IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

SSDL NEWSLETTER

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CONTENTS

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EDITORIAL NOTE

The first article of this issue of the SSDL Newsletter is the report of the 10th SSDL Scientific Committee Meeting held from 25 February–1 March 2002. The Committee members were renewed, since the former members have completed their 5-year term as stipulated in the terms of reference of the Committee. The representative of the BIPM (Dr P. Allisy-Roberts) was not changed.

The second article was prepared jointly by the BIPM and the IAEA. It is on the operation of the Comité International des Poids et Mesures (CIPM) Mutual Recognition Arrangement (MRA) and its relevance to the SSDL members of the IAEA/WHO network. The signing of the MRA by the IAEA was announced in the SSDL Newsletter No. 43 (July 2000). A circular letter with a copy of the signed MRA was sent to all members of the IAEA/WHO Network of SSDLs in December 1999. Following its activities within the MRA, the IAEA has developed its own Calibration and Measurement Capabilities (CMCs). These have been accepted and appear now on the BIPM key comparison database. The IAEA organizes comparisons for SSDL members of the IAEA/WHO network. In doing this, the IAEA is effectively functioning as an international metrology organization. By including, in such comparisons laboratories, that have taken part in other CIPM comparisons, the IAEA provides a strong link to the MRA for its Member States that are not members of the Metre Convention, since they would be excluded from the process otherwise. This action should bring benefits to those SSDLs in terms of strengthening their position as the dosimetry reference centre for their country.

As planned, the International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry took place at the IAEA headquarters in Vienna from 25 to 28 November 2002. More than 250 scientists representing 62 Member States attended the four-day meeting at which 140 presentations were delivered covering a broad range of topics in medical radiation dosimetry. Work is underway to complete the process of refereeing and editing the symposium proceedings, which should consist of about 85 papers.

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[a] This is the general e-mail address of the DMRP Section where all correspondence not related to specific tasks of the staff above should be addressed. Please note also that there is a considerable circulation of the staff of the Agency, so that messages addressed to someone who has left might be lost. All incoming messages to this mailbox are internally distributed to the appropriate staff members.

SERVICES PROVIDED BY THE IAEA PROGRAMME IN DOSIMETRY AND MEDICAL RADIATION PHYSICS

The IAEA's Dosimetry and Medical Radiation Physics programme is focused on services provided to Member States through the IAEA/WHO SSDL Network and a system of dose quality audits. The measurement standards of Member States are calibrated, free of charge, at the IAEA's dosimetry laboratory. The audits are performed through the IAEA/WHO TLD postal dose assurance service for SSDLs and radiotherapy centres, and the International Dose Assurance Service (IDAS) for SSDLs and radiation processing facilities, mainly for food-irradiation and sterilisation of medical products.

The range of services is listed below.

Services	Radiation quality
1. Calibration of ionization chambers (radiotherapy, diagnostic radiology including mammography, and radiation protection, including environmental dose level).	x-rays (10-300kV) and gamma rays from ^{137}Cs and ^{60}Co
2. Calibration of well-type ionization chambers for brachytherapy Low Dose Rate (LDR).	γ rays from ^{137}Cs
3. Comparison of therapy level ionization chamber calibrations (for SSDLs).	γ rays from ^{60}Co
4. TLD dose quality audits for external radiotherapy beams for SSDLs and hospitals.	γ rays from ^{60}Co and high energy x-ray beams.
5. TLD dose quality audits for radiation protection for SSDLs.	γ rays from ^{137}Cs
6. ESR-alanine dose quality audits for radiation processing (for SSDLs and industrial facilities), through International Dose Assurance Service (IDAS).	γ rays from ^{60}Co, dose range: 0.1-100 kGy
7. Reference irradiations to dosimeters for radiation protection (for IAEA internal use).	x-rays (40-300 kV) and γ rays from ^{137}Cs and ^{60}Co

Member States who are interested in these services should contact the IAEA/WHO Network Secretariat for further details, at the address provided below. Additional information is also available through the Internet at the web site: http://www.iaea.org/programmes/nahunet/e3/

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REPORT OF THE TENTH MEETING OF THE SSDL SCIENTIFIC COMMITTEE OF THE IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

IAEA, Vienna, 25 February – 1 March 2002

Participants

Committee members:

P. Allisy-Roberts, BIPM, Chair of the SSC

J. Böhm, PTB, Germany

H. Paretzke, ICRU

E. Podgorsak, McGill University, Canada

M. Saraví, CNEA, Argentina

S. Seltzer, NIST (*unable to attend*)

N. Takata, NMIJ/AIST, Japan

D. Webb, ARPANSA, Australia

IAEA/WHO Network Co-Secretaries:

K.R. Shortt, IAEA

H. Østensen, WHO *(unable to attend)*

Observer:

J. Witzani, BEV, Austria

Rapporteur:

G. Ibbott, RPC, USA

IAEA staff members:

W. Burkart, Deputy Director General and Head of the Department of Nuclear Sciences and Applications

S. Groth, Director, Division of Human Health *(unable to attend)*

P.R. Danesi[1], Director, Agency's Laboratories Division, Seibersdorf

P. De Regge, Head, PCI Laboratory, Seibersdorf

K.R. Shortt, Head, Dosimetry and Medical Radiation Physics Section (DMRP) (Co-Secretary, as above)

J. Izewska, TLD Officer and Head of the Dosimetry Laboratory Unit, DMRP

P. Ortiz Lopez, Head, Patient Protection Unit, Radiation Safety Section, Division of Radiation and Waste Safety

A. Meghzifene, SSDL Project Officer, DMRP

F. Pernicka, Medical Radiation Physicist, DMRP

H. Tölli, Medical Radiation Physicist, DMRP

S. Vatnitsky, Medical Physicist, DMRP

P. Bera, Senior Laboratory Technician, DMRP

L. Czap, Senior Laboratory Technician, DMRP

R. Girzikowsky, Senior Laboratory Technician, DMRP

1. FOREWORD

The report of the ninth meeting (held in November 2000) of the Scientific Committee (SSC) of the IAEA/WHO network of Secondary Standards Dosimetry Laboratories (SSDLs) was published in the SSDL Newsletter No. 44, January 2001.

The tenth meeting was held in Vienna at the Agency Headquarters from 25 February – 1 March 2002. Opening remarks were made by Mr. Werner Burkart, Deputy Director General and Head of the Department of Nuclear Sciences and Applications, Mr. Piero Danesi, Director of the Agency's Laboratories at Seibersdorf (NAAL), and Mr. Ken Shortt, Head of the Dosimetry and Medical Radiation Physics (DMRP) Section. Mr. Steffen Groth, Director of the Division of Human Health (NAHU), sent regrets, as did Mr. Harald Østensen (WHO), Co-Secretary of the IAEA/WHO SSDL network.

Mr. Burkart welcomed the Committee and explained the significance of the SSC. The SSC is the only standing committee that oversees activities in the Division of Human Health, and it has been of value in focusing the work of the Section of Dosimetry and Medical Radiation Physics. He informed the Committee that most of the recommendations made by SSC-9 had been implemented. He stressed that the recommendations of the SSC would help the Agency to plan for the next

[1] Mr. P. Danesi has retired. Ms. G. Voigt is the new Director of the Agency's Laboratories Division (Seibersdorf).

biennium. He underlined the important role of the DMRP in establishing links between developing countries and the international metrology community and in assuring consistency among Secondary Standards Dosimetry Laboratories (SSDLs). Mr. Burkart then emphasized that the incidence of cancer was continuing to increase worldwide, and that the rate of increase was even greater in developing countries. This continual increase in cancer incidence underlined the importance of the Agency's work, such as the IAEA/WHO TLD audits and the contribution to development and implementation of physical and technical aspects of quality assurance (QA) in radiation therapy in Member States. He reminded the Committee that SSC-9 recommended a new facility at NAAL. The Agency has held discussions on mechanisms to implement this recommendation, but to date, no funding has been made available.

Mr. Danesi then spoke to the Committee about the organization and operations of the Agency's Laboratories at Seibersdorf. He mentioned also the recommendation of SSC-9 to develop a new facility at NAAL. He said that NAAL agrees that this is an important priority and that the Dosimetry Laboratory (DOL) facilities are presently insufficient and require expansion. Ms. Allisy-Roberts, BIPM, Chair of the SSDL Scientific Committee, replied on behalf of the Committee and thanked Mr. Burkart and Mr. Danesi for the Agency's comments and support. She thanked the Agency for the efforts made to respond to past recommendations of the SSC. Mr. Shortt then introduced the DMRP staff members who would be presenting reports on their activities during the first two days of the meeting. Mr. Shortt referred to the Agency's mandate and quoted from the IAEA Statutes: "The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." Mr. Shortt noted that the prominent mention of "health" in the mandate emphasized the importance of health issues to the Agency, and the corresponding significance of the DMRP. Extracting further from Article III of the statutes, he indicated those Agency functions that he felt were key to the DMRP's activities:

1. To foster the exchange of scientific and technical information on peaceful uses of atomic energy.
2. To encourage the exchange and training of scientists.

Mr. Shortt reviewed the organizational structure of the Agency and explained how the DMRP fits within the Division of Human Health (NAHU) under the Department of Nuclear Sciences & Applications (NA). He presented charts showing that the DMRP is one of four Sections within NAHU. Mr. Shortt concluded by describing the function of the DMRP. He stated that for the Agency to disseminate nuclear technology in the area of human health, it is necessary for Member States to be able to accurately measure ionising radiation. The DMRP supports the activities of Member States by ensuring international consistency in dosimetry standards and by monitoring the implementation and dissemination of those standards to end-users. It contributes to the increase in scientific and technical capacity in medical physics worldwide by fostering research and development in dosimetry techniques and playing a role in the education of medical physicists. The DMRP is also responsible for quality assurance (QA) aspects of the use of radiation in medical applications to ensure that it is safe and effective.

The DMRP staff members presented reports during the first two days of the meeting on the various activities of the Section. The SSC then met in closed session with Mr. Shortt until Friday afternoon, deliberating on the accomplishments and direction of the Agency's sub-programme, and developing specific recommendations.

The SSC evaluated the activities of the DMRP reported for 2000–2001 and discussed the proposed sub-programme for the Section for 2002–2003. In addition, the SSC reviewed an initial proposal for 2004–2005. The scope of the SSC evaluation addressed the questions of:

1 The objectives of the sub-programme areas.
2 The impact (benefit to the Member States).

3 The continuing relevance of Agency activities.
Specific recommendations from the SSC are underlined throughout the text, but are also reiterated at the end of the report.

2. INTRODUCTION

The SSC wishes to thank the DMRP staff members for preparing a comprehensive report covering the activities of the sub-programme on Dosimetry and Medical Radiation Physics. The availability of this report in advance of the meeting enhanced the Committee's ability to develop thoughtful and appropriate recommendations.

The SSC is pleased to note that most of the recommendations of SSC-9 have been implemented in spite of the shorter time frame on this occasion, since the Committee met only 14 months after the previous meeting and not the 24 months that is customary. The SSC notes that the DMRP intends in the current biennium to implement the SSC-9 recommendations that are outstanding.

In the biennium 2000–2001, the DMRP Section's activities were performed under four identifiable projects:

1 PROJECT E.3.01: Network of Secondary Standards Dosimetry Laboratories (SSDLs)
2 PROJECT E.3.02: Quality Assurance and Dose Audits to End-users
3 PROJECT E.3.03: Quality Assurance, Dosimetry and Education in Radiotherapy
4 PROJECT E.3.04: Support to Technical Co-operation Activities.
Beginning with the biennium 2002–2003, the projects and their titles are changed to:

1 PROJECT F.3.01: Network of Secondary Standards Dosimetry Laboratories (SSDLs)
2 PROJECT F.3.02: Quality Assurance and Dose Audits to End-Users
3 PROJECT F.3.03: Research and Development in Radiation Dosimetry Techniques
4 PROJECT F.3.04: Developments in Radiotherapy Physics Quality Assurance.

In the new format, F.3.01 and F.3.02 continue to address the provision of services to Member States while all CRPs (research and development) have been moved to F.3.03 and F.3.04. Projects F.3.03 and F.3.04 separate the activities in the former project E.3.03 ("Quality Assurance, Dosimetry and Education in Radiotherapy") with the new F.3.04 focusing on all projects in the field of quality assurance in medical radiation physics. Technical Co-operation activities, previously performed under E.3.04 are now merged under the relevant new project titles. This SSC report is organized following the new project numbers as specified during the current biennium 2002–2003. For the biennium 2004–2005, it is planned to alter the name of F.3.04 to "Developments in Medical Radiation Physics Quality Assurance" in order to reflect properly the number of activities in support of diagnostic radiology and nuclear medicine that are already performed by the DMRP under that activity.

This report begins with a general discussion of administrative items and collaborative efforts within the Agency. Each project is then discussed in turn. The report summarizes only those particular activities of the Section for which the SSC has comments or recommendations at this time. Exclusion of specific activities should be interpreted positively, as concurrence by the SSC with the activity as reported.

