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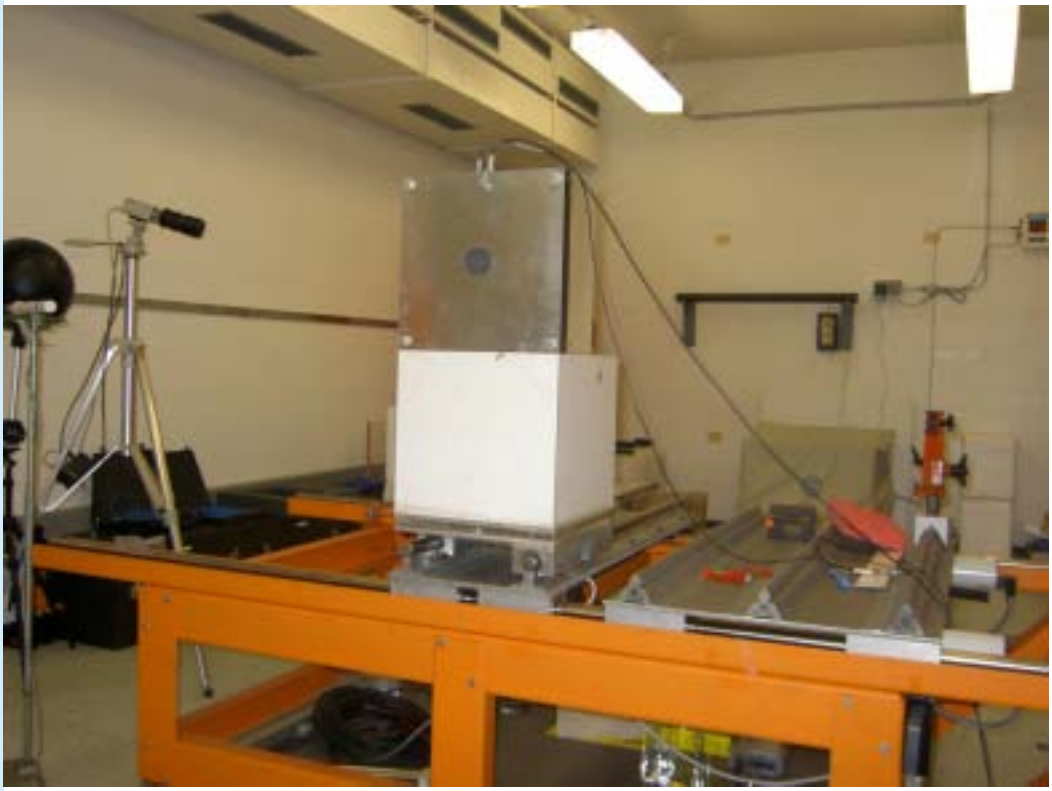

EUROMET supplementary comparison of the personal dose equivalent for photon radiation (EUROMET.R(I)-S5): calibration of a transfer ionization chamber at the IAEA Dosimetry Laboratory during October 2004.

Contents

From the editor

This issue of the SSDL Newsletter starts with the draft report of the 11th SSDL Scientific Committee (SSC) Meeting held at the IAEA Headquarters from 2-5 March 2004. In general, the SSC conducts biennial reviews and evaluations of the Dosimetry and Medical Radiation Physics activities. Following each meeting, the report of the SSC is addressed to the Directors General of the IAEA and WHO and circulated subsequently to Member States through this Newsletter. The report is pending acceptance by the IAEA and WHO.

The second article is a report on an international comparison of radioactivity measurements between seven national laboratories and the BIPM. Since the laboratory facilities at Seibersdorf are not yet ready, the IAEA did not participate in the measurements; however, it has organized the comparison and participated in the preparation of the report.

During 2004, the IAEA Dosimetry Laboratory participated in two international comparisons to substantiate its calibration and measurement capabilities in dosimetry. The first comparison was organized by EUROMET and concerned personal dose equivalent for photon radiation. The second comparison was organized by APMP and concerned air kerma and absorbed dose to water for ^{60}Co gamma beams.

IAEA International Atomic Energy Agency

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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 IAEA Calibration and Measurement Capabilities (CMCs) have been reviewed and published in the CIPM's (Comité International des Poids et Mesures) Appendix C. Additional information can be found at the web site: http://kcdb.bipm.org/AppendixC/search.asp?met=RI

The range of services is listed below.

Services	Radiation quality
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
Calibration of well-type ionization chambers for Low Dose Rate (LDR) brachytherapy.	γ rays from ^{137}Cs
Comparison of therapy level ionization chamber calibrations (for SSDLs).	γ rays from ^{60}Co
TLD dose quality audits for external radiotherapy beams for SSDLs and hospitals.	γ rays from ^{60}Co and high energy x-ray beams
TLD dose quality audits for radiation protection for SSDLs.	γ rays from ^{137}Cs
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
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 SSDL Network Secretariat for further details, at the address provided below. Additional information is also available through the Internet at the web site: http://www-naweb.iaea.org/nahu/dmrp/ssdl.asp

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Report of the 11th Meeting of the SSDL Scientific Committee

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1. Foreword

The Scientific Committee (SSC) of the IAEA/WHO network of Secondary Standards Dosimetry Laboratories (SSDLs) is a standing committee within the framework of the International Atomic Energy Agency. It is tasked with conducting periodic reviews and evaluations of the Dosimetry and Medical Radiation Physics Subprogramme and reporting the results of the reviews to the Directors General of the IAEA and the WHO. The report of the tenth meeting (held in February-March 2002) of the SSC (SSC-10) was published in the SSDL Newsletter No. 47 in January 2003.

The eleventh meeting was held in Vienna at Agency Headquarters from 2-5 March 2004. Opening remarks were made by Mr. W. Burkart, Deputy Director General and Head of the Department of Nuclear Sciences and Applications; Mr. P. Andreo, Director of the Division of Human Health (NAHU); Ms. G. Voigt, Director of the Agency's Laboratories at Seibersdorf (NAAL); Dr. H. Østensen (WHO), of the Department of Essential Health Technologies and Co-Secretary of the IAEA/WHO SSDL Network; and Mr. K. Shortt, Head of the Section of Dosimetry and Medical Radiation Physics (DMRP) and Co-Secretary of the IAEA/WHO SSDL Network.

1.1 Introductions

Mr. Burkart welcomed the SSC and spoke of the need to ensure that Agency resources were distributed effectively. He explained that the SSC report was of great significance, as the Directors General of both IAEA and WHO would receive the report. He mentioned that one of the highlights of the last biennium was the November 2002 Dosimetry Symposium. The symposium developed recommendations from which a separate independent committee developed an action plan that, after further revision, would be used as guidance for implementation

by the medical physics and radiation metrology communities. Mr. Burkart spoke also of the increasing cancer incidence in developing countries, and referred to an Agency publication entitled "The Silent Crisis", which discusses the lack of adequate cancer treatment facilities in the developing world. The Agency's mission is to improve access to and the quality of cancer treatment in these countries, indeed the increases in requests from Member States for direct services from DMRP indicate the Agency's success in raising awareness about the cancer crisis in those countries. The increase in requests for training and instrument calibrations has demanded that the Agency's facilities at Seibersdorf be expanded. SSC-10 had recommended the construction of an additional bunker for calibration work, and Mr. Burkart reported that USD 1.1M has been allocated to build an additional bunker. This was the first significant increase in the DMRP budget for a number of years.

Mr. Burkart listed several areas that he hoped SSC-11 would consider:

DIRAC – the Agency's database of radiotherapy facilities
Diagnostic radiology, and the DMRP's role
Coordination with WHO Department of Essential Health Technologies
Advice to establish future directions.

Mr. Andreo acknowledged the close collaboration between DMRP and the Section of Applied Radiation Biology and Radiotherapy (ARBR) and indicated that he would like to see the relationships strengthened between all 4 sections in the Division of Human Health. He emphasised the importance of the SSC as a mechanism to provide direction for DMRP and acknowledged the great strides made by DMRP to accomplish the impressive list of recommendations made by SSC-10. He reminded the SSC-11 of DMRP's budget limits and asked it to identify activities that could be discontinued. Keeping in mind the recent increases in requests for calibrations from SSDLs and hospitals, he asked whether DMRP might seek additional support from other major laboratories and hospitals to help, perhaps by directing Member States to seek service from neighbouring countries rather than the Agency. He pointed out the need to achieve a balance between basic dosimetry and clinical medical physics (between "D" and "MRP") and noted that several of the SSC-11 members are laboratory people who may not appreciate the needs in developing countries for clinical assistance. He was pleased that DMRP has participated successfully in the MRA process but noted that the programme requires a lot of resources for the Agency to maintain its status as signatory of the MRA and asked the SSC to consider if these resources are wisely spent.

Ms. G. Voigt acknowledged the close relationship between the DMRP and the Seibersdorf laboratories and that NAHU and NAAL have overlapping interests in the dosimetry area. She indicated her continuing support for the laboratory and the SSDL Network activities. She pointed out that if, as has been suggested, Member States are asked to take over more of the service functions, this would likely require training of more Fellows, which might stress the capabilities of the laboratory. She was pleased that the construction of the new facility at Seibersdorf should begin soon, but noted that selecting and purchasing new equipment and recruiting new staff would be needed. Ms. Voigt indicated that she was looking forward to seeing the SSC-11 recommendations.

Dr. Østensen began by remarking on the convenience of the timing of the SSC-11 meeting just prior to the European Congress of Radiology, which he would be attending as well. He explained that WHO also had limited funds and that as a result, a closer collaboration between WHO and IAEA, might lead to a more efficient use of resources. He concluded by describing the desperate state of health care in a number of developing countries, which he said was the result not only of insufficient equipment but also of inadequate training.

