IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

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CONTENTS

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EDITORIAL NOTE

This issue of the SSDL Newsletter consists of three reports. The first article is a report from the first Research Coordination Meeting (RCM) for the Coordinated Research Programme (CRP E2.10.02) on the development of a quality assurance programme for SSDLs. The objective of this CRP is to develop specific guidance for the SSDLs to establish Quality Systems and to prepare appropriate Quality Manuals. The guidance will cover the maintenance of standards, the calibration procedures, the operation of calibration services and the activities of quality audit services, when available. The recommendations to be prepared shall be based on the general guide and on the competence of testing and calibration laboratories, ISO/IEC Guide 25, and on the available technical guidelines relevant to the SSDL operation, i.e. the IAEA/WHO Network Criteria for the Establishment of a Secondary Standard Dosimetry Laboratory and the IAEA Technical Reports Series (No 374 and 133). The guidance shall be published and distributed to all SSDL Network members.

The second article reports on the results of the 1997 intercomparison of ionization chamber calibration factors in the IAEA/WHO Network of SSDLs. Since January 1998, this service is offered to all Network members. Interested SSDLs are invited to contact the Network Secretariat for practical arrangements and scheduling. It should be emphasized that only field class chambers should be used for the intercomparison, and not the reference or working standard of the SSDL. The chamber should be one of the type reported in the IAEA TRS 277. SSDLs which are not able to conduct component calibration can be supplied, upon request, with a constant current source for checking their electrometer. Efforts are being made to provide assistance to SSDLs when large deviations are identified. This has not been always successful due to the lack of cooperation from some SSDLs. If a large deviation is identified, the Agency will try to arrange for an on-site visit by an expert. However, limited resources do not allow the use of expert services whenever required.

The third article reports on a national quality audit programme for radiotherapy centers in Iran. This programme has been set up and run by the SSDL in Iran. It is worthwhile mentioning that many SSDL Network members have now started to run quality audit programmes for end users in their countries. This trend is certainly very encouraging. National audit programmes should be viewed in the framework of other national or regional audit networks. Information on national quality audit programmes should be published to add to the growing data base being established in this field. It has been demonstrated that the effect of quality audits themselves contribute to the improvement of the local situations with repeated runs. To be successful and attractive to end users, these quality audit programmes should be conducted in the spirit of collaboration and assistance. It is our hope that many SSDL Network members will submit reports on their national quality audit programmes for publication in this Newsletter.

Calibrations of well type chambers, for ^{137}Cs sources, can now be provided by the Agency to all SSDL Network members. The Agency standards are directly traceable to the National Institute for Standards and Technology (NIST), USA. Interested SSDLs are invited to contact the Network Secretariat for further details.

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DEVELOPMENT OF A QUALITY ASSURANCE PROGRAMME FOR SSDLs: REPORT OF THE FIRST RESEARCH COORDINATION MEETING.

ABSTRACT

The optimum outcome of treatment in radiotherapy requires high accuracy of dosimetry, which imposes the need of accurate calibrations and measurements by the SSDLs. This can only be achieved through quality assurance systems which cover quality control of standards, calibration equipment and calibration procedures, and which introduces external audits for the operation. The SSDL Scientific Committee as well as a Consultants' meeting have suggested the development of such Quality Systems (QS) at the SSDLs within a Coordinated Research Project (CRP). At this first Research Coordination Meeting (RCM), the status of efforts made by the participating laboratories to achieve the goals of the CRP were reviewed. The outline for the joint study in order to develop guidance for quality systems was established, and the work assignments defined. It was agreed that the final aim would be to prepare a suitable document, for the Agency, to provide guidance for the SSDLs to develop their own QS and to prepare appropriate Quality Manuals. This guidance shall be based on the general quality criteria in accordance with ISO/IEC guide 25 while also adopting the Criteria of the SSDLs and the practical recommendations on calibration procedures issued by the IAEA. To provide experience and confidence in the methods for the preparation of the guidelines, a Quality Manual of each participating laboratory will be prepared during the three years of the CRP. Trial programmes for the whole duration of the CRP on internal quality control testing as well as external quality audits of the participating SSDLs were also established.

BACKGROUND

In modern radiotherapy the optimum outcome of the treatment requires that the dose to the patient is known very accurately, in general within ±3.5%. For this requirement, the role of the SSDLs is crucial in providing traceable calibration to hospitals with the goal of achieving therapy beam calibration uncertainty within approximately 2 %. This can only be achieved by developing a quality assurance system which covers quality control of standards, calibration equipment and calibration procedures, and which introduces external audits for the operation.

In radiation dosimetry the traceability chain from PSDL through SSDLs to hospitals has been based for a long time on the quantity "air kerma". From this, the absorbed dose to water is determined by hospitals using an appropriate code of practice (national, regional or international; the IAEA Code of Practice TRS 277 is recommended and widely used). The development of dosimetry standards in terms of absorbed dose to water at PSDLs will result, as a long term goal at the SSDLs, in a change. SSDLs would be expected to provide users with calibrations in terms of air kerma and directly in terms of absorbed dose to water. This means that the demands on measurement set up will increase dramatically and consequently, new evaluations of uncertainties will be required. The change of the calibration method should be backed by sufficient experience in the new method and the knowledge of its impact on the clinical dose determination. Discrepancies between absorbed dose to water primary standards up to 1 % have been observed so far, and these should be settled out. Meanwhile, all SSDLs should develop experimental methods, adapted to the local conditions, to implement the change of calibration methods in a near future. Moreover, the change of the calibration quantity cannot be made until a new Code of Practice for direct measurement of absorbed dose to water has been established.

The general issue of practical problems encountered in calibration procedures in SSDLs was discussed during the "Fifth Meeting of the SSDL Scientific Committee (SSC)", November 23-27, 1992, IAEA Headquarters and IAEA Consultant's Meeting (REF.: 326-E2.94CT-1843), October

18-21, 1994, IAEA Headquarters. Both experts groups recommended to produce a programme to be developed and implemented by a CRP.

The scientific scope of this CRP is to develop specific guidance for the SSDLs to establish Quality Systems (QS) and to prepare appropriate Quality Manuals (QM). The final aim of the CRP is to get the guidance published e.g. as an IAEA Technical Document.

The guidance to be prepared shall be based on the general guide and on the competence of testing and calibration laboratories, i.e. ISO/IEC Guide 25, and on the available technical guides relevant to the SSDL operation, i.e. the Criteria for the Establishment of a Secondary Standard Dosimetry Laboratory (IAEA/WHO) and IAEA Technical Reports Series No 374 and 133 (the latter being revised). This means that the general aspects of Quality Systems applicable to any calibration and testing laboratory, which are the pre-requisite for official certification of the QS or for the verification of the competence by accreditation, are combined with the specific subject oriented towards technical rules and recommendations.

The development of the guidance on QS within this CRP should cover the maintenance of standards and the running of calibration, testing and irradiation services both at therapy and protection levels, the priority being given to the former, as well as the activities of dosimetry audits for radiotherapy hospitals when these activities are part of the SSDL operation. The QS should feature appropriate intercomparisons (proficiency testing) and audit procedures and define *the minimum Quality Control (QC) program* for the standards, calibration equipment and calibration procedures. For the QC programmes, a trial program within the CRP will be undertaken, in order to prepare recommendations on various tests, test methods, frequencies, tolerances or action levels and follow-up actions. For the QC of calibration procedures, special emphasis will be laid on the sound implementation of the new method of the direct calibration in terms of absorbed dose to water. For the QC of dosimetry audit activities, a minimum testing program will be defined for the equipment and procedures for mailed systems as well as for on-site measurements (i.e. field instruments for follow-up visits or beam calibration services). For the mailed dosimetry audit, the quality requirements for TLD systems will be covered.

It is understood that it is not possible to define a detailed QS or QM which would be directly applicable to each of the varying levels of the SSDLs. Further, it is anticipated that a somewhat simplified approach is needed for the first preparation of the QM. Therefore, the special guidance to be developed within the CRP will concentrate on explaining the general principles and objectives of QS and the general structure of QM, trying to review the appropriate contents of the different parts of QM and giving advice on the interpretation of the ISO/IEC Guide. However, the recommended structure and the broad guidelines for the preparation of the QM will be developed with strict reference to the ISO/IEC Guide, so that the QM can easily be supplemented to comply with all exact requirements in case an individual SSDL wishes to seek for QS certification or formal accreditation from the recognized certification or accreditation bodies.

