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SSDL Newsletter

IAEA/WHO NETWORK OF
SECONDARY STANDARD DOSIMETRY LABORATORIES

No. 31 DECEMBER 1992

Prepared by the Joint IAEA/WHO Secretariat of the SSDL Network
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REPORT ON THE FIFTH MEETING

OF THE SSDL SCIENTIFIC COMMITTEE (SSC)

Vienna, 23-27 November 1992

1. FOREWORD

Historical review on the IAEA/WHO Network of SSDLs and the report on the previous meeting of the SSC (held in November 1990) were published in the SSDL Newsletters No. 29, April 1990, and No. 30, April 1991.

The fifth meeting was held in Vienna at the Agency's headquarters from 23 to 27 November 1992. For the first three days, agency staff presented reports on their various activities and a visit was made to the IAEA Dosimetry Laboratory outside Vienna in Seibersdorf. For 2 days the SSC met in closed session deliberating recommendations. The participants in the meeting are listed in Appendix I and the agenda is Appendix II.

2. INTRODUCTION

Today there are an estimated 6000-7000 megavoltage therapy units (cobalt 60, and photon/electron accelerators with energy exceeding 3 MeV) in use worldwide, treating 2,500,000 patients yearly. Historically an accuracy of $\pm$ 5% in the delivery of the prescribed dose has been the goal. Data suggests that more than 10 % of the patients receive doses that differ from the prescribed dose by more than 20%, 4 times the goal, through lack of proper equipment, personnel or training. Thus, at least 250,000 patients annually receive poor radiotherapy. The IAEA and WHO have recognized the need to make access to radiation standards traceable to the international measurement system available to every radiotherapy centre and to develop quality assurance procedures to identify and resolve discrepancies in the dose delivery to patients.

In recent years linear accelerators, many with electron beams as well as photon beams, are replacing cobalt 60 as the major megavoltage treatment modality, even in developing countries. This suggests strongly that quality assurance programmes should also include high-energy x ray and electron capabilities, as well as cobalt 60. Brachytherapy including high-dose rate applicators are also becoming widespread.

Other areas of radiation dosimetry including high-dose applications (sterilization, food processing, and blood irradiation), diagnostic radiology, nuclear medicine and radiation safety are also of interest. Although the levels of accuracy are lower, these modalities would benefit greatly from access to the international measurement system and to efforts to monitor radiation dose.

3. TRENDS IN RADIATION DOSIMETRY AND THE IAEA/WHO SSDL PROGRAMME

The SSDL programme has extended to many developed countries and to virtually all developing countries who have radiation therapy capabilities. The SSDL Network is becoming a more and more important tool for quality assurance, not only providing radiation standards for radiotherapy but extending to radiation safety and to concern for the radiation dose delivery to individual patients in the hospital. As the quality of the SSDLs improves and the resources of the Agency laboratory are limited, it is becoming increasingly important for the SSDLs to assume more responsibility for assuring the quality of the therapy treatment at the hospitals in their region. This includes responsibility for providing follow-up when a significant discrepancy in dosimetry is suspected in a hospital. Specifically SSDLs now organize regional training sessions in their area and a number of SSDLs have established their own mailed TL dosimetry service to spot check basic machine calibration. A number of SSDLs also carry out more complete checking of dosimetry at the local centres through established routines of site visits.

There is a worldwide trend in increasing quality assurance of radiotherapy treatments. Besides the SSDLs, several other scientific bodies have set up programmes in quality assurance of treatment in the hospital which are parallel to some Agency programmes. It is also increasingly obvious that the Agency does not have the resources to provide quality assurance to all radiotherapy centres. The Agency can serve a very important role in coordinating quality assurance programmes to minimize duplication of effort and to identify radiotherapy centres in the world who have access to quality assurance from either the SSDLs or the other scientific bodies.

Brachytherapy, particularly intracavitary treatment for cervix cancer including high--doserate afterloading techniques, continues to grow, as does the need for radiation safety and quality controls. Efforts in radiation safety (i.e. radiation protection of personnel) and quality assurance should continue and brachytherapy should be addressed by the Agency as soon as practical.

There is an increased use of high and medium dose irradiators for products sterilization, food preservation, and blood component irradiation. It is important for the Agency to continue to help the development of dosimetry systems for these dose ranges. Alanine/ESR appears to be such a dosimetry system for high-energy photon irradiations, with promise for electron dosimetry and for dose levels appropriate for radiation therapy. It is appropriate for the Agency to continue to help the development of alanine as a dosimeter.

4. REPORT

The SSC was presented with reports on the many facets of the Dosimetry Section programme. This report will not summarize these reports, rather will discuss only those aspects of the programme about which the SSC offers comment, recommendations, or direction.

4.1. PROJECT E.3.01 - SECONDARY STANDARD DOSIMETRY LABORATORIES (SSDL) NETWORK

There are presently 71 SSDLs in 50 countries providing radiation dosimetry services in radiation therapy, radiation safety, etc. The network has reached a plateau were virtually all countries which have radiotherapy capabilities, do have access to radiation standards traceable to the international measurement system through the SSDL Network. The Agency effort today should go toward maintaining, utilizing, and coordinating the SSDL activities. The Agency must continue to transfer technology and responsibility to the SSDLS. while developing mechanisms to strengthen the scientific link between the Agency, the SSDLs and the radiotherapy centres themselves.

4.1.1. CRP ON THE PRACTICAL PROBLEMS ENCOUNTERED IN CALIBRATION PROCEDURES IN THE SSDLs

The Agency presented data to the SSC outlining a comprehensive internal quality control and quality assurance programme linking their standards and programme to the international measurement system. The SSC appreciates the quality of the Agency's SSDL in Seibersdorf. However, it is obvious from data presented to the SSC, that some SSDLs could benefit from improved internal quality assurance procedures at their own SSDL. It was also obvious that efforts presently made by the Agency to follow up on suspected discrepancies is not accomplishing that end. The SSC recommends that several qualified experts be brought to Vienna in 1993 to review the SSC recommendations below and produce a programme to be developed and implemented by this CRP. The SSC recommends that the SSDLs have substantial representation on the CRP.

The SSC suggests that this CRP produce a code of practice for quality assurance within an SSDL and with the Agency. This should:

- Discuss the scientific link between the SSDL radiation standards and the Agency's radiation standards. Both the mailed TL dosimetry programme and the CARE programme should be utilized;

- Continue to extend the TLD and CARE programme to radiation safety programmes;

- Develop procedures for follow-up action to resolve potential discrepancies identified by either the CARE or mailed TL-programme;

- Include procedures for internal coherence (quality assurance) within an individual SSDL;

- Encourage and develop procedures for inter-SSDL comparisons to provide cross linking of standards.

4.1.2. REVISION OF TECHNICAL REPORTS SERIES (TRS) No. 277: ABSORBED DOSE DETERMINATION IN PHOTON AND ELECTRON BEAMS - AN INTERNATIONAL CODE OF PRACTICE

Much data has been collected on the code of practice. The results can be summarized in 3 areas. A Consultants' Meeting (CS) to discuss these considerations is scheduled.

a) Calibration of high energy photons and electrons using cylindrical chambers in water

Reports suggest that there may be minor updates in some data in TRS No. 277, however they introduce changes of less than 0.5 %. Further data suggests that the precision is comparable whether chambers are calibrated in air kerma or absorbed dose to water. The Agency proposes to publish these results with a recommendation that no change be made to the protocol for these energies. The SSC strongly concurs.

b) Conventional x-ray calibration

There are indications that errors as great as 8% can be incurred at conventional x-ray energies. The SSC recommends that:

- A warning to that effect be published in the SSDL Newsletter;
- The warning be printed and inserted into all copies of TRS No. 277 to be distributed;
- The warning be incorporated into any future printing or translation.

c) Low energy electrons measured with a plane parallel chamber

There is much discussion in the literature of the techniques (including problems) of calibration and use of plane parallel chambers. The Agency proposes a CRP on a code of practice for radiation measurements with a plane parallel ionization chamber (in project E.3.03). The SSC strongly concurs, with representation on the CRP from those national groups presently working on this problem.

4.1.3. DIRECTORY OF RADIOTHERAPY EQUIPMENT AND FACILITIES

In the 1970's the IAEA published several directories of radiotherapy equipment and facilities, the latest in 1976 (Directory of High-Energy Radiotherapy Centres, IAEA 1976). This publication was extremely popular. A listing of hospitals, radiation oncologists, and physicists would be very useful to the Agency when planning for and organizing workshops and training sessions. The SSC suggests that an informal list be developed through a letter to the SSDLS. The Agency should consider publishing the lists in the SSDL Newsletter or equivalent publication.

4.1.4. SSDL NEWSLETTER

It is essential for the Dosimetry Section to maintain a communication link with the SSDL Network. The SSC believes that the SSDL Newsletter is an excellent medium for this communication. Due to the effort needed to bring such a publication to press, the SSC recommends that the newsletter be published only once per year. Because of the high demand for this newsletter, the SSC recommends that the copies printed be increased from 400 to 500 copies.

4.1.5. REVISION OF TRS No. 185: CALIBRATION OF DOSE METERS USED IN RADIOTHERAPY

Members of the SSC are invited to send their comments on the draft (July 1992) to the Dosimetry Section by the end of February 1993.

4.2. PROJECT E.3.02 DOSE INTERCOMPARISON AND ASSURANCE

4.2.1. DOSE INTERCOMPARISON FOR COBALT 60 AND LINAC BEAMS IN A REFERENCE GEOMETRY AND DOSE INTERCOMPARISON IN RADIOTHERAPY USING A BODY SHAPED PHANTOM

See discussion of the quality assurance network under project E.3.03 and Appendix III.

4.2.2. ALANINE/ESR DOSIMETRY SYSTEM

The SSC toured the alanine laboratory at Seibersdorf and heard presentations by Dr. Mehta and Mr. Girzikowsky. The SSC is satisfied that the two can work as a team and that Dr. Mehta can take the scientific lead in the alanine project. Alanine continues to show promise as a dosimeter with a wide latitude, small energy dependence and minimal fading. Work to develop this dosimeter should continue, specifically:

a) CRP on therapy level dosimetry with alanine/ESR system

The development of alanine dosimeters for use at therapy levels has not been as rapid as expected. majority of participants in this CRP have changed their priorities and are slow in developing such dosimeters. The SSC therefore recommends that this CRP be terminated and that the effort be continued in conjunction with the CRP on development of alanine samples for ESR (see project E. 3.03).

b) CRP on Development of Quality Control Dosimetry Techniques for Particle Beam Radiation Processing

The second meeting of this CRP has been postponed to 1994. Since Dr. Mehta has assumed responsibility for this programme and since the data requested at the first CRP meeting has been submitted (with one exception), the SSC recommends that the second meeting of this CRP be rescheduled for 1993 rather than 1994, to study closely the data already complete.

