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SSDL Newsletter

IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

No. 27 DECEMBER 1988

Prepared by the Joint IAEA/WHO Secretariat of the SSDL Network
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NEWS FROM THE NETWORK SECRETARIAT

The SSDL Network Secretariat has two joint scientific secretaries, one from WHO and one from IAEA. A change of secretaries took place during 1987 due to the retirement of the two officers, Dr. N. Racoveanu and Dr. H. Eisenlohr. The new secretaries are Dr. Gerald P. Hanson (WHO) and Prof. Hans Svensson (IAEA).

Dr. Gerald P. Hanson was transferred to the Headquarters in Geneva in April 1987 to be the Senior Scientist and Chief of the WHO Radiation Medicine unit.

Dr. Hanson, a native of Michigan, USA, is 53 years old, is married, and has two children, ages 17 and 19. He obtained a B.S. degree in Engineering from the University of Michigan in 1958, a Master's degree in Engineering in 1959, and a Master's in Public Health (Health Physics, Radiological Health) in 1960. These also from the University of Michigan in Ann Arbor.

After post-graduate work at the Argonne National Laboratory in the summer of 1960, he began his professional career as the first Chief of the Radiation Hygiene programme of the state health department of Kansas. In 1962, he moved to Washington, D.C. and accepted the post of the first Radiation Safety Officer of the Harry Diamond Laboratories, a U.S. government research and development laboratory. After 2 years in Washington, Dr. Hanson joined the Pan American Health Organization (PAHO), which is also the Regional Office of WHO for the Americas, and became their first Regional Adviser in Radiation Protection. At first, his duty station was in Lima, Peru, from where he travelled extensively throughout Latin America and the Caribbean area assisting the health authorities to establish radiation protection programmes. In 1967, Dr. Hanson's duty station was moved to Santiago, Chile from where as the PAHO/WHO Regional Adviser he continued to work throughout the Region of the Americas.

During the period of 1969-1971, he took leave from his duties in the field and returned to the USA where he began a combined study programme in Medical Radiation Physics and in Public Health at the University of California, Los Angeles (UCLA); and in 1971 earned his Doctor of Public Health Degree. After leaving UCLA, in 1971, he rejoined PAHO/WHO in Washington, D.C. where he became the Regional Adviser in Radiological Physics, combining the responsibilities for Health Physics and Medical Physics. In 1979, the PAHO/WHO programme in Radiation Medicine was also entrusted to Dr. Hanson, and from 1979 until 1987, when he was transferred to the WHO Headquarters, he was responsible for PAHO/WHO activities in the areas of diagnostic radiology, radiotherapy, nuclear medicine, medical radiation protection, and environmental and emergency radiation protection.

Among Dr. Hanson's qualifications are certification by the American Board of Health Physics (first certified in 1971 and re-certified in 1981 and 1986), plus certification in physics by the American Board of Radiology (1974). When in Washington, D.C. he also served as Clinical Assistant Professor of Radiology at Georgetown University (1971-1987), and as Assistant Professorial Lecturer of Radiology at George Washington University (1983-1987). Currently, Dr. Hanson is a member of the American Association of Physicists in Medicine, the American Public Health Association (Fellow), and the Health Physics Society. His non-professional interests include art, languages, music, photography, tennis and downhill skiing.

Prof. Hans Svensson is on leave from his University in Umea, Sweden. He was appointed head of the dosimetry section, IAEA, in November 1987.

Prof. Svensson is 53 years old, married and has four children. He obtained a B.Sc. in 1960 and a M.Sc. in Mathematic and Physics, a Ph.D. in 1968 and a D.Sc. in 1970 in Radiation Physics.

After his M.Sc. (in Lund, Sweden) he was working with radiation protection research at a research reactor station, 1961-1963. From 1963, he has been employed by the University and University Hospital of Umea, and from 1979 as head of radiation physics department. He was appointed by the university to assistant professor (docent) in 1971 and by the Swedish Government to full professor in medical radiation physics in 1982.

As head of the department he has been responsible for physics in nuclear medicine, diagnostic radiology and therapeutic radiology. However, his major research activity has been in medical dosimetry. He has about 70 publications in this field. He was the chairman of the ICRU task group for electron dosimetry (report no. 35) and was one of the authors of the International Code of Practice (TRS 277, IAEA). He has been awarded for his research activity in the field of physics in radiotherapy (Sjögren's prize, 1983, Klaus Breur Award Medal, 1987, Nordic Prize in Radiology, 1987). He was the first physicist in the board of ESTRO (European Society of Therapeutic Radiation Oncology) and is associate editor of Acta Oncologica and advisory editor of Radiotherapy and Oncology.

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REPORT OF THE THIRD MEETING OF THE SSDL SCIENTIFIC COMMITTEE (SSC)

Vienna, 19-23 September 1988

INTRODUCTION

The SSDL Scientific Committee (SSC) was appointed in 1985 by the Director General of the IAEA, in consultation with and the concurrence of the Director General of the WHO. As indicated in its Terms of Reference, the main objective of the SSC is to advise the Directors General of the IAEA and WHO regarding the programme of work of the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDLs).

The first meeting of the SSC was held in May 1986 and the recommendations were reported in IAEA SSDL Newsletter No.25, October 1986. The second meeting of the SSC was held in June 1987 and the recommendations were reported in the Newsletter No. 26, October 1987.

Prior to its third meeting, the SSC was informed that the Director General of the IAEA requested that the SSC, in addition to the review and evaluation of the work of the SSDL Network, should also be invited to advise on the whole dosimetry programme of the IAEA. Accordingly, the length of the meeting was extended from three to five days.

DATE

The third meeting of the SSC took place at the Agency's Headquarters from 13 through 23 September 1988.

PARTICIPANTS

Committee members:

A. Allisy, Chairman of the ICRU, representing the BIPM

C.E. de Almeida, Instituto de Radioproteçao e Dosimetria, Brazil

G. Drexler, GSF, Germany, F.R.

S.G. Subrahmanian, Bhabha Atomic Research Centre, India

H.O. Wyckoff, former Chairman of the ICRU

K. Zsdánszky, Chairman of the SSC, former Vice President of OMH (National Office of Measures), Hungary

WHO:

G.P. Hanson, WHO Secretary of the SSDL Network, Chief, Radiation Medicine, WHO

Agency consultants:

R. Loevinger, former Dosimetry Group leader, Center for Radiation Research, NBS, U.S.A.

H.H. Eisenlohr, former secretary of the SSDL Network, former head of the IAEA Dosimetry Section

IAEA staff members:

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

P. Bera, Dosimetry Laboratory (part-time)
R. Griffith, Radiation Protection Section
R. Girzikowsky, Dosimetry Laboratory (part-time)
J.G. Haider, Dosimetry Section
J.W. Nam, Dosimetry Section
P. Nette, Head, Dosimetry Laboratory, Dosimetry Section
Ms. A. Salzer, Secretary, Dosimetry Section

AGENDA

- Opening address by Prof. M. Nofal, Director, Division of Life Sciences
- Introductory remarks by Prof. H. Svensson (IAEA) and Dr. G. Hanson (WHO), Secretaries of the SSDL Network
- Opening remarks by Dr. Zsdánszky, Chairman of the Committee
- Adoption of the Agenda
- Nomination of Rapporteur

1. New additional task of the SSDL Scientific Committee
2. Programme CARE
3. IAEA Code of Practice
4. Appraisal of the SSDL Annual Reports 1987
5. Future activities of SSDLs
6. Membership in the Network
   (a) New Members (SSDLs)
   (b) Proposals for new affiliated members (PSDLs)
   (c) Proposals for withdrawal of membership
7. Revision of IAEA TRS 185: Calibration of Dosemeters Used in Radiotherapy
8. IAEA TEC-DOC: SSDL Quality Assurance for Environmental Monitoring of External Radiation
9. SSDL Newsletter
10. Report on the workshops and seminar in Malaysia
11. IAEA Dosimetry Laboratory Activities
    (a) Calibrations
    (b) Intercomparisons for SSDLs (with ionization chambers and TLD)

(c) Intercomparisons for radiotherapy (IAEA/WHO postal dose TLD intercomparison service)

(d) Training at the IAEA Dosimetry Laboratory

12. Radiation protection activities: e.g. Intercomparison for Personnel Dosimetry (IAEA Radiation Protection Section)

13. Information on IAEA high-dose measurement activities (IDAS)

14. Video-film on Dosimetry

15. Forthcoming activities (Workshop and Seminar in Turkey, etc.)

16. Dosimetry programme of the IAEA in 1991-92

17. Manpower of the IAEA Dosimetry Section and Laboratory

18. Any other business

19. Report of the Committee

(a) to the Director General of the IAEA (concerning the whole Dosimetry Programme)

(b) to the Director General of the WHO (concerning the IAEA/WHO Network of SSDLs)

DISCUSSION

Three additions to the agenda were requested:

- Information on the relationship between the Scientific Committee and the Secretariat of the Network;
- Information on the expanded IAEA radiation protection programme;
- Discussion of means for comparison of diagnostic dosimetry.

1. New additional tasks of the SSDL Scientific Committee (SSC)

H. Svensson presented the history of the Agency Scientific Advisory Committee (SAC), and indicated that it has been replaced by some specialized committees, of which SSC is the first to meet. He discussed the kind of advice and consultation expected from the SSC. It was pointed out that proposals for specific activities such as meetings, symposia, study groups, etc, would be especially welcome.

2. Programme CARE (Coherent and Accurate REference instrumentation)

P. Nette gave a detailed report on the state of the programme. Two sets of instruments have been tested extensively. One at OeFZS, OMH and NBS, one at the IAEA Dosimetry Laboratory, Seibersdorf. They were found to be stable and reproducible within a few tenths percent. Instruments have been distributed to six SSDLs, and show agreement with the IAEA Dosimetry Laboratory within one percent. It was concluded that the CAD (Calibration Assurance Dosimeter) systems to be used for programme CARE are now operating satisfactorily and the programme is starting to function. There are however problems of staff shortage. The CARE programme alone is estimated to occupy about one-half man-year. The two technicians at the Agency Dosimetry Laboratory (DOL) cannot perform the full Dosimetry Section (DS) programme. It was suggested that part of the the CARE programme should be shifted to the SSDLs, if the staff situation will not improve. The high cost of the CARE programme was shown, in particular the cost of shipping the instruments. It was suggested that the equipment be sent to one advanced SSDL, which could then send it to the SSDLs in that region, but it was noted that the Agency might be requested to furnish the shipping costs to the SSDL.

3. IAEA Code of Practice

Svensson gave a detailed survey of the problems that were resolved in writing the new Code of Practice, starting with the change in the physical constants adopted by the PSDLs in 1986. Many inconsistencies were removed. After a careful survey of G-values, the Code was studied with Fricke dosimeters at energies from ^{60}Co to 20 MeV, and the Code was verified to about 0.8%. The Agency received good cooperation from the companies that make ionization chambers, in obtaining the characteristics of chambers.

A remaining problem concerns medium-energy x rays. There are two methods to obtain absorbed dose to water: Method A (ICRU Report 23) involves an air-to-water conversion, starting with an air-kerma (or exposure) calibration; and Method B (PTB) involves a graphite-to-water conversion, starting with absorbed dose from a graphite phantom. Method B gives air-kerma-to-dose conversion factors larger than Method A by as much as 10%, in some cases. There appears to be work in publication supporting both methods. There was discussion of whether medium-energy x rays are used enough to justify an Agency study (perhaps a research contract) of the difference. It was stated that there is still some use of medium-energy x rays in radiation therapy, but they are being phased out. Perhaps radiation biology will continue to need this information.

