The Development and Functions of the Indian Secondary Standards Dosimetry Laboratory

by G. Subrahmanian

At the International Atomic Energy Agency Symposium on "National and International Standardization of Radiation Dosimetry" held in Atlanta during 5–9 December 1977, it became quite evident that the institutions in the IAEA/WHO network of Secondary Standards Dosimetry Laboratories (SSDLs) have become recognized as having a necessary and well-defined objective. The link they have established with the primary standardization laboratories and with the radiation users is quite commendable within the metrology system.

A number of SSDLs are well established around the world and have started to organize national and regional dose intercomparison programmes, closely following the IAEA recommendations. The development and functioning of the Indian SSDL which has brought about considerable improvement in clinical dosimetry through a dose intercomparison programme, is outlined.

WHAT IS A SSDL?

A group of experts under the auspices of the World Health Organization in collaboration with the International Atomic Energy Agency met in Geneva in November 1968 to discuss the need for and effective ways of improving radiation dosimetry particularly for radiotherapeutic applications and also for radiation protection purposes on a worldwide scale. This was necessary because of the spectacular increase in the use of ionizing radiation in medicine, industry and scientific research and the subsequent need for reliable communication of results between the radiation users. This group recognized there was an urgent need for improving dosimetry of radiation applied to different branches of radiation medicine, for example X-ray diagnosis, radiotherapy and nuclear medicine, as well as in the non-medical applications of ionizing radiation and radio-isotopes and in radiation protection.

It was also realized by the group that the problem of calibration in radiation dosimetry could be solved by setting up Secondary Standards Radiation Dosimetry Laboratories (SSLDs), the standard instruments of which are carefully calibrated against a primary standard dosimeter. These laboratories were intended to from a worldwide network (the present IAEA/WHO network of SSDLs) and similar principles and methods would be followed in each of them. The network would also provide mutual information and distribution of reports, guidelines and recommendations relevant to the whole field of dosimetry.

India embarked on its atomic energy programme during the late fifties and since then the isotope production programme has been launched. With the increased availability of a large

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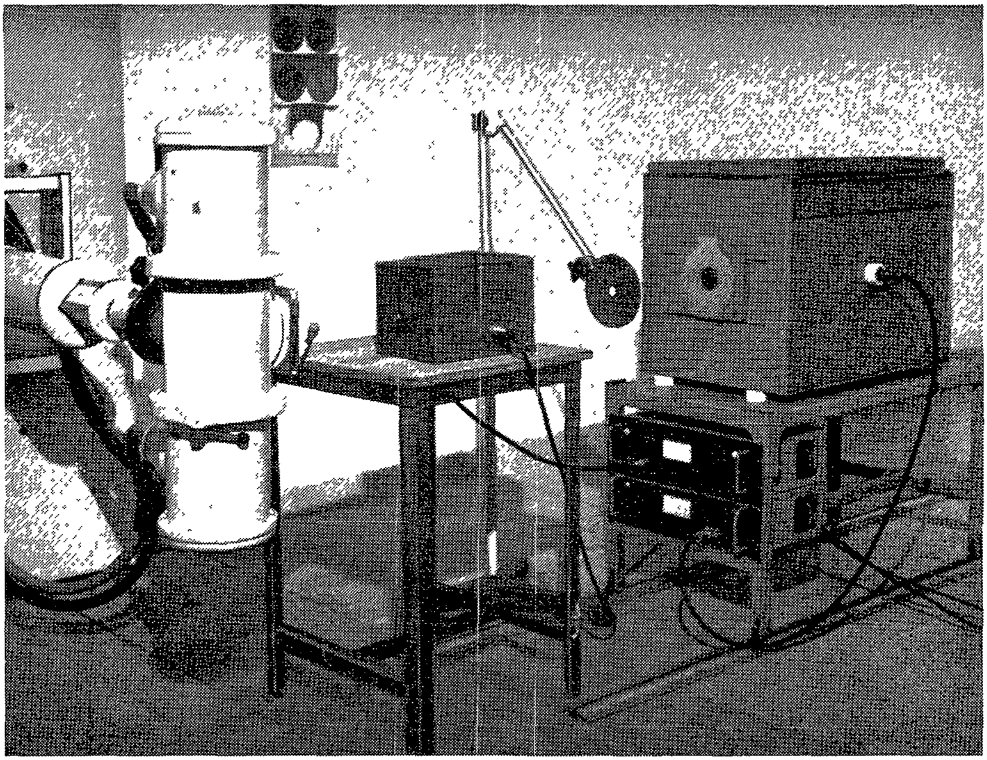