4.2.3. BRACHYTHERAPY

At the last SSC meetings, the SSC recommended that a CRP be established to investigate the possible action the Agency can take to improve the care of women with gynaecologic cancers using brachytherapy. The SSC recognized the importance of other intracavitary, interstitial and plaque applications but considered gynaecologic brachytherapy as the highest priority. The Agency was unable to undertake this task in the period 1993-1994. The SSC recommends that this problem be addressed beginning in the period 1995-1996.

4.3. PROJECT E.3.03 TRANSFER OF DOSIMETRY TECHNIQUES

4.3.1. REVISION OF TRS No. 110: MANUAL OF DOSIMETRY IN RADIOTHERAPY, AND TECHNICAL REPORT: CODE OF PRACTICE ON THE CALCULATION OF THE DOSE IN A TARGET VOLUME IN RADIATION THERAPY

The SSC recommends that these two projects be merged into a single document. More extensive work than originally anticipated, will be needed to combine these two, so the report will not be ready by the original time table of 93-94. The SSC recommends that the completion date be extended to 1995-96. The SSC further recommends that the title specify that the document is "A Manual on Determination of Dose in a Target Volume in Radiation Therapy". This manual should have 3 sections:

- Summarize the Code of Practice for determination of dose at a reference point (TRS No. 277) in an early chapter;

- Present a unified methodology for calculating dose to an arbitrary point in an homogeneous phantom starting from the dose at the reference point;

- Provide practical procedures for measuring the dosimetry parameters needed in the unified methodology.

4.3.2. ALANINE DOSIMETRY

a) CRP on development of alanine dosimeters for ESR

There have been very few alanine dosimeters commercially available; however, there are suggestions that new commercial dosimeters may be available in the next several years. The SSC recommends that this CRP begin in several years when more dosimeters are exacted to be available. This CRP should consider dosimeters for high dose, medium dose (necessary for blood irradiation), and therapy level doses.

b) CRP on evaluation of high-dose reference dosimetry techniques

An advisory group meeting is scheduled for spring 1993 which should give guidance to this CRP. The SSC recommends it proceed as scheduled.

4.3.3. CRP ON THE CODE OF PRACTICE FOR MEASUREMENTS WITH A PLANE PARALLEL IONIZATION CHAMBER

This topic is timely and should be pursued.

4.3.4. CRP ON QUALITY ASSURANCE PROGRAMMES FOR RADIATION THERAPY DOSIMETRY IN DEVELOPING COUNTRIES

The SSC commends the Agency on the successful completion (1992) of the CRP on performance testing of radiotherapy equipment. The formal report of this CRP has developed a programme which indicates a new direction to the IAEA/WHO efforts to provide some level of quality assurance to the dosimetry of all radiotherapy facilities in the world (as mentioned in chapter 3). This will be accomplished through a quality assurance network that will provide 3 levels of quality assurance. These levels proceed from assurance of basic calibration (Step 1), through quality assurance of dose delivery to various points of calculation throughout the target of a homogeneous phantom (Step 2), to quality assurance of dose to a generalized target volume including considerations of tissue heterogeneities (Step 3). The plan calls for transfer of technology to various SSDLs or other scientific bodies throughout the world , thus reducing the burden on the Agency.

The Agency mailed TL programme has been expanded to include the calibration check of high energy x-ray and electron beams, and a verification of the quality of the photon or electron beam. The SSC was presented data on the development of the mailed TL programme for high-energy x-rays for this step. The data were developed by the Agency and include determination of the energy response of the TLD as a function of photon energy and correction factors necessary to interpret the beam quality data. Step 1 for x-rays appears highly successful and has already been implemented by the Agency. The CRP also suggested a phantom for verifying the basic calibration of electron beams and developed a phantom to be used for Step 2.

The Agency has already begun to transfer technology to participating pilot reference centres in Europe through ESTRO. ESTRO, through a Technical Contract, has successfully taken over responsibility for Step 1 for photons and is in the process of developing and testing Step 2 for photons. There remain technical questions concerning the phantom and detectors used for Step 2 as well as administrative concerns over proper coordination of the programme with input from the Agency.

The SSC recommends that this CRP (quality assurance programmes for radiation therapy dosimetry in developing countries) be initiated to continue expanding this quality assurance network with 2 major aims:

Aim 1: To transfer assurance of basic calibration, Step 1, to developing countries. This has already begun for cobalt 60 and high energy photon beams. It should also be extended to high energy electron beams.

Aim 2: Continue to develop the methodology to verify dose throughout a homogeneous phantom, Step 2, and establish cooperation with other scientific bodies who have programmes relating to step 2 or step 3. In addition to improving the phantom and dosimeters used, it is imperative to establish channels for cooperation and mechanisms of quality assurance over the programme by the Agency. (See Appendix III for more details).

4.4. TECHNICAL CO-OPERATION

During the 1970's and 1980's, the Agency's principle effort was to establish the SSDL Network. That job is largely done so the Agency now needs to concentrate on maintaining the network, utilizing the network, and assuring the quality of the network. The SSC suggests that support through Technical Co-operation may be needed in the following areas:

- Replacement and updating of old or obsolete equipment at the SSDLs;

- Purchase of TLD equipment for SSDLs to set up TLD programmes to monitor hospitals in their region;

- Travel for experts and possible other procedures to follow up on potential discrepancies identified by the mailed TLD programme;

- To support training courses at an SSDL wishing to upgrade its facilities or extend them to other quality assurance procedures (training courses should be for both SSDL personnel and the users in the hospitals);

- To advance the SSDL link with the Agency standards to a high level of precision through the use of the CARE programme.

4.5. TRAINING PROGRAMME

At the last SSC meeting, the committee commended the Dosimetry Section for transferring responsibility for some training courses to the SSDLs and urged the Dosimetry Section to transfer even more responsibility. This transfer of responsibility continues.

a) TRAINING COURSES ORGANIZED BY THE AGENCY

Four regional training courses (workshops) are scheduled for the coming year:

One scheduled in Australia is designed for SSDL staff and includes lectures and laboratory exercises, principally on metrology.

Three are scheduled in Turkey, Algeria, and Thailand. These are intended to meet the special needs in developing countries, and designed for physicists and radiation oncologists. The SSC strongly urges that in addition to treatment planning, these courses cover all aspects of measurement and calculation. These courses would also be an excellent forum to discuss coordination of the global quality assurance network discussed above.

b) SYMPOSIA

At the 1990 meeting, the SSC recommended that an international symposium be planned. A symposium on Measurement Assurance in Dosimetry is scheduled in Vienna in conjunction with the ESTRO meeting in Prague in May 1993.

c) SEMINARS

A regional seminar on radiotherapy dosimetry is scheduled for Latin America in 1994, tentatively in Mexico City. The SSC discussed the pros and cons of trying to schedule this seminar in conjunction with the International Medical Physics meeting in Rio de Janeiro in August 1994. The SSC suggests the Agency consider the possibility.

d) SEMINARS AND SYMPOSIA WHOSE PROCEEDINGS ARE PUBLISHED BY THE AGENCY

In order to assure high quality scientific content, the SSC recommends that the Agency appoint the chairman of each session to be responsible for scientific review of all papers presented in this session. The Agency found this to work well at the recent workshop in Leuven, Belgium.

4.6. STAFF

The SSC wishes to thank the Director General for the two new posts identified for the Dosimetry Section. This will add welcomed stability to the section by replacing two positions presently filled by temporary assistance staff. Due to the rapid developments in the field, particularly in quality assurance, the SSC feels additional staff support will be needed. It is hoped that additional staff support will be available at least through temporary assistance staff.

5. RECOMMENDATIONS

The SSDL Scientific Committee urges the Dosimetry Section of the IAEA to continue to develop their programme to follow the trends in radiation therapy, specifically to transfer technology to and place responsibility on the SSDLs and other scientific bodies providing similar services. The Agency can then concentrate its efforts on coordinating efforts worldwide and providing direct quality assurance to only those centres not otherwise covered (see Appendix III).

The highest priority for the Dosimetry Section remains monitoring radiation therapy and high dose radiation processing dosimetry. The SSC continues to recommend that radiation protection is also a high priority and that the Dosimetry Section and the Radiation Safety Section continue to collaborate and expand the Agency role in calibration of radiation protection instruments and monitoring personnel. Diagnostic radiology and heavy particle dosimetry continue to need international standardization, however, with limited personnel; the Dosimetry Section cannot be expected to expand these areas at this time.

Various suggestions and recommendations are made throughout the document. However, three specific recommendations are reiterated here.

a) It is essential that the Agency seek new ways to provide technology transfer to the SSDLs and other scientific bodies.

b) The efforts of the Agency must then be directed to quality assurance of the SSDL and other scientific bodies providing comparable services, and to assume responsibility for coordination of the programme worldwide.

c) The Director General is to be thanked for the 2 promised new posts in 1994 replacing the presently available temporary staff; however, because of the additional workload due to rapid development in this field, additional staff support is needed at least through temporary assistance staff.

6. CONCLUSIONS

Review of the activities of the Dosimetry Section and the Dosimetry Laboratory show that the activities cover the principle aims of the Section, and that the laboratories link to the international measurement system is outstanding. The Committee wishes to complement the staff for developing and maintaining the programme and for presenting it coherently to the Committee.

The SSDL Network has been very successful in making access to the international measurement system available worldwide but it will now have to assure the quality of treatment to individual patients. The Agency is on the verge of promoting a global quality assurance network at the local centre level. This network will incorporate efforts from scientific bodies, including the SSDLS, with minimal resources from the Agency. The SSC is confident that this programme will also make a significant impact on patient carte worldwide. Alanine/ESR dosimetry system appears near fruition as a high-dose dosimeter for both photons and electrons and also shows promise as a radiotherapy dosimeter.

Lastly, the SSC wishes to commend the Agency for its continued support for this essential programme. The SSC also commends the Dosimetry Section staff for their competent and professional implementation of their programmes.

