Technical protocol of APMP key comparison of high-dose dosimetry using alanine dosimeters (APMP.RI(I)-S1)

1. Introduction

The objective of this key comparison is to establish the degrees of equivalence high-dose dosimetry for absorbed dose to water, and to appreciate the dosimetry systems of other laboratories, and for the world community of radiation processing to establish a greater confidence in their traceability. Alanine-ESR transfer dosimeters are used for this inter-laboratory comparison in the (0.1 to 50) kGy dose range and the mean of dose value will be evaluated by the OAP. One or two Primary Standard Dosimetry Laboratories will be invited or directed linked to BIPM. The results will be given in term of a normalized ratio [1, 2] for each participating laboratories.

2. Participants

Participant	Institute	Country	Contact person (E-mail)
1	OAP	Thailand	Arag Vitittheeranon arag@oaep.go.th Harinate Mungpayaban harinate@oaep.go.th, harinate@hotmail.com
2	Nuclear Malaysia	Malaysia	Taiman Bin Kadni taiman@nuclearmalaysia.gov.my
3	NIM	China	Yuandi Yang yangyd@nim.ac.cn
4	BARC	India	Sudesh M. Tripathi sudeshtripathi@yahoo.com
5	INER	Taiwan	Mr. Chun-Liang CHEN cliangchen@iner.gov.tw
6	NIS	Egypt	Dr.Gamal Mohamed Hassan Ph.D. gamalhassan65@hotmail.com gama_m_lhassan@yahoo.com

3. Procedure

3.1 Comparison methodology

Alanine dosimeters will be used as transfer dosimeters for the comparison that are supplied by the Bruker BioSpin AG, Thailand. The four alanine dosimeters from each set, individually sealed in the cylindrical holders, will be sent to each laboratories and be irradiated under controlled condition with ^{60}Co gamma-radiation to absorbed dose to water at five consecutive doses, 0.1, 3, 10, 30 and 50 kGy (two set dosimeters for each dose point). However, the participants could select any irradiation dose points in the range of (0.1 to 50) kGy that depend on the facilities. The irradiation temperature should be controlled by each laboratory to be between 25 °C and 35 °C (± 2 °C) and the relative humidity should be less than 55%RH [3, 4]. After irradiations, all irradiated and blank alanine dosimeters will be posted back with the information to OAP within three weeks. The pilot laboratory will measure the complete set of alanine dosimeters at one time using a Electron Spin Resonance Analyzer (Bruker BioSpin, model A300) and evaluate the results of these measurements. The information should consist of nominal dose, date of irradiation, irradiation temperature, source type, dose rate at irradiation position, irradiation phantom material and size, associated uncertainty and their traceability. The participants should irradiate the alanine dosimeters and return them immediately to the pilot laboratory in order to avoid the fading effects. The OAP will pay for the transport of the dosimeters to each laboratory and each laboratory will pay for posting back to the OAP.

3.2 Reference conditions

The absorbed dose to water for ^{60}Co at OAP is traceable to the National Physical Laboratory (NPL), UK in the range of (0.1 to 50) kGy, annually. The Gammacell 220 Excel Co-60 irradiator (Nordion, Canada), activity as of March, 2010 is approximately 376 TBq (10.15 kCi). The relative standard uncertainty is 2.6% at coverage factor k = 2, providing a level of confidence of approximately 95%.

3.3 Irradiation geometry

The irradiation geometry is not specified in detail in the protocol. However, the irradiations should be carried out using a ^{60}Co gamma field and performed in a phantom (preferably water or water-equivalent) large enough to achieve electron equilibrium. The radiation should be incident on the side of the cylindrical dosimeter in order to avoid a significant variation in dose along the stack of four alanine pellets within dosimeter.

The dosimeters provided by the OAP are supplied in cylindrical holders nominally 12 mm in diameter and 22 mm in length, each vial contains four alanine pellets. This vial is designed to fit a 13 mm hole in the phantom nominally 7 cm diameter and 8.5 cm in length.