Figure 1. This parallel-plate free air chamber provides primary standards for X-rays up to 300 kV.

number of ^{60}Co teletherapy sources the number of teletherapy units installed registered a steep rise. As part of the national atomic energy programme, the countrywide radiation protection responsibility was also taken up by the Bhabha Atomic Research Centre. During the early sixties the above programme was initiated and it was soon revealed to us that there was a total or near total absence of radiation dosimetry and treatment planning in many of the radiotherapy centres in the country. It could be seen that radiotherapy was done purely on an *ad hoc* basis depending on the clinical experience of the radiotherapist. The complementary physics support was nearly absent as there was only a handful of medical physicists in the country Dosimeters were not manufactured locally and the dosimeters which were earlier imported for some of the hospitals could not be used for long due to the unavailability of special batteries in the local market. Moreover these dosimeters were never recalibrated following their purchase. The need was felt to develop the necessary infrastructure in India and to provide hospitals with the basic requirements

EARLY DEVELOPMENTS

The initiative in this regard was taken up by the Research Centre at Trombay and soon a multipronged programme was begun The salient features of this programme were as follows.

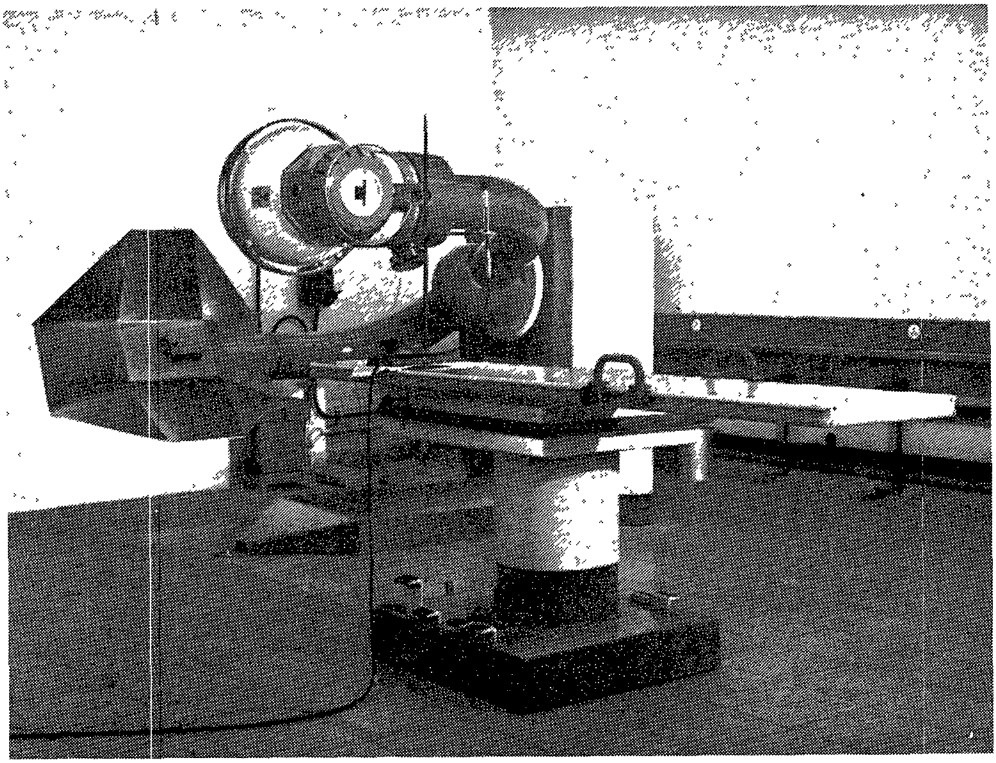

Figure 2. Graphite cavity chambers such as this are used for calibration of Cobalt-60 gamma beams.

