The IAEA/WHO Network of Secondary Standard Dosimetry Laboratories

SSDL NETWORK CHARTER

INTERNATIONAL ATOMIC ENERGY AGENCY

THE IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

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INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

In 1976, the International Atomic Energy Agency (IAEA) together with the World Health Organization (WHO) established a Network of Secondary Standard Dosimetry Laboratories (SSDLs), known as the IAEA/WHO SSDL Network. This Network, through SSDLs designated by Member States, provides a direct linkage of national dosimetry standards to the international measurement system of standards traceable to the Bureau International des Poids et Mesures (BIPM,) and the dissemination of S.I. quantities and units through the proper calibration of field instruments by the SSDLs.

The Network has proved to be of value in improving national capabilities for instrument calibration and the awareness of better accuracy and traceability. Fifty-eight countries have nominated SSDLs for membership in the Network. Unfortunately, some of these SSDLs do not yet function as full members, perhaps because of some uncertainty as to their obligations concerning the Network. Consequently, the Scientific Committee which advises the Network Secretariat has recommended that a Charter be drawn up explaining the privileges, rights and duties of members in the Network which would strengthen their links to the international measurement system.

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In addition to the duties of members in the Network and the benefits that full members can receive, the Charter also describes how the Network functions and the scope of the work of the SSDLs. In producing this Charter, the advisory group has drawn heavily on the IAEA publication "Secondary Standard Dosimetry Laboratories: Development and Trends" (1985) which summarizes the origin, development, status and prospects of the IAEA/WHO SSDL Network. The various appendices are effectively up-dates of different parts of this earlier publication, and the original drafting and reviewing bodies are given due recognition. The revisions take into account the experience the Agency has gained in coordinating the activities of the Network for more than 20 years.

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1.THE SECONDARY STANDARD DOSIMETRY LABORATORY NETWORK AND ITS MEASUREMENT TRACEABILITY

1.1. Introduction

A Secondary Standard Dosimetry Laboratory (SSDL) is a laboratory which has been designated by competent national authorities to undertake the duties of providing the necessary link in the traceability of radiation dosimetry to national/international standards for users within that country. An SSDL is equipped with secondary standards which are traceable to the primary standards of laboratories participating in the international measurement system (Primary Standard Dosimetry Laboratories (PSDLs) and the Bureau International des Poids et Mesures (BIPM)).

The need for international traceability for radiation dose measurements has been understood since the early nineteen-sixties when the acute need for high dosimetric accuracy was recognized, particularly in external beam radiation therapy, where the outcome of treatment is highly dependent on the radiation dose delivered to the patient. Similar levels of accuracy are being urged and required by radiation regulatory agencies for sealed source brachytherapy, including high dose-rate treatment, and for unsealed source therapy, such as radioiodine. In other fields too, such as radiation sterilization, successful dose delivery is important as under-dose could result in bacterial or viral contamination of foodstuffs or of medical supplies.

When considering radiation protection of patients, the uncertainty in the dosimetry may be greater than for therapy, but proper traceability of the measurements with a defined level of uncertainty is equally as important. The *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources* (BSS) [1] stresses the importance of accurate patient dosimetry in diagnostic radiology, as such investigations are responsible for the vast majority of the man-made radiation burden. In addition, interventional radiology potentially presents conditions for acute harm. Diagnostic nuclear medicine also is a growing field in which a patient can be given an incorrect activity of a radionuclide unless proper calibration procedures are followed. Also for occupational radiation protection, especially in view of the new reduced occupational dose limits in the BSS [1], traceability at a defined level of uncertainty is still important although the uncertainty level may be even greater. All of these applications relate directly or indirectly to human health, emphasizing the importance of traceability of dosimetry to avoid unintended radiation exposures of individuals.

One of the first rules of any measurement system is that redundancy is essential for confidence in the system. A popular and robust method used by standardizing laboratories is to compare their standards against each other at regular intervals. In 1976, with the formation of the IAEA/WHO SSDL Network, the IAEA, in collaboration with WHO, undertook a programme to provide a forum in which national SSDLs could perform these comparisons and thus strengthen radiation dosimetry coherence worldwide. (See Appendix 1 for the history of the Network and Appendix 2 for a short history of radiation metrology).

1.2. The IAEA/WHO SSDL Network

The IAEA/WHO SSDL Network is an association of national SSDLs which agree to cooperate in promoting the objectives of that Network under international auspices. Its objectives are:

- to improve dosimetric accuracy, particularly in radiation therapy, radiation processing and radiation protection, by supporting centres and laboratories for the transfer of radiation standards and for the creation and distribution of knowledge in applied dosimetry;
- to promote further the exchange of experience between the members and affiliated members, and to provide support to each other where necessary;

- to establish and facilitate links between the members and the international measurement system for radiation measurements, through PSDLs; and
- to promote the compatibility of methods applied for calibration and performance of dosimetry in order to achieve uniformity of measurements throughout the world.

The organization of the Network is through the Network Secretariat which is advised by the SSDL Scientific Committee. The composition and role of this Committee, which was established in 1984, is given in Appendix 3. A short report of the past and current support for the Network given by the IAEA, the WHO and the BIPM is given in Appendix 4. A short description of four other affiliated organizations associated with the Network is also given in this appendix.

Normally, the competent national authority in a Member State will designate a single SSDL for the IAEA/WHO Network and this SSDL will undertake calibrations and perform other services in all the fields of radiation dosimetry. Occasionally this is not possible and more than one SSDL from a country participating in the Network might then be necessary. Guidelines to Member States on the designation of SSDLs is given in Appendix 5 and the criteria for establishing an SSDL for the IAEA/WHO Network are given in Appendix 6.

1.3. Measurement Traceability

The IAEA/WHO SSDL Network assists individual members in carrying out their functions involving the measurement of ionizing radiation, the creation of expertise in applied dosimetry and its transfer to the users of ionizing radiation, and the training of radiation workers. The Network serves as a means of achieving worldwide coherence in radiation measurements which can be traced back to the measurement standards of the BIPM and the PSDLs. This is an important service because the BIPM and the PSDLs cannot provide the amount of calibration work which has arisen from the widespread requirement for accurate and traceable measurements.

As of 1998, there are 58 countries with SSDLs in the Network and seven of these countries have their PSDLs as Affiliated Members. A list of current members is given in Appendix 7. In addition to providing calibrations for end-users, the SSDL should also provide calibrations for the other measurement laboratories in the country. In this way, radiation dosimetry throughout these countries has metrological links to the international measurement system.

Six countries, which have their own internal system of SSDLs, have their PSDLs as Affiliated Members. In total, there are fourteen PSDLs and the BIPM which support and participate in the IAEA/WHO SSDL Network together with the IAEA Dosimetry and Medical Radiation Physics Section (described in Appendix 8). This strengthens the metrological links and ensures the robustness of the Network as no single link is crucial to sustain traceability. Figure 1 illustrates the global metrological links of the international measurement system for radiation dosimetry.

The chain of traceability should ensure that radiation doses are being delivered as intended at the end-point. An effective way to do this is by cooperative external audit. In practice, the SSDL may be the only centre available in the country to provide support on quality audit and expertise on quality assurance. The SSDLs themselves are similarly audited at an international level (by the IAEA) and thus quality of radiation calibration is assured throughout the measurement chain to the point of use of radiation. Table I shows how this quality audit works in practice for the three programmes currently active in the IAEA/WHO SSDL Network.

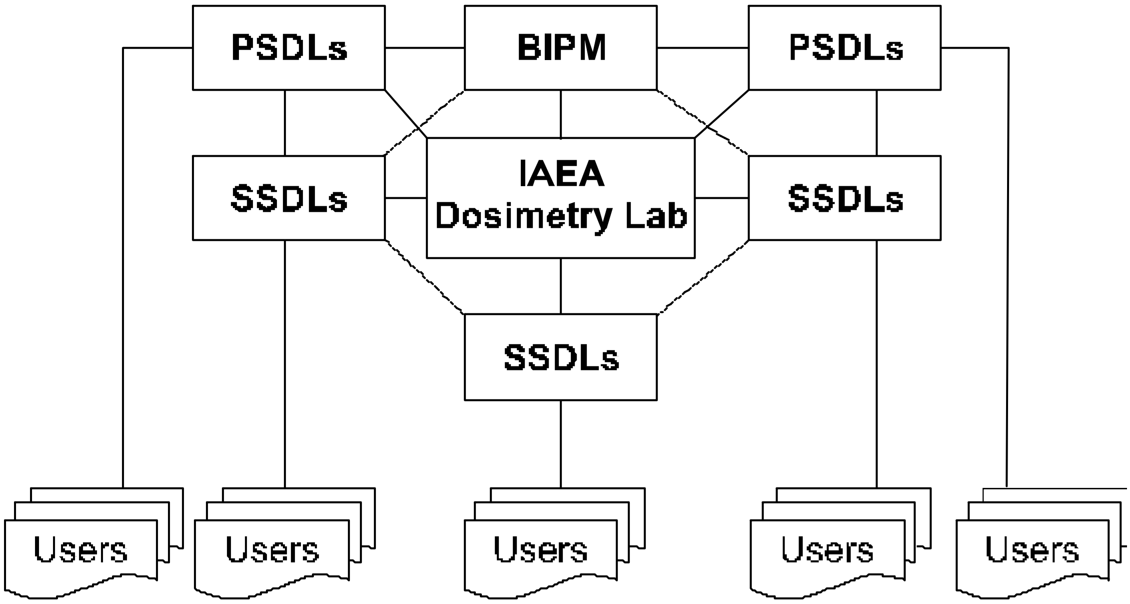

Figure 1. The global metrological links of the international measurement system for radiation dosimetry

1.4. The SSDL Network Charter

In being designated by its country as an SSDL in the Network, it agrees to cooperate in the objectives of the Network which are listed in Section 1.2. The SSDL may then derive the benefits of membership as described in detail in Section 2 of this document.

While the scope of the work of an SSDL may be quite broad in some countries (as described in Section 3) and restricted in others depending on national needs, there are certain duties which an SSDL is required to fulfil to retain full membership in the IAEA/WHO SSDL Network. These duties under the Charter are listed in Section 4. If a laboratory nominated to serve as an SSDL does not meet all the criteria for membership (see Appendix 6), it will be unable to fulfil the Charter but could be granted a provisional membership for an interim period while arranging to rectify the various shortcomings. Similarly, a full member who lapses in fulfilment of its duties will be designated as a provisional member for an interim period until the situation is rectified.