Svensson is collecting corrections and suggestions concerning the Code of Practice, and expects to publish a revised version in 1991 or 1992. He hopes to work cooperatively with the ICRU on its Report on Dosimetry Protocols.

4. Summary of the SSDL Annual Reports, 1987

The large number of calibrations reported makes clear that the SSDLs are meeting a genuine need. It was noted that it is difficult to interpret the report summaries, because it is not easy to relate the numbers to the quality of the SSDL performance. It was suggested that the Agency financial input be shown, for comparison with the SSDL activities. In reporting intercomparisons, some SSDLs used the total number of dosimeters and some used the number of sets; the two numbers may be very different, so it should be made clear which should be reported. It was requested that the types of radiation and also types of protection instruments calibrated be reported. It was stated that a further analysis of the annual SSDL reports cannot be expected, since it requires much staff time. It was suggested that the summary be circulated to the SSDLs, with possibly the exception of the results of the intercomparisons. It may be necessary to obtain permission of each SSDL before doing this. It is considered commendable that 47 out of 61 SSDLs submitted annual reports.

5. **Future activities of SSDLs**

Svensson presented the following suggested activities by the SSDLs:

1. Postal dose intercomparison service within the country/region. Agency support may be necessary for this.
2. Quality assurance for radiation therapy. The Agency has an anthropomorphic phantom, which the SSDL could send to the hospitals. This could be like the programme now going on in the EORTC (European Organization for Research and Treatment of Cancer) and ought to be in collaboration with the WHO.
3. Site visits inside the country/region. This might include isodose measurements and other clinical dosimetry, utilizing the SSDL staff and its experience.
4. Radiation protection. This might be a personnel dose service, either direct or supervisory.
5. Dosimetry in diagnostic procedures.
6. Environmental dosimetry.

Other suggestions for SSDL activities included afterloading dosimetry intercomparisons, and prototype testing of instruments.

It was agreed that it would be desirable if the work of the SSDLs could be based on a legal requirement in each country. The representative of the WHO pointed out that in Argentina this is the case, as in the European Community. According to the inquiry of BIML (in 1986) the calibration of dosimeters is based on legal requirements in about 30 % of the OIML Member States. In consideration of the difficulty of influencing legal regulations, it was suggested that a useful first step would be to conduct a survey of the legislative situation in the IAEA Member States. This could serve to call the attention of the national authorities to the need for good dosimetry in radiation therapy, radiation protection, and diagnostic radiology, and might result in additional support for the SSDLs. This survey should contain specific examples of how certain countries have made such regulations, and should call attention to existing documentation of the ISO, IEC, ICRU, etc.

6. **Membership in the Network**

(a) New members (SSDLs)

Since the last SSC meeting, Chile, Poland, and Saudia Arabia have been nominated as new members; a proposal was received that Hong Kong be nominated; a national SSDL organization has been created in Thailand; in Mexico two SSDLs have joined together to create a single laboratory; in Portugal there is confusion concerning two SSDLs, one of which receives Agency technical assistance -the Secretariat agreed that it should resolve this confusion. It was suggested that the list of members of the Network with their mailing addresses, should also give the name of the responsible person to whom mail could be addressed.

(b) Proposals for new affiliated members (PSDLs)

A proposal for affiliation of three new members to the SSDL network was discussed. Some of the discussion centered around the lack of information for this proposal. It was pointed out that according to the definition in the Criteria for the Establishment of an SSDL: "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 BIPM, and provides calibration services for secondary standard instruments".

It was proposed that a PSDL, to be affiliated membe of the SSDL, shall agree to provide calibration services to appropriate SSDLs. Finally, the PSDLs of Austria (BEV) and Spain (JEN) were accepted as affiliated members of the network.

It was reported that one of the existing affiliated PSDLs, the U.S. National Bureau of Standards (NBS) has undergone a change of name to National Institute of Standards and Technology (NIST); the leader of the NIST Dosimetry Group has expressed his intention to continue cooperation with the IAEA and the SSDL Network.

(c) There was a discussion of what should be done about SSDLs that have not responded in any way for several years. It was decided that after three years without an annual report, a letter be sent calling this situation to the attention of the appropriate national authority, and suggesting that the laboratory withdraw from the SSDL Network.

7. Revision of TRS 185: Calibration of Dosemeters Used in Radiotherapy

A report on this subject was submitted to the Committee by J. E. Burns and R. Loevinger, who had been appointed as consultants for this purpose. The report outlined the changes proposed in each chapter, and provided a draft of a new chapter on measurement of absorbed dose. In general the report was accepted, and it was agreed that the special units would be used only in the chapter on quantities and units; thereafter only SI units would be used. It was agreed that a comprehensive system involving redundant measurements would be recommended to provide assurance of constancy. Numerical values should be given for the magnitude of the inconsistencies that would be tolerated before recalibration of the local standard is required, and Programme CARE should be referred to and discussed in connection with maintaining the reliability of the calibration factor of the local secondary standard.

8. IAEA TEC-DOC: SSDL Quality Assurance for Environmental Monitoring of External Radiation

This document has been compiled from the working papers of a consultants' meeting that took place in January 1987. It provides guidance to the SSDLs for interpretation of measurement of external gamma radiation. The document was circulated to the SSC before the meeting, and comments were requested from the Committee within one month following the meeting. A few suggestions for additions were made during the discussion, and it was agreed that this would be sent to the SSDLs after it was suitably edited.

9. SSDL Newsletter and other publications

It was agreed that the Newsletter fulfils an important purpose. Scientific articles should be carefully edited to ensure their accuracy. Articles on aspects of Programme CARE are considered by the Committee to be very important, and should be written by the Secretariat or by a member of the

SSC. Suggestions for future articles included the following: activities in the SSDLs and the DOLs; announcements of future meetings; abstracts of current literature of interest to the SSDLs, occasional reprints of current articles in journals; exchange of experience in the SSDL and the Agency laboratories; and carefully chosen scientific articles of interest to the SSDLs. An example of the last might be a discussion of the new quantities for radiation protection put forth in ICRU Report 39. It was suggested that the SSDLs might be more likely to contribute to the Newsletter if the Agency indicated that it would help with editing.

It had been commented that reports of symposia and similar meetings should be professionally edited, and consideration given to including input from the audience. Svensson described the difficulty of proper scientific editing in the publications of the recent dosimetry symposium. The Committee commented that not all of the papers were of high value, and the technical editing was inadequate, while the language editing was entirely satisfactory. Svensson pointed out that the limited staff of the Dosimetry Section could not take on the added burden of editing the symposia publications. Suggestions for improving the situation included the following: including the comments of the audience with each paper as in earlier years, and appointing a rapporteur for each session to edit the papers in cooperation with each author.

The current status of the technical report series was reviewed, and it was suggested that TRS 110, Manual of Dosimetry in Radiotherapy (Massey, 1970), might be ready for revision. C. E. De Almeida was asked to review that publication and advise whether it would be appropriate to revise it, and report to the Secretariat.

It was noted that the Atlases of Radiation Dose Distributions are still available. It may be that some parts are now obsolete, but it is too large a job to revise these atlases. The last volume is just now becoming ready for distribution.

10. Report on workshops and seminar

A detailed report was given by P. Nette and J. Haider on the seminar and the dosimetry workshops in Kuala Lumpur, Malaysia, held from 6 to 25 July 1987. It is usual to have one representative of a PSDL at the seminar; on this occasion it was N. J. Hargrave of the Australian Radiation Laboratory (ARL). Participants from 12 different calibration laboratories brought along with them 23 secondary standard instruments and participated either in the calibration comparison measurements or obtained scale correction factors (provisional calibration factors).

The Agency's travelling Secondary Standards were the reference standards and are traceable to BIPM. They were employed at 15 different calibration qualities (cobalt-60, caesium 137, x rays) at therapy-level or protection-level. A total of 76 calibration comparisons were performed and 60 scale correction factors were determined. The therapy-level calibration comparisons (^{60}Co) agreed with the Agency value within 1%, the protection-level comparisons within 3% (^{60}Co and ^{137}Cs).

J. W. Nam reported on the IAEA/RCA Regional Workshop on Photon, Electron, and Neutron Dosimetry in Radiotherapy. This workshop took place in Seoul, Korea (Republic of), 1987 June 8 - 19. Nineteen participants from 10 RCA member states took part. The workshop was arranged by persons in Korea, and Nam was the scientific secretary.

11. IAEA Dosimetry Laboratory activities

(a) Calibrations. It was reported that the number of calibrations performed by the DOL is increasing.

(b) Intercomparisons for SSDLs. 35 SSDLs participated in the reported TLD intercomparison. The deviation from the Agency value was within 3.5%, except for one laboratory that deviated by 5.7%. Six SSDLs participated in a CARE programme using TLD and ionization chambers; the TLD results agreed within 3.3% and the ionization chamber results within 0.6%.

(c) Intercomparisons for radiotherapy. WHO requested for 1988 the preparation, calibration and evaluation of 320 sets of TLDs for an equal number of radiotherapy centers. Each center is receiving 4 TLD capsules. In addition to Argentina, Brazil and India, where the TLD service is already done by the national SSDL, the SSDL Mexico announced to take over in national responsiblity this service in the near future. The representative of the WHO recalled that the goal of the programme was to cover every high energy facility (^{60}Co and accelerator) every year. Every therapy unit not covered by a national calibration system should be covered once each year using dosimeters provided by IAEA/WHO. A member of the Scientific Committee called to the attention of the meeting that the hospitals in India receive two such TLD mailings, one from the Indian SSDL and one from the WHO, and this is considered to be an unnecessary duplication. It was stated that it is the goal of the DS to limit its postal dose comparison to the SSDLs, and to those centers not served by an SSDL.

(d) Training. The training took place in two groups. Six fellows received training 3 months each in therapy-level calibration, and one fellow in protection-level calibration. In addition there were 10 scientific visits of several 3 to 5 days each.

12. Radiation protection activities

R. Griffith from NENS described his CRP on Intercomparison for Individual Monitoring, with the objective to implement an international comparison of individual dosemeters, and which could initiate a regular broad-scale test programme for the IAEA member states. This programme involves 19 participating countries, and covers mean photon energies from 17.5 keV to 1250 keV. The irradiating laboratories are Berkeley Nuclear Laboratories (UK), ASMW (GDR), and OeFZS (Austria), and consideration is being given to including the DOL. Evaluation is done by the PTB (FRG). It is considered essential to include the SSDLs in this programme.

Griffith also reported on the rewriting of TRS 133, Handbook on Calibration of Radiation Protection Monitoring Instruments (1971). A draft of a new report in the Safety Series, with the same title, was furnished to the Scientific Committee, with the request that they submit comments by December 1. TRS 133 will be withdrawn when the new report is issued.

13. IAEA high-dose measurement activities

A detailed report was given by J. W. Nam on progress in these activities, which have been carried out by means of 39 research projects. The alanine/ESR dosimetry method has been chosen as the most suitable, because of its wide linearity (from 10 Gy to 100 kGy), insensitivity to environmental conditions, and lack of fading. Operation of the alanine/ESR dosimetry laboratory is being provided under contract with GSF in Munich, FRG. High-dose measurement assurance is made available through the International Dose Assurance Service (IDAS), which has provided dose intercomparisons with 19 laboratories in 14 countries and the reference laboratory for IDAS, the GSF. 51% have shown agreement with the GSF standard within ±5%, and 86% within ±10%. The spread of values was between -15% and +19%. Nine SSDLs are involved in the IDAS programme. It was stated that there are about 270 high-dose facilities, without including those in the USSR.

Svensson stated that he wants to have a quality assurance programme for IDAS within the Agency, including clear traceability to the BIPM, which will involve sending an alanine sample to BIPM for irradiation.