2. OBJECTIVES OF THE MEETING

The aim of the meeting was to discuss the progress made by the participating laboratories to achieve the goals of the CRP and to draft the outline for the joint study in order to develop guidance for quality systems for SSDLs.

External Participants	Participants from IAEA
Liu Shulin ,SSDL-Shanghai, CHINA	Georg Matscheko (scientific secretary)*
Jose A. Morales , SSDL CUBA	Czap Ladislav
Hannu Järvinen , SSDL FINLAND	Appukuttan Shanta

Kijja Chongkitivitya , SSDL THAILAND
Sedat Yasar , SSDL TURKEY

*The present scientific secretary is Ahmed Meghzifene

STATUS REPORTS FROM THE PARTICIPANTS

During the first day of the meeting the IAEA staff members gave presentations on the relevant activities of the IAEA Dosimetry and Medical Radiation Physics Section for quality assurance, followed by presentations given by the participants describing their research efforts relevant to the CRP and the future plans for the duration of the entire project.

IAEA

Georg Matscheko presented the general purpose of the RCM and the various types of contracts or agreement for the CRP. He described the systematic approach taken by the Dosimetry and Medical Radiation Physics Section for the QS, including the structure of the QM with a number of separate documents called Standard Operating Procedures (SOPs). The QS includes external audits or peer reviews of the IAEA dosimetry laboratory. Georg Matscheko also described in details (on the second day of the meeting) the QA aspects of the IAEA TL-dosimetry mailed audit with summaries of updated overall results. Ladislav Czap described the practical aspects and details of the QS developed at the IAEA laboratory, making a distinction between the quality assurance of standards and services. He pointed out a number of principles in the QC programme of equipment and services, and also presented good examples on how the results can be summarized. Appukuttan Shanta presented the plans of the IAEA to provide traceability for brachytherapy calibrations by the SSDLs. This was based on the consultants' recommendations and consisted of making calibrated sources and well chambers available to SSDLs. The method had been studied for LDR ^{137}Cs sources, including effects of source type and position in well type chambers.

Liu Shulin (SSDL - Shanghai, CHINA)

The national SSDL organization in China consists of 4 SSDLs with main activities both at therapy and protection level, also including high-dose dosimetry. The work program relevant to the CRP consisted of renewal or supplementing the equipment needed to study the calibration and quality control procedures defined in the CRP proposal. Calibration of the secondary standard in terms of absorbed dose to water will be acquired and the comparison of the old and new calibration methods carried out in connection with the trial calibration audits of the CRP. QC on dosimetry audit and the development of QM according to ISO/IEC Guides will be included in the programme.

Jose A. Morales (CUBA)

The Cuban SSDL was established in 1995 and since September of that year, it has been a member of the IAEA/WHO Network of SSDLs. The laboratory is equipped with reference and working standards for both therapy and protection levels, but instrument calibrations at only protection level have been done from its start. As soon as the laboratory obtains a ^{60}Co unit, calibrations at therapy level will be implemented. During 1995, the SSDL paid great attention to the establishment of a Quality Assurance System according to the requirements of ISO/IEC Guide 25 and to documenting that in a form of an Internal Quality Management Manual. All this work was done as part of an accreditation process started with the Standard National Office. At the moment a Quality Manual and an internal quality control programme have been accepted. With respect to the

present CRP, the SSDL is able to present an example of Quality Manual and share its experiences on the improvement of the Quality System whicht will be introduced during the next three years. The SSDL can participate in carrying out quality control checks of standards, radiation beams and ancillary equipment. A special software that could record and process the information relevant to quality assurance is proposed to be developed under the project. The construction or purchasing of a highly accurate positioning system for calibrations in water phantom, and the study of different influence quantities and phantom-dependent problems are also proposed to be studied.

Hannu Järvinen (FINLAND)

The Finnish national standards laboratory for ionizing radiation quantities is maintained by the Finnish Centre for Radiation and Nuclear Safety (STUK), the supervising authority for radiation protection, this position being based on the Radiation Act of Finland. The standard dosimetry and calibration activities are organized at STUK in a uinique organizational unit (called Radiation Metrology Laboratory) which also holds the responsibility for the supervision in radiotherapy. The work of the unit consists of maintenance of standards, calibration, testing and irradiation activities for therapy, protection as well as diagnostic level measurements, supervisory activities, quality audits for radiotherapy clinics through regular site visits and research, training and co-operation with several national and international bodies. The laboratory has been a member of the IAEA/WHO Network since 1977 (SSDL-Helsinki).

In recent years, the laboratory has built-up a QS and QM according to the requirements of ISO/IEC Guide 25 and the technical manuals issued by the IAEA. The structure of the QM consists of three levels of documents to facilitate the preparation, administration and up-dating of the QS documentation. The practical testing of the system would be done in connection with the present CRP, within the next three years, and the laboratory could coordinate the preparation of general guidance for the establishment of QS and QM at an SSDLs as well as participate in the testing of the proposed QC programmes.

Kijja Chongkitivitya (THAILAND)

The SSDL at the Division of Radiation Protection Services (DRPS), Department of Medical Sciences (DMS), is one of the two SSDLs under the SSDL organization of Thailand. The SSDL (DRPS) is responsible for the calibration of dosimeters at both therapy and protection levels when applicable to medical field. It is the policy of the DMS to establish a QS. The DRPS, as a calibration laboratory, is developing a QM in accordance with ISO/IEC Guide 25 for the calibration services and for the TLD intercomparison service. Internal quality control of methods and equipment as well as long term stability tests of the measuring system will be carried out as part of the CRP.

Sedat Yasar (TURKEY)

Since 1989, the SSDL of Turkey has operated a TLD intercomparison program using the IAEA/WHO method for users of ^{60}Co teletherapy units, in order to increase dosimetric accuracy in radiotherapy. This method has a fading problem that has been solved by the following two ways: (1) the readout of LiF capsules is done not earlier than two months after irradiation and (2) the irradiation at the SSDL for establishing the calibration curve (TL-signal versus dose) is carried out at the same time as in the hospitals, and all irradiated LiF capsules are evaluated together. This procedure not only causes a long time span between irradiation and reporting, but also cannot respond to the frequent necessity of hospital, such as instant dose verification.

On the other hand, alanine/ESR dosimeter shows no effect on dose rate, have a much broader useful dose range than TLD, and the ESR signal is very stable, with a fading rate of less than 1 % per year at doses below 10^4 Gy. Alanine/ESR dosimeters represent a non-destructive technique, the dosimeters may be read repeatedly and stored for documentation of absorbed dose calibration. For these reasons, the SSDL aims at comparing these two dosimetric methods using the IAEA/WHO

method among the Turkish radiotherapy centers. If the results from the alanine/ESR dosimeters are good compared with the TL dosimeters, the alanine/ESR can be adopted also as a quality control method for the SSDLs.

Federico Gutt (VENEZUELA)

In a QA program, dosimetry systems and radiation sources should be considered separately for better management of SSDL equipment and accessories. QC program should consider the following equipment and systems:

Dosimetry systems

- Therapy level systems: secondary standards, working standards, field instruments
- Dosimeters for brachytherapy
- TLD systems

Radiation sources

- ^{60}Co (therapy level)
- ^{60}Co and ^{137}Cs (protection level)
- X-rays (both levels)

SSDL Quality Manual

The manual should include separate information about the test, frequency, and procedure for each item and should define the actions in case tolerance levels are exceeded. The SSDL of Venezuela is also recommending other activities in relation to hospitals, for example the development of QC program for linear accelerators, ^{60}Co treatment units as well as low and medium energy conventional X-ray therapy equipment. Another recommendation is to establish a unified model for the calibration certificates (therapy and protection levels).

DISCUSSIONS AND CONCLUSIONS

The scope of the CRP, the existing proposal for the CRP, the detailed efforts and research to be undertaken, organization of the work or work assignments were discussed in details. The following conclusions and resolutions for the plan of the CRP were made:

1. *Guidance for the preparation of QM.* It was agreed that each participating SSDL shall prepare a QM for its own operation within the three years of the CRP. This will provide the participants with practical insight on the possible problems to be encountered and the optimum structure and contents of the QM. It was agreed to use ISO/IEC Guide 25 as the fundamental reference for the general aspects of the QM, and the approach used by the Finnish SSDL as a basis for discussions and development of the practical QM of the SSDLs. Further, it was agreed that by the next RCM the participants will prepare plans for their individual QM, outline the structure and the different elements of the QM, in order to be prepared to discuss in more details the future efforts towards establishing unified guidelines for the preparation of QMs.
2. *Intercomparisons and audits.* It was agreed that all SSDLs participating in the CRP shall participate in the external intercomparison and audits given in Appendix 2. It was also considered important, as a part of the policy of the SSDL in order to maintain and verify good quality and international traceability for calibrations, to participate in regional

intercomparisons between national standard laboratories whenever these activities exist (e.g., EUROMET in Europe).