TABLE I. TRACEABILITY CHAIN FOR RADIATION DOSIMETRY

Level	Standard	National Audit	International Audit
International	BIPM primary standards	QA programme	International comparisons of PSDLs (BIPM)
National	PSDL or SSDL	QA programme/PSDL	
SSDL	Secondary standard	PSDL or IAEA	IAEA comparisons of SSDLs
	Calibrated dosimeters	SSDL/PSDL	IAEA ion chamber calibration intercomparisons
Radiotherapy user			
Radiation source in radiotherapy centre	Measurement with calibrated dosimeters, following a protocol (IAEA TRS 277 and 381 [3, 4])	TLD/ion chamber SSDL or IAEA	IAEA/WHO TLD programme
Dose distribution in a phantom	Protocol ESTRO/IAEA [5]	Complex Phantom or Standard Data (SSDL or Other)	IAEA/WHO TLD programme project
Dose distribution in individual humans	Protocol ICRU Reports [6, 7]	Anatomical Phantom or Reference Cases (SSDL or Other)	IAEA project
Radiation protection user			
Radiation source used for calibrating personal dosimeters	Measurement with calibrated dosimeter (IAEA TRS 133 [8])	TLD/ion chamber SSDL (or IAEA)	PSDL or IAEA
Personal dosimeters	Protocol	Blind irradiations by SSDL	
Radiation processing user			
Radiation source used for sterilization or irradiation of food	Measurement with calibrated dosimeter	Alanine/Fricke IAEA or SSDL	PSDL or IAEA

2. BENEFITS OF MEMBERSHIP IN THE IAEA/WHO SSDL NETWORK

The IAEA/WHO Network of SSDLs was set up to improve dosimetric accuracy in radiation dosimetry. The metrological links established within the Network provide traceability to the international measurement system through the Agency Dosimetry Laboratory. The Network conducts dose comparison to assure the coherence of the Network standards and supports the implementation of a quality audit programme at every level of the measurement chain which gives more confidence to its members and to the supporting organizations (see Table1). Training in all these aspects is provided to Network members.

Membership and interaction in the Network not only help SSDL members achieve confidence in their measurement capabilities but also facilitate international co-operation and provide robustness to the whole measurement system. The substantial benefits offered by the IAEA/WHO Network to its members are listed below.

2.1. International traceability

The support provided to the Network, through the international measurement system of the international metrological organizations (primarily BIPM) and affiliated Primary Standard Dosimetry Laboratories (PSDLs), is aimed at providing the coherence and robustness needed for radiation measurements world-wide as illustrated in Figure1. This is achieved by:

- The PSDLs in the Network, together with the BIPM, provide the first link in the chain of the international measurement system. These thirteen laboratories cooperating with the IAEA provide the redundancy in the traceability chain which gives the SSDL Network a high level of robustness.
- The Network provides direct comparison with the Agency Dosimetry Laboratory Standards for SSDLs with secondary standards calibrated by PSDLs.
- The Network provides periodic calibration of SSDL reference standards through the Agency Dosimetry Laboratory. Thus when end-user field instruments are calibrated against the reference standards at the SSDL facilities, the metrological link to the international measurement system is established.
- The Network also provides quality audit services to its members through the Agency Dosimetry Laboratory. Two programmes help the SSDLs maintain their national standards, verify their application of protocols, and monitor their calibration procedures.
    1. The first programme relies on the IAEA/WHO postal TLD service in which SSDL Network members are supplied with TLDs and asked to irradiate them to a specified dose under reference conditions. The Agency evaluates the TLDs, reports the results to the SSDL in confidence and provides scientific support to resolve discrepancies if needed.
    2. The second programme uses ionization chambers to help SSDL Network members verify the integrity of their national standards and the procedures for transferring these standards to users' equipment. Under this programme, participating SSDLs are asked to calibrate an ionization chamber in terms of air-kerma and absorbed dose to water, and send it to the Agency Dosimetry Laboratory where it is then calibrated against the Agency reference standards. The chamber is then returned to the SSDL for a second calibration. The Network Secretariat evaluates the results and reports them confidentially to the participating SSDL. As with the TLD programme, the Agency is prepared to provide support to help resolve any significant discrepancy.
- The Network, through the WHO, provides quality audit services to members for the application of radiotherapy dosimetric protocols by users. This programme relies on a postal TLD service from the Agency Dosimetry Laboratory in which hospitals are supplied, through WHO regional offices, with TLDs and asked to irradiate them to a specified dose under reference conditions. The Agency Dosimetry Laboratory evaluates

the TLDs, reports the results to the participants in confidence and provides scientific support together with the SSDL for the resolution of any significant discrepancies. Some SSDLs provide the postal TLD services themselves. For these SSDLs, the Network also provides an audit service to assure traceability.

- SSDLs in the Network co-operate with each other for radiation protection services by dose comparisons for personnel monitoring. The Agency also has comparison programmes in radiation protection. Similar quality audit programmes for diagnostic X-rays are being developed by the Agency and will be developed for nuclear medicine measurements as the needs arise, to cover all applications of ionizing radiation within the scope of the SSDLs.
- The Agency provides an International Dose Assurance Service (IDAS) to ensure that radiation processing doses are properly controlled. Under this service, alanine dosimeters are distributed to SSDLs or participating institutions for irradiation to a dose in the range of 100 Gy-100 kGy. The alanine dosimeters are then returned to the Agency for evaluation and reporting, in confidence, to the participants. Again, the Agency provides advice for the resolution of discrepancies.

2.2. Training

SSDL staff should possess qualifications and experience in measurement procedures and practices appropriate to their responsibilities. Individual training of SSDL staff can be provided to Network members, with the financial support of the Agency, if appropriate. When SSDL staff members come to the Agency Dosimetry Laboratory for practical training, they should take the opportunity to bring their dosimetry equipment and participate in its calibration with the Agency staff.

Training programmes to suit the responsibility levels of the various SSDL staff, offered by the Agency include:

- scientific visits, beneficial to the head of the laboratory who is responsible for calibration procedures and certification;
- fellowships, workshops and training courses held by the Agency, of interest to scientists, engineers and technicians in charge of calibration measurements;
- on-site training of SSDL staff members can also be provided by Agency experts, through technical cooperation projects, especially for new SSDLs who are starting their activities.

2.3. Networking

Maximum benefits will accrue to those SSDLs which participate actively in all aspects of the Network. The extent to which an SSDL involves itself in the Network will depend on individual circumstances but it should take advantage of all opportunities offered for sharing similar experiences. This can be achieved through:

- SSDL meetings organized by the SSDLs or the Agency at regional or inter-regional levels. Members of the Network will be able to share common experiences and exchange information on their activities. SSDLs conducting quality audits of clinical beams, at the national or regional level, could share their results and experiences with the follow-up activities.
- SSDL Newsletter, where scientific reports on SSDL activities are published and solutions to common problems are discussed. The Newsletter is prepared by the joint IAEA/WHO Secretariat of the SSDL Network and produced from contributions supplied by the members of the Network.
- An effective Network needs interaction with all its members. To support this process, contact names and addresses are distributed by the IAEA.
- SSDL Network members are supplied with updated relevant documentation (training manuals, technical reports, etc.).

– Network members can obtain scientific support from the Agency as well as from each other to help solve specific problems relating to their activities.

3. SCOPE OF THE WORK OF THE SSDLs

The prime function of an SSDL is to provide calibration services. As a holder of secondary standards it provides an essential link to the international measurement system which is itself based on the intercomparison of standards held by primary standards laboratories under the aegis of the BIPM.

3.1. Maintenance of Radiation Dosimetry Standards at the SSDL

The following are considered essential to maintain a recognizable traceability chain for radiation standards.

1. The laboratory's standards shall be calibrated by a PSDL or the BIPM (if appropriate) or by the IAEA, at intervals not to exceed 5 years; this is to maintain traceability to the international measurement system.
2. Radiation sources, calibration facilities, and associated equipment shall be properly documented and maintained in full working order.
3. A comprehensive Quality Assurance Programme should be developed which follows the Agency recommendations in the Coordinated Research Project (CRP) on "Development of a Quality Assurance Programme for SSDLs" (E2.10.02), which includes as a minimum:
    a) <u>Internal QA</u> (e.g. ISO / IEC Guide 25) including redundancy checks on the standards and peripheral equipment, up-to-date staff training, improvement to equipment or techniques as appropriate, documentation and record keeping [2].
    b) <u>External QA</u> including measurement assurance tests through the IAEA/WHO TLD or ion chamber irradiation programmes and intercomparison of standards and techniques with other SSDLs.
4. The SSDL should participate with the PSDL or the Agency in the resolution of any dosimetry discrepancies identified by adopting the appropriate action levels established by the SSDL Network Secretariat.
5. The SSDL should cooperate with the SSDL Network Secretariat in the exchange of information and in improvements to their instruments, measurements and techniques.
6. Annual reports should be made to the SSDL Network Secretariat on the status of the standards and radiation sources, on the type and number of calibrations performed for users, the present number of staff, the training received and training provided, and on the implementation of the Quality Assurance Programme.

3.2. Collaboration with end-users and services provided

The major role of the SSDL is the dissemination of radiation dosimetry standards to users through instrument calibration, which includes dissemination of information on calibration procedures, and practical help to end-users on instrument use in their particular application.

Calibration certificates for the users' equipment should be developed which provide not only the numerical value of the calibration factor but also all other information necessary to understand how to use the factor. This includes the conditions of calibration, the instrumentation used, any special conditions and a full uncertainty statement.

Some SSDLs, with the appropriate facilities and expertise, may also conduct quality audits of the end use of the calibrated dosimeters, for example, by:

1. providing postal dosimeters for dose comparisons for medical institutions within a country or region. This is done either by:

a) coordinating the distribution of TLDs from the IAEA/WHO postal service or the national/regional affiliated centres, or
b) providing the service themselves according to the procedures promulgated by the Agency CRP on ”Development of Quality Assurance Programmes for Radiation Therapy Dosimetry in Developing Countries” (E2.40.07). Strict confidentiality of the results must be maintained to encourage participants join the audit programme.

2. providing on-site dosimetry audits with an ion chamber and other appropriate equipment,
3. organizing dose comparisons for radiation processing within a country e.g. using alanine dosimeters from the Agency Dosimetry Laboratory,
4. providing calibration services for personal radiation dosimeters,
5. providing postal dosimeters for patient dosimetry in diagnostic X-ray,
6. supplying sources to audit nuclear medicine calibrators.

In conjunction with any of the above quality audits, the SSDL must collaborate with the end user in the resolution of dosimetry discrepancies. It is important to note that each quality audit is performed in the spirit of collaboration and support rather than in the spirit of inspection. This ensures the fullest possible cooperation from the end user.

If the SSDL has the additional expertise and equipment necessary, it can provide other services where appropriate including:

1. maintenance of measuring instruments for end users;
2. national training courses in radiation measurement and calibration techniques and in the use and maintenance of the users instrumentation, and
3. advice on QA programmes.

The Agency recommends that the SSDLs should not perform the duties of Medical Physicists or Radiation Safety Officers at the end-user’s facility except in dire situations where no such staff are available in the country.

4. DUTIES OF THE SSDLs IN THE IAEA/WHO SSDL NETWORK

The SSDLs in the Network are expected to cooperate in promoting the objectives of the Network as described in Section 1.2. For SSDLs to maintain full membership in the IAEA/WHO SSDL Network, they are required to fulfil the following obligations.

1. To maintain traceability to the international measurement system by having their reference instruments calibrated against primary standards or at the Agency Dosimetry Laboratory at least every 5 years.
2. To provide calibration services and certificates for either therapy or protection levels or both.
3. To implement QA procedures including internal quality assurance and external quality audit (e.g. following ISO/IEC Guide 25 and IAEA) .
4. To participate in the periodic Network measurement assurance tests with a frequency established by the SSDL Network Secretariat. These tests include:
   a) verification of radiation source calibration with TLD,
   b) verification of the SSDL calibration procedure with an ion chamber.
5. To submit their annual report to the Network Secretariat (the form is included as Appendix 9).

An SSDL who is unable to fulfil these obligations cannot be a full member but may be listed as a provisional member for an interim period while efforts are being made to comply.

The IAEA will provide support for SSDLs in developing countries through its technical co-operation programme. Some details are given in Appendix 4.