1.2. General discussion

The comments of several of the speakers stimulated a short discussion. Mr. Burkart indicated that it is not possible to give radiation therapy without knowing the dose accurately but it is also not possible to treat effectively without a proper diagnosis, which may be a problem in developing countries. Mr. Andreo remarked that, in some countries, there might be only one medical physicist, and perhaps only one cobalt unit in the entire country. In such situations, many patients are diagnosed at such a late stage that there is no chance for curative treatment and hence the strengthening of the diagnostic infrastructure is needed before the introduction of advanced technology for radiation therapy. Dr. Østensen mentioned examples of appalling situations observed by him during field missions where some hospitals could not even diagnose broken bones properly as their inadequate dark-room facilities produced such poor quality films. He also pointed out some problems often seen in relation to donations of equipment, such as a user's handbook and manuals in another language, or equipment requiring a different electrical supply than is available. He indicated that a close collaboration between IAEA and WHO is critical to ensure a comprehensive approach to address all aspects of health care.

Mr. Burkart agreed on the need to balance efforts to introduce high-technology medicine into countries that do not even have basic antibiotics, and acknowledged the importance of proper and early diagnosis. He stressed that, in the case of cancer management, improving diagnostic capabilities without providing a corresponding capability to deliver treatment is a disservice to patients.

Similarly, introduction of radiotherapy facilities without having basic diagnostic facilities and possibilities in place, would be equally inappropriate. Each organization, the IAEA and the WHO should listen to the Member States to determine their needs and then do what it can to support them.

Dr. Allisy-Roberts thanked Mr. Burkart and the other speakers. She noted that the SSC-11 had clearly heard their requests and would consider balance: between budgets and priorities, diagnosis and treatment, and calibrations and medical physics support. She said the SSC-11 was pleased to know that all directors felt the earlier contributions of the SSC had been beneficial.

1.2.1. Confirmation of Chair and Rapporteur

At this point, Mr. Shortt asked for confirmation of the chair and rapporteur. Both were confirmed.

1.2.2. Programme of Meeting

The DMRP staff members presented reports on the various activities of the Section during the remainder of the first day of the meeting. The SSC-11 met with Mr. Shortt on the second day, to review in detail specific activities and responses to previous recommendations. On the third day, the SSC-11 met in closed session, deliberating on the accomplishments and direction of the Agency's sub-programme, and developing specific recommendations. The draft recommendations were refined on the morning of the fourth day, after which the SSC-11 heard final comments from the DMRP staff. The draft recommendations were discussed with Mr. Shortt on the afternoon of the fourth day.

The SSC evaluated the activities of the DMRP reported for 2002–2003 and discussed the proposed sub-programme for the Section for 2004–2005. In addition, the SSC reviewed an initial proposal for the biennium 2006–2007. The scope of the SSC-11 evaluation addressed the questions of:

The objectives of the sub-programme areas.
The impact (benefit to the Member States).
The continuing relevance of Agency activities.

Specific recommendations from the SSC are underlined throughout the text, and are also reiterated at the end of the report.

2. Introduction

The SSC-11 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 during the biennium 2002-2003. The availability of this report in advance of the meeting enhanced the Committee's ability to develop thoughtful and appropriate recommendations.

The SSC-11 is pleased to note that most of the recommendations of SSC-10 have been implemented. The SSC notes that the DMRP intends in the current biennium to implement the SSC-10 recommendations that are outstanding.

Beginning with the biennium 2002–2003, the DMRP Section's projects and their titles are:

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

PROJECT F.3.02: Quality Assurance and Dose Audits to End-Users

PROJECT F.3.03: Research and Development in Radiation Dosimetry Techniques

PROJECT F.3.04: Developments in Radiotherapy Physics Quality Assurance.

In this 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. This SSC report is organized following the new project numbers. For the biennium 2004–2005, the name of F.3.04 is changed 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 performed by the DMRP under that project.

This report begins with a general discussion of administrative items and collaborative efforts within the Agency. Selected projects are then discussed in turn. The report mentions 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 described in the DMRP Report.

3. Report

3.1. General Organizational Items

3.1.1. Timing for the SSC meeting

The SSC-11 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 2006–2007.

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 should be scheduled early in the appropriate year. Consequently, the meeting of SSC-12 is scheduled for 07 to 10 March 2006.

3.1.2. Staffing issues

The SSC-11 notes with pleasure that the Agency implemented a recommendation of SSC-10 to convert the position of IAEA/WHO SSDL Network Project Officer to a 5-year renewable-term position. The position of IAEA/WHO International Dose External Audit (TLD) Project Officer had previously been converted to a 5-year renewable-term position. The conversion of both positions will help to maintain the continuity of the service and the credibility of the network. In addition, the Agency has regularized the position of Diagnostic Radiology Dosimetry Officer, an adjustment that will greatly improve the opportunities for recruiting for this position when it becomes vacant in the near future.

3.1.3. Laboratory Organization

The SSC-11 is very pleased to note the successful assessment by an international peer review panel of the Quality System developed by the DMRP for its dosimetry laboratory (DOL). The panel had expressed its highly favourable impression of the quality of services provided by the DMRP Section and stated their utmost confidence in the assigned calibration certificates and the audit reports. The SSC recognizes that the technical operation of the DOL as a laboratory entity in terms of ISO/IEC 17025 is the sole responsibility of the DMRP and supports the peer-review panel in ensuring clarity in the Quality Manual. This could be achieved, for example, by the use of figure 2 on page 8 of the DMRP report reproduced here as Figure 1.

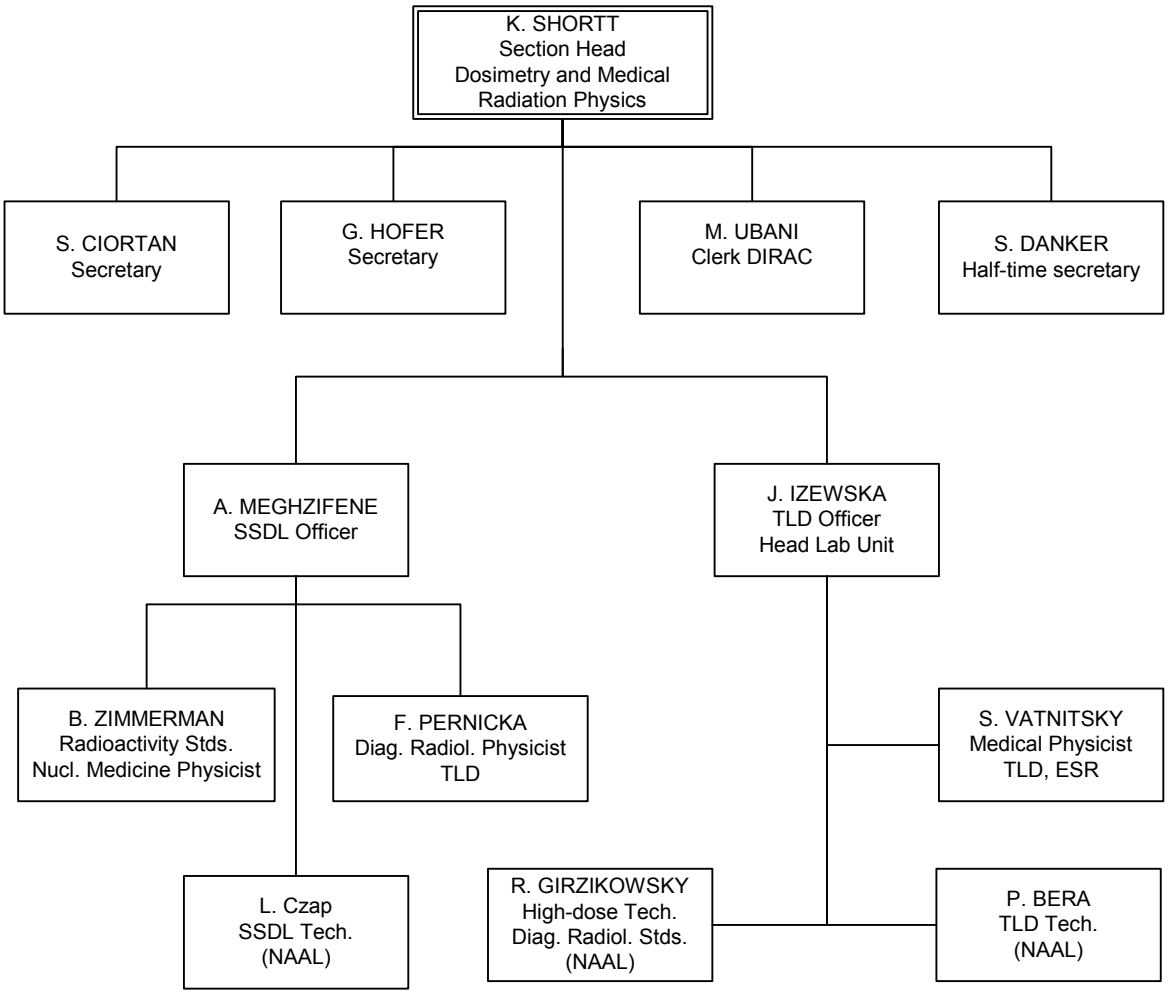

Figure 1.Responsibility chain within the DMRP and laboratory

1. As a consequence of the peer review, the SSC-11 recommends that an appropriate staff member of the DMRP be designated as Quality Manager, and that the Quality System documentation be revised to indicate clearly this chain of responsibility. The SSC-11 further recommends that the Agency communicate to the JCRB the status of the assessment of the DOL Quality System and indicate as fast a schedule as feasible to correct the

minor deficiencies identified in the laboratory documentation

3.1.4. Facilities at the Dosimetry Laboratory

The SSC-11 is pleased that in response to previous recommendations of the SSC, funding has been provided for the design and construction of the new bunker to house a modern ^{60}Co teletherapy unit and a new therapy x-ray machine. The addition of this new facility will support increased training programmes and allow the DMRP to function more efficiently and provide more x-ray calibrations in response to Member States' requests.