3. *Internal Quality Control Programmes for SSDLs.* It was agreed to carry out a trial Quality Control program among the participating SSDLs as outlined in Appendix 1 for the whole period of the CRP (three years). For this programme, it is assumed that the SSDLs comply with the general technical requirements derived from the IAEA/WHO Criteria for an SSDL and the recommendations of TRS 374 and 133, and that the acceptance and commissioning procedure for each equipment has been completed accordingly. The purpose of this trial programme is then to collect experiences and statistical data from a number of tests in order to be able to recommend a practical programme with proposals for optimum methods, frequencies, action levels and follow up actions when needed. Due to the varying conditions at different SSDLs it was agreed that no specific action levels for the tests are introduced at this stage of the work, but SSDLs are expected to apply their own conventions until the results of several laboratories are available for possible general recommendations. It should also be noted that only the most essential tests relevant to the study or the trial use are included, while a comprehensive QC programme of the SSDL should cover all equipment and procedures needed to carry out the activities defined in the scientific scope (e.g. control of all auxiliary equipment such as pressure test boxes or safety equipment).

The results of the tests, supplied with comments and observations by the SSDL, will be annually and mutually exchanged between the participants for analysis and discussion. It was agreed to use EXCEL tables as a basis for recording the results. It was agreed that Mr. Jose Morales is responsible for providing summaries of all results for the discussion to all participants. For this purpose, he will distribute to the participants proposed EXCEL forms for recording the results. The results of testing for the first year should be transmitted to Mr. Morales by the 15th of November 1997, and the summaries prepared by Morales to the participants by the end of year 1997.

Methods of calibration and estimation of uncertainties. It was considered that the implementation of the ionization chamber audit (cf. test no 3, Appendix 2) will cover, within this CRP, the efforts of studying the new method of direct absorbed dose to water calibrations. As the new method of calibration will introduce new type of uncertainties in the calibration procedure, it was agreed that each participant will carefully re-evaluate their estimation of uncertainties. The SSDLs will produce a list of uncertainties, according to the general guidelines of TRS 374, for both types of therapy level calibrations (at ^{60}Co) as well as for protection level calibrations. The lists of uncertainties together with explanations on how the estimated figures were derived will be distributed to all participants for comments. The results of the review and comparison of uncertainties will be discussed at the next RCM. The estimated uncertainties related to the results of the ionization chamber intercomparison will also be discussed.

APPENDIX 1

INTERNAL QUALITY CONTROL PROGRAM FOR TRIAL USE BY THE SSDLs

Test No	Title	Methods and equipment concerned	Trial frequency	Partic. SSDLs
1	Re-calibration of the secondary standards (SS)	It is recommended that for the re-calibration of therapy level standards, a physicist from the SSDL visits the PSDL (or IAEA laboratory) with the secondary standard (reference standard): chamber and reference electrometer. The reference electrometer is compared with PSDL electrometer in connection with the calibration.	3 years	All
2	Re-calibration of working standards against reference standards	All working standards. At radiation qualities simulating those used by PSDL for the calibration of SS.	6 months	All
3	Control of the charge measuring system	Cross comparison of electrometers and/or capacitors by using a constant current source (electrical or check source device).	6 months	All (as applicable)
4	Stability tests of standards by check source measurements	All reference standards (RS) and working standards (WS). Includes measurement of the leakage current.	1 month (RS) 1 month and in connection with each calibration. (WS)	All
5	Stability test of working standards by measurements at a fixed position in a gamma ray beam	Therapy and protection level working standards. The same position used for calibrations.	1 month & in connection. with each calibration.	All
6	Stability test of working standards by measurements at a fixed position in X-ray beams	Therapy level standards for X-ray calibrations. Selected X-ray qualities most frequently used for calibrations. Measurement of: 1. air kerma rate 2. ratio of currents from the standard chamber and the monitor chamber.	1 month and in connection with each calibration.	All
7	Re-calibration of working thermometers, barometers, and hygrometers	Other meters except mercury-type thermometers and barometers and whirling-arm hygrometers.	1 month	All (as applicable)

Test No	Title	Methods and equipment concerned	Trial frequency	Participating SSDLs
8	Beam irradiation characteristics 1. Geometrical characteristics: beam alignment, reference distance, light field/radiation field consistency 2. Uniformity 3. Timer correction	All gamma and X-ray beams. Methods according to the local practice (e.g. by irradiation of films or using beam scanning equipment for in-air measurements)	1 year	All
9	X-ray beam quality	Determination of HVL values at the lowest and highest voltages used for calibrations methods according to IAEA TRS 374.	1 year	All
10	Quality of mailed dosimetry audit	Reference irradiation at the IAEA laboratory for the SSDL TLD system for mailed dosimetry audit. Simultaneous irradiation at the SSDL (^{60}Co beam). Comparison of results.	1 year	All except Finland
11	Performance of equipment for mailed dosimetry audit	Minimum tests for the TL equipment to be prepared by Sedat Yasar by the end of March 1997 and then discussed by other participants by correspondence. The agreed test program will then be applied at the SSDLs, and the program with results of testing discussed at the next RCM.		All except Finland
12	Stability test of field instruments	Check source measurements including the measurement of leakage current. Field instruments (ionization chambers + electrometers) used e.g. for follow-up visits or beam calibration services.	1 month and in connection with each calibration or beam measurement	All

APPENDIX 2

EXTERNAL QUALITY AUDIT PROGRAM FOR TRIAL USE BY THE SSDLs

Test No	Title	Methods and equipment concerned	Trial frequency	Partic. SSDLs
1	Mailed dosimetry audit at SSDL ^{60}Co beam	According to the current practice of the IAEA	1 year	All
2	Mailed dosimetry audit at hospital photon beam	According to the current practice of the IAEA	1 year	All
3	Ionization chamber audit (calibration comparison for a therapy level chamber)	For a field class chamber according to the recent proposal by the IAEA, for both air kerma and absorbed dose to water.	1 year	All
4	Protection level audit (calibration comparison for a protection level instrument)	According to the principles of test no 3.	3 years (i.e. once during the CRP)	All

INTERCOMPARISON OF IONIZATION CHAMBER CALIBRATION FACTORS IN THE IAEA/WHO NETWORK OF SSDLs.

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International Atomic Energy Agency, Vienna.

ABSTRACT. An intercomparison of ionization chamber calibration factors was conducted in 1995 which included 17 participants. The results were published in the SSDL Newsletter No. 35. In 1997, a second intercomparison was carried out involving 21 participants. The calibration factors of 24 ionization chambers were checked. For all chambers, mean ratios of SSDL to IAEA measured factors of 1.002 (standard deviation of 1.3%) and 1.004 (standard deviation of 1.3%) were obtained for the air-kerma and absorbed dose to water calibration factors, respectively. Four SSDLs had large deviations and three of them took immediate corrective actions. One deviation has not yet been resolved. The results of the intercomparison are presented and discussed in this report.

1. INTRODUCTION

During the decade which followed the establishment of the IAEA/WHO network, the activities of the IAEA towards the SSDLs mainly aimed at the establishment of the necessary infrastructures, especially in developing countries. Since then, more laboratories have joined the network and the scope of their work is continuously expanding. Today, quality assurance aspects have become an essential component of the IAEA programme. To ensure that the services provided by SSDL members to end-users follow internationally accepted standards, the Agency has set up two intercomparison programmes. The first relies on the IAEA/WHO postal TLD service and has been reviewed in the past [1,2]. The second programme uses ionization chambers to help the SSDLs verify the integrity of their national standards and the procedures used for the transfer of the standards to the end-users. Initially, a tentative programme was introduced in 1986 but was discontinued for reasons of costs and reliability. In 1995, a new programme was initiated using ionization chambers. SSDLs were requested to participate with their own working standard. In this first trial run, 24 ionization chambers were sent by 17 participants, of which 13 were members of the SSDL Network. The results of this intercomparison were published in the Newsletter No. 35 [3].

Following the positive feedback received from some SSDL network members, it was decided to organize a second intercomparison in 1997. Thirty five SSDLs were contacted and 21 participated effectively in this run by sending a calibrated ionization chamber to the IAEA Dosimetry Laboratory. The results of this second intercomparison are presented and discussed in this report.

