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NETWORK OF
SECONDARY
STANDARD
DOSIMETRY
LABORATORIES

SSDL NEWSLETTER

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CONTENTS

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EDITORIAL NOTE

The Agency has decided to standardize the format of all its Newsletters and we have taken this opportunity to change the layout of the cover page. The new A4 format was changed at the time of publishing the issue No. 38, in July 1998. Two months later, issue No. 39 was also published with the date of July 1998. Readers have probably noticed this unfortunate mistake. In fact, many readers have expressed their confusion regarding the time delay between the date on the cover page of the Newsletter and the date of its effective publication by the Agency. This time delay has now been resolved and hopefully all future issues will be published on time, one in January and the other in July of each year.

The Code of Practice IAEA TRS-381 complements and extends the IAEA TRS-277. It describes procedures that may be used to calibrate plane-parallel chambers against air kerma or absorbed dose to water standards at ^{60}Co gamma ray energy, in order to obtain the absorbed-dose-to-air chamber factor ($N_{D,air}$) or the absorbed dose to water chamber factor ($N_{D,w}$). This Code of Practice also updates some of the data and concepts presented in TRS-277. Soon after the publication of this report, the Agency has launched a Co-ordinated Research Project (CRP) to ascertain that the Code of Practice meets the highest scientific standards and yields the most accurate results available today. Furthermore, the CRP should offer an opportunity to quantify the differences with the existing recommendations and analyze the possible impact in patient dosimetry. The first Research Co-ordination Meeting (RCM) of this CRP was held in Vienna, 2-5 December 1996 and its report published in this Newsletter (No. 36, January 1997). The report of the Second RCM, held in Barcelona 30 March-3 April 1998 is published in this issue.

The second article is the report of the 8th SSDL Scientific Committee meeting held during 5-9 October 1998. The editor wishes to draw the readers' attention to the recommendations of the Scientific Committee. The recommendation “h” to ensure that all SSDLs of the Network comply with the requirements of the SSDL Network Charter will be implemented. In particular, SSDLs that have not yet participated in the Agency audit programmes (TLD or ionization chamber) are highly advised to do so during this year. The SSDL Scientific Committee also recommends to evaluate the potential use of the calibration services in diagnostic radiology and brachytherapy. For that purpose, the Secretariat of the IAEA/WHO network has prepared a survey form to be sent to all SSDLs of the network. It is hoped that the network members will fill the questionnaire and return it to the Secretariat as soon as possible.

All SSDLs, members of the network, are reminded that the Agency’s Dosimetry Laboratory provides cost-free calibration services of reference standards for radiotherapy (external and brachytherapy) and radiation protection (including environmental) dose levels. Interested SSDLs are invited to send a request to the Secretariat for scheduling.

We have observed that the long-term stability of some PTW chambers (type 30001 and 31003) calibrated at the Dosimetry Laboratory has varied up to 1.4%. Comparable results obtained at other SSDLs have been reported to us. PTW was requested to investigate and correct this anomalous behaviour. In November 1998, a Technical Note[1] D165.200.0/1 on the “Long-term stability of PTW-Ionization Chambers” was prepared by PTW, where the lack of constancy was attributed to an ageing effect of the chamber materials used during the years 1993-1997. PTW is now using pre-aged parts and chambers delivered in 1998 or later should no longer show that behaviour. It is strongly recommended to check the stability of the response of all chambers of these types against an ion chamber of well known stability and re calibrate them as often as possible till stability is reached. Readers are encouraged to report the results of their checks on theses types of chambers to the Secretariat of the network.

The title of the Department of Research and Isotopes (RI) has been changed to “Department of Nuclear Sciences and Applications” (NA), effective 8 December 1998. Consequently, the abbreviation of the Division of Human Health changes from RIHU to NAHU and that of the Agency Laboratories from RIAL to NAAL.

Finally, the Secretariat of the IAEA/WHO network wishes a happy new year to all its members and readers of this Newsletter.

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[1] Copies of this note are available on request from the Secretariat of the Network.

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DOSE DETERMINATION WITH PLANE-PARALLEL IONIZATION CHAMBERS IN THERAPEUTIC ELECTRON AND PHOTON BEAMS

Report of the 2nd Research Co-ordinated Meeting (326-E2-RC-641.2), March 30-April 3, 1998 Barcelona, Spain

Scientific Secretary: P. Andreo
Dosimetry and Medical Radiation Physics Section,
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SCIENTIFIC BACKGROUND

In 1987, the IAEA published a report entitled "Absorbed Dose Determination in Photon and Electron Beams: An International Code of Practice" (IAEA Technical Reports Series No. 277) to advise users how to obtain the absorbed dose in water from the measurements made with an ionization chamber, calibrated in terms of air kerma. For high-energy photons (energies above 1 MeV) the chamber calibration was at a single photon quality (Cobalt-60 gamma rays). The Code of Practice described procedures and provided data to use such ionization chambers to obtain absorbed dose for higher energy photons and also for electron beams. It was so designed that a variety of cylindrical chambers could be used, which represented the existing conditions world-wide. However, most national and international dosimetry protocols recognized the advantages of plane-parallel ionization chambers, explicitly for electron beams and especially low-energy electron beams (below 10 MeV). Although this was acknowledged in TRS-277, the calibration and use of these chambers were not fully developed.

Since the publication of TRS-277 in 1987, various recommendations for the specific procedures for the use of plane-parallel ionization chambers have been published. Additional knowledge about the use of cylindrical chambers has also appeared. Accordingly, the IAEA formed an international working group that prepared a new Code of Practice for the calibration and use of plane-parallel ionization chambers. The new Code of Practice was published in 1997 as IAEA TRS-381, which complements and extends IAEA TRS-277. It describes options on how to calibrate plane-parallel chambers against air-kerma or absorbed dose to water standards at Cobalt-60 gamma ray energies, in order to obtain $N_{D,air}$, the absorbed-dose-to-air chamber factor, or $N_{D,w}$, the chamber absorbed dose calibration factor, respectively. The procedure for the use of these chambers to calibrate therapeutic electron beams, as well as relative dose measurements for photon and electron beams, is presented. It also updates some of the data and concepts in TRS-277.

SCIENTIFIC SCOPE

The scientific scope of the Co-ordinated Research Project is to investigate the accuracy of the new data and procedures included in the Code of Practice IAEA TRS-381. Differences with existing recommendations, published by national organizations, are to be evaluated to analyze the possible impact on patient dosimetry. The second Research Co-ordination Meeting (RCM) was organized to revise the activities in the Co-ordinated Research Project (CRP) and the status of the various projects .

The status of the on-going work under the frame of the CRP was presented by the participants in the RCM during the first two days and each contribution discussed in detail. During the following days, plans were made on the work left for each participant to complete the project and the feasibility of preparing a report describing in detail the work done in the project.

Results of the project are scheduled for presentation in the ESTRO-Physics conference in Göttingen, Germany in 1999.

MAIN POINTS DISCUSSED

The main points discussed during the meeting were:

- review of work done since the last RCM in December 1996 (Vienna),

- comparisons with dosimetry protocols recently issued by different national organizations (AAPM TG-39, USA; IPEMB, UK; DIN, Germany) using different types of plane-parallel ionization chambers and phantom materials,

- investigation on the performance of various commercial plane-parallel ionization chambers from the point of view of saturation, polarity effect, and effective point of measurement,

- comparison of the three methods recommended in TRS-381 for the calibration of plane-parallel ionization chambers in terms of $N_{D,air}$ using electron and Co-60 radiation beams in different phantom materials,

- investigation of the data for converting electron fluence from plastic to water, compiling data measured by all participants for PMMA,

- investigation of the accuracy of the data and procedures included in the Code of Practice, comparing absorbed dose to water determined under reference conditions with that obtained from absolute methods (Fricke),

- investigation of the fluence perturbation correction factors for cylindrical ionization chambers in electron beams, as these are used as reference detectors for the calibration of plane-parallel ionization chambers.

RESULTS OF THE PROJECT

As a result of the presentations and subsequent discussions, the following points are considered to have the maximum relevance for the project.

FRICKE DOSIMETRY

The use of Fricke dosimetry had been discussed as the only possible way to resolve the large discrepancy between IAEA TRS-381 and AAPM TG-39 when measurements are performed in plastic phantoms. In water the differences are approximately within 1%. For PMMA the discrepancy is worse at an energy of approximately 10-12 MeV, and has therefore a possible large impact in clinical dosimetry.

A first set of Fricke data has become available from one of the participants (AVdP, Belgium), where all measurements had been made in plastic, which are shown in figure 1.

It is still necessary:

a) to perform Fricke measurements where the quantity D_w is measured directly in a water phantom, and

b) to compare it with D_w obtained from ionization chamber measurements in plastic according to TRS-381 (i.e. with scaling of depths and fluence conversion).

It is agreed that participants performing Fricke dosimetry should use a Co-60 beam as reference for both Fricke and for a cylindrical ionization chamber, with all measurements performed in water. Measurements with the same Fricke solution should then be compared with a plane-parallel chamber and a cylindrical ion chamber in a high energy electron beam. Then, measurements at low energy electrons can be performed.

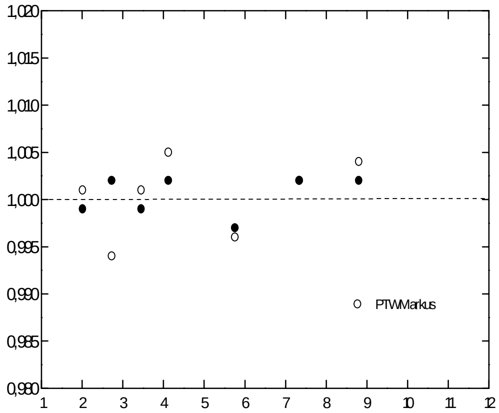


Fig. 1. A comparison of the IAEA TRS-381 Code of Practice for plane-parallel ionization chambers using two different ion chambers with a dose determination using Fricke dosimetry. All measurements made in PMMA

SCALING PLASTIC MEASUREMENTS TO WATER

Several participants have measured carefully the factor h_m to convert electron fluence from PMMA to water, as a function of the mean electron energy at depth. A compilation of the data obtained using different ionization chambers, mainly of the plane-parallel type, is presented in figures 2 (a-c). It can be observed that the agreement with the data presented in TRS-381 Table XVIII, adopted from reference [6] in the Code of Practice, is by no means clear. The following issues can be raised:

The very large scatter of data at low electron energies, which has not been shown before in related publications, clearly indicates the great difficulty to perform this type of measurements in a clinical environment (as in all previous publications in the topic).

A dependence on the type of plane-parallel ionization chamber used, or even on chamber to chamber variations, seems to be possible although it has been ignored so far.

The importance of this topic is so large that it is felt it still deserves further investigation. For this purpose common measurement conditions are agreed: use constant SCD if possible, 15x15 cm field size, no electron cones, external monitor placed in the lowest position in the treatment head, avoid use of scaling rules and do measurements at z_{max} in each medium, perform water/PMMA/water or PMMA/water/PMMA triple measurements at each energy during the same session, use $f_{P,T}$ for water and plastic, perform a minimum of three independent measurements for each data point. All participants will perform a new set of measurements before July 1998. The difficulties in performing this type of measurements is interpreted as a demonstration of how any measurement in plastic will have an increased uncertainty solely due to this conversion factor.