14. Video film on dosimetry

The video film describing the facilities and activities of the DOL was shown to the Scientific Committee. The Committee expressed the opinion that the video film was of excellent quality and should be made available to the scientific community (SSDLs, national authorities, other interested organizations, etc.).

15. Forthcoming activities

P. Nette described the forthcoming workshops and seminar to be held in Istanbul, Turkey in October-November 1988. The programme will be very similar to that in Malaysia. A. Jakab from the OMH (Hungary) will be the representative from a PSDL.

16. Dosimetry programme of the IAEA in 1991-92

H. Svensson discussed the tentative programme for 1991-92 in the Area of Activity for E.3, Dosimetry. These were discussed under the headings

E.3.01: SSDL Network,
E.3.02: Dose Intercomparison and Assurance,
E.3.03: Development of Dosimetry Techniques.

It is intended that an increasing fraction of the laboratory and training activities, including part of the CARE programme, will be taken over by the SSDLs in each region, with Agency support and supervision.- The workshops scheduled each year through 1990 are to be conducted by the Agency, after which they will be planned and organized in each region by an SSDL. The Agency expects to send only one staff member and perhaps an outside lecturer for those workshops.- One symposium is planned during that period, on Measurement Assurance in Dosimetry, directed to the SSDL staff.- It is expected that few new SSDLs will be created during this period; instead emphasis will be placed on improving the quality of the existing SSDLs.

Svensson noted that he is collecting comments and corrections for IAEA TRS 277, the Code of Practice, and by 1992 it might be appropriate to produce a revision or an appendix. It was noted that a careful connection should be established between the IDAS and the CARE programme, which would establish traceability between IDAS and the BIPM.

17. Manpower of the IAEA Dosimetry Section and Laboratory

The Committee again expressed its concern over the very limited manpower available in the DS and DOL. The Committee agreed that only the following activities can be accomplished with the present manpower, and only at the present level of activity (which is considered insufficient in some cases):

CARE programme - therapy
CARE programme - protection (irradiation at the DOL)
IAEA/WHO TLD postal dose intercomparison programme for hospitals
Evaluation of technical cooperation projects
Symposium, 1992
Seminar/workshop each year, as planned
SSDL Newsletter
IDAS
CARE programme for processing-level dosimetry
Handling two coordinated research projects
Maintenance and repair of DOL equipment

18. Other business

G. Drexler described a programme now underway in the EC countries for intercomparison of diagnostic dosimeters. Because it may be expected that such a programme will soon become of importance in other parts of the world, he proposed that the DOL join this programme. It was suggested that the IAEA might jointly sponsor a meeting on this subject and that a CARE programme on this subject be started on a small scale at the DOL. This would involve distribution of TLD that had been calibrated on the diagnostic x-ray generator at the DOL.

It was proposed that short progress reports covering the period between meetings, be sent to the members of the Scientific Committee.

The representative of the WHO expressed his desire for improved cooperation between the WHO and the IAEA, and with this in mind he mentioned that he plans to visit the Agency headquarters a few times each year for working sessions with the IAEA co-scientific secretary.

RECOMMENDATIONS

The medical and industrial use of ionizing radiation is widespread and is increasing throughout the world. In the advanced countries (where such information is generally available), about one person in four gets cancer, and about half the cancer patients are treated with radiation therapy; in the developing countries cancer is steadily becoming a more important medical problem, as life-span increases, and the need and demand for radiation therapy is increasing rapidly. In the advanced countries there are about 5 accelerators per 1 million persons, while in the developing countries only about 1 per 10 million persons, and this number is steadily increasing. All indications are that radiation therapy will continue to increase in importance as a modality for cancer therapy. In addition to the increase in the number of radiation therapy sources, there is an increasing need for accuracy in dose measurement due to the introduction of new therapy techniques, such as after-loading of brachytherapy sources, intra-cavitary brachytherapy, intraoperative electron irradiation, new methods of field shaping with high dose administered to restricted target volumes, etc.

The dosimetry measurements of diagnostic radiology, radiation protection, and environmental exposure do not require the accuracy of therapy-level measurements, but they do require a coherent relationship to the international measurement system. Without such a relationship, all such dosimetry measurements are of doubtful value.

Diagnostic radiology necessarily increases in amount as the level of health care improves, introducing new techniques such as computer tomography, mammography, digital radiology, high-intensity screens, image amplification, etc. A tremendous increase in diagnostic radiology is to be expected, bringing with it a large increase in the need for reliable diagnostic-radiology dosimetry. In the advanced countries, on the average every person receives diagnostic radiation every year, and the developing countries are moving in that direction, some more rapidly than others. There is a trend in the advanced countries to require quality control and quality assurance by legal means, and the developing countries will surely follow suit. Improved dosimetry in this area will not only improve the quality of diagnostic radiology, while reducing the dose to the patients, but it will also help to reduce the overall cost of health care.

In the area of occupational radiation exposure, primary limits are under discussion, and a more restrictive approach is foreseeable, arising at least in part from reevaluation of the dose assessment at Hiroshima and Nagasaki. It is likely that occupational exposure limits will approach more closely to environmental exposure, necessitating more accurate dosimetry measurements; the current overestimation as a safe strategy will probably give way to a more realistic dose assessment.

Environmental dosimetry is now widespread, playing an essential role in early-warning strategy. The recent Chernobyl experience has shown the importance of coherent and accurate measurements to provide a world wide basis for public information and sound decisions by national and international authorities.

In the face of these increasing demands for increasing services in radiation dosimetry, the staff of the Dosimetry Section and the Agency Dosimetry Laboratory has been steadily shrinking. In recent years, 2 positions have been lost, and one has been assigned full time from the laboratory to Headquarters. The Dosimetry Section staff is now too small to meet its assigned responsibilities much less attempt to meet, and is at its limit in attempting to meet needs that are increasing. The present programme is essential, especially Programme CARE for therapy and protection, and these must be maintained.

The Committee noted with approval that the appointment of Dr. Svensson to the position of Section Chief brings to that position a person with a distinguished record as a scientist. He can be expected to provide important leadership to the Dosimetry Section. He cannot, however, ensure that the Dosimetry Section fulfills the role that it should play, without replacement of lost staff. He is badly in need of a highly qualified scientist to carry out new projects, and a competent technician to carry the additional work load in the laboratory.

The SSDL Scientific Committee unanimously passed a motion that the Director General be respectfully urged to add to the staff of the Dosimetry Section:

One highly qualified scientist
One competent technician

at the earliest possible time.

In addition to the various recommendations noted above in the discussion by the SSC, the Committee considered the main recommendations under the headings E.3.01, E.3.02, and E.3.03, of the Tentative Area of Activity for E.3 (Dosimetry), 1991-1992.

E.3.01: SSDL NETWORK

CARE Programme - Therapy

This programme, introduced at the first meeting of the SSC in 1986, is considered essential for the entire dosimetry programme. It is functioning well, but the ionization chamber method is both timeconsuming and expensive. The use of TLDs therefore should be continued as part of the CARE programme with the same precision realized up to the present.

It is desirable to transfer to SSDLs in some regions the main responsibility for the CARE programme. The SSDLs selected for this responsibility should be designated by the Secretariat of the Network on the basis of criteria to be established by the Scientific Committee. The procedures to be followed should be established by the Secretariat, with the approval of the SSC. Training activities should be increased at the DOL and at the SSDLs, including seminars and training courses in the regions, with only a few experts supplied by the Agency and WHO.

The symposium planned for 1992 should emphasize SSDL activities. (Suggested working title: Measurement Assurance in Dosimetry.) The participants should come predominantly from the SSDLs.

CARE Programme - Protection

Although coherence is also of importance in protection-level measurement, it is not necessary to have the same accuracy as for therapy-level measurements. The DOL and many of the SSDLs possess x-ray generators and measurement equipment that is easily adapted to this programme.

The DOL should participate in the protection-level intercomparisons organized by NENS and be prepared to provide reference irradiations.

It would be very desirable to include some CARE aspects in the NENS training programme.

E.3.02: DOSE INTERCOMPARISON AND ASSURANCE

IAEA/WHO TLD Postal Dose Intercomparison Programme for cobalt-60 therapy units

This very important project is handled jointly with WHO. It has given much useful information on the current state of therapy dosimetry. Although the programme should eventually be taken over by qualified SSDLs, with continuing supervision by the Agency, the workload of the DOL is not expected to decrease for two reasons: the number of radiation therapy departments is increasing, especially in the less-developed areas, and we are far from the goal suggested by the WHO, namely a yearly test of every cobalt-60 therapy unit not covered by a national calibration service. This essential programme must continue.

TLD for Protection-Level Dosimetry

A programme to develop TLD methods for protection-level dose intercomparison and assurance should be developed in connection with a co-ordinated research programme, jointly with the WHO.

SSDL Outreach

Support should be given to some SSDLs for outside activities, e.g., dose measurements in hospitals. Some SSDLs are now doing that with good results, as shown by the TLD survey.

Experts sent to the SSDLs should have hospital training, so they can both provide on-site training at the SSDL and go with the SSDL staff to the hospitals for dose measurement.

A simple portable system for isodose measurement should be furnished to some of the SSDLs for measurements at the hospitals. Preferably someone from the SSDL should accompany the equipment, but if that is not possible, the Agency should furnish a suitable expert.

A human-shaped phantom is to be used for investigation of the complete therapy procedure. This should be sent to suitable SSDLs, who should take the phantom to the hospitals. This project should be done in collaboration with the WHO and with relevant medical and scientific societies.

Processing-Level Dosimetry

It is important to provide a tighter link to the BIPM for high-dose measurements. Programme CARE should be extended to processing-level dosimetry. This could easily be done through the DOL, and it should be started as soon as practicable.

Diagnostic-Level Dosimetry

Diagnostic radiology is the most wide-spread medical application of ionizing radiation and it is spreading and developing. In spite of its importance, it is not realistic to expect the present limited staff to enter into the highly specialized subject of image quality, nor even into the dosimetry of diagnostic radiology.

Inventory of High-Energy Sources

The recent Brazilian radiation accident has shown the value of an up-to-date inventory of radiation sources, such as the IAEA publication Directory of High-Energy Radiotherapy Centres, first published in 1968 and revised in 1970 and 1976. A new inventory is now being assembled by the Radiation IAEA Protection Section, in cooperation with the DS. As with the earlier editions, WHO should be requested to assist. The SSDLs have access to some of the needed information, and in any event can provide a cross-check.

E.3.03: DEVELOPMENT OF DOSIMETRY TECHNIQUES

Therapy

The above mentioned simple isodose system should be developed and eventually the SSDLs should be equipped with it.

A Co-ordinated Research Programme is underway for testing the Code of Practice (IAEA TRS No. 277). There is widespread interest in the report, and many comments have already been received. A revision or annex embodying the necessary changes should be planned for 1991 or 1992.

The interstitial application of brachytherapy sources is increasing, and will soon be in wide use. Accurate absorbed doses are needed, but are difficult to obtain. A method should be developed to provide a quality assurance programme to the SSDLs for brachytherapy sources. Consideration should be given to developing a Code of Practice for the measurement and comparison of brachytherapy sources. In spite of its importance, it is unrealistic to expect the DS to develop an important role with the present limited staff.

Processing

The IDAS project is already functioning for cobalt-60 radiation. It should be extended to high-energy electron beams, because the number of facilities using electron beams for processing is increasing. A co-ordinated research project on electron-beam dosimetry is now underway, and its recommendations should be received before suggesting procedures for this extension of IDAS. Simple ESR read-out equipment is expected to become available in the near future, after which it may be feasible to involve more SSDLs in high-dose dosimetry. (At present, nine SSDLs are engaged in this work.)