2. The SSC-11 strongly recommends that the new teletherapy unit be equipped with the highest activity of ^{60}Co consistent with the design of the facility for radiotherapy-level calibrations, and that the existing older unit is maintained to serve for training of Fellows and for radiation-protection-level calibrations.

The SSC notes that the current calibration workload has exceeded projections by 30 % and is expected to increase due to the success of the programme and the consequent demands of Member States. The SSC-11 will recommend in a later section that the Agency appoint a new staff member. This is in view of the additional workload envisioned in 2006 from the "Silent Crisis" of impending increases in cancer cases in developing countries, and the additional workload in therapy and the training requirements that this will involve. The laboratory is almost overwhelmed at this point, and the additional predicted workload will exceed their capabilities.

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

The IAEA/WHO SSDL network presently consists of 74 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 defined 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). In addition, some SSDLs provide quality audits of radiotherapy dosimetry by postal TLD and on-site measurements, and some perform measurements at radiation processing levels. Almost all SSDLs provide radiation protection level calibrations, although most do so without demonstrating traceability to the International Measurement System (SI). 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. Since 1997, a routine comparison service using ionization chambers has been conducted by the DMRP 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 its efforts on following up the results of all audit services whenever an SSDL (or hospital) has results outside the Agency's acceptance limits. This follow-up programme has been very successful.

3.2.1. SSDL Network Membership Issues

The SSDL project provides traceability of measurements through the PSDLs or the Agency to the SI by maintaining the link to hospitals and other end users. The SSDL project also provides quality audit services to verify that the laboratory members follow internationally accepted metrological standards. Only laboratories designated by their national competent authority are admitted to the network. The performance of the SSDLs is monitored through a postal TLD service, and a routine comparison programme using ionization chambers verifies the integrity of the reference standards at the SSDLs. Another regular postal TLD programme monitors the radiation protection-level calibrations provided by the SSDLs.

The SSC-11 notes with pleasure that a regional SSDL has been set up in Latvia, initially for radiation protection measurements. This SSDL will serve, in addition to their own country, the neighbouring Member States of Lithuania and Estonia. The SSC-11 believes that this arrangement can serve as a model for other regional SSDLs to provide calibrations for more than one Member State.

Noting the success of the regional SSDL in Latvia, the SSC-11 suggests that the Agency might consider encouraging and assisting Member States in the designation of regional SSDLs.

The SSC-11 congratulates the Agency for bringing new SSDLs in Georgia and Russia into the network, and further congratulates the Agency for applications under re-

view from Morocco and Sudan. The SSC notes with pleasure that positive feedback has been received from provisional membership of SSDLs in Ecuador, Egypt, and Libya, which should bring them into compliance with the SSDL Charter. The status of the SSDLs in Iran was reviewed with the DMRP staff.

3. The SSC-11 recommends that the Iranian AEC be substituted for the Khomeini Hospital SSDL in the IAEA/WHO SSDL Network.

3.2.2. The SSDL Newsletter

The SSC is pleased to see the continuation of the SSDL Newsletter and that it is freely available from the Agency web site, but is concerned as to whether knowledge of its existence was reaching further than the SSDLs themselves. Some suggestions to augment the readership to include some end users were raised perhaps through notifying the various national and international medical physics societies, or using an e-mail distribution list supplied by them to notify their members of the URL for downloading.

Noting that the SSDL Newsletter contains information that is useful and relevant not only to SSDLs but also to the local medical physics community, the SSC suggests that the DMRP review the distribution methods for the SSDL Newsletter to ensure that it is made available to the appropriate end users.

3.2.3. Establishment of Priorities for Calibrations

The DMRP showed data describing the workload at the DOL. A total of 138 ionization chambers were calibrated by the DOL during 2002-2003. Therapy-level instruments constituted 76 % of these chambers, while 16 % were protection-type instruments. A large increase has been seen in the number of requests from hospitals in Member States without SSDLs, from 4 in 2001, to 12 in 2002, to 22 in 2003. A peer review, conducted shortly before the SSC-11 meeting, noted the increase in workload and commented that "… the workload of the present staff continues to increase. The panel is concerned that this demand may have a negative impact on the quality of the services provided." The SSC-11 also is concerned that the increase in workload be addressed to avoid a deterioration of the DOL's services.

The SSC-11 discussed the procedures by which the DMRP should establish priorities for serving Member States. First priority should be given to Member States that are not signatories to the Convention of the Metre, while Member States that have signed the Metre Convention would be given second priority. Hospitals approaching the DMRP directly should be given third priority. While some of the additional workload is in the area of diagnostic radiology, the highest priority should be given to therapy calibrations. Whenever possible, hospitals should be referred to the SSDL Network to address their needs.

4. Noting the increasing workload on the Agency's calibration service, the SSC-11 recommends that the Agency gives utmost priority to therapy-level calibrations before undertaking diagnostic- and protection-level calibrations, until additional facilities in the new bunker are available. The SSC-11 further recommends that the Agency encourage the use of the SSDL Network to reduce its workload of non-therapy calibrations for hospitals.

3.2.4. CIPM Mutual Recognition Arrangement

The DMRP reported that it had made significant progress in the core area of dosimetry. The DMRP calibration and measurement capabilities (CMCs) had been reviewed and accepted for publication in the CIPM's Appendix C, being among the first internationally to be published. One consequence of having signed the MRA and being able to publish CMCs is that the Dosimetry Laboratory's Quality System has to be peer-reviewed. The peer review was in fact conducted prior to the meeting of SSC-11 and, while the peer reviewers' report was not available, selected recommendations from a draft of the report were provided to the SSC.

The DMRP requested clarification from the SSC-11, as it is customary at the DOL to use $k = 1$ to describe uncertainties in their calibration certificates. However, the acceptance of the DMRP CMCs into the Key Comparison Data Base (KCDB) requires the reporting of an expanded uncertainty, using $k = 2$.

5. Noting that an expanded uncertainty ($k = 2$) is required for CMCs in the MRA KCDB, the SSC-11 recommends that the Agency quote $k = 1$ or $k = 2$ in their calibration certificates for SSDLs or end users, respectively, and continue to state clearly the chosen coverage factor in each respective calibration certificate.

Another consequence of the MRA is that SSDLs need to demonstrate their calibration capabilities. In general, the SSC-11 feels that an SSDL that is within a regional metrology organization (RMO) should be encouraged to approach their RMO first to participate in regional or bilateral comparisons to demonstrate their capability to disseminate the SI and generally discouraged from using the Agency for such comparisons. The SSC-11 felt it was beneficial to the Agency itself to participate in regional comparisons, as this would also encourage the SSDLs.

6. The SSC-11 recommends that the Agency encourage SSDLs to participate whenever possible in RMO comparisons to support their CMCs.

3.2.5. Brachytherapy Dosimetry

The Agency has previously published IAEA-TECDOC-1274, which describes a procedure of calibrating a thimble ionization chamber in air at beam qualities bracketing that of ^{192}Ir. The Agency has also noted the lack of primary standards for ^{192}Ir HDR sources, and has organized a comparison of calibration coefficients for ^{192}Ir HDR, based on the interpolation method. Four laboratories participated in the comparison held during 2002–2003: ADCL-Wisconsin, PTB, NMi and IAEA-DMRP. Four Farmer type ion chambers were used for the comparison: Exradin A-12, Exradin A3, NE-2571 and TW30010. The PTB and NMi use several beam qualities in the determination of the $N_{K,\mathrm{Ir}}$ coefficient whereas the ADCL and the IAEA use only two qualities. Mr. Tölli, the former DMRP brachytherapy officer, who has since left the Agency, initiated the comparison. A report is under preparation. However, the question was asked whether the DMRP could use the interpolation method to provide calibrations at this quality.

7. The SSC-11 recommends that the Agency calibrates ^{192}Ir HDR sources following the validation of the interpolation method using a chamber with a nearly-constant response to air kerma over the appropriate photon energy range as a traceable standard.

3.2.6. Protection-Level Calibrations for X-Rays

The Agency presently provides only narrow-spectrum beam qualities for protection-level calibrations. A few inquiries have been received regarding calibrations of protection equipment in the ISO wide-spectrum series of beam qualities. The SSC-11 recognizes that while the ability to provide these calibrations might be desirable, this service is not in high demand and should be a low priority.

Noting that the demand is currently low for protection-level calibrations in the ISO wide-spectrum series, the SSC-11 suggests that the Agency should only consider developing a programme to implement such calibrations once the new facilities are in place, and only if requested by several Member States.

3.2.7. Calibration of Low- and Medium-Energy X-Rays

According to the DMRP's survey, most SSDLs (70%) maintain secondary standards based on low- and medium-energy x-ray qualities. Of these SSDLs, most report that such beam qualities are used in their countries for radiotherapy. The DMRP also maintains standards for these beam qualities, and conducts periodic reviews of the SSDLs. The Agency participated in a key comparison organized by the APMP on the measurement of air kerma for medium-energy x-ray beam qualities (APMP.RI(I)-K3). Ionization chambers were compared at four beam qualities. The Agency submitted two PTW-30001 ion chambers to be compared. A summary of results obtained that was reviewed by the SSC indicated that the Agency's instruments compared favourably with those of the other participating laboratories.

In congratulating the DMRP on their very successful performance in the APMP regional comparison of medium-energy x-ray calibrations, a key comparison linked to the CCRI(I), the SSC-11 encourages the Agency to participate in other regional comparisons as appropriate commending the proposed participation in the EUROMET [$H_{\mathrm{P}}(10)$] chamber comparison scheduled for October 2004.

The DMRP calibrates instruments for ISO x-ray beam qualities at 2 m or 3 m. However, the DMRP staff pointed out that ISO Guide 4037 states that measurements of HVL should be made at 1 m from the target. The SSC-11 discussed this question at some length but concluded that the issue of concern was the HVL at the location of measurement. It was recognized that SSDLs may not be able to duplicate exactly the beam qualities, geometry, and scattering conditions at the DOL, and that determination of the HVL at the point of measurement would best enable the SSDLs to mimic the Agency's beam qualities. As measurement at low dose rates carries with it greater uncertainty, the Agency's stated uncertainties for these HVL measurements might need to be increased.