2. PROCEDURES

The calibration set up used in this intercomparison is identical to the one used in the 1995 run and was described in the previous report [3]. In this section, the procedure followed by the SSDLs and the Agency Dosimetry Laboratory is briefly outlined.

Prior to sending the ionization chamber to the Agency, SSDLs are asked to make a check source measurement and then calibrate it. The reported calibration

factors are corrected for reference temperature and pressure (20^0C and 101.3 kPa). The following reference conditions are recommended:

Air-kerma calibration factor:

a) source to chamber distance (SCD): 100 cm

b) field size at SCD: 10 x 10 cm^2

c) chamber reference point: geometrical center.

Absorbed dose to water calibration factor:

a) source to chamber distance (SCD): 100 cm

b) field size at SCD: 10 x 10 cm^2

c) chamber reference point: geometrical center

d) depth in water of the geometrical center of the chamber: 5 g/cm^2.

The ionization chamber is sent for calibration at the Agency Dosimetry Laboratory along with a data sheet. It is returned back to the SSDL for a second calibration. Again, the SSDL is asked to perform check source measurements upon arrival of the chamber to make sure nothing happened to it during transport. Then the SSDL performs a second calibration and reports the factor to the Agency. To some extent, this second calibration gives an indication on the reproducibility of the calibrations.

The results are transmitted to participants individually and an anonymous overview is published in this report.

3. RESULTS AND DISCUSSION

The values of N_K and $N_{D,w}$ determined both by the SSDL and the IAEA Dosimetry Laboratory, and the respective ratios are given in Table I.

The absorbed dose to water factors, $N_{D,w}$, were determined as the ratio of the absorbed dose to water at the reference depth D_w(5 g cm^{-2}), and the response of the ionization chamber positioned with its geometrical center (i.e. not with the effective point of measurement) at this point. The factors $N_{D,w}$ are therefore referred to the geometrical center of the chamber. However, some $N_{D,w}$ factors reported by the participating laboratories were related to the effective point of measurement of the chamber, P_{eff}. These factors were therefore recalculated to $N_{D,w}$ factors related to the geometrical center of the chamber.

A plot of the ratios of SSDL stated factors to IAEA determined factors is given in Fig.1. The consistency of the determination of N_K and $N_{D,w}$ factors is in general acceptable. However, the results of four participants (indicated by the arrows in the figure) were found to be outside the acceptable limits. These discrepancies deserve special comments.

Table I. Values of N_K and $N_{D,w}$ determined by the SSDLs and by the IAEA Dosimetry Laboratory. Ratios of SSDL stated to IAEA factors, are given in columns 5 and 8.

Participant Number.	Chamber model	N_K(SSDL) [Gy/μC]	N_K(IAEA) [Gy/μC]	Ratio SSDL/IAEA	$N_{D,w}$(SSDL) [Gy/μC]	$N_{D,w}$(IAEA) [Gy/μC]	Ratio SSDL/IAEA
1	NE-2561	94.39	94.20	1.002	103.8	102.77	1.010
2	NE-2581	53.52	53.63	0.998	58.31	58.54	0.996
3	NE-2571	42.13	41.20	1.023	45.62	44.90	1.016
4	NE-2561	93.14	93.08	1.000	100.6	101.67	0.990
5	NE-2561	97.68	93.39	1.046	105.6	101.21	1.036
6	NE-2505/3	40.76	41.67	0.978	44.20	45.22	0.977
7	NE-2571	41.21	41.37	0.996	45.45	45.13	1.007
8	NE-2571	41.38	41.23	1.004	45.58	45.14	1.010
9	NE-2571	41.08	41.35	0.994	45.41	45.36	1.001
10	NE-2571	41.72	41.73	0.999	45.46	45.38	1.002
11	NE-2505/3	40.52	40.75	0.994	44.43	44.50	0.998
12	NE2581	52.40	52.94	0.989	57.08	57.07	1.000
13	NE-2571	41.23	41.10	1.003	45.54	44.74	1.018
14	W-30002	45.39	45.74	0.992	50.19	49.99	1.004
15	M-23332	95.70	96.29	0.994	104.60	105.96	0.987
16	W-30001	48.22	48.48	0.995	52.41	52.72	0.994
16	M-30001	47.93	47.85	1.002	52.01	52.03	1.000
16	M-23331	28.29	28.31	--------	30.80	------	------
17	NE-2571	41.36	41.08	1.007	45.73	44.77	1.022
18	NE-2571	41.54	41.49	1.001	45.63	45.53	1.002
19	NE-2505/3	41.14	41.03	1.003	45.22	44.66	1.013
20	M-01	66.89	66.09	1.012	--------	------	-----
			Mean:	1.002			1.003
		Standard Deviation:		0.013			0.013

Except for one participant (No.13), the deviations related to the air kerma factor are consistent with the deviations related to the absorbed dose to water factors. In these cases, the $N_{D,w}$ factor was derived by calculations from the air kerma factor (and exposure factor, for one case) using TRS 277 [4]. Participant No. 20 is an SSDL which participated with a home made ionization chamber. This a special case and its results will not be discussed further in this report. The four participants who obtained large deviations were immediately contacted for follow-up actions. Three of them took immediate actions to resolve the discrepancies. The fourth participant was not very cooperative and did not even accept an Agency's suggestion for an on-site visit to the SSDL. Up to this date, the discrepancy remains unresolved. A case by case

analysis is presented below to explain the three other discrepancies.

Participant No.3: The deviation between the first reported N_K and the second N_K value (upon return of the ionization chamber) is 1%. The participating SSDL did not report the results of check source measurements but the discrepancy may well be due to the ionization chamber itself. This particular SSDL did participate in the 1997 TLD postal audit and the deviation with respect to the IAEA measured value was acceptable (1.6%). He was advised to increase the checks on this chamber and monitor its long term stability.

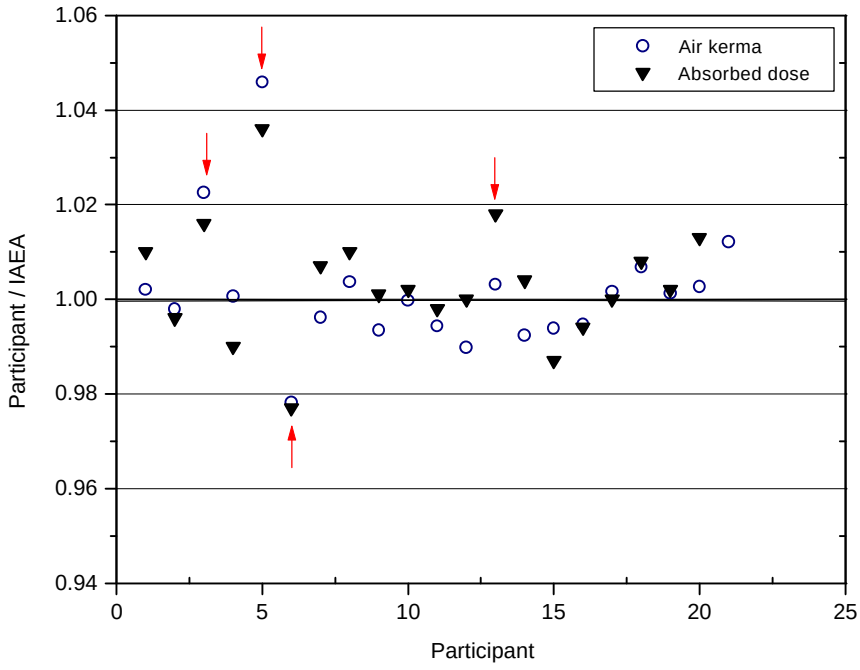

Fig 1: Ratios of the SSDL chamber factors to the IAEA values). Symbols correspond to the results for air kerma calibration factors (circles) and for dose to water chamber factors (triangles). The arrows correspond to three large discrepancies.

Participant No.5: This is an unexpected result as it involves an SSDL which has obtained consistently acceptable deviations in the past IAEA/WHO TLD postal audits. Direct contacts with this SSDL have been established but no satisfactory explanation was found. An on-site visit was proposed to resolve this discrepancy but the SSDL declined the offer.

Participant No.6: This participant calibrated again the chamber upon its return to the SSDL and the ratio of the first N_K to the second N_K value was found to be 0.981. It is clear that some problems may have occurred during the first calibration at the SSDL. The ratio of IAEA measured N_K to the second SSDL N_K is 0.997, and this is considered acceptable. It should be mentioned that this participant obtained very good result during the 1997 TLD postal audit.