3. REPORT

3.1 General Organizational Items

3.1.1 Timing for the SSC meeting

The SSC is pleased to be able to make input early enough in the planning process to have impact on preparations for the programme of the biennium 2004–2005. To ensure that future SSCs also are able to review the programme early in the biennium and impact on preparations of the programme for the subsequent biennium, the SSC meetings will be scheduled early in the year. For example, the meeting of SSC-11 is tentatively scheduled for 1–5 March 2004.

3.1.2 Mutual Recognition Arrangement (MRA)

The Agency devoted considerable effort during the past biennium to prepare its Calibration and Measurement Capabilities (CMCs) and submit them to the Joint Committee of the Regional Metrology Organisations and the Bureau International des Poids et Mesures (JCRB), following a review by selected members of the CCRI(I) (BIPM, PTB and NIST). Acceptance by the JCRB into Appendix C of the BIPM Key Comparison Data Base (KCDB) is the first step in linking the metrology systems of the SSDL Network members to the International Measurement System. The SSC is very pleased that the Agency's CMCs have undergone regional review and should be approved by the JCRB for inclusion in the MRA. The SSC notes that they will be among the first CMCs to be included in the BIPM KCDB.

The SSC recommends that the DMRP continues to participate in comparisons of regional metrology organizations (RMOs), e.g., EUROMET, SIM and APMP, to demonstrate routinely its own calibration and measurement capabilities (CMCs) as well as helping members of the SSDL network to demonstrate their CMCs.

3.1.3 Membership of the SSC

The Committee is pleased that the DMRP has addressed the recommendation of SSC-9 to add a member who has experience with an external audit group (EAG).

3.1.4 The Agency's Dosimetry Laboratory

The Dosimetry Laboratory (DOL) is integrated into the Agency's Laboratories at Seibersdorf. The range of services provided to the SSDL network includes:

1 Calibration of ionization chambers for radiotherapy, diagnostic x-rays including mammography, and radiation protection.

2 Calibration of well type ionization chambers for low dose rate brachytherapy sources (^{137}Cs).

3 TLD dose quality audits for external radiotherapy beams (for SSDLs and for hospitals).

4 ESR-alanine dose quality audits for radiation processing (for SSDLs and for industrial facilities).

5 TLD dose quality audits for SSDLs providing calibrations for radiation protection.

6 Comparisons with SSDL members, using ionization chambers for air kerma and absorbed dose to water.

Cobalt-60 gamma radiation is essential for radiotherapy calibrations. The Agency's present cobalt unit is now 25 years old, and it is becoming increasingly difficult to maintain the metrological quality needed in the Agency's measurement programme for radiotherapy. Commercially available replacement units cannot be located in the present bunker, because the bunker is too narrow to accommodate the source transfer container required to replace the source and perform proper maintenance of the unit.

The SSC further notes that the calibration capability is now limited both by the number of technicians available (3) to do the work and by demands for access to the radiation sources in the existing facility. With the demand from the SSDL network for five new calibration services (absorbed dose to water calibrations in cobalt-60 beams, protection-level, diagnostic x-ray qualities, mammography qualities and brachytherapy), the number of requests for calibrations is expected to increase further. The high number of calibration requests also makes it impractical to conduct training sessions at the laboratory and so the number of training sessions has been reduced. The SSC is pleased to note that the recommendation of SSC-9 to build a new bunker will be included in the biennium 2004–2005. The SSC believes that an additional calibration area is now essential to meet the increased calibration requirements of the Member States, and the SSC recommends that the facility should be sufficiently large and the internal construction be flexible to allow future changes of use.

The SSC notes that once the additional calibration capability has been implemented, the DMRP will be able to provide the laboratory space required for the systematic training of fellows at the appropriate level.

3.1.5 Collaboration with the World Health Organization (WHO)

Collaboration between the Agency and the WHO has a long history of mutual benefit in many areas. In the case of the DMRP, collaboration with the WHO has helped to improve the turn-around time and the level of participation in the IAEA/WHO postal TLD service. The education of regional officers concerned with human health is an important component of this programme as the regional officers can encourage further participation in the programme. SSC-9 recommended that joint IAEA/WHO seminars be organized for these regional officers. These seminars should explain:

1 the importance of coherent dosimetry linked to the international measurement system,

2 the role of staff training in dosimetry techniques,

3 the promotion of the IAEA/WHO hospital audit service in radiotherapy dosimetry, and

4 the importance of the SSDL network in providing the necessary measurement assurance.

The SSC would be pleased to see the training programme for regional officers included in the 2004–2005 biennium.

SSC-9 recommended that training programmes in radiation dosimetry and medical physics applications, proposed by the Agency, PAHO or WHO, be planned and carried out in collaboration with each other, where there are common interests. This is particularly important because PAHO and WHO have direct contacts with the health authorities in the Member States.

The SSC recommends that the Agency continue to support programmes to train radiographers in quality control of radiographic equipment and procedures. The SSC notes that the training offered to medical physicists can include, as one component, instruction for training radiographers in QC procedures in diagnostic radiology.

3.1.6 Staffing

With the addition of the position in radioactivity standardization, the number of professional staff within the DMRP will reach 7 persons. Because of the core activities involved in operating a calibration laboratory and providing dose verification services, there is a considerable administrative burden within the DMRP. In addition, there is a need for clerical assistance to deal with data entry into the DIRAC database.

The SSC would be pleased to see the Agency consider providing additional administrative support to the DMRP to handle the secretarial work and support the DIRAC project.

The SSC also notes that the addition of a technician to the staff at Seibersdorf is necessary already to deal with the present workload since there is only time for the technicians to perform calibrations and no time to develop new techniques to improve efficiency. By engaging such a person now, training could be carried out to enable a smooth implementation of the expanded facilities that are requested above.

The SSC would be pleased to see the Agency consider adding a technician to the staff working at the DOL in Seibersdorf to begin the biennium 2004–2005.

3.2 Project F.3.01: Network of Secondary Standards Dosimetry Laboratories (SSDLs)

The IAEA/WHO SSDL network presently consists of 75 laboratories and 6 SSDL national organizations in 63 Member States, of which more than half are developing countries. The network includes 20 affiliated members, all of which are international organizations or Primary Standards Dosimetry Laboratories (PSDLs). Membership in the network is open only to laboratories designated by their national competent authority. The privileges, rights and duties of members in the network are laid down in the

SSDL Network Charter, published by the Agency in 1999.

The principal objective of the SSDL network is to provide traceable instrument calibrations for use in radiation therapy, radiation protection, diagnostic radiology including mammography, and brachytherapy (^{137}Cs). Some SSDLs provide quality audits of radiotherapy dosimetry by postal TLD and on-site measurements, and some perform measurements at radiation processing levels. It was noted by SSC-9 that almost all SSDLs (97%) provide radiation protection level calibrations, although most do so without demonstrating traceability to the International Measurement System through the Agency. Nevertheless, in general, the implementation of a programme to develop and maintain dosimetry standards and to disseminate them requires demonstration of traceability of the SSDL's standards to a PSDL or to the Agency. Traceability should be verified periodically through quality audits and chamber comparisons organized by the DMRP. Since 1997, a routine comparison service using ionization chambers has been conducted to verify the integrity of the reference standards of SSDLs in the therapy dose range. Postal TLD programmes are in place to check calibrations provided by the SSDLs in both the radiotherapy and radiation protection dose ranges.

Since 1991, the DMRP has focused efforts on following up the results of all the audit services when an SSDL (or hospital) has results outside the Agency's acceptance limit. This follow-up programme has been very successful.

3.2.1 Membership issues

The SSDL Network Charter established the category of 'provisional' member for SSDLs who do not fulfil the obligations of full membership. This category is considered to be temporary while efforts are made by the provisional member to comply with the Charter. Three SSDLs considered as provisional members were informed recently through their Government authorities that they would be deleted from the network.

The SSC commends the DMRP for identifying, as provisional members, SSDLs that do not comply with the SSDL Network Charter. Five SSDLs have not submitted annual reports for 1999 and 2000. If they do not respond to recent reminders, they will be transferred to the list of provisional members[2].

The SSC recommends that the Agency move the SSDLs of five countries, Bolivia, Ecuador, Egypt, Libyan Arab Jamahiriya and Iran Islamic Republic (the Khomeini Hospital) to the provisional list to implement the actions required by the Agency. In addition, the SSC recommends that the Agency investigate the support needed to bring these SSDLs back into compliance with the SSDL Network Charter.

The SSC also recommends that the DMRP identify the hospitals that are coming directly to the Agency for calibrations and consider encouraging their Member States to establish national SSDLs.

In the light of new memberships in the SSDL network, SSC-9 recommended that the Agency review the guidelines to Member States on the designation of an SSDL in the IAEA/WHO network. The review was to take into account the main objective of the network, i.e., to ensure traceability of measurements for those countries that do not have access to Primary Standards Dosimetry Laboratories.

SSC-9 recommended that the Agency invite Member States to review the status of membership of their laboratories in the SSDL network, with a view to reclassifying the SSDL as an affiliate member in cases where it has developed a primary dosimetry standard linked to the International Measurement System.

The SSC recommends that when contacting Member States with a view to changing their network membership, the Agency consider the implementation of a primary standard for absorbed dose to water as the key criterion for becoming an affiliate member.

[2] Note the new development after the SSC-10 meeting: the SSDLs of Egypt and Libya have responded favourably to the reminder.

3.2.2 Training issues

The SSC supports the DMRP initiative to become more systematic in their training of SSDL members and would welcome the development of training materials for this purpose.

The SSC recommends that the DMRP undertake an initiative to become more systematic in their training of SSDL staff members. The SSC recommends that until the Agency's laboratory facilities are available for training of SSDL staff, consideration should be given to using affiliate PSDLs and well-developed SSDLs for such venues.

3.2.3 Provision of dose-to-water calibration coefficients

An important and significant activity during the past biennium was the publication in December 2000 of TRS-398: "Absorbed Dose Determination in External Beam Radiotherapy". This is the only international code of practice for dosimetry based on standards of absorbed dose to water. In addition to the IAEA, WHO, PAHO, and ESTRO have also endorsed the protocol. Use of the protocol requires that hospitals be provided with calibration standards in terms of absorbed dose to water. At the moment, the Agency is preparing to disseminate absorbed dose to water calibration standards, but it is essential, during the ensuing transition period, that the Agency help the SSDLs and particularly the hospitals to avoid confusing the new standard and the existing air-kerma standard.

The SSC recommends that the DMRP calibrations in terms of absorbed dose to water be linked explicitly to TRS-398 for the hospital or country concerned.

3.2.4 Comparison of ionization chamber calibration coefficients for dose to water and air kerma

A proficiency test programme that began in 1995 verifies the ability of SSDLs to transfer a calibration from their standard to the user. The SSDL calibrates an ionization chamber of its choice, and forwards it to the DMRP Section for an IAEA calibration. The chamber is returned to the SSDL where the calibration is repeated to ensure stability of the instrument during transit. Eight SSDLs participated in this ionization chamber comparison programme during 2000–2001 and the results are presented in Figure 1. Calibrations both in terms of air kerma and absorbed dose to water were included. The two participants exceeding the DMRP action level (1.5%) were contacted for follow-up action.

The SSC notes that the Agency has conducted a successful programme of comparison of ionization chamber calibration coefficients for SSDLs. It is understood that many SSDLs have requested that the Agency expand this programme to include x-rays. The SSC recommends that the Agency implement the guidelines put forward by the Consultants' Meeting on the Intercomparison of Ionization Chamber Calibration Factors in X-ray Beams (held 22–25 October 2001).

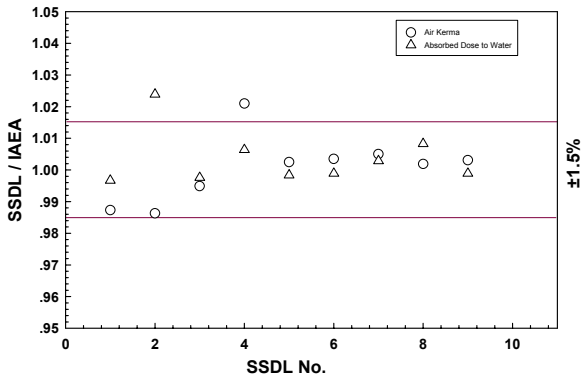

Fig. 1: Ratios of ionization chamber calibration coefficients supplied by the SSDLs to those measured by the Agency. Circles correspond to air kerma calibration coefficients and triangles to absorbed dose to water coefficients.

Comparisons with SSDLs should support the uncertainty claims for each SSDL's Calibration and Measurement Capabilities (CMCs). The Agency should consider two tiers of exercises to verify calibration consistency: TLD audits could be used to indicate the achievement of a basic level of functionality, while chamber comparisons would test calibration accuracy to support the SSDL's claimed CMCs. Adapting the monitoring programme in this way would help guide SSDLs in establishing their own uncertainty budgets.

The SSC recommends that the DMRP implement the proposal to organize consultants' meetings to help SSDLs to establish dosimetry uncertainty budgets. The SSC further recommends that the Agency continue to provide chamber comparisons to SSDLs in support of their CMCs.