Nuclear Medicine and Neutron Dosimetry

In both these fields the Agency had an active programme until about 1978. Both these fields are important, and measurements in both need to be coherent with the international measurement system, but again it is unrealistic to expect the DS to take an active part with the present limited manpower and equipment. The same applies to beta-particle dosimetry.

In closing, the Scientific Committee congratulated the Dosimetry Section for the many accomplishments successfully carried out with limited staff and facilities. The Committee again expressed its satisfaction at the appointment of Dr. Svensson as Section Chief; it looks forward to the many benefits to the dosimetry programme of the Agency that will result from his high level of scientific ability and accomplishments.

A B B R E V I A T I O N S

ARL	Australian Radiation Laboratory, Yallambie, Australia
ASMW	Amt für Standardisierung, Messwesen und Warenprüfung, Berlin, GDR
BEV	Bundesamt für Eich- und Vermessungswesen, Wien, Austria
BIML	Bureau International de Métrologie Légale
BIPM	Bureau International des Poids et Mesures
CAD	Calibration Assurance Dosimeter
CARE	Coherent and Accurate REference (instrumentation)

CRP	Co-ordinated Research Programme
DOL	Dosimetry Laboratory (IAEA, Seibersdorf)
DS	Dosimetry Section (IAEA)
E.C.	European Community
EORTC	European Organization for Research and Treatment of Cancer
GSF	Gesellschaft für Strahlen- und Umweltforschung (München, Germany, F.R.)
IAEA	International Atomic Energy Agency
IAEA/RCA	Regional Co-operation Agreement (for Research, Development and Training related to Nuclear Science and Technology for Asia and the Pacific Region)
ICRU	International Commission on Radiation Units an Measurements
IDAS	International Dose Assurance Service
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JEN	Junta de Energía Nuclear, Madrid, Spain
NBS	National Bureau of Standards (Gaithersburg, U.S.A.)
NENS	Division of Nuclear Safety (IAEA)
NIM	National Institute of Metrology, Beijing, China
NIST	National Institute of Standards and Technology (formerly National Bureau of Standards), Gaithersburg, U.S.A.
OeFZS	Oesterreichisches Forschungszentrum Seibersdorf
OIML	Organization Internationale de Métrologie Légale
OMH	Országos Mérésügyi Hivatal (National Office of Measures, Budapest, Hungary)
PSDL	Primary Standard Dosimetry Laboratory
PTB	Physikalisch-Technische Bundesanstalt (Braunschweig, Germany, F.R.)
SAC	Scientific Advisory Committee
SSC	SSDL Scientific Committee
SSDL	Secondary Standard Dosimetry Laboratory
TLD	Thermoluminescence Dosimeter
WHO	World Health Organization

PRESENTATION OF TRS No. 277 "ABSORBED DOSE DETERMINATION IN PHOTON AND ELECTRON BEAMS" AN INTERNATIONAL CODE OF PRACTICE

by Hans Svensson*

Introduction

The IAEA/WHO Network of SSDLs was set up in order to "improve accuracy in applied radiation dosimetry throughout the world". The first step in this procedure has been to establish a number of SSDLs. The next step involves the transfer of calibrations to hospitals, laboratories, etc. from the SSDLs.

Transfer of calibrations from SSDLs to the users includes many problems, for instance, the radiation quality may be quite different at the beams used by the SSDLs and by the hospitals and the radiation quantity may be different for the calibration and application. TRS No. 277 deals with the procedure to be used.

During the past few years, several national organizations have prepared codes of practice, protocols and documents (see e.g. ESTRO 1985)[1], which give recommendations for absorbed dose determination for high energy electron and photon beams based on the use of ionization chambers calibrated in exposure or air kerma. In general, the recommendations are somewhat too specific in that they serve for the conditions in the countries in which the documents originated. An advisory group met therefore in Vienna in 1985 to outline an international code of practice. This group consisted of nine members, who all had been involved in similar work on a national scale. From this group, four principle authors were chosen: P. Andreo (Spain, now Sweden), J.R. Cunningham (Canada), K. Hohlfeld (Federal Republic of Germany) and H. Svensson (Sweden, now IAEA). Before its publication, the manuscript was circulated for comments to the advisory group and also to a number of other persons with special interest in the field.

The final test of the Code will take place when it is applied in SSDLs and hospitals. Several comments have now been submitted to the IAEA Dosimetry Section. A co-ordinated research programme carried out to test the Code has just started. Both, SSDLs and hospitals are participating. The test will probably result in a revision of the Code.

The general philosophy behind the Code as well as some comments received till now will be given.

High energy electron and photon beams

The idea is that an ionization chamber should be calibrated in a ^{60}Co gamma beam in quantities of air kerma or exposure. It is also possible to make the calibration in the quantity absorbed dose to water, but all the transfer factors to be used in this case are not given, see the broken line from $D_{w,c}$ to $N_{D,c}$ in Fig. 10 of the Code (copied in the present text).- Ionization chamber specific factors are then applied to determine the absorbed dose to air chamber factor (or more strictly, the quotient of mean absorbed

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dose to air in the chamber cavity and the meter reading for the device), N_D. This factor is defined by

$$N_{D,c} = \frac{\bar{D}_{air,c}}{M_c} \quad \left[= \frac{\bar{J}_{air,c} \cdot W_c/e}{M_c} \right] \qquad (1)$$

where $\bar{D}_{air,c}$ is the mean absorbed dose to the air in the cavity of an ionization chamber. M_c is the meter reading for that mean absorbed dose. Index c is used for the calibration quality. It is however assumed that equation 1 is also valid for the user's beam, i.e.

$$\frac{\bar{D}_{air,c}}{M_c} = \frac{\bar{D}_{air,u}}{M_u} = N_D. \qquad (2)$$

This means that the W/e is assumed to be constant in the energy region here considered. (In eq. 1, $(W/e)_c$ is the mean energy expanded per ion pair formed and per electron charge, $\bar{J}_{air,c}$ is the mean specific charge of ions of one sign liberated in the air cavity). This assumption may not be quite true but the change with energy should at least be small, see Svensson and Brahme (1986)[2].

Many of the national protocols seem to have failed in presenting a coherent set of interaction coefficients when utilizing the air-kerma or exposure calibrations from a PSDL or an SSDL for the determination of N_D. As can be seen from Figure 10 in the Code, some interaction coefficients are already applied in the determination of exposure or air-kerma by the PSDLs [i.e. $s_{gr,air}$, $(\mu_{en}/\rho)_{air,gr}$ for exposure and in addition W_c/e for air-kerma in "step a"]. Stopping-power ratios and ratios of mass energy attenuation coefficients are again introduced in step d for the calculation of k_m to determine $N_{D,c}$ and in step g for determination of the absorbed dose to water, D_w, for the user's beam. Some errors in these constants will cancel out if the same set of data is applied throughout the calibration chain, see Andreo et al. (1987)[3].

There was also some inconsistency in the assignment of stopping power ratios and mass energy absorption coefficient ratios to the quality of the radiation beams. For instance, the protocols by the NACP 1980[4], AAPM 1983[5] and SEFM 1984[6] use ratios determined from ionization chamber measurements at two phantom depths for the specification of the beam quality but the input parameter for choosing the stopping-powers and the mass energy absorption coefficients were the accelerating potential. However, there is no unique relation between this ratio and the accelerating potential. Thus, the ratio is depending not only on the energy of the accelerated electrons but also on the construction of the target, flattening filter, etc. The HPA 1983[7] uses nominal MV for quality specification but monoenergetic photon beams for calculation of stopping-power ratios. Instead, the IAEA Code uses the measured

$$TPA_{10}^{20} \quad \text{or} \quad D_{20} \; / \; D_{10}$$

which was shown to be directly related to the ratios of stopping-powers and to mass energy coefficients, see Andreo et al. 1987[8].

For the electron beam the mean energy at the phantom surface, $\bar{E}_o$, is determined from the depth of the 50% depth dose at the beam axis. The stopping-power ratios are however computed for monoenergetic beams. This procedure seems to give an uncertainty in assigning the correct stopping power of about $\pm 1\%$ when the measurements are carried out at the reference depth (see technical note by Mattson in this Newsletter). This does, however, not include the "absolute" uncertainty in the stopping-power ratio.

Medium energy X-ray: 100 to 300 kV

The basic relationship for the determination of absorbed dose to water is given by (see p. 40 and p. 54 in the Code)

$$D_w = M_u N_K k_u (\bar{\mu}_{en}/\rho)_{w,air} p_u$$

Here, M_u is the meter reading, N_K the air kerma calibration factor free in air. k_u corrects for the fact that N_K may change due to the difference in the spectral distribution of the radiation field used for the calibration free in air and that in the phantom at the position of the detector. However, this factor includes only a part of the corrections for the differences in conditions between calibration (free in air) and the measurements at the reference condition (5 cm depth in water, 10 cm x 10 cm field size). All other corrections are included in the perturbation correction factor p_u. In the literature, this correction is often referred to as being due to "replacement" or "displacement" of the water by the chamber cavity and wall. The only numerical value found in the literature that is directly applicable was for one special type of cylindrical chamber and determined by the dosimetry group at the PSDL in Braunschweig (Schneider 1986)[9]. Schneider 1986 determined in reality the product of $k_u \cdot p_u$ (see Schneider 1988). This fact will not influence the end result as it is assumed in the Code of Practice that k_u is unity for those chambers recommended for use. It was assumed in the Code that the values given by Schneider could be used for chambers between 0.3 and 1 cm^3 with an outer diameter between 5 and 9 mm and a wall thickness of about 0.5 mm. However, more date on p_u for different types of chambers are needed.

Low energy X-rays: 10 to 100 kV

In this quality region the calibration of the ionization chamber at the SSDL (or PSDL) is either in absorbed dose to water at the surface of a phantom or in air kerma (alternative exposure) free in air. The only problem in these measurements is the determination of the beam quality which is needed for the choice of correct input data. However, for hospital practice it is pointed out that a fairly simple experimental set-up may be used for the half-layer determinations.

Check of the Code

Already before the publishing of the Code this was checked in experiments by Mattsson (see separate Note). The choice of $\epsilon_m G$-value for the ferrous sulphate dosimeter was based on the following facts:

Mattsson had participated in several absorbed dose intercomparisons at the ^{60}Co-γ quality including various laboratories (BIPM, NBS, NPL, IAEA, etc.). Very good agreement was obtained between the determination of absorbed dose based on the ferrous sulphate dosimeter and on the graphite calorimeter (recalculated from dose in graphite to dose in water) if $\epsilon_m G$ was assumed to be 353 x 10^{-6} $m^2kg^{-1}Gy^{-1}$.

Mattsson had also determined values of $\epsilon_m G$ with a water calorimeter, (Mattsson 1984)[10]. His values on $\epsilon_m G$ for $^{60}Co-\gamma$, high energy X-rays and electrons were all between

$$349 \times 10^{-6} \text{ and } 354 \times 10^{-6} \ m^2kg^{-1}Gy^{-1}.$$

No energy dependence could be proven. The total uncertainty was estimated to $\pm$ 1 per cent (1.S.D.).

Pettersson 1967 used a water calorimeter of a different construction to determine the G value for $^{60}Co-\gamma$ and 20 MeV electrons. He reported within 0.1% the same $\epsilon_m G$ for these two qualities. A very recent experimental work by Berkvens gave a constant $\epsilon_m G$, within parts of one per cent in the electron energy range from 2.7 to 8.7 MeV, Berkvens 1988[11]. (This latter result differs from that obtained by Cottens et al. 1980[12] at the same laboratory who reported a small energy dependency. The reason for this difference is the present better knowledge of some applied correction factors.) Therefore, it seems that a constant $\epsilon_m G$

$$(\text{i.e. } 353.10^{-6} \ m^{-2}kg^{-1}Gy^{-1})$$

could be used for $^{60}Co-\gamma$, high energy X-rays and electrons.