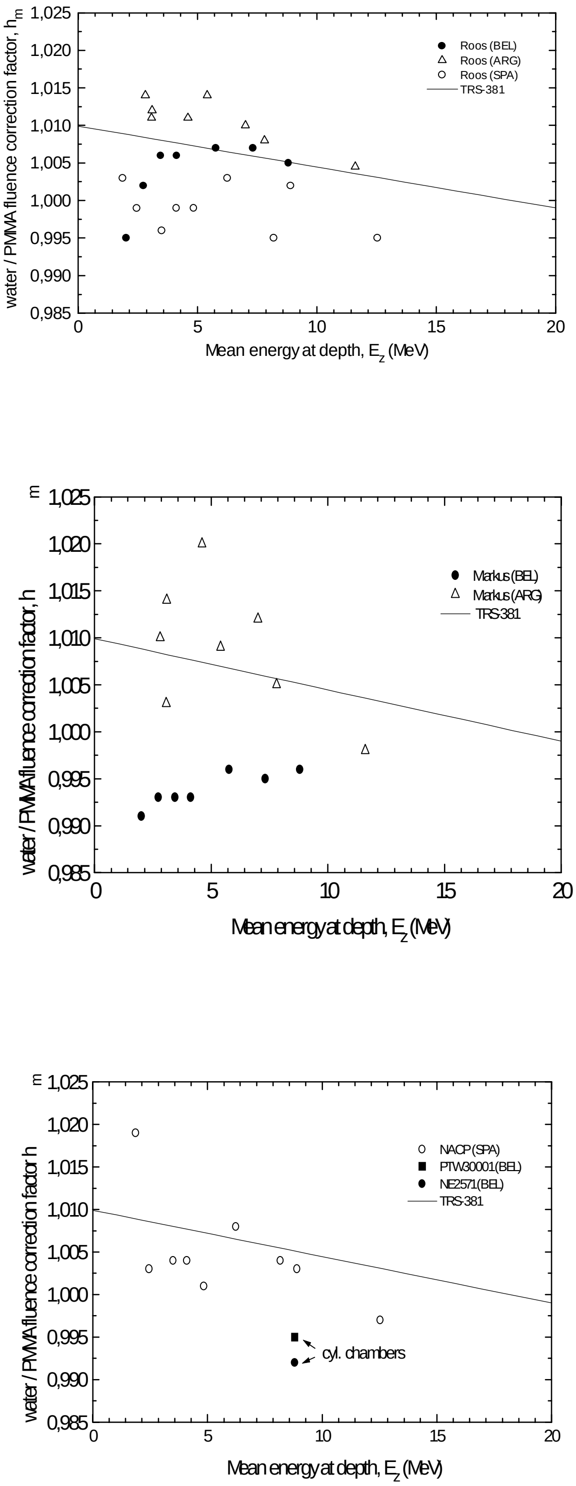


Fig 2 (a-c). A compilation of the data measured for the factor h_m to convert electron fluence from PMMA to water, as a function of the mean electron energy at depth using different ionization chambers, mainly of the plane-parallel type

DETERMINATION OF THE $N_{D,AIR}$ FACTOR USING THE METHODS RECOMMENDED IN TRS-381

With regard to the determination of the $N_{D,air}$ factor of plane-parallel ionization chambers, excellent agreement was obtained for all ionization chambers when measurements are performed in electron beams, even of different energies and properties (different clinical accelerators). However, when measurements are made in a Co-60 beam, the $N_{D,air}$ factor for some of the plane-parallel chambers has been different from that obtained in electron beams. This cannot be excluded in the case of the PTW Roos ionization chamber, see Table I.

Table I. Overall comparison of the $N_{D,air}$ factor of plane-parallel ionization chambers in electron and ^{60}Co beams in water and PMMA

Ion chamber:	NACP	PTW-Markus	PTW-Roos
BEL (Fricke measurements confirm electron results)		all data agree within 0.5%	^{60}Co data in water differ by up to 1.7% (NCS-protocol used for D_w; requires recalculation)
ARG		all data agree within 0.3%	^{60}Co data in water differ by up to 2% (two different cyl ref chambers confirm data)
SPA	all data agree within 0.1%	all data agree within 0.5%	^{60}Co data in PMMA differ by up to 2.8%

The discrepancies in $N_{D,air}$ factors were discussed in depth although no clear conclusion could be reached. The need for additional measurements, especially with the PTW-Roos ionization chamber, was emphasized and most participants will increase the number of data available to allow a more comprehensive analysis.

EFFECTIVE POINT OF MEASUREMENT

It has been confirmed by measurements performed by two participants that the effective point of measurement of the PTW-Markus plane-parallel ionization chamber is not in the front of the air cavity but approximately 0.5 mm below.

FLUENCE PERTURBATION CORRECTION FACTORS FOR CYLINDRICAL ION CHAMBERS

The correction factors p_{cav} in TRS-277 and TRS-381, which have been taken from Johansson et al (1978), have been confirmed within better than 0.5% using the same set of ionization chambers and phantom material (PMMA) as used in the original work. A new set of chambers has been built, with graphite walls instead of PMMA walls with dag (a thin lining of graphite and epoxy resin). The air cavity diameters of the two set of chambers are similar (new diameters equal to 2, 4, 7, and 8 mm versus 3, 5, and 7 mm respectively). Measurements have now been carried out in water. Preliminary results show that for a mean energy at depth of about 6 MeV and the largest chamber, 7 mm diameter and therefore similar to a Farmer-type, a difference in p_{cav} close to 1% has been found between the two types of chambers. This points at the need for further investigations related to wall/phantom and other possible interface effects (sleeve, air) of cylindrical ion chambers in electron beams.

Status reports from the participants are given in the following pages. Extended abstracts of the presentations are available from the Scientific Secretary.

STATUS REPORT FROM ARGENTINA: IMPLEMENTATION OF THE NEW IAEA CODE OF PRACTICE FOR DOSE DETERMINATION WITH PLANE-PARALLEL IONIZATION CHAMBERS IN THERAPEUTIC ELECTRON AND PHOTON BEAMS

CALIBRATION OF A PLANE-PARALLEL IONIZATION CHAMBER PTW 34001(ROOS) VS A CYLINDRICAL CHAMBER.

Brunetto M.(FaMAF (UNC) - Centro Médico Dean Funes), Germanier A. (CEPROCOR, Vélez G.(FaMAF (UNC) - Hospital San Roque).

The $N_{D,air}^{pp}$ calibration factor for the Roos chamber was determined following the methods recommended by the TRS-381 protocol: *^{60}Co in water* and *electron-beam methods.*

^{60}*Co* in water

The $N_{D,air}^{pp}$ calibration factor was determined in ^{60}Co beam, using two different cylindrical chambers as reference: *NE-2571* and *Capintec PR06G*.

The effective points of measurement of the (cylindrical) reference chamber and the plane-parallel chamber were placed at the same depth: this point is 0.6r in front of the geometrical centre for the cylindrical chamber and at the center of the front surface of the air cavity for the pp-chamber. The effect of the PMMA waterproofing sleeve for the pp-chamber was corrected according to the ratio of the electron densities between water and PMMA.

The difference between the values of $N_{D,air}^{pp}$ obtained was about 0.4% independent of the reference chamber employed.

Electron- beam method

Measurements were performed in a water phantom. Two independent determinations of $N_{D,air}^{pp}$ factor for the Roos chamber were done (November,1997 and February, 1998) at the highest electron energy of the linear accelerator (Varian Clinac 18). In both cases the reference conditions were the same, and they are shown in the next Table.

Electron Beam	
Nominal Energy (MeV)	18
Eo (MeV)	17.5
SSD(cm)	100
Field Size (cmxcm)	15x15
Depth (cm)	2.5

A Farmer-type ionisation chamber NE-2571 was used as an external reference monitor detector and was positioned within the phantom close to the chambers.

The difference between the values of $N_{D,air}^{pp}$ obtained was 1%.

The difference between the $N_{D,air}^{pp}$ values obtained using the Co-60 and the electron beam methods was 2%, indicating the need for more measurements and investigations for the Roos chamber.

COMPARISON OF ABSORBED DOSE VALUES OBTAINED WITH DIFFERENT IONIZATION CHAMBERS: *PTW 34001(ROOS), PTW 23343 (MARKUS)* AND *NE 2571.*

Determinations of the absorbed dose to water in electron beams were performed using three ionization chambers: a cylindrical *NE-2571*, with a calibration factor N_K given by a SSDL, and two plane-parallel chambers *PTW 34001 (Roos)* and *PTW 23343 (Markus).* Both pp-chambers were calibrated against the cylindrical chamber following the procedures and correction factors of the TRS-381 Code of Practice.

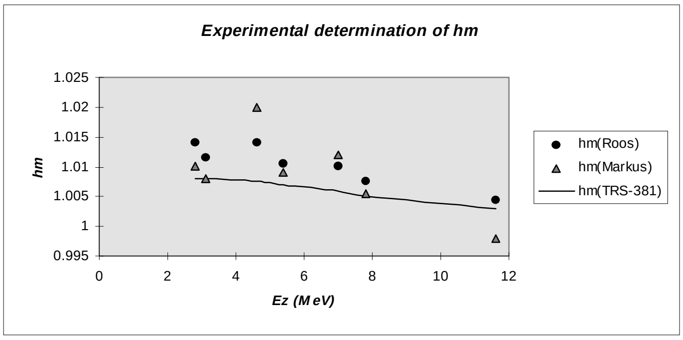
The absorbed dose values were determined in the electron beam of a *Varian Clinac 18* accelerator, at SSD=100cm, and field size =15cmx15cm. The measurements were performed in water, at z=*12.5 mm* for the 6 MeV (nominal energy) electron beam, and z=*24.5 mm* for the 9, 12, 15 and 18 MeV (nominal energies) electron beams. These depths correspond to the position of maximum dose.

The results showed good agreement (within 1%) in the values of the absorbed dose obtained using the different chambers at high energies. The biggest differences were found at low energies (for example, 2.8% between Markus chamber and Roos chamber at 9MeV). The values obtained using the NE-2571 ionization chamber at low energies were included only as a comparison, since its use is not recommended at low energies.

EXPERIMENTAL DETERMINATION OF H_M IN PMMA

The values of h_m were obtained as the ratio of the average readings at the reference depth in a water phantom ($z_{ref,w}$) to the average readings at the equivalent reference depth in a PMMA phantom ($z_{ref,PMMA}$), using two pp-chambers *PTW 34001-Roos* and *PTW 23343-Markus.* An external monitor detector was positioned in air to normalize the readings both in water and PMMA.

The results are presented in the table below. The measured values of h_m are in good agreement with the values given in TRS-381(better than 0.6%, which is within the experimental uncertainty), except one value for the Markus chamber at 4.6 MeV, probably due to an error in the experimental set-up.



E_{nom}	E_z	h_m	h_m	%dif	h_m	% dif
		TRS-381	PTW-Markus		PTW-Roos	
6	2.81	1.008	1.010	0.2	1.014	0.6
6	3.07	1.008	1.003	-0.5	1.011	0.3
9	3.09	1.008	1.014	0.6	1.012	0.4
12	4.60	1.008	1.020	1.2	1.014	0.6
12	5.39	1.007	1.009	0.2	1.011	0.4
15	7.00	1.006	1.012	0.4	1.010	0.4
15	7.79	1.005	1.006	0.1	1.008	0.3
18	11.62	1.003	0.998	-0.5	1.004	0.1

STATUS REPORT FROM BELGIUM: ANALYSIS OF THE TRS-381 CODE OF PRACTICE - VERIFICATION OF THE ABSORBED DOSE VALUES DETERMINED WITH PLANE-PARALLEL IONISATION CHAMBERS IN THERAPEUTIC ELECTRON BEAMS USING FERROUS SULPHATE DOSIMETRY

Ann Van der Plaetsen, A.Z Sint Lucas Hospital, Ghent; H. Palmans, H, Thierens, Standard Dosimetry Laboratory, University Ghent

RELATIVE DOSE MEASUREMENTS

Relative dose parameters were determined in a water phantom using a PTW/Roos plane-parallel ionisation chamber. Values obtained for R_{100}, R_{50} and R_p are in agreement within the statistical uncertainty with the results obtained previously with a PTW/Markus chamber or with diodes or a diamond detector.