5. CONCLUSION

Following the above Charter guidelines, the SSDL Network Secretariat has identified full members, and provisional members in the Network in 1997. It is hoped that establishing and issuing this Charter will encourage provisional members to acquire the necessary expertise, equipment and procedures to fulfil all conditions for full membership.

It is also hoped that provisional Network members who are presently providing all services necessary but are not reporting them, or are not actively participating in Network activities, will become active so that they may return to full membership and thus become part of the worldwide Network. In addition, this Charter encourages non-Network SSDLs to contact the Network Secretariat and become members. Lastly, it is hoped that countries that do not presently have an SSDL will be encouraged to establish an SSDL. Therefore, in the foreseeable future all countries will have direct links with the international measurement system for ionizing radiation dosimetry.

APPENDIX 1
HISTORY OF THE IAEA/WHO SSDL NETWORK

In 1966, as a first step towards overcoming the inadequacies of dosimetry in radiation therapy which existed at that time, the IAEA established a dose intercomparison service using thermoluminescent dosimetry (TLD). Although the service was valuable it did not get to the heart of the problem, which was the need for ready access to traceable standards for ion chamber calibration.

In April 1968 the IAEA convened a panel of experts, who met in Caracas, Venezuela, to discuss the dosimetric requirements of radiotherapy centres. The panel included representatives of WHO and its regional offices. They could not have been cheered by what they heard. In the whole of Latin America, for example, there were at that time at most only five qualified hospital physicists, whereas at least 50 were needed to support the work of the radiotherapy units in the region. There was not a single laboratory in the whole of Latin America which could calibrate dosimeters, or compare measurements made with them. The situation was scarcely better in some other regions. The implication was that thousands of cancer patients were being treated every year without proper control of the dosage.

The panel of experts did not simply receive reports. They made a number of practical suggestions to overcome the obvious inadequacies in radiotherapeutic dosimetry in many parts of the world. One was that dosimeter calibration laboratories should be set up in various regions. The work of these laboratories which later came to be called Secondary Standard Dosimetry Laboratories could be supported by existing primary standard laboratories, and co-ordinated by the IAEA.

The suggestion received considerable support, but there was little real achievement for some time. It was not until the end of 1974 that the IAEA invited a number of experts, mainly from the large national standards laboratories, to a joint IAEA/WHO meeting in Rio de Janeiro, Brazil, to discuss the concept of SSDLs and their role in metrology. An SSDL was defined there as a laboratory designated by the competent national authorities to undertake the duties of calibration in dosimetry in each country taking part in the scheme. The scheme outlined at that meeting also provided for the designation of regional SSDLs by intergovernmental agreement or by an international organization to provide calibration services to other countries. It was proposed that such laboratories should be equipped with secondary standard dosimeters that is, reference dosimeters calibrated against primary standards.

It is a requirement in metrology that standardizing laboratories should compare their standards against each other at regular intervals. For primary standards, the organization of such intercomparisons is the responsibility of the Bureau International des Poids et Mesures in Paris. It was recognized that if SSDLs were to function properly, the need for dose intercomparisons and for co-ordination of their work called for some kind of international SSDL organization.

Working out the details of the project again took some time, but in 1976 the IAEA and WHO were able to notify their Member States of the formation of the SSDL Network. Within a few months, governments had nominated about 25 laboratories to take part in the scheme. Membership in the SSDL Network by 1985 had risen to about 50 laboratories, of which 36 were in developing countries, and by 1998 had grown to 75 SSDLs in 58 countries. A number of other SSDLs also exist although they are not formally part of the SSDL Network. The participating laboratories are listed in Appendix 7.

Secretariat functions in support of the SSDL Network are shared between the IAEA and WHO, the IAEA being responsible for the technical development of the member laboratories. Thirteen primary standards laboratories and five international bodies, among them the Bureau International des Poids et Mesures, the International Office of Legal Metrology and the International Commission on Radiation Units and Measurements, have agreed to support the SSDL Network. The Secretariat can also call for advice from a standing SSDL Scientific Committee, which meets biennially to review the programme of the Network (the composition and role of this committee is in Appendix 3). Consultants and advisory groups also advise and assist the Secretariat in the implementation of specific projects such as the drafting of technical reports, guidelines and manuals.

The scope of the work done by the SSDLs is expanding continuously. Many are fully operative and identified as full members in Appendix 7. They are calibrating the dosimeters used in radiotherapy and in radiation protection. Such work is required by law in an increasing number of countries. The staff of some SSDLs are also providing quality audits of the output of radiotherapy units in local hospitals. Others are organizing or operating national or regional dose comparison services, testing new dosimetric or radiographic equipment, introducing and implementing quality assurance programme in diagnostic radiology, conducting courses in applied radiation dosimetry for physicists, technicians and radiation oncologists and measuring the doses delivered by the large irradiation units used for industrial radiation processing. Today, many SSDLs are the only national standards laboratory in their country.

APPENDIX 2
A SHORT HISTORY OF RADIATION METROLOGY

In 1895 Röntgen discovered X-rays and in the following year Becquerel discovered the phenomenon of radioactivity. These two fundamental advances in science sparked off decades of intense research, which continues today. X-rays were found to be powerful tools for use in medical diagnosis and therapy. Research workers discovered other forms of ionizing radiation: alpha and beta particles, and gamma rays. Neutrons and pions were found to have effects similar to those of ionizing radiation. All these forms of radiation have been put to use. Gamma rays from ^{60}Co sources are widely used for cancer therapy, and clinical accelerators which produce megavoltage photons and electrons are used heavily in developed countries and to a lesser extent in developing countries. These radiation sources are also used in modern industry for a wide variety of purposes: checking the integrity of welds or the moisture content of papers, sterilizing health care products, preserving food, the list is almost endless.

However, from the very beginning of radiation science, research workers realized that they had a challenge. In order to make measurements of anything to do with radiation, it is necessary to use techniques requiring complex scientific instruments. The development of these instruments took many years. Increasingly sophisticated measurement techniques made use of the fact that the colour of some chemical compounds changes when they are exposed to X-rays, and that this colour change can be related to the absorbed dose. Special dyes whose colour changes in a known way on exposure to radiation were developed: such dyes are still used today to measure high doses. However, the techniques available for dose measurement remained rather qualitative and unsatisfactory for some time.

In 1905, at the Röntgen Congress in Berlin, it was proposed that a committee should be set up to define a unit for the measurement of X-ray intensity. The proposal lapsed, because not enough was known at that time about the physical and chemical effects of radiation. The next important step forward was in 1908, when Villard suggested that as X-rays change the electrical conductivity of air through which they pass, measuring this change might be useful as a way of determining X-ray dose. This physical effect results from the fact that most kinds of radiation have the power to displace electrons from atoms which they strike, thus giving them an electrical charge. Charged atoms are termed ions, and hence the radiation which causes the charged atom is said to be ionizing. The phenomenon of ionization is used today in instruments such as the widely known Geiger counter and in ionization chambers.

Further research was undertaken, and in 1925 the German Röntgen Society was able to adopt the röntgen (R) as the unit of X-ray dose. Three years later, with minor modifications, the röntgen was adopted by the second International Congress of Radiology in Stockholm, Sweden. In 1957, at the fifth International Congress of Radiology in Chicago, USA, the röntgen was accepted as the unit to be used for both X-ray and gamma-ray dose. It was not until 1962, however, that the röntgen was defined as a special unit for the quantity of exposure.

The definition of the röntgen involved quantities which are measurable with a high degree of accuracy[1]. As early as 1913, however, it was realized that measuring the amount of ionization which photons produce in air (which is the basis of the definition) tells us very little about their biological effect on the body exposed to them. Although there were rapid developments in measurement techniques and in the scientific understanding of the effects of radiation, 40 years were to pass before the International Commission on Radiation Units and Measurements adopted a new quantity, the absorbed dose, and its unit, the rad (the word rad is an acronym formed from the initial letters of the words ‘radiation absorbed dose’). This unit can be used to measure doses of ionizing radiation of all kinds. It was defined as the amount of energy that leads to the deposition of 10^{-2} joule of energy per kilogram in the absorbing material.

For X-rays and gamma rays of average energy (about 1 MeV) an exposure of 1 röntgen results in the deposition of 0.96 x 10^{-2} joule per kilogram of soft body tissue. This is very nearly 1 rad. In bone, however, an exposure of 1 röntgen results in the deposition of more than 1 rad. It is this differential energy deposition which underlies the production of X-ray photographs.

In 1975, as part of the rationalization of scientific units promulgated by the General Conference on Weights and Measures, the unit used to measure absorbed dose was changed to the gray (abbreviated Gy), corresponding to 100 rad and hence 1 $J.kg^{-1}$. Yet another unit, the sievert (Sv), is used to measure the dose equivalent of a given exposure, taking into account the differing ‘biological effectiveness’ of different types of radiation. The sievert replaces a unit used earlier, the rem (an acronym from “röntgen equivalent-man”).

This short account of the principles of radiation metrology and recitation of history is a necessary background for the reader to appreciate the importance of work performed today by the Network of Secondary Standard Dosimetry Laboratories, co-ordinated by the International Atomic Energy Agency.

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[1] The röntgen is defined as the quantity of either X or gamma rays which will produce, as a result of ionization, electrons carrying a total charge of 2.58 x 10^{-4} coulomb in 1 kilogram of dry air.

APPENDIX 3
THE COMPOSITION AND ROLE OF THE SSDL SCIENTIFIC COMMITTEE

In 1984 the Scientific Committee of the IAEA/WHO SSDL Network was formed. The committee currently consists of 7 members appointed by the Directors General of the IAEA and WHO. Membership consists of one representative from the BIPM, the ICRU, one PSDL, one SSDL, and three other scientists from the metrological community. Members serve 5 year terms and meet 3 times during this period.

In general, the Committee advises the Network Secretariat on methods to carry out its responsibilities. Specifically, the Committee is charged with making recommendations and comments on:

- techniques for carrying out intercomparisons between SSDLs;
- techniques for establishing and maintaining traceability to BIPM or to PSDLs;
- metrological consistency within the Network;
- the need for site visits, improved equipment, techniques, etc.;
- the dissemination of information, including the format and contents of the SSDL Newsletter and,
- the need for training, and topics to be covered.

The Scientific Committee prepares a report to the Directors General of the IAEA and WHO following each meeting and this report is circulated subsequently to Member States through the SSDL Newsletter.

APPENDIX 4
INTERNATIONAL SUPPORT FOR THE IAEA/WHO SSDL NETWORK

1. THE IAEA

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 80 projects in the field of dosimetry were completed in 40 Member States; expert services and equipment worth between US$400.000 and US$1.500,000 per year were supplied. At the end of 1997, a further 25 projects in 19 countries were under way, representing a total of 145 man-months of expert services and equipment worth more than US$2 million. Under the 1998 programme, an additional 48 man-months of expert services and equipment worth more than US$1.6 million were approved. The figures for 1999 are expected to be of the same order. Additionally, co-ordinated research projects covering a wide range of topics related to radiation metrology and quality assurance procedures have been organized with the participation of many SSDLs.

The Agency's Dosimetry Laboratory at Seibersdorf plays a key role in the IAEA activities. Chamber calibration and postal dose audits with TLD and alanine form a major part of this support. The laboratory also accepts SSDL staff for training, and has designed special equipment for calibration purposes. Every two years, training courses for SSDL staff are held at advanced SSDLs. In the past, laboratory staff and experts engaged for the purpose by the Agency visited groups of SSDLs in a particular region, taking calibrated dosimeters with them to perform dose comparisons on the site. By 1985, these exercises were being replaced by regional calibration workshops, held at advanced SSDLs, with staff from other SSDLs in the region participating. Each calibration workshop is guided by an expert from a national primary laboratory, and complemented by lectures on specific subjects.