ABBREVIATIONS

BIPM	Bureau International des Poids et Mesures
CARE	Coherence and Accuracy of Reference Instrumentation
CRP	Coordinated Research Programme
CS	Consultants' Meeting
ESR	Electron Spin Resonance
ESTRO	European Society for Therapeutic Radiology and Oncology
IAEA	International Atomic Energy Agency
ICRU	International Commission on Radiation Units and Measurements
NENS	Division of Nuclear Safety
PSDL	Primary Standard Dosimetry Laboratory
SSC	SSDL Scientific Committee
SSDL	Secondary Standard Dosimetry Laboratory
TLD	Thermoluminescent Dosimeter
WHO	World Health Organization

Appendix I

PARTICIPANTS

Committee members:

A. Allisy, ICRU, Chairman of SSC

K. Chongkitivitya, Thailand

W.F. Hanson, USA

H. Järvinen, Finland

A. Leitner, Austria

J.W. Müller, BIPM

IAEA staff members:

P. Bera, Dosimetry Laboratory

L. Czap, Dosimetry Laboratory

R. Girzikowsky, Dosimetry Laboratory

R. Griffith, Radiation Safety, Division of Nuclear Safety

K. Mehta, Dosimetry Section

P. Nette, Head, Dosimetry Laboratory

H. Svensson, Head, Dosimetry Section, Division of Life Sciences, IAEA Secretary of the SSDL Network

K. Zsdánszky, Dosimetry Section

WHO staff members:

G. Hanson, WHO Secretary of the SSDL Network

Appendix II

A G E N D A

- Opening address by Dr. S. Machi
  Deputy Director General, Department of Research and Isotopes
- Introductory remarks by Dr. G. Hanson and Dr. H. Svensson
  Secretaries of the IAEA/WHO SSDL Network
- Adoption of the Agenda
- Nomination of Rapporteurs

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2.	Overview of the programme by the Dosimetry Section	Hans Svensson
3.	The dose intercomparison programme, therapy level	Hans Svensson
4.	Statistical data on the SSDL Network	Kálmán Zsdánszky
5.	Intercomparison with SSDLs	Peter Nette
	a) Programme CARE	Pranabes Bera
	b) TL-postal dosimetry	Ladislav Czap
6.	TL-postal dosimetry for hospitals	Hans Svensson
	a) Summary of old data (until 1987)	Peter Nette
	b) Recent values	Pranabes Bera
7.	The Quality Assurance network	Hans Svensson
	a) IAEA-measurements	Peter Nette
	b) Transfer of the programme to Europe	Pranabes Bera
	c) Transfer to other regions	Ladislav Czap
8.	TLD-method extended to high-energy photons	Hans Svensson
	from accelerators; Results	Peter Nette
	Plans for electron beams	Pranabes Bera
9.	General discussion of the dose intercomparison programme	Chairman of SSC
10.	Calibration of reference instruments of the IAEA-SSDL	Peter Nette
		Ladislav Czap

11.	IAEA activities on high-dose measurements	Kishor Mehta Reinhard Girzikowsky
12.	Coordinated Research Programmes (CRPs)	Hans Svensson Kishor Mehta Peter Nette
13.	Publications	Hans Svensson
14.	Training courses, seminars and symposia	Hans Svensson
15.	Technical Cooperation programmes	Hans Svensson
16.	Radiation Protection Activities in NENS	Richard Griffith
17.	Dosimetry programme of the IAEA in 1993-1994 and 1995-1996	Hans Svensson
18.	Staff situation	Hans Svensson
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STRUCTURE OF THE IAEA/WHO GLOBAL QUALITY ASSURANCE PROGRAMME FOR RADIATION THERAPY

The IAEA/WHO SSDL programme has historically had two goals:

- To provide easy access to radiation standards traceable to the international measurement system (through chamber calibrations);
- To provide some level of assurance that the radiation dose to patients is clinically comparable throughout the world (through a mailed TLD programme).

The workload at the Agency Dosimetry Laboratory continues to be at capacity without being able to satisfy both of the above goals. It is obvious that technology must be transferred to other scientific bodies to relieve the burden on the Agency. The Agency's role then becomes one of maintaining an adequate quality assurance programme to assure that the technology transfer is complete and correct.

The SSC believes that the SSDL Network has been very successful in providing easy access for calibration of instruments. Now that the SSDLs have been established, the role of the Agency is to provide metrological quality assurance by an independent verification of the ability of an SSDL to provide a correct calibration factor. This is accomplished through a mailed TLD programme and the CARE programme. These quality assurance programmes must be provided for all SSDLs and must come from the Agency. The CRP on practical problems in the SSDL (E.3.01 #8) speaks to refining this link.

The SSC believes that the SSDL Network has yet to be successful in providing some level of quality assurance for the delivery of dose at hospital level. The recently terminated CRP on performance testing of dosimetry equipment has outlined a programme for extending the level of quality assurance at the hospital level, and providing important mechanisms for follow-up on discrepancies discovered at participating hospitals. This has been termed the global quality assurance network.

The SSC recommends that the implementation of the global quality assurance network be a priority for the Agency. The Agency will play the major role as overall coordinator of this programme. In addition, the Agency will be responsible for quality control of the coordinating centres and national/regional centres in the programme through intercomparison of methodologies and quality audits with mailed dosimeters or other mechanisms. The Agency will also be responsible for providing quality assurance for those local centres not otherwise covered by the network. This may be through coordinating national/regional programme or by direct mailed TLD to the local centre.

Figure 1 outlines the IAEA/WHO co-ordinated quality assurance programme as envisioned by the SSC.

IAEA/WHO CO-ORDINATED QUALITY ASSURANCE PROGRAMME: RADIOTHERAPY DOSIMETRY

METROLOGY
Accuracy: ± 1 %

Q. A. OF PATIENT CARE
Accuracy: ± 5 %

IAEA/WHO SSDL NETWORK

GLOBAL Q.A. NETWORK
Co-ordinated by IAEA/WHO

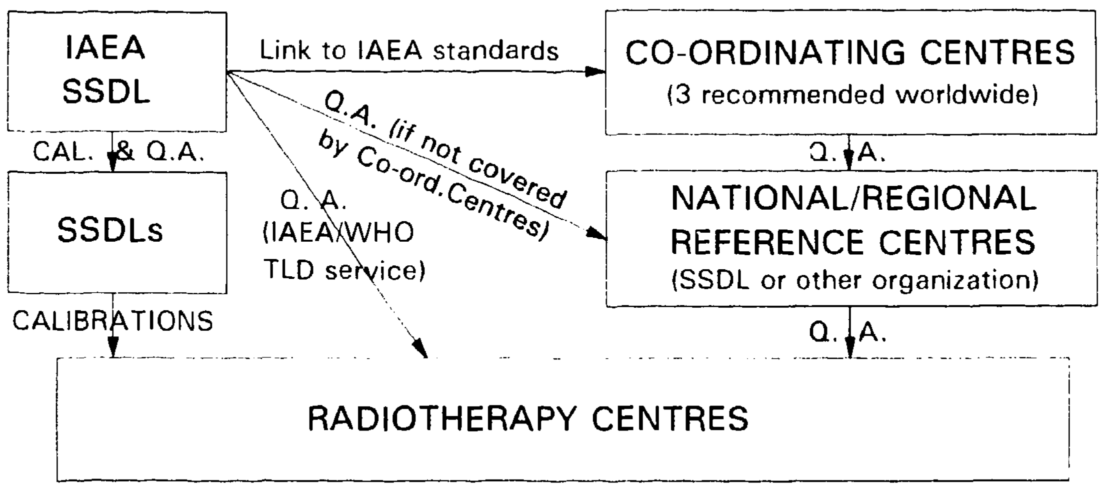

Figure 1. shows the relationship between the components of the IAEA/WHO co-ordinated quality assurance programme on radiotherapy dosimetry as outlined in this report.

Quality Assurance Network for Radiotherapy Dosimetry: I. The Programme

H. Svensson, IAEA, Vienna

The IAEA/WHO postal dosimetry intercomparison service was introduced in the late 1960's and is still increasing in volume. The technique has already been described [1,2] and results have been given for the period 1969-1987 [3]. The results showed that for $^{60}Co-\gamma$ the standard deviation of the dose value was fairly large 6.7% including results from measurements in almost 2000 beams and that 11% of the hospitals were off in dosimetry at least once with more than 20% [3]. Significant improvements were observed for those participating more than once in this service.

In modern radiotherapy it has been stressed that the accuracy, or at least the repeatability, in the delivery of a dose should be within 5% [4]. Even a higher accuracy is considered to be desirable for some treatments [5). To be able to deliver a dose within 5% to a target volume would require an accuracy of about 3% in the reference point using a confidence limit corresponding to 1 σ [6]. The IAEA/WHO postal dosimetry showed that this accuracy was far from being met and that there is a great need to extend this service.

The IAEA/WHO postal dosimetry service was restricted to measurements in a reference point for $^{60}Co-\gamma$ radiation. A coordinated research programme (CRP) was set up to extend the service to photon and electron beams from accelerators and also to different points in an irregular phantom simulating patient irradiation.

The increased service would require much more resources which are not available at the IAEA dosimetry laboratory. A pilot study is now under way to investigate a) if there are problems in extending the service to photon and electron beams from accelerators, b) if the service also can include dose measurements in a patient shaped phantom and, finally, c) if the service in part could be transferred from the IAEA to regional or national reference centres in some of the more developed parts of the world. A three-level procedure was suggested in the CRP (Fig. 1). The first step in this programme will be reported below in a separate paper. The second step will include intercomparisons using an irregular phantom. These measurements will also make it possible to check the accuracy in dose-planning. Different phantoms have been constructed and tested. Finally, the third step would either include measurement using a patient-like phantom or in-vivo dose measurements. This step is still under consideration.

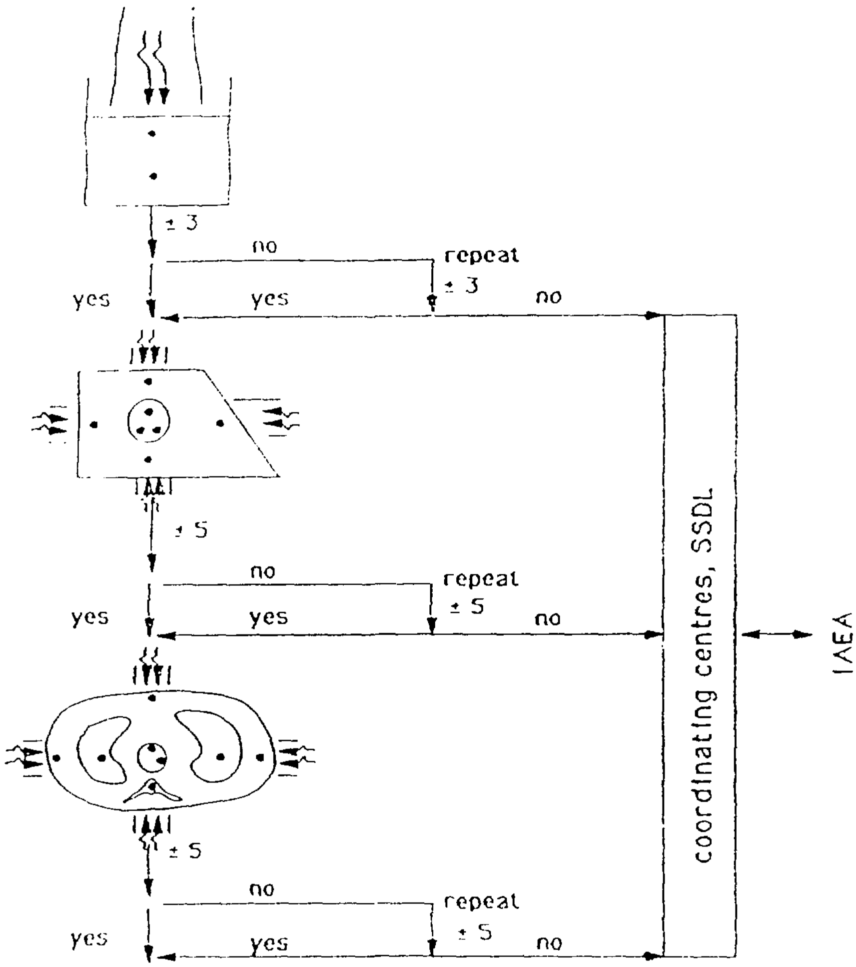

Figure 1 Scheme of the 3 levels of Quality Audit networkmailed dosimetry programme. The acceptable deviations compared to the reference standard are those given by EORTC (European Organization for Research and Treatment of Cancer, Ref. 6). Larger discrepancies are resolved through dosimetry review by coordinating centres or by the SSDL. (The EORTC recommend site visits in their Quality Audit programme. It might be necessary to accept in a mailed dosimetry system at least in a first phase, somewhat larger deviations.)