Comparison of the values for R_{100} and R_{50} determined with the Markus chamber with those determined with the Roos chamber revealed a shift of the effective point of measurement for the Markus chamber of 0.5 mm from the front of the chamber towards its centre.

EXPERIMENTAL DETERMINATION OF THE FLUENCE CORRECTION FACTOR H_M

When the absorbed dose is determined in a PMMA phantom instead of a water phantom, the

h_m factor corrects for the difference in the fluence. The first set of measurements resulted in values different from those proposed in the TRS-381 protocol. We continued this study for a PMMA phantom using the PTW/Markus and the PTW/Roos chambers.

The h_m factors obtained with the Roos chamber are in agreement with those from the TRS-381 protocol except at low energies. All h_m correction factors obtained with the Markus chamber are lower than those proposed by the protocol, up to 1.8% for the lowest energy. The results are presented in the next table. The uncertainties on the different measurements are given at the level of 1 SD (i.e., k=1). More measurements need to be performed, especially with another Markus chamber to see if the h_m factor is chamber dependent.

E_{nom}	E_z	h_m TRS-381	h_m PTW-Markus	SD	%dif	h_m PTW-Roos	SD	%dif
4	2.01	1.009	0.991	0.003	1.8	0.995	0.003	-1.4
6	2.73	1.008	0.993	0.0003	1.5	1.002	0.002	-0.7
8	3.45	1.008	0.993	0.001	1.5	1.006	0.002	-0.2
10	4.12	1.008	0.993	0.001	1.5	1.006	0.002	-0.2
12	5.76	1.007	0.996	0.0003	1.2	1.007	0.001	0
15	7.34	1.006	0.995	0.0004	1.1	1.007	0.002	0.09
18	8.8	1.004	0.996	0.0004	0.8	1.005	0.003	0.08

DETERMINATION OF THE $N_{D,AIR}$ CALIBRATION FACTORS FOR THE PTW/ROOS AND THE PTW/MARKUS PLANE PARALLEL CHAMBERS.

We compared the $N_{D,air}$ calibration factors obtained following the different methods described in the TRS-381 protocol. The results are summarised in the next table. The stated uncertainties are for k=1, representing the statistical uncertainties for different measurements.

The measurement conditions for $N_{D,air}$ determined in a water phantom for ^{60}Co (Standard Dosimetry Laboratory) were as follows:

- reference depth: centre of the cylindrical reference chamber at 5 cm, centre of the front of the plane-parallel chamber at 5 cm,
- SSD = 70cm,
- determination relative to absorbed dose to water secondary standard

The measurement conditions for $N_{D,air}$ determined in an electron beam against a cylindrical chamber were as follows:

- reference depth : depth of maximum dose (3 cm),
- SSD = 100 cm
- cylindrical chambers: PTW 30001, NE-2571

measurements performed in water and in PMMA.

	Markus	Roos
$N_{D,air}$ derived fom N_K	0.480 (0.002)	0.071 (0.003)
$N_{D,air}$ determined in an electron beam against a cylindrical chamber	0.476 (0.003)	0.0707 (0.003)
$N_{D,air}$ determined in a water phantom in ^{60}Co	0.478 (0.003)	0.0719 (0.0002)
$N_{D,air}$ derived from the Fricke measurement in the 18 MeV electron beam	0.471 (0.003)	0.0705 (0.0003)

The $N_{D,air}$ derived fom N_K compared to the calibration factor determined in the electron beam is in agreement within 1%.

The deviation between the $N_{D,air}$ determined in the electron beam and the $N_{D,air}$ determined in a water phantom in a Co-60 beam points that the value for p_{wall} of the plane-parallel chamber needs to be reconsidered.

COMPARISON OF THE IONOMETRICALLY DETERMINED ABSORBED DOSE FOLLOWING THE TRS-381PROTOCOL WITH THE DOSE VALUES OBTAINED WITH THE FRICKE DOSIMETER

These measurements were performed in a PMMA phantom. The field size and the SSD were 10cmx10cm and 100 cm, respectively.

Following the TRS-381 protocol rigorously, we obtained an agreement within 1 % between the Fricke dose value and those determined with the PTW/Roos and the PTW/Markus chambers. Using the experimentally determined value of the h_m correction factor for PMMA introduced a deviation of more than 2 %. We can therefore conclude that these measurements should be performed in water to exclude the effect of PMMA.

STATUS REPORT FROM GERMANY: INVESTIGATION OF THE ACCURACY OF PROCEDURES AND DATA IN IAEA TRS-381

Dr. Martin Roos (PTB)

The accuracy which is achievable with the new procedures and data of TRS-381 depends strongly on the performance characteristics of the plane-parallel ionization chambers available. The present investigations include the dependence of the response on the polarity (polarity effect) and on the absolute value of the polarizing voltage (correlated with the saturation correction) of commercial plane-parallel chambers.

The polarity effect of various chambers has been checked, including its dependence on the depth and the field size. It has been shown that, in general, it is not sufficient to relate the polarity effect exclusively to the mean energy at the depth of measurement. If the polarity effect is not negligible, it must be determined for all sets of irradiation parameters. In this case it is particularly important that the stabilization times after reversing the polarity are short. It has been shown that these times extend from a few minutes up to about half an hour for dose rates of a few Gy/min, which are usual for clinical accelerators.

Due to the long stabilization times for most of the plane-parallel chambers after a change in the absolute value of the polarizing voltage, the experimental procedures for the determination of the saturation correction are also very time consuming. It has been demonstrated that, depending on the stabilization time and on the inherent drifts of the accelerator/monitor/ dosimeter under test system, the uncertainty of the correction may be comparable with its magnitude. In this case the analytical expression by Boag for conventional beams (ICRU Report 34 (1982)), included in TRS-381, allows a convenient evaluation of the saturation correction factor. This expression, which so far had been the only one available, takes only volume recombination into account, which is the main source of recombination.

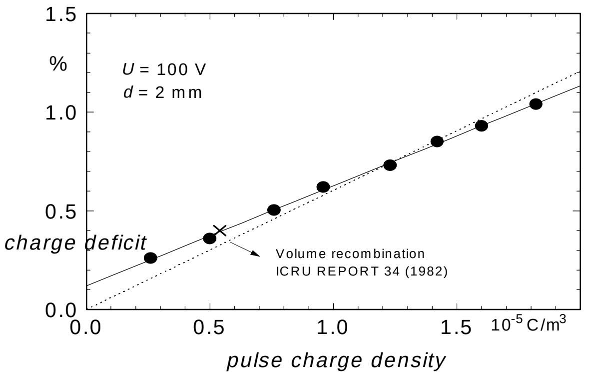
The saturation behaviour of plane-parallel chambers has now been investigated in detail and a formula based on the experimental data has been deduced which takes account of the initial recombination and the diffusion loss. The correction factor can be determined from the electrode spacing d, the polarizing voltage U, and the dose per pulse D_i, for chambers with an electrode spacing of about 2mm (applicable to most of the commercially available chambers) according to:

$$k_s = 1 + (0.12 + 0.46 \cdot d^2 \cdot D_i) / U$$

Figure below shows experimental results of the charge deficit as a function of the pulse charge density for an electrode spacing of 2mm and a polarizing voltage of 100V. The solid line and the dotted line represent the new formula and the Boag expression, respectively. The difference between the Boag expression and the new formula is mainly caused by the initial recombination and by the more accurate estimation of the free electron component in the new expression. Since, in practice, the saturation correction for conventional beams is usually below 1%, the deviations of the Boag formula, which are of the order of 0.1%, are not too important for practical dosimetry.

It has to be emphasized that both formulas apply to plane-parallel chambers exclusively, i.e. for chambers with a plane-parallel arrangement of the electrodes. In the case of the PTW-Markus chamber, however, most of the high-voltage electrode is perpendicular to the collecting electrode, increasing the recombination in comparison with a plane-parallel arrangement of the electrodes. This has been demonstrated by calculations using the finite elements method.

Furthermore, the position of the effective point of measurement of the PTW-Markus chamber has been investigated in detail. Measurements at the PTB linac show that the peculiar cavity properties and the negligible guard-ring width (both deviating from the desirable properties given in TRS-381) result in a shift of the effective point of measurement by about 0.5-0.6mm (depending on the energy and on the depth) from the front surface of the air volume towards the chamber centre in the descending part of the depth-dose distributions. Even in the vicinity of R_{85}, neglecting this effect may cause dose deviations of various percent at low energies.



The dependence of the chamber response on the polarity and on the absolute value of the polarizing voltage for commercial chambers has been studied in detail. It has been shown that almost all chambers show a strong curvature of the 1/M over 1/V relation, particularly at high voltages. In addition, it has been shown that the polarity effect shows a strong dependence on the absolute value of the polarizing voltage for most chambers. Examples of severe chamber-to-chamber variations of all these properties have been given.

The selection of the stopping power ratios based on the half-value depth and the depth of measurement, as described in TRS-277 and TRS-381, and the selection according to the new DIN standard 6800-2, which also considers the practical range, have been compared with the Monte-Carlo results by Ding et al. (Med. Phys. 22, 1995) for various clinical accelerators. According to them, the DIN method results in a slight improvement in the selection of the stopping power ratios. In beams containing a large component of contaminating photons, the results may be further improved if this is properly taken into account.

In addition, the stopping power ratios according to TRS-381 have been compared with those according to DIN 6800-2 for the beams of the PTB linac. Apart from the selection procedures, additional slight deviations are caused by different fit polynomials to the energy-range relationship tables of TRS-277. The maximum deviation between the two values of the stopping power ratios according to the two procedures is, however, not larger than 0.6%.

In order to draw definite conclusions, experimental results (e.g. using Fricke dosimeters) from different clinical accelerators would be extremely valuable. The most comprehensive set of data is still constituted by the investigations of the energy-dependence of the response of the plane-parallel chambers at different types of clinical accelerators by Johansson and Svensson in 1981 (Johansson, Thesis, Univ. of Gothenburg, 1982). Since that time, however, various new accelerator types have entered the market.

STATUS REPORT FROM SPAIN: ELECTRON BEAM DOSIMETRY, CALIBRATION AND USE OF PLANE-PARALLEL IONIZATION CHAMBERS FOLLOWING THE IAEA TRS-381 RECOMMENDATIONS AND OTHER PROTOCOLS

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INTRODUCTION

The goal of the project is to study the different factors related to the determination of absorbed dose to water using the plane-parallel chamber Roos (PTW) in comparison to NACP 02. This project is continuation of the work presented in the First Research Coordinated Meeting (RCM) for the Co-ordinated Research Project(CRP) on *Dose determination with plane-parallel ionization chambers in therapeutic electron and photon beams*.

Previously we had investigated the difference between the absorbed dose determined with Markus and NACP pp-chambers in water and PMMA phantoms, following the formalism of TRS-381, TRS-277 and TG-39 protocols. A significant difference (up to 3%) was found between TG-39 and TRS-381 when measurements were made in PMMA phantoms.

