A modern approach to radiation metrology

by H.H. Eisenlohr*

Increasing public concern about radiation safety has generated a strong demand for reliable and accurate dose measurements. This demand for assurance of radiation safety applies to the protection not only of man but of his environment also, and covers all activities in which ionizing radiation is intentionally used, including radiotherapy and industrial radiation processing.

Conscious of the importance of reliable radiation measurement, the IAEA started an active programme in dosimetry soon after its foundation. In 1960, the Agency's Laboratory designed and built an absorbed-dose calorimeter, stimulated by the fact that at that time neither national nor international absorbed-dose standards existed. Seven years later, the IAEA set up the Dosimetry Section, whose main task is to advise Member States in the use of established techniques and procedures for the measurement of ionizing radiations and the calibration of dosimeters. In the 23 years of its existence, the Agency's Dosimetry Programme has created a greater awareness among radiotherapists and other radiation users of the need for proper dosimetry, and it has effectively helped improve dosimetric accuracy all over the world.

Nuclear activities in many developing countries have been expanding rapidly during the past few years. Nuclear techniques are being used in medicine (diagnosis and therapy), agriculture, animal science, hydrology, and industry. These activities require a reliable radiation-protection service for radiation workers, and a facility for the calibration and checking of dosimeters. Such a facility must have properly calibrated radiation sources and reference dosimeters, and must be linked to the world's dosimetry system in order to ensure calibration of the measurements against primary radiation standards. Problems of this kind in many developing countries have led to the establishment of the IAEA/WHO network of Secondary Standard Dosimetry Laboratories (SSDLs).

Growing need for accurate dosimetry

It is now perhaps no longer possible to identify the person, or group of persons, who first articulated the concept of Secondary Standard Dosimetry Laboratories. It is documented, however, that in 1967 staff members of the Agency's Dosimetry Section discussed the idea of promoting regional dosimetry centres for the Latin American countries, and in the Far East and Pacific region, and the possible role of the Agency in establishing such centres. These ideas became more tangible during preparations for an IAEA experts' meeting on dosimetric requirements of radiotherapy centres, and at the meeting itself in Caracas, Venezuela, in 1968. There it became evident that, in Latin America, thousands of cancer patients were being treated by ionizing radiation without appropriate dosimetric control. It was also observed that in this and other regions of the world there was no laboratory capable of, and equipped for, dosimetric calibrations. As a result of this meeting, the World Health Organization (WHO), which had been invited to send representatives, became interested in the problem. Consequently, both the IAEA and WHO took the initiative in propagating the idea of regional dosimetry centres and in assisting developing countries to set up such laboratories.

Between 1968 and 1975, WHO designated seven laboratories as Regional Reference Centres for Secondary Standard Radiation Dosimetry. These laboratories are located in Argentina, Iran, Mexico, Nigeria, Romania, Singapore, and Thailand. In Brazil, another laboratory was recognized as an SSDL by the IAEA. However, the demand for more reliable and accurate dosimetry grew rapidly throughout the world, and it became clear that the concept of regional dosimetry reference centres – i.e. the idea that about a dozen such laboratories should serve all the developing countries – was inadequate. In fact, there was evidence already by the early 1970s that at least another ten countries were considering setting up dosimetry laboratories to calibrate dosimeters used in radiotherapy and radiation protection.

Pressing need

The Agency's Dosimetry Laboratory had established close contacts with some primary-standards laboratories concerning the establishment of a postal dose-intercomparison service for radiotherapy centres in developing countries. In discussions with representatives from these primary-standards laboratories it became clear that there were three pressing reasons for setting up SSDLs:

- The complete lack of calibrating facilities in the developing countries.
- The national primary-standards laboratories in the industrialized countries were no longer able to cope with the rapidly increasing workload caused by calibrations required by law, and testing of new dosimeters.

