors were determinated, such as, μ_{kar} is the uncertainty in air kerma rate; μ_{Ld} is the uncertainty in dosimeter indication; Ci_{ld} is the sensibility coefficient for Ld; μ_{FC} is the uncertainty in calibration factor; Ci_{FC} is the sensibility coefficient for FC; μ_{fp} is the uncertainty in temperature and atmospheric pressure factor; Ci_{ftp} is the sensibility coefficient for ftp; μ_t is the uncertainty in time of charge collection of the electrometer; Ci_t is the sensibility coefficient for t. The equation 1 shows the expression for the uncertainty evaluation in the air kerma rate for gamma irradiation system of the LCI, used for calibration of the portable survey meters.

The Table 2 shows the results obtained of the uncertainty evaluation in the air kerma rate for gamma irradiation system of the LCI, for the Cs-137 source.

$$\mu^{kar*} = \mu^{Ld*} \times Ci^{ld*} + \mu^{FC*} \times Ci^{FC*} + \mu^{fp*} \times Ci^{ftp*} + \mu^{t*} \times Ci^{t*} \qquad (1)$$

Where * is exp +02

Table 2. Uncertanties evaluation of the air kerma rate for radioactive source of Cs-137 for the STS gamma irradiator of the LCI (IPEN-CNEN/SP)

Distance from the center of the irradiator (cm)	Air kerma rate (mGy/h)	Uncertainty* (mGy/h)	Relative uncertainty* (%)
75	80.45	1.14	1.42
120	30.40	0.44	1.45
126.9	27.31	0.39	1.43
226.9	8.47	0.12	1.42
326.9	4.05	0.06	1.48
426.9	2.37	0.04	1.69

* Coverage factor k = 2 (95.45 %)

The Table 2 shows that the air kerma rate obtained follows the inverse square law of distances, and the main uncertainty component is the uncertainty of the calibration factor. The uncertainties obtained for the Co-60 source are very close to the results for the Cs-137 source.

The Figure 1 to 3 show the Autolab™ worksheets (protocol, calibration and calibration uncertainties) that should have some modifications to reach a final lay-out, and need to receive some adjusts to attend the specific application of the LCI-IPEN. It is necessary to do a continuously improvement of that.

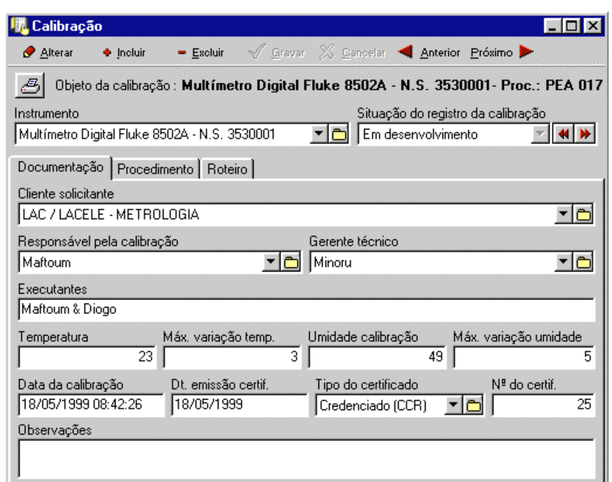

Figure 1. Calibration protocol developed in Autolab™ software.

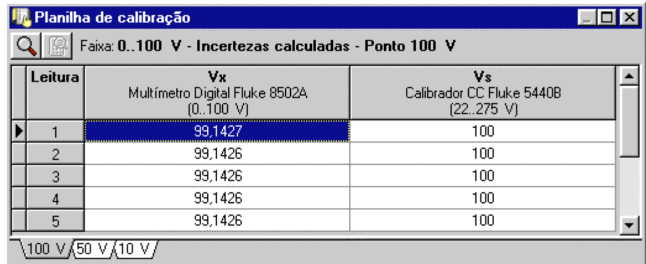

Figure 2. Calibration worksheet developed in Autolab™ software.