All the measurements were performed at two linear accelerators: VARIAN Clinac 18 and Clinac 2100 C. A Theratron 780 Cobalt unit was also used. The measurement conditions are given in the following table.

Nominal energy E_n *(MeV)*	4 - 18
Mean energy at surface $\bar{E}_0$ **(MeV)**	3.5 - 17
Reference depth (z_{eff})	Depth of maximum absorbed dose
Mean energy at depth z_{eff} $\bar{E}_z$ **(MeV)**	1.9 - 12.5
SSD (cm)	100
Reference chamber	NE-2571 (cylindrical chamber)
Phantom material	Water and PMMA
Monitor chamber	NE-2571 (cylindrical chamber)
Dose / pulse (mGy/p)	— 0.45 - 0.97

DETERMINATION OF $N^{pp}_{D,air}$ FOR A ROOS PLANE-PARALLEL IONIZATION CHAMBER

The determination of this factor has been made in electron beams, using water and PMMA phantoms, following the method recommended in TRS-381. The measurements were performed at two linear accelerators, using the highest energy available at each , with four determinations at each energy. No significant difference was found between the $N^{pp}_{D,air}$ values obtained for the two electron beams and for the different phantom materials (0.3%, k= 1).

Three more determinations were made in a Co-60 beam with PMMA phantom at 5 cm depth. For this case, the $N^{pp}_{D,air}$ factor was 2.8% higher than the value determined in electron beams. One of the reasons for this discrepancy could be the effect of the perturbation factor p^{pp}_{wall} for the Roos chamber in PMMA phantoms for the cobalt beam, which was assumed equal to 1 for the present measurements.

DETERMINATION OF RECOMBINATION AND POLARITY CORRECTION FACTORS FOR ROOS AND NACP PLANE-PARALLEL CHAMBERS

The determination of the recombination correction factor p_s for the pp-chambers has been made using the *"two voltage"* method and the polynomial fit given in TRS-277. Measurements have been performed in electron beams under the conditions given in the table above. In all cases, one external monitor chamber (NE-2571) was used. The polarising voltages used were -300, +300 and -100 V.

The values presented are the average values obtained from the measurements in water and PMMA phantoms, using dose/pulse between 0.45 and 0.97 mGy.
The polarity effect of the Roos chamber is negligible (p_{pol} =1.0001 ± 0.02%) and the calculated saturation (99.2 % -99.7%) agrees well with the value given by the manufacturer: 99.5% for pulsed radiation with dose/pulse up to 0.15 mGy. The influence of the two effects is slightly more important in the case of a NACP chamber.

ELECTRON BEAM QUALITY SPECIFICATION WITH ROOS AND NACP CHAMBERS

The energy parameters that specify the quality of an electron beam have been determined from the depth ionization curve measured in water phantom with Roos and NACP chambers under the conditions given in the table above and with a radiation field of 25x25 cm^2. No correction for polarity and saturation effects was applied. The effective point of measurement was taken into account. $\bar{E}_0$ and $E_{p,0}$ were calculated from the ranges R^J_{50} and R_p using the empirical relationships recommended in TRS-381 and TRS-277. The determined values of the ranges R^D_{100} , R^J_{50} and R_p , and the energy parameters $\bar{E}_0$, $E_{p,0}$ from the measurements made with the two pp-chambers are presented. The shift between the two depth ionisation curves was 0.4 - 1.1 mm depending on the beam energy.

ABSORBED DOSE TO WATER

Absorbed dose to water, under the reference conditions given in the table above, has been determined using the four combinations of

NACP and Roos chambers in PMMA and water phantoms in electron beams of mean energy $\overline{E}_0$ from 3.5 to 17 MeV. This was done according to TRS-381 recommendations. The dispersion (1 SD) in relation to the mean value of the 4 set of determinations varied between 0.5 and 1.0%.

EVALUATION OF THE FLUENCE CORRECTION FACTOR: H_M

The measurements have been performed with two plane-parallel ionization chambers, NACP and Ross, under the conditions given in the table above. The discrepancy between h_m in TRS-381 and the ratio D_{water}/D_{PMMA} was about 1% for the two chambers. Due to the difficulty of reproducing the measurement conditions for water phantom and PMMA phantom, this difference is consistent with the experimental uncertainty obtainable under clinical conditions.

A second group of determinations of h_m factor was performed in May 1998, just after the RCM. The measurement conditions were those agreed upon: SCD 100 cm, 15x15 cm^2 field, no electron cones and external monitor chamber placed close to the photon jaws. The results obtained are presented in Figure 8.1 The measured values of h_m are always lower than the h_m in TRS-381 with an average difference of about 0.5 %; however, the discrepancy increases with the energy.

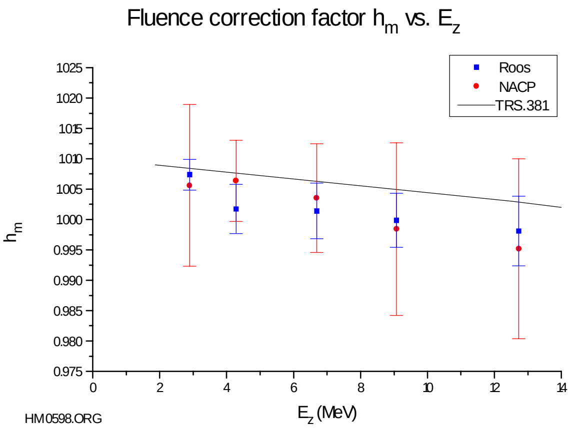

Fig. 8.1. – Factor h_m to convert fluence from PMMA to water, as a function of mean energy at depth, estimated for the NACP and Roos plane-parallel chambers

COMPARISON BETWEEN TRS-381 AND TG-39 CODES OF PRACTICE

The ratio of absorbed dose to water in electron beams determined according to the TRS-381 and TG-39 protocols from the measurements in water and PMMA phantoms using a Roos chamber was calculated for various mean energies. Results of this determination are given in Figures 8.2 and 8.3, together with the values obtained in the previous part of this work for the NACP, Markus and NE-2571 chambers.

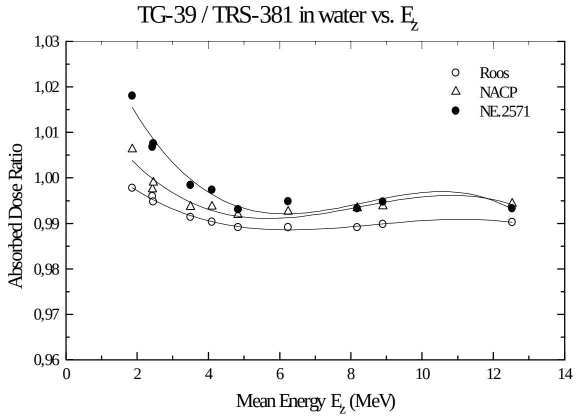

Fig. 8.2.- Ratio of absorbed dose to water determined according to TG-39 and TRS-381 CoP as a function of mean energy at depth Measurements performed in a water phantom

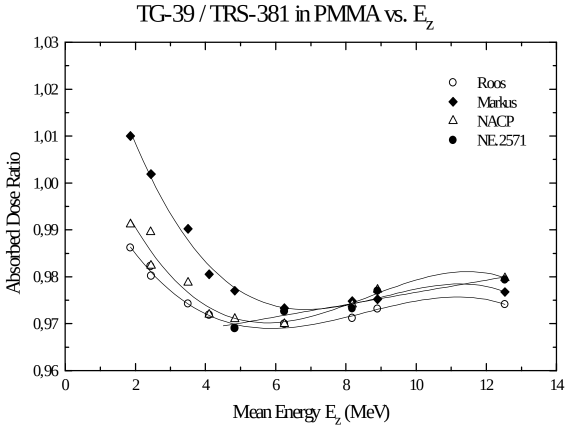

Fig.8.3.- Ratio of absorbed dose to water determined according to TG-39 and the TRS-381 CoP as a function of mean energy at depth. Measurements performed in a PMMA phantom

STATUS REPORT FROM SWEDEN-1: PLANE-PARALLEL IONISATION CHAMBER DOSIMETRY IN CLINICAL ELECTRON BEAMS OF ENERGIES 4-50 MEV

H Svensson, A Björeland (Umeå)

The work by the Umeå group was carried out by Mr Håkan Nyström till the end of 1997. As he then moved to another department, there has been some transfer problems. An investigation to determine extreme differences between the different protocols, later to be verified by measurements, was undertaken in the beginning of 1998. A PhD student, Anders Björeland, was involved in this activity under the supervision of the head of the Radiation Physics department, Mr Hans Svensson, who is the official participant from Umeå.

It is possible to compare theoretically the differences in dosimetry that would be derived using the AAPM protocol TG-39 and the IAEA TRS-381, as the same set of measurements is required. The numerical values of the interaction coefficients and the correction factors differ which results in deviations. A complete data set for different types of chambers is presented. For the so called "electron beam method", deviations up to 2.5 % were shown. In the "Co-60 in phantom method" deviations up to 3.0 % were derived, and for the "Co-60 in air" the largest deviation was 1.7 %. In all these methods using different combinations of plane-parallel and cylindrical chambers, a somewhat higher dose would generally be determined using the IAEA protocol.

The methods in IAEA TRS-381 could not be compared directly with the IPEMB 1996 (i.e. UK report) and NCS report 5 1998 (i.e. the Dutch code) as the procedures to carry out measurements differ. However, some values of the interaction coefficients used in these protocols could be compared. There are some minor deviations ($\leq$ 0.5 %) for chamber factors. Further, the stopping power data used for the electron beam measurements differ by about 0.5 % for depths usually relevant for reference dose determination. Measurements are needed to determine the difference in the end results .

It can be concluded that the dose deviations of 1.5 – 2.5 % can be attributed to the choice of the dosimetry protocol. In modern radiotherapy, it is often recommended that the dose to the patient should be within 3.5 – 5 % (see ESTRO 1997). It is therefore very important to reduce the uncertainty at every step. Deviations, just due to different values of the interaction coefficients, of up to 2.5 % seem to be too large and further work is needed.
The Umeå group will therefore continue to improve and verify the data using the ferrous sulphate dosimetry method. A special care must be taken to set up the experiment, however, to investigate the deviations in the order of 1 – 2 %. It should, however, be possible to verify the inconsistencies at least in the energy dependence as we intend to carry out plane-parallel and cylindrical chamber measurements, and also ferrous sulphate dosimeter measurements in both high-energy photon and electron beams of different energies.

STATUS REPORT FROM SWEDEN-2: P_{CAV} FACTORS FOR CYLINDRICAL IONIZATION CHAMBERS IN ELECTRON BEAMS

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The electron beam method for calibrating plane-parallel ionization chambers involves cavity correction factors for cylindrical chambers. The cavity correction factors in TRS-381 are based on the experimental results by Johansson et al (1978). In the present work their method was used to determine cavity correction factors for a new set of cylindrical graphite chambers in water. The cavity radii were 1, 2, 3.5 and 4 mm. Measurements were done at the recommended reference depth (TRS-381), in photon and electron beams using a Varian Clinac 2300CD. The procedure was then repeated for the depth used by Johansson et al, i.e. placing the centre of the chamber at the peak of the depth ionization curve. Further studies involved the same chambers and PMMA phantom previously used by Johansson et al. The only difference between the two sets of measurements was the accelerator beams. In addition, a plane-parallel chamber was used in all measurements.