(1) Design and development of primary standards such as free air chambers, graphite chambers, calorimeters for fundamental radiation units and also for establishing a calibration facility for calibration of dosimeters on a countrywide basis.

(2) Design, development and fabrication of radiation measuring devices and dosimeters from locally available components and materials to the extent possible.

(3) Training of young and enthusiastic physicists, in radiological physics.

(4) Research and development in the field of radiological physics.

An important aspect of the dosimetry programme was to render advisory services to the radiotherapy institutions in dosimetry and treatment planning aspects. Medical physicists were encouraged to spend some time in our laboratories to apprise themselves of modern techniques and computational methods in the field. Among other services extended to the hospitals were the planning of radiation installations from a radiation protection point of view.

ROLE OF THE RADIOLOGICAL STANDARDS LABORATORY

The Radiological Standards Laboratory is the custodian of the national primary standards for radiological quantities such as X-ray and gamma -ray exposure and absorbed dose.

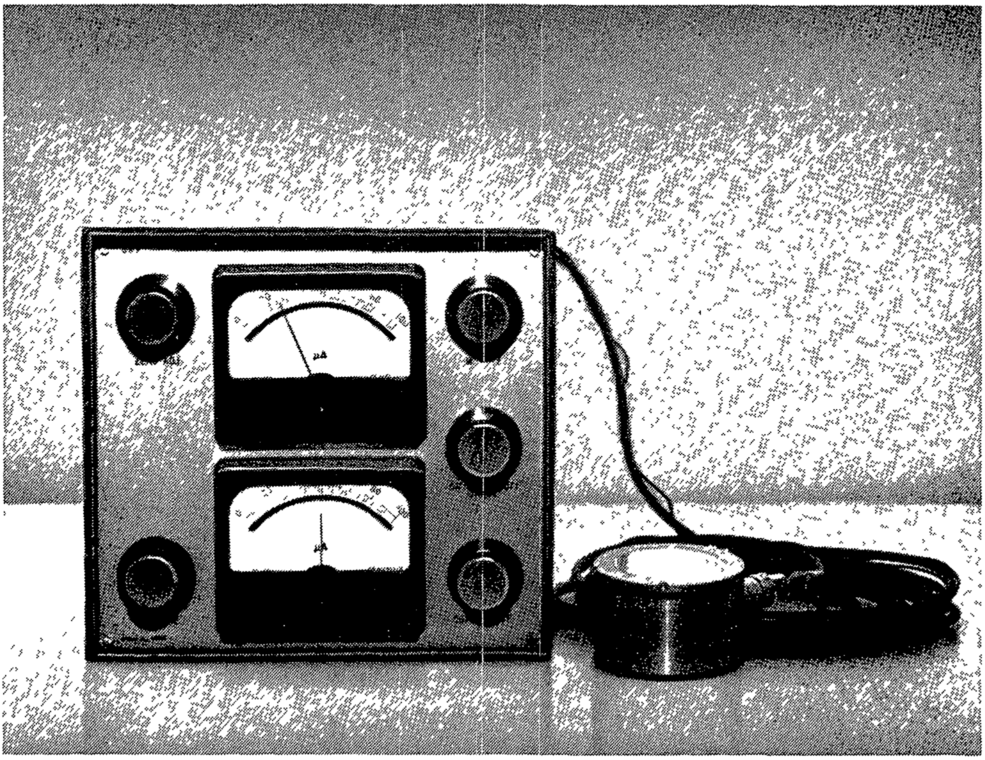

Figure 3. A dosimeter for soft X-rays is shown in this photo.