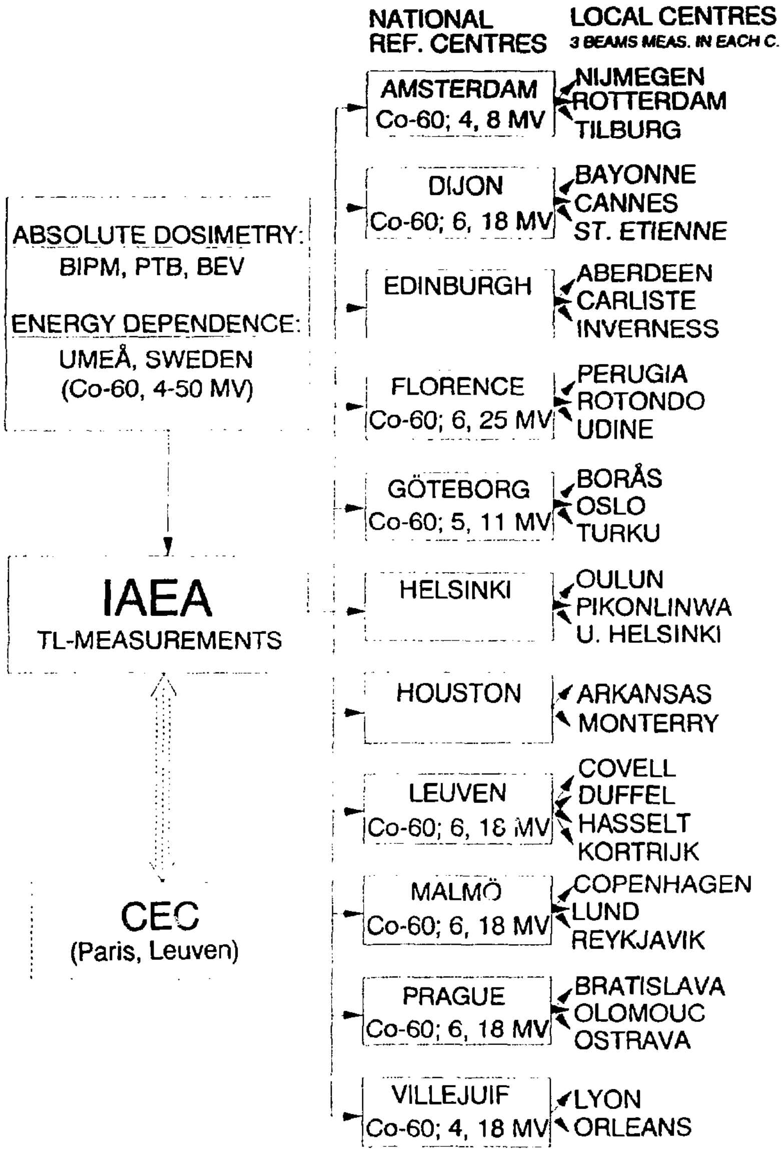

Figure 2 Centres participating in level 1 pilot study. The C.E.C. group has repeated these measurements, but with somewhat different division into national centres. Also, each national reference centre will be responsible for more local centres than according to this pilot study.

TABLE I

CRP participants:

A. DUTREIX	Radiotherapy Department, University Hospital St-Rafael, Leuven, Belgium
W. HANSON	Radiation Physics Department, MD Anderson Cancer Center, Houston, Texas, USA
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The participants in the CRP (Table 1) all came from very advanced departments, below named reference centres. The first test of level 1 (Fig. 1) was made by the reference centres. IAEA-supplied dosimeters which were irradiated by the reference centres and the stated dose values by the centres were compared with the measured dose, see separate paper.

In a future structure each reference centre will be responsible for the coordination of neighbouring centres. To test also this situation the IAEA sent TL dosimeters to the reference centres for further supply to neighbouring centres (see Fig. 2).

The test of step 1 has been successfully completed. Indeed, the CEC now sponsors a programme for Europe very similar to that by the IAEA. Parallel measurements have been made by this group and IAEA. A central measuring centre has been set up, taking over the programme by IAEA in Europe. This centre will give service on TL-dosimetry to national reference centres. Each of these centres will then organize the service in its own country (see Fig. 2) but using the supplied TL-dosimeters.

The IAEA can now transfer the first step of this programme to developing countries. A co-ordinated research programme will be set up 1993/94 covering developing countries.

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Quality Assurance Network for Radiotherapy Dosimetry:
II. Measurements Procedures and Results

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BASIC DOSIMETRY

The IAEA-calibrations are directly traceable to BIPM. The IAEA calibrates its secondary standard (NPL therapy secondary standard NE 2561) regularly at the BIPM and calibrations are also made frequently at national primary standards dosimetry laboratories. The air-kerma calibration value for our secondary standard chamber from 1987 is according to our most recent calibration at BIPM still valid (Table 1).

TABLE I: INTERCOMPARISON BETWEEN BIPM, PTB, BEV AND IAEA. THE IAEA MEASUREMENTS WERE MADE WITH AN IONIZATION CHAMBER AT THE THREE LABORATORIES

Date	Intercomparison
June 1991	$\frac{K_{air}\,(IAEA)^{a)}}{K_{air}\,(BIPM)} = 1.000$
June 1991	$\frac{D_w\,(IAEA)^{b)}}{D_w\,(BIPM)} = 1.001$
February 1990	$\frac{D_w\,(IAEA)^{b)}}{D_w\,(PTB)} = 0.998$
February 1990	$\frac{D_w\,(IAEA)^{b)}}{D_w\,(BEV)} = 1.001$

[a)] Based on an earlier BIPM calibration (from 1987)

[b)] The absorbed dose to water was determined by the IAEA using the *TRS 277*

IAEA uses the TRS 277 [1] to determine the absorbed dose to water from the air-kerma calibration. Intercomparisons with BIPM show that this method gives a very high accuracy, within parts of one per cent. Intercomparisons between IAEA, PTW, and BEV of absorbed dose determinations confirm these results, Table 1. Also, the TL-dosimeters were intercompared at the BIPM and BEV and are in fair agreement considering a repeatability in the method of about 2% (2 σ), Table 2.

TABLE II: INTERCOMPARISON BETWEEN BIPM, BEV AND IAEA. THE IAEA REFERENCE TL-DOSIMETERS HAD BEEN CALIBRATED USING TRS 277. DOSIMETERS WERE SENT FROM IAEA TO THESE LABORATORIES FOR IRRADIATION

Date	Intercomparison
February 1990	$\frac{D_w\,(IAEA/TLD)^{a)}}{D_w\,(BEV)} = 1.016$
December 1990	$\frac{D_w\,(IAEA/TLD)^{a)}}{D_w\,(BEV)} =$ 0.982, 0.992, 0.982
December 1990	$\frac{D_w\,(IAEA/TLD)^{a)}}{D_w\,(BIPM)} =$ 0.983, 0.993

QUALITY DEPENDENCE OF THE TLD SYSTEM

TL-dosimeters have a response depending on the radiation beam quality. The response is a complicated function of many influencing parameters (stopping-powers, attenuation coefficients, scattering powers, etc. for water, dosimeter capsule and TL-powder). The best way to determine the response variation with the radiation quality is by experiment. BIPM does not have a calibration service for high energy x-rays. Primary standards for high energy x-rays are under development in some of the PSDLs. There is, however, a long experience in this field at many research departments. The Radiation Physics Department of Umeå has a research team working in this field since early 1960's involving measurements carried out using water-calorimeter [2], ferrous sulphate dosimeters [3], and liquid ionization chambers [4]. These types of dosimetry systems should have a very small or insignificant quality dependence and it should be possible to determine the radiation quality dependent of the TL dosimeter using these systems as a reference. Furthermore, the department has a variety of beam qualities including $^{60}Co-\gamma$ and x-ray beams in the range 4-50 MV. The basic dosimetry was checked using the CARE system.

The quality dependence of the TL-dosimeters has been determined at the department in Umeå. The TL-dosimeters were irradiated at 5 cm depth for D20/D10 ≤ 0.6 and at 10 cm depth for D20/D10 > 0.6 using the perspex tube holder shown in Figure 1.