The governments of a large number of developing Member States have realized that setting up a standards laboratory such as an SSDL will be of immediate benefit to the health of their people and to their industrial development.

Given the uncertain basis from which the SSDL Network began, and the paucity of resources identified by the IAEA in the 1960s, it is hardly surprising that a shortage of adequately trained staff is still the main obstacle to the full operation of some SSDLs. The Agency therefore gives particular attention to the provision of information, and special training for the technical staff of such laboratories. For example, it organizes regional training courses and seminars held at operating SSDLs in developing countries.

In addition, the Agency has prepared training manuals and publications in the area of radiation dosimetry. The list of the IAEA publications is given in Appendix 11.

2. THE WHO

The Constitution of the World Health Organization was adopted on 22 July 1946 by the International Health Conference, which was convened by the Economic and Social Council and held in New York. WHO came into being on 7 April 1948, when the 26th United Nations member ratified the Constitution.

The World Health Assembly is the policy-making body of WHO and meets in annual sessions. The Executive Board, which meets twice a year, acts as the executive organ of the Assembly. Six regional organizations have been established as integral parts of the Organization, each consisting of a regional committee and a regional office.

Regional committees meet in annual sessions. The Secretariat consists of a Director General, six Regional Directors, and such technical and administrative staff as is required.

The objective of WHO is the attainment by all people of the highest possible level of health. Health, as defined in the WHO Constitution, is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. In support of its main objective, the Organization has a wide range of functions, including the following:

– to act as the directing and co-ordinating authority on international health work;

– to promote technical co-operation;

– to assist Governments, upon request, in strengthening health services;

– to furnish appropriate technical assistance and, in emergencies, necessary aid, upon the request or acceptance of Governments;

– to stimulate and advance work on the prevention and control of epidemic, endemic and other diseases;

– to promote, in co-operation with other specialized agencies where necessary, the improvement of nutrition, housing, sanitation, recreation, economic or working conditions and other aspects of environmental hygiene;

– to promote and co-ordinate biomedical and health services research;

– to promote improved standards of teaching and training in the health, medical and related professions;

– to establish and stimulate the establishment of international standards for biological, pharmaceutical and similar products, and to standardize diagnostic procedures; and

– to foster activities in the field of mental health, especially those activities affecting the harmony of human relations.

In April 1976 the IAEA and the WHO concluded a Working Agreement concerning the establishment and operation of a Network of Secondary Standard Dosimetry Laboratories, based on a relationship agreement of 1959 between the two organizations. After 10 years of operation of the SSDL Network, a new arrangement was drafted during 1985 and signed by the two Directors General in October/November 1985. The purpose of this arrangement was to define the responsibilities of IAEA and WHO in the operation and support of the Network and to establish criteria for the establishment of SSDLs.

3. THE BIPM

The laboratories at the BIPM, based in France, were set up as a result of the Convention du Mètre in 1875 and their work is monitored by the Conférence Générale des Poids et Mesures (CGPM).

The Ionizing Radiation Section of the BIPM, set up in 1960, develops and maintains primary standards for air kerma and absorbed dose used for radiotherapy and dose equivalent for radiation protection, in addition to maintaining activity standards. Dosimetry comparisons are held regularly at the BIPM with the primary standards of national PSDLs. The secondary standards of the IAEA Dosimetry Laboratory are calibrated regularly at the BIPM in terms of both air kerma and absorbed dose to water. The BIPM laboratory also calibrates the secondary standards of national laboratories for those countries which are signatories to the Convention du Mètre and which do not hold primary standards.

The BIPM irradiates TLDs from the Agency Dosimetry Laboratory, as do two PSDLs, as independent external audits of the IAEA/WHO TLD programmes. Staff members are available as consultants to the IAEA and have served on various advisory groups. The BIPM is also represented at the SSDL Scientific Committee, the ICRU, the OIML and the IEC amongst others.

An international consultative committee (CCEMRI) meets every two years to discuss the reports from the BIPM Ionizing Radiation Section and recommend future work. Reports from the national PSDLs which attend are also discussed. The IAEA and the ICRU are represented at these meetings.

4. THE ICRU

The International Commission on Radiation Units and Measurements (ICRU) was established in 1925 by the International Congress of Radiology. Since its inception, it has had as its principal objective the development of internationally acceptable recommendations regarding:

- quantities and units of radiation and radioactivity;
- procedures suitable for the measurement and application of these quantities in radiation therapy, diagnostic radiology, radiation biology, and industrial situations; and
- physical data needed in the application of these procedures, the use of which tends to assure uniformity in reporting.

The ICRU endeavours to collect and evaluate the latest information pertinent to the problems of radiation measurement and dosimetry, and to recommend in its publications the most acceptable values and techniques for current use.

Measurements of radiation is a complex subject and is a science in itself. Yet many users of radiation who need to make radiation measurements cannot be expected to become experts in this field. What they need is authoritative guidance on how to deal with the measurement problems connected with their particular use of radiation. The ICRU has long met this need. Guidance on measurements as diverse as those involved in measuring the radiation used in medical practice and the exotic radiation found in space has been provided by the Commission. The ICRU is recognized as a source of helpful, practical and authoritative recommendations on all types of radiation measurement problems. For example, progress made in radiation therapy requires the ability to compare clinical results achieved in different centres using different radiation modalities and protocols. Thus, a common language for reporting fractionation schedules, doses, and techniques is required for optimum treatment. The ICRU has devoted considerable effort in that direction.

5. THE IEC

The International Electrotechnical Commission (IEC) was founded in 1906 as a result of a resolution passed at the International Congress held in St. Louis (USA) in 1904. The membership consists of 57 participating countries. Membership includes all the world's major trading nations and a growing number of industrializing countries.

The mission of the International Electrotechnical Commission (IEC) is to promote, through its members, international co-operation on all questions of standardization and related matters, such as the assessment of conformity of standards, in the field of electricity, electronics and related technologies. It therefore provides a forum for the preparation and implementation of consensus-based voluntary international standards, facilitating trade in its field and helping to meet expectations for an improved way of life.

To fulfil its mission, among other activities the IEC publishes international standards and technical reports; the international standards serve as a basis for national standardization and as references when drafting international tenders and contracts.

The supreme authority of the IEC is the Council, which is the general assembly of the National Committees, who are the Commission's members. The IEC also comprises executive and advisory bodies and officers.

The IEC co-operates with numerous other international organizations, particularly with the International Organization for Standardization (ISO) and increasingly with the International Telecommunication Union (ITU). Close links are also enjoyed with other bodies in non Electrotechnical areas, examples being liaisons with the World Health Organization, the International Labour Organization, the International Organization of Legal Metrology and the International Atomic Energy Agency.

6. THE OIML

The International Organization of Legal Metrology (OIML) was established in 1955 as an intergovernmental body dedicated to harmonize the national metrology regulations of its members. Its administrative and technical operations are co-ordinated by a central secretariat: the International Bureau of Legal Metrology (BIML), located in Paris, France.

Metrology infrastructures have been established in most countries although these may vary according to specific needs and levels of development, there is a common denominator for their existence: each government takes responsibility for ensuring the establishment and proper functioning of a credible measurement system, including its legal applications.

A credible system of measurement is vital for the overall well-being of society. The OIML aims to harmonize the activities of its members in order to create an international legal metrology framework where mutual cooperation and confidence lead to acceptable ranges of measurement credibility. The OIML strives to provide the metrology community with the structures and activities necessary for reaching agreements on metrological subjects relevant to public concern.

The main task of the OIML is to furnish its members with models for establishing harmonized legal metrology requirements and practices. International recommendations and documents are published for this purpose.

At the intergovernmental level, OIML has close links with the "Convention du Mètre", whose executive body is the Bureau International des Poids et Mesures (BIPM).

The membership of OIML consists of 56 Member States and 44 Observers from Corresponding Members.

7. THE IOMP

The concept of an international organization for medical physics was first discussed at the International Congress of Radiology, Munich, 1959, at which it was decided to set up an international committee which later met in Stockholm in 1961. At this meeting, attended by over fifty medical physicists from twelve countries, a steering committee was elected to prepare a constitution for the proposed International Organization. This committee met in Montreal in 1962 and formally agreed to the setting up of the International Organization for Medical Physics (IOMP) as from January 1963. At this meeting the committee elected acting officers.

The objectives of IOMP are to organize international co-operation in medical physics and allied subjects, to contribute to the advancement of medical physics in all its aspects, especially in developing countries, and to encourage and advise on the formation of national organizations of medical physics in those countries which lack such organizations.

The IOMP is administered by a Council, which consists of delegates from each of the Adhering National Organizations. Regular meetings of Council are held every three years at the International Conference on Medical Physics.

Membership of the IOMP consists of all individual members of the Adhering National Organizations. Two other forms of membership are available, namely Affiliated Regional Organizations and Corporate Members. By 1997 the membership has reached 64 affiliated countries, two regional organizations, and 26 Corporate Members.

Official publications of the IOMP are *Physiological Measurement*, *Physics in Medicine and Biology*, and the *Medical Science Series* published by IOP Publishing, Ltd. The IOMP publishes a bulletin *Medical Physics World* twice per year.

APPENDIX 5
GUIDELINES TO MEMBER STATES ON THE DESIGNATION OF SSDLS

These guidelines were first published under the title "Guidelines for Member States Concerning Radiation Measurements Standards and Secondary Standard Dosimetry Laboratories" and is available from the Network Secretariat.

1. INTRODUCTION

In the early nineteen-sixties an acute need developed for higher dosimetric accuracy in radiation therapy, particularly in developing countries. This need led to the establishment of a number of dosimetry laboratories around the world, specializing in the calibration of radiation measuring instruments and dosimeters.

In order to co-ordinate the provision of guidance and assistance to such laboratories, the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) set up a Network of Secondary Standard Dosimetry Laboratories (SSDLs) under their joint aegis. The present guidelines deal with the functions and status of SSDLs, in particular with the need for recognition and support by the competent national authorities.

1.2. The need for measurement standards

The highest possible accuracy is needed in radiation therapy, where success or failure of the treatment is at stake. In radiation protection measurements lower accuracy is acceptable, particularly in environmental monitoring. However, when dosimeters are used to determine doses received by individuals under working conditions, such measurements need to be traceable though an unbroken chain of comparisons to national and international standards. Such traceability is needed to ensure accuracy and reliability, and also on account of legal and economic implications. This aspect is of acute relevance as it may be expected that many SSDLs will become engaged in dosimetric measurements of persons and the environment, and in instrument calibrations in connection with unintentional radiation exposures.

Traceability and confidence in known levels of measurement are also required for radiation processing facilities, such as those used in sterilizing health care products and the treatment of food.

1.3. SSDLs and metrology

The prime function of an SSDL is to provide a service in metrology. As holder of a secondary standard instrument, it provides an essential link to the international measurement system which is itself based on the comparison of standards held by primary standards laboratories under the aegis of the Bureau International des Poids et Mesures (BIPM). The secondary standard may constitute a country's national standard (for a particular quantity), and the laboratory may be part of a larger metrology organization. The functions and status of a particular SSDL are determined by national or local circumstances but, in all cases, necessary recognition and support by the competent national authorities are crucial to the success of the SSDL in practice. Indeed, such support is a prerequisite for holding full membership in the SSDL Network.