The primary standards for X-ray are two parallel-plate, free air ionization chambers designed and fabricated at this laboratory for standardization of X-ray exposure at potentials ranging from 10–60 kV and 80–250 kV respectively. The primary standard for ^{60}Co gamma exposure is a graphite chamber (see Figs. 1,2,3,4). The status of the primary standards was established through various international intercomparisons.

Subsequent to the setting up of radiation standards, the dosimeter calibration service was also offered to all hospitals in India as well as to those in neighbouring countries. Such calibrations are carried out against reference standards for soft X-rays, Orthovoltage X-rays and ^{60}Co gamma rays. After calibration, certificates are issued specifying the calibration factors, accuracies and other essential information.

DESIGNATION AS AN IAEA/WHO COLLABORATING CENTRE

At this stage of development, it was felt that the hospitals had been provided with the necessary manpower and equipment to perform reasonably good dosimetry for clinical applications. It was also felt that a stage had been reached where the emphasis should be to ensure that the equipment and expertise made available to the hospitals was made use of properly and that clinical dosimetry performed at these hospitals was sufficiently accurate and consistent with the efforts already made. At this time the designation of this laboratory

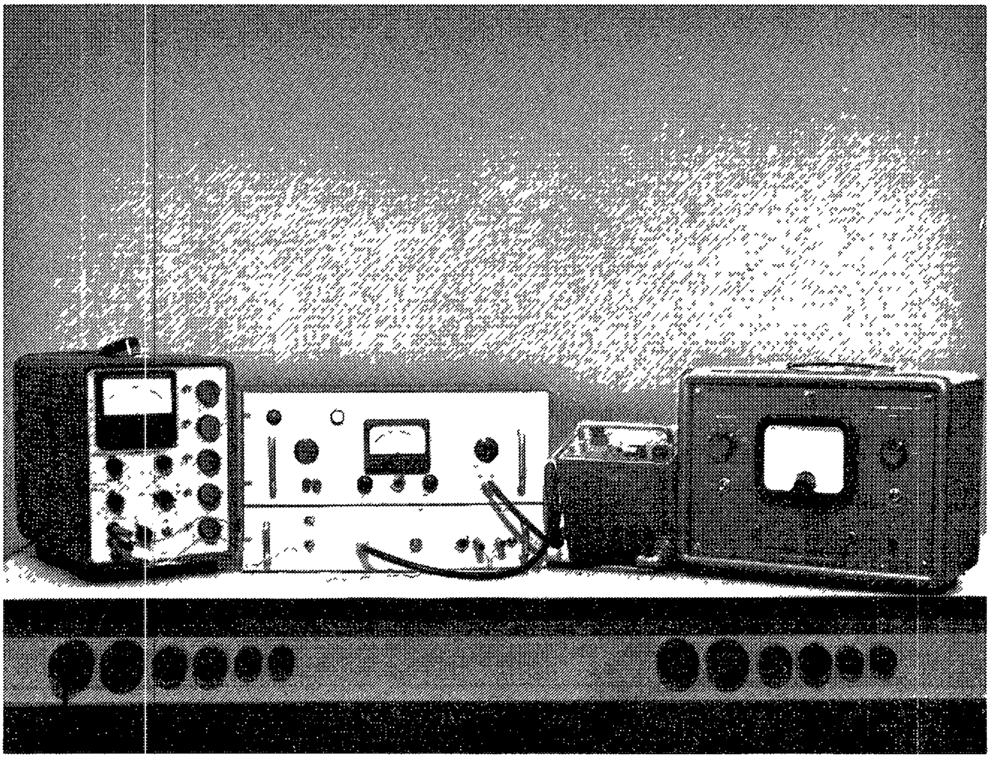

Figure 4. Pictured here is the charge measuring system used in primary/reference standard measurements with X-rays.

as an IAEA/WHO collaborating centre for secondary standards radiation dosimetry was most opportune.