The results by Mattsson indicate that the absorbed dose determinations based on the Code agree with the ferrous sulphate dosimeter measurements generally within 1 %.

Further experiments to check the Code will be carried out. A special co-ordinated research project was started including one PSDL, several SSDLs and also hospitals. The idea is that the absorbed dose shall be determined according to the Code using several types of ionization chambers and also applying other methods (e.g. ferrous sulphate dosimetry and calorimetry).

Criticism of the Code

One major criticism of the Code seems to be that it is somewhat complicated to find the data as tables needed for use are to be found in several chapters. Also, it has been pointed out that the Code is incomplete. Thus, for dosimetry at low energy electrons, the method by the NACP 1981 is recommended, and this protocol is therefore needed. However, it is hoped that the worksheets which can now be obtained from the dosimetry section at the Agency will simplify the use. Local efforts have also been made to help in the use of tables. Thus, the National Radiation Laboratory in New Zealand has condensed some of the tables for simplicity (Smyth 1988[13]).

The central electrode correction factor seems to have caused some problems (comments from Smyth 1988[14] and Johansson 1987[15]). Here, the authors of the Code have been in trouble as they wanted a very simple set of corrections. Therefore, they disregarded a correction which ought to have been introduced in step d (see copy of Fig. 10). The only corrections now applied in the equation in this step are: factor k_m which is introduced to take account of "the lack of air equivalence" and the factor k_{att} to take account of "the attenuation and scatter" of the ionization chamber material. In the theoretical calculations only the chamber wall and build-up cap were regarded as "chamber material". Strictly an additional correction k_{cel}

should therefore be needed to correct for "the lack of air equivalence" of the central electrode. A corresponding factor would then be needed for the correction needed at the user's beam quality, eq. g in Fig. 10. These two factors would in most cases, within parts of one per cent, cancel out. Corrections would only be needed for the high energy electron and X-ray beams (over about 25 MV for common sizes of central electrodes). To simplify a composed correction factor was suggested, p_{cel}. Equation g (Fig. 10) would then read $D_w\ (P_{eff}) = M_u \cdot N_D\ (s_{w,air})_u \cdot p_u \cdot p_{cel}$. This correction factor was unfortunately not included in the worksheets or in Figure 10 (again in order not to complicate). However, in the reprint of new worksheets this factor will now be found.

The most controversial part of the report is probably that for medium energy X-rays. If the Code is used for determination of absorbed dose at the reference depth in water then the reported dose values will be several per cent higher for some beam qualities than if the method from ICRU report No. 23 is used. Recent water calorimeter investigations support at least partly this change (see Mijnheer and Chin 1988[16]). Other investigators consider that ICRU report No. 23 will give more correct absorbed dose determinations (Kristensen 1988[17], and Seuntjens 1988[18]). More investigations are therefore needed regarding medium energy X-ray dosimetry.

Conclusions

The International Code of Practice gives a method for the determination of absorbed dose to water based on the use of an air-kerma calibrated ionization chamber. A coherent set of interaction coefficients and correction factors are introduced. The absorbed dose determination agrees in an excellent way with that based on the ferrous sulphate method for high energy photon and electron radiation (see enclosed Note).

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The Code has been well received, but some criticism has been presented, mainly as it is difficult to "find the tables" of the Code.

It is to-day not a general concensus on the dosimetry at medium energy X-rays. More work needs to be done in this energy range.

The Code will now be checked by several institutes in a "co-ordinated research project". It might be that some changes will be necessary after this evaluation.

References

[1] EUROPEAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY, Proc. Symp. on New Protocols for the Dosimetry of High-Energy Photon and Electron Beams, Radiother. Oncol. 4 (1985) 289-328.

[2] SVENSSON, H., BRAHME, A., "Recent advances in electron and photon dosimetry", Radiation Dosimetry, Physical and Biological Aspects (ORTON, C.G., Ed.), Plenum Press, New York (1986) 87.

[3] ANDREO, P., NAHUM, A.E., SVENSSON, H. (1987) Recent Developments in Basic Dosimetry, Radiother. Oncol. 10:2 (1987) 117-126.

[4] NORDIC ASSOCIATION OF CLINICAL PHYSICS, Procedures in external radiation therapy dosimetry with electron and photon beams with maximum energies between 1 and 50 MeV, Acta Radiol., Oncol. 19 (1980) 55.

[5] AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE, Code of practice of X-ray therapy linear accelerators, Med. Phys. 2 (1975) 110; A protocol for the determination of absorbed dose from high-energy photon and electron beams, Med. Phys. 10 (1983) 741.

[6] SOCIEDAD ESPAÑOLA DE FISICA MEDICA, Procedimientos Recomendados para la Dosimetría de Fotones y Electrones de Energías Comprendidas entre 1 MeV y 50 MeV en Radioterapia de Haces Externos, SEFM Publ. No. 1/1984, Comité de Dosimetría en Radioterapia, Madrid (1984).

[7] HOSPITAL PHYSICISTS ASSOCIATION, Revised code of practice for the dosimetry of 2 to 35 MV X-ray, and of caesium-137 and cobalt-60 gamma-ray beams, Phys. Med. Biol. 28 (1983) 1097-1104.

[8] ANDREO et al., op. cit. (1987) 117-126.

[9] SCHNEIDER, U., Bestimmung der Wasser-Energiedosis im Wasserphantom mit frei in Luft kalibrierten Ionisationskammern, Jahresbericht 1985, Physikalisch-Technische Bundesanstalt, Braunschweig (1986).

[10] MATTSSON, L.O., Application of the water calorimeter, Fricke dosimeter and ionization chamber in clinical dosimetry. Paper I, p. 12. Thesis, University of Gothenburg, ISBN 91-7222-7 29-X (1984).

[11] BERKVENS, P., Results from a technical contract with the IAEA, "Study with the yield of the Fricke Dosimetry for electron energies from 2 to 90 MeV", (1988).

[12] COTTENS, E., JANSSENS, A., EGGERMONT, G., JACOBS, R., Absorbed dose calorimetry with a graphite calorimeter and G-value determinations for the Fricke dosemeter in high energy electron beams, Biomedical Dosimetry: Physical Aspects, Instrumentation, Calibration (Proc. Symp. Paris, 1980), IAEA, Vienna (1981) 189.

[13] SMYTH, V.G., National Radiation Laboratory, 108 Victoria Street, Christchurch, New Zealand (private communication) (1988).

[14] SMYTH, V.G., cit. (1988).

[15] JOHANSSON, K.-A., Radiofysika Institutet, Sahlgrenska Sjukhuset, S-41 345 Gothenburg, Sweden (private communication) (1987).

[16] MIJNHEER, B.J., CHIN, L.M., Dosimetry of orthovoltage X-ray beams, Dosimetry in Radiotherapy (Proc. Symp. Vienna, 1988), Vol. 1, IAEA, Vienna (1988) 129.

[17] KRISTENSEN, M., HJORTENBERG, P., HANSEN, J.W., WILLE, M., Determination of ionization chamber kerma correction factors for measurements in media exposed to orthovoltage X-rays, Dosimetry in Radiotherapy (Proc. Symp. Vienna, 1988), Vol. 1, IAEA, Vienna (1988) 149.

[18] SEUNTJENS, J., THIERENS, H., VAN DER PLAETSEN, A., SEGAERT, O., Absorbed dose to water for medium energy X-rays, (report), Gent (1988).

COMPARISON OF ABSORBED DOSE DETERMINATIONS USING THE IAEA DOSIMETRY PROTOCOL AND THE FERROUS SULPHATE DOSIMETER

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INTRODUCTION

In 1985 a comparison of different revised protocols for the dosimetry of high-energy photon and electron beams was published (Mattsson, 1985). The conclusions were that the agreement in absorbed dose to water determined using the different protocols is very good and that the agreement between ionization chamber and ferrous sulphate dosimetry is generally good. For electron beams the differences obtained with the ionization chamber and ferrous sulphate dosimeters were up to about 2 %. The influence of the energy and angular digribution of the electron beams on the ionization chamber dosimetry is not fully considered in the dosimetry protocols.

The basis for the ionization chamber dosimetry has recently been changed when the Bureau International des Poids et Mesures (BIPM) in 1986 changed the air-kerma standard. The reason was the adaption of the new stopping-power values reported in the ICRU Report No. 37. To achieve consistency in the ionization chamber dosimetry the interaction coefficients and correction factors given in the dosimetry protocols should also be based on the same set of stopping-power values. This is not the case with the protocols included in the comparison made by Mattsson. However, in the international code of practice by the International Atomic Energy Agency (IAEA, 1987) the new stopping-power values have been used. The formalism is the same as in most of the previous protocols. Mattsson et al. (1989) have shown that the differences in the various steps cancel out for the protocols published by NACP (1980) and by IAEA (1987) for cobalt 60 gamma quality. However, it is also of interest to investigate the influence of the new air-kerma standard and the new values on coefficients and factors given in the IAEA protocol for other beam qualities. Therefore, the data given by Mattsson (1985) have been recalculated using the new air-kerma standard and the IAEA protocol. In the present report an $\epsilon_m G$ of

$$352 \cdot 10^{-6}\ m^{-2}\ kg^{-1}\ Gy^{-1}$$

was used for all beams quantities, see Svensson 1988 (in this newsletter).

RESULTS

The recalculated absorbed dose values are given in table 1. The agreement between the two dosimetry methods is within about ± 1 per cent for all of the investigated qualities.

TABLE 1.

Comparison of absorbed dose determinations using the IAEA dosimetry protocol and ferrous sulphate dosimeter measurements (Mattsson 1985)

Beam quality	$D_{w,IAEA}$	$D_{w,Fricke}$	Difference %
Co-60	2.000	2.018	-0.9
4 MV X-ray	2.001	2.017	-0.8
16 MV X-ray	1.990	1.996	-0.3
6 MeV Electron	1.989	2.010	-1.1
10MeV Electron[1)]	1.986	2.008	-1.1
10MeV Electron[2)]	1.986	1.964	+1.1
18.8 MeV Electron	1.983	2.002	-1.0

[1)]Thick scattering foil, applicator scattered electrons

[2)]Thin scattering foil, no applicator scattered electrons

CONCLUSION

It can be concluded that the ionization chamber dosimetry using a graphite chamber and the new IAEA protocol gives absorbed dose values which are in good agreement with ferrous sulphate dosimetry. The maximum difference was 1.1 % observed in very "clean" electron beams. For the measuring conditions used in this investigation the agreement between ionization chamber and ferrous sulphate dosimetry is thus satisfactory.

REFERENCES

MATTSSON, L.O., Comparison of different protocols for the dosimetry of high-energy photon and electron beams. Radiotherapy and Oncology 4 (1985) 313.

International Atomic Energy Agency (IAEA): Absorbed Dose Determination in Photon and Electron Beams. An International Code of Practice. Vienna 1987.

MATTSSON, L.O., SVENSSON, H., WICKMAN, G., DOMEN.S.R., PRUITT, J.R., LOEVINGER, R., Absorbed Dose to Water: Comparison of several methods using a liquid ionization chamber. To be published 1989.

THE SWEDISH NATIONAL LABORATORY FOR RADIATION STANDARDS

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Introduction

The first instrument to fulfill the purpose of a standard in Sweden was an ionization chamber designed by Rolf Sievert in 1925 (Sievert, 1925). It had been calibrated for the R-unit at the Physikalisch Technische Reichsanstalt in Germany. The roentgen unit was first internationally accepted in 1928, so radiation standards in Sweden have an old tradition. The first Swedish primary standard - a free air ionization chamber - was in use from 1930 (Thoreaus, 1932). Since then, a few more have been built and primary standards for X-rays were used towards the end of the 1960's. For higher photon energies, such as 1.25 MeV, a secondary standard, traceable to the National Bureau of Standards, USA, was established in 1956 (Thoreaus, 1962).