At present, two types of SSDLs exist. Firstly, those laboratories that fulfil a nationwide metrological function based on traceability to approved measurement standards. This includes the provision of certified calibrations for instruments used in radiation therapy and other fields. Secondly, those calibration laboratories that take care of a particular radiation therapy centre, or group of such centres, without a formal national mandate. Clearly, the latter type of SSDL must also possess a calibrated secondary standard instrument, though it may not have been designated as the national measurement standard. It is anticipated that the latter type of SSDL may evolve into the former type, though both large and small laboratories are of equal concern to the Secretariat of the IAEA/WHO Network of SSDLs, provided they are operational, participate in dose intercomparison measurements organized by the Network secretariat, and their official status is recognized and supported by the competent national authorities.

2. PRINCIPLES AND RECOMMENDATIONS

2.1. Measurement standards

It is a basic principle of metrology that measurements of physical quantities should be traceable to approved measurement standards, thus providing assurance that the accuracy of measurements is adequate for the purpose.

Every country in which ionizing radiation is used should either maintain a national measurement standard, which may be a primary or a secondary standard, for each relevant quantity, or make arrangements for ready access to such standards established and maintained in another country, or the IAEA/WHO Network of SSDLs, for the calibration of relevant instruments.

National measurement standards may be maintained by a primary standard dosimetry laboratory (PSDL), or if no PSDL exists, by an SSDL. Such national standards may be calibrated at the International Bureau of Weights and Measures (BIPM).

For a particular country, there should be only one national measurement standard for a given quantity, and this should be recognized in a regulatory form by the competent national authorities. This standard should be compared periodically with other national standards forming part of the international measurement system under the aegis of the BIPM.

The competent national authorities may designate one SSDL as the holder of the national measurement standard for a specified quantity. If a county has more than one SSDL, the working standards of other SSDLs must be traceable to the national standard, and it is recommended that the SSDLs should be grouped into a national SSDL organization.

2.2. SSDLs and the Network

The competent national authorities may nominate a single SSDL, or an SSDL organization, for participation in the SSDL Network. Establishment of an SSDL organization allows a country to have as many dosimetry laboratories as are deemed necessary or desirable. Because of the metrological nature of the work of SSDLs, it is essential that every SSDL be legally identifiable, and it is preferable that the SSDL organization be linked to the national metrology office.

If, in a country, the establishment of an SSDL organization is not practicable, the IAEA/WHO Network of SSDLs may accept, upon request from the competent national authorities, more than one SSDL for participation in the Network. Such arrangements are, however, exceptional and for a limited period only.

National recognition and support of an SSDL are prerequisite for participation in the SSDL Network. However, such participation does not depend on the designation of the secondary standard held at the laboratory as a national standard.

Participation in the SSDL Network does not constitute a prerequisite for obtaining assistance through the IAEA Technical Cooperation programme. The provision of such assistance will be based on a request from the competent national authorities and will take into account the priorities set by them, within the limits of resources available for the implementation of that programme.

APPENDIX 6
THE CRITERIA FOR ESTABLISHING AN SSDL FOR THE IAEA/WHO NETWORK OF SSDLs

(Recommendations of an expert's group)

1. SCOPE

This document sets forth the criteria to be met when a member state wishes a national SSDL to be accepted for membership in the IAEA/WHO Network. It may also serve as a recommendation to governments in the process of designating a laboratory to become an SSDL. These criteria are minimum requirements only.

2. THE IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

In a working arrangement (1976) between the IAEA and WHO, it was agreed to set up an "IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDLs)" in order to improve accuracy in applied radiation dosimetry throughout the world. The working arrangement specifies details of the structure of the Network and lays down procedures for membership.

A laboratory fulfilling the general criteria set forth here may become, at the request of its government, a member of this Network. In cases where these criteria are not initially met, provisional membership may be appropriate during the period needed to satisfy these requirements. Application for membership in the IAEA/WHO SSDL Network must be based on a nomination from the Government of the Member State concerned. The nomination specifies a laboratory which is suitable for the purpose and names the responsible person who will be in charge of the work. Membership in the Network facilitates international co-operation, enables the member to obtain assistance in solving specific problems and provides access to the international measurement system. There is no membership fee.

Only one SSDL organization should be nominated for each Member State. If national radiation standards do not already exist, the Member State should recognize as national measurement standards the radiation measurement standards maintained by the SSDL.

Membership of a laboratory in the Network does not impose any liability on the IAEA, WHO or other collaborating institutions in connection with the performance of the work within the laboratory.

3. DEFINITIONS

3.1 Secondary Standard Dosimetry Laboratory (SSDL).

An SSDL - in this context - may be either national or regional. A national SSDL is a laboratory which has been designated by the competent national authorities to undertake the duties of a calibrating laboratory within that country. A regional SSDL is an SSDL which is designated, by intergovernmental agreement or by an international organization, not only to carry out national functions but also to provide calibration services and advice to other countries within the geographical area concerned.

An SSDL is equipped with secondary standards which are calibrated against the primary standards of laboratories participating in the international measurement system.

3.2. Primary Standard Dosimetry Laboratories (PSDLs)

A PSDL is a national laboratory designated by the government for the purpose of developing, maintaining and improving primary standards in radiation dosimetry. A PSDL participates in the international measurement system by making comparisons through the medium of the Bureau International des Poids et Mesures (BIPM), and provides calibration services for secondary standard instruments.

3.3. The IAEA/WHO Network of SSDLs

The SSDL Network is an association of SSDLs which agree to co-operate in promoting the objectives of that Network under international auspices. Its objectives are:

- to improve dosimetric accuracy, particularly in radiation therapy and radiation protection, by supporting centres and laboratories for the creation and distribution of knowledge in applied dosimetry;
- to further the exchange of experience between the members and affiliated members, and to provide support to each other where necessary;
- to establish and facilitate links between the members and the international system of radiation measurements through PSDLs; and
- to promote the compatibility of methods applied for calibration and performance of dosimetry in order to achieve uniformity of measurements throughout the world.

3.4. Classification of instruments

For the purpose of this publication the various classes of instruments referred to are defined as follows:

3.4.1. Primary standard.

An instrument of the highest metrological qualities, which allows determination of the quantity to be measured from measurements of basic physical quantities, and the accuracy of which has been verified by comparison with equivalent standards of other institutions participating in the international measurement system.

3.4.2. Secondary standard.

An instrument of precision and long-term stability which has been calibrated against a primary standard.

3.4.3. Field instrument.

An instrument used for routine measurements.

4. LABORATORY ORGANIZATION AND STAFF

4.1. Organizational structure

The work of the laboratory should be independent in character and free from any external influence which could adversely affect the quality or impartiality of the service it offers.

4.2. Head of laboratory

- The head of the laboratory should be a scientist with several years of experience in radiation measurement and calibration.
- The head of the laboratory is responsible for the work performed at the laboratory and should hold a full-time appointment.
- The head of the laboratory is responsible for adequately documented calibration procedures, certification and the implementation of QA programmes.

4.3. Laboratory staff

As the prime obligation for the correctness of a measurement lies with the person making it, laboratory staff should possess adequate qualifications and experience in measurement procedures and practice appropriate to their responsibilities.

4.4. SSDL calibration certificates

When a laboratory has been designated, arrangements must be made by the competent national authority to authorize the head of the laboratory to sign SSDL calibration certificates.

5. LABORATORY ACCOMMODATION

5.1. Location

For an appropriate location of the laboratory the following criteria need to be considered.

- It should be located in a geographically central position in relation to the demand for its services and the practical performance thereof.
- It should be free from external environmental disturbances which are likely to affect the measurements (consideration must also be given to the laboratory's own impact on the environment).
- Allowance should be made for the possibility of extending the facilities.
- If accommodation is found in existing buildings, compromises on some of the above criteria may be unavoidable; the basic principles should, however, be observed.

5.2. Premises

The following minimum requirements for premises should be fulfilled.

- It is desirable that the laboratory should not share space with other activities.
- At least one large room (e.g. 6 m x 3 m x 3 m) is required for X-ray calibrations. A second room is required for calibrations with ^{60}Co radiation, but, if this cannot be provided initially, access to a ^{60}Co source elsewhere must be made available as an interim measure.
- Shielded control space next to the calibration rooms is necessary.
- Structural shielding, particularly for ^{60}Co radiation, may be required in order to avoid unacceptable radiation exposure of staff and the public and to keep background radiation at levels consistent with protection-level calibrations.
- One laboratory room should be available for electronic measurements and other physical experiments, e.g. checking and preparing dosimeters for calibration, operation of TLD services, etc.
- A mechanical and electronic workshop should be available.
- Office space for the head of the laboratory, scientific-technical staff and secretarial staff should be available.

5.3. Services

The following are essential.

- Appropriate stability of the mains voltage supply (for which voltage stabilizers may be necessary).
- Appropriate water supply and water removal for cooling systems (X-ray machines, etc.).
- Control of environmental conditions, particularly air conditioning, with automatic temperature and humidity control.

6. CALIBRATION FACILITIES AND EQUIPMENT

- An SSDL must be able to provide calibration services for either therapy or protection levels, or both.

- Duplicate secondary standard instrumentation should be provided to cover each of the energy and dose-rate ranges for which services are offered. One of the secondary standards must be retained in the laboratory solely as a basic reference instrument. Methods of checking stability are essential, and rely on the use of radioactive check sources.
- The secondary standards must initially be calibrated for the ranges of interest against a primary standard of a recognized national standards laboratory, and then recalibrated at least every 5 years.
- Radiation sources giving appropriate dose rates must be provided to cover the energy ranges of interest. In the case of X-ray generators they should be of the constant potential type, and highly stabilized power supplies are required.
- Essential ancillary equipment includes diaphragms, a set of filters, a shutter mechanism, a transmission monitor chamber with measuring assembly, and calibration benches with positioning devices.
- Other equipment required include precision instruments for measurement of time, temperature, pressure and humidity. Additional laboratory equipment is also desirable, either as back-up in case of malfunction of instrumentation, or to provide alternative techniques to confirm the measurements made. For example, current/charge measurements and precision voltage and current sources are needed for this purpose.
- The design of the calibration facilities must be in accordance with the relevant national and international safety regulations and should take into account the International Basic Safety Standards (Safety Series No 115) [1].
- Depending on the services to be made available, the requirements may include equipment or instrumentation for thermoluminescence dosimetry, film dosimetry and chemical dosimetry.

7. RESPONSIBILITIES OF THE SSDL

The responsibilities for the SSDL include, but are not limited to, the following activities:

- maintaining secondary standard instruments in agreement with the international measurement system, and performing re-calibrations at least every 5 years;
- performing calibrations of radiation measurement equipment and issuing calibration certificates with all necessary information, including the estimated uncertainties;
- organizing dose comparisons for radiation therapy for institutions within the country or region, and participating in measurement comparisons within the IAEA/WHO SSDL Network, and with other standardizing laboratories;
- co-operating with the IAEA/WHO Network and with other metrological laboratories in the exchange of information and improvement of measurement instruments and techniques;
- documenting and preserving records of all procedures and the results of calibrations;
- keeping up to date on progress in radiation measurement techniques, so as to improve calibration techniques as required, and thereby provide a better service to the users of radiation,
- Providing training in radiation measurement and calibration techniques and in the use and maintenance of the relevant instrumentation, appropriate to the users of radiation served by the SSDL, and
- reporting to the Secretariat, at least annually, on the status of its secondary standards, radiation sources, calibrations performed and related activities.