It may be recalled that the primary objective in establishing the SSDL network was to build a nucleus to improve radiation dosimetry as applied in medicine and in radiation protection. When other countries in a geographical region have their own national calibration facilities for dosimeters, the task of a centre would be to harmonize the work of these national laboratories by making intercomparisons in order to ensure conformity of radiation measurements and by continuing to provide training for the staff of the laboratories. One of the techniques to check the accuracy and uniformity of the radiation dose delivered to patients undergoing radiotherapy is by postal dose intercomparison of absorbed dose, a techniques initiated and perfected by IAEA for ^{60}Co radiation. This programme has been in existence for the past two decades.

THERMO-LUMINESCENT DOSIMETER (TLD) INTERCOMPARISON PROGRAMME

As one of the main functions of the SSDL, the Trombay laboratory initiated this dose intercomparison programme soon after its designation by the IAEA/WHO. This programme is solely aimed at attaining the technical expertise and organization needed to enable the

SSDL to take over that part of the international programme pertaining to its region and not intended to supplement the IAEA/WHO programme. In this context, it is essential that the two intercomparison programmes should be identical, so that the results obtained independently in each programme are comparable and can finally be integrated. The two programmes are expected to run concurrently until an SSDL reaches the required level of perfection. With this in view, the Trombay SSDL has not only identified its own programme with that of IAEA/WHO but has combined the IAEA/WHO batches with two of the SSDL batches After the participants irradiated the TLD capsules belonging to SSDL and IAEA/ WHO under identical conditions, the dosimeters were independently evaluated at the Trombay SSDL, and at the IAEA in Vienna and the results compared. (Table 1)

In order to check the consistency of TLD readers used by SSDL & IAEA, the laboratory participated in the IAEA experiments and the result of the intercomparison showed an agreement within 1%. A visiting IAEA/WHO expert also performed the calibration check of the ^{60}Co beam output independently using a WHO-owned NPL-calibrated secondary standard dosimeter. All these checks have confirmed the capability of the Trombay SSDL to organize its own TLD intercomparison programme which is accurate and at the sametime comparable in quality with that of the IAEA/WHO service.

In the course of these intercomparison experiments, it was brought to light that most of the hospitals in India do not possess a properly calibrated dosimeter and an undue reliance was placed on the beam output values supplied to these institutions at the time of source loading several years earlier. Serious errors in the use of correction factors for ^{60}Co decay and in the use of conversion values were also noticed. Efforts were made to educate the participants and errors in dosimetry were corrected through protracted correspondence. However, in situations where the deviations were larger than 10%, it was found necessary to perform an on-the-spot measurement of the beam output.

BEAM OUTPUT MEASUREMENT SERVICE

In the course of our initial TLD intercomparison programme it was realized that this programme is not sufficient to achieve accuracy and region-wide uniformity of absorbed dose measurement in a reasonably short time. Accuracy and uniformity of radiation dosimetry implies that all basic measurements pertaining to radiation dosimetry practices at each and every radiotherapy centre must be traceable to national standards. This is possible only if the physicists concerned take sufficient care to ensure periodic recalibration of the dosimeter and to check for possible changes in its sensitivity by regular measurement using a ^{90}Sr check source. Furthermore, every radiotherapy centre should ideally maintain at least two dosimeters, one being of the secondary standard category. The second dosimeter must be periodically calibrated against the secondary standard by the physicist himself. This second dosimeter is then used for all the routine measurements while the secondary standard dosimeter should be treated as the local standard and used only on special occasions. In many instances, recalibration of the dosimeter is ignored and hence the measured output of teletherapy units could be in error by several percent. This can result in underdosage or overdosage to the patient. Identification of institutions where this is the case from TLD intercomparison is time-consuming and correcting the mistake by correspondence may further reduce the chances of curing patients particularly in cases where the dosimeter is very much in error.