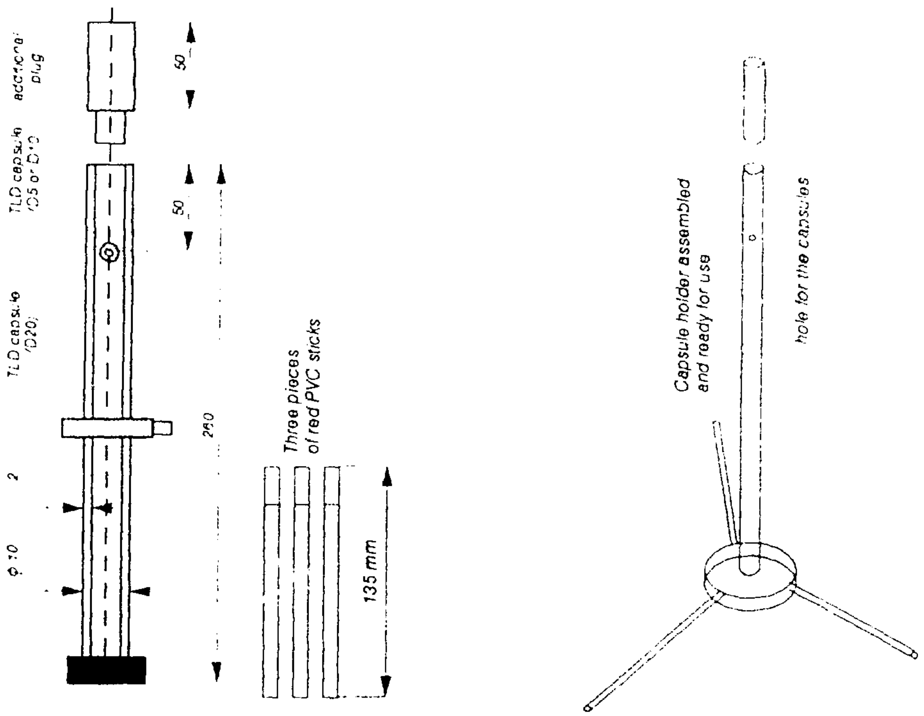

Figure 1 The TL-dosimeter holder for irradiation using a vertical beam is shown. The holder consists of a lucite tube with two holes for TL-dosimeters. An additional solid lucite plug is used for measurements at 10 cm depth and for determination of D20/D10. The holder is placed in a water bucket for the irradiation. The bucker should have a diameter of about 30 cm (or more). The top of the lucite tube should be at the water surface for dosimeter irradiations at 5 cm depth. The top of the plug should be at the water surface for dosimeter irradiations at 10 cm or for D20/D10 determinations. The irradiations are made through the water surface with the beam axis on the lucite tube direction.

In IAEA, the TL-dosimeter calibration values, valid for ^{60}Co-γ, have been applied at all beam qualities. Compared to the reference measurements at the Department in Umeå, a small increase in the response of the TL-dosimeters is observed as a function of the accelerating potential. This increase is 2.5% (Fig. 2) at a Quality Index (D20/D10) of 0.66 (≈ 21 MV). The indicated line in Figure 2 has been used for radiation beam quality corrections of the TL-dosimeter readings.

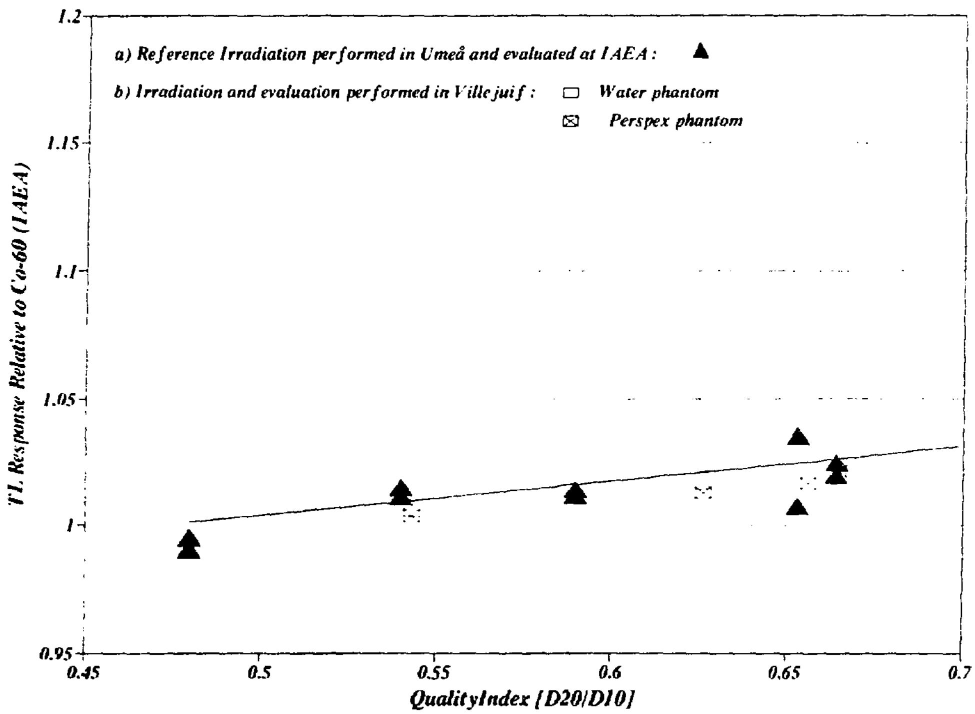

Figure 2 The relative response of TL-dosimeters irradiated at the reference depths using the Umeå dose measurements as a reference. The values from Villejuif are based on TLD powder of a different make than the TLD powder used in IAEA and were normalized to Co-60 radiation quality.

Similar measurements were performed at all the centres included in the intercomparison. The spread is now much larger but at least all these measurements indicate that the quality dependence is in agreement with that determined in Umeå given as the line in Figure 3.

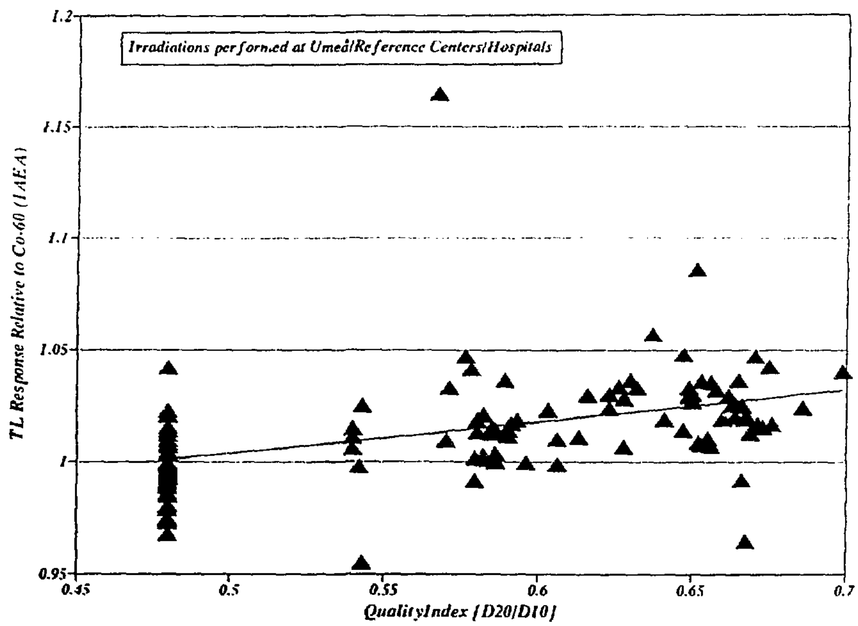

Figure 3 **Same types of measurements as in Figure 2 but now including all participating centres. The reference line derived from the measurements in Umeå is also shown.**

BEAM QUALITY

TRS 277 recommends the ratio of the values obtained from dose measurements at 20 cm and 10 cm depths as an index on the beam quality. Such measurements could either be done using a fix SSD (D20/D10) or a fix source-to-chamber distance (TPR_{10}^{20}). The field size is set to 10 cm x 10 cm on the phantom surface or at the chamber distance, respectively. The quality index measured with an ionization chamber in a water phantom and that measured with the TL-dosimeters differ somewhat. The reason is that the plastic tube used in the water phantom to keep the TL-dosimeters, disturbs the radiation dose distribution to be measured. Also the dosimeter at 10 cm depth might disturb that at 20 cm depth. A correction was applied considering these facts. The expected values in the measurements from the Umeå-results should then be obtained. The results seem reasonable. All measured TL-indices would then agree within 0.02 Q.I. units with ionization chamber measurement values (Fig. 4).

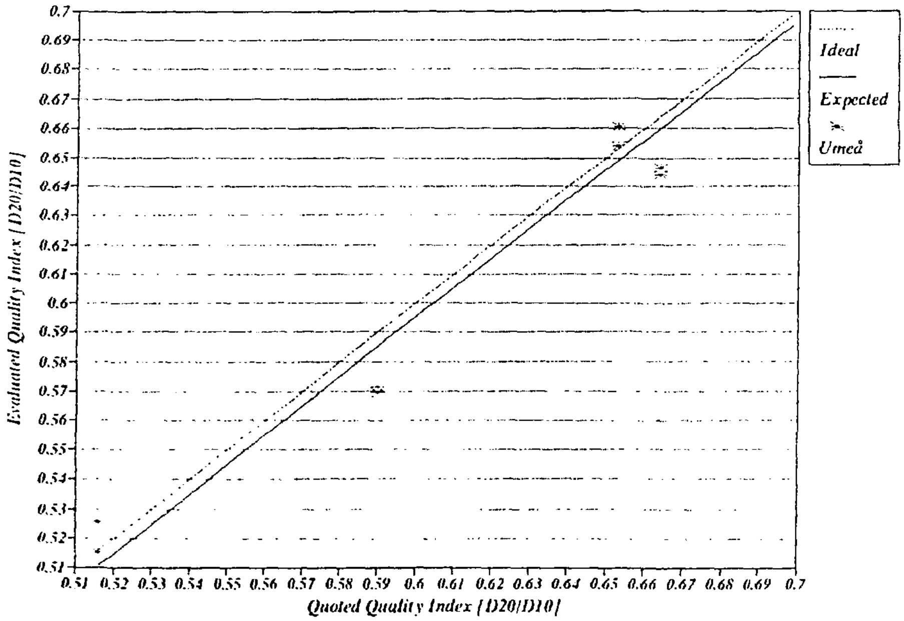

Figure 4 Quality index (D20/D10) measured in Umeå, using TL-dosimeter holder, as a function of D20/D10 measured with an ionization chamber in a water phantom without the TL-holder (see Fig. 1). The expected line is obtained using a correction for the holder and one TL-dosimeter when irradiating the two TL-dosimeters.

Results from all the centres are compiled in Figure 5. The TL-measured D20/D10-values are as a mean 0.01 units lower than the expected values. The reason should further be analyzed. For instance, in some cases the depth dose curves used for the determination are based on diode measurements. At least earlier diodes did not always give correct relative depth dose curves.

As the calibration curve for the TL-dosimeters is a fairly slowly varying function with Q.I. (see Fig. 2) the accuracy in the absorbed dose determination would not significantly be influenced of the uncertainty in TL measured Q.I.