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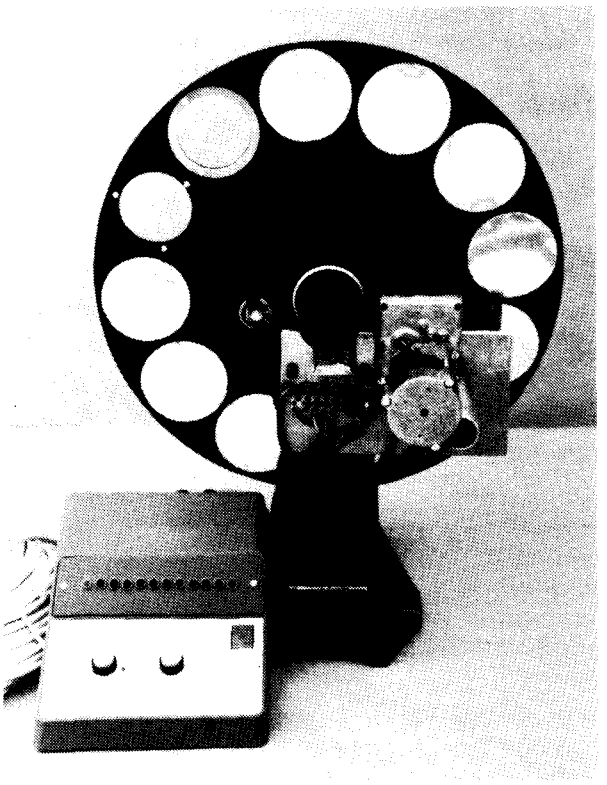
• In both developing and developed countries it was felt desirable to bridge the gap between the primary measurement system and the user of ionizing radiation by laboratories which could take care of the particular problems of the users and link them to the primary dosimetry standards.

So that the SSDLs could fulfill this metrologic function, it was proposed to establish an international network of the SSDLs with its secretariat jointly run by the IAEA and WHO. Several primary-standards dosimetry laboratories were to be asked to join this network as affiliated members to render the necessary technical support. This proposal was the central point of recommendations submitted by a group of experts to an IAEA/WHO meeting held in Rio de Janeiro in 1975. Subsequently, in November 1976, the two organizations formed the network of SSDLs, and Criteria for the Establishment of a Secondary Standard Dosimetry Laboratory were worked out and disseminated to Member States of the IAEA and WHO.

The need for the network can best be demonstrated by the fact that, within a few months, about 25 laboratories were nominated for membership. To date, the network comprises 45 member laboratories, 30 of them in developing countries. The network is supported by 12 affiliated national primary-standards laboratories and five collaborating international organizations. An advisory group of 11 experts assists the secretariat of the network in technical matters. The Agency's Dosimetry Laboratory in Seibersdorf, which is equipped with modern calibration facilities, acts as the central laboratory of the network.



The automated wheel for quick positioning of filters needed in specifying radiation quality of X-rays.

Technical Co-operation

From 1979 to 1982 the Agency's Technical Co-operation programme supported 23 SSDLs in developing countries. Some five more laboratories are expected to obtain support in 1983. The total sum spent from 1979 to 1982 has amounted to about US $1.5 million (Table 1). The Agency's Dosimetry Laboratory, although manned by a staff of only three, plays a very active and essential role in this technical co-operation programme. It organizes and performs annual dose intercomparisons among member laboratories of the SSDL network. In a recent intercomparison between 22 member laboratories, the average deviation between the dose quoted by the laboratory and that measured by the IAEA Dosimetry Laboratory was 1.6%, with 16 of the SSDLs having differences of less than 2%. Such dose intercomparisons offer an excellent opportunity for SSDLs to check their working performance, and give them a feeling of belonging to a family. The

Table 1. Countries receiving Technical Assistance in support of SSDL projects (1979–1982)

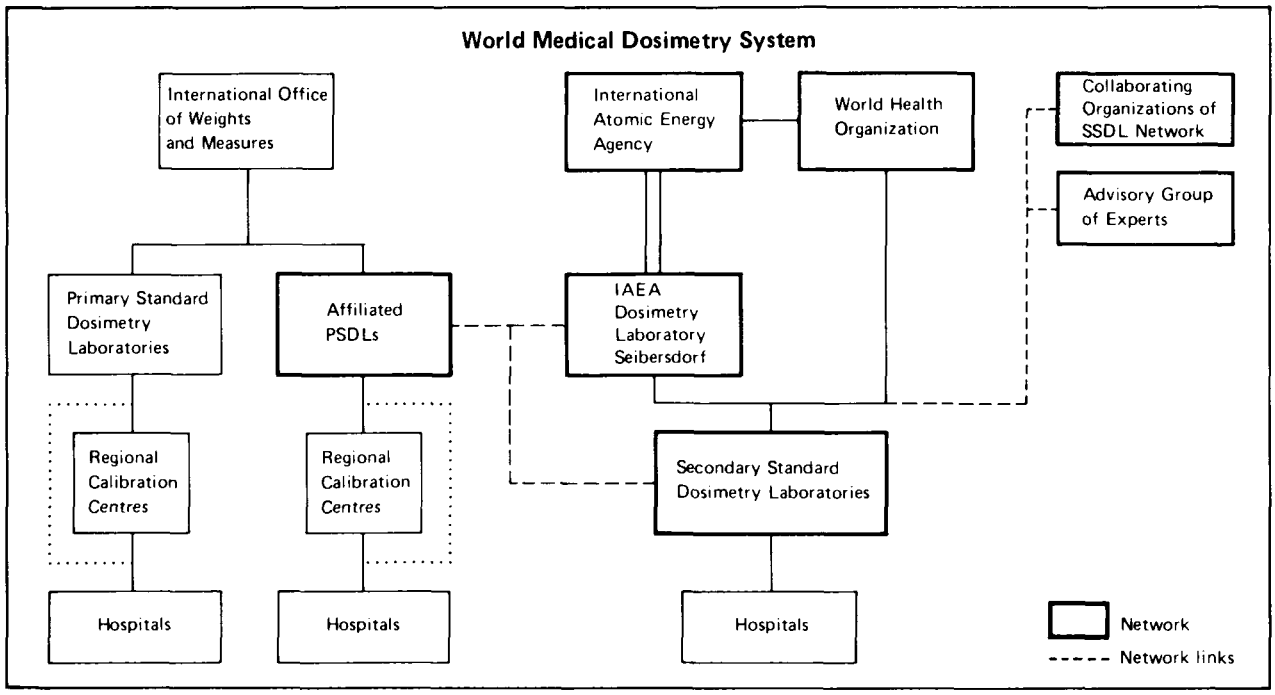
Region	Africa	Asia and Pacific	Latin America	Middle East and Europe
Countries	Algeria Ghana Sudan	Indonesia Korea, Dem. People's Rep. of Korea, Rep. of Malaysia Pakistan Thailand	Bolivia Brazil Chile Colombia Cuba Ecuador Peru Uruguay Venezuela	Bulgaria Greece Iran Israel Portugal Turkey
Technical Assistance expenditure (US $)	77 828	526 207	554 664	234 623