Table 1. Comparison of SSDL-WHO Concurrent batch results

SSDL batch (Institute number)	IAEA/WHO batch (Institute number)	Deviation in % (SSDL)	Deviation in % (IAEA/WHO)	Difference (%)
7802	1142	−0.9	+1.4	+2.3
7804	1143	+8.1	+10.8	+2.7
7805	1144	+1.4	+2 9	+1.5
7806	1145	+4.9	+6.1	+1.2
7807	1146	−2.8	−0.5	+2.3
7810	1147	−0.1	+3.6	+3.7
7811	1148	−2.8	+1.8	+4 6
7817	1150	+11.3	+14.6	+3.3
7819	1152	+1.6	+3.7	+2.1
7822	1153	+18 1	+15.6	−2.5
7823	1154	−3.5	−3.5	0 0
7826	1155	+0.4	+0.3	−0.1

Therefore, concurrently with the TLD intercomparison programme, calibration of the beam output of ^{60}Co teletherapy units was also initiated. A senior physicist of the SSDL toured the country and performed beam output measurements for all field sizes and source-to-tumour distance required by the hospital authorities. The hospital dosimeter was also compared with the SSDL secondary standard. Tentative values of calibration factors were provided instantly and wherever necessary the hospital was advised to send the dosimeter for repair/recalibration to the SSDL. These visits were also utilized to convince the radiotherapist and physicist at each hospital of the need for accuracy and uniformity in clinical dosimetry. The response shown by radiotherapists and physicists after the tour bears testimony to the success of this programme. It is proposed to continue this calibration service and extend it to all hospitals in the geographical region. Simultaneously, TLD intercomparisons will also be continued and extended to all centres in the future

Since inception of the SSDL programme about 90 institutions have been covered in the postal dose intercomparison. This number includes some hospitals where repeat intercomparisons were conducted. This was found to be necessary due to large deviations in the earlier results and in other cases due to the replacement of decayed sources. It was gratifying to note that most of the hospitals where repeat intercomparisons were done showed better agreement. (Table 2)

Table 2. Results of the repeated intercomparisons

Number	Deviation in % – First intercomparison	Deviation in % in repeated intercomparison
1	–4.5	–0.9
2	–1.7	–1 0
3	–14.7	+8.1
4	+2.8	+1.4
5	–9.6	+0.7
6	High dose	+0.6
7	–7.8	–2.8
8	–5.0	–1.6
9	–5.0	–3.0
10	–3.9	+1.6
11	+8.9	–2.8
12	–5.5	–5.1
13	+44.8	+7.9
14	+2.9	–3.3
15	–8.2	+3.4
16	–1.8	+2.4
17	+7.1	+0.7
18	–26.4	+11.3
19	+7.6	+1.6
20	–1.7	–1.2
21	–5.8	–3.9
22	+0.2	–1.3
23	–3.5	–3.5
24	–5.5	+0.3
25	–19.5	–10.0

MEDICAL PHYSICS TRAINING

The establishment of a medical physics training programme in India followed closely the launching of the country's atomic energy programme. Unlike the advanced countries where there are regular graduate programmes in radiological and medical physics conducted by the universities and medical institutions, there was no academic programme of this sort in any of the Indian universities. Hence, the responsibility for the training programme was necessarily undertaken by the Department of Atomic Energy in the early sixties. A one-year post-graduate training programme was initiated in 1962 with the active collaboration of the World Health Organization. The course dealt extensively with all aspects of radiation including its applications and also the attendent safety aspects. At present, this course leads to a Diploma in Radiological Physics from the University of Bombay. So far, 16 courses have been held with a total number of 260 candidates, of which 30 were from other South-east Asian countries.

In addition to the long-term course, short courses on safety aspects in the medical uses of radiation and safety aspects in the industrial use of radiation are being conducted at regular intervals for the benefit of radiologists, X-ray technicians and others working with radiation sources.

The experience of the laboratory at Trombay has shown that the objectives of a SSDL can be effectively achieved with the co-operation of IAEA/WHO and through the concentrated efforts of the SSDL itself. The Trombay SSDL has the advantage of a primary standard laboratory of its own and various other facilities available at the research centre. Moreover since the laboratory was performing these functions even earlier, the experience and expertise accumulated over the years is being utilized to reach the goals expeditiously.