The SSC-11 recommends that the Agency measures and states the HVL of x-ray beams for protection-level calibrations at 3 m, the point of measurement with the appropriate uncertainty, noting that this is not in contradiction with the ISO specification at 1 m.

3.2.8. Calorimetric Measurements

The SSC-10 recommended that the Agency's graphite calorimeter be made available to the ARPANSA for absorbed dose measurements in Australia. This recommendation was accepted, and the calorimeter has been in Australia for the past two years while the intended measurements were made. It was noted that the calorimeter would be returned in working order in 2006. This would give the opportunity to the Agency to consider its loan to another Member State.

The SSC-11 suggests that the Agency use the calorimeter to measure absorbed dose to water in the new ^{60}Co facility expected during the biennium 2006-2007 and subse-

quently lend the equipment to one of the more advanced SSDLs for them to gain direct experience in calorimetry. It is noted that a Fellow from a Member State and perhaps Agency staff will need appropriate training, perhaps from the ARPANSA to conduct such an exercise.

3.2.9. Dosimetry for Diagnostic X-Rays

The DMRP's survey in 2002 indicated that about 40% of the SSDLs calibrate instruments for diagnostic radiology. Another 20% had indicated that they were preparing to offer this service. The DMRP has continued to develop a range of diagnostic beam qualities to be consistent with IEC 61267. In particular, development of a facility to calibrate CT ionization chambers, using a slit method, has been undertaken. Testing of this method was conducted recently, with good results. Dosimetry for computed tomography (CT) should be considered a high priority since the use of CT in medicine is continuing to increase rapidly, and CT contributes significantly to the global population dose.

8. In view of the increasing use of CT techniques worldwide, the SSC-11 recommends that the DMRP introduce its new capability to calibrate CT chambers for the biennium 2006-2007.

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

The F.3.02 project is intended to assure the quality of the dosimetric chain from the Agency and PSDLs, through the SSDLs, to hospitals in Member States. The mechanism includes independent verification of the dose to be delivered to patients receiving radiotherapy, and to the products irradiated by industrial processing facilities. This project provides two specific services.

3.3.1. The TLD Audit Programme

The SSC is pleased to note that the TLD audit programme has sustained a 95 % return rate for the TLDs that are issued. In addition, it notes the increased level requested by PAHO and WHO (for Africa) and the potential demand from China. China has a national audit programme but is unable to handle the increase anticipated from the doubling of the number of therapy beams over the past 5 years.

As indicated in Figure 2, the Agency has experienced a doubling of TLD requests from hospitals since 1996 and expects a further significant increase of 25 % by 2006. This is to be welcomed as it demonstrates the success of the programme. The SSC applauds the introduction of the second TLD reader, and the development of an automated system for analyzing the TLD results and generating reports as this provides greater capacity to cope with the demand. However, more staff time is likely to be needed to cope with the increased throughput, although some of this demand might be transferred to external audit groups (EAGs).

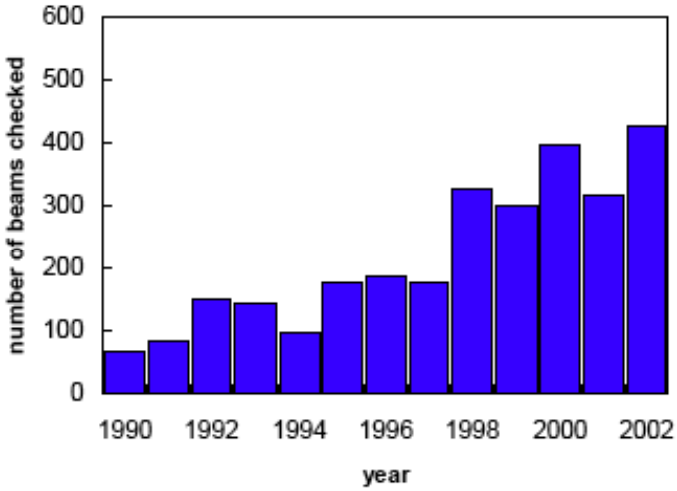

Figure 2. The requests for radiotherapy beam calibration checks through the Agency's TLD postal audit have increased steadily since the programme was introduced, and has seen a step increase since the introduction of an automatic TLD system in 1998.

9. The SSC-11 recommends that the Agency fosters the formation of EAGs and encourages hospitals to participate in those audits. However, it is recognized that EAGs may be slow or difficult to form and the TLD programme should be prepared to cope with the predicted immediate increases in demand.

The Agency's data indicate that during 2002 to 2003, approximately 88 % of the TLD measurements fell within the acceptance limit of 5 %. However, of hospitals receiving TLD for the first time, only 81 % of the results fell within the acceptance limit. Hospitals receiving TLD previously showed 91 % of the results within 5 %. Similarly, a larger fraction of hospitals receiving TLD for the first time fell outside 10 %. In both 2002 and 2003, the number of significant dosimetry discrepancies exceeded previous levels by more than a factor of 2 (see Figure 3), which is believed to be due to the large number of hospitals participating for the first time. These discrepancies have required additional time and effort to follow up and it is pleasing to see that a significant number has been resolved, which is to the credit of the DMRP. Ultimately, in 2002-2003, 95 % of the hospitals monitored were brought within the 5 % criterion. The number of discrepancies is expected to continue to increase as new centres join the audit. It is crucial to resolve these discrepancies, some of which could be symptomatic of serious underlying problems for patient dosimetry, and staff time must be available to do this.

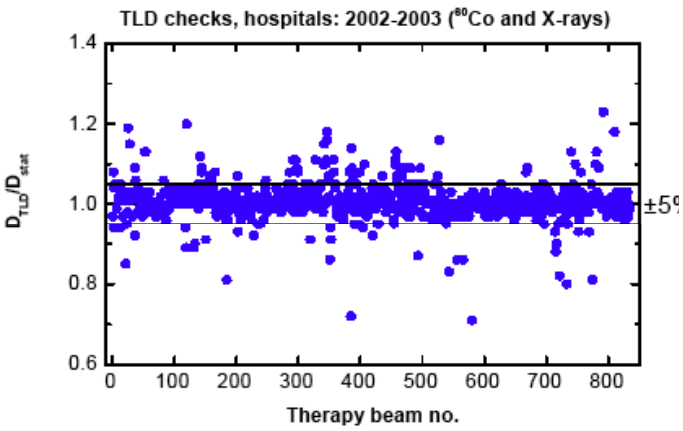

Figure 3. Results of the WHO/IAEA TLD postal audit of radiotherapy hospitals. The data indicate the ratio of the Agency's determined dose to the hospital's stated dose. Approximately 12 % of the results were outside the DMRP's 5 % acceptance limit.

A recommendation is made later suggesting that the Agency add sufficient staff to the DMRP to ensure that the new TLD equipment is used effectively to meet the increased demand, and to address the anticipated discrepancies, the resolution of which is critically important to assure adequate patient care.

The DMRP has analyzed the data sheets submitted by the participants in the TLD audit and determined that 20 % of the facilities did not report any dosimetry data. This suggests that these institutions either do not have physicists or do not have dosimetry equipment available. Not surprisingly, the results from these hospitals are significantly poorer than the pool of results.

The SSC-11 suggests that the Agency and the WHO collaborate to identify the support needed for institutions identified in the TLD audit response as lacking in dosimetry data, to remediate their radiotherapy dosimetry through improved equipment or staff training.

3.3.2. Medical Physics Investigation Team (MPIT)

During the 2002-2003 biennium, the DMRP initiated work on a recommendation of SSC-10 and created a new mechanism to respond quickly to radiation incidents in hospitals. The Medical Physics Investigation Team will be able to investigate possible radiation accidents and other events at hospitals, without requiring that the Member State wait to invoke the formal process of seeking help through the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. The clear value of the MPIT programme is that it allows an investigation to be conducted under informal circumstances, and to be performed quickly. The MPIT team will be tailored to each specific event, but generally will include members representing medical physics, radiation oncology and radiation protection, so that all aspects of the event can be analyzed and understood thoroughly. Due to the nature of radiation misadministrations, it is impossible to anticipate the number of such events each year, much less when they might occur, and establishing a budget for this activity is extremely difficult.

10. The SSC-11 supports the concept of MPIT to address serious misadministrations of dose in radiation therapy. Noting that members of MPIT come from medical physics, radiation safety, and radiation oncology, and that the need for action cannot be predicted, the SSC-11 recommends that the Agency define the procedures for MPIT operation and identify financial support for this important, potentially life-saving, programme.

3.3.3. International Dose Assurance Service (IDAS)

The International Dose Assurance Service (IDAS) uses ESR/Alanine dosimeters to provide a high-dose auditing programme for ^{60}Co beams. It is used primarily by facilities offering medical-device sterilization, food irradiation and mail irradiation. The doses can be between 0.1 kGy and 100 kGy, although the Agency rarely receives requests for doses larger than 10 kGy. About 20-30 countries per year request the service, totalling 50-60 measurements. Use of the service is distributed among developing and developed countries, and between commercial and non-commercial organizations.

As is the case with the TLD postal audits, the DMRP conducts both internal and external quality audits. Internal audits use previously irradiated ESR dosimeters to verify the overall system performance. The external audit system makes use of reference dosimeters irradiated at the NPL or the NIST. Of the 92 calibrations performed on request, 80% were within 5%. Follow up with the Member State is conducted whenever the results fall outside 5%. Of 5 cases that fell outside this criterion, three were resolved at subsequent audits. In the 2004/5 biennium, it has been decided to maintain the service for about 20 permanent users from non-commercial institutions. A TC project might be pursued to establish regional reference high-dose calibration laboratories in Member States.