In addition, the working documents of the 15th Meeting of the Comité Consultatif des Rayonnements Ionisants (Section I), CCRI(I) encouraged laboratories to participate in dosimetry comparisons. The SSC also recommends that the Agency participate in CCRI(I) dosimetry comparisons as appropriate.

3.2.5 TLD monitoring of SSDL measurements at therapy levels

The IAEA/WHO TLD postal dose quality audit service has monitored the performance of the SSDLs in the therapy dose range since 1981. Results of this programme indicate that approximately 95% of the SSDLs that participate in the TLD audits have results within the acceptance limit of 3.5%.

The results for dose delivery under reference conditions in a water phantom for the laboratories providing therapy level calibrations are presented in Figure 2, where deviations of the laboratory's results from the Agency's results are plotted for ^{60}Co and high energy x-rays. During the review period, three SSDL TLD runs (2000/2, 2001/1 and 2001/2) were completed for 55 laboratories, in which 124 beams were checked (84 ^{60}Co beams and 40 high-energy x-ray beams from medical accelerators).

For laboratories with deviations outside the acceptance limit, a follow up programme has been established to resolve the discrepancies. Those laboratories are informed by the Agency about the discrepancy and assisted to understand and resolve the problem. A second (follow-up) TLD set is sent to each of these SSDLs and the deviations outside the 3.5% limit are explained and corrected.

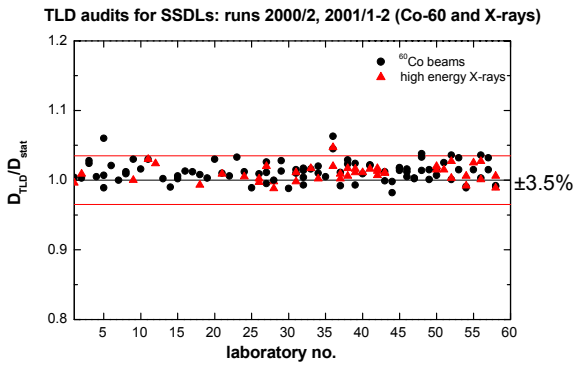

Fig. 2. Results of the IAEA/WHO TLD runs 2000/2, 2001/1 and 2001/2. Data in the graph correspond to the ratio of the Agency's determined dose from the TL-response (D_{TLD}) to that stated by the SSDL (D_{stat}). Each data point corresponds to the average of three dosimeters. A total of 124 beam calibrations were checked in 55 laboratories, which include 84 ^{60}Co beams (circles) and 40 high energy x-ray beams (triangles). The number of therapy beams checked in different TLD runs was: 44 beams in batch 2000/2, 38 beams in 2001/1 and 42 beams in 2001/2. A total of six deviations in 124 were found outside the acceptance limit of 3.5% (two deviations in 2000/2 run and four in 2001/2 run).

3.2.6 Calibration of ionization chambers at diagnostic x-ray energies, including mammography

A discrepancy between the calibration coefficient for the IAEA standard (Radcal 10X5-6M ionization chamber) provided by PTB and that provided by NIST was investigated. As a result, the ionization chamber was recalibrated at both PSDLs in 2001 in order to resolve the discrepancy. Now, the maximum difference in N_K for similar beam qualities is 0.3%, which is regarded as acceptable. As of January 2001, the Agency's Dosimetry Laboratory began to offer calibrations at 17 different beam qualities for mammography.

The Agency recently participated in the EUROMET Project No. 526, which is a co-operative research project involving 14 European metrological institutes. The main objective of the project was to investigate the suitability of radiation qualities available at standards laboratories for the calibration of dosimeters used in mammography, according to the requirements of IEC 61674. In addition,

the project also aimed to compare the calibration accuracy between laboratories.

The SSC recognizes the research that has gone into setting up the 17 mammography beam qualities and resolving the discrepancy in calibration of the standard. However, the SSC recommends that the Agency rationalize the number of qualities provided for mammography calibration of a given instrument. Guidance may be taken from the results of the EUROMET Project No. 526. The SSC is pleased to see that a pilot study comparing mammography calibrations at SSDLs is planned for 2003.

SSC-10 notes that patient doses from CT may be significant, and the availability of CT scanners in developing countries has resulted in an increase in the number of procedures performed. There is a need for calibrated pencil chambers for measuring patient doses from CT procedures.

The SSC recommends that an investigation be conducted into the calibration of pencil-type chambers for use in dosimetry of radiation fields produced by CT scanners.

3.2.7 *Activities in common with NSRW*

A Co-ordinated Research Project on "Image quality and patient dose optimisation in mammography in eastern European countries" is being conducted by the Division of Radiation and Waste Safety (NSRW). The DMRP has organized a comparison of TL dosimetry measurements. The results given in Figure 3 show significant variations among the participants, although repeat measurements were generally better than the initial results. Nevertheless, a considerable number of results fell outside the 10% acceptance criterion established by the DMRP.

The SSC is pleased to note the involvement of the DMRP in the dosimetry aspects of the CRP "Image quality and patient dose optimisation in mammography in eastern European countries" in collaboration with NSRW. The SSC recommends that the DMRP play a leading role in projects related to image quality and patient dose optimization within the limited resources presently available.

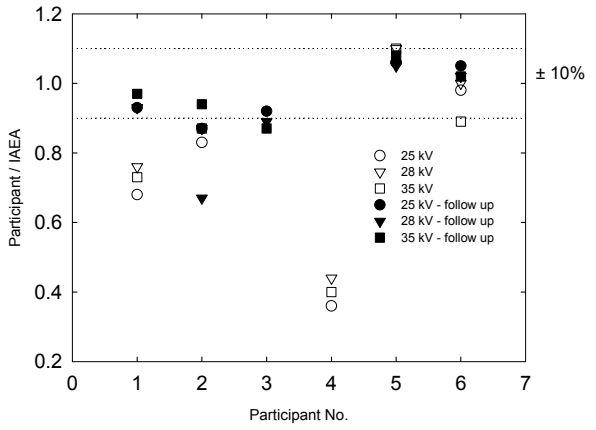

Fig. 3. Ratios of the air kerma stated by the participant to the value used at the Agency's Dosimetry Laboratory for irradiation of TLDs in x ray beams generated by a tube with a molybdenum anode. Empty symbols are for the initial tests and filled symbols are for the follow-up tests.

The SSC is pleased to recognize the work done by the DMRP in reviewing and promulgating NSRW documents, and in particular the comparison of TL dosimetry systems for mammography. The SSC recommends that collaboration with NSRW continues to the extent possible and that provision for recognition of these collaborative efforts be entered into the DMRP list of activities for the biennium. The SSC is pleased to learn about the possibility of harmonizing the protocols in mammography that were developed within the framework of various TC projects.

3.2.8 *Activities in brachytherapy dosimetry standards*

The Agency has two ^{137}Cs low dose rate (LDR) brachytherapy sources calibrated at NIST and a well-type ionization chamber for use as a transfer instrument. The Agency presently disseminates only LDR ^{137}Cs calibrations. SSC-9 recommended that a survey be conducted to determine the number of SSDLs that might use calibration and subsequent measurement quality assurance services from the Agency, specifically for ^{192}Ir high dose rate (HDR) brachytherapy. The survey indicated that there was substantial interest on the part of the SSDLs for these services. Consequently, the Agency has

developed a plan to investigate the introduction of these services.

Within the DMRP, most of the work in brachytherapy dosimetry to date has been concerned with source calibration techniques, leaving investigations of determining the dose to the patient and treatment planning issues for subsequent work.

The SSC supports the DMRP plan to investigate the use of the high dose rate (HDR) unit at the Allgemeine Krankenhaus (the AKH or Vienna General Hospital) or other local hospitals to conduct calibrations of well chambers for HDR ^{192}Ir. The SSC recommends that subsequent to the pilot study with AKH, the DMRP investigate a future programme that might include dose verification techniques and brachytherapy treatment planning issues.

3.2.9 *TLD dose quality audits for radiation protection*

TLD audits of protection-level calibrations were discussed. The Agency conducted several measurement runs during 1999–2001 as shown in Figure 4[3]. SSC-10 is favourably impressed by the Agency's determination that the uncertainty of the TLD system (at 5 mGy) is 1.7%. However, a large number of SSDLs fall outside the acceptance limit based on twice the TLD standard uncertainty. The SSC recommends that the acceptance limit for TLD results used in radiation protection be set at not less than 3-sigma, or 5%.

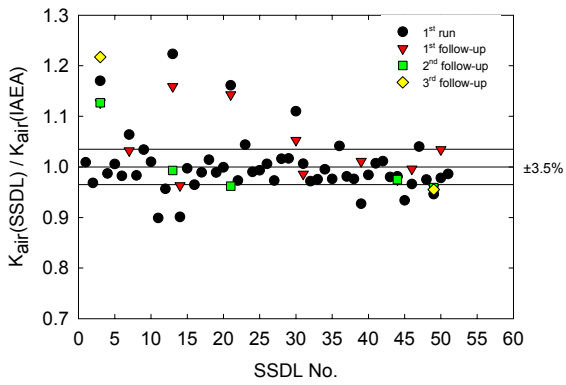

Fig. 4. Results of TLD audits in radiation protection, showing the air kerma stated by the SSDL to that determined by the Agency.

3.2.10 *Radiation protection operational quantities and calibration of protection level dosimeters*

SSC-9 recommended that the DMRP extend its capabilities to include standards for and dissemination of calibration in terms of personal dose equivalent [$H_p(10)$] using the ISO water slab phantom, for those SSDLs involved in personal dosimetry. The Agency is currently working towards establishing a calibration service for personal dose equivalent $H_P(10)$ traceable to PTB. The SSC-10 is pleased to see progress in the area of radiation protection dosimetry and the acquisition of an appropriate chamber and phantom. The SSC-10 recommends that the Agency continue to develop services concerning radiation protection dosimetry standards. The DMRP should encourage those SSDLs that provide personal dosimetry services to implement the ISO 4037 Parts 1 to 4 for photon radiation.

3.2.11 *Activities in radioactivity standardization and nuclear medicine*

The DMRP should plan to develop and provide calibration and auditing services, organize educational material, and develop a Code of Practice for Nuclear Medicine. The SSC is disappointed to note that the vacant medium-term Nuclear Medicine position has not yet been filled[4]. The SSC recommends that

[3] *It should be noted that a second run scheduled in 2001 was cancelled because of the possibility of the detectors being irradiated during transit due to increased security following the terrorism activities within the United States on September 11, 2001.*

[4] Note the new development after the SSC-10 meeting: the position was filled and a new professional is expected to join the Agency in April 2003.

the details of the DMRP programme to develop standards for the measurement of radioactivity and to support nuclear medicine dosimetry at the SSDLs be defined during the upcoming Consultants' Meeting on Methodology of Radioactivity Standardization, to be held 29 November – 3 December 2002.

3.3 Project F.3.02: Quality Assurance and Dose Audits to End-users

The Dosimetry and Medical Radiation Physics Programme performs dose quality audits for

1 radiotherapy centres using mailed thermoluminescence dosimeters, and
2 industrial radiation processing facilities using alanine-ESR dosimeters.

In both services, users are requested to irradiate the dosimeters with a given dose under known irradiation conditions; the dosimeters are then returned to the Agency for dose evaluation.

3.3.1 The IAEA/WHO TLD postal service for hospitals

In the last 32 years, the IAEA/WHO TLD audit service has checked the calibration of more than 4300 radiotherapy beams in about 1200 hospitals worldwide. The Agency has established a regular follow-up programme for hospitals with poor results, including on-site visits by local or international scientists that provide support and training in medical physics to hospital staff.

During the review period, the IAEA/WHO TLD postal dose audit service for hospitals has maintained the previous achievements related to organization and efficiency of the service. The automation of the TLD system has allowed a reduction in the time needed for the TLD evaluation and an increase in the number of hospitals monitored to 300–400 per year. Due to the joint efforts of IAEA and WHO, the return rate of the irradiated dosimeters now exceeds 90%.

In 2000–2001, the TLD programme audited 507 beams in 351 radiotherapy centres with 186 additional radiotherapy centres joining the TLD network. The global results are shown in Figure 5. Approximately 84% of the results are within the acceptance limit of 5%.

Only 74% of the hospitals that received TLDs for the first time have results within the acceptance limit (5%), while 88% of institutions that benefited from a previous TLD audit have results within the 5% limit. The percentage of results that deviate by more than 10% is twice as high for the new hospitals (8%) as for those having already participated in the audits (4%).

In the past, about one third of the persistent TLD discrepancies had not been resolved. At present, the follow-up procedure has been improved through closer contacts with local experts where available (mainly from SSDLs), or by recruitment of external experts in medical physics.

