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SSDL Newsletter

IAEA/WHO NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

No. 25 OCTOBER 1986

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Editorial Note

With this issue the SSDL Circular Letter presents itself in new format and under a new name. These changes should not be understood to reflect any discontinuity in the Network policy of the two sponsoring organizations but merely indicate that the LETTER is now produced and published by the IAEA. Since 1973 the WHO secretary of the Network has taken the trouble to assume responsibility for producing the LETTER and credit must be given to WHO for having accomplished this task with so much effort and success. It appears to be only fair that IAEA, the organization that is in fact responsible for the technical development of the SSDL project, now takes over the task.

The last regular Circular Letter, No. 23, was distributed in March 1985. Only in March 1986 some relevant material was sent from IAEA to all SSDLs as an ordinary letter which was given, for easy reference, the number CL 24. It seems reasonable, therefore, to give this Newsletter the number 25, despite of the changes mentioned.

The SSDL Newsletter is not intended to compete with scientific journals. But it also should not be understood to be a mere organ of the Network secretariat. Many SSDLs have been accomplishing nice and interesting work and it is strongly suggested that they submit brief reports on their work for publication in the Newsletter. I am also asking staff of PSDLs to contribute to the Newsletter by providing technical information and know-how for their colleagues at SSDLs. Without such contributions from SSDLs and PSDLs the letter cannot fulfill its primary function, i.e. serving as a forum for exchange of information among member laboratories and keeping the network alife.

On this occasion I wish to inform all readers of the Newsletter that I did resign from my position as head of the IAEA Dosimetry Section (and IAEA secretary of the network) and shall leave my office on 31.12.1986. I would like to thank all those wo have actively supported this project and I can assure you that I would be happy to see the SSDL Network develop and flourish under the continuing guidance and support from IAEA and WHO.

Horst H. Eisenlohr

News from the Network Secretariat

In April 1976 the IAEA and the WHO concluded a Working Arrangement concerning the establishment and operation of a network of Secondary Standard Dosimetry Laboratories, based on a relationship agreement between the two organizations of 1959. This Working Arrangement was the outcome of rather lengthy consultations on the subject which rooted in recommendations of an experts' meeting on SSDL Activities, held in Rio de Janeiro 1974, and which put the bulk of responsibility for running the network on WHO. In particular, it was agreed then that WHO would provide the secretariat for the Network and be responsible for the SSDL Advisory Group of experts, the terms of reference of which were laid down in a separate document.

After about ten years of operation of the SSDL Network it was felt that revision of the Working Arrangement should be considered, taking care of the actual involve- ment of the two organizations in the project and providing a more fairly balanced share of responsibilities between the IAEA and WHO secretaries of the Network. The new Arrangement was drafted during 1985 and signed by the two Directors General in October/November 1985. The full text is attached as Annex 1.

Upon recommendation of an SSDL Advisory Group which met in November 1984 the Directors General of IAEA and WHO appointed 6 scientists as members of a standing SSDL Scientific Committee, with Dr. K. Zsdánszky, Vice-President of the Hungarian Office of Measures as Chairman. The appointment is for a period of three years. In its terms of reference the functions of this Committee are defined as follows:

- to provide technical advice to the Directors General of the IAEA and WHO regarding the programme of work of the IAEA/WHO Network of Secondary Standard Dosimetrey Laboratories;

- to assist the Network Secretariat with scientific advice and to regularly review the work undertaken by members of the SSDL Network;

- to make recommendations on the techniques for carrying out intercomparisons between SSDLs;

- to advise and make recommendations on the techniques for establishing and maintaining traceability to the Primary Standard Dosimetry Laboratories;

- to review the metrological consistency within the SSDL Network;

- to evaluate and comment on the dissemination of information including format and content of the circular letters distributed among the SSDLs;

- to prepare annual reports to the Directors General of the IAEA and WHO on the Network of the SSDLs, including a review of the SSDL reports;

- to advise and assist in any other related matters which may be referred to the Committee by the Directors General of the IAEA and WHO.

The Committee had its first meeting at the Agency's Headquarters in Vienna 12-15 May, 1986. Prior to the meeting the IAEA secretary of the Network had pre-evaluated the Annual Reports submitted by the member SSDLs, and drafted Guidelines for Member States concerning Radiation Measurement Standards and SSDLs for appraisal and discussion by the Committee members. The observations and recommendations of the Committee are attached as Annex 2. The "Guidelines" have been distributed to all Member States by Circular Letter from the Director General of IAEA and are attached as Annex 3 to this News Letter.

At its last meeting in April 1985 the members of CCEMRI (1) recommended new values of certain physical factors pertinent to dosimetry work. Upon suggestion by the SSDL Scientific Committee an information paper on this subject was written by H. Eisenlohr and K. Zsdánszky which should also be used for the discussions at the forthcoming IAEA Dosimetry Workshop in Quito, Ecuador. As it is felt that this subject is of major concern to all SSDLs it is published here as Annex 4.

We are glad to report that the authors of the IAEA "Code of Practice for Absorbed Dose Determination in Photon and Electron Beams" have completed their work. The Code will be published in the IAEA Technical Report Series soon.

An investigation concerning compliance with IEC standards of two widely used ionization chamber systems was carried out by the SSDL Helsinki/Finland under IAEA Research Contract. As the results of this study are also of direct interest to all SSDLs a summary of the Helsinki report is published as Annex 5.