The DMRP indicated mixed feelings over the continuation of this programme. While it provides a service seen as valuable by the small number of institutions that take advantage of it, it appears to be expensive to operate. The SSC-10 recommended in its report that the IDAS programme be continued, and that plans be made for the replacement of the ageing and expensive equipment. The Agency's Office of Internal Oversight Services (OIOS) also conducted a review of this programme, and expressed concern over the continuation of the programme in light of its cost and the DMRP's budgetary limitations. The OIOS recommended that the DMRP "Make a deliberate decision on the future of IDAS."

11. The SSC-11 is pleased to note that the DMRP has addressed the current budgetary constraints by scaling back the number of IDAS audit runs to two a year, and limiting them to non-commercial institutions. The SSC-11 recommends the phasing out of the system by 2006 due to the high cost of replacing the ageing equipment unless financial support is forthcoming from other divisions of the Agency.

A CRP (E2.40.11 on EPR Biodosimetry) was created to review the available methods, current research and developments in EPR biodosimetry that can be of use with this programme. There were 9 participants from 6 countries, and the results were published as TECDOC-1331 in 2003.

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

The SSC-11 was impressed by the number of active CRPs, and the involvement of DMRP staff in the various projects. The SSC was particularly gratified to learn that many of the CRPs were developed in response to recommendations from previous SSCs.

3.4.1. International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry

The SSC-11 is pleased to note that the DMRP held an international symposium on medical radiation dosimetry that was attended by over 250 scientists representing 62 nations. This number of participants greatly exceeded expectations. One hundred forty scientific presentations were received, of which 80 are published in the symposium proceedings that are now available. As part of the symposium, each scientific session was encouraged to develop recommendations of issues to be addressed by the medical physics community. A total of 91 recommendations was generated. The SSC-11 commends DMRP on a particularly successful symposium, and is delighted that the Agency recognized this success with a team award.

12. Noting that the participants at the international symposium on medical radiation dosimetry recommended that a further symposium be held in 2008, the SSC-11 strongly recommends that the Agency put this into their conference calendar for 2008.

13. Further noting that a preliminary action plan was developed in response to the symposium's 91 recommendations, the SSC-11 recommends that the Agency consider hiring a consultant to produce a final report for circulation to the participants and that the outcomes be reviewed at the 2008 symposium.

The SSC-11 has reviewed the recommendations from the dosimetry symposium, and feels that many would be appropriately addressed by the Agency. Indeed some specific recommendations of SSC-11 in this report already identify certain of the symposium recommendations for action by the Agency.

3.4.2. TRS-398 Calibration Protocol

Since the introduction of the Agency's TRS-398 calibration protocol in 2000, approximately 50 % of the hospitals known to use megavoltage treatment equipment have converted to this protocol. (This figure is based on the DMRP's survey in 2002 that indicated that 50 % of SSDLs report that hospitals in their countries have converted to the TRS-398 protocol.) This evidently confers an advantage to hospitals, as data from the DMRP's TLD audit programme have shown that the measurement results are generally better at hospitals using dose-to-water based calibration protocols. Of the 2002-2003 TLD results, approximately 26 % of the participating hospitals used a dose-to-water calibration protocol. Figure 4 indicates that hospitals using dose-to-water calibrations agreed better with the Agency (mean = 1.006, s.d. = 2.3 %), than did hospitals using N_x-based code of practice (mean = 1.029, s.d. = 4.8 %). In fact, the DMRP's data show that one of the most common errors in 2002-2003 was the use of inconsistent data to convert from a measurement of exposure to absorbed dose. Further adoption of dose-to-water-based protocols could be fostered through increased education of the staff at hospitals in developing countries.

14. The SSC-11 recommends that the Agency encourage SSDLs in Member States that are currently using N_x-based protocols to send Fellows to the DMRP for training in the use of the IAEA TRS-398 $N_{D,w}$-based protocol, as soon as the new calibration facilities are operational.

The SSC-11 notes that the DMRP has been compiling errata with respect to TRS-398. It also recognizes that the Agency's protocol for calibration at x-ray beam qualities, TRS-374, is now out of date and inconsistent with the new TRS-398.

15. The SSC-11 recommends that the Agency's TRS-398 be reviewed to accommodate new data and an errata list, and that the manual on calibration of dosimeters used in radiotherapy, TRS-374, be updated to be consistent with TRS-398.

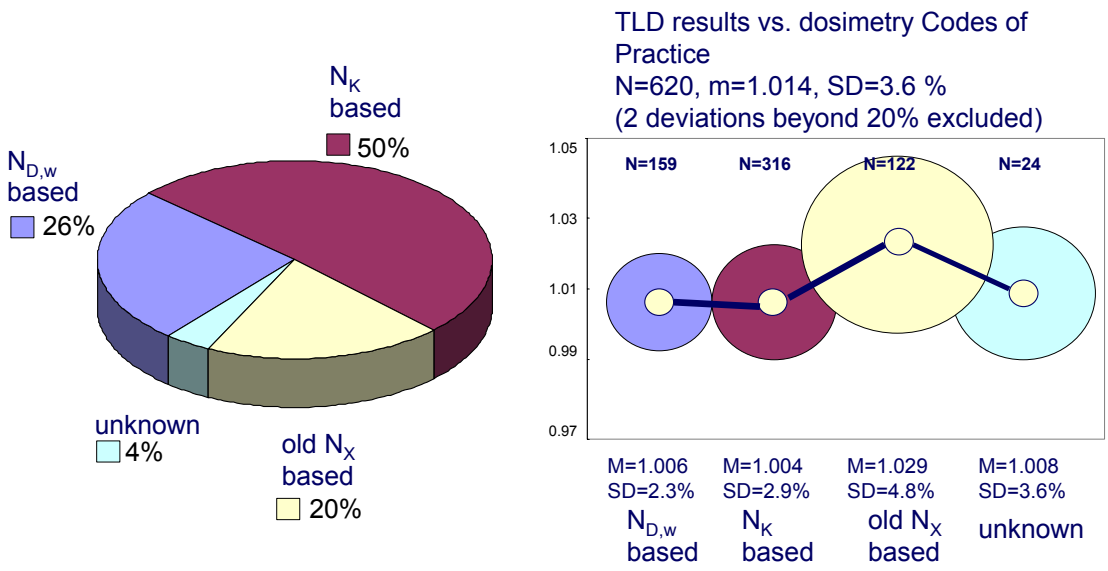

Figure 4: The impact of dosimetry code of practice on TLD results.

The SSC-11 is pleased to note the translation of TRS-398 into Russian and the progress toward translating the protocol also into Spanish. Translation of the TRS-398 protocol into additional languages could stimulate further adoption of the protocol.

The SSC-11 suggests that the Agency view favourably requests from Member States for translation of TRS-398 into other official Agency languages to encourage the worldwide adoption of this protocol.

3.4.3. Standards for Radioactivity in Nuclear Medicine

The SSC-11 commends the Agency on appointing a radiochemist to concentrate on issues of radioactivity standardization and traceability in nuclear medicine. The SSC-11 also fully supports the DMRP in their search for laboratory space and equipment, and hopes that this takes place in a timely fashion to enable the programme to take place as envisaged. The SSC notes that this programme will require an additional technician to fully realize its potential capabilities. A budget will be required to purchase radionuclides and to pay the expenses associated with shipping radionuclide samples to Member States.

The SSC notes that a survey conducted by the DMRP to determine the number of interested countries received an 82% positive response. Twenty-three Member States have indicated their interest in such a programme.

16. The SSC-11 recommends that an operating budget should be identified to provide the necessary materials and transport for the radioactivity standards programme to cover the needs of the Member States that have expressed interest in the programme.

The SSC is pleased to note that a CRP was recently approved that includes the development of a Code of Practice that will address the quality of radioactivity measurements for end users. The CoP will also include quality assurance and audit protocols. The project will include laboratories from both developed and developing countries to formulate and test the Code of Practice.

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

3.5.1. New Coordinated Research Projects

The SSC-11 is pleased to learn of several new CRPs concerning quality assurance. Noteworthy among these are the DMRP's CRP on TLD measurements under non-reference conditions. The SSC also noted the new CRP on in-vivo dosimetry in radiation oncology, which will assess the suitability of several different measurement systems. The SSC supports the DMRP's proposed CRPs addressing the QA of radiotherapy dosimetry calculations and dosimetry audits in diagnostic radiology. Finally, the SSC noted with interest the development of a TECDOC on quality assurance of radiotherapy treatment planning systems.

3.5.2. Maintenance of the Agency's Databases

The Agency maintains a number of important databases that store information of value and interest not only to the Agency but also to the medical radiation community.

The Directory of Radiotherapy Centres (DIRAC) includes data related to radiotherapy centres within Member States. The DIRAC lists not only data related to teletherapy machines, but also sources and devices used in brachytherapy, equipment for dosimetry, treatment-planning systems, and quality-assurance equipment. DIRAC is a very important project and should be supported fully by the Agency.

International Dose External Audits (IDEA) is a database that maintains the WHO/IAEA TLD postal dose quality audits for hospitals. IDEA provides fast access to the TLD results for individual hospitals and facilitates analysis of the results for selected countries or regions as a function of time. Rapid access to the data assists in the follow-up of institutions whose results fall outside the criteria for acceptability.

The SSC notes the importance and value of the databases maintained by the DMRP, as these contain information on the distribution of radiotherapy facilities throughout the world, and also the locations of SSDLs and their capabilities. The SSC feels that the information contained in DIRAC should be openly available on the Agency's web site as an important means for its dissemination. Efforts must be made to ensure that the data are complete and reliable. The IAEA is the only agency that can collect and maintain these data.

Noting that the Agency is the only international body that has the access and capability to collect and maintain the data in the DIRAC database, the SSC-11 suggests that the database should be made available on the Internet as soon as possible. The SSC-11 feels that the Agency could promote the use of the DIRAC database to the governments of Member States through the mailing of fliers or other advertising.

17. The SSC-11 recommends that the Agency appoint a staff member to be responsible for maintaining the DIRAC and the DMRP web page, noting that this person could also be responsible for maintaining databases in the other Sections of NAHU.