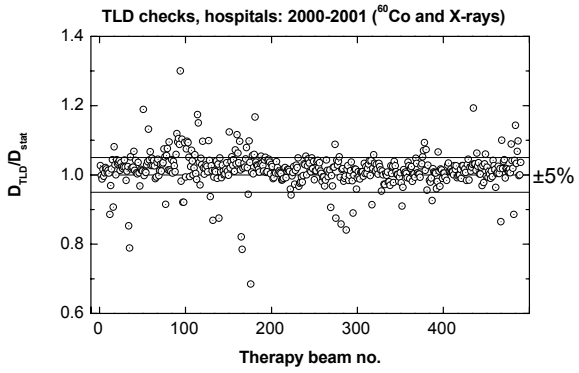

Fig. 5. Results of the IAEA/WHO TLD postal dose audits of radiotherapy hospitals for the delivery of absorbed dose to water under reference conditions during 2000–2001(starting after October 2000) for the TLD batches B116 to B128. Data in the graph correspond to ratios of the Agency's determined dose (D_{TLD}) relative to the dose stated by the hospital (D_{stat}). Each data point corresponds to the average of two dosimeters. A total of 507 beam calibrations were checked in 351 hospitals. Approximately 17% of the results were found outside the 5% acceptance limit. Two extreme deviations, $D_{TLD}/D_{stat}=1.30$ and $D_{TLD}/D_{stat}=0.685$, were explained and corrected.

The IAEA/WHO TLD postal programme for monitoring the calibration of radiation therapy beams at hospitals in Member States continues. The SSC makes no recommendation but wishes to acknowledge the good work performed by the DMRP.

3.3.2 Activities in the IDAS project

The International Dose Assurance Service (IDAS audit service) continues to serve the industrial facilities and research institutes in Member States involved in radiation processing. Since the service was made more 'accessible' following an earlier recommendation of the Scientific Committee, it has seen an increase in the number of facilities participating yearly. That number was under 20 up to 1995. Since 1996, it has varied between 20 and 30 facilities per year.

In this review period, the number of facilities involved was 21 and the number of dosimeter sets distributed and analysed was 63, as shown in Figure 6. Approximately 80% of the results are within the acceptance limit of 5%. Seven follow up dosimeters were sent to the participants and in four cases the discrepancy was resolved.

The Agency's laboratory provides dosimetry quality audit services for high-dose irradiation facilities in support of Member States' programmes sponsored by other Divisions in the Agency (specifically the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (NAFA) and the Division of Physical and Chemical Sciences (NAPC)). The SSC regrets that the financial support requested in the past for the high-dose dosimetry service (IDAS) has not been forthcoming. The continuing need for the IDAS facility is evident. Recent events in the US have resulted in the establishment of new radiation sterilization facilities, and these may become more common in the developing world. Food irradiation also is likely to become more prevalent in the future as the benefits of increasing storage time become accepted.

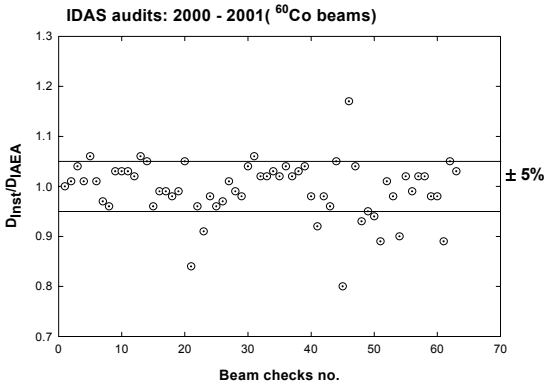

Fig. 6. Results of the IAEA IDAS postal dose audits of radiation processing facilities for the delivery of absorbed dose to water under standard conditions during 2000–2001 (starting after October 2000). Data in the graph correspond to ratios of the dose stated by the institution (D_{inst}) relative to the Agency's determined dose (D_{IAEA}). Each data point corresponds to the average of three dosimeters. A total of 63 beam calibrations were checked. Approximately 20% of the results were found outside the 5% acceptance limit.

In addition, the technology for dosimetry at high doses is changing rapidly and new desktop ESR analyzers are now available that can improve the cost effectiveness of high-dose dosimetry. The use of ESR-alanine dosimeters for bio-dosimetry may be a natural link to a new programme in radioecology to be established at NAAL.

The SSC recommends that this valuable service using alanine-ESR for dosimetry be maintained. Although the existing equipment may be kept viable for a few more years, plans need to be made for its ultimate replacement.

3.4 Project F.3.03: Research & Development in Radiation Dosimetry Techniques

Research and development of dosimetry techniques in the DMRP sub-programme is provided through Co-ordinated Research Projects (CRPs), training courses, fellowships, seminars, symposia and publications.

3.4.1 TRS-398

The benefits of adopting TRS-398 as an international standard are recognized by the SSC.

The SSC recommends that current collaborations with international (e.g. ICRU) and national bodies (e.g. ESTRO) working in the area of dosimetry standards for the measurement of radiation quantities be reinforced so that standards and codes of practice produced by the Agency are of the highest quality and widely accepted.

3.4.2 Activities in QC for diagnostic radiology

By far, the largest contribution to population dose from manmade sources is from diagnostic x-rays. Even a modest reduction of patient doses can have a profound impact on the collective dose equivalent to the patient population. As long as image quality does not deteriorate, reductions in patient doses are desirable. Accurate determination of dose from diagnostic x-ray units can aid in reducing patient doses. However, diagnostic instrument calibrations at the SSDLs are not provided in a consistent fashion. A code of practice is under development under CRP E2.10.03 to provide systematic guidelines for such calibrations. Once the code of practice is developed, it will need to be implemented.

The SSC recommends that the DMRP implement a plan to test the Code of Practice now being developed under the CRP E2.10.03.

Once consistent diagnostic instrument calibrations are disseminated by the SSDLs, audits should be conducted to assure that the calibrations have been adopted properly by the hospitals.

The SSC recommends that the DMRP implement a CRP or a CM to produce guidelines for SSDLs to conduct TLD audits in diagnostic radiology dosimetry for end-users.

Medical physicists in some Member States lack proper education and training in diagnostic dosimetry and quality assurance techniques. The Agency should be able to assist by developing training materials for such physicists.

The SSC would be pleased to see the DMRP develop a syllabus for training in diagnostic radiation physics along the lines of the training syllabus in radiotherapy physics.

Member States require assistance in conducting clinical diagnostic radiology programmes at the highest level.

The SSC would be pleased to see the Agency collaborate with the WHO on the proposal to write a TECDOC tentatively entitled “Design and Implementation of a Diagnostic Radiology Programme” along the lines of the similar Agency documents on radiation therapy programmes (e.g., TECDOC-1040 or its revision).

Medical physicists in Member States rely on kVp meters to determine the quality of the x-ray beams from diagnostic equipment. They often are dependent upon the manufacturer of the meter to ensure that the device is properly calibrated, and as a result, such pieces of equipment may not receive frequent calibrations.

The SSC would be pleased to see the Agency investigate the possibility of calibrating kVp meters as an additional service to be provided to SSDLs.

3.4.3 Biodosimetry

After the successful completion of the CRP on biodosimetry, the SSC recommends that the DMRP should now consider collaboration with NSRW on the provision of reference irradiations of EPR samples for future biodosimetry comparisons.

3.4.4 Quality assurance, dosimetry and education

An International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry has been scheduled for 25–28 November, 2002, in Vienna. Presentations will be organized into 15 topical sessions. Chairs and invited speakers have been identified for each session. Following the symposium, the chairs will collate the presentations and it is hoped that the proceedings will be published in mid-2003.

3.4.5 Proton dosimetry

Meetings have taken place with ICRU chairman André Wambersie to initiate collaboration to prepare an ICRU report on proton therapy including a part revising ICRU report 59 on proton dosimetry. The SSC supports the DMRP's involvement with the ICRU activities regarding proton dosimetry and recommends that the formal collaboration with the ICRU continues.

3.4.6 Calorimeter

The SSC supports the request from the ARPANSA to borrow the Agency's graphite calorimeter and recommends that the Agency proceed with this equipment loan, noting that it is to be returned in working condition. The calorimeter may then be made available to an SSDL in the future.

3.5 Project F.3.04: Developments in Radiotherapy Physics Quality Assurance

3.5.1 Activities in establishing national TLD networks for radiotherapy dosimetry

The Agency continues to assist Member States to establish national TLD programmes and, whenever possible, establishes links between the national programmes and the Agency's Dosimetry Laboratory. There are twelve Member States (Algeria, Argentina, China, Colombia, Cuba, Czech Republic, India, Israel, Malaysia, Philippines, Poland and Viet Nam) that have established national TLD programmes to audit radiotherapy beams in their countries with assistance of the Agency (CRP E2.40.07). Recently a new co-ordinated research project (CRP E2.40.12) has been initiated for national TLD audits in non-reference conditions, which is a continuation of the previous CRP.

3.5.2 Activities involving in-vivo dosimetry

The Agency has considered various alternative technologies for in-vivo dosimetry for patients undergoing radiotherapy. However, not all technologies meet the criteria for accuracy, precision and reliability needed by the Agency, and some are more appropriate for use in some Member States than others. The SSC recommends that the DMRP propose a new CRP to determine which technologies are most appropriate for Member States to use for in-vivo dosimetry.

3.5.3 Activities in treatment planning systems

In view of new developments in treatment planning (e.g. Monte Carlo calculations), the SSC commends the Agency for having identified a person on the team to specialize in treatment planning issues.

Hospitals in Member States must rely on computerized methods for dosimetry calculations and treatment planning systems to determine isodose distributions for their patients, but frequently they have no way to validate dosimetry calculations and the plans produced by these systems. The hospitals would benefit from the ability to implement treatment QA procedures for dose computation and to compare treatment plans produced by local treatment planning systems with treatment planning benchmark cases.

The SSC would be pleased to see the DMRP consider a CRP to develop treatment planning QA procedures and test benchmark cases, to be used by medical physicists at the end-user level in a hospital to verify the accuracy of the doses calculated by their computerized treatment planning systems.

3.5.4 DIRAC

The Directory of Radiotherapy Centres (DIRAC) is an important database that is maintained by the DMRP. The international nature of this project demands that the Agency provide the service. The SSC welcomes the work of the DMRP to update DIRAC and to revise the software. Being aware that the data in the database are still incomplete and require quality assurance, the Committee recognizes the need for continuous staffing support as opposed to temporary assistance that is being used at present to support this activity.

The SSC recommends that DIRAC be adequately supported and maintained on a continuous basis with appropriate quality control of the data and be strengthened in its database structure. When completed, this will

provide a valuable service to the Member States as well as fulfilling Agency in-house information needs regarding radiotherapy facilities worldwide.

3.5.5 Activities to develop comprehensive educational programmes

The Agency supports several educational programmes in medical physics, including the plans to support the establishment of Co-operative Centres of Quality Assurance in designated Member States. However, cancer incidence is expected to grow and training requirements will increase commensurately. It is believed that an additional 500 medical physicists at least will be needed over the next 10 years just to meet the incremental demand for services originating in developing countries. The demand for other medical and paramedical staff also will increase correspondingly. In fact, the shortage of staff is already apparent. There are known to be several issues that have limited the success of such training programmes in the past. In some cases, the trainee's home country refuses to recognize the education earned in a host country. In other cases, the host government permits the trainees to remain thus preventing their acquired skills being applied in their home countries. In some cases, the home country's promise to improve the infrastructure and expand facilities fails to be honoured with the result that the trainee's skills remain unused at home.

Several solutions to the training issue were proposed. One model would involve expanding the Agency's traditional involvement in short-term training of professionals. In this model, links would be developed with institutes granting accredited academic degree programmes in medical physics. These links would allow physicists from developing countries to obtain formal academic graduate degrees in medical physics through bursaries supplied by the Agency. The students would follow didactic courses at an approved university, receive practical degree training either in the Agency's laboratories or at an approved university clinic, and then return to their country upon graduation. The special category of affiliate member of the SSDL network may be of use to provide additional training locations in dosimetry in an environment similar to the trainee's eventual work situation. In many cases it would be necessary for the Agency to award a fellowship to the trainee. In a programme fully funded by the Agency involving 50 students with 25 in each year of a two-year course, the estimated cost would total about US$250,000 per year. Some partnerships might be created to help reduce the Agency's cost and increase the financial participation of donors such as the host country, the home country or some third country or philanthropic organisation. Properly trained medical physicists would be able to educate radiographers upon their return, which is clearly an additional benefit to the home country of the trainee.

The SSC acknowledges the severe shortage of medical physicists both in developed and developing countries, and recommends that the Agency support formal educational programmes for medical physicists. The SSC recommends that the Agency seek to develop relationships with existing accrediting bodies such as CAMPEP, or other mechanisms to accredit appropriate two-year graduate training programmes, which should ensure acceptance of the training by the trainee's home country.

The SSC would like to see the Agency identify funds to support a five-year project preferably starting with five trainees in each year. The SSC would like the Agency to consider co-ordinating with universities and the SSDL Network Affiliates or hospitals in Member States to mentor the second year of training.

The SSC further notes that opportunities exist within the Agency for collaboration on training programmes and recommends that the DMRP take advantage of these opportunities.

3.5.6 Professional recognition of medical physicists

The absence of formal recognition of medical physicists in some countries is a serious impediment to attracting people into the profession. Several medical physicists with strong international connections have been

working through IOMP to try to improve the professional status of medical physicists.

The SSC recommends that the Agency and WHO work together to promote the recognition of the profession of medical physics within international classification schemes of professionals such as that maintained by the ILO.