To obtain the cavity correction factors, the measured charge was normalised to the smallest chamber. A plot of the inverse of p_{cav} as a function of cavity radius was made for various electron beam energies. According to Johansson et al this yields a straight line. This function was renormalised such that p_{cav} is unity for cavity radius of zero.

In the first study, with P_{eff} placed at z_{ref}, a linear relation was found for the higher energies only. This might be caused by the fall-off in the dose in the region close to the chamber for the largest chamber in the low energy electron beams, in combination with the problems related to the use of the effective point of measurement for the small chambers. However, straight lines were obtained when the measurements were done, in both water and PMMA phantoms, with the centre of the chamber placed at the peak of the depth ionization curve.

The cavity correction factor can also be determined using a plane-parallel chamber as a reference. As p_{wall} for these chambers is considered to be uncertain a plot for each energy was drawn, yielding the volume ratio of the plane-parallel chamber to the smallest cylindrical chamber. The mean value of the six volume determinations was used to derive p_{cav}.

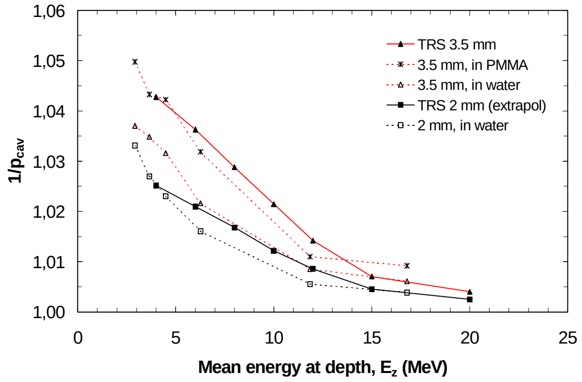

Fig. 10.1. $1/p_{cav}$ determined at the depth of D_{max} using graphite chambers in water and Johansson et al's chambers in PMMA, compared with data from TRS-381 for cavity radius 2 and 3.5 mm

In figure 10.1, the inverse of p_{cav} as a function of the mean energy at the depth of the chamber for different cavity radii is shown. Data for the graphite chambers in water with the centre of the chamber at the peak of the depth ionization curve are shown. The results are compared with the data from TRS-381. For comparison, the results derived using the same equipment as Johansson et al are included. These results were obtained using a plane-parallel chamber as a reference. For the water measurements, a Roos chamber was used, while for the PMMA measurements an NACP02 was used. It can be concluded that the measurements in PMMA are in good agreement with the original data from Johansson et al. Compared to TRS-381, a smaller correction was found (??) for the cavity perturbation for the graphite chambers used in water. For the highest energies, that are recommended for the calibration of the plane-parallel chambers, the difference is small.

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[2] AAPM American Association of Physicists in Medicine, Task Group 39: The calibration and use of plane-parallel ionization chambers for dosimetry of electron beams: An extension of the 1983 protocol, Med. Phys. 21 (1994) 1251-1260.

[3] Johansson, K.A., Mattsson, L.O., Lindborg, L., Svensson, H., "Absorbed-dose determination with ionization chambers in electron and photon beams having energies between 1 and 50 MeV (IAEA-SM-222/35)", National and International Standardization of Radiation Dosimetry (Proc Symp. Atlanta, 1977), Vol. 2, IAEA, Vienna (1978) 243-270.

REPORT OF THE EIGHTH MEETING OF THE SCIENTIFIC COMMITTEE OF THE IAEA/WHO NETWORK OF SSDLs

IAEA, VIENNA, 5-9 OCTOBER 1998

Scientific Secretary: P. Andreo
Dosimetry and Medical Radiation Physics Section, NAHU

FOREWORD

The report of the seventh meeting (held in Sept/ Oct., 1996) of the Scientific Committee (SSC) of the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDL) was published in the SSDL Newsletter No. 36, January 1997.

The eighth meeting was held in Vienna at the Agency headquarters from 5 October to 9 October 1998. Opening remarks were made by Professor S. Groth, Director, Division of Human Health (NAHU), Dr. H. Østensen , Co-Secretary of the IAEA/WHO SSDL Network, Dr. P. De Regge, Head, PCI Lab, (NAAL), and Professor P. Andreo, Head, Section of Dosimetry and Medical Radiation Physics (DMRP). Professor Groth spoke of the role, mission, and functions of the Agency and the Division, including the particular interest of the Division in nuclear medicine and diagnostic radiology, and their interest in electronic transfer of information. Dr. De Regge spoke of the importance of the Dosimetry Laboratory activities within NAAL. Dr. Østensen stated that he had recently joined WHO and was interested in significantly improving the WHO participation in the IAEA/WHO joint programme. He also emphasized the importance of quality assurance in diagnostic radiology, which leads to a reduction of the dose to the patient and physician, without degrading the quality of the image. Professor Andreo introduced the Agency staff members who presented reports on their various activities for the first two days of the meeting and part of the third. The SSC then met in closed session with Professor Andreo until Friday noon, deliberating the accomplishments and direction of the Agency’s programmes, and developing specific recommendations. The list of participants in the meeting and the meeting agenda are enclosed as Appendices I and II, respectively.

Conforming to its Terms of Reference, the SSC evaluated the activities of the DMRP reported for 1997-1998 and discussed the proposed programme for the Section for 1999-2000. Long range plans for seminars and teaching courses (until 2002) were also discussed, as well as a strategic plan for the Section. The scope of the evaluation addressed the questions of:

- the objective of the programme areas,
- the impact (benefit to the Member States), and
- the continuing relevance of Agency activities.

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

The committee wishes to commend the DMRP staff for presenting the various programmes in a clear and concise manner, and for their straightforward responses to questions from the SSC. The SSC particularly wishes to thank the DMRP Section Head for providing a comprehensive overview of the activities of the Section for 1997-98 together with a projection for 1999-2000. This report gave the SSC a clear overall picture prior to the meeting and served as a written reference for discussions during the meeting.

INTRODUCTION

The DMRP report and the presentations from the staff clearly showed the SSC that the DMRP had responded to all recommendations of the previous SSC report (Oct 1996) and that significant efforts had been made to establish formal and informal links with other divisions within the Agency. In general, the activities of the DMRP support the aims of the Agency's Dosimetry Programme.

The DMRP Section's activities are performed under four identifiable projects:

- PROJECT E.3.01: Secondary Standards Dosimetry Laboratory (SSDL) Network.
- PROJECT E.3.02: Dose Intercomparison and Assurance
- PROJECT E.3.03: Transfer of Dosimetry Techniques
- PROJECT E.3.04: Technical Co-operation Activities

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 activities of the Section for which the SSC has comments or recommendations. Exclusion of specific activities should be interpreted positively, as concurrence by the SSC with the activity as reported.

REPORT

GENERAL ORGANIZATIONAL ITEMS

Within the past year the Section of Dosimetry has been renamed the Section of Dosimetry and Medical Radiation Physics (DMRP), to emphasize the areas of primary expertise and involvement.

The Agency's Dosimetry Laboratory

The multiple activities undertaken at the Agency's Dosimetry Laboratory require measurements of high accuracy. In addition, these programmes have a significant influence on radiation metrology worldwide and consequently on doses received by individual patients or irradiated products.

The Dosimetry Laboratory is integrated into the IAEA's Siebersdorf Laboratories. The range of services provided to the SSDL network includes:

- calibration of ionization chambers for radiotherapy, diagnostic x rays including mammography[*] and radiation protection,
- calibration of re-entrant ionization chambers for low dose rate brachytherapy sources (^{137}Cs)[*],
- TLD dose quality audits for external radiotherapy beams (for SSDLs and for hospitals),
- ESR-alanine dose quality audits for radiation processing (for SSDLs and for facilities), and
- TLD dose quality audits for SSDLs providing dosimetry for personnel monitoring*.

Following the recommendations of the last SSC report, individual professional staff have been identified as having responsibilities for the various services.

It is the policy of the DMRP Section to operate at the highest possible quality standards. To achieve this, the DMRP has recently completed a quality assurance (QA) manual documenting the Dosimetry Laboratory procedures. This manual sets out, in compliance with ISO 9000 guidelines, the general requirements for the operation of the laboratory as well as an extensive documentation of its procedures in accordance with ISO Guide 25 for calibration laboratories. The SSC hopes that SSDLs will find portions of this manual useful as models for their quality manuals.

The Section Head of DMRP has developed an effective working relationship with the Director of the Agency Laboratories (NAAL). The SSC commends the development of this working arrangement between the two divisions (NAHU and NAAL) with regard to implementation of the Agency's Dosimetry programme. However, the SSC notes that the development of a quality

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[*] Indicates services developed or introduced in the past two years.

system for the metrological activities of the DMRP requires that the responsibilities and duties of the staff at NAHU and NAAL be clearly defined. This is especially relevant to its laboratory activities. Consequently the SSC recommends that the responsibilities and duties of the staff at NAHU and NAAL be clearly defined and documented.

The High-Dose Dosimetry Programme

The Agency's laboratory provides dosimetry quality assurance services for high-dose irradiation facilities in support of programmes sponsored by other Divisions in the Agency (specifically the Division of Physics and Chemistry (NAPC) and the Division for Food and Agriculture (NAFA)). The SSC recommends that a more formal relationship be developed between NAHU and the other divisions interested in high-dose irradiations (NAPC, NAFA) for future collaborative development of the high-dose dosimetry programme.

Radiation Therapy Issues

The SSC is pleased that, based on the Interoffice Memorandum "Assurance of Quality and Safety in the implementation of Radiotherapy Projects" dated 7 August 1996, Dosimetry and Medical Radiation Physics (DMRP-NAHU), Applied Radiation Biology and Radiotherapy (ARBR-NAHU), and Radiation Safety (RS-NSRW) are sharing information and responsibility for projects in Radiation Therapy that may have some overlap.

Collaboration with the World Health Organization (WHO)

Dr. ∅stensen attended his first meeting of the SSC as the representative from WHO. Since joining WHO, he has demonstrated a commitment and has dedicated resources to improving turn around time and participation in the IAEA/WHO postal TLD programme. The SSC is pleased to note that the improved collaboration with WHO has already resulted in an increased involvement of the hospitals in the programme and hopes that this improvement will continue. The SSC welcomes the proposal for a WHO seminar for regional officers and recommends that this seminar promotes the hospital audit programme in radiotherapy dosimetry, and reinforces the importance of the SSDL network.

Collaboration with ESTRO and Other Organizations

The SSC welcomes the IAEA collaboration with ESTRO on a number of mutual programmes, particularly in regard to the Memorandum of Understanding between the IAEA and ESTRO on their mutual cooperation in radiotherapy dosimetry quality audit programmes, and recommends that, where possible, similar arrangements be made with other external organizations, noting that such collaborations optimize the use of resources.

PROJECT E.3.01 SECONDARY STANDARD DOSIMETRY LABORATORY (SSDL) NETWORK

The IAEA/WHO SSDL Network presently consists of 69 laboratory members and 6 Primary Standard Dosimetry Laboratories (PSDLs) in 58 member states. The SSC welcomes the new members in Madagascar, Peru and Tunisia. It was noted that five of the laboratory members are considered as provisional members, Libya, Nigeria, Sudan and the two SSDLs in Iraq (see Section 3.2.1 below). The University of Singapore has resigned from the Network due to a change in the direction of its activities.