APPENDIX 7
CURRENT MEMBERS OF THE IAEA/WHO SSDL NETWORK

1. ALGERIA
Centre de Radioprotection et de Sûreté
Département de l'Etalonnage et de la Calibration
2, Bld Frantz Fanon B.P. 399 Alger-Gare,
Algiers

2. ARGENTINA
Comision Nacional de Energia Atomica (CNEA)
Centro Regional de Referencia Para Dosimetria
Unidad Ciencias de la Salud
Av. del Libertador 8250,
1429 Buenos Aires

3. AUSTRALIA
Australian Nuclear Science and Technology
Organization (ANSTO)
Physics Division
Private Mail Bag 1 NSW,
2234 Menai,

4. AUSTRIA
Österreichisches Forschungszentrum Seibersdorf
Ges.m.b.H (ÖFZS)
Institut für Strahlenschutz
Dosimetrie Eichlabor,
A-2444 Seibersdorf

5. BANGLADESH
Secondary Standard Dosimetry Laboratory
Institute of Nuclear Science and Technology
Atomic Energy Research Establishment (AERE)
Ganakbari, Savar G.P.O. Box 3787,
Dhaka-1000

6. BELGIUM
Universitaet Gent
Laboratorium Standaard Dosimetrie
Proeftuinstraat 86,
B-9000 Gent

7. BOLIVIA
Centro de Protección Radiológica
Instituto Boliviano de Ciencia y Tecnologia
Avenida 6 de Agosto 2905
Casilla de Correo,
4821 La Paz

8. BRAZIL
Laboratório Nacional de Metrologia
das Radiaçoes Ionizantes
Instituto de Radioproteção e Dosimetria / CNEN
Ave. Salvador Allende s/n Recreio,
CEP. 22780-160 Rio de Janeiro

9. BULGARIA
University Hospital "Queen GIOVANNA"
Medical Academy, Base No. 2
Laboratory of Clinical Dosimetry and
Ionizing Radiation Metrology
Bialo More Street 8,
1527 Sofia

10. CANADA
Radiation Protection Bureau
775 Brookfield Road, AL: 6302C1,
Ottawa, Ontario K1A 1C1

11. CHILE
Laboratorio de Metrologia de Radiociones Ionizantes
LMRI
Amunátegui no. 95
Casilla,
188-D Santiago

12. CHINA
National SSDL Organization
State Bureau of Technical Supervision
P.O. Box 2112,
Beijing

Members:
12.1 Institute of Atomic Energy
Radiometrology Centre
P.O. Box 275 (20),
Beijing 102413

12.5. SSDL Laboratory
Institute of Radiotherapy and Oncology
Room 9, Block K
Queen Elizabeth Hospital,
Kowloon,
Hong-Kong

13. COLOMBIA
Instituto de Ciencias Nucleares y Energias Alternativas
Laboratorio Secundario de Calibracion Dosimetrica
Apartado Aereo 8595 Avenida el Dorado, Carrera 50,
Santafé de Bogotá, D.C.

14. CUBA
Centre for Hygiene and Radiation Protection
Laboratorio Secundario de Calibración Dosimétrica
Calle 20 No. 4109 e/18A y 47, Miramar A.P. 6195,
Habana 6

12.2 Institute for Radiation Protection
P.O. Box 120, TaiYuan,
Shanxi

12.3 Shangai Institute of Metrological Technology
Division of Ionizing Radiation
716 Yisham Road,
Shangai 200233

12.4 Laboratory of Industrial Hygiene
Ministry of Public Health,
2 Xingkang Street, Deshengmenwai,
Beijing 100088

15. CYPRUS
Radiation Dosimetry Laboratory
Department of Medical Physics
Nicosia General Hospital,
1450 Nicosia

16. CZECH REPUBLIC
National SSDL Organization
Institute of Hygiene and Epidemiology
Srobárova 48,
113472 Prague 1

Members:
16.1 Reference Laboratory for X-ray Dosimetry
National Radiation Protection Institute.
Srobarová 48,
100 00 Prague 10

16.2 Czech Metrological Institute
Inspectorate of Ionizing Radiation
Radiová 1,
102 00 Prague 10

17. DENMARK
National Board of Health
National Institute of Radiation Hygiene
Dosimetry Laboratory
Knapholm 7,
DK-2730 Herlen

18. ECUADOR
SSDL
Comisión Ecuatoriana de Energía Atómica (CEEA)
San Javier 295 y Av. Orellana Y RioFrio
Apartado Postal 2517,
Quito

19. EGYPT
National Institute for Standards
Radiation Physics Unit
Dosimetry Laboratory
Tersa Street, El-Ahram PO Box 136,
12211 El Giza

20. FINLAND
Finnish Centre for Radiation and
Nuclear Safety (STUK)
Dosimetry Laboratory
P.O. Box 41,
FIN-00881 Helsinki

21. FRANCE
Ministère de la Santé
Service Central pour la Protection Contre les
Rayonnements Ionisants
Dosimetry Laboratory,
Boîte Postale No. 35 F-78110 Le Vésinet

22. GERMANY
GSF - Forschungszentrum für Umwelt und Gesundheit,
GmbH / Institut für Strahlenschutz
Dosimetry Laboratory
Postfach 1129,
D-85758 Oberschleisssheim

23. GHANA
Radiation Protection Board
Ghana Atomic Energy Commission
P.O. Box 80,
Legon, Accra

24. GUATEMALA
Ministerio de Energía y Minas
Dirección General de Energía Nuclear (DGEN)
Laboratorio Secundario de Calibracion Dosimetria
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Guatemala C.A. 01812

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Members:

25.1 Paks Nuclear Power Plant
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25.2 National Institute of Oncology
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Bureau International des Poids et Mesures (BIPM)
International Commission on Radiation Units and Measurements (ICRU)
International Electrotechnical Commission (IEC)
International Organization of Legal Metrology (OIML)
International Organization of Medical Physics (IOMP)

Affiliated members of the IAEA/WHO Network of SSDLs:

Bundesamt für Euch und Vermessungswesen (BEV)	Vienna, AUSTRIA
Australian Radiation Laboratory (ARL)	Melbourne, AUSTRALIA
National Research Council (NRC)	Ottawa CANADA
Laboratoire de Metrologie des Rayonnements Ionisants (LMRI)	Saclay, FRANCE
Physikalisch-Technische Bundesanstalt (PTB)	Braunschweig, GERMANY
National Office of Measures (OMH)	Budapest, HUNGARY
Ente per le Nuove Tecnologie L'Energia e L'Ambiente (ENEA)	Rome, ITALY
Electrotechical Laboratory (EL)	Tokyo, JAPAN
Rijks Institut voor Volksgesundheid (RIV)	Bilhoven, NETHERLANDS
National Radiation Laboratory (NRL)	Christchurch, NEW ZEALAND
VNIIFTRI	Moscow, CIS RUSSIAN FEDRERA
National Physical Laboratory (NPL)	Teddington, UNITED KINGDOM
National Institute for Standards and Technology (NIST)	Gaithersburg, USA

APPENDIX 8
DOSIMETRY AND MEDICAL RADIATION PHYSICS SECTION (IAEA)

The emphasis of the activities of the IAEA Dosimetry and Medical Radiation Physics (DMRP) Section is focused on services provided to developing Member States through the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDLs) and dose quality audits. The latter are performed through the IAEA/WHO TLD postal service to SSDLs and radiotherapy centres, the intercomparison on ionization chamber calibration factors for SSDLs and the International Dose Assurance Service (IDAS) for radiation processing facilities and SSDLs, mainly for food irradiation and sterilization of health care products.

The Agency's Dosimetry and Medical radiation Physics Subprogramme is reviewed biennially by an external Advisory Group (the SSDL Scientific Committee) which, acting as an independent auditor, verifies that the work performed by the DMRP Section covers the aims of the Agency's Subprogramme E.3. The Committee includes a member of the International Commission for Radiation Units and Measurements (ICRU) and of the Bureau International des Poids et Mesures (BIPM), and members of Primary and Secondary Standard Dosimetry Laboratories (PSDLs and SSDLs, respectively).

The Agency Dosimetry Laboratory at Seibersdorf, about 30 km from Vienna, is integrated within a complex of other laboratories at Seibersdorf which share support services. Main facilities include a ^{60}Co teletherapy unit, two highly stabilized X-ray systems with metal-ceramic tubes of 160 kV and 320 kV, a mammography machine (being set-up) and two gamma irradiator with 740 GBq of ^{137}Cs and 37 GBq of ^{60}Co. Calibrated reference secondary standards and a number of working standards for therapy level, radiation protection and environmental dosimetry are available as well as several different TLD systems and an Electron Spin Resonance (ESR) unit for high dose dosimetry are in use for the quality audit services to Member States.

Under the supervision of the Agency's Division of Human Health DMRP Section Head, the Laboratory activities are as follows:

- calibrating reference dosimeters of Network members;
- performing annual dose intercomparison among member laboratories of the SSDL Network;
- performing quality audits for about 200 radiation therapy centres each year;
- performing high dose quality audits for SSDLs and radiation processing facilities,
- accepting SSDL staff for on-site training; and
- designing and developing special devices for calibration activities.

The staff consists of 3 technicians supervised by professional staff from the DMRP Section. The organizational chart and activities of the Section are shown in Figure 1.