4. ACTIVITIES PLANNED FOR 2004–2005

In general, the SSC supports the tasks developed within the four project areas for the 2002–2003 cycle and the proposed projects for 2004–2005, with the inclusion of the recommendations in this report. However, outside the framework of the biennium 2002–2003, which was used as the basis of the structure for this report, there are a number of specific topics that the SSC feels would benefit from detailed recommendations regarding the future activities of the DMRP.

4.1 Medical Physics Investigation Team

In December 2001, Agency consultants met on "Establishing Procedures for On-Site Review Visits for QA in Radiotherapy Treatment Planning". Their first recommendation to the Agency was that "a flexible route should be established for general requests to the IAEA, DMRP section, for support in reviewing the radiotherapy treatment process or specific aspects of that process in an institution." The SSC discussed the need to provide a rapid response to such requests from Member States seeking assistance on issues related to radiotherapy dosimetry and medical physics issues at various stages of the radiotherapy treatment chain. The goal would be to investigate radiotherapy dosimetric discrepancies and other requests for medical radiation physics help in a timely fashion. This can only be achieved with special funds, as experts will likely be required to provide the needed expertise.

The SSC strongly recommends that the DMRP establish a Medical Physics Investigation Team using existing staff to co-ordinate an expedient response in the event of any difficulty in the radiation therapy dose delivery process. The SSC also recommends that the Agency set up a mechanism to facilitate a prompt response so as to minimize adverse human health consequences.

SSC recommends that the DMRP follow the guidance provided by the Consultants' Meeting of December 2001 to develop flexible mechanisms for responding to requests of various types, including those that may require on-site visits, the development of procedures, the provision of standard beam data and the transfer or loan of equipment to make measurements and conduct tests.

4.2 New Dosimetry and Treatment Planning Techniques

There was a general discussion about the needs for verification of three-dimensional dose distributions particularly for complicated radiotherapy treatment plans using Multi-Leaf Collimators (MLC) or Intensity Modulated Radiotherapy (IMRT). The technique of Gel Dosimetry may contribute to solving some of these dosimetry problems; however, the best method and media to be used for gel dosimetry remain to be identified. Similarly, problems in 3-dimensional treatment planning systems might be alleviated if hospitals in Member States had access through the Internet to treatment planning benchmark data. Neither the technology to provide for gel dosimetry nor that for web access to treatment plans is completely mature. Hence, the SSC recommends that the Agency keep a watching brief on developments in new dosimetry and treatment planning techniques so that Member States may benefit from them in a timely fashion.

4.3 Environmental Dosimetry

There was a general discussion about the difficulty of performing measurements of environmental dose levels particularly that due to establishing the background signal. Since the newly announced Director of the Agency's Laboratories at Seibersdorf is an expert in radioecology and wishes to start a programme in that area, there may be mutual benefit for the DMRP to scope out the

problems that are of interest in environmental monitoring.

The SSC proposes that the DMRP convene a meeting of consultants to advise the Agency on the establishment of traceability in environmental dosimetry. Also, the SSC recommends that the DMRP conduct a survey to investigate the level of interest by SSDLs in calibration of dosimeters for environmental levels.

If the survey demonstrates a significant level of interest, the DMRP may choose to participate in the EURADOS committee studying this matter and to investigate the needed equipment, procedures, and measurement techniques to become involved in these measurements.

4.4 Dosimetry for ^{125}I Seeds Used to Treat Cancer

The use of ^{125}I seeds for the treatment of certain cancers, particularly cancer of the prostate, is increasing dramatically. Consequently, there was a general discussion about how to perform dosimetry for these seeds. The SSC recommends that the DMRP conduct a survey among the SSDLs to identify the need for a calibration service to be provided by the Agency for ^{125}I seeds. Guidelines on the calibration of such seeds are included in TECDOC 1274 along with the calibration of brachytherapy sources. Although it is not practical for the Agency to provide a calibration service for such seeds at this time, the Agency may be able to provide assistance to SSDLs who would like to develop such a service through a TC project.

CONCLUSIONS

The Agency's Dosimetry and Medical Radiation Physics sub-programme is crucial for the traceability of radiation dosimetry standards and the quality of radiation measurements in Member States, particularly those that are developing. The present programme covers a wide range of dose levels, from radiation protection and diagnostic radiology through radiotherapy and up to the very high doses used in radiation processing. The SSC was impressed by the increasing need for these services provided by the DMRP to the Member States and the importance that the DMRP attaches to trying to meet the needs, for example by making five new calibration services available in response to such requests and planning for a Medical Physics Investigation Team to respond to questions of incorrect radiotherapy doses being delivered.

The SSC commends the Agency for the programmes organized by the DMRP and acknowledges that the highest priority has been given to extending and upgrading core services, specifically those supporting the IAEA/WHO network of SSDLs and the IAEA/WHO network for TLD-based QA of radiation dosimetry. It is particularly pleasing to note that the efforts made to follow-up measurements that are outside the action levels are helping the SSDLs and hospitals to improve the quality of their dosimetry.

The SSC is also pleased to see the effort directed to international harmonization of radiation dosimetry QA for all applications. It strongly supports the Agency's Coordinated Research Projects in this area including several planned new initiatives in the field of medical physics.

The SSC commends the staff of the DMRP for their clear and well presented accounts describing the implementation of the Agency's DMRP sub-programme. The visit to the Agency's laboratories was also much appreciated. Members of the SSC would like to be kept informed of the on-going work of DMRP throughout the biennium by receiving copies of its publications and reports as they become available.

Although the SSC has actually made a large number of recommendations (that are reproduced below), this should not be viewed as a criticism but rather as strong support for the development of the Agency's DMRP sub-programme.

5. SSC-10 RECOMMENDATIONS

The recommendations are summarized below, in order of presentation in the report.

1 The SSC recommends that the DMRP continues to participate in comparisons of regional metrology organizations (RMOs), e.g., EUROMET, SIM and APMP, to demonstrate routinely its own calibration and measurement capabilities (CMCs) as well as helping members of the SSDL network to demonstrate their CMCs.

2 The SSC believes that an additional calibration area is now essential to meet the increased calibration requirements of the Member States, and the SSC recommends that the facility should be sufficiently large and the internal construction be flexible to allow future changes of use.

3 The SSC recommends that the Agency continue to support programmes to train radiographers in quality control of radiographic equipment and procedures. The SSC notes that the training offered to medical physicists can include, as one component, instruction for training radiographers in QC procedures in diagnostic radiology.

4 The SSC recommends that the Agency move the SSDLs of five countries, Bolivia, Ecuador, Egypt, Libyan Arab Jamahiriya and Iran Islamic Republic (the Khomeini Hospital) to the provisional list to implement the actions required by the Agency. In addition, the SSC recommends that the Agency investigate the support needed to bring these SSDLs back into compliance with the SSDL Network Charter.

5 The SSC also recommends that the DMRP identify the hospitals that are coming directly to the Agency for calibrations and consider encouraging their Member States to establish national SSDLs.

6 The SSC recommends that when contacting Member States with a view to changing their network membership, the Agency consider the implementation of a primary standard for absorbed dose to water as the key criterion for becoming an affiliate member.

7 The SSC recommends that the DMRP undertake an initiative to become more systematic in their training of SSDL staff members. The SSC recommends that until the Agency's laboratory facilities are available for training of SSDL staff, consideration should be given to using affiliate PSDLs and well-developed SSDLs for such venues.

8 The SSC recommends that the DMRP calibrations in terms of absorbed dose to water be linked explicitly to TRS-398 for the hospital or country concerned.

9 The SSC recommends that the Agency implement the guidelines put forward by the Consultants' Meeting on the Intercomparison of Ionization Chamber Calibration Factors in X-ray Beams (held 22–25 October 2001).

10 The SSC recommends that the DMRP implement the proposal to organize consultants' meetings to help SSDLs to establish dosimetry uncertainty budgets. The SSC further recommends that the Agency continue to provide chamber comparisons to SSDLs in support of their CMCs.

11 The SSC also recommends that the Agency participate in CCRI(I) dosimetry comparisons as appropriate.

12 The SSC recognizes the research that has gone into setting up the 17 mammography beam qualities and resolving the discrepancy in calibration of the standard. However, the SSC recommends that the Agency rationalize the number of qualities provided for mammography calibration of a given instrument. Guidance may be taken from the results of the EUROMET Project No. 526. The SSC is pleased to see that a pilot study comparing mammography calibrations at SSDLs is planned for 2003.

13 The SSC recommends that an investigation be conducted into the calibration of pencil-type chambers for use in dosimetry of radiation fields produced by CT scanners.

14 The SSC recommends that the DMRP play a leading role in projects related to image quality and patient dose optimization within the limited resources presently available.

15 The SSC is pleased to recognize the work done by the DMRP in reviewing and promulgating NSRW documents, and in

particular the comparison of TL dosimetry systems for mammography. The SSC recommends that collaboration with NSRW continues to the extent possible and that provision for recognition of these collaborative efforts be entered into the DMRP list of activities for the biennium. The SSC is pleased to learn about the possibility of harmonizing the protocols in mammography that were developed within the framework of various TC projects.

16 The SSC supports the DMRP plan to investigate the use of the high dose rate (HDR) unit at the Allgemeine Krankenhaus (the AKH or Vienna General Hospital) or other local hospitals to conduct calibrations of well chambers for HDR ^{192}Ir. The SSC recommends that subsequent to the pilot study with AKH, the DMRP investigate a future programme that might include dose verification techniques and brachytherapy treatment planning issues.

17 The SSC recommends that the acceptance limit for TLD results used in radiation protection be set at not less than 3-sigma, or 5%.

18 The SSC-10 recommends that the Agency continue to develop services concerning radiation protection dosimetry standards. The DMRP should encourage those SSDLs that provide personal dosimetry services to implement the ISO 4037 Parts 1 to 4 for photon radiation.

19 The SSC recommends that the details of the DMRP programme to develop standards for the measurement of radioactivity and to support nuclear medicine dosimetry at the SSDLs be defined during the upcoming Consultants' Meeting on Methodology of Radioactivity Standardization, to be held 29 November – 3 December 2002.

20 The SSC recommends that this valuable service using alanine-ESR for dosimetry be maintained. Although the existing equipment may be kept viable for a few more years, plans need to be made for its ultimate replacement.

21 The SSC recommends that current collaborations with international (e.g. ICRU) and national bodies (e.g. ESTRO) working in the area of dosimetry standards for the measurement of radiation quantities be reinforced so that standards and codes of practice produced by the Agency are of the highest quality and widely accepted.

22 The SSC recommends that the DMRP implement a plan to test the Code of Practice now being developed under the CRP E2.10.03.

23 The SSC recommends that the DMRP implement a CRP or a CM to produce guidelines for SSDLs to conduct TLD audits in diagnostic radiology dosimetry for end-users.

24 After the successful completion of the CRP on biodosimetry, the SSC recommends that the DMRP should now consider collaboration with NSRW on the provision of reference irradiations of EPR samples for future biodosimetry comparisons.

25 The SSC supports the DMRP's involvement with the ICRU activities regarding proton dosimetry and recommends that the formal collaboration with the ICRU continues.

26 The SSC supports the request from the ARPANSA to borrow the Agency's graphite calorimeter and recommends that the Agency proceed with this equipment loan, noting that it is to be returned in working condition.

27 The SSC recommends that the DMRP propose a new CRP to determine which technologies are most appropriate for Member States to use for in-vivo dosimetry.

28 The SSC recommends that DIRAC be adequately supported and maintained on a continuous basis with appropriate quality control of the data and be strengthened in its database structure.

29 The SSC acknowledges the severe shortage of medical physicists both in developed and developing countries, and recommends that the Agency support formal educational programmes for medical physicists. The SSC recommends that the Agency seek to develop relationships with existing accrediting bodies such as CAMPEP, or other mechanisms to accredit appropriate two-year graduate training programmes, which should ensure acceptance of the training by the trainee's home country.

30 The SSC further notes that opportunities exist within the Agency for collaboration on training programmes and recommends that the DMRP take advantage of these opportunities.

31 The SSC recommends that the Agency and WHO work together to promote the recognition of the profession of medical physics within international classification schemes of professionals such as that maintained by the ILO.

32 The SSC strongly recommends that the DMRP establish a Medical Physics Investigation Team using existing staff to co-ordinate an expedient response in the event of any difficulty in the radiation therapy dose delivery process. The SSC also recommends that the Agency set up a mechanism to facilitate a prompt response so as to minimize adverse human health consequences.

33 SSC recommends that the DMRP follow the guidance provided by the Consultants' Meeting of December 2001 to develop flexible mechanisms for responding to requests of various types, including those that may require on-site visits, the development of procedures, the provision of standard beam data and the transfer or loan of equipment to make measurements and conduct tests.

34 The SSC recommends that the Agency keep a watching brief on developments in new dosimetry and treatment planning techniques so that Member States may benefit from them in a timely fashion.

35 The SSC proposes that the DMRP convene a meeting of consultants to advise the Agency on the establishment of traceability in environmental dosimetry. Also, the SSC recommends that the DMRP conduct a survey to investigate the level of interest by SSDLs in calibration of dosimeters for environmental levels.