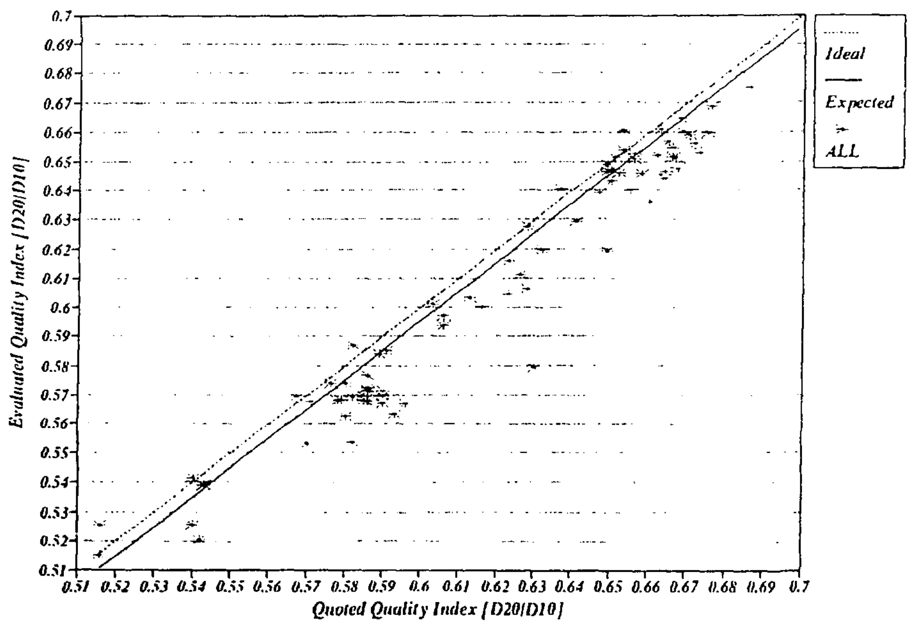

Fig. 5 **Same measurements as in fig. 4, but now including all centres.**

INTERCOMPARISON OF ABSORBED DOSE IN A REFERENCE POINT

The calibration curve for the TL-dosimeters (inverse of Fig. 2) has now been used to determine the dose values in 115 beams from al' those centres participating in the service (see paper I). There are only 7 beam calibrations outside ± 3%, see Figure 6. The mean deviation is only 0.1% and the standard deviation 2.2% (excluding one centre which is far outside the rest of the results would have given a mean deviation of - 0.1% and σ = 1.6%). There is therefore a considerable improvement compared to results from the 1970's and 1980's, but still some centres need to improve.

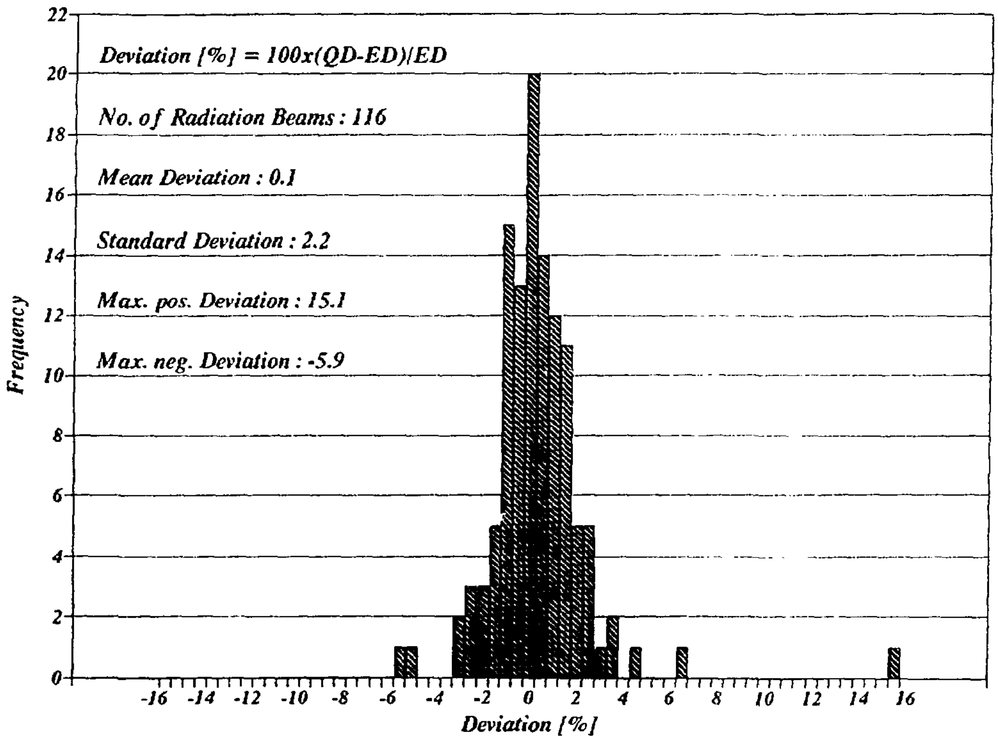

Fig. 6 **Results from dose intercomparison measurements. The participants listed in paper I have participated. The calibration curve from Figure 2 has been used for high-energy photon radiation.**

CONCLUSION

The first step in a quality audit network has been tested in mainly Europe. This pilot study gives very encouraging results and shows

- that it is feasible to organize this type of network,
- that the extension of the TL-service from Co-60 beams to high energy x-ray beams is well functioning,
- that there has been a considerable improvement in the accuracy in dosimetry at the hospitals but still some hospitals are off in dosimetry by more than what should be considered acceptable in modern radiotherapy.

In a separate investigation by a CEC group, it is shown that the procedure could now be used in Europe. The IAEA will now include the developing world in this programme.

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IAEA ACTIVITIES ON HIGH-DOSE MEASUREMENTS

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Introduction

While radiotherapy application involves doses in the range of 1 to 100 Gy the radiation processing technology invokes higher absorbed doses - in the range of 0.1 to hundreds of kGy. Increased understanding of the benefits of ionizing radiation technology in modern industry has led to its wider use. It is now an indispensable tool in many areas and is used extensively to sterilize medical products and in the plastics industry for curing, crosslinking, polymerizing and grafting materials. Radiation also has unique advantages for food preservation and these will be more fully exploited as regulatory approvals for food treatment is achieved. The effects of radiation in these processes are well understood and new product development is continuing. On the other hand, new uses such as generation of novel and valuable chemicals from biomass are still at the frontiers of development.

Several guidelines and standard practices have been developed - and are frequently updated - by international organizations, such as ISO, ASTM and AAMI [1-6]. These publications provide recommendations for the radiation processes, such as sterilization and food irradiation, that should be followed. One of the principal concerns of all the guidelines is process validation, the objective of which is to establish documentary evidence that the radiation process will reliably achieve the desired results. The key element in this is a well understood, reliable dosimetry system that is traceable to a Primary Standard Dosimetry Laboratory (PSDL).

To help the developing member states to establish such a dosimetry system in particular, and the radiation processing technology in general, the Agency started the High-Dose Dosimetry Programme in 1977. Table I [7] depicts the progress of this programme from the beginning. This programme is now firmly established and has created a strong impact in the processing industry. It has helped several laboratories and industrial facilities in the developing countries to install the new technology in a confident fashion. During this period three Co-ordinated Research Programmes (CRPs), two dose inter-comparisons and two international symposia were carried out. The principal vehicle of this achievement has been the International Dose Assurance Service (IDAS).

Progress of IDAS

In 1985 when the IDAS programme was initiated it was a bold decision to use alanine/ESR as a transfer dosimetry system. This decision has now been vindicated. In those days not a single Secondary Standard Dosimetry Laboratory (SSDL) or a PSDL was using this system. On the other hand, today nearly every one of them is in the process of establishing that system as expeditiously as possible. In 1985, Agency did not have the required equipment and expertise to operate this dosimetry system and thus Gesellschaft für Strahlen- und Umweltforschung mbH (GSF) (recently renamed to GSF-Gesellschaft für Umweltschutz und Gesundheit GmbH) of Munich, Germany was selected to provide the dosimeters as well as the analysis service on a contractual basis. That arrangement worked

TABLE I. HIGH DOSE STANDARDIZATION PROGRAMME

1977	Initiation of programme
1977-1983	World survey of high dose facilities
1977-1982	Dose intercomparison studies (gamma)
1978-1983	CRP, *High Dose Standardization and Intercomparison for Industrial Radiation Processing*
1982-1985	Dose intercomparison studies (electron)
1982	Seminar on high dose dosimetry in industrial radiation processing
1983-1986	CRP, Electron High Dose Intercomparison for Radiation Processing
1983	Pilot dose assurance service (gamma)
1984	International Symposium on High Dose Dosimetry
1985	International Dose Assurance Service (IDAS)
1988-1993	CRP, Development of Quality Control Dosimetry Techniques for Particle Beam Radiation Processing
1990	International Symposium on High Dose Dosimetry for Radiation Processing

CRP = Co-ordinated Research Programme

well for several years in spite of many shortcomings. For several reasons, however, it was decided about three years ago to be in a position to operate the alanine/ESR dosimetry system from the IAEA Dosimetry Laboratory in Seibersdorf. The reasons included: lack of proper traceability to a PSDL, need to have a total control over the programme to avoid unnecessary administrative complexity, and desire to exploit the ESR technology for other applications. As a first step to accomplishing this, an ESR spectrometer (ESP-300-9/2.7) from Bruker was purchased and commissioned in the spring of 1989.

Present Status of IDAS

Today the Agency has firmly established a quality-assured alanine/ESR dosimetry system with traceability operating out of IAEA's Seibersdorf Laboratory. We have in-house expertise to operate the ESR spectrometer and the alanine dosimeters are purchased from a Japanese supplier. These "Aminogray" alanine-polystyrene dosimeters were developed under collaboration between JAERI (Japan Atomic Energy Research Institute) and Hitachi Cable Ltd. Based on the recommendations of an IAEA consultant, the spectrometer was recently updated by the manufacturer to include a frequency monitor, an automatic tuning system and a PC connected directly to the spectrometer for convenient data analysis. A temperature control unit that monitors and controls the temperature in the cobalt-60 Gammacell irradiator between -40 and +50 °C is ready for use. This is essential since the ESR response of the alanine dosimeters is influenced by the temperature during irradiation.

The alanine/ESR dosimetry system has now been calibrated over the full range of the IDAS, namely from 0.1 to 100 kGy of absorbed dose in water. For this, three dosimeters were irradiated at each of the 18 dose values in this range.

We consider traceability to Primary Standard Laboratories to be absolutely essential; and from the beginning we have endeavor to do that. As shown in Figure 1, there are three cobalt-60 irradiators at the Dosimetry Laboratory: (i) teletherapy unit (dose rate ~0.3 Gy/min at 80 cm from the source) used for calibrating TL dosimeters and ionization chambers, (ii) Gammacell-1 (dose rate ~4 Gy/min in the center of the irradiation chamber) used for TL dosimeters and alanine dosimeters for IDAS programme, and Gammacell-2 (dose rate ~80 Gy/min in the center of the irradiation chamber) used mainly for alanine irradiation for IDAS. The Gammacell-1 was recently calibrated using Fricke dosimetry system from the German PSDL (PTB). Subsequently, the Gammacell-2 was calibrated against the Gammacell-1 with alanine/ESR dosimetry. Fricke dosimetry from PTB was also compared against the secondary standard ionization chambers (traceable to BIPM) in the teletherapy unit; the agreement was within 0.6%. We are currently in the process of establishing a direct traceability for the Gammacell-2 to the UK PSDL (National Physical Laboratory). Also in progress is the comparison of the dose rates in the teletherapy unit and the Gammacell-2 with alanine/ESR system. Over next few months, we would have the complete traceability network in place.