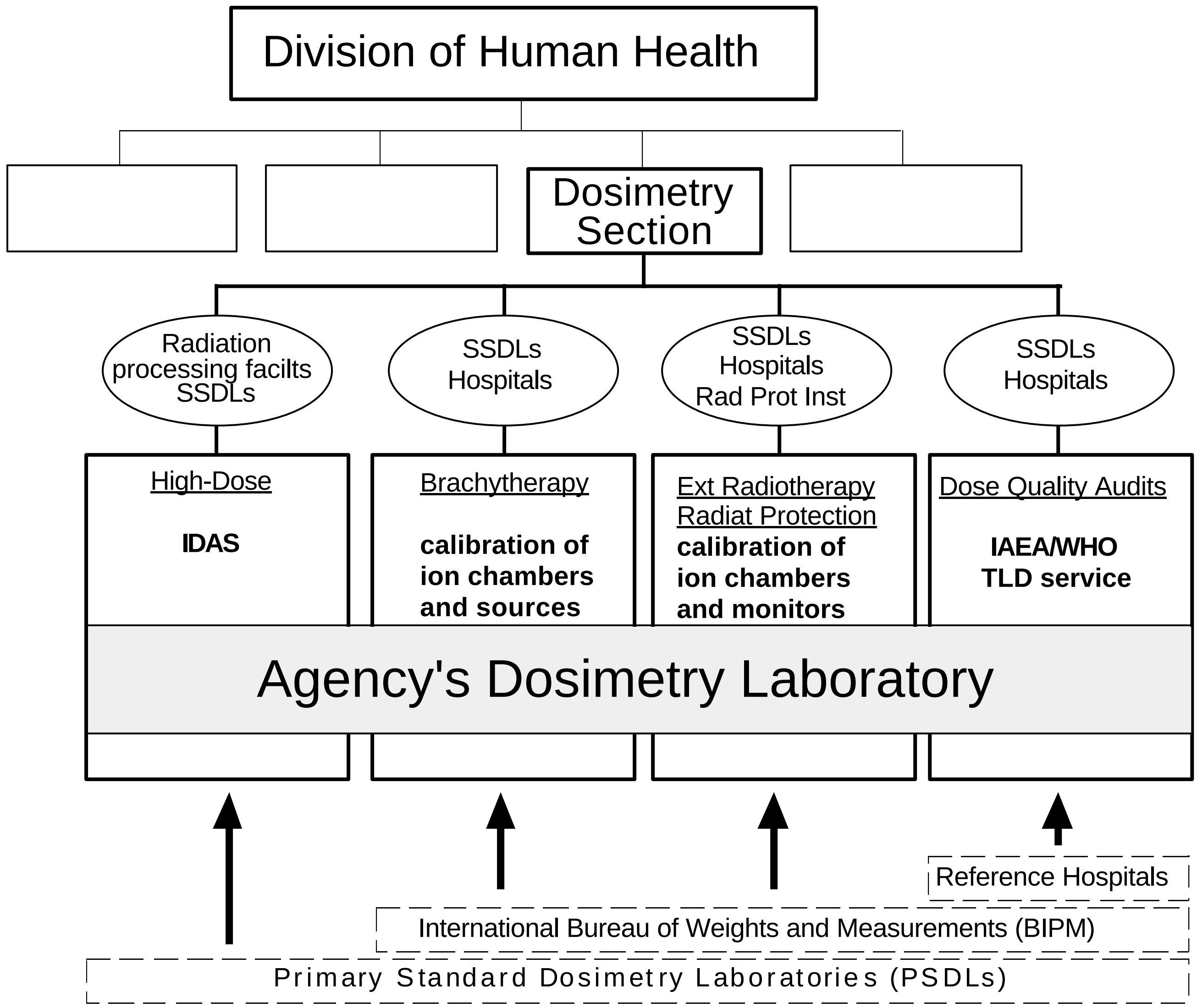

FIG. 1. Organizational chart of the Agency's Dosimetry and Medical Radiation Physics Section, RIHU, showing the main fields of activity and services provided to Member States. Indicated are also the target users of the services and the organizations providing reference irradiations to the Dosimetry Laboratory .

1. ACTIVITIES FOR THE SSDL NETWORK

In addition to contributing economically to the installations and purchase of equipment for SSDLs in the Member States, the programme to establish the Network of SSDLs has the responsibility to guarantee that the services provided by the laboratories follow internationally accepted metrological standards. This is accomplished first with the transmission of the calibration factors for ionization chambers from PSDLs or the BIPM through the Agency's Dosimetry Laboratory. As a second step, follow-up programmes and dose quality audits are implemented for the SSDLs to guarantee that the standards transmitted to users in the Member States are kept within the levels required by the international measurement system.

The activities of the IAEA towards the SSDL Network have not only been addressed to establish "metrological institutions of high quality", but also to emphasize the support of the SSDLs to QA programmes for radiotherapy. This is accomplished by insuring that the calibrations of instruments provided by SSDLs are correct, but also by promoting the contribution of SSDLs to perform dosimetry quality audits in therapy centres, and if needed, performing calibrations of radiotherapy equipment at hospitals. Depending on the equipment and the staff available at the laboratory, and sometimes depending also on the functional organization of the SSDL, these activities vary between different countries.

During 1997, the Agency's Dosimetry and Medical Radiation Physics Subprogramme has provided calibrations of 46 reference ionization chambers and dosimeters for SSDLs. The quality audit system based on mailed thermoluminescence dosimeters (TLDs) has been applied to 60 SSDLs in order to verify their calibrations of ^{60}Co therapy units and medical accelerator radiation beams. The coherence and accuracy of the reference instrumentation of 20 SSDLs have been verified through intercomparison measurements using ionization chambers as transfer instruments.

A new programme to develop procedures for the calibration of radiation sources used in brachytherapy (intracavitary and interstitial) and related measuring equipment, first at the Agency's Dosimetry Laboratory and later at the SSDLs, has been initiated. Standards for measurements in diagnostic radiology are also under development. The full implementation of this programme is, however, conditioned by the limited staff available at the Dosimetry Laboratory

2. DOSE INTERCOMPARISON AND ASSURANCE

The second main activity of the DMRP Subprogramme consists in dose quality audits for radiotherapy centres using mailed thermoluminescence dosimeters and the IDAS for industrial facilities where alanine-ESR dosimeters are sent to food irradiation and sterilization plants. In both services users are requested to irradiate the dosimeters with a given dose under known irradiation conditions; the dosimeters are then returned to the Agency's Dosimetry Laboratory and evaluated.

2.1. The IAEA/WHO TLD postal service

In 1969 the IAEA, together with the World Health Organization (WHO), implemented the IAEA/WHO TLD postal dose quality audit service to verify the calibration of radiotherapy beams in developing countries. The Agency's Dosimetry and Medical Radiation Physics Section is responsible for the technical aspects of the TLD system, including reference irradiations and evaluation of the TLDs. WHO takes care of the distribution and collection of the TLDs to and from radiotherapy institutions using WHO national or regional affiliated centres. Because the tasks of the Agency are usually performed in collaboration with government nuclear energy authorities in the Member States, the role of WHO is to establish the connection to radiotherapy centres through the health ministries of developing countries. The TLD audits receive support of the BIPM, the Austrian PSDL (BEV), the German PSDL (PTB) and some advanced radiotherapy centres. These institutions provide reference irradiations of the TLDs, acting as an external quality control of the Agency's TLD dose quality audit service. Within this programme there are activities conducted in collaboration with other organizations, such as European Society for Therapeutic Radiology and Oncology (ESTRO), Radiological Physics Centre in Houston (USA), etc.

The IAEA/WHO TLD postal service performs dose checks for the radiotherapy machines. TLDs are irradiated by the users in pre-determined reference conditions, using radiation doses of clinical relevance. The dose absorbed in the TL-dosimeter is determined at the Agency's Dosimetry Laboratory and the results compared with the dose value stated by the participating hospital. Originally the service was developed for 60Co therapy units and in 1992 it was extended to high-energy photon beams produced in clinical accelerators. The IAEA has, during 28 years of operation, verified the calibration of about 3000 radiotherapy beams, and for 35% of these the results show deviations larger than acceptance limit of ±5%. In many instances significant errors have been detected in the calibration of therapy beams with subsequent patient mistreatments that are close to the criterion of "radiological accident"; in all instances the service provides an independent and impartial quality audit of the dosimetry procedures.

During 1997, the TLD postal service had performed more than 300 dose quality audits of photon beams from ^{60}Co therapy units and medical accelerators in radiotherapy hospitals. The follow-up of hospitals with dose quality audit results outside the acceptance limits (±5%) includes since recently a user-blind repetition of the exercise. The second verification has not been satisfactory in many cases indicating a persistent problem. In case of persisting deviations the Agency tries to field experts to provide support in resolving discrepancies and to train the hospital staff. The recruitment of experts traveling to the site is a major goal of the project to be implemented, although funds for this task are considerably restricted. Moreover, for a fast and effective TLD service a strong interaction with the national structures, such as SSDLs, is required. Rapid resolution of the discrepancies can only be achieved if the follow up actions are taken locally. The Agency thus decided to transfer its well established methodology to national centres where existing resources enable nationally recognized groups to conduct external quality audits for radiotherapy dosimetry. Unfortunately, the level of expertise in developing countries does not allow the expansion of this programme world-wide.

In the future, the number of radiotherapy centres undergoing dose quality audits per year will be increased due to the implementation of a TLD automatic system, and could almost be doubled upon the allotment of one additional technical staff at the Dosimetry Laboratory. Speeding up the TLD service will allow the communication of results to the participants within the shortest possible time following the TLD irradiations. The number of patient treatments affected by poor dosimetry practices can be decreased if the delays are reduced and fast resolution of the discrepancies is provided.

2.2. The IDAS programme for industrial facilities

Several guidelines and standard practices have been developed by international organizations that provide recommendations for the radiation processes, such as sterilization of medical products and food irradiation. One of the principal concerns of all the guidelines is process validation, and the key element of this is a well characterized, reliable dosimetry system that is traceable to a PSDL. To help the Member States establish such a dosimetry system in particular, and the radiation processing technology in general, the Agency established the High-Dose Dosimetry Programme in 1977. The principal ingredient of this programme has been the International Dose Assurance Service (IDAS).

The IDAS performs dose quality audits for SSDLs and for the industrial facilities used for radiation processing applications. Alanine-ESR dosimeters are irradiated by the participants using radiation doses relevant to industrial application (0.1 to 100 kGy). The reference irradiation conditions are monitored and this information forwarded to the Agency's Dosimetry Laboratory along with the dose values. The dosimeters are then analyzed at the laboratory and the results compared with the stated values; a certificate is then issued stating the relative deviations. The IDAS thus provides an independent check on the entire dosimetry system of the participant; namely their routine and/or reference dosimetry system, analysis equipment, procedure for the dosimetry systems, any computer software being used, skill of the technical staff, etc. In case of a discrepancy that is greater than 5% advice is provided through letters as to its possible causes and then followed by another dose check.

During 1997, the IDAS has distributed 67 dosimeter sets (each consisting of 4 dosimeters) to 47 participating institutes/facilities. According to the QA programme, the annual dosimetry audit of the IDAS is conducted by the National Physical Laboratory, the PSDL of the United Kingdom. Also, the new batch of dosimeters was calibrated in the Agency Gammacell-220, the dose rate of which is traceable to the NPL. In collaboration with the BIPM, an intercomparison for ^{60}Co gamma rays was recently organized between nine calibration laboratories. The last such exercise was held more than ten years ago. The standard deviation of the population was 2.1% at 15 kGy and 2.4% at 45 kGy. The Agency value agreed with the mean value within 1% for both the dose levels.

Presently, the IDAS is limited to ^{60}Co gamma rays, however, a field test for electron beams with energy greater than 8 MeV is in progress, using the same transfer dosimetry system.

Radiation processing is an important application where more SSDLs are becoming active because of their expertise and in view of their role as standardizing laboratories.

ANNUAL REPORT FOR IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

Name of the SSDL	**ANNUAL REPORT FOR YEAR ....**	Page 1 ( )[1]

I. GENERAL

Full mailing address	Head of Laboratory	Date and signature[2]
	Staff time (staff-years) dedicated to SSDL activities[3] Physicists .... Technicians	

II. SECONDARY STANDARDS FOR X- AND GAMMA RADIATION AND THEIR STABILITY CHECK DEVICES

Data on secondary standards and their stability check devices is given in Annexes to this report.[4] It should be completed only if there were changes compared to the previous annual report.

III. CALIBRATION OF DOSIMETERS

III.1 Number of therapy level calibrations done at the SSDL

	Low energy X-rays 10-100 kV	Medium energy X-rays 100-300 kV	^{137}Cs	^{60}Co
-Number of calibrations done for internal checks				
-Number of calibrations done for external institutions				

III.2. Number of protection level calibrations

Survey meters			Personnel dosimeters		
Photon	Beta	Neutron	TLD	Film	Others

IV. CALIBRATIONS AT HOSPITALS

IV.1. Number of absorbed dose determinations under reference conditions at the radiation beams used for treatment

High energy electrons	High energy photons			Medium energy X-rays 100-300 kV	Low energy X-rays 10-100 kV
	X-rays	^{60}Co	^{137}Cs		

IV.2. Procedure used for absorbed dose determination (name of code of practice, protocol or document)

Name of the SSDL	**ANNUAL REPORT**	Year .... Page 2

V. OTHER SERVICES

V.1. Personnel dosimetry service

Method	Film	TLD	Others
Number of dosimeters issued per year Period of use (months)			

V.2. Site visits/On-site output measurements

Number of visits[5] ....Staff-days required .... Number of institutions visited........................