36 The SSC recommends that the DMRP conduct a survey among the SSDLs to identify the need for a calibration service to be provided by the Agency for ^{125}I seeds.

The SSC has also highlighted some additional suggestions that are summarized below.

1 The SSC would be pleased to see the training programme for regional officers included in the 2004–2005 biennium.

2 The SSC would be pleased to see the Agency consider providing additional administrative support to the DMRP to handle the secretarial work and support the DIRAC project.

3 The SSC would be pleased to see the Agency consider adding a technician to the staff working at the DOL in Seibersdorf to begin the biennium 2004–2005.

4 The SSC would be pleased to see the DMRP develop a syllabus for training in diagnostic radiation physics along the lines of the training syllabus in radiotherapy physics.

5 The SSC would be pleased to see the Agency collaborate with the WHO on the proposal to write a TECDOC tentatively entitled "Design and Implementation of a Diagnostic Radiology Programme" along the lines of the similar Agency documents on radiation therapy programmes (e.g., TECDOC-1040 or its revision).

6 The SSC would be pleased to see the Agency investigate the possibility of calibrating kVp meters as an additional service to be provided to SSDLs.

7 The SSC would be pleased to see the DMRP consider a CRP to develop treatment planning QA procedures and test benchmark cases, to be used by medical physicists at the end-user level in a hospital to verify the accuracy of the doses calculated by their computerized treatment planning systems.

8 The SSC would like to see the Agency identify funds to support a five-year project preferably starting with five trainees in each year. The SSC would like the Agency to consider co-ordinating with universities and the SSDL Network Affiliates or hospitals in Member States to mentor the second year of training.

THE OPERATION OF THE CIPM MUTUAL RECOGNITION ARRANGEMENT AND ITS RELEVANCE TO THE SSDL MEMBERS OF THE IAEA/WHO NETWORK

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Abstract. This paper presents the background, history and current operation of the arrangement for the mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes (MRA). The organization of key comparisons and the operation of the BIPM key comparison database resulting from the MRA are described and the relevant roles of the International Committee, the regional metrology organizations and the IAEA are outlined.

1. THE CIPM MUTUAL RECOGNITION ARRANGEMENT (MRA)

1.1 Introduction

At a meeting held in Paris on 14 October 1999, the directors of the national metrology institutes (NMIs) of thirty-eight Member States of the Metre Convention and representatives of two international organizations signed the mutual recognition arrangement (MRA) [1]. The MRA was drawn up by the International Committee for Weights and Measures (Comité International des Poids et Mesures CIPM[1]) and is for the mutual recognition of national measurement standards and of the calibration and measurement certificates issued by NMIs. Since that date in 1999, the directors of the NMIs of other Member States and of Associates of the General Conference (Conférence Générale des Poids et Mesures CGPM) have also signed the MRA. The full list of signatories, currently comprising forty-two Member States of the Metre Convention and nine associates of the CGPM together with the IAEA and one other international organization, is given on the BIPM web site at http://www.bipm.org/pdf/signatories.pdf.

This international MRA is a response to a growing need for an open, transparent and comprehensive scheme to give users reliable quantitative information on the comparability of national metrology services, and to provide the technical basis for wider agreements negotiated for international trade, commerce and regulatory affairs.

Mutual recognition agreements for international trade negotiated by governments require mutual recognition of various aspects of the standards and conformance infrastructure. These include the capabilities of calibration, verification and test laboratories as well as those of laboratory accreditation bodies. The NMIs provide the traceability to the international system of units (SI) required for these services and thus mutual recognition of the capabilities of the NMIs is a prerequisite for the mutual recognition of metrology services in general.

1.2 Historical development of the MRA

NMIs have been collaborating and carrying out international comparisons of their national measurement standards for more than one hundred years. However, the *ad hoc* recognition that has resulted is no longer considered to be sufficient, hence the move towards the MRA. This move was initiated by Resolution 2 of the 20th CGPM in 1995 that called for increased cooperation between the NMIs, the regional metrology organizations (RMOs) and the BIPM to improve worldwide traceability of measurement standards. Discussions with the International Laboratory Accreditation Cooperation (ILAC) reinforced this view as to the need for a more formal recognition of national measurement standards. During 1996, discussions took place among the RMOs related to the possibility of drawing up regional mutual recognition agreements. These

[1] All acronyms regarding the Metre Convention are from the French.

stimulated a BIPM draft of a worldwide agreement that was presented at a meeting of directors of the NMIs held in Sèvres in February 1997. An overall favourable reception to this initiative led to a second draft being developed during the year that followed. This was presented at the following meeting in February 1998 and initialled by the directors of thirty-nine NMIs. Further discussions then took place and, in August 1999, agreement was reached on the final text of the MRA that was signed on 14 October 1999.

The meeting of directors on 14 October 1999 took place at the Collège de France during the week of the 21st CGPM. The signature of the MRA was formally welcomed by the delegates of the governments of the thirty-six Member States of the Metre Convention present, as stated in Resolution 2 of the CGPM, adopted on 15 October. The IAEA was invited to attend the meeting and to sign the MRA in view of its important role in forming the link between the IAEA/WHO SSDL network members and the international measurement system, particularly for those countries not within the Metre Convention either as members, or as Associates of the CGPM. The Head of the Dosimetry and Medical Radiation Physics Section (DMRP), signed the MRA on behalf of the Director General of the IAEA.

1.3 The essential points of the MRA

The MRA was drawn up by the CIPM, under the authority given to it in the Metre Convention, for signature by directors of the NMIs of Member States of the Convention.

The objectives of the MRA are

(a) to establish the degree of equivalence of national measurement standards maintained by NMIs
(b) to provide for the mutual recognition of calibration and measurement certificates issued by NMIs, and thereby
(c) to provide governments and other parties with a secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs.

These objectives are achieved through a process of

(a) international comparisons of measurements, known as key comparisons
(b) supplementary international comparisons of measurements, and
(c) quality systems and demonstrations of competence by the NMIs.

Key comparisons are used to establish the degrees of equivalence of national measurement standards and supplementary comparisons of measurements are used to extend the range of parameters covered or, more usually, to demonstrate calibration capabilities. Key and supplementary comparisons are agreed by the relevant Consultative Committee (CC) of the CIPM, the CC for ionizing radiation being the Consultative Committee for Ionizing Radiation (CCRI). The CIPM key comparisons are normally operated by the CCs, and the RMO comparisons by the RMOs.

1.4 The outcome of the MRA

The outcome of the MRA is a determination of the degrees of equivalence of national standards and a set of statements of the measurement capabilities of each NMI in a database maintained by the BIPM. This database is known as the BIPM key comparison database (KCDB), and is available on the web at http://www.bipm.org/kcdb.

The degrees of equivalence of each NMI holding national standards for a given quantity are determined from the key comparisons. These are entered into Appendix B of the MRA which is maintained as part of the BIPM key comparison database. (Note that Appendix A is the list of signatories to the MRA). The results of the comparisons are analysed by the relevant CC and presented in two ways. A graph is used to present the degree of equivalence of each NMI with the key comparison reference value (KCRV) and, secondly, a matrix is used to show the inter-laboratory degrees of

equivalence taking inter-laboratory correlations into account. (See section 3.3 on key comparisons.)

Statements of the measurement capabilities of each NMI, once agreed between all the RMOs through the Joint Committee of the RMOs and the BIPM (JCRB), are displayed in Appendix C of the BIPM KCDB and so are also publicly available at http://www.bipm.org/kcdb/ Appendix C. (See section 3.4).

To participate in the measurements and comparisons, NMIs must be able to demonstrate their competence. In the future, this competence will be assessed through the implementation of appropriate quality systems, usually ISO 17025 [2].

1.5 The engagement of NMIs

The NMI directors, when signing the MRA do so with the approval of the appropriate authorities in their own country, and thereby:

(a) accept the process specified in the MRA for establishing the database
(b) recognize the results of key and supplementary comparisons as stated in the database, and
(c) recognize the calibration and measurement capabilities of other participating NMIs as stated in the database.

Signature of the MRA engages the NMIs as indicated above but does not necessarily engage any other agency in their country. The responsibility for the results of calibrations and measurements rests wholly with the NMI that makes them and this responsibility is not extended to any other participating NMI through the MRA.

1.6 Participation in the MRA

The MRA is open to the NMIs of the Member States of the Metre Convention, to certain international and intergovernmental organizations invited by the CIPM, such as the IAEA, and to the NMIs of Associate States and Economies of the General Conference[2]. This third category of participant results from the decision of the 21st CGPM to create a category of Associate of the CGPM. The specific purpose of this category is to provide a way of establishing links to the world's measurement system for those States not yet Members of the Metre Convention. The NMIs of Associates of the CGPM participate in the MRA through their local regional metrology organization as specified in the text of the MRA.

The current Members States and Associates of the CGPM are listed in Annex 1.

2. ORGANIZATIONAL STRUCTURE

2.1 Role of the CIPM and its Consultative Committees

The overall coordination of the MRA is made by the BIPM under the authority of the CIPM, which is itself under the authority of the Member States of the Metre Convention.
The Consultative Committees of the CIPM and the BIPM are responsible for carrying out the CIPM key and supplementary comparisons that are destined for Appendix B of the KCDB.

The organizational structure of the MRA is indicated in Figure 1. This figure is illustrative only; the text of the MRA and the *Guidelines for CIPM Key Comparison* should be consulted for full details. Printed copies of the MRA and the *Guidelines* can be obtained from the BIPM or downloaded from http://www.bipm.org.

2.2 The role of the BIPM

The BIPM has a central role in organising the international comparisons that lead to the equivalence of national standards. The Consultative Committees (CCs) identify the

[2] The procedure for a State to become a Member State of the Metre Convention or a State or Economy to become an Associate of the General Conference can be obtained from the BIPM web site at http://www.bipm.org

key comparisons and these are known as CIPM comparisons, the CCs being committees of the CIPM. In certain fields, such as ionizing radiation, the BIPM takes a lead at the Consultative Committee for Ionizing Radiation (CCRI) in maintaining international standards against which NMIs can compare their primary standards at any time and these comparisons are identified as BIPM ongoing key comparisons.

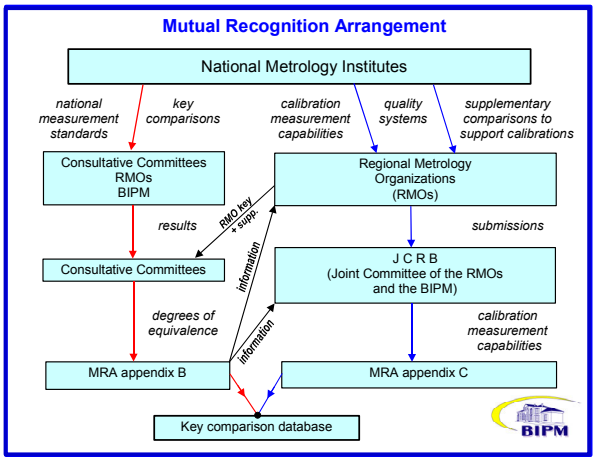

FIGURE 1. *The organizational structure of the MRA*

2.3 Role of the RMOs

The regional metrology organizations (RMOs) play an important role in the MRA, as shown in Figure 1. They have responsibility for carrying out key comparisons within their regions. They also carry out supplementary comparisons and other actions to support mutual confidence in the validity of calibration and measurement certificates of their member NMIs.

The Joint Committee of the Regional Metrology Organizations and the BIPM (the JCRB) is responsible for analysing and transmitting entries into the database for the calibration and measurement capabilities (CMCs) declared by the NMIs. The RMOs are responsible for reviewing the CMCs for the NMIs in their own region before submitting these to the JCRB and coordinating, through the JCRB, these entries into Appendix C of the MRA for their member NMIs. They are also responsible for reviewing the CMCs submitted to the JCRB by other RMOs for the NMIs within these other regions.

2.4 Role of the IAEA

In this context, the IAEA, by virtue of its statutes acts as an international organization in the field of radiation dosimetry for the NMIs in IAEA Member States that are not yet party to the Metre Convention. The comparisons organized by the IAEA between SSDLs help to support them and link them to the international measurement system through the central laboratory of the IAEA/WHO Network of SSDLs, located within the Agency's Laboratories at Seibersdorf. In addition, the IAEA participates directly in some comparisons with RMOs, and thus contributes to strengthening the international metrology links in radiation dosimetry. The IAEA maintains a database of its 75 laboratory members. This database includes results of IAEA/SSDL comparisons. The signing by the IAEA of the MRA will impose stricter demands on these comparisons and may require a modification of the criteria "acceptability" of the level of performance achieved by laboratories in these comparisons.

3. KEY COMPARISONS

3.1 Introduction

A key comparison is one of a set of comparisons selected by a Consultative Committee (CC) to test the principle techniques and methods in the field. Key comparisons may include comparisons or representations of multiples and sub-multiples of SI base and derived units, and comparisons of artefacts. A CIPM key comparison is executed by a CC, or by the BIPM and leads to a key comparison reference value (KCRV). An RMO key comparison is executed by an RMO for its member countries, some of whom may not be party to the Metre Convention. They may also include NMIs from other RMOs. The results of

an RMO key comparison are linked to the CIPM KCRV by the CC through the mutual participation of at least two NMIs. However, only results from the MRA signatories will appear in the BIPM key comparison database (KCDB) (see section 3.3).