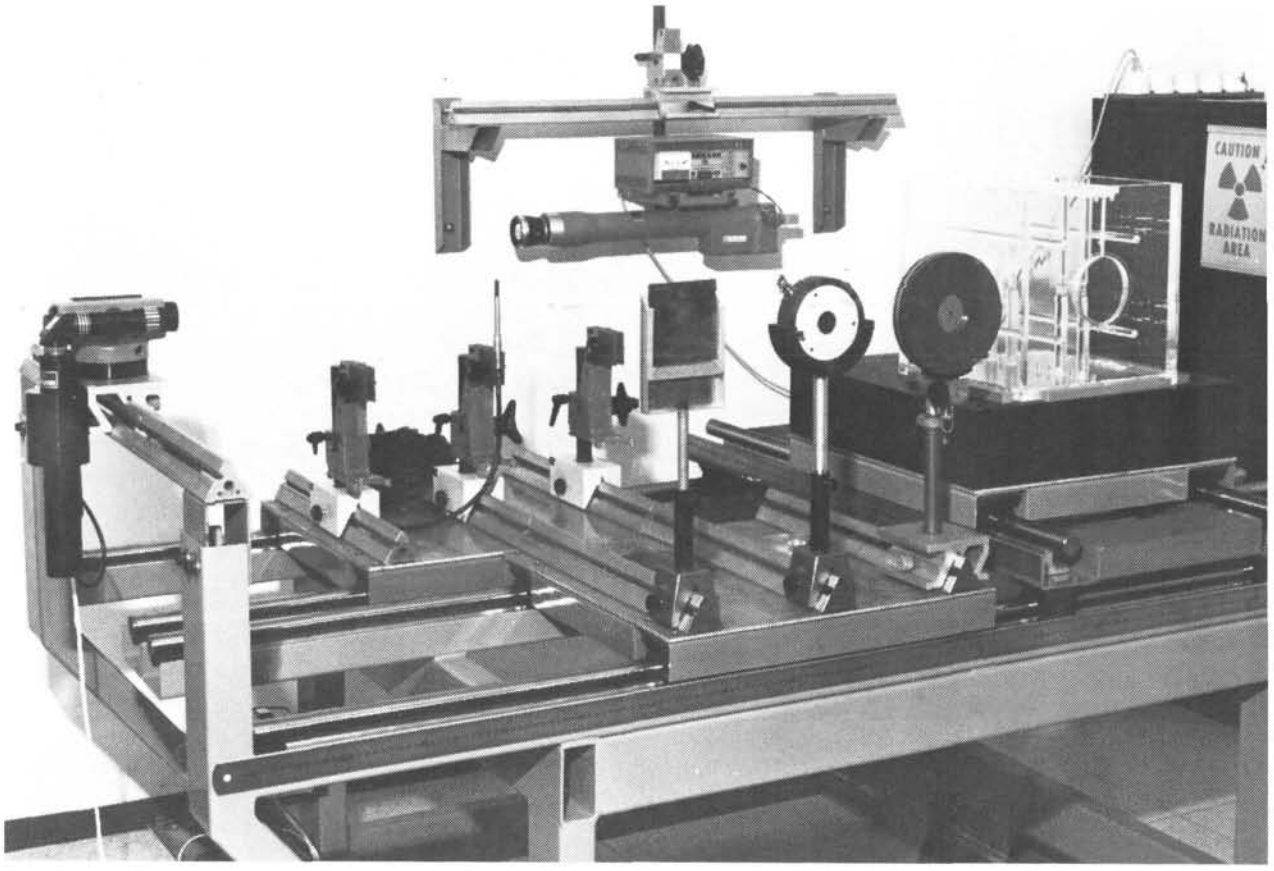
Table 2. Countries visited for dosimetry calibration trips