The active SSDLs provide traceable instrument calibrations for radiation therapy and diagnostic radiology, provide quality audits of radiotherapy dosimeters by postal TLD and occasionally on-site measurements, and some perform measurements at radiation processing levels, and evaluate personnel dosimeters. The implementation of such a programme requires that the traceability of the SSDLs to a PSDL or to the Agency be verified periodically through quality audits and intercomparisons organised by the DMRP.

Within the past several years the DMRP has focused efforts on follow up of the results of all of the audit programmes where an SSDL (or hospital) fails the audit with a disagreement with the Agency exceeding appropriate action levels. The SSC recommends that the SSDL Network Secretariat establishes Action Levels for all audit programmes, and notifies the participants of these action levels.

SSDL Charter

Following a recommendation of the 7th SSC, an SSDL Charter was prepared outlining the benefits as well as the duties and responsibilities of an SSDL Network Member. The Charter also establishes a 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.

- The SSC is pleased to see that the SSDL Charter has been completed and that the IAEA will publish the Charter jointly with the WHO. The SSC recommends that the Agency and WHO collaborate to ensure that all those involved in the SSDL Network receive a copy of the charter.

- The SSC notes that some SSDLs have not participated in any IAEA organized audit for over 2 years. The SSC recommends that the periodic measurement assurance tests required in the SSDL Charter be made at a minimum of 2 year intervals, and that the Network Secretariat notifies all members of the network of this requirement.

- The SSC has noted that a number of SSDLs have not resolved dosimetry discrepancies outside the Agency action levels, as required by the Charter. The SSC recommends that SSDLs who do not comply with the requirements of the Network Charter (*e.g.*, participation in external audits or resolution of discrepancies) should be advised that they risk losing their traceability to international standards unless action is taken. The SSC also recommends that the DMRP takes such action as necessary to encourage these SSDLs to comply with the SSDL Network Charter. The SSC recommends that, if an SSDL fails to comply within one year of notification, the Member State be informed that the SSDL will cease to be a full member but rather be listed as a provisional member of the network.

Intercomparison of Therapy Level Ionization Chamber Calibration Factors

In this proficiency test programme, the SSDL calibrates an ionization chamber of its choice, and forwards it to the DMRP laboratory for their calibration. This test verifies the ability of an SSDL to transfer a calibration from their standard to the user. Twenty one SSDLs participated. The results are presented in Figure 1. The figure includes calibrations in terms of air kerma and absorbed dose to water. Any difference between the SSDL and DMRP exceeding the indicated action levels is pursued by the Agency for resolution. Three of the SSDLs collaborated with the DMRP to resolve the discrepancies, while one did not.

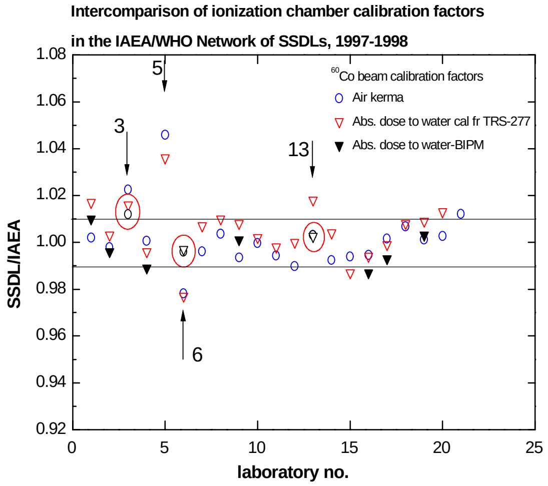

Figure 1: Ratios of ion chamber calibration factors supplied by the SSDLs to those measured by the IAEA. Circles correspond to air kerma calibration factors and triangles to absorbed dose to water factors. The arrows correspond to the four large discrepancies, the results following corrections being enclosed in the large circles

The SSC considers this SSDL to have broken its traceability to international standards and therefore should be a provisional member of the SSDL network, until the discrepancy is resolved. The identification of the discrepancies and the ability of the DMRP to resolve them, emphasizes the importance of this programme in assuring that traceability is not compromised by the SSDLs.

TLD Monitoring of SSDL Measurements at Therapy Levels

This measurement assurance programme is to verify the ability of the SSDL to transfer the ionization chamber calibration to the determination of absorbed dose under reference conditions in a water phantom. The SSDL irradiates TLD at a reference depth in a cobalt-60 or high-energy x-ray beam. The TLDs are evaluated at the Agency's Dosimetry Laboratory. The results for the last 5 cycles (2.5 years) are shown in Figure 2. The 11 results outside the Agency action level were pursued to identify and resolve the discrepancies. One of the SSDLs has, as yet, failed to cooperate with the DMRP to resolve the discrepancy. The SSC considers this SSDL to have broken its traceability to international standards and therefore should be a provisional member of the SSDL network, until the discrepancy is resolved. The identification of the discrepancies, and the ability of the DMRP to resolve the discrepancies, emphasizes the importance of this programme in assuring the traceability is not compromised by the SSDLs.

The SSC notes that 4 of the SSDLs having radiotherapy activities have not participated in the TLD audits in the period 1996 to 1998. The SSC suggests that these SSDLs have failed to complete an appropriate proficiency test, therefore are at risk of losing traceability and, as such, should be identified as provisional members of the network.

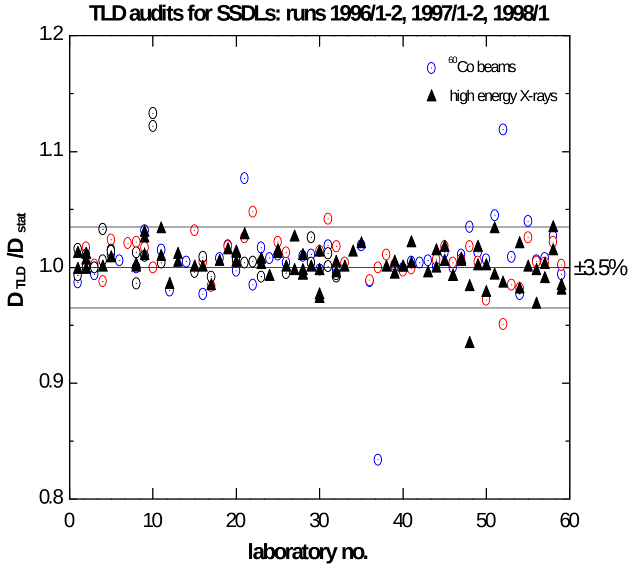

Figure 2: Results of the IAEA/WHO TLD postal dose audits of SSDLs for the delivery of dose to water under reference conditions for the TLD runs 1996/1, 1996/2, 1997/1, 1997/2 and 1998/1. Data in the graph correspond to the ratio of the Agency's determined dose from the TL-response (D_{TLD}) to that stated by the SSDL (D_{stat}). Each data point corresponds to the average of three dosimeters. A total of 196 beam calibrations were checked in 59 laboratories, which include 122 ^{60}Co (circles) and 74 high-energy x-ray beams (triangles). The number of therapy beams checked in different TLD runs was: 45 beams in 1996/1, 39 beams in 1996/2, 35 beams in 1997/1, 36 beams 1997/2 and 41 beams in 1998/1. A total of 11 deviations were found outside the acceptance limit of ±3.5% *(one large deviation in 1996/1 run, 4 in 1996/2, and two in each of 1997/1, 1997/2 and 1998/1 runs).*

New Calibration Services

The DMRP has introduced three new services since the last SSC meeting. The SSC recognizes that the development of these new technologies was possible only because three temporary professional staff were available from various programmes not on the DMRP budget.

Brachytherapy calibrations

A calibration service for brachytherapy re-entrant (well-type) ionization chambers for ^{137}Cs sources has been established. Stability checks of the service suggest reproducibility of the order of ± 0.5 %. To date, one brachytherapy chamber has been submitted for calibration. In order to evaluate the potential level of use of the brachytherapy calibration service at the DMRP, the SSC recommends that the Network Secretariat survey brachytherapy services provided by the SSDLs.

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

There is a growing need for quality control and quality assurance in diagnostic radiology, particularly in mammography, where routine screening of asymptomatic women could lead to significant radiation doses. DMRP has been developing facilities and procedures for the calibration of ionization chambers at mammography beam qualities. Seventeen beam qualities with HVL from 0.27 to 0.85 mm Al have been developed. These represent both Mo and Ru target and absorbers for both entrance and exit dose qualities. To evaluate the potential use of the calibration services in diagnostic x rays at DMRP, the SSC recommends that the Network Secretariat survey the SSDLs to identify the services provided and the equipment used in diagnostic x-ray calibrations, including mammography.

TLD dose quality audits for radiation protection

Following a recommendation of the 7th SSC, the DMRP laboratory has developed a postal TLD programme to audit the ability of an SSDL to calibrate their ^{137}Cs beam used in the SSDL's personnel dosimetry programme. Two pilot studies have been performed in which 24 SSDLs participated. The results are shown in Figure 3. The SSC commends the DMRP for the significant amount of work performed at a high level of expertise. This will benefit radiation protection services for a significant portion of the world's radiation workers and should be developed further. The SSC recommends that the pilot study for measurement standards in radiation protection dosimetry using ^{137}Cs be made a regular service. It further recommends that a similar service be investigated for ^{60}Co.

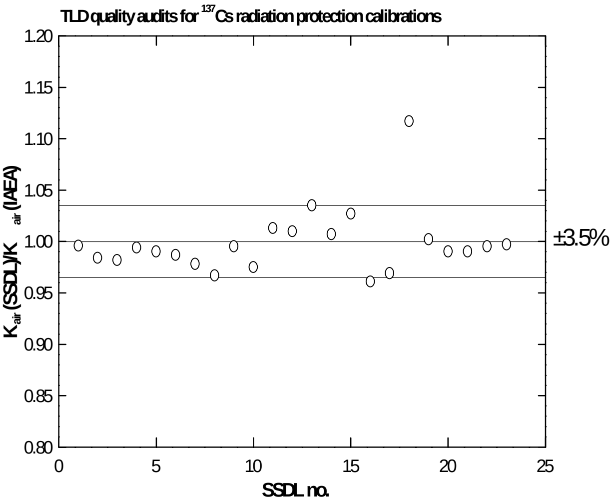

Figure 3: Ratios of the air kerma stated by SSDLs to the TLD measured value at the Agency's Dosimetry Laboratory

PROJECT E.3.02 DOSE INTERCOMPARISON AND ASSURANCE

The IAEA/WHO TLD Postal Service for Hospitals

The IAEA/WHO TLD postal programme for monitoring the calibration of radiation therapy beams at hospitals in Member States continues. The SSC applauds the DMRP and WHO on a number of changes already implemented or proposed to improve the efficiency of the programme.

Improved return rate

During recent years the return rate for the TLD has increased dramatically as seen in Figure 4. The average return between 1990 and 1996 was 60 % and in 1993 to 1995 it was 70 %. Since the last SSC report, the average return rate has increased to 90 % due to the joint efforts of the WHO and the DMRP. The SSC is pleased to note this important result.

Benefits of repeat TLD

SSC recognizes the impact of the TLD progamme on the individual hospitals. Typically, only 65 % of those hospitals that receive TLD for the first time have results within the DMRP action levels (± 5 %), while 80 % of institutions that have benefited from a previous TLD audit are expected to have results within the DMRP action levels.