Each Consultative Committee of the CIPM determines the quantities that should be compared in the MRA key comparisons. These key comparisons are listed in Appendix D of the MRA, which is maintained in the KCDB. For example, there are over 110 comparisons listed in the field of ionizing radiation. More than seventy-seven of these comparisons are activity comparisons for the many different radionuclides that are compared, mostly through the International Reference System (SIR). Each key comparison, whether an ongoing BIPM key comparison, such as the SIR or the dosimetry comparisons held at the BIPM, follows established guidelines with written protocols. In practice, the ongoing comparison results are updated as additional NMIs take part. In the field of ionizing radiation, there is still some debate in the CCRI about the analysis of the results for the activity comparisons and also for the dosimetry comparisons. It is hoped that these issues will be resolved during 2002 and the results will then be displayed in Appendix B.

3.2 Guidelines for key comparisons

The *Guidelines for key comparisons* were last revised on 1 March 1999. The revised version takes into account the various comments received from members of Consultative Committees, the discussions at the meeting of the CIPM in September 1998, the key comparison discussion meeting held in Sèvres in January 1999 and the meeting of the JCRB held at the BIPM in February 1999. The Guidelines are available from http://www.bipm.org/pdf/guidelines.pdf .

In principle, every quantity could have its own key comparison and every NMI signatory of the MRA could participate. However, there are too many NMIs for each to participate in every comparison, and there are too many comparisons for an NMI to participate in each one. There are currently 402 key comparisons in Appendix B. If a number of NMIs participate in a CIPM key comparison and some of these also participate in a linked RMO key comparison, degrees of equivalence between NMIs can be extended to many more participants through the linking NMIs. The schema in Figure 2 indicates how this can work.

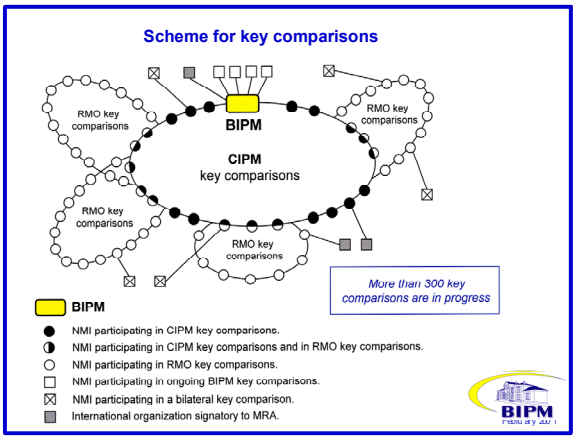

FIGURE 2. *Schema for linking key comparisons*

It is important to have at least two NMIs in any given RMO key comparison, which have already participated in the corresponding CIPM key comparison to provide a robust link.

Comparisons themselves can be organized in several different ways. For example, an instrument can be circulated for calibration by each NMI and either returned to the pilot NMI between each measurement in a star formation or only at the beginning and the end of all the measurements in a round formation when the transfer instrument is robust and stable, or in some combination of these two extremes. An example of this is the IAEA dosimetry comparisons for the IAEA/WHO SSDL network. An alternative method is for every NMI to bring its own standard to the pilot NMI where everyone measures the same quantity under the same conditions and at the same time.

This method was used recently during a neutron dosimetry comparison, with the PTB acting as the pilot NMI. Yet another example, which can work when a primary standard is stable over time is the ongoing BIPM key comparisons, such as the dosimetry comparisons with primary standard dosimetry laboratories (PSDLs). These comparisons can be made individually at any time in a given period of 10 years and the results can all be linked to each other through the relevant BIPM standard. This method is also used for voltage and resistance standards.

3.3 The BIPM key comparison database

The BIPM key comparison database (KCDB), referred to in the MRA and the *Guidelines* is operated by the BIPM. The Appendix B database was first launched onto the web in November 1999.

Since February 2000, the BIPM has developed the KCDB to take into account the needs of the MRA and of the NMIs, in particular the whole of Appendix C regarding the calibration and measurement capabilities of the NMIs.

The BIPM key comparison database is defined in the text of the MRA as "the database maintained by the BIPM which contains Appendices A, B, C and D of the Mutual Recognition Arrangement". The content of the BIPM key comparison database is growing rapidly as results come in from comparisons and submissions of measurement and calibration capabilities. The KCDB now includes all the Appendices of the MRA, namely:

- **Appendix A (MRA signatories)** – The list of national metrology institutes that are signatories to the arrangement. Usually, it is the Director of the NMI who signs and then lists any other laboratories that are recognised as holding the national standards for that country. It is often the case that ionizing radiation standards are not held or maintained by the NMI, but at another laboratory, often associated with an atomic energy agency that may be linked to the IAEA. In these cases, the laboratories need to be identified and designated by the NMI or by the appropriate governmental authority of their country for their results to be included in the MRA Appendices.

- **Appendix B (Results of key and supplementary comparisons)** – The results of CIPM and RMO key and supplementary comparisons containing individual values for each institute together with their declared uncertainties. The key comparison reference value (KCRV) is given with its associated uncertainty and for each institute, the deviation from the KCRV and the uncertainty in that deviation (at a 95% level of confidence). This is defined as the degree of equivalence for the NMI. The difference between each NMI and another NMI and the uncertainty of that difference is defined as the degree of equivalence between the standards of each of the participating institutes. The results are usually presented graphically and in the form of a matrix for key comparisons.

  A new version of Appendix B was launched in June 2000 and since November 2001, the BIPM has been publishing, on the average, the results of one key or supplementary comparison each week. By July 2002, the KCDB Appendix B included about 450 key and supplementary comparisons, conducted under the auspices of the CIPM and the RMOs. Even this number does not give a complete picture of the world-wide key comparison network since many regional comparisons have not been declared to the relevant CCs and are thus not yet entered into the database.

- **Appendix C (Calibration and measurement capabilities CMCs)** – The quantities for which calibration and measurement certificates are recognized by NMIs participating in the MRA. The

quantities, ranges and calibration and measurement capabilities expressed as an uncertainty (normally at a 95% level of confidence) are listed for each of the participating institutes.
The submissions to Appendix C are made by the RMOs through the JCRB. A peer review is carried out by the other RMOs, and once acceptable the CMCs are placed into Appendix C. At the moment, there are three sets of ionizing radiation CMCs that have gone through the peer review process. In particular, those submitted by the IAEA have been accepted and appear on the KCDB. Other submissions may also appear by the time this Newsletter is in print. As an illustration, the present version of the IAEA CMCs is given in Annex 2.

In January 2002, Appendix C was using two databases; one for electricity and magnetism, photometry and radiometry, acoustics, ultrasound and vibration and length, and another one for quantity of material, the chemistry database. A third database has been launched recently to support the CMCs in ionizing radiation, particularly for radionuclide activity.

- **Appendix D** –This Appendix contains the list of key and supplementary comparisons and the structure for identifying a key comparison.
There are currently 449 key and supplementary comparisons listed in Appendix D. For a comparison to be listed, it has to be submitted to and accepted by the relevant Consultative Committee whether it is a CIPM or an RMO comparison (see Figure 2).

3.4 CIPM ionizing radiation key comparisons

The BIPM operates a system of ongoing key comparisons for ionizing radiation dosimetry for the CIPM through its CCRI. This includes dosimetry comparisons for air kerma in low- and medium-energy x- and gamma-ray beams and for absorbed dose to water in ^{60}Co gamma radiation for each of which the BIPM maintains primary standards against which the NMIs can compare their primary standards at any time. In each case, the key comparison reference value is taken to be the BIPM value. These comparisons have been running since the 1960's but to enter the results in the key comparison database (KCDB) a comparison has to have been made within the last 10 years. There are currently seventy-four participant entries across these comparisons. Indeed, the PSDLs affiliated to the IAEA/WHO Network of SSDLs are participants for their NMIs. However, as yet, there are no entries in the KCDB. This is because at the last meeting of the CCRI, it was agreed that various correction factors should be verified and comparison reports completed before the results could be published in the KCDB. This work is in progress.

The BIPM also operates the international reference system for activity measurements of gamma emitting radionuclides, the SIR, which enables degrees of equivalence to be established between the NMIs holding primary or secondary standards. However, although all entries are included for the degrees of equivalence, only those NMIs holding primary standards can contribute to the key comparison reference value. The SIR is being extended to enable comparisons of beta emitters, firstly using liquid scintillation and the NIST/CIEMAT method, and ultimately using primary measurement techniques such as triple-to-double coincidence ratios. The key comparison working group of CCRI Section II is currently determining the appropriate KCRVs for each of the radionuclide activity comparisons.

On the other hand, the BIPM no longer holds any neutron standards (since 1995). Any key comparison in this field is piloted by one of the NMIs holding primary standards and the key comparison reference value is determined as the mean of the results of all the NMIs that

participated. This does mean that these CIPM key comparisons are valid only at the time they are undertaken and it is not possible to add participants at a later stage except by an indirect bilateral comparison with an NMI that has already taken part in the primary comparison.

The CCRI also operates CIPM key comparisons in dosimetry. A relevant comparison at the moment is that of absorbed dose to water. Currently, this comparison has been limited to NMIs holding primary standards for absorbed dose to water, for example graphite or water calorimeters. However, the CCRI is considering extending the list of participants to those holding secondary standards although such NMIs would normally compare through regional key comparisons with some PSDLs as participants. The IAEA has its dosimetry standards calibrated regularly at the BIPM and, as a signatory of the MRA can have measurement results included in the KCDB. The IAEA is of course a special case as it is an international organization and, as a delegate at the CCRI(I) should normally be able to participate in CCRI key comparisons.

3.5 Calibration and measurement capabilities (CMCs)

Appendix C contains the calibration and measurements capabilities of the NMIs for each of the metrology areas. This part of the database is filling rapidly as the NMIs define their services and submit their CMCs to the JCRB for inclusion in Appendix C.

The RMOs are responsible for submitting the CMCs for the NMIs in their region and to ensure that the CMCs are consistent across the world, most of the RMOs have collaborated in each metrology field to define the CMCs that are needed. In the field of ionizing radiation, a meeting was held to ensure this consistency and the resulting classification scheme is shown in Annex 3.

The RMOs execute comparisons to confirm the calibration capabilities of the NMIs. The IAEA normally takes part in these, especially EUROMET and SIM comparisons, to demonstrate its calibration and measurement capabilities.

At the moment, there are only three sets of ionizing radiation CMCs in the KCDB, this year 2002 is expected to see over 2000 lines of submitted CMCs. Those from the IAEA were among the first three to appear in the database newly designed for ionizing radiation CMCs.

4. RELEVANCE OF THE MRA TO THE IAEA/WHO SSDL NETWORK

The main objective of the SSDL network is to ensure traceability of measurements, for those Member States that do not have access to primary standards dosimetry laboratories, by providing and maintaining the link between the end users of radiation and the international measurement system [3].
Active SSDLs provide traceable instrument calibrations for radiation beam therapy, diagnostic radiology including mammography, brachytherapy (^{137}Cs) and radiation protection. Occasionally, they provide quality audits of radiotherapy by postal TLD and on-site measurements, and some perform measurements at radiation processing levels. The standards of about 40% of the SSDL members are traceable to the Agency, 45% to a PSDL and 15% (for NMIs of the Metre Convention), to the BIPM. However, the dissemination of each type of calibration needs to be verified periodically through quality audits and comparisons organized by the IAEA or an RMO. These comparisons, if agreed by the CCRI(I) beforehand, can be listed in Appendix B as supplementary comparisons and referenced in the submissions to Appendix C for the CMCs. By linking to its NMI, any SSDL can take part in a calibration comparison, however their results cannot be included in the

BIPM key comparison database unless their NMI is a signatory to the MRA and the SSDL is specifically mentioned as a designated laboratory for ionizing radiation standards.

There are about sixty-three Member States in the SSDL Network[3] but with only forty-eight signatories to the MRA, this leaves a number of NMIs that will not be able to submit their results to the BIPM key comparison database, nor have their CMCs included in Appendix C. For these NMIs in particular, traceability of their standards to those of the IAEA and the radiation dosimetry comparisons with the IAEA are both crucial supports for the credibility of their measurement infrastructure.

Each time the IAEA organizes dosimetry comparisons with the SSDLs, it is effectively functioning as an international metrology organization. By including in such comparisons some NMIs that have taken part in CIPM comparisons, the IAEA provides a strong link to the MRA for the IAEA Member States that are otherwise excluded. This should bring benefits to those SSDLs in terms of strengthening their position as the dosimetry reference for their country.

REFERENCES

[1] MRA: *Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes*, International Committee for Weights and Measures, 14 October 1999, 45 pp. Available from the BIPM website: www.bipm.org/pdf/mra.pdf (1999).

[2] International Organization of Standardization/International Electro-technical Commission, General Requirements for the Competence and Testing Calibration Laboratories, ISO/IEC 17025, ISO, Geneva (2000).