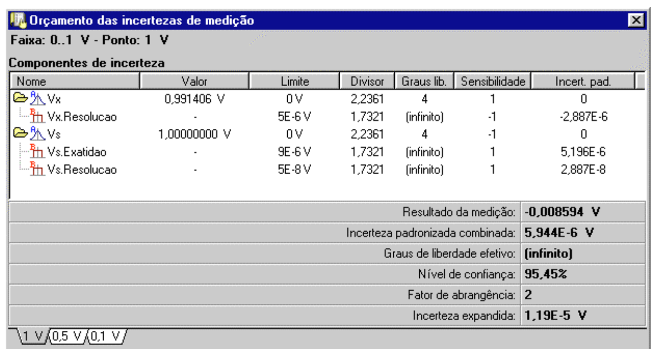

Figure 3. Calibration uncertainties worksheet developed in Autolab™ software.

4. CONCLUSIONS

The great advantage of that software system is: the automatic transfer of the calibration worksheets and client information to the calibration report after the finished calibration procedures and a central data base of all calibration information. That process improved operates with a main microcomputer (server) in a computer network. That system improves the quality of the data and information (reduces writing mistakes, change of the information, reduces costs like re-work, few paper printed, etc.) and increase the speed of the whole calibration process (reducing in about 15 % the time spend in that calibration procedures).

ACKNOWLEDGMENTS

The authors acknowledge the partial financial support of the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), the Conselho Nacional de Desenvolvimento Cientifico e Tecnológico (CNPq), and the Financiadora de Estudos e Projetos (FINEP), Brazil.

REFERENCES

1. “Calibration of radiation protection monitoring instruments”. *International Atomic Energy Agency*, IAEA, Vienna, 2000, (Safety Reports Series No. 16).
2. Vivolo, V. “Aplicação de metodologia de testes de desempenho para monitores portáteis de radiação”. São Paulo: 2000. Dissertação (Mestrado). Universidade de São Paulo (USP).
3. Vivolo, V. “Desenvolvimento de um sistema referência para determinação do equivalente de dose pessoal e da constância de feixes de radiação X”. São Paulo: 2006. Tese de doutorado (Doutorado). Universidade de São Paulo (USP).
4. Vivolo, V.; Costa, A. M.; Manzoli, J. E.; Caldas, L. V. E. “Determinação de parâmetros dos campos de radiação gama do Laboratório de Calibração do IPEN”. In: International Congress, Industrial Business Forum and Measurement Instruments Exhibition in Advanced Metrology. 4-7 dezembro, 2000, São Paulo. *Anais…* São Paulo: 2000. 1 CD-ROM.
5. Caldas, L. V. E.; Albuquerque, M. P. P. “Calibration of parallel plate ionization chambers in different kinds of radiation”. *Proceed. 8th International Congress of IRPA,* Montreal, Canada, 17-22 May 1992, p. 144-147, 1992.
6. “Medidores e monitores portáteis de taxa de exposição de raios x e gama, para uso em radioproteção”. *Associação Brasileira de Normas Técnicas*. Rio de Janeiro, Set. 1987. (ABNT NBR 10011).
7. “Manual do usuário do programa computacional para gestão e automação de laboratórios do tipo “Autolab””. *Lactec; Automa*. Primeira edição em língua portuguesa. Curitiba: 1999.
8. “X and gamma reference radiations for calibrating dosemeters and dose ratemeters and for determining their response as a function of photon energy. PART 1: Characteristics of the radiation and their methods of production”. *International Organization for Standardization*, ISO, Geneva, 1996. (ISO 4037 – 1).
9. “Guide to the expression of uncertainty in measurement”. *International Organization for Standardization*, ISO, Geneva, 1995.
10. “Requisitos gerais para competência de laboratórios de ensaio e calibração”. *Associação Brasileira de Normas Técnicas*. Rio de Janeiro, 2001. (NBR ISO/IEC 17025).