3.5.3. Agency Publications

The Agency produces a number of publications that are of great value and importance to medical physicists in the developing, as well as the developed world. In many cases, these publications are the result of efforts by experts in the field, who contribute a significant amount of time and effort to produce the work. In many cases, the authors and editors of such works are not identified, or are listed only through an acknowledgement at the back of the volume. In particular, the Agency has commissioned an extensive syllabus in radiation-oncology physics with contributions from a number of highly respected medical physicists. This work was completed more than a year ago, but is not yet published because agreement has not been reached on the method of recognition of the editor and authors. This is of great concern to the SSC-11.

A valuable continuation of this project that the SSC-11 supports in full is the development of a similar syllabus for medical physicists working in diagnostic-imaging procedures. There is a paucity of suitable training materials for physicists working in the developing world to learn the physics of imaging procedures, and in particular the quality-assurance procedures that are necessary to assure acceptable-quality medical care in these Member States.

However, when the IAEA publishes or plans to publish a textbook that involves a significant amount of scientific input, the SSC-11 feels that recognition of the editor and his institution as well as the authors and their respective institutions, according to normal academic publication practices, is essential.

18. Consequently, the SSC-11 recommends that the DMRP support initiatives to seek more flexibility in the policy of recognising authors and editors in Agency publications. It is hoped that some flexibility would enable the immediate publication of the current syllabus on radiation-oncology physics and facilitate the production of a new volume on diagnostic-radiology physics.

3.5.4. Implementation of Advanced Radiotherapy Procedures

The International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry, held by the Agency in Vienna in November 2002, resulted in the development of a list of 91 recommendations. To develop a procedure for addressing these recommendations, the DMRP brought together a number of experts in June/July 2003 to develop an Action Plan. The Action Plan calls for all radiotherapy institutions to implement an independent monitor unit or time calculation protocol for each patient to reduce the risk of accidental over-exposures of patients.

19. The SSC-11 recommends that the Agency develop guidelines for independent monitor unit and time calculation protocols for radiation treatment to reduce the risk to patients from incorrect dose delivery.

The SSC-11 is concerned about the possibilities for causing harm to patients when using complex treatment techniques including stereotactic radiosurgery, IMRT, 3D conformal therapy, total body irradiation, etc., particularly in developing countries when the scientific support may be less than adequate.

20. In view of the risk to radiotherapy patients, the SSC-11 recommends that the Agency develop a CRP on audit methodologies for dosimetry of complex treatment techniques, including 3D conformal therapy, stereotactic radiosurgery, and IMRT.

The SSC-11 understands that hospitals and Member States are asking for assistance to implement advanced-technology radiation therapy, but that many of these hospitals are not properly prepared to make the transition from basic radiotherapy. The SSC-11 feels that these hospitals should be encouraged to follow a logical sequence of increasing sophistication. For example, 2D planning should be implemented before 3D planning, and 3D planning, before inverse planning. Similarly, hospitals should progressively escalate the complexity of their treatment techniques, from standard therapy to conformal therapy, and ultimately to IMRT.

21. In view of the dangers inherent in using complex radiotherapy techniques, the SSC-11 recommends that DMRP collaborate with the radiation oncology section of NAHU to produce guidelines that Member States can use to evaluate their preparedness to introduce more complex radiation therapy techniques in a step-wise fashion.

The SSC-11 applauds the increased emphasis in the DMRP on medical radiation physics in the areas of research and education.

3.5.5. Training and Educational Efforts

While discussing the worldwide shortage of persons skilled in radiation techniques, the SSC also reflected on the skill drain from countries that are developing advanced radiological techniques. The DMRP has indicated its awareness of the risk that individuals who receive advanced training might be tempted to leave their countries of origin and move to more developed or advanced countries where the equipment is more easily maintained and the support facilities are more abundant. In particular, individuals who receive grants for training in developed countries are sometimes reluctant to return to their country of origin, and consequently there is a migration of skilled individuals from the developing world to the developed world.

22. To address the potential loss of radiological skills acquired during external training, the SSC-11 recommends that the Agency develop a CRP, with Member States having the potential for 3D CRT and IMRT, for doctoral programmes offered at the candidates' local universities but in collaboration with clinical training in Member States presently offering these capabilities.

The SSC-11 noted reports from the DMRP and elsewhere indicating the increased use of diagnostic-imaging devices in radiation therapy, for image-guided therapy and documentation of treatment delivery. In addition, the summary report of the thematic planning meeting on diagnostic radiology discussed the expected increases in cancer, cardiovascular disease, osteoporosis, and trauma, in the developing world. The Agency could play an important role in ensuring that imaging equipment is used effectively in radiation therapy and that radiation oncology staff are properly educated in its use.

The SSC-11 suggests that the DMRP develop recommendations for QA procedures for imaging equipment and associated devices used in radiotherapy.

3.5.6. Nuclear Instrumentation Technology

In discussing the recommendations on radioactivity standards, as identified earlier in this report, that are likely to be forthcoming from the Agency, the SSC feels that any such recommendations should include recommendations for QA audits in nuclear medicine. The view was also expressed by the WHO that the level of nuclear medicine technology should differ depending on the needs of different Member States. If a Member State did not have the radiotherapy or other oncology facilities to treat cancers that are diagnosed, it might be inappropriate to establish high-level diagnostic facilities.

23. The SSC-11 recommends that the DMRP in collaboration with other Sections of the Agency establish guidelines for appropriate nuclear medicine technology for different patient populations within Member States.

3.5.7. Pixel-Based Dose Assessment

Modern methods of dose assessment in nuclear medicine are based on digital images and can accommodate the calculation of doses based on individual patient data. In particular, they allow variations in organ size and position, as well as individual pharmaceutical uptake, to be taken into account. This requires both accurate image quantification techniques and the ability to perform radiation transport calculations at the voxel level. The SSC-11 suggests that the Agency hold a consultants meeting to review different methodologies of nuclear medicine dose assessment, including voxel-based methods, as part of its programme to develop and introduce guidelines for Member States.

3.6. Recommendations on DMRP staffing

Earlier in this report, the SSC addressed several areas in which the DMRP's workload had increased and new capabilities had been added. The SSC-11 chose to consolidate some recommendations on staffing in this section rather than distribute them throughout the report.

24. Despite the small gain in technical work capacity that would be achieved by phasing out the IDAS service, the SSC-11 strongly recommends that the Agency make plans to appoint two new DMRP staff members. This would meet the demands of Member States related to:

a. the current and predicted additional workload in therapy-level calibrations;

b. the increased training requirements for staff from SSDLs that will be facilitated by the addition of the new bunker;

c. the new programme for radioactivity traceability; and

d. the current and predicted increase in TLD measurements to support the IAEA/WHO and the PAHO dosimetry audit programmes.

4. Conclusions

The current review of the Agency's Dosimetry and Medical Radiation Physics (DMRP) sub-programme by the SSC took place in March 2004. The Committee was suitably impressed with the implementation of its previous recommendations and commends the Agency for the breadth, diversity and quality of the services provided to its Member States by the DMRP. It is evident that the Member States appreciate the sub-programme as their requests to use the DMRP services increase each year. Understanding that an ever-increasing budget cannot be provided to fund such demands, the SSC has made a number of recommendations concerning the direction and priorities for the biennium 2006-2007.

The services provided to support the IAEA/WHO network of SSDLs are crucial in addressing the dosimetric needs for the quality of cancer treatment, particularly of the Members States that are developing their cancer facilities. In addition to dosimetric traceability and verification through the TLD-based comparisons, the SSC feels that the Medical Physics support provided by the DMRP is well focused on the Agency's mission to improve the quality of cancer treatment as the "silent crisis" approaches. This support includes training, development and use of codes of practice, a syllabus on radiation oncology physics and audit methodologies, as well as the newer services responding to diagnostic radiology needs and, for the future, the medical physics aspects for nuclear medicine.

The work of the SSC was facilitated by the comprehensive DMRP report and the very clear presentations made to the Committee by the staff. Their enthusiasm and dedication in responding to the needs of Member States is exemplary whether this is for a service facility, for training or through collaboration, for example in the Co-ordinated Research Projects. In particular, the SSC is pleased to see that the success of the DMRP in running the International Dosimetry Symposium in November 2002, and in producing the consequent conference publication, was recognized by the Agency's team award.

The recommendations of the SSC for the next programme of the DMRP, copied hereinafter from the main text, are in the order that they appear in the report of the Committee and so not necessarily in priority order. A number of suggestions have also been made by the Committee for the Agency to consider during the formulation of the future programme and these are listed after the recommendations. Recommendations have been made only when the SSC feels that a change in direction or priority is necessary. Consequently, if an aspect of the current programme has not been mentioned it is because the Committee feels that the service is being delivered at the correct level and should be so maintained.

5. Summary of recommendations of the SSC-11

1. As a consequence of the peer review, the SSC-11 recommends that an appropriate staff member of the DMRP be designated as Quality Manager, and that the Quality System documentation be revised to indicate clearly this chain of responsibility. The SSC-11 further recommends that the Agency communicate to the JCRB the status of the assessment of the DOL Quality System and indicate as fast a schedule as feasible to correct the minor deficiencies identified in the laboratory documentation.
2. The SSC-11 strongly recommends that the new teletherapy unit be equipped with the highest activity of ^{60}Co consistent with the design of the facility for radiotherapy-level calibrations, and that the existing older unit is maintained to serve for training of Fellows and for radiation-protection-level calibrations.
3. The SSC-11 recommends that the Iranian AEC be substituted for the Khomeini Hospital SSDL in the IAEA/WHO SSDL Network.