4. Analysis the results

The irradiated dosimeters will be measured by the OAP and the dose estimates derived from the alanine calibration curve which is traceable to the NPL. The result for each dosimeter will be expressed as the ratio of the participant doses and the reference value, together with the uncertainty of this ratio.

The pilot laboratory will prepare a draft report for circulation to all participants for comments and discussion of the results. A revised final report will be the official report of the comparison and submitted to the APMP/TCRI Chairman and the CCRI(I). After the approval of APMP and CCRI (I), it should be published in the Technical Supplement of the journal *Metrologia*. In addition, the comparison results will be sent to the BIPM for inclusion in the key comparison database (KCDB).

All participating laboratories should evaluate the irradiated dose uncertainty according to the criteria given in the "Standard Guide for Estimating Uncertainties in Dosimetry for Radiation Processing" issued by the International Organization for Standardization (ISO) in 2005 [5]. The Type A uncertainty is obtained by statistical analysis of a series of observations; the Type B uncertainty is obtained by means other than the statistical analysis of series of observations. In order to analyze the uncertainties and take correlation into account for the degrees of equivalence entered in the BIPM key comparison database [2], the CIPM has recommended that the participating laboratories submit their detailed uncertainty budgets (with relative standard uncertainties, k =2) to the pilot laboratory. The **MS-Excel worksheets** will provided by the pilot laboratory.

5. Calibration results submission

It is expected that all participating laboratories submit the reports within 4 weeks after the irradiations. An MS-Excel sheet will be provided by the pilot laboratory in which information about the conditions used by the participants together with the reported doses.

6. Comparison schedule

The comparison is scheduled to commence at the end of July 2010 and expected to be completed within 5 months. The proposed schedule is shown in Table 3.

Table 3. Proposed schedule for the comparison (September 2010 until January 2011)

Activities	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
1. The pilot laboratory will prepare and maintain the systems for this comparison: consisting of a traceable ESR and the alanine dosimeters.	←	—	→					
2. The alanine dosimeters are sent to the participating laboratories.				←	→			
3. Each participant will irradiate alanine dosimeters and prepare report and return to the pilot laboratory.				←	→			
4. The pilot laboratory analyzes the alanine doses and comparison results.				←	—	→		
5. Conclusion and Discussion of the comparison results.						←	—	→
6. Reporting the results back to each laboratory and prepare a draft report.							←	→

5. References

[1] K. Mehta and R. Giirzikowsky, IAEA high-dose intercomparison in ^{60}Co field, *Appl. Radiat. Isot.* **52**, 1179-1184 (2000).

[2] D.T. Burns, P.J Allisy-Roberts, M.F. Desrosiers, V. Yu. Nagy, P.H.G. Sharpe, R.F. Latitano, K. Mehta, M.K.H. Schneider and Y, Zhang, CCRI supplementary comparison of standards for absorbed dose to water in ^{60}Co gamma radiation at radiation processing dose levels, *Radiat. Phys. Chem*. **75**, 1087-1092.

[3] M.F. Desrosiers, Dose Interpretation of Customer-Irradiated NIST Transfer Dosimeters, Ionizing Radiation Division Quality Manual, NIST Physicals Laboratory, http://www.physics.nist.gov/Divisons/Div846/QualMan/procedures.html [Accessed March 3,2010].

[4] American Society for Testing and Materials, Standard Practice for Use of an Alanine-EPR Dosimetry System, Inernational Standards Organisation & American Society for Testing and Materials, Designation iso/astm 51670: 2004(E).

[5] American Society for Testing and Materials, Standard Practice for Use of Estimating Uncertainties in Dosimetry for Radiation Processing, Inernational Standards Organisation & American Society for Testing and Materials, Designation iso/astm 51707: 2005(E).