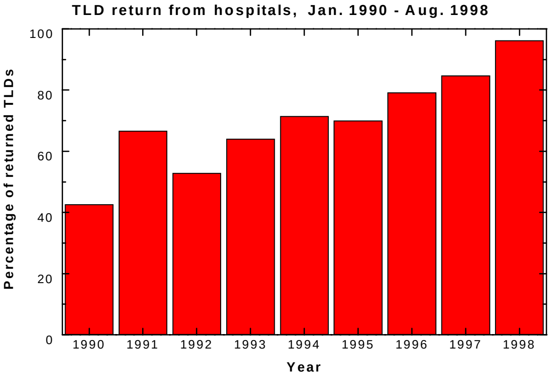

Figure 4: Improvement in return rate from hospitals in the IAEA/WHO dosimetry programme.

Follow up of hospitals outside the acceptable limits

The results of 429 beam verifications at 241 hospitals are shown in Figure 5. As shown, 17 % are outside the ± 5 % action level. On the recommendation of the SSC, the DMRP has established a follow-up programme for hospitals outside acceptable limits, contacting the hospital either through WHO or directly by DMRP staff. All hospitals were contacted. The results of this follow-up are seen in Figure 6. These data pertain to the 72 hospitals where a discrepancy was discovered. Among these hospitals, 33 resolved their discrepancies. For the rest of the discrepancies (see the dark circles in Figure 5), 13 continue to be unresolved and 26 hospitals have not yet responded to efforts by the DMRP to help them identify and resolve the problem. The SSC recommends that the successful efforts on efforts on follow-up of hospital TLD discrepancies be pursued for those hospitals still outside the action levels.

Individual TLD reports

The SSC wishes to commend the DMRP on their new policy of providing each hospital with an individual TLD report for each beam measured.

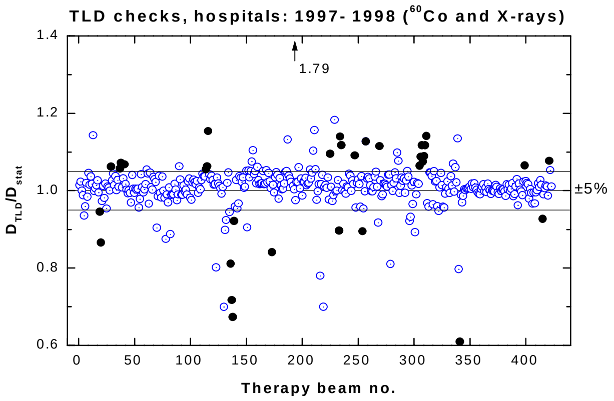

Figure 5: Results of the IAEA/WHO TLD postal dose audits of radiotherapy hospitals for the delivery of absorbed dose to water under reference conditions during 1997-1998 for the TLD batches B78 to B95. Data in the graph correspond to ratios of the Agency's determined dose (D_{TLD}) relative to the dose stated by the hospital (D_{stat}). Each data point corresponds to the average of two dosimeters. A total of 429 beam calibrations were checked in 241 hospitals. Approximately 17% of the results were found outside the ±5% action level. Black dots indicate the deviations which have not been corrected (before August 98).

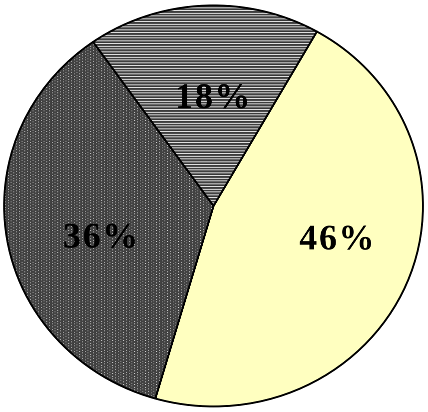

Figure 6: Pie chart showing the outcome of follow-up dosimeters sent to hospitals outside the action level: 46 % resolved; 36 % not yet returned; 18 % not yet resolved

Improved cost effectiveness

The SSC also wishes to commend the DMRP on various actions taken to improve the cost effectiveness of the TLD programme without significant compromise on accuracy and precision. These include:

- Utilization of a TLD reader that is essentially automatic.
- Reducing the number of TLD in a given dosimetry pack issued for hospital use.
- Projected change to TLD 100 which is significantly less expensive that the TLD 700 presently used.

Turn-around time

DMRP has been able to reduce significantly the total turn-around time for the postal TLD, partly through in-house improvements but principally through efforts in dissemination of the postal packs as coordinated by WHO. The SSC was pleased to note these improvements.

Transfer of TLD programmes to member states

There are four Member States (China, India, Argentina, and Algeria) that have established TLD programmes to audit hospitals in their countries and which have a formal link to the DMRP laboratory. Recently three other Member States have established such programmes (Czech Republic, Israel, Malaysia). The SSC notes the positive results from the CRP on 'the establishment of national programmes for quality assurance in radiotherapy dosimetry'. The SSC recommends that the Agency continue to assist Member States to establish national TLD programmes, that whenever possible the DMRP establishes links between the national programmes and the Agency, and that the possibility of TC projects be explored for this effort.

Radiation Processing Dosimetry

The DMRP continues to provide the International Dose Assurance Service (IDAS) at radiation processing dose levels using alanine dosimeters issued and evaluated at the Agency's Dosimetry Laboratory. The SSC recognizes that this is a dosimetry programme with a high level of accuracy that must be recognized for the value of its services. However, the Agency programmes that benefit most from these services are not within the DMRP. This dosimetry programme therefore consumes more than its fair share of resources in the DMRP. The need to spread the support for this programme throughout other Divisions in the Agency has been addressed above. The real challenge to DMRP is to impress the merits of this dosimetry programme on those benefiting from the programme.

The results of the IDAS programme from 1992 to 1998 are shown in Figure 7 where 61 % of the results are within ± 5 % and 86 % within ± 10 % of the DMRP standard.

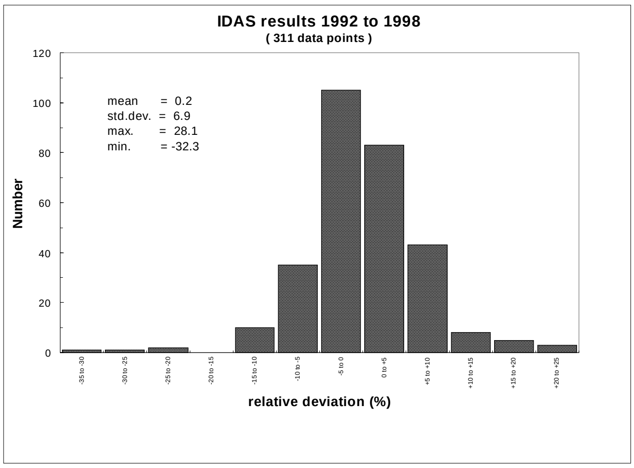

Figure 7: IDAS results from 1992 to 1998

The programme to follow up results outside the action level includes correspondence by letter and repeat dosimeter irradiations. The SSC recommends that the DMRP define the action level for dosimetry discrepancies to be investigated within the IDAS programme and further recommends that the follow-up procedure be improved.

PROJECT E.3.03: TRANSFER OF DOSIMETRY TECHNIQUES

The transfer of dosimetry techniques in the DMRP dosimetry programme is provided through coordinated research programmes (CRPs), training courses, fellowships, seminars, symposia, and publications. Technical Co-operation projects (TCs), which are an important mechanism to transfer technology to developing countries are covered under Project E.3.04.

Co-ordinated Research Projects (CRPs)

The list of active CRPs is included in Table 1 and the list of proposed CRPs is given in Table 2.

The SSC is pleased to see that the development of a Code of Practice for radiotherapy dosimetry based on an ‘absorbed dose to water’ standard in CRP E2 40 09 has been endorsed by the IAEA, WHO and ESTRO and that the DMRP is proceeding to the testing phase. The SSC recommends that the Code of Practice for radiotherapy dosimetry based on an ‘absorbed dose to water’ standard be published as a TecDoc to ensure the widest possible distribution. The foreword should indicate that the protocol is being distributed for evaluation for two years.

The CRP E2 40 10 has been formally proposed and approved pending external funding. The DMRP is encouraged to operate this CRP on the basis of interested countries self-funding their participation.

The proposed CRP E3.01 should be preceded by a survey to the SSDLs to ascertain the research needs at this stage.

The SSC recognizes the need of developing countries to have tools for evaluating treatment-planning systems, many of which utilize Monte Carlo calculations and supports the proposal in the CRP E3.03.

Table 1: Co-ordinated Research Projects (CRPs) currently active:

Year of start	Subject	Year of completion	Participating Institutions
1995	E2 40 06 Characterization and evaluation of high-dose dosimetry for quality assurance in radiation processing	1999	10
1996	E2 10 02 Development of a quality assurance programme for Secondary Standard Dosimetry Laboratories.	1998	6
1994	E2 40 07 Development of a quality assurance progamme for radiation therapy dosimetry in developing countries.	1998	9
1996	E2 40 08 Dose determination with plane-parallel ionization chambers in therapeutic electron and photon beams	2000	6
1997	E2 40 09 Development of a Code of Practice for dose determination in photon, electron, and proton beams based on measurements standards of absorbed dose to water.	2000	7
1998	E2 40 11 EPR biodosimetry (jointly with NSRW)	2000	9

Table 2:CRP's proposed for 1999-2000:

Year of start	Subject	Year of completion	Participating Institutions
	E2 40 10 Alanine-ESR dosimetry for radiotherapy		
1999	E3.01 (Task 11) Development of techniques for the dissemination of Absorbed dose to water standards to the Secondary Standards Dosimetry Laboratories.	2000	
2000	E3.01 (Task 12) Dosimetry and quality assurance for diagnostic x-rays at SSDLs	2003	
	E3.03 (Task4) Transport simulation for photon/electrons in radiotherapy. (Jointly with RIPC, Nuclear Data)		

Training Courses and Symposia

The following courses have been approved for 1999 and proposed for 2000.

1999

- Calibration Procedures and Quality Assurance in SSDLs: Interregional (Cuba)
- Modern Techniques and Dosimetry In Brachytherapy: Regional Africa (Egypt)

2000

- Quality Assurance and Process Control in Radiation Processing: Latin America
- Physical Aspects of Quality Assurance in Radiotherapy: West Asia
- Dosimetry Quality Audits in Radiotherapy: East Asia and Pacific

As the interregional seminar on QA for the SSDLs recommended in the 7th SSC Report could not be funded by the Agency, the SSC recommends that a further training course to cover the remaining SSDLs should be held in the year 2000.

PROJECT E.3.04 TECHNICAL CO-OPERATION

Technical co-operation projects (TCs) are an important way to transfer technology to developing Member States, and a large fraction of the manpower of the DMRP Section is dedicated to TC tasks. In 1997 DMRP provided support to 74 on-going TC projects, either as the main section responsible for providing the required technical support or sharing the responsibilities with other sections, mainly Applied Radiation Biology and Radiotherapy . Manpower planned for this programme was 20%, however, the true professional manpower dedicated to TC reached up to 35%.

The SSC notes the significant increase in Technical Co-operation programmes in the domain of the DMRP which together with the increase in services to Member States provided by the DMRP has significantly increased the DMRP workload. The SSC recommends that the welcome growth in demand for radiation dosimetry input to TC projects and DMRP services be balanced by an increase in resources.