4. Noting the increasing workload on the Agency's calibration service, the SSC-11 recommends that the Agency gives utmost priority to therapy-level calibrations before undertaking diagnostic- and protection-level calibrations, until additional facilities in the new bunker are available. The SSC-11 further recommends that the Agency encourage the use of the SSDL Network to reduce its workload of non-therapy calibrations for hospitals.
5. Noting that an expanded uncertainty ($k = 2$) is required for CMCs in the MRA KCDB, the SSC-11 recommends that the Agency quote $k = 1$ or $k = 2$ in their calibration certificates for SSDLs or end users, respectively, and continue to state clearly the chosen coverage factor in each respective calibration certificate.
6. The SSC-11 recommends that the Agency encourage SSDLs to participate whenever possible in RMO comparisons to support their CMCs.
7. The SSC-11 recommends that the Agency calibrates ^{192}Ir HDR sources following the validation of the interpolation method using a chamber with a nearly-constant response to air kerma over the appropriate photon energy range as a traceable standard.
8. In view of the increasing use of CT techniques worldwide, the SSC-11 recommends that the DMRP introduce its new capability to calibrate CT chambers for the biennium 2006-2007.
9. The SSC-11 recommends that the Agency fosters the formation of EAGs and encourages hospitals to participate in those audits. However, it is recognized that EAGs may be slow or difficult to form and the TLD programme should be prepared to cope with the predicted immediate increases in demand.
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12. Noting that the participants at the international symposium on medical radiation dosimetry recommended that a further symposium be held in 2008, the SSC-11 strongly recommends that the Agency put this into their conference calendar for 2008.
13. Further noting that a preliminary action plan was developed in response to the symposium's 91 recommendations, the SSC-11 recommends that the Agency consider hiring a consultant to produce a final report for circulation to the participants and that the outcomes be reviewed at the 2008 symposium.
14. The SSC-11 recommends that the Agency encourage SSDLs in Member States that are currently using N_x-based protocols to send Fellows to the DMRP for training in the use of the IAEA TRS-398 $N_{D,w}$-based protocol, as soon as the new calibration facilities are operational.
15. The SSC-11 recommends that the Agency's TRS-398 be reviewed to accommodate new data and an errata list, and that the manual on calibration of dosimeters used in radiotherapy, TRS-374, be updated to be consistent with TRS-398.
16. The SSC-11 recommends that an operating budget should be identified to provide the necessary materials and transport for the radioactivity standards programme to cover the needs of the Member States that have expressed interest in the programme.
17. The SSC-11 recommends that the Agency appoint a staff member to be responsible for maintaining the DIRAC and the DMRP web page, noting that this person could also be responsible for maintaining databases in the other Sections of NAHU.
18. Consequently, the SSC-11 recommends that the DMRP support initiatives to seek more flexibility in the policy of recognising authors and editors in Agency publications. It is hoped that some flexibility would enable the immediate publication of the current syllabus on radiation-oncology physics and facilitate the production of a new volume on diagnostic-radiology physics.
19. The SSC-11 recommends that the Agency develop guidelines for independent monitor unit and time calculation protocols for radiation treatment to reduce the risk to patients from incorrect dose delivery.
20. In view of the risk to radiotherapy patients, the SSC-11 recommends that the Agency develop a CRP on audit methodologies for dosimetry of complex treatment techniques, including 3D conformal therapy, stereotactic radiosurgery, and IMRT.
21. In view of the dangers inherent in using complex radiotherapy techniques, the SSC-11 recommends that DMRP collaborate with the radiation oncology section of NAHU to produce guidelines that Member States can use to evaluate their preparedness to intro-

duce more complex radiation therapy techniques in a step-wise fashion.

22. To address the potential loss of radiological skills acquired during external training, the SSC-11 recommends that the Agency develop a CRP, with Member States having the potential for 3D CRT and IMRT, for doctoral programmes offered at the candidates' local universities but in collaboration with clinical training in Member States presently offering these capabilities.

23. The SSC-11 recommends that the DMRP in collaboration with other Sections of the Agency establish guidelines for appropriate nuclear medicine technology for different patient populations within Member States.

24. Despite the small gain in technical work capacity that would be achieved by phasing out the IDAS service, the SSC-11 strongly recommends that the Agency make plans to appoint two new DMRP staff members. This would meet the demands of Member States related to:

    a. the current and predicted additional workload in therapy level calibrations;

    b. the increased training requirements for staff from SSDLs that will be facilitated by the addition of the new bunker;

    c. the new programme for radioactivity traceability; and

    d. the current and predicted increase in TLD measurements to support the IAEA/WHO and the PAHO dosimetry audit programmes.

In addition to the recommendations, the SSC-11 has made a number of suggestions that the Agency might like to consider in the context of the DMRP programme.

25. Noting the success of the regional SSDL in Latvia, the SSC-11 suggests that the Agency might consider encouraging and assisting Member States in the designation of regional SSDLs.

26. Noting that the SSDL Newsletter contains information that is useful and relevant not only to SSDLs but also to the local medical physics community, the SSC suggests that the DMRP review the distribution methods for the SSDL Newsletter to ensure that it is made available to the appropriate end users.

27. Noting that the demand is currently low for protection-level calibrations in the ISO wide-spectrum series, the SSC-11 suggests that the Agency should only consider developing a programme to implement such calibrations once the new facilities are in place, and only if requested by several Member States.

28. In congratulating the DMRP on their very successful performance in the APMP regional comparison of medium-energy x-ray calibrations, a key comparison linked to the CCRI(I), the SSC-11 encourages the Agency to participate in other regional comparisons as appropriate commending the proposed participation in the EUROMET [$H_P(10)$] chamber comparison scheduled for October 2004.

29. The SSC-11 suggests that the Agency use the calorimeter to measure absorbed dose to water in the new ^{60}Co facility expected during the biennium 2006-2007 and subsequently lend the equipment to one of the more advanced SSDLs for them to gain direct experience in calorimetry. It is noted that a Fellow from a Member State and perhaps Agency staff will need appropriate training, perhaps from the ARPANSA to conduct such an exercise.

30. The SSC-11 suggests that the Agency and the WHO collaborate to identify the support needed for institutions identified in the TLD audit response as lacking in dosimetry data, to remediate their radiotherapy dosimetry through improved equipment or staff training.

31. The SSC-11 suggests that the Agency view favourably requests from Member States for translation of TRS-398 into other official Agency languages to encourage the worldwide adoption of this protocol.

32. Noting that the Agency is the only international body that has the access and capability to collect and maintain the data in the DIRAC database, the SSC-11 suggests that the database should be made available on the Internet as soon as possible. The SSC-11 feels that the Agency could promote the use of the DIRAC database to the governments of Member States through the mailing of fliers or other advertising.

33. The SSC-11 suggests that the DMRP develop recommendations for QA procedures for imaging equipment and associated devices used in radiotherapy.

34. The SSC-11 suggests that the Agency hold a consultants meeting to review different methodologies of nuclear medicine dose assessment, including voxel-based methods, as part of its programme to develop and introduce guidelines for Member States.

Report of the CIPM Key Comparison CCRI(II)-K2.Y-90

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1. Introduction

International comparisons of radioactivity measurements are traditionally carried out with radionuclides having long half-lives (e.g. > 14 d) in order to obviate problems associated with transportation and customs clearances. In addition, most of these comparisons are performed with nuclides that emit one or more gamma rays so that they can be measured in the Système International de Référence (SIR) ionization chamber maintained by the Bureau International des Poids et Mesures (BIPM). This methodology provides a link between all the results and enables further links to be established between different comparisons of the same radionuclide. The pure beta emitter ^{90}Y has become increasingly important in the field of radionuclide therapy and as a result, is expected to present demands on National Metrology Institutes (NMIs) for accurate measurement standards for this radionuclide. As part of the need by the NMIs to establish equivalence for the measurement of ^{90}Y in support of their calibration and measurement capabilities (CMC) claims, a comparison between the laboratories and the BIPM was organized by the International Atomic Energy Agency (IAEA) and carried out during the last quarter of 2003.

Logistics played an important role in the success of the comparison because of the short half-life of ^{90}Y (2.7 days) and the wide geographical distribution of the participants. A single master solution containing nominally 80 MBq·g^{-1} of ^{90}Y (as of the shipping date, 22 October 2003) in 1 mol·L^{-1} HCl and approximately 50 ∝g of YCl_3 per gram of solution was prepared by the National Institute of Standards and Technology (NIST) and divided into 5 mL aliquots that were subsequently distributed in the form of a flame-sealed NIST-style ampoule. As each laboratory performed measurements on aliquots of the same solution, the results could be easily compared.

2. Participating Institutions

A total of 7 NMIs and the BIPM took part in the exercise. Details for each of the laboratories are given in Table 1.

Table 1. List of participants in comparison CCRI(II)-K2.Y-90

Acronym	***Full Institute Name***	***Country***	***Regional metrology organization***
NMIJ	*National Metrology Institute of Japan*	*Japan*	*APMP*
NPL	*National Physical Laboratory*	*United Kingdom*	*EUROMET*
BIPM	*Bureau International des Poids et Mesures*	–	–
CSIR-NML	*Council for Scientific and Industrial Research-National Metrology Laboratory*	*South Africa*	*SADCMET*
BNM-LNHB	*Bureau National de Métrologie - Laboratoire National Henri Becquerel*	*France*	*EUROMET*
PTB	*Physikalisch- Technische Bundesanstalt*	*Germany*	*EUROMET*
CIEMAT	*Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas*	*Spain*	*EUROMET*
NIST	*National Institute of Standards and Technology*	*United States of America*	*SIM*

3. NMI standardization methods

All the laboratories assayed their aliquot of the ^{90}Y solution using some form of liquid scintillation (LS) spectrometry. The NMIJ, CIEMAT, NIST, NPL, BIPM, and the PTB used the CIEMAT/NIST ^{3}H-standard efficiency tracing method [1, 2], while the CSIR-NML and the BNM-LNHB used different applications of the triple-to-

double coincidence ratio (TDCR) method [3, 4]. In addition, the NPL reported a value based on 4πβ proportional counting. An additional result was submitted by the CSIR-NML based on LS counting with efficiency tracing (ET) using ^{60}Co as the efficiency tracer. In this case, however, the laboratory indicated that only the TDCR result was to be used for the calculation of an average value for the comparison.