Participant No.13: This is the only participant who has obtained a relatively large deviation only with respect to the $N_{D,w}$ factor. For the air kerma factors, the ratio was found to be 1.003. Communication was established with the SSDL in an attempt to help resolving the discrepancy in $N_{D,w}$. As the $N_{D,w}$ factor is calculated from an exposure calibration factor, the SSDL was requested to provide the detailed calculations to enable a throughout check. The source of discrepancy, related to the reference point of the ionization chamber to which the

absorbed dose to water factor is referred, was identified. A displacement factor, using data from reference [5] was applied to the reported $N_{D,w}$. The new ratio of IAEA to recalculated $N_{D,w}$ of the SSDL was found to be 1.003.

For the three SSDLs that obtained large deviations, new ratios of the SSDL to IAEA factors were recalculated with the corrected calibration factors and the results are shown in Fig.2.

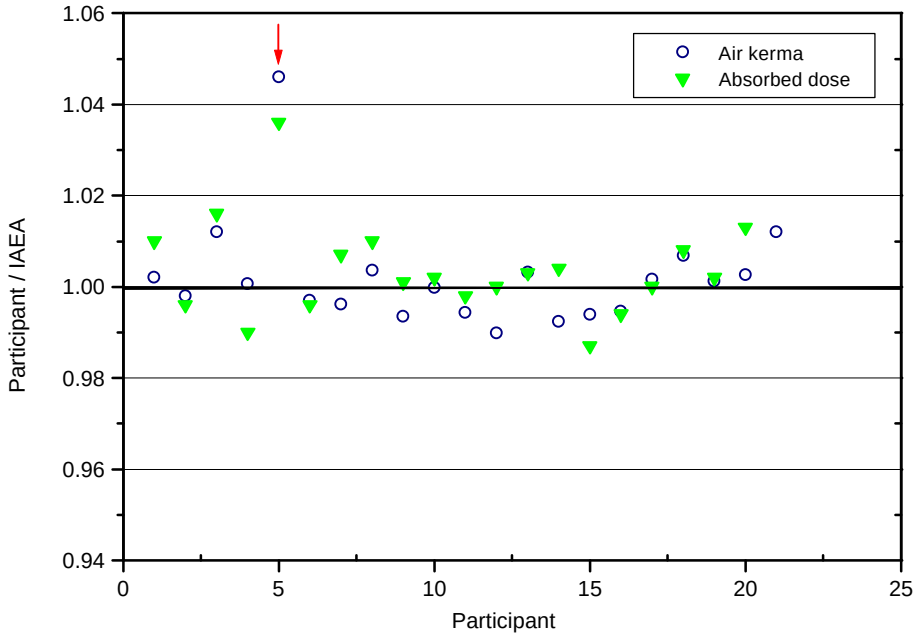

Fig 2: Ratios of the SSDL chamber factors to the IAEA determined values following corrective actions by three participants.

It should be noticed that reference standards of the SSDLs are traceable to different PSDLs and most of them are calibrated in terms of air kerma. As the international agreement between air kerma standards is excellent, this is expected to be reflected in this SSDL intercomparison. Most participants have used a dosimetry protocol to determine the absorbed dose to water and then derive a chamber factor, but the protocol used has not always been IAEA TRS-277 [4].

4. CONCLUSION

The intercomparison on ionization chamber calibration factors between members of the IAEA/WHO Network and the IAEA Dosimetry Laboratory has been running for a short period of time. So far only 2 runs were organized (1995 and 1997) with 13 SSDLs participating in the first run and 21 SSDL in the second run. Hopefully, this trend will continue in the future. The service is now run on a permanent basis and all SSDLs are encouraged to participate in this programme.

The intercomparison programme has generally demonstrated consistent radiotherapy dosimetry for photon beams at the level of the SSDLs. Few discrepancies were identified and steps were taken to resolve them. The procedure implemented can identify problems to be investigated and rectified with the assistance of the participants. It is worth mentioning that most of the participants that obtained large deviations in this intercomparison showed a good spirit of co-operation with the Agency for identifying and resolving the discrepancies. Three

out of four identified discrepancies were resolved.

Interestingly enough, it also appears that the discrepancies identified through the TLD audits do not correlate with the ones identified in this intercomparison programme. Whether this is due to the relatively higher uncertainty of the TLD compared to ionization measurements is not yet established. More data is of course required to make a sound statement on this subject but it is sure there is a need for considering this aspect in the future to adapt the quality audit programmes of the Agency to help meet the requirements of better accuracy in radiation therapy dosimetry.

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RESULTS OF A NATIONAL QUALITY AUDIT PROGRAMME FOR RADIOTHERAPY CENTERS IN IRAN

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ABSTRACT- The SSDL of Iran has established a quality audit programme for radiotherapy centers in the country. Most of the radiotherapy departments are now audited annually by the SSDL dosimetry team. During the site visits, beam characteristics of the teletherapy units are determined or tested. This report presents the results of the on-site output measurements conducted during the period 1985-1996 and demonstrates the role of traceability of absorbed dose to water determinations in hospitals to the SSDL standard.

1. INTRODUCTION

Historically, an accuracy of ±5% in the delivery of the prescribed dose has been the goal in radiotherapy and even a higher accuracy is considered to be desirable for some treatments [1,2]. It is suggested that more than 10% of the 2,500,000 patients who are treated by an estimated 6000-7000 teletherapy units (Co-60 and linear accelerators) yearly, receive doses that differ from the prescribed dose by more than 20% [3]. This means that at least 250,000 patients annually receive poor radiotherapy through lack of proper equipment, personnel or training.

Recognizing the importance of quality assurance in radiotherapy and the need to make access to radiation standards traceable to the international measurement system to every radiotherapy center, the SSDL of Iran, as a national standard dosimetry laboratory, started a quality audit programme in 1985. This programme was initiated by mailing an “information sheet questionnaire” to all radiotherapy centers regarding general information about their radiotherapists, medical physicists, type of equipment, dosimeters, etc. This provided the SSDL with a data file and led to necessary links between the SSDL and the clinics. Therefore a quality control network was set up and site visits were arranged according to a suitable time-table. The audits were usually conducted by two physicists using Farmer type ionization chambers for measurements. Usually, the output of radiotherapy units at definite conditions are measured and compared with corresponding values quoted by the medical physicists. The light field/radiation field coincidence of the units are always checked by a square field radiography. During the audits, the radiation leakage of Co-60 heads and other safety aspects like radiation level at control room during machine-on time, interlocks, etc. are also checked. On request, other beam characteristics and parameters like output factor (collimator scatter correction), beam flatness, wedge factors, HVL (for soft and medium x-rays), etc. are determined or tested. In this report, however, only the main objective of the audits, i.e. dosimetry measurement results, are presented.

2. STRUCTURE OF EXTERNAL RADIOTHERAPY IN IRAN

At present, there are 18 radiotherapy centers in Iran for a total population of about 60 millions. Half of these clinics are located in Tehran with 18 percent of the total population. Others are located mainly in the centers of 6 provinces that cover 44% of the population. There are 36 teletherapy units in use in these clinics that include 24 ^{60}Co units, 11 conventional x-ray therapy machines (superficial and orthovoltage) and only one LINAC (CGR Saturn 20). There are three computerized treatment planning systems, but only one is actually functional. Ten clinics possess their own dosimeters, but measurements are carried out mainly in air (except for the LINAC). Dosimetry in other clinics, mainly the private ones, is conducted by part time physicists from other centers. Most of these dosimeters were calibrated at least once at the SSDL.

More than 90% of the patients are treated by Co-60 units and the loads of patients in all radiotherapy departments are very high. On the average, there are 730 patients for each physicist (1996). Table 1 shows a summary of the present status of external radiotherapy in Iran.