During the 1970's, the laboratories were renovated and modern instrumentation and equipment were installed. Realizing the greatly improved qualities of modern ionization chambers and electrometers, as well as the amount of manpower necessary to keep primary standards of high quality, it was decided to abandon the primary standards and for the near future, rely on secondary exposure standards. This decision was made easier, as primary exposure standards had become available at the International Bureau of Weights and Measures (BIPM), Sêvres.

A Swedish Official Standards Laboratory Organization (SMO) was set up by the Swedish government in 1972. It consists of two kinds of laboratories, National Laboratories (riksmätplatser, RMP) and Authorized Laboratories (auktoriserade mätplatser, AMP). Its headquarter is the Centre for Metrology (Mätcentrum). Since 1980, the National Institute of Radiation Protection is recognized as a National Laboratory for the quantities absorbed dose, dose equivalent, exposure and kerma.

Local organization and staff

There are four divisions at the National Institute of Radiation Protecti
Two deal with inspections and regulations of radiation sources, ionizing as well as non-ionizing. The third is concerned with administration

and the fourth is devoted to technical developments and research and consists of laboratories for radiation biology, environmental measurements and dosimetry. The duties of the National Laboratory are at present organized by the dosimetry laboratory.

The staff of the dosimetry laboratory consists of 6 persons; two physicists (of which one is a doctor in radiation physics), two engineers, one technical assistant and a part-time secretary. Almost two full-time working persons are needed for the maintenance of radiation standards and calibrations. In practice, the work is split between all members of the laboratory staff, according to their qualifications, but also with an aim to achieve individual versatility.

Premises

A plan of the dosimetry laboratory is given in Fig 1. Irradiation laboratories occupy about 160 m^2 of which 110 m^2 are shown on the figure. More recently, a low scatter irradiation laboratory for calibration of exposure meters used in environmental measurements, has become available in another part of the building. Two electronics laboratories as well as one room suitable for TL-dosimetry exist.

Economy

The work connected with the National Laboratory is made possible by calibration fees, allowances from the Centre for Metrology and the National Institute of Radiation Protection. The contribution from the Centre of Metrology covers the cost for one person as well as committee work at the BIPM and travelling expenses in connection with calibration of the radiation standards. For projects or expensive equipment, further contributions may be available. The calibration fees contribute with about 20 per cent of the total cost.

Radiation sources

For calibration of instruments used in high energy radiation therapy or other areas where rather large dose rates are involved, two collimated ^{60}Co-γ and one collimated ^{137}Cs-γ source are available. Their air kerma rates were - at 1 m distance from the source with standard field size - 4520 μGy/s and 12.5 μGy/s for the cobalt sources, and for 24.3 μGy/s, for the Cs-source on the 31 of December 1984.

X-ray beams with peak voltages from 25 kV and above, are generated by one X-ray machine (high voltage generators Model HF 420, X-ray tube

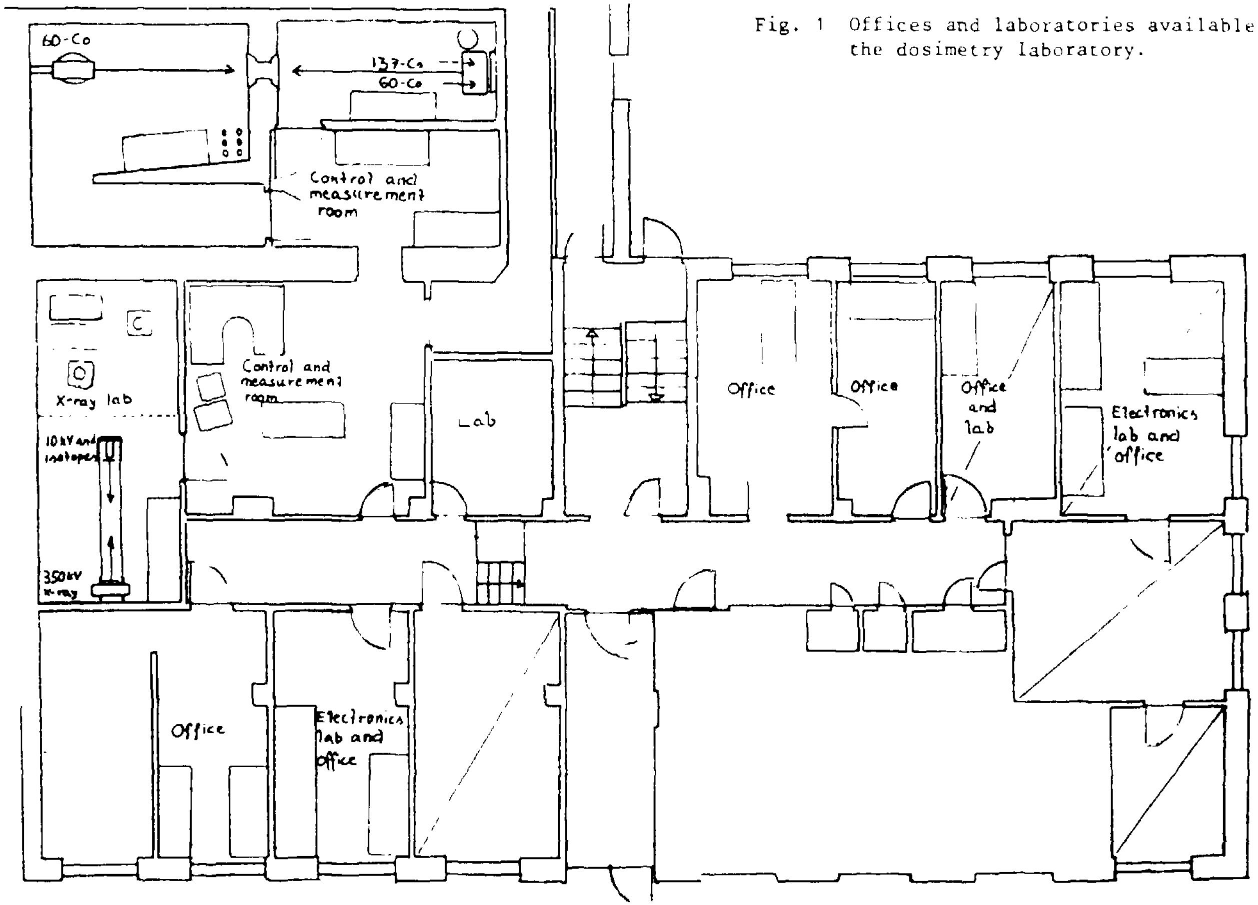

Fig. 1 Offices and laboratories available for the dosimetry laboratory.

AEG, Telefunken Type MB 350/1, delivered from Pantak Ltd, England). The equipment was installed in 1984 and some experience has been reported elsewhere (Lindborg and Grindborg, 1985). A typical voltage drift is 0.1 % or less per hour at 10 mA. With this equipment, the kerma rate at 10 kV becomes about a quarter of the desired rate for calibration of ionization chambers as used in soft X-ray therapy. A 10 kV voltage power supply (Fluke, Model 410 B) and an end window X-ray tube (Machlett, Type OEG 60) complete the X-ray facilities.

Table 1 gives the standard radiation beams. Qualities 1 to 8 correspond with radiation qualities at the BIPM and they are primarily used for calibration of therapy dosemeters. The beams 9 to 14 are narrow photon spectral distribution beams suggested by ISO (ISO, 1979) and they are used for energy response tests and calibrations of X-ray diagnostic and, sometimes, radiation protection instruments (Jensen and Lindborg, 1980).

Most often calibrations in our laboratory of instruments used in radiation protection work are done in beams from radionuclide sources.

Table 1

X-ray beams used for calibrations. Internal filtration for the beams 2 to 14 is 0.2 mm Cu and for 10 kV 2 mm Be.

Beam No	Voltage	Added filter mm			Half Value layer		Eff. energy	Appr. kerma rate at 10 mA	Notes
	kV	Sn	Cu	Al	mm Al	mm Cu	keV	µGy/s	
1	10				0.048		7	399.3	calibration distance 500 mm
2	25			0.31	0.242		13	2260	
3	50			0.94	0.98		21	3080	
4	50			4.08	2.23	0.071	30	620	
5	100			3.14	3.81	0.141	40	917	calibration distance 1000 m
6	135		0.19	3.18		0.47	60	832	
7	180		0.40	3.59		0.92	80	1193	
8	250		1.69	1.02		2.47	120	1525	
9	40		0.2	4.13		0.085	32	8.8	
10	60		0.65	3.05		0.24	46	13.6	
11	80		2.15	3.05		0.59	64	6.8	
12	100		5.0	3.11		1.10	82	4.06	
13	120	1.01	5.0	2.12		1.70	103	4.62	
14	150	2.54	-	2.12		2.38	120	(33.4)	

Table 2

Air kermarates of radionuclides used for calibration of radiation protection instruments. Some of the Am-241 sources have only a thin window which allows soft x-rays to escape and lower the mean photon energy. When these sources are furnished with a filter that absorbs these photons, the source is denoted with f as Am 3f for instance.

KERMA RATES IN AIR IN μGy/h — Date: 1984-12-31

	Co-60	Cs-137		Am-241						Pu-238	Fe-55
		740 MBq	185 MBq	185 GBq	18.5 GBq		2.2 GBq		0.4 GBq	7.4 GBq	1.72 GBq
	Red cyl.			perman. filter	no filter	with filter	no filter	with filter	perman. filter		
Mean energy (kev)	1250	662	662	60	25	60	25	60	60	15	6
Distance (m)	Co	Cs 1	Cs 2	Am 1	Am 2	Am 2f	Am 3	Am 3f	Am 4	Pu	Fe
0.5		260.7	47.5	1131	1019	147	152	23.2	3.29	124.4	
0.75				5072	443	65.2	65.3	10.2		53.3	
1.0	291	65.9	12.03	287.5	241	37.0	35.8	5.89		28.9	
1.5		29.6	5.40	130	102	16.9	15.3	2.69		11.8	
2.0	72.9	16.9	3.10								
$\left(\frac{\mu_{en}}{\rho}\right)^{tissue}_{air}$	1.10	1.10	1.10	1.00	0.96	1.00	0.96	1.00	1.00	0.95	0.97
λ^{-1} (d)	2778	15898	15898	∞	∞	∞	∞	∞	∞	∞	1423

Table 2 gives their activities, air kerma rates at different distances and factors to convert from air kerma in free air to dose equivalent in free air.

A set of secondary standard β-radiation sources from the National Physical Laboratories (NPL), England, are also used for calibration of β-ray radiation protection instruments, Table 3. Inverted decay constants used for calculation of kerma rates on a particular day are shown in Table 4.

Table 3

Absorbed dose rates in air for β-emitting nuclides 84-13-31

Nuclide	ABSORBED DOSE RATE IN AIR µGy/h							
$^{90}Sr + ^{90}Y$	Source No	125	126	127	128	129	130	
		5.39	14.65	54.8	152.4	492.5	1763	
^{204}Tl	Source No	325	326	327	328	329	330	411
		0.755	2.130	8.20	21.69	63.64	210.3	666
^{147}Pm	Source No	525	526	527	528	529	530	611
		1.25	4.87	14.95	28.12	103.2	332.2	648

Table 4

Inverted decay constants and half times used (1a = 365.2536d)

Nuclide	λ^{-1}(d)	$t_{1/2}$(a)
Co-60	2778	5.271
Cs-137	15898	30.17
Sr-90	15345	29.1
Pm-147	1382.41	2,6234
Ra-226	$2.31 \cdot 10^3$a	$1,60 \cdot 10^3$
Tl-204	1987	3.77
Cf-252	1391	2.64
Pu-238	126.5a	87,74
Am-241	625a	433
Fe-55	1423	2,7

Recently a ^{137}Cs-source and a ^{60}Co-source with low activities had their air kerma rates determined at various distances in a low scatter radiation arrangement. The rates are in the range 0.2 µGy/h to 1 µGy/h with scattered radiation contributing less than 15 %.