The half-life used in the comparison was 64.057 h; u = 0.016 h [or 2.6690 (7) d] and is the result of a recent re-evaluation of the ^{90}Y half-life [5] that included new data from the PTB. All of the participants used this value with the exception of the PTB, which used its own recently determined value of 2.6689 d; u = 0.0009 d [6].

4. Results

4.1 Mean activity and proposed key comparison reference value (KCRV)

The activity concentration values (in units of kBq·g^{-1}) at the reference date of 0 h UTC 1 November 2003 reported by each laboratory for the purposes of establishing equivalence are presented, along with their respective standard (k = 1) uncertainties, in Table 2 and Figure 1. The value presented as the final result from the NPL is the weighted average of the reported activities obtained from both the LS counting and 4πβ proportional counting methods since no preference was indicated. The value listed for the CSIR-NML is the one based on TDCR measurements.

Table 2. Activity concentration, C_A*, of the* ^{90}*Y solution at the reference date of 0 h UTC 1 November 2003 as reported by each laboratory. The uncertainties,* u*, are the combined standard (*k = 1*) uncertainties as reported by each participant.*

Laboratory	C_A / *kBq·g*$^{-1}$	u / *kBq·g*$^{-1}$
NMIJ/AIST	8658	36
NPL (LSC)	8665	20
NPL (4πβ PC)	8690	30
NPL (weighted average)	8673	17
BIPM	8674	37
CSIR-NML (TDCR)[1]	8675	28
CSIR-NML (ET)	8744	40
BNM-LNHB	8670	12
PTB	8656	14
CIEMAT	8641	24
NIST	8667	27

[1] CSIR-NML has indicated that the TDCR result is to be used for purposes of establishing equivalence.

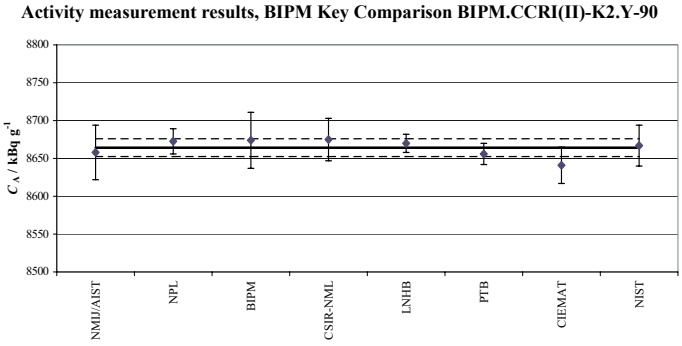

Figure 1. Plot of results from the participants of Key Comparison BIPM.RI(II)-K2.Y-90. The uncertainty bars represent the standard uncertainties on the measured activity concentration, C_A*, as reported by each laboratory. The solid line represents the mean value of the comparison results and the dashed lines correspond to one standard uncertainty interval on the comparison mean.*

A visual inspection of the data would suggest that the CIEMAT value, being appreciably lower than those from the other laboratories, could be an outlier. Applying Grubbs' test [7] to this datum, a test statistic of 1.97 is calculated and compared to a critical value of 2.20 (for n = 8 points and significance level α = 0.05). As the critical value is not exceeded, the CIEMAT value cannot be considered to be an outlier using this test.

The arithmetic mean of the reported values from the participants is 8664 kBq·g^{-1}; u = 4 kBq·g^{-1}, where the uncertainty is the standard deviation of the mean of the final results from the 8 laboratories. The Key Comparison Working Group of the CCRI(II) has proposed that the mean activity value be adopted as the Key Comparison Reference Value (KCRV), x_R.

4.2 Impurity Analyses

The analysis of possible radionuclidic impurities was not performed uniformly. Several laboratories analysed only for gamma-emitting radionuclides despite the fact that the most common impurity associated with ^{90}Y is the pure beta-emitter ^{90}Sr. Those that analysed for beta-emitting impurities (assuming ^{90}Sr) are listed in Table 3, along with their results and methods of analysis. From these data, it appears that the impurity ratios are spread over a range having a factor of 100 between the smallest and largest values. There are insufficient data to draw definite conclusions but there is at least a suggestion that the determination of the ^{90}Sr/^{90}Y ratio is somewhat method-dependent. This warrants further investigation. The uncertainty of the ratio, and indeed the level of ^{90}Sr impurity in the sample, is unlikely to influence the LS counting results as long as the ^{90}Y solution has not decayed significantly. In this regard, there does not appear to be any dependence of the results on the mean measurement date.

Table 3. Relative activity of identified impurities in analysed ^{90}Y solution.

Laboratory	*Impurities identified*	*Activities of impurities relative to ^{90}Y at reference time*	*Relative standard uncertainty (%)*	*Method of analysis*
NPL	^{90}Sr	$5 \cdot 10^{-7}$	*1.8*	*Chem. separation*
PTB	^{90}Sr	$< 4 \cdot 10^{-6}$	*Not reported*	*N/A*
CIEMAT	^{90}Sr	$5 \cdot 10^{-5}$	*60*	*Fit*
NIST	^{90}Sr	$4.8 \cdot 10^{-6}$	*10*	*Decay*

4.3 Degrees of equivalence

The degree of equivalence of a given measurement standard is the degree to which this standard is consistent with the key comparison reference value [8]. The degree of equivalence is expressed quantitatively in terms of the deviation from the key comparison reference value and the expanded uncertainty of this deviation ($k = 2$). The degree of equivalence between any pair of national measurement standards is expressed in terms of their difference and the expanded uncertainty of this difference and is independent of the choice of key comparison reference value.

The degree of equivalence of a particular NMI, *i*, with the key comparison reference value is expressed as the difference between the results

$$D_i = x_i - x_R \qquad (1),$$

where x_i is the specific activity value as submitted by the laboratory, and x_R is the key comparison reference value. The uncertainty on the degree of equivalence for a particular laboratory, U_i, is given by

$$U_i = 2\sqrt{(1-\frac{2}{n})\cdot u_i^2 + \frac{\sum u_j^2}{n^2}} \qquad (2),$$

where u_j are the uncertainties reported by the n participating laboratories and u_i is the combined standard uncertainty as reported by laboratory i [9].

The degrees of equivalence for participants in this comparison are presented graphically in Figure 2 and numerically in Table 4.

Table 4. Degrees of equivalence for all comparison participants.

NMI	**D_i / *kBq·g^{-1}***	**U_i / *kBq·g^{-1}***
BIPM	10	67
BNM-LNHB	6	28
CIEMAT	-23	45
CSIR-NML	11	52
NIST	3	50
NMIJ	-6	65
NPL	8	34
PTB	-8	30

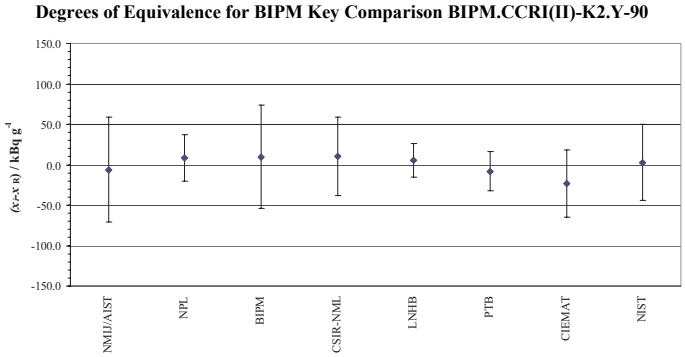

Figure 2. Plot of degrees of equivalence for participants in the CIPM key comparison CCRI(II)-K2.Y-90. The values x_i and x_R are the laboratory reported result and the KCRV of 8664 (4) kBq·g^{-1}, respectively.

5. Conclusion

An international comparison of a single solution of ^{90}Y has been carried out successfully with 7 participating NMIs and the BIPM. The average value for the activity concentration of the solution was 8664 kBq·g^{-1}; u = 4 kBq·g^{-1} at a reference time of 0 h UTC on 1 November 2003. Degrees of equivalence for the results have been calculated with the key comparison reference value equal to the comparison mean. Assays of the $^{90}Sr/^{90}Y$ impurity ratio gave values ranging from $5 \cdot 10^{-7}$ to $5 \cdot 10^{-5}$ at the reference time and there is evidence that its evaluation could be method-dependent.

6. Acknowledgements

The authors would like to thank the NIST for providing the solution for this comparison and the NMIs for their participation.

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COURSES, MEETINGS AND CONSULTANCIES TO BE HELD DURING 2005

Courses and workshops

Regional Training Course on Quality Assurance of Physical and Technical Aspects in Radiotherapy, Argonne National Laboratory, Illinois (USA), 6-17 June 2005

Regional Training Course on Monitor Unit Calculations, Tunis, Tunisia, September 2005

Regional (RAF) Training Course on physical aspects of SPECT imaging, Cairo, Egypt, June 2005 (date and location to be confirmed during first Coordination Meeting)

Regional Training and Educational Workshop on Physical Aspects of Quality Assurance in Radiotherapy, Asia and Pacific Region (place not yet known), August 2005

Meetings and consultancies

Workshop on Training of Audit Teams for Comprehensive Audit in Radiotherapy, Vienna, 9-11 May 2005

Research Coordination Meeting on the CRP E.2.40.14 "Development of procedures for in vivo dosimetry", IAEA, Vienna, 4-8 April 2005

Consultant’s meeting on QA of dosimetry calculation in external radiotherapy, Vienna, March 2005

First Coordination Meeting for AFRA Regional Project RAF/6/032: Promoting Regional and National Quality Assurance Programmes for Medical Physics in Nuclear Medicine, Cape Town, South Africa, January 2005

First Coordination Meeting for AFRA Regional Project RAF/6/031: Medical Physics in Support of Cancer Management, Cape Town, South Africa, 21-25 November 2005

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** **Provisional Network members**

* SSDL Organization

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

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