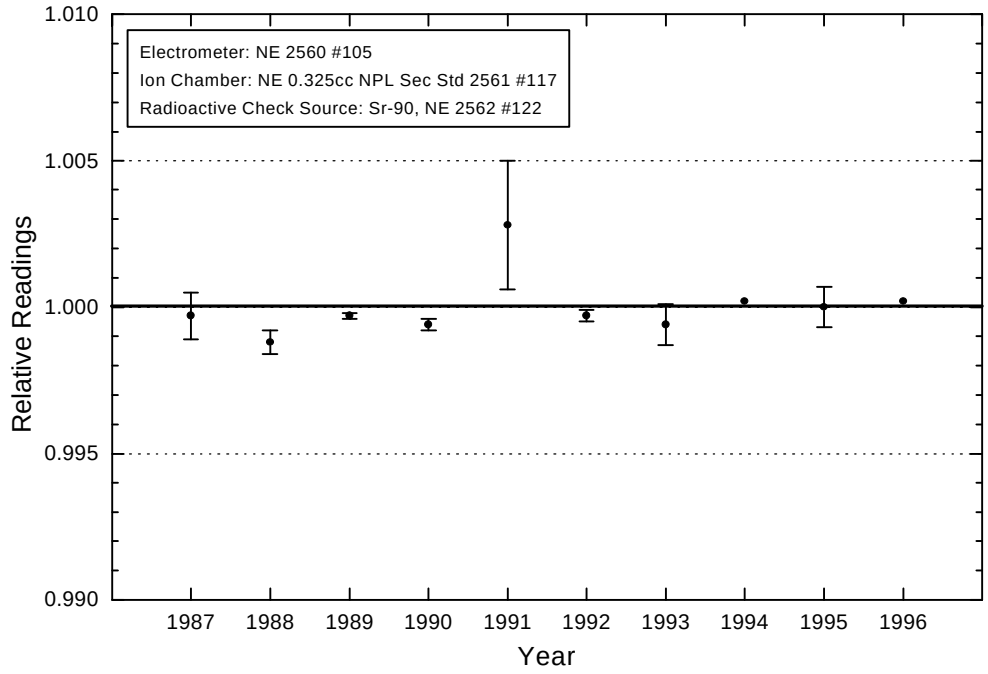
^{60}Co units	24 (4 are not in use))
Medium energy X-ray	7 (2 are not in use)
Soft X-ray	4 (2 are not in use)
Linear accelerator	1
Dosimetry equipment	10
Radiation therapist	43
Medical physicists	21
Technicians	85
Patients/year	15,400

Table 1. Structure of radiotherapy in Iran (1996)

3. DOSIMETRY SYSTEM

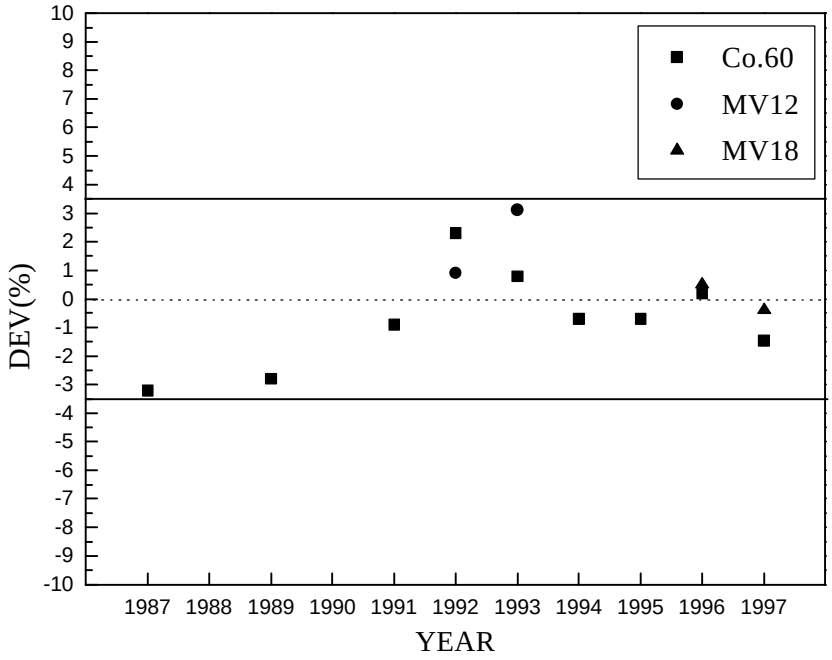
The reference standard of the SSDL of Iran is an NPL secondary standard therapy level dosimeter (0.325 cc NE2561 ionization chamber connected to an NE 2560 electrometer). This dosimeter was calibrated for the first time at the National Physical Laboratory (UK) in terms of exposure (R) in 1977. The last calibration was carried out at the IAEA Dosimetry Laboratory in terms of air kerma at different x-ray qualities and Co-60, and absorbed dose to water for Co-60 gamma ray and is traceable to BIPM. The combined uncertainties of calibration factors in terms of air kerma and absorbed dose to water are 1 % and 1.2% respectively. The long term stability of this dosimeter is checked by a reference stability check source (^{90}Sr.) and the variations in the response of the system have always been less than ±0.5% during several years (Fig.1).

Fig.1-Long term stability of the response of Iran SSDL therapy level secondary standard dosimeter against a radioactive check device,1987-96.



The SSDL of Iran has participated in the IAEA/WHO TLD Postal Dose Quality Audits during 1987-1997 and the deviations of the doses quoted by the SSDL from those determined by the IAEA have always been within the acceptable limits of ±3.5% (Fig.2).

Fig.2- IAEA TLD Postal Dose Intercomparison for the SSDL of Iran



In 1995, the SSDL participated in an intercomparison on ionization chamber calibration factors, organized by the IAEA The deviations between the calibration factors determined by the SSDL in terms of air kerma and absorbed dose to water (N_K and $N_{D,w}$), and those determined by the IAEA for a farmer type ionization chamber, were both about 0.5%.

Two Farmer dosimeters have been used for on-site output measurements. The ionization chambers used are of type NE 2571 and NE 2505/3B and both of them were calibrated at the IAEA Dosimetry Laboratory. These chambers are calibrated regularly against the reference standard of the SSDL in terms of air kerma and the combined uncertainties associated with the calibration factors are unlikely to exceed 2%. In addition, a third ionization chamber of type NE 2532 (PTW 23342) calibrated at the IAEA Dosimetry Laboratory was used for soft x-ray measurements.

4. DOSE MEASUREMENTS

Most of radiotherapy departments in Iran still use methods based on exposure for their clinical dosimetry [4,5]. The SSDL has encouraged medical physicists to shift gradually to dosimetry protocols based on air kerma and in phantom measurements. However, since the majority of dosimeters in use indicate the quantity to be measured in terms of exposure (R) and the medical physicists are not yet well familiar with modern protocols; no attempt was made either to force the clinics to change their dosimetry methods nor to calibrate their dosimeters in terms of air kerma or absorbed dose to water. During the audits, the procedure followed by the SSDL was to measure the outputs of the Co-60 and conventional x-ray therapy units in terms of exposure at fixed conditions in air or in phantom (depending on the method used in each clinic) and then convert it to absorbed dose to water at maximum buildup (as it was done by the medical physicist in clinic). For Co-60 units, the exposure rate is measured at a normal SSD and a field size of 10 cm × 10 cm in air, or at 5 cm depth in water with a normal SSD and a field size of 10 cm × 10 cm on the phantom surface. For x-ray generators, the exposure rate has been measured at normal treatment distances (50 cm and a field of size 10 cm × 10 cm when limiting diaphragm is used; and at different FSDs and field sizes when treatment applicators or cones are used). For the unique linear accelerator in use in the country, the measurements are carried out in a water phantom according to the IAEA recommended code of practice [6].

5. RESULTS AND DISCUSSION

A total number of 140 audits have been conducted by the SSDL dosimetry team during 1985-1996. These include a total number of 273 output measurements of 36 external therapy units (x-ray, Co-60, LINAC). The number of audits and beam measurements conducted in each year are shown in Fig.3.

^{60}Co units are major external radiotherapy tools in Iran and therefore the data based on output measurements of these machines are analyzed in more detail. The results of the quality audits of Co-60 units during 12 years of quality audit programme are summarized in Table 2 and Fig.4. The difference between the value quoted by the clinic, $\mathbf{I_Q}$ (usually the absorbed dose at maximum buildup, field size 10 cm × 10 cm at normal SSD), and the value obtained by the SSDL, $\mathbf{I_m}$, is expressed as a percent deviation, i.e. $\mathbf{DEV(\%)=100\times(I_Q-I_m)/I_m}$. Table 2 includes also the results of the IAEA/WHO TLD audits for the SSDL of Iran in corresponding years. The summary results of x-ray measurements are given in Table 3. Few measurements were done with high energy photon and electron beams and are also shown in Table 3.

The frequency distributions of deviations for the total audits on Co-60 and X-ray therapy units are shown in Fig. 5. The frequency distributions of the results of audits for which the output of Co-60 and X-ray beams as quoted by the clinics may or may not traceable to SSDL standard, are given in Figs. 6 and 7 respectively. The traceability to SSDL is established either through calibration of dosimeter at the SSDL or from on site beam calibrations during the auditing process. The corresponding normal curves of frequency distributions are shown for deviations obtained by clinics with traceable measurements (TR) and non traceable (NTR). The critical role of traceability in dosimetry is demonstrated.