APPENDIX A: Pictures of the equipments and alanine dosimeters

Figure 1: Alanine pellet dosimeters from Bruker

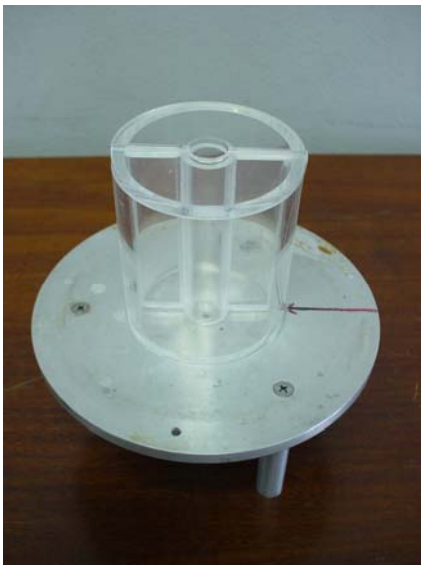

Figure 2: Phantom for irradiation

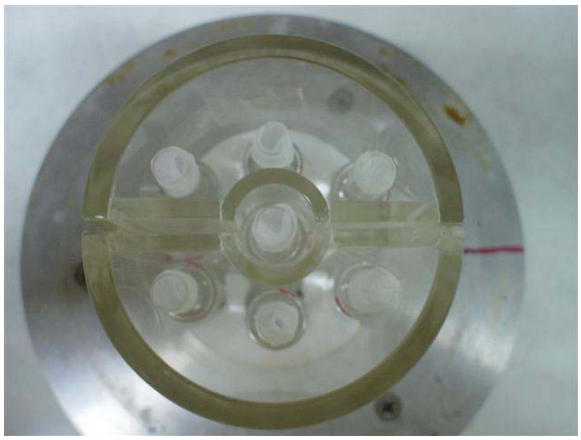

Figure3: Fricke dosimeter as reference standard

of absorbed dose to water in ^{60}Co field.

Figure 4: Gammacell 220 excel irradiator

Figure5: Electron Spin Resonance

APPENDIX B: Complete address of the participants

Pilot laboratory

OAP, Thailand

Contact person: Mr. Arag Vitittheranon

Ms. Harinate Mungpayaban

Office of Atoms for Peace

16 Vibhavadi Rangsit Road, Ladyaw,

Chatuchak, Bangkok 10900

Thailand

Tel: +66 8 6570 4359

Fax: +66 2562 0093

e-mail: arag@oaep.go.th

: harinate@oaep.go.th

Participants

Nuclear Malaysia, Malaysia

Contact person: Mr.Taiman Bin Kadni

Malaysian Nuclear Agency (Nuclear Malaysia),

Bangi, 4300 Kajang, Selangor Darul Ehsan, Malaysia

Tel: +60 3 8928 2983

Fax: +60 8925 0575

e-mail: taiman@nuclearmalaysia.gov.my

NIM, China

Contact person: Mr. Yuandi Yang

Division of Ionizing Radiation

National Institute of Metrology (NIM)

No.18, Bei San Huan Dong Lu,

Beojong 100013, P.R.China

Tel: +86 10 64525001

Fax: +86 10 64219860

e-mail: yangyd@nim.ac.cn

BARC, India

Contact person: Mr. Sudesh M. Tripathi

Radiation Standards Section,

Radiation Safety Systems Division,

Bhabha Atomic Research Centre,

Trombay, Mumbai 400085, India

Tel: +91 98 69406741

Fax: +91 22 25505151

e-mail: sudeshtripathi@yahoo.com

INER, Taiwan

Contact person: Mr. Chun-Liang CHEN

Institute of Nuclear Energy Research (INER)

No.1000, Wenhua Rd., Jiaan Village, Longtan Township,

Taoyuan Country, 32546, Taiwan (R.O.C.)

Tel: +886 3 4711400 ext 7672

Fax: + 886 3 4713489

e-mail: cliangchen@iner.gov.tw

NIS, Egypt

Contact person: Dr.Gamal Mohamed Hassan Ph.D.

National Institute for Standards (NIS)

Department of Ionizing Radiation Metrology

Quality manager

Tersa Street El-Haram El-Giza

P.O. Box: 136 Giza, El-Giza Egypt

Fax: 202-33867451

Mobile: 2-0100079285

e-mail: gamalhassan65@hotmail.com

gama_m_lhassan@yahoo.com