[3] International Atomic Energy Agency, The SSDL Network Charter, IAEA, Vienna (1999).

[3] The complete list of the SSDL Network members is given on the last 2 pages of this SSDL Newsletter

ANNEX 1

Member States of the Metre Convention and Associates of the CGPM

Member States of the Metre Convention

Argentina
Australia
Austria
Belgium
Brazil
Bulgaria
Cameroon
Canada
Chile
China
Czech Republic
Denmark
Dominican Republic
Egypt
Finland
France
Germany
Greece
Hungary
India
Indonesia
Iran (Islamic Rep. of)
Ireland
Israel
Italy
Japan
Korea (Dem. People's Rep. of)
Korea (Republic of)
Malaysia
Mexico
Netherlands
New Zealand
Norway
Pakistan
Poland
Portugal
Romania
Russian Federation
Singapore
Slovakia
South Africa
Spain
Sweden
Switzerland
Thailand
Turkey
United Kingdom
United States
Uruguay
Venezuela
Yugoslavia

Associates of the General Conference

Chinese Taipei
Hong Kong, China
Malta
Cuba
Latvia
Philippines
Ecuador
Lithuania
Ukraine

ANNEX 2

IAEA CMCs-January 2002 version

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty				Reference Standard used in calibration		Comparisons supporting this measurement/ calibration service	Comments	Services Administration			
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage factor	Is the expanded uncertainty a relative one?	Standard	Source of traceability			NMI Service Identification	Service Category	NMI	Comments
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15bis	16	17	18	19
Absorbed dose to water	Secondary standard ionisation chamber	Calibration against a transfer standard in a water phantom	0.5	5	Gy	Co-60	10 cm by 10 cm field at 1 m distance absorbed dose to water rate 5 mGy/s	1	%	2	Yes	Secondary standard ionization chamber NE-2561	BIPM	EUROMET 335 (1996) & SIM (2000)		IAEA-RAD-1001	1.2.7	IAEA	
Air kerma	Secondary standard ionisation chamber	Calibration against a transfer standard free in air	0.5	5	Gy	Co-60	10 cm by 10 cm field at 1 m distance air kerma rate 5 mGy/s	0.8	%	2	Yes	Secondary standard ionization chamber NE-2561	BIPM	EUROMET 335 (1996) & SIM (2000)		IAEA-RAD-1002	1.6.7	IAEA	
Air kerma	Secondary standard ionisation chamber	Calibration against a transfer standard free in air	0.5	2.5	Gy	X-ray, 50 to 420 kV	100 kV to 250 kV, air kerma rate 1.5 mGy/s	0.8	%	2	Yes	Secondary standard ionization chamber NE-2561	BIPM			IAEA-RAD-1003	1.6.5	IAEA	
Air kerma	Secondary standard ionisation chamber	Calibration against a transfer standard free in air	0.01	2	Gy	X-ray, 10 to 50 kV	air kerma rate 7 mGy/s	0.8	%	2	Yes	Secondary standard ionization chamber PTW-23342	BIPM			IAEA-RAD-1004	1.6.4	IAEA	
Reference air kerma rate	Well type ionization chamber	Irradiation with a calibrated Cs-137 brachytherapy low dose rate source	1.4E-08	2E-06	Gy/s	Cs-137	Source type CDC1100 and CDCS J5	2.4	%	2	Yes	Cs-137 brachytherapy gamma ray source	NIST			IAEA-RAD-1005	1.7.8	IAEA	
Air kerma	Secondary standard ionisation chamber	Calibration against a secondary standard free in air	2E-04	2E-02	Gy	X-ray, 10 to 50 kV	23 kV to 35 kV, Mo target, unattenuated and attenuated beams, HVL= 0.272 to 0.699 mm Al, air kerma rate= 0.1 to 6.7 mGy/s	1.6	%	2	Yes	Secondary standard ionization chamber Radcal 10X5-6M	PTB	EUROMET 526 (03-04/2002)		IAEA-RAD-1006	1.6.4	IAEA	

Air kerma	Secondary standard ionization chamber	Calibration against a secondary standard free in air	2E-04	2E-02	Gy	X-ray, 10 to 50 kV	25 kV to 40 kV, Rh target, unattenuated and attenuated beams, HVL= 0.336 to 0.854 mm Al, air kerma rate= 0.1 to 5 mGy/s	1.2	%	2	Yes	Secondary standard ionization chamber Radcal 10X5-6M	NIST	EUROMET 526 (03-04/2002)		IAEA-RAD-1007	1.6.4	IAEA	
Air kerma	Secondary standard Ionization chamber	Calibration against a transfer standard free in air	1E-05	3.5E-03	Gy	X-ray, 50 to 420 kV	40 kV to 300 kV, narrow/ISO 4037, air kerma rate 4E-06 Gy/s	1.8	%	2	Yes	Secondary standard ionization chamber LS-01	PTB			IAEA-RAD-1008	1.6.5	IAEA	
Air kerma	Secondary standard ionization chamber	Calibration against a transfer standard free in air	4E-05	1.5E-03	Gy	Cs-137	75 cm field at 3 m distance air kerma rate 1.3E-06 Gy/s	1.6	%	2	Yes	Secondary standard ionization chamber LS-01	PTB			IAEA-RAD-1009	1.6.8?	IAEA	
Air kerma	Secondary standard ionization chamber	Calibration against a transfer standard free in air	2.5E-06	3E-04	Gy	Co-60	75 cm field at 3 m distance air kerma rate 2.7E-07 Gy/s	1.6	%	2	Yes	Secondary standard ionization chamber LS-01	PTB			IAEA-RAD-1010	1.6.7?	IAEA	
Ambient dose equivalent	Secondary standard Ionization chamber	Calibration against a transfer standard free in air	1E-05	3.5E-03	Sv	X-ray, 50 to 420 kV	40 kV to 300 kV, narrow/ISO 4037, air kerma rate 4E-06 Sv/s	4.1	%	2	Yes	Secondary standard ionization chamber HS-01	PTB			IAEA-RAD-1011	1.8.5	IAEA	
Ambient dose equivalent	Secondary standard Ionization chamber	Calibration against a transfer standard free in air	4E-05	1.5E-03	Sv	Cs-137	75 cm field at 3 m distance air kerma rate 1.3E-06 Sv/s	4.1	%	2	Yes	Secondary standard ionization chamber HS-01	PTB			IAEA-RAD-1012	1.8.8	IAEA	
Ambient dose equivalent	Secondary standard Ionization chamber	Calibration against a transfer standard free in air	2.5E-06	3E-04	Sv	Co-60	75 cm field at 3 m distance air kerma rate 2.7E-07 Sv/s	1.2	%	2	Yes	Secondary standard ionization chamber HS-01	BIPM			IAEA-RAD-1013	1.8.7	IAEA	

ANNEX 3

Classification scheme for ionizing radiation CMCs

Classification of services for RI CMCs									
Level 1		**Level 2**		**Level 3**		**Level 4**		**Level 5**	
1	Dosimetry	1	Absorbed dose/rate to air	1	Other				
		2	Absorbed dose/rate to water	2	Electrons				
		3	Absorbed dose/rate to graphite	3	Beta radiation				
		4	Absorbed dose/rate to tissue	4	X-ray, 10 to 50 kV				
		5	Absorbed dose/rate to other material	5	X-ray, 50 to 420 kV				
		6	Air kerma/rate	6	Photons, high energy				
		7	Reference air kerma rate	7	Co-60				
		8	Ambient dose equivalent/rate	8	Cs-137				
		9	Directional dose equivalent/rate	9	Ir-192				
		10	Personal dose equivalent/rate, penetrating	10	Am-241				
		11	Personal dose equivalent/rate, superficial	11	Co-57				
		12	Air kerma length product	12	I-125				
		13	Air kerma area product	13	Pd-103				
		14	X-ray tube voltage						
2	Radioactivity	1	Activity	1	Other	1	Single-radionuclide source	1	Kx-rays
		2	Activity per unit mass	2	Gas	2	Multi-radionuclide source	Xx-00	format for any radionuclide
		3	Activity per unit area	3	Liquid			Mn-54	^{54}Mn (example)
		4	Activity per unit volume	4	Solid			U-235	^{235}U (example)
		5	Surface emission rate	5	Aerosol			Be-7	^{7}Be (example)
		6	Surface emission rate per unit area					Sr-90/Y-90	^{90}Sr/^{90}Y (example)
		7	Emission rate per unit solid angle	6	Reference material	1	Other	Nb-93m	^{93}Nb^{m} (example)
		8	Emission rate			2	Foods		
		9	Efficiency of γ-ray spectrometers (vs energy)			3	Water		
		10	Efficiency of ionization chambers			4	Biological materials		
		11	Efficiency of contamination monitors			5	Soils/sediments		
						6	Flora		
						7	Building materials		

Level 1		**Level 2**		**Level 3**	
3	Neutron	1	Emission rate	1	Other
	Measurements	2	Emission anisotropy	2	Monoenergetic neutrons
		3	Fluence	3	Thermal neutron distribution
		4	Fluence rate	4	Wide energy range neutrons
		5	Ambient dose equivalent	5	Cf-252 source
		6	Ambient dose equivalent rate	6	Cf-252 source, D_2O moderated
		7	Personal dose equivalent	7	Am-241/Be-9 source
		8	Personal dose equivalent rate	8	Am-241/B-11 source
		9	Absorbed dose to water	9	Am-241/Li-7 source
		10	Absorbed dose rate to water	10	Am-241/F-19 source
		11	Absorbed dose to graphite		
		12	Absorbed dose rate to graphite		
		13	Absorbed dose to tissue		

COURSES, MEETINGS AND CONSULTANCIES TO BE HELD DURING 2003

Courses

Regional Workshop on Dosimetry of therapeutic x-ray beams, Accra, Ghana, 7-11 July 2003 (RAF/6/027)

Regional Workshop on Acceptance Testing and Commissioning of radiotherapy equipment, Tripoli, Libya, October 2003 (RAF/6/027)

Sub-regional Workshop on the Implementation of the International Code of Practice, TRS-398, Guatemala-City, Guatemala (RLA/9/030), dates to be decided.

Regional Workshop on Radiotherapy Physics, Sydney, Australia, 18-22 August 2003

ESTRO courses under RER/6/012

Training Course on Radiotherapy Treatment Planning: Principles and Practice, Dublin, Ireland, 9-13 March 2003

Training Course on Dose Determination in Radiotherapy: Beam Characterization, Dose Calculation and Dose Verification, Barcelona, Spain, 6-10 May 2003

Training Course on Physics for Clinical Radiotherapy (Russian Edition), Moscow, Russia, 25-29 May 2003

Training Course on Imaging for Target Volume Determination in Radiotherapy, Nice, France, 8-12 June 2003

Training Course on Physics for Clinical Radiotherapy, Leuven, Belgium, 31 August - 4 September 2003

Training Course on Evidence-Based Radiation Oncology: Methodological Basis and Clinical Application, Tenerife, Spain 9-14 November 2003

Meetings and consultancies

Consultancy to finalize the Agency's medical physics syllabus, IAEA Headquarters, Vienna, 24 -28 February 2003

Second Research Coordination Meeting on the Development of an International Code of Practice in x-ray diagnostic radiology, IAEA Headquarters, Vienna, 13-17 Jan 2003

Second Research Coordination Meeting on the Development and dissemination of absorbed dose to water calibration techniques for SSDLs, Oslo, Norway, 23-27 June 2003

Consultants' meeting to develop guidelines for activity measurements in nuclear medicine, IAEA Headquarters, Vienna, dates to be decided

Consultants' meeting to develop procedures for in-vivo dosimetry, IAEA Headquarters, Vienna, September 2003

Consultants' meeting to develop procedures for the evaluation of treatment planning calculations, IAEA Headquarters, Vienna, dates to be decided

Consultants' meeting to develop procedures on TLD-based quality audits for radiotherapy dosimetry in non-reference conditions, IAEA Headquarters, Vienna, June 2003

RCA Project Coordinators Meeting on Strengthening Medical Physics in Asia and Pacific Region, Bangkok, Thailand, 31 March-4 April 2003

RAF6027 and RAF6024 (AFRA II-4) Project Coordinators' Meeting on Medical Physics and the Management of the Most Common Cancers in Africa, Bangkok, Cairo, Egypt, 13-17 December 2003

Task Group Meeting on Strengthening Medical Physics in the Asia & Pacific Region, place and dates to be decided

Task Force Meeting on upgrading medical physics in Africa, Quatre Bornes, Mauritius, dates to be decided

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* SSDL Organization

[1] Kindly notify the Dosimetry and Medical Radiation Physics Section if the information here is incorrect or changes.

COLLABORATING ORGANIZATIONS ASSOCIATED WITH THE IAEA/WHO NETWORK OF SSDLs

International Bureau of Weights and Measures (BIPM)
International Commission on Radiation Units and Measurements (ICRU)
International Electrotechnical Commission (IEC)
International Organization of Legal Metrology (IOML)
International Organization of Medical Physics (IOMP)

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Bundesamt für Eich und Vermessungswesen (BEV)	Vienna, AUSTRIA
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