FIG.3. N0. OF AUDITS AND OUTPUT MEASUREMENTS CONDUCTED DURING 1985-1996.

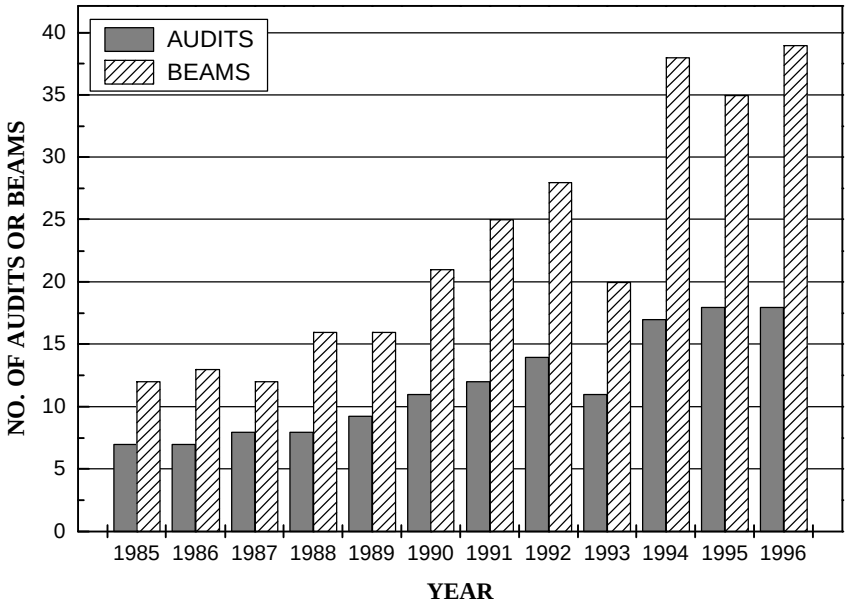


FIG.4. SUMMARY RESULTS OF AUDITS OF CO-60 UNITS DURING THE PERIOD 1985-1996.

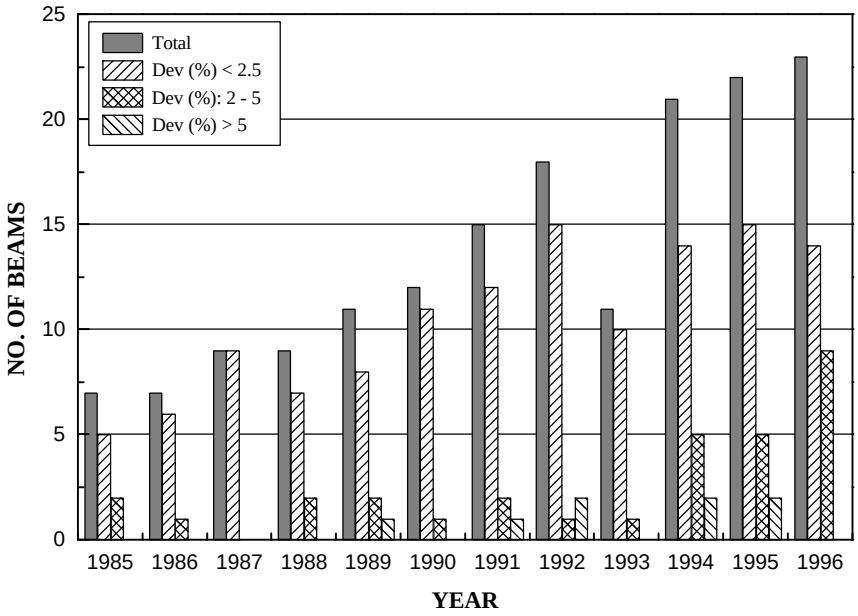


Table 3- SUMMARY RESULTS OF AUDITS FOR RADIOTHERAPY CENTERS IN IRAN (X-RAY & ELECTRON), 1985-1996

Beam Quality	X-Ray			Electron[a] (6-20MeV)
	<100 kV	12&18MV[a]	100-300 kV	
No. of Audits	23	30	4	3
No. of Beams	34	56 (51)[c]	6	12
Mean Dev. (%)[b]	-0.1	-1.0	0.7	1.8
St. Dev.	6	3.5	1.4	6.0
Max. Pos. Dev(%)	13.2	11.2(847)[c]	2.4	12.9
Max. Neg. Dev(%)	-14.0	14.0	-0.9	-9.4
$100\times(I_S-I_A)/I_A$[d]	-	-	1.5[d]	-

a) Only for 1991-1996,

b) [b]) $Dev(\%)=100\times(I_{user}-I_{SSDL})/I_{SSDL}$

[c]) In one of the audits in 1990, it was found that the output of the orthovoltage x-ray machine, in radiotherapy department no.II, had dropped to less than 1/9 of its normal value and the physicist was unaware of this fact. The treatment by this machine was interrupted immediately after the audit. This case is included in the number of audits but excluded from statistics.

[d]) Mean result of the IAEA TLD Postal Dose Intercomparison (1992, 1993& 1996) for the SSDL of Iran at high energy x-rays.

FIG.5- FREQUENCY DISTRIBUTION OF AUDIT RESULTS FOR RADIOTHERAPY CENTERS IN IRAN, 1985-1996.