Region	Africa		Asia and Pacific		Latin America		Middle East and Europe	
Country	Egypt	1980	Indonesia	1979	Argentina	1979, 1982	Bulgaria	1981
	Ghana	1980	Malaysia	1979	Bolivia	1979, 1982	Cyprus	1981
	Liberia	1980	Singapore	1979	Brazil	1979, 1982	Romania	1981
	Nigeria	1980	Thailand	1979	Chile	1982	Turkey	1981
	Sierra Leone	1980			Colombia	1982	Yugoslavia	1981
					Cuba	1982		
					Ecuador	1982		
					Guatemala	1982		
					Mexico	1979, 1982		
					Peru	1982		
					Uruguay	1982		
					Venezuela	1979, 1982		

Dosimetry Laboratory also accepts SSDL staff for on-site training. In 1982 a total of 11 man-months training was given to five trainees from Indonesia, Democratic People's Republic of Korea, Pakistan, and Thailand. Staff of the Dosimetry Laboratory also undertake Technical Co-operation missions (9 man-months in 1982) and dosimetry calibration trips to SSDLs, supported by the interregional dosimetry programme (Table 2). These visits have covered most of the existing SSDLs and have proved of enormous value. They provide the visited laboratories not only with a direct calibration of their dosimetry standards, but also offer a possibility for discussions of the particular problems of each laboratory. All these activities aim to integrate the member laboratories of the SSDL network into the world's dosimetry system and to support their professional status.

However, there is another way in which the Agency's Dosimetry Laboratory renders technical assistance to SSDLs. Dosimetry calibration work requires specialized laboratory equipment which is not available on the market or, if available, is very expensive. Staff of the Dosimetry Laboratory have therefore designed a number of devices especially for use in SSDLs. These include a precision cart with benches on which dosimeters can be moved in three dimensions for exact positioning in the calibration beam, a standard perspex water tank for in-phantom measurements, and an automated filter wheel for quick positioning of a set of filters needed for specifying radiation-quality of X-rays. These devices are manufactured by the mechanical workshop of the Agency's Laboratory in Seibersdorf, or by local firms, and are obtainable through the IAEA at a reasonable cost.





The precision cart designed by Agency staff members at the Seibersdorf Laboratory. Dosimeters can be moved in three dimensions for exact positioning in the calibration beam. On the right of the picture is the standard perspex water tank for in-phantom measurement.

A recognized institution

The tasks and functions of an SSDL may differ from country to country. All have in common, however, that they are national or regional laboratories that have been authorized by a government to perform dosimetry calibration measurements at the secondary standard level. They may also be engaged in measurements of radioactivity and in work concerned with dosimetric quality assurance. Most SSDLs calibrate dosimeters used for radiotherapy and for radiation protection, and some provide a personnel dosimetry service, and a radiation quality-assurance programme for radiotherapy and diagnostic X-ray facilities. A few advanced SSDLs do research in dosimetry and perform a postal dose-intercomparison service for hospitals in their respective countries which provide radiotherapy. The IAEA expects that, within a few years, such services will be organized by many SSDLs, relieving the Agency's Dosimetry Laboratory of most of the work.

The SSDLs were set up in order to fill the gap between the primary-standards laboratories and the ultimate users of ionizing radiation. In a time of transition to the use of a new system of radiation measuring units (the SI system), they fulfill an even more important role in helping radiotherapists obtain accurate doses.

Six years after its founding, the IAEA/WHO network of SSDLs has become a recognized institution. Many national laboratories, professional associations, and international bodies have taken note of its existence. For example, the Organisation Internationale de Métrologie Légale (OIML) has established a pilot secretariat dealing with SSDL matters and is preparing a document on the calibration, in secondary standard dosimetry laboratories, of dosimeters used in radiotherapy and related fields. The network is also represented by its secretary at the regular meetings of Section I (measurement of X- and gamma-rays, electrons) of the Consultative Committee for the Standards of Measurement of Ionizing Radiations, set up by the International Committee for Weights and Measures (CIPM).