Secondary standard instruments and the working standard for ^{60}Co

As mentioned earlier almost all standards are secondary exposure standards, which are converted to air kerma standards through the relation

$$N_K = \frac{W/e}{1-g} N_X \quad (1)$$

N_K air kerma calibration factor

N_X exposure " "

W/e mean energy necessary to create an ion pair in air

g correction for bremsstrahlung-losses

The secondary standards are suitable for determining large air kerma rates. At lower rates, tertiary or lower order of standards are used.

For all energies except the X-ray beams 1 to 4, spherical ionization chambers, so called Shonka-Wyckoff transfer chambers (Boag, 1966), are used as secondary standard instruments (Manufacturer Exradin, USA). They are calibrated each fifth year at the primary standards laboratories and in between they are checked twice a year by a constancy check source. The mean current corrected for the decay of the check source (^{226}Ra), temperature, pressure and leakage currents are shown in Fig 2 and 3. For a period of 10 years, the whole measurement system has been stable within ± 0.1 % for a few of the chambers. When larger changes occur, they become the subject of an investigation. On a few occasions chambers have had to be opened and cleaned (chambers Sh 1010 and Sh 131). This may change the sensitivity by a couple of per cent. An advantage of having several similar chambers checked at the same check source and according to the same procedure is that small deviations, if they occur in all chamber signals, probably indicate a systematic change. For instance in 1975 and 1978 an increase was observed for all chambers (see Fig 2 and 3) and was traced to drifts in the pressure meter.

For the X-ray beams 1 to 4, the secondary standards are soft X-ray chambers manufactured by PTW, Western Germany. They are checked quarterly in a fixed geometry. The soft X-ray chambers have a thin membrane that

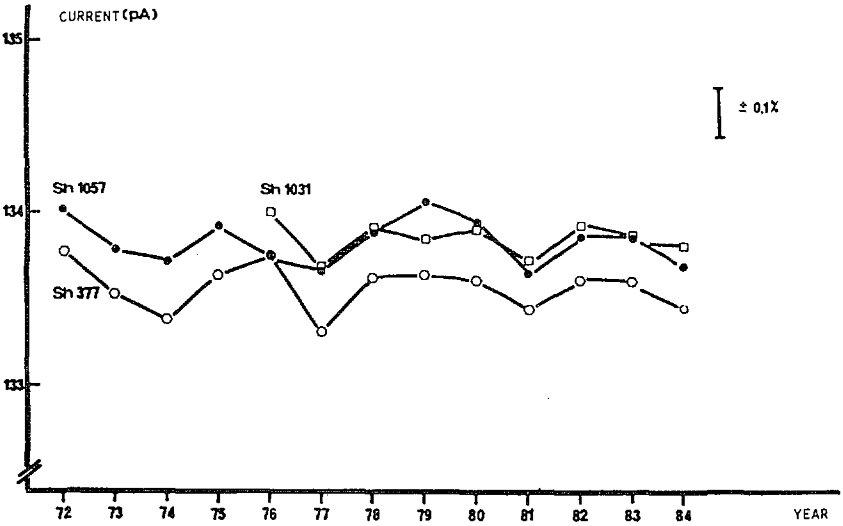

Fig. 2
Currents from secondary standard ionization chambers (thin-walled) in a check source arrangement for the time period 1972 to 1984.

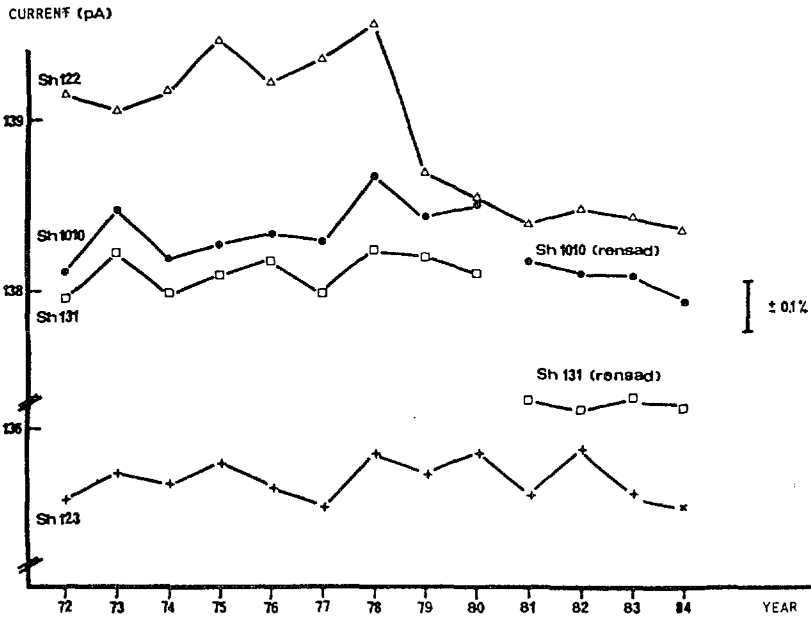

Fig. 3
Currents from secondary standard ionization chambers (thick-walled) for the time period 1972 to 1984.

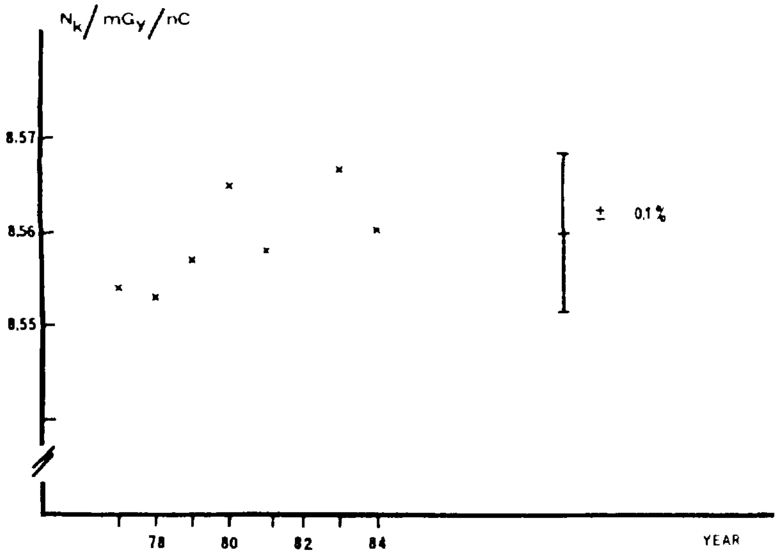

Fig. 4 The result of calibrations of one of our ionization chambers against our working standard.

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Instr. for influence quantities												
Thermometers	x				x			x				
Pressure meters					x				x			
Timers				x			x		x			
Voltage meters	x			x			x			x		
Capacitors			x							x		
Ionization chambers												
Shonka type												
PTW - type			x			x			x			
NPL - 2561	x				x			x				
Monitor	x				x							
LEP 01				x					x			
Radiation beams												
^{60}Co-, ^{137}CS-therapy		x						x				
Low activity nuclids									x			
β-sources						x						
HVL-measurements						x	x					
Leakage radiation			x									

Fig. 5 Schedule for constancy checks during 1985.

covers the air cavity, which is only 1.5 mm deep. There is thus good reason to expect less stability of these chambers. Nevertheless their sensitivities over periods of six and eight years have been ± 0.5 %, which may very well include an instability in the constancy check source arrangement which is not ideal.

The most accurate calibrations are needed in high energy therapy. Instruments used for that purpose are in the Nordic countries calibrated in ^{60}Co γ beams. With such a calibration factor and by use of the protocol by the Nordic Association of Clinical Physics, the absorbed dose to water in any high energy photon or electron beam can be determined (NACP, 1980). The calibrations are made free in air at 1 m and with a field size of 10 x 10 cm. The kerma rate was accurately determined in connection with the installation of the source and the kerma rate from the source is our working standard. Rather than determining experimentally the air kerma rate at each calibration, the kerma rate is only checked and has to agree within ± 0.2 % of the expected rate, if a calibration is to be done. In the calculation of the calibration factor the expected air kerma rate is used. The stability of the working standard can be visualized by the calibration factor for one of our Shonka chambers (No 377), which has been calibrated in the beam a few times a year since 1977. Its value has been the same within less than ± 0.1 %, Fig 4. The cobalt source is usually replaced after 5 years. The last time was in 1982.

Electrometers are corner-stones in dosimetry laboratories. Good electrometers are now commercially available but could also be built (Samuelson and Bengtsson, 1972). The low leakage current integrated amplifier CA 3420 (manufactured by RCA) is now used by us in electrometer constructions. It is usually used with a standard operational amplifier as output circuit, to achieve full output voltage range (approx ± 10 V).

Other constancy checks

Most instruments used in the calibration procedure are the subject of constancy checks, Fig.5, and regular calibrations at other National Primary Calibration Centres. Such instruments are voltage dividers,thermometers, pressuremeters, capacitors, voltmeters and timers. The checking procedures are documented and officially reported once a year (Grindborg and Ljungberg, 1984).

Intercalibrations

The Swedish Primary Calibration Centre is a member of the IAEA/WHO SSDL-network and has taken part in a few of the TLD-postal absorbed dose intercomparisons. However, the calibration technique used is not a good check of our quality as we do not have a routine for in water calibrations. Of more importance to us has been inter-Nordic comparisons on a regular basis performed free in air (Järvinen and Lindborg, 1982, Bjerke et al, 1983 and Ennow et al, 1985). In a ^{60}Co γ beam the agreement of the Nordic standards was within 0.3 % in 1982. For soft X-rays the differences were less than 1 % and not considered significant. For X-ray qualities with HVL between 0.14 mm Cu and 2.5 mm Cu the preliminary results also are within 1 %.

Some of the radiation beams used for calibration of protection level instruments took part in an international comparison reported by Spanne et al, 1984. The agreement at 60 keV and 662 keV among all the participants was (with one exception) within ± 5 %.

References

Bjerke H, Ennow K, Järvinen H, Lindborg L, and Samuelson G: Intercomparison of Nordic Exposure Secondary Standards for soft Roentgen Rays. Acta Radiol. Onc. 22 (1983).

Boag J W: Ionization chambers. In: Radiation dosimetry II, Attix F H, Roesch, W.C. (eds), p 1, New York, London: Academic Press 1966.

Grindborg J-E and Lindborg L: Some Experience with Pantak High Voltage Generators. CCEMRI (I)/85-14, BIPM, 1985.

Grindborg J-E and Ljungberg M: Constancy checks of standards at the National Calibration Centre for radiation standards. SSI-Report 85-09, (In Swedish), National Institute of Radiation Protection, Box 60204, S-104 01 STOCKHOLM.

Jensen M and Lindborg L: Calibration of Reference Instruments Used in Diagnostic X-rays. IAEA-SM-249/62. 1980.

Järvinen H and Lindborg L: Intercomparison of Nordic Therapy Level Exposure Secondary Standards for ^{60}Co Gamma Radiation. Acta Radiol. Onc. 21 (1982).

Sievert R: A portable instrument for the measurement and registration of X-ray intensity. Acta Radiologica IV, 129. (1925).