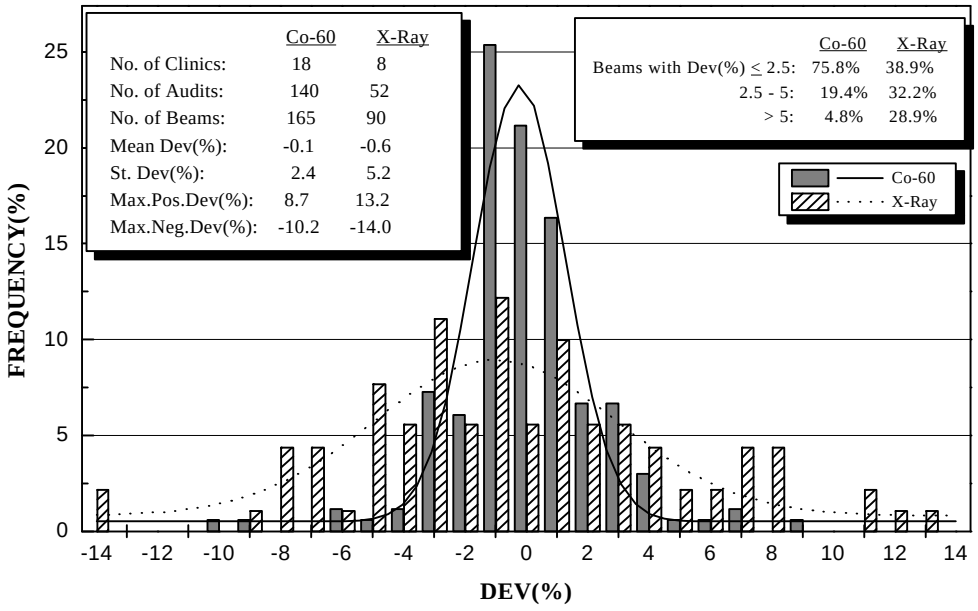


FIG.6- ROLE OF TRACEABILITY TO SSDL IN QUALITY AUDITS OF CO-60 BEAMS

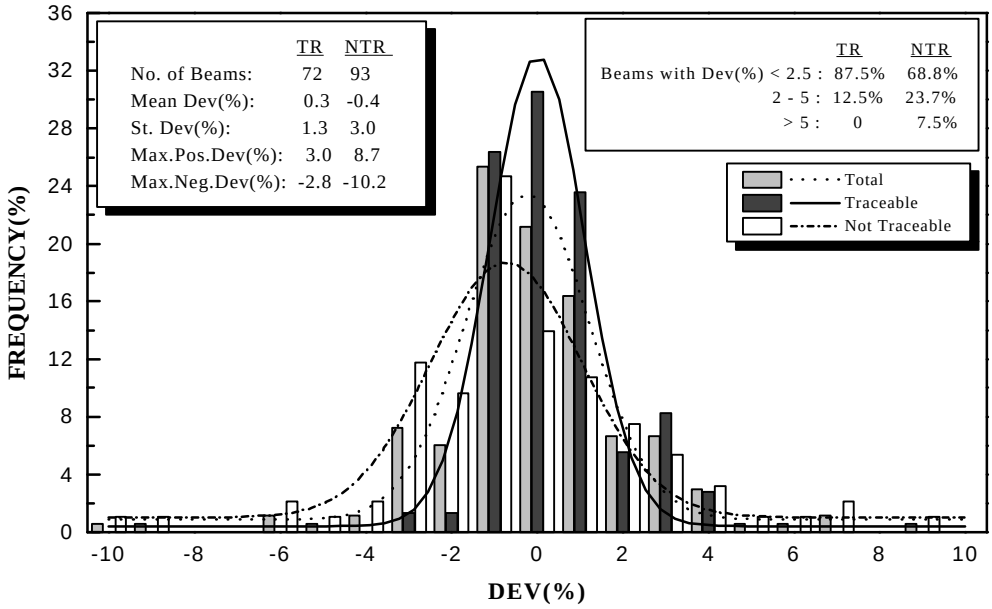
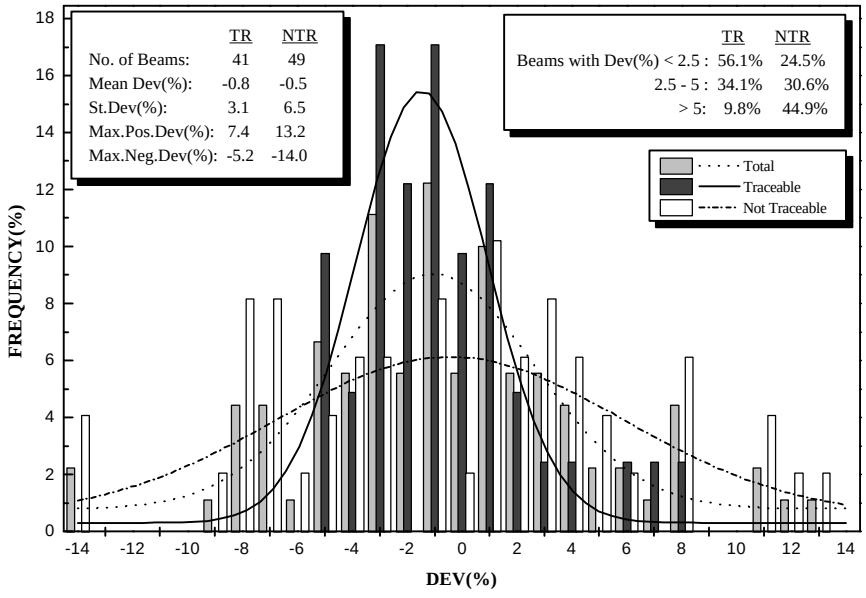


FIG.7- THE ROLE OF TRACEABILITY TO SSDL IN QUALITY AUDITS OF X-RAY BEAMS.



As a general rule followed by the SSDL up to now, clinics are informed of the results of the audit but the exact magnitude of the deviations is not given.

Most of the dosimeters used in hospitals, were calibrated at the SSDL at least once. However there are other factors that, although avoidable, but nevertheless can influence dosimetry intercomparison results and contribute to the deviations. The correction for air density (temperature and pressure) is a factor that sometimes introduces errors. Most of the clinics in Iran do not have their own barometers and rely on the air pressure that is quoted during measurements by local meteorological offices, sometimes a few kilometers far from the clinic. In one case, the barometer and thermometer of the clinic were deviating from SSDL instruments by 10 mb and

4°C, respectively even if the temperature was measured in air. In other clinics where their dosimeters were not calibrated at the SSDL, the dosimetry had been carried out by the medical physicists using calibration certificates issued by manufacturers. These certificates include calibration factors for some X-ray qualities but not for Co-60. The calibration factor for Co-60 was then derived by the medical physicist through extrapolating from the X-ray to Co-60 energy. This is of course, not correct because of discontinuity introduced by buildup cap. Also, applying slightly different values for factors such as conversion from exposure to absorbed dose, backscatter, etc. and mistakes made in calculations by medical physicists have contributed to the deviations. Although the results were later corrected for such factors and mistakes, the initial values quoted by clinics and used for treatments are considered for the purpose of this report.

6. CONCLUSION

The aim of quality audit programme is to provide radiotherapy centers with external checks in order to ensure that the radiation doses delivered to patients are as close as possible to the prescribed dose. During 12 years of audit programme, the SSDL of Iran was successful in setting up close links with most radiotherapy centers in the country and convince them that the delivered and prescribed doses are not necessarily the same. The importance of this point and the necessity of traceability to radiation standards in absorbed dose determination must be realized, specially by radiotherapists due to their overall responsibility in radiotherapy departments. From about 122000 patients treated by teletherapy units in Iran during 1985-96, an estimated 7300 patients (6%) received doses that differ from the prescribed dose by more than 5%. This estimation is based only on errors made in connection with measurements of radiation beams. Errors made in dose estimation, treatment planning and treatment set up will certainly increase the number poorly treated patients.

The SSDL of Iran is going to continue the quality audit programme as a national duty. As more therapy units are going to be in use in the future, attempts will be made to unify the methods of clinical dosimetry in the country according to the recommended international codes of practice.

Acknowledgment

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COURSES AND MEETINGS DURING 1998

Training Courses in the field of Dosimetry and Medical Radiation Physics

- Regional Course on **Clinical and Physical Aspects of Quality Assurance in Radiation Oncology** (RAF/6/019, in collaboration with the Applied Radiation Biology and Radiotherapy Section). Accra, Ghana, 15-24 April.
- Regional Course on **Dosimetry and Treatment Planning of Radiotherapy Treatments** (C7-RLA-6.035/1998). Mexico City, MEXICO, November 9-21
- Regional Course on the **Implementation of the ARCAL XXX, Programme for Quality Assurance in Radiotherapy (Physical Aspects).** La Habana, CUBA, 23 November-4 December

Other meetings

International Symposium on techniques for high-dose dosimetry in industry, agriculture and medicine.	Vienna	November 2-5
Consultant's Meeting to develop brachytherapy calibration procedures for SSDLs.	Vienna	9-22 October
Second Research Co-ordination Meeting on development of a QA programme for SSDLs.	Vienna	29 June-3 July
8th SSDL Scientific Committee Meeting on evaluation of and recommendation on the dosimetry programme.	Vienna	October 5-9
Second Research Co-ordination Meeting on dose determination with plane-parallel ionization chambers in therapeutic electron and photon beams.	Barcelona	March 30-April 3
Consultant's 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.	Vienna	May 25-29
Consultant's Meeting on the preparation and edition of international directory of radiotherapy centres (DIRAC).	Vienna	4-8 May
Consultant's Meeting on the organization of regional education programmes in medical radiation physics.	Vienna	12-16 October
Consultant's Meeting on the resolution of discrepancies of SSDLs	Vienna	November

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*** SSDL Organization**

Collaborating organizations associated with the IAEA/WHO Network of SSDLs

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

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Australian Radiation Laboratory, Melbourne, AUSTRALIA
National Research Council, Ottawa, CANADA
Laboratorie de Metrologie des Rayonnements Ionisants, Saclay, FRANCE
Physikalisch-Technische Bundesanstalt, Braunschweig, GERMANY
National Office of Measures, HUNGARY
Electrotechical Laboratory, Tokyo, JAPAN
Rijks Institut voor Volksgesundheid, Bilhoven, The NETHERLANDS
National Radiation Laboratory, Christchurch, NEW ZEALAND
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National Physics Laboratory, Teddington, UNITED KINGDOM
National Institute for Standards and Technology, Gaithersburg, USA

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1. Page 20, Appendix 3 “The composition and role of the SSDL Scientific Committee”

   The Committee consists of **7 members** appointed by the Directors General of the IAEA and WHO

2. Page 21, Appendix 4 “International support for the IAEA/WHO Network”

   The IAEA’s technical assistance programme has played an important role in the establishment of many of the SSDLs which now form the Network. Its assistance has ranged from small projects involving one or two months of expert advice, to large-scale projects in which the Agency has provided, over a period of several years, major basic equipment for use in an SSDL (including irradiation facilities and radiation-safety installations), and training for staff. **Between 1977 and 1997, more than 20 projects in the field of dosimetry were completed in 20 countries; the services of 22 experts and equipment worth over US$ 1.500,000 were supplied.**

3. Page 53, Appendix 9 “Annual Report for the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories”

   Item 6) “Deviation” means:

   $$\text{Deviation} = 100\% \, (\mathbf{D_P - D_{SSDL}}) / D_{SSDL}$$

   Where D_P : Dose stated by the participant, and

   D_{SSDL}: Dose determined from the dosimeter reading by the SSDL