These measurements along with the protocols that are being presently developed for the alanine/ESR dosimetry system would provide us with a reliable and quality-assured system. After that point, it would only be a short step to establishing the IAEA Dosimetry Laboratory as a Secondary Standard Dosimetry Laboratory (SSDL) also for high-dose measurements.

Today, the IDAS programme serves 30 irradiation facilities in 22 countries, mostly in the developing countries. Any facility in a member state that is engaged in radiation processing can participate in the programme after its designation by the relevant national authority in the country.

Results

The principal objective of IDAS is to assist member states in establishing a highly reliable dosimetry system in their radiation facilities. IDAS fulfills this mandate by providing

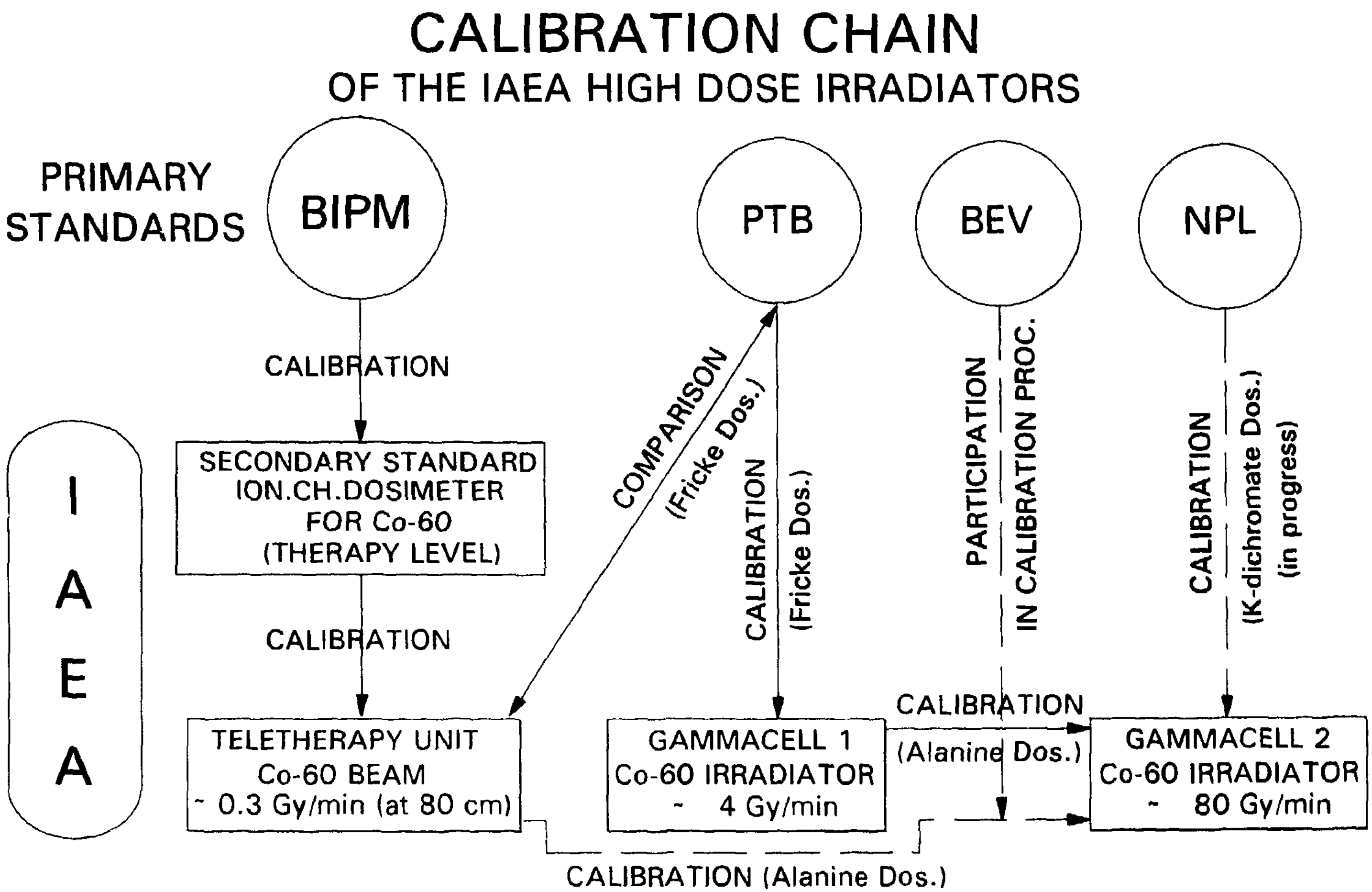

Figure 1. Calibration chain for the three cobalt-60 irradiators at the IAEA Dosimetry Laboratory in Seibersdorf.

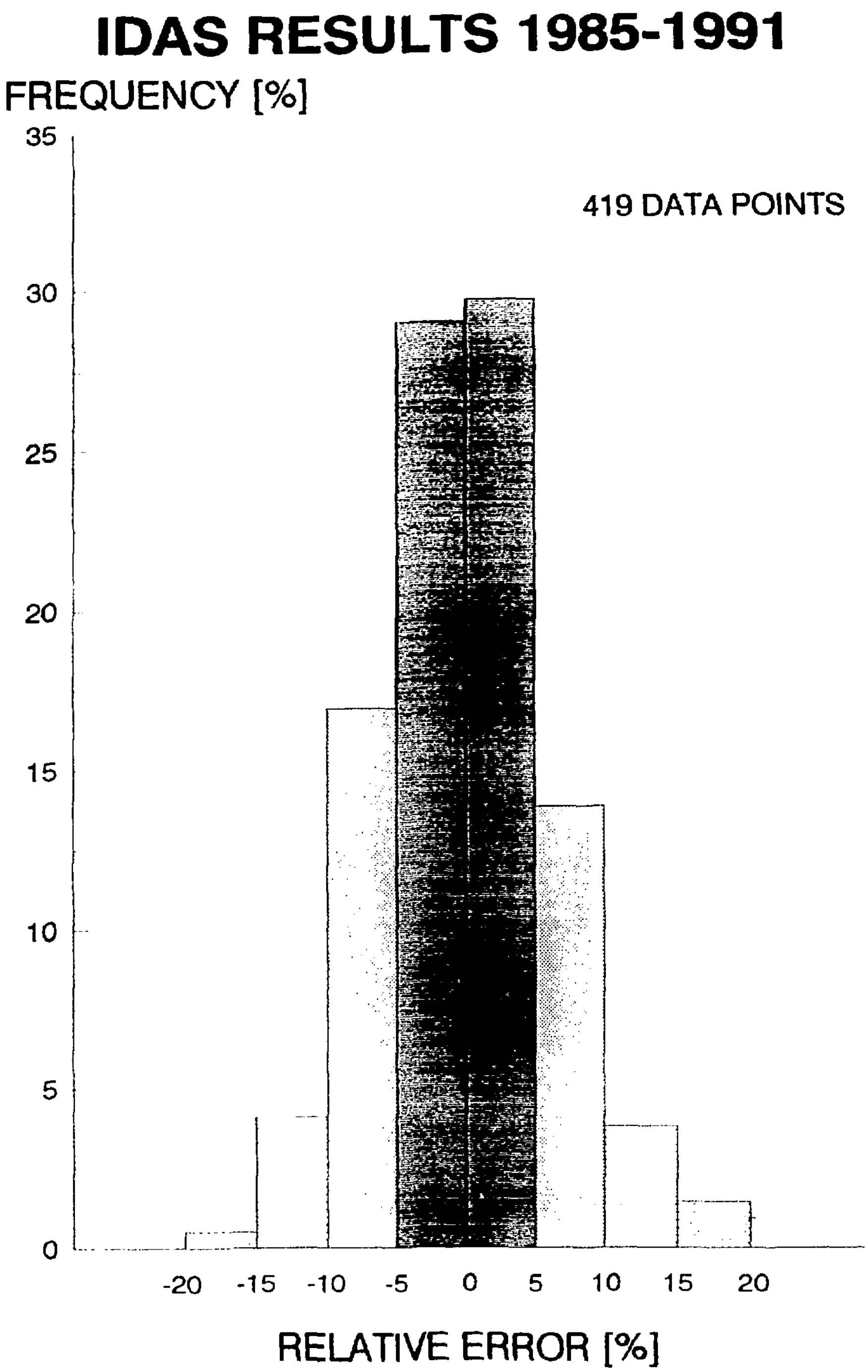

Figure 2. A histogram showing the distribution of the relative errors in the participants' measured dose values from 1985 to 1991 in the frame of IDAS.