Spanne P, Carlsson C A and Alm Carlsson G: International Intercomparison of Standards for Low Collision Kerma Rates in Air by Means of Low Dose TLD Techniques. Radiation Protection Dosimetry. Vol 6 No 1-4 pp 261-264 Nuclear Technology Publishing. 1984

Thoreaus R: A Study of the Ionization Method for measuring the Intensity and Absorption of Roentgen Rays and of the Efficiency of Different Filters Used in Therapy. Acta Radiologica, Supplementum XV.(1932).

Thoreaus R: The Swedish Gamma Radiation Standard Laboratory. Acta Radiologica 58, 445. (1962).

HITTILLS UTGIVNA SSI-rapport 1985

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STABILITY CHECK SOURCE MEASUREMENTS WITH A SECONDARY STANDARD DOSIMETER IN SSDL-PAKISTAN

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INTRODUCTION

The stability check source is an integral part of a Secondary Standard Dosimetry System. The purpose of the stability check source is to confirm that the overall response of the dosimeter has not changed significantly since the instrument was calibrated. In case any change in the sensitivity of the ionization chamber or measuring assembly occurs the same is reflected in the reference check source measurements.

Stability check source measurements are taken in a Primary Standard Dosimetry Laboratory (PSDL) at the time of calibration of secondary standard dosimeter and mean time (in seconds) to the reference setting of 50 scale divisions with ambient conditions of air at 20°C, 101.3 kPa and 50% RH is quoted in a calibration certificate. This quoted stability check source time figure is the basis for future confirmation of overall response of the secondary standard dosimeter system.

This note presents the results of stability check source measurements carried out in SSDL Pakistan over a period of five years.

SECONDARY STANDARD DOSIMETER

The National Physical Laboratory (NPL) therapy level X-Ray exposure meter known as therapy level secondary standard dosimeter was received by PINSTECH Secondary Standard Dosimetry Laboratory (SSDL) in June, 1982, under an International Atomic Energy Agency's (IAEA) Regular Technical Assistance Programme. This Secondary Standard Dosimeter serves as a link between a primary standard and field instruments currently in use particularly in Radiotherapy Institute/Centres in the country.

RESULTS AND DISCUSSIONS

The stability check source time measurements were corrected for standard conditions of 20°C and 101.3 kPa, 50% RH and for the Strontium-90 source decay. The percentage deviations of these measurements from quoted value in the calibration certificate have been calculated. the year-wise percentage deviation of the measured check source time against the date of measurement has been plotted and shown in Fig. 1.

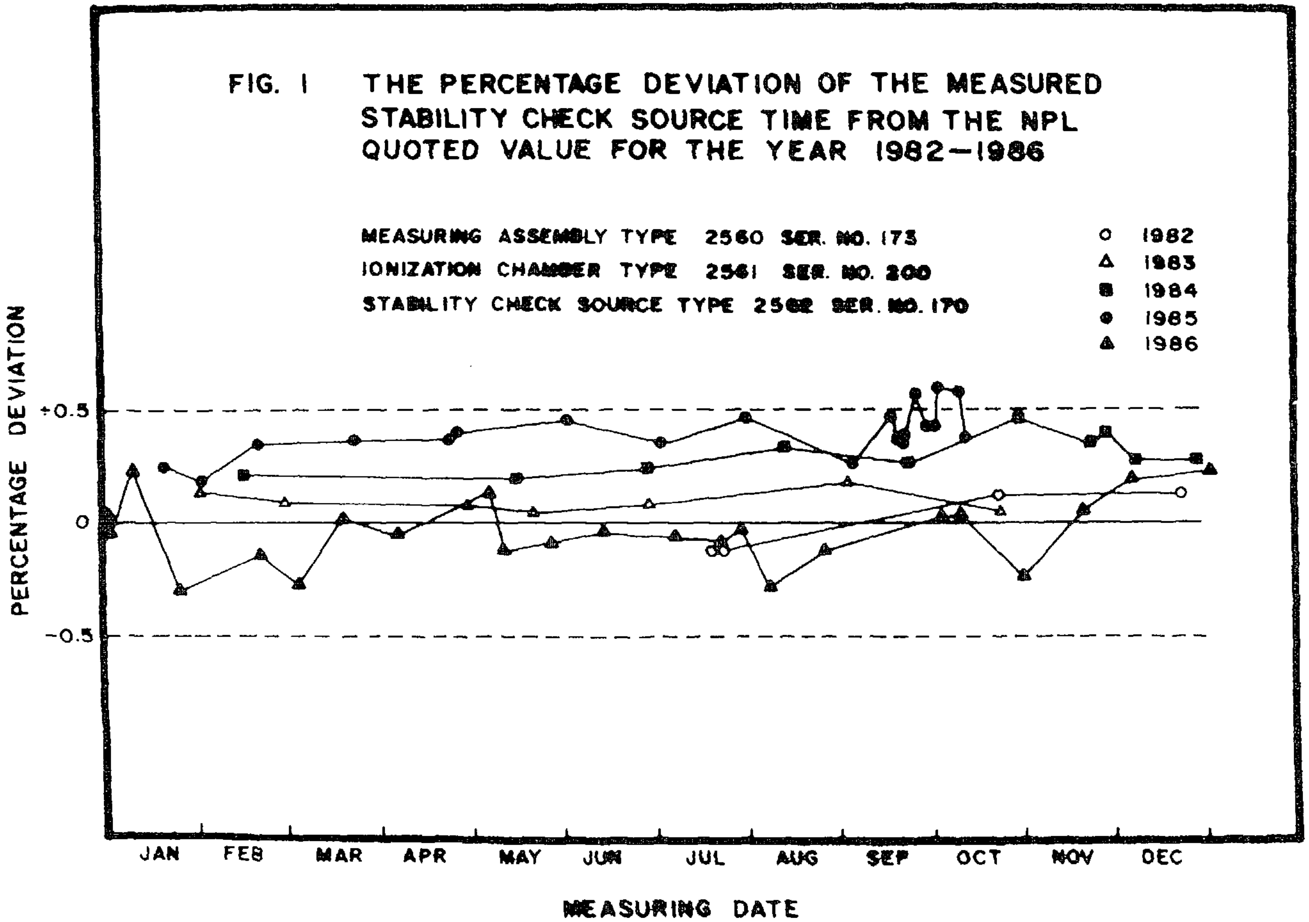

FIG. 1 THE PERCENTAGE DEVIATION OF THE MEASURED STABILITY CHECK SOURCE TIME FROM THE NPL QUOTED VALUE FOR THE YEAR 1982–1986

In 1982, the percentage, deviations from the quoted value are within $\pm$ 0.12. Whereas, it is recommended in the calibration certificate that this deviation should not be more than $\pm$ 0.5% in any case. As such the results obtained during 1982, are quite good. In 1983, the percentage deviation from the quoted value varies from 0.05 to 0.14. Although the deviations are well below the allowed limit but from the figure it appears that trend of measurements is always positive. In 1984, the percentage deviation varies from 0.18 to 0.46. During this year the deviations have been increased and again the trend of deviation is positive. In 1985, the same trend of deviation was observed but with the slightly increased value, that is more than 0.5%. This increasing trend of percentage deviation particularly above 0.5% from the quoted value in one direction only, has indicated that there was something wrong somewhere. Investigations were started to find out the reasons for this discrepancy in the results.

Various operational checks of the dosimeter were performed repeatedly and the reasons of this discrepancy could not be traced. Two anaeroid barometers are available in the SSDL and both of them were indicating the same pressure reading. It could not be suspected that this discrepancy is due to wrong barometer readings. Finally after checking everything, it was thought to compare our barometers with a barometer of meteorological laboratory at Islamabad. During this intercomparison it was found that both the barometers of SSDL were indicating wrong pressure resulting in a systematic error in the pressure measurement readings. The barometers were then adjusted accordingly and check source measurement readings were started on a daily basis for a period of about three weeks. The results of these measurements were found in good agreement with the quoted value. Moreover, the trend of these measurements was also found O.K. In 1986, percentage deviation varies from -0.30 to +0.23 and the trend of measurement is also acceptable.

CONCLUSION

It is not sufficient to check that the measured stability check source time after applying all the necessary corrections is within the allowed limit of $\pm$ 0.5% deviation from the quoted value in a NPL calibration certificate but also the trend of the deviation must be observed. It should not always be in one direction as shown in Fig. 1.

The barometers and thermometers should be intercompared with each other and must also be compared with the national institute of meteorology in the country, on a regular basis. A complete record of daily pressure reading must be maintained in a separate log book.

EQUIPMENT DONATED TO THE IAEA DOSIMETRY LABORATORY

Through the Governments of Austria and the Federal Republic of Germany (FRG), advanced equipment for radiation measurements has been donated to the IAEA Dosimetry Laboratory by the Austrian Research Center in Seibersdorf (OeFZS) and by the Physikalisch-Technische Werkstätten (PTW) in the F.R.G.

The equipment from Austria, a digital current integrator DCI 8500 is controlled by the Small Microprocessor System SESAM 80 built in Seibersdorf. Mean value and standard deviation are computed for measurement series. All parameters, results and possible error messages are also available via an asynchronous serial (V24-RS232) interface. It can be connected to an IBM (or compatible) personal computer for process control and calculation of e.g. dose or dose rate, including corrections for temperature and air pressure. It is used in the Agency's Dosimetry Laboratory to calibrate transfer standard ionization chambers and to determine their long-term stability with highest achievable precision. With these transfer standard ionization chambers, the performance evaluation of the SSDLs of the IAEA/WHO Network, the Agency's CARE programme (improving Coherence and Accuracy of SSDL REference Instrumentation) is implemented.

Instrumentation from the F.R.G. is the newest generation of a PTW X-ray beam monitor system. This system replaced an outdated one in its use to correct output fluctuations of the X-ray tube during calibration procedures. It consists of a transmission chamber M 7861 with built-in temperature sensor, a measuring assembly IQ 4/762, a temperature and air pressure measuring device TL 4/9222, an interface IF4/22376 for data communication with a computer equipped with RS 232, and corresponding software. It is used to calibrate ionization chambers in X-ray beam in the Agency's Dosimetry Laboratory.

The donations would considerably enhance the laboratory's capability to serve Member States in general and would particularly contribute to improve the performance of the IAEA/WHO Network of SSDLs.

N E W S

A video programme entitled "Dosimetry Programme of the IAEA" was produced by the IAEA Dosimetry Section, Division of Life Sciences, in late 1987. Information on the activity of the IAEA Dosimetry Laboratory especially concerning the service provided for the SSDLs and calibration procedures of dosimeters have been presented. The video of 21 minutes' duration was produced in the English, Spanish and Chinese language. A copy of it (VHS system) will be provided free of charge to each SSDL which sent their Annual Report of 1987. The readers who are interested in obtaining a copy may contact the respective SSDL in their country. Those who are from countries without SSDL may request for a copy of the video from Dosimetry Section, IAEA. In such a case, a blank video cassette should be provided together with information on television system in their countries.

A combined Workshop and Seminar on Calibration Procedures in SSDLs was held from 17 October to 4 November 1988 in Istanbul, Turkey.

A Co-ordinated Research Programme on "the testing of the code of practice for absorbed dose determination in photon and electron beams" started.

Ms. Monica Gustafsson, from Sweden, Head of IAEA Dosimetry Laboratory left the Agency in October 1987. She was replaced by Mr. Peter Nette (originally from Germany, F.R., later from SSDL Brazil).

The IAEA Dosimetry Section has been fortunate to have Mr. Kálmán Zsdánszky (from PSDL Hungary, Chairman of the SSDL Scientific Committee) as a consultant for 9 months and Mr. József Hizó (from PSDL Hungary) for 4 months in 1988.

SSDL NEWSLETTER

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