V.3. TLD quality audit checks for radiotherapy beams [6]

Number of participating institutions Number of dosimeters sent and returned ...…...
Number of dosimeters evaluated .... and with deviation >±5% ....
Repeated measurements: number of dosimeters sent……………………..
and returned ....and with deviation >±5% ....……………………..............
Follow-up actions, if any……………………………………………………………………………..

VI. TRAINING AND EDUCATION

VI.1. Training courses organized by the SSDL

Title	Number of courses	Number of participants[7]

VI.2. Training courses attended by the staff of the SSDL

Title	Organizer	Place	Duration (days)	Number of Participants[7]

PLEASE USE ADDITIONAL PAGES TO FURNISH MORE DETAILS AND/OR OTHER INFORMATION WHICH YOU CONSIDER RELEVANT AND IMPORTANT

Name of the SSDL	**ANNUAL REPORT**	Year .... Page 3

VII. HIGH-DOSE MEASUREMENTS: Yes ( ) No ( )[8]

VIII. RADIOACTIVITY MEASUREMENTS: Yes ( ) No ( )

IX. CALIBRATION OF BRACHYTHERAPY SOURCES: Yes ( ) No ( )

HDR ( ) LDR ( ) **Number of calibrations:……..**

at the hospital ( )….. **at the SSDL ( )……**

X. DIAGNOSTIC RADIOLOGY MEASUREMENTS: Yes ( ) No ( )

Mammography measurements: Yes ( ) No ( )

XI. QUALITY ASSURANCE PROGRAMME

Internal Quality Assurance Programme: Yes ( ) No ( )

Quality manual available: Yes ( ) No ( )

Participation in external quality audit checks : Yes ( ) No ( ) last participation:

XII. SSDL NEWSLETTER: Received regularly Yes ( ) No ( ) Last issue received No.:

XIII. OTHER RELEVANT INFORMATION

Name of the SSDL	**ANNUAL REPORT** **HIGH-DOSE MEASUREMENT ACTIVITIES** **(Dose >0.1 kGy)**	Year .... Page 4
H-I. CALIBRATION OF SSDL's HIGH-DOSE REFERENCE DOSIMETRY SYSTEM		
H-I.1 Reference dosimetry system of the SSDL:		
HI.2 Latest calibration: H-I.3 Frequency of calibration:		
H-I.4 Calibration laboratory:		
H-II. CALIBRATION OF CUSTOMER's HIGH-DOSE DOSIMETRY SYSTEMS		
H-II.1 Number of high-dose calibrations/year: H-II.2 Dose range: kGy		
H-II.3 Source of radiation and irradiation conditions:		
H-III. CUSTOMERS		
H-III.1 For how many customers do you provide this calibration service:		
H-III.2 Types of facilities of your customers:		
H-III.3 Customers' dosimetry systems:		
H-IV. TRAINING AND EDUCATION ON HIGH-DOSE MEASUREMENTS		
H-IV.1 Training courses organized by the SSDL:		
H-IV.2 Training courses attended by the SSDL staff:		
H-IV.3 Is there a need for training of: - SSDL's staff - staff at other facilities in your country		

Name of the SSDL	**ANNUAL REPORT BRACHYTHERAPY SOURCE CALIBRATION (LDR/HDR/MANUAL/ REMOTE)**	Year .... Page 5

B- DATA ON BRACHYTHERAPY SOURCE CALIBRATIONS

B-1. Dosimeters Available:

Type of ionization chamber	Manufacturer	Ref. No. & volume	Last calibration (energy, date & calibration lab.)
Well-type			
Spherical			
Cylindrical			
Any other			

B-2. Type of Sources Calibrated and Reference Sources Available:

Type of radionuclide	Specifications (size, shape, sheathing, etc.)	Manufacturer & code No.	Activity with date	Remarks

B-3. Is there any National Manufacturer for Sources: Yes / No

If "Yes", type of radionuclide: ^{60}Co / Cs-137/ Ir-192/ any other

Specifications (as above) :

B-4. Hospital Calibration, if any:

Type of treatment units	Type of sources	No. of calibrations

Name of the SSDL	**ANNUAL REPORT**	Year .... Page 6

DATE ON SECONDARY STANDARD AND ITS STABILITY CHECK DEVICE

Secondary standard identification

	Manufacturer	Type	Serial No.
Chamber Measuring assembly or electrometer (when applicable)			

Latest calibration

Primary calibration laboratory	Date of calibration	Reason for calibration[9]

Calibration factor (F) as a function of radiation energy (HVL)

HVL ( )[10]							
KV							
F ( )[11]							
HVL ( )[10]							
kV					^{137}Cs	^{60}Co or 2 MV	
F ( )[11]							

Stability check device[12]

Device Manufacturer	Type	Serial No.	Source Type	Serial No.	Radionuclide	Half-life Used

EXPLANATIONS

1) Put the total number of pages in the parenthesis.

2) Date of completion of the report and signature by the Head of the SSDL.

3) Example: If one physicist had worked full time through the year and another about six months during the year for the SSDL activities reported in this Annual Report, this makes 1.5 physicist staff-years.

4) Fill in data for each secondary standard and its stability check device in a separate sheet and enclose as Annex(es) to the Report.

5) Visits at therapy clinics.

6) "Deviation" means: Deviation =

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

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

D_P : Dose stated by the participant

7) Give also the profession of participants (e.g. physicists, technicians).

8) If yes, complete the attached separate sheet on High-Dose Measurement Activities.

9) Write "first calibration" if the calibration was carried out in connection with the acquisition or purchase of the standard. For re-calibrations indicate whether it was a periodic procedure or caused by suspected sensitivity change, or by repair.

10) Give the unit in parenthesis, i.e. t(mm) & material.

11) Give the unit in parenthesis.

12) Give information which is applicable.

APPENDIX 10
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APPENDIX 11
RECENT IAEA PUBLICATIONS IN THE FIELD OF DOSIMETRY AND MEDICAL RADIATION PHYSICS

For details on acquiring any of these publications please contact IAEA Division of Publications.

Design and implementation of a radiotherapy programme: Clinical, medical physics, radiation protection and safety aspects. (TECDOC-1040, 1998)

The use of plane-parallel ionization chambers in high-energy electron and photon beams. An International Code of Practice for Dosimetry. (Technical Reports Series No. 381, 1997).

Absorbed Dose Determination in Photon and Electron Beams: An International Code of Practice (Technical Reports Series No. 277, 2nd edition, 1997).

Review of data and methods recommended in the International Code of Practice IAEA. Technical Reports Series No. 277 for Absorbed dose determination in photon and electron beams. (TECDOC-897, 1996).

Radiation dose in Radiotherapy from prescription to delivery, Proc. of a Seminar in Rio de Janeiro (1994). (TECDOC-896, 1996).

Measurement Assurance in Dosimetry (Proceeding Series - STI/PUB/930, 1994).

Radiation dose in Radiotherapy from prescription to delivery, Proc. of a Seminar in Leuven (1991). (TECDOC-734, 1994).

Calibration of Dosimeters used in Radiotherapy (Technical Reports Series No. 374, 1994).

Absorbed Dose Determination in Photon and Electron Beams: An International Code of Practice (Technical Report Series No. 277, 1987). This edition is out of print, see 2nd edition above in 1997).

Other IAEA publications related to the field

Some of these publications might be out of print. Please contact IAEA publications for details.

Research in Radiation Processing Dosimetry, IAEA-TECDOC-321, IAEA, Vienna (1984).

Cobalt-60 Teletherapy: A Compendium of International Practice, IAEA, Vienna (1984).

Advances in Dosimetry for Fast Neutrons and Heavy Charged Particles for Therapy Applications, Panel Proceedings Series, IAEA, Vienna (1984).

Biomedical Dosimetry: Physical Aspects, Instrumentation, Calibration (Proc. IAEA/WHO Symp. Paris, 1980), IAEA, Vienna (1981).

High-Dose Measurements in Industrial Radiation Processing, Technical Reports Series No. 205, IAEA, Vienna (1981).

Intercomparison Procedures in the Dosimetry of High-Energy X-ray and Electron Beams, IAEA-TECDOC-249, IAEA, Vienna (1981).

Calibration of Dose Meters Used in Radiotherapy, Technical Reports Series No. 185, IAEA, Vienna (1979).

Intercomparison Procedures in the Dosimetry of Photon Radiation, Technical Reports Series No. 182, IAEA, Vienna (1978).

National and International Standardization of Radiation Dosimetry (Proc. Symp. Atlanta, 1977), IAEA, Vienna (1978).

Manual of Food Irradiation Dosimetry, Technical Reports Series No. 178, IAEA, Vienna (1977).

Directory of High-Energy Radiotherapy Centres, Technical Directory, IAEA, Vienna (1976).

Some Physical, Dosimetry and Biomedical Aspects of Californium-252, Panel Proceedings Series, IAEA, Vienna (1976).

Biomedical Dosimetry (Proc. Symp. Vienna, 1975), IAEA, Vienna (1975).

Californium-252 in Teaching and Research, Technical Reports Series No. 159, IAEA, Vienna 1974).

Dosimetry in Agriculture, Industry, Biology and Medicine (Proc. Symp. Vienna, 1972), IAEA, Vienna, (1973).

National and International Radiation Dose Intercomparisons, Panel Proceedings Series, IAEA, Vienna (1973).

Standardization of Radiation Dosimetry in the Soviet Union, France, the United Kingdom, the Federal Republic of Germany and Czechoslovakia, Study Tour Reports Series No. 4, IAEA, Vienna (1973).

Biophysical Aspects of Radiation Quality (Proc. Symp. Lucas Heights, 1971), IAEA, Vienna (1971).

Manual of Dosimetry in Radiotherapy, Technical Reports Series No. 110, IAEA, Vienna (1970).

Biophysical Aspects of Radiation Quality, Panel Proceedings Series, IAEA, Vienna (1968).

Biophysical Aspects of Radiation Quality, Technical Reports Series No. 58, IAEA, Vienna (1968).

Role of Computers in Radiotherapy, Panel Proceedings Series, IAEA, Vienna (1968).

Physical Aspects of Radioisotope Brachytherapy, Technical Reports Series No. 75, IAEA, Vienna (1967).

Solid-State and Chemical Radiation Dosimetry in Medicine and Biology (Proc. Symp. Vienna, 1966), IAEA, Vienna (1967).

Solid-State Dosimetry, Bibliographical Series No. 23, IAEA, Vienna (1967).

Computer Calculation of Dose Distributions in Radiotherapy, Technical Reports Series No. 57, IAEA, Vienna (1966).

Atlas of Radiation Dose Distributions, 4 Vols., IAEA, Vienna (1965-1972).

Clinical Dosimetry, Technical Reports Series No. 43, IAEA, Vienna (1965).

Single-Field Isodose Charts for High-Energy Radiation: an International Guide, Technical Reports Series No. 8, IAEA, Vienna (1962).

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[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Calibration of Dosimeters used in Radiotherapy, Technical Reports Series No. 374, IAEA, Vienna (1994).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed Dose Determination in Photon and Electron Beams: An International Code of Practice, Technical Reports Series No. 277, Second Edition, IAEA, Vienna (1997).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, The use of plane-parallel ionization chambers in high-energy electron and photon beams. An International Code of Practice for Dosimetry, Technical Reports Series No. 381, IAEA, Vienna (1997).

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