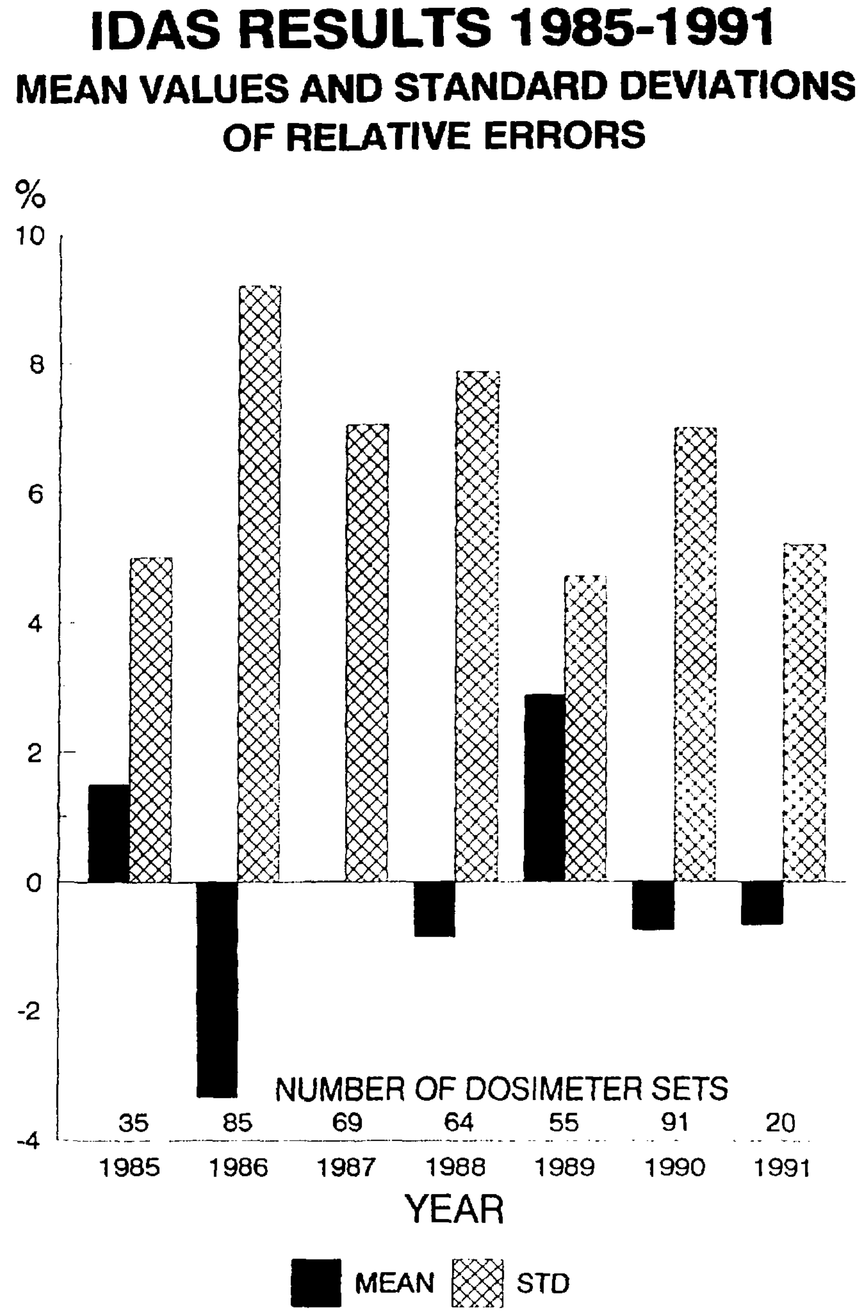

Figure 3. Trends from 1985 to 1991 of the mean value and the standard deviation of the relative errors in the participants' measured dose values.

the transfer standard dosimeters to these facilities and analyzing the measurement results after irradiation. The facility operators irradiate these dosimeters along with some of their dosimeters under similar conditions. The relative error of their dosimetry system is then calculated and reported back to them. Figure 2 shows a histogram of the data points (419) from all the measurements accomplished since the beginning of the programme. It shows that about 60% of the measured values have the relative error within $\pm 5\%$, and about 90% within $\pm 10\%$. Similar histograms were constructed for each year from 1985 till 1991. The mean value and the standard deviation of these distributions are plotted in Figure 3. The general tendency of the mean value and the standard deviation to decrease with time are encouraging signs.

It is important to identify the possible causes of these discrepancies with a view of eliminating them. There are three identifiable causes that can contribute to the errors:

a) environmental factors; mainly irradiation temperature,

b) geometry of irradiation; equivalency between the irradiation conditions as seen by the alanine dosimeters and by the participant's dosimeters, and

c) status and frequency of calibration of the participant's dosimetry system including any auxiliary equipment that is part of the dosimetry system.

We are presently exploring ways of setting up better communication between the Agency and the participants to help identify and possibly eliminate the cause(s).

Future

Within several months the alanine/ESR transfer dosimetry system would be fully operational at the IAEA Dosimetry Laboratory in Seibersdorf. That would help the IDAS programme operate more efficiently and effectively, and thus to realize its full potential. Alanine/ESR dosimetry has a number of distinct advantages, including: near tissue equivalency, insensitivity to ambient physical parameters, broad dose range, and non-destructive measurement. These make this system a candidate for therapy-level dose measurements. However, improvements in sensitivity and lower uncertainty of the measurement are needed before alanine/ESR dosimetry system can be successfully employed in this dose range (1-100 Gy). It has proved its value to the high-dose programme and we hope that it would be useful for the therapy-level dosimetry also.

Another application of the ESR spectrometry would be for "accident dosimetry". This technique could provide a suitable retrospective measurement of integrated absorbed dose to atomic radiation workers and the general population in the event of an accident. Current research effort suggests that radiation-induced ESR signals in such materials as tooth enamel, bone tissue and sugars can be used for this purpose.

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STATUS REPORT ON TRS 277

DECEMBER 1992

P. ANDREO, A.E. NAHUM, K. HOHLFELD, H. SVENSSON

Editorial

A working group consisting of the above-mentioned scientists has reviewed the status of the international code of practice, TRS 277, which was published in 1987. The main conclusions are given below, categorised according to radiation quality.

MEDIUM ENERGY X-RAYS: 100 TO 300 KV

Absorbed dose values determined according to TRS 277 are a few per cent higher than those according ICRU report 23, which most national codes follow. The maximum deviation exceeds 10% at 100 kV tube potential.

A thorough analysis has been made of the main methods of determining the correction factors needed when an ionization chamber calibrated free in air is used in the water phantom. The four methods considered to evaluate the correction factors are:

a) extrapolation chamber measurements in a graphite phantom and transfer of the calibration factor to the conditions of the water phantom

b) water absorbed dose calorimetry

c) Monte Carlo calculation of kerma values free in air and in the phantom and comparison with ionization chamber measurements

d) determination of all separate factors contributing to a global correction factor

Comparing the ratio N_W/N_K of the calibration factors determined according to the methods mentioned above, for two ionization chamber types (NE 2571 and PTW M 23331), values of the global factor that are significantly lower than the 1.10 in TRS 277 at the lowest energies (HVLs) can now be recommended. The uncertainties on these new determinations are no better than 2 and 3% (1 σ) however. The results are assumed to apply to other chambers of similar geometry within the given uncertainties, though this may be modified when more information becomes available.

An amendment sheet is recommended to be issued with TRS 277 to replace table XV of the IAEA code. The changes are according to the table:

Tube potential kV	HVL mm Cu	Perturbation correction factor p_u from TRS 277, Table XV to be replaced	Perturbation correction factor p_u New recommended values
100	0.17	1.10	1.03
120	0.30	1.09	1.03
140	0.49	1.08	1.03
150	0.83	1.06	1.02
200	1.70	1.04	1.02
250	2.47	1.02	1.01
280	3.37	1.01	1.01

HIGH-ENERGY PHOTONS

For ^{60}Co radiation the dose to water determined according to TRS 277 for most chambers specified in the code agrees within 1% with the calorimetric determinations of absorbed dose recently reported by several PSDLs. Furthermore, for the different megavoltage x-ray qualities the dose determined according to TRS 277 is within $\pm 1\%$ of that given by non-ionometric methods, e.g. Fricke and water calorimetry.

A study of the separate factors given in TRS 277 for the conversion from K_{air} to $D_{w,u}$ has revealed the following. Concerning the shift of P_{eff}, a value of $0.6r$ is more consistent with experimental work than the $0.75r$ recommended in TRS 277 for 'high' energy photon beams and $0.5r$ for ^{60}Co. Concerning $(s_{w,air})_u$, the use of alternative formulations of the density-effect correction parameter δ makes at most 0.5% difference and only at the highest energies. The $(s_{w,air})_u$-TPR_{10}^{20} correlation given in TRS 277 has been thoroughly investigated using 3 independent Monte-Carlo codes, with much reduced statistical noise through the exploitation of a convolution-based depth-dose computation; differences from the TRS 277 values are never more than 0.5% at any TPR for typical *clinical* beams.

HIGH-ENERGY ELECTRONS

The absorbed dose to water over a range of electron energies determined according to TRS 277 agrees within 1% with determinations based on non-ionometric methods. The values of the fluence perturbation factors for cylindrical chambers, p_u has been found to be somewhat too high, but the change in dose would be less than 0.4%. Possible changes in the basic stopping-power data due to alternative derivations of the density-effect correction have been found to have a negligible effect (sub 0.5%) on $(s_{w,air})_u$. Similarly, recomputations of $s_{w,air}(\bar{E}_0,z)$ using 3 different Monte-Carlo codes have not revealed any significant differences from the database of values given in TRS 277 despite the discovery of a major error in the particular Monte-Carlo code used to derive these values. The method of choosing $s_{w,air}(\bar{E}_0,z)$ based on the $\bar{E}_0 = 2.33R_{50}$ formula has been thoroughly investigated for a range of clinical qualities varying from *clean to very contaminated beams* and found to be accurate to within 0.5% at $z=D_{max}$ in the worst case. The central-electrode correction factor p_{cel} for chambers with aluminium electrodes appears to be too high in TRS 277, but this gives a small correction and the improved value results in a dose only 0.4% lower for electron beams when the central electrode has 1 mm diameter.

PLANE-PARALLEL CHAMBERS

For low-energy electrons ($\bar{E} \leq 10$ MeV) it has been confirmed that a plane-parallel chamber is the instrument of choice. The N_D may be determined in a ^{60}Co beam but in this case larger uncertainties must be accepted. It has been confirmed in recent experimental investigations that values of the perturbation factor $p_{u,pp}$ for properly designed chambers are negligible different from unity at energies down to $\bar{E}_z = 2$ MeV. The use of a plane-parallel chamber to determine the absorbed dose to water in a *photon* beam cannot be recommended as a result of the lack of consistency among the various determinations of the p_{wall} factor.

SUMMING UP

In conclusion, the IAEA code (TRS 277) can be used with a high degree of confidence for high-energy photons and electrons. An erratum will be inserted into TRS 277 giving correction values of the chamber conversion fac tor for medium-energy x-rays. An extension or "addendum" to the IAEA TRS 277 devoted to plane-parallel chambers is in preparation.

NEWS

The following meetings are organized by the IAEA Dosimetry Section during 1993:

15 March - 2 April	Regional Training Course on Calibration Procedures in an SSDL AUSTRALIA, Melbourne
24 - 27 May	Symposium on Measurement Assurance in Dosimetry AUSTRIA, Vienna
28 - 30 May	ESTRO's Second Biennial Meeting on Physics in Clinical Radiotherapy (This is a meeting organized by ESTRO linked to the IAEA Symposium on Measurement Assurance in Dosimetry) CZECH REPUBLIC, Prague
8 - 25 June	Regional Training Course on Radiotherapy Treatment Planning TURKEY, Istanbul/Ankara
4 - 20 October	Regional Training Course on Radiotherapy Dosimetry ALGERIA, Algiers
15 November - 3 December	Regional Training Course on Radiotherapy Treatment Planning THAILAND, Bangkok

SSDL Annual Report on 1992

The Annual Report forms for 1992 will be sent to the SSDLs in March 1993. The completed form should be submitted to the Secretariat of the IAEA/WHO Network of SSDLs before 1 May 1993. One should bear in mind that, according to the Criteria" of the SSDLs, the submission of an annual report is one of the conditions of membership in the Network.