FUTURE TRENDS

The Head of the DMRP presented a strategic plan listing short-term, medium-term and long-term goals. The SSC appreciates these efforts to develop a strategic plan for the DMRP programme. This will be a valuable document to provide continuity and guide future activities of the DMRP. The short-term goals include completing the tasks listed in the Blue Book and diverting resources from the field of high-dose dosimetry to diagnostic radiology dosimetry, as well as recruiting a new staff member in this field by the end of 1999. The SSC recommends that the short-term goals of the DMRP strategic plan be implemented

RECOMMENDATIONS

a) The SSC commends the development of this working arrangement between the two divisions (NAHU and NAAL) with regard to implementation of the Agency's Dosimetry programme. However, the SSC notes that the development of a quality system for DMRP metrological activities requires that the responsibilities and duties of the staff at NAHU and NAAL be clearly defined. This is especially relevant to its laboratory activities. Consequently the SSC recommends that the responsibilities and duties of the staff at NAHU and NAAL be clearly defined and documented.

b) The SSC recommends that a more formal relationship be developed between NAHU and the other divisions interested in high-dose irradiations (NAPC, NAFA) for future collaborative development of the high-dose dosimetry programme.

c) The SSC welcomes the proposal for a WHO seminar for regional officers and recommends that this seminar promotes the hospital audit programme in radiotherapy dosimetry, and reinforces the importance of the SSDL network.

d) The SSC welcomes the IAEA collaboration with ESTRO on a number of mutual programmes, particularly in regard to the Memorandum of Understanding between the IAEA and ESTRO on their mutual cooperation in radiotherapy dosimetry quality audit programmes, and recommends that, where possible, similar arrangements be made with other external organizations, noting that such collaborations optimize the use of resources.

e) The SSC recommends that the SSDL Network Secretariat establishes Action Levels for all audit programmes, and notifies the participants of these action levels.

f) The SSC is pleased to see that the SSDL Charter has been completed and that the IAEA will publish the Charter jointly with the WHO. The SSC recommends that the Agency and WHO collaborate to ensure that all those involved in the SSDL Network receive a copy of the charter.

g) The SSC recommends that the periodic measurement assurance tests required in the SSDL Charter be made at a minimum of 2 year intervals, and that the Network Secretariat notifies all members of the network of this requirement.

h) The SSC recommends that SSDLs who do not comply with the requirements of the Network Charter (*e.g.*, participation in external audits or resolution of discrepancies) should be advised that they risk losing their traceability to international standards unless action is taken.

i) The SSC also recommends that the DMRP take such action as necessary to encourage these SSDLs to comply with the SSDL Network Charter.

j) The SSC recommends that, if an SSDL fails to comply within one year of notification, the Member State be informed that the SSDL will cease to be a full member but rather be listed as a provisional member of the network.

k) In order to evaluate the potential level of use of the brachytherapy calibration at the DMRP, the SSC recommends that the Network Secretariat survey brachytherapy services provided by the SSDLs.

l) To evaluate the potential use of the calibration services in diagnostic x rays, the SSC recommends that the Network Secretariat survey the SSDLs to identify the services provided and the equipment used in diagnostic x-ray calibrations, including mammography.

m) The SSC recommends that the pilot study for measurement standards in radiation protection dosimetry using ^{137}Cs be made a regular service. It further recommends that a similar service be investigated for ^{60}Co.

n) The SSC recommends that the successful efforts on follow-up of hospital TLD discrepancies be pursued for those hospitals still outside the action levels.

o) The SSC recommends that the Agency continue to assist Member States to establish national TLD programmes, that whenever possible the DMRP establishes links between the national programmes and the Agency, and that the possibility of TC projects be explored for this effort.

p) The SSC recommends that the DMRP define the action level for dosimetry discrepancies to be investigated within the IDAS programme and further recommends that the follow-up procedure be improved.

q) The SSC recommends that the Code of Practice for radiotherapy dosimetry based on an ‘absorbed dose to water’ standard be published as a TecDoc to ensure the widest possible distribution.

r) As the interregional seminar on QA for the SSDLs recommended in the 7th SSC Report could not be funded by the Agency, the SSC recommends that a further training course to cover the remaining SSDLs should be held in the year 2000.

s) The SSC recommends that the welcome growth in demand for radiation dosimetry input to TC projects and DMRP services be balanced by an increase in resources

t) The SSC recommends that the short-term goals of the DMRP strategic plan be implemented.

CONCLUDING COMMENTS

The Agency’s DMRP programme is vital to ensure the traceability of radiation standards and the quality of radiation dosimetry over a wide range of dose levels in developing countries.

The present programme makes basic radiation standards available to the majority of developing countries. External-beam radiation therapy and radiation processing (high dose) have the longest history of robust links to international standards. However, the DMRP has recently implemented new projects providing robust links for calibration of mammography x-ray beams, brachytherapy sources, and personnel monitoring programmes at the participating SSDLs. Perhaps the most significant progress has been made in the follow-up of quality audit measurements in which a difference outside the established action levels has been recorded between the SSDL or other user and the DMRP. The SSC continues to consider this a high-priority item and commends the DMRP on the efforts that they have made in the past and encourages them to continue to develop programmes and expand in this area. The SSC also commends the DMRP on their efforts to transfer the postal TLD programmes to national and perhaps sub-regional programmes and establishing and maintaining links between these programmes and the DMRP.

The SSC commends the Agency for their continued support for the programmes sponsored through the Dosimetry and Medical Radiation Physics Section. The SSC wishes to emphasize that radiation dosimetry is a necessary adjunct to many programmes that utilize radiation at various levels. The SSC therefore commends the DMRP and the Agency for the action already taken to develop communications and programme sharing between DMRP and other Divisions, which can benefit from the expertise of the DMRP staff and the standards maintained by the Section.

The SSC again commends the staff of the Dosimetry and Medical Radiation Physics Section for their clear and comprehensive presentation of the Agency’s DMRP programme.

APPENDIX I

PARTICIPANTS

Committee members:
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P. Sharpe, NPL, UK
S. Shen, China

WHO:
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Observers:
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A. Leitner, BEV, Austria
J. G. Pereira-Peixoto, IRD, Brazil

IAEA staff members:
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L. Czap, Dosimetry and Medical Radiation Physics Section
P. De Regge, Head, Physics and Chemistry Instrumentation Laboratories, NAAL
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H. Toelli, Dosimetry and Medical Radiation Physics Section

APPENDIX II

AGENDA for the 8th biennial meeting of the Scientific Committee of the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories, IAEA, Vienna, October 5-9, 1998

05/10	am (9:00)	Opening address by DIR-NAHU, DIR-NAAL	
		Introductory remarks by P. Andreo and H. Østensen (WHO), co-secretaries of the IAEA/WHO SSDL Network	
		Adoption of the Agenda and nomination of rapporteur	
		OVERVIEW OF THE IAEA DMRP SUBPROGRAMME (E3)	
		∗ Dosimetry Laboratory, QA Manual	PA
			PA, KM
	pm (13:30)	PROJECT E3.01: SSDL NETWORK	PA
		• Information on the Network	AM
		• Development and QC of standards	
		∗ External beam radiotherapy	LC
		∗ Brachytherapy	HT
		∗ Radiation Protection	LC
		∗ Diagnostic radiology (mammography)	FP
		• Audits to SSDLs (intercomparisons)	
		∗ TLD results (RT)	JI
		∗ Ionization chambers (RT)	LC
		∗ TLD results (RP)	FP
06/10	am (9:00)	PROJECT E3.02: DOSE ASSURANCE	PA
		• The IAEA/WHO TLD postal service	JI
		∗ Operation of the TLD postal service	BP
		∗ Analysis of TLD results for hospitals	
		∗ On-going developments	JI
		• The high-dose dosimetry programme	KN
		∗ Operation of the IDAS postal service	KM
		∗ Analysis of IDAS results	RG
			KM
	pm (13:30)	PROJECT E3.03: TRANSFER OF DOSIMETRY TECHNIQUES	PA
		• Co-ordinated Research Projects	All
		• Symposium	KM
		• Publications	PA
		• DIRAC (Directory RT Centres)	HT
		PROJECT E3.04 TECHNICAL CO-OPERATION ACTIVITIES	
		• Training courses and seminars	PA
		• Strategy Plan for the DMRP programme	PA
		• Other	
07-09/10		Meeting of the Committee. Draft report.	

ABBREVIATIONS

BEV	Bundesamt für Eich- und Vermessungwesen (Austria)
BIPM	Bureau International des Poids et Mesures
CRP	Co-ordinated Research Programme
IAEA	International Atomic Energy Agency
DMRP	Dosimetry and Medical Radiation Physics Section
ICRU	International Commission on Radiation Units and Measurements
IDAS	International Dose Assurance Service
NIST	National Institute of Standards and Technology (USA)
NPL	National Physical Laboratory (UK)
NSRW	Division of Radiation and Waste Safety, Department of Nuclear Safety
PTB	Physikalisch-Technische Bundesanstalt (Germany)
NA	Department of Nuclear Sciences and Applications (formerly, RI) IAEA
NAAL	Agency’s Laboratories, Department of Nuclear Sciences and Applications (formerly, RIAL)
NAHU	Division of Human Health, Department of Nuclear Sciences and Applications (formerly, RIHU)
NAPC	Division of Physics and Chemistry, Department of Nuclear Sciences and Applications (formerly, RIPC)
NAFA	Division for Food and Agriculture, Department of Nuclear Sciences and Applications (formerly, RIFA)
RPC	Radiological Physics Center, Houston (USA)
SSC	SSDL Scientific Committee
SSDL	Secondary Standard Dosimetry Laboratory
TC	Department of Technical Co-operation. General abbreviation for Technical Co-operation project.
TLD	Thermoluminescent Dosimeter
WHO	World Health Organization

COURSES AND MEETINGS TO BE HELD DURING 1999

Training Courses in the field of Dosimetry and Medical Radiation Physics

- Interregional Training Course on **Calibration Procedures and Quality Assurance in SSDLs**, 27 September-8 October 1999, Havana, Cuba.
- Regional Training Course on **Modern Techniques and Dosimetry in Brachytherapy,** 1999, Cairo, Egypt (exact date not yet known)
- Regional training Course on **Clinical Treatment Planning for Teletherapy and Brachytherapy**, Palanga, Lithuania, 7-18 June 1998
- AFRA Workshop on **Harmonised Methods of Beam Calibrations in External Radiotherapy**, June 1999, Rabat, Morocco.
- IAEA/ESTRO Workshop on **Quality Assurance Networks for External Audits in Radiotherapy** (during the International Conference on Medical Physics), Patras, Greece, 31-August-4 September 1998 (workshop duration 1.5 day).

Meetings

Consultant's Meeting to develop brachytherapy calibration procedures for SSDLs	Vienna	May 1999
Consultant Meeting on the organization of regional education programmes in medical radiation physics and preparation of a "Primer in Radiotherapy Physics"	Vienna	To be scheduled
Consultant Meeting on dosimetry in diagnostic radiology,	Vienna	May 1999
2nd Research Co-ordination Meeting on development of procedures for the determination of absorbed dose with therapeutic photon, electron and proton beams based on measurement standards of absorbed dose to water	Brussels	3-7 May
Consultant Meeting on qualify assurance methods for radiotherapy dose calculations and computerized treatment planning system	Vienna	To be scheduled
Consultant Meeting on the verification of the Code of Practice for radiation measurement with parallel plate ionization chambers	Vienna	To be scheduled
Consultant Meeting on quality assurance programmes for radiation therapy dosimetry in developing countries	Vienna	To be scheduled
Consultant Meeting on evaluation of high dose reference dosimetry techniques	Vienna	May 1999
3rd Research Co-ordination Meeting on Development of Quality Assurance Procedures for SSDLs.	Vienna	29 November-03 December 1999

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