As can be seen from Annex 2, the members of the SSDL Scientific Committee have offered their assistance in appraising proposals for research programmes in the field of dosimetry. They expressed their opinion that Research Contracts with members of the SSDL Network are an excellent means to upgrade the technical and scientific standard of the Network. Member SSDLs are therefore encouraged to submit to the secretariat proposals for research work that they would like to carry out in the framework of an IAEA Co-ordinated Research Programme. Two such programmes which may come up soon will be on Testing of the Code of Practice for Absorbed Dose Determination in Photon and Electron Beams, and the Determination of Quality Control Parameters for Standardization of Reference Radiation Qualities. Member SSDLs which want to participate in these programmes, or would like to proprose other research programmes are invited to contact the IAEA secretary of the SSDL Network.

As a consequence of the Chernobyl nuclear accident it was proposed that consideration be given to ways of enhancing the capacity of SSDLs so that they can carry out dosimetry in connection with unintentional radiation exposures and ensure adequate accuracy and reliability in survey instruments and dosimeters used for radiation protection measurements and environmental monitoring. An Advisory Group on The Role of SSDLs in the Dosimetry of Unintentional Radiation Exposures will meet from 26 through 30 January 1987 and assist IAEA in the implementation of this proposal.

ANNEX 1

ARRANGEMENT BETWEEN THE INTERNATIONAL ATOMIC ENERGY AGENCY AND THE WORLD HEALTH ORGANIZATION CONCERNING THE ESTABLISHMENT AND OPERATION OF A NETWORK OF SECONDARY STANDARD DOSIMETRY LABORATORIES

The International Atomic Energy Agency (IAEA) and the World Health Organization (WHO),

RECOGNIZING that they have been co-operating in the operation of a network of Secondary Standard Dosimetry Laboratories (the Network), established pursuant to a Working Arrangement, dated 5 April 1976; and

DESIRING to continue this co-operation in accordance with Article V of the relationship agreement concluded by IAEA and WHO in 1959;

HEREBY enter a new arrangement to guide their work in operating the Network and providing assistance, when needed, to individual Secondary Standard Dosimetry Laboratories (SSDLs).

Article 1

Purpose

The purpose of this Arrangement is to set forth responsibilities of IAEA and WHO in the operation and support of the Network and to establish criteria for SSDLs.

Article 2

Network Secretariat

(a) The Network Secretariat shall be composed of:

(i) two professional officers, not lower in rank than P-5, appointed respectively by IAEA and WHO as Joint Secretaries of the Network;

(ii) any support staff designated by a Joint Secretary to assist in carrying out the tasks incumbent on the latter in accordance with this Arrangement;

(iii) the IAEA Dosimetry Laboratory.

(b) While the Joint Secretaries shall consult each other with respect to all aspects of the Network and shall jointly sign communications from the Network, each Joint Secretary shall be responsible for Network matters that predominantly fall within the competence of his organization. It is recognized that IAEA is competent with respect to dosimetry in general, including linkage of the Network to the international primary measurement system, WHO being essentially competent with respect to clinical aspects of quality control in radiotherapy. Any matter that does not clearly fall predominantly within the competence of WHO shall be dealt with by the IAEA Joint Secretary until the two Secretaries have agreed on an appropriate allocation of responsibilities.

(c) The IAEA Dosimetry Laboratory shall serve as the central co-ordinating laboratory for the Network.

(d) In conformity with the above, the Network secretariat shall

(i) maintain contact with Network members by direct correspondence and circular letters;

(ii) organize dose comparisons for Network members;

(iii) organize or assist in organizing training activities for staff of Network members;

(iv) assist Network members in obtaining access to international measurement standards;

(v) establish links between Network members and PSDLs;

(vi) advise Network members concerning the organization and performance of national/regional/dose comparison programmes.

(e) The Network Secretariat shall draw technical advice from an SSDL Scientific Committee, established in accordance with the recommendations in the Report of the Advisory Group on the Present Status and Future of the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories, 19 - 23 November 1984.

(f) IAEA and WHO shall each bear its own expenses incurred in implementing this Arrangement unless, by agreement, expenses for specific items are to be met either on a shared basis or by reimbursement from one of the Parties.

Article 3

Operation of the Network

The operation of the Network shall be in accordance with the principles and definitions contained in the Annex. In order to implement the Annex, IAEA and WHO, acting within the framework of the Network Secretariat, shall, from time to time:

(a) agree on appropriate documents to be used in connection with Government designation of a laboratory for membership in the Network;

(b) establish measures to ensure that laboratories that have been participating in the Network as heretofore organized are given ample opportunity to continue participation in the Network;

(c) establish standards for continued membership of laboratories in the Network and provisions for member laboratories to voluntarily withdraw from the Network.

Article 4

Entry into Force and Duration

This Arrangement shall enter into force upon signature on behalf of IAEA and WHO and shall continue in force until either Party by written notification, given one year in advance of its effective date, informs the other Party of its intention to terminate the Arrangement.

ANNEX 2

RECOMMENDATIONS OF THE FIRST MEETING
OF THE SSDL SCIENTIFIC COMMITTEE

Vienna, 12-15 May 1986

1. Programme for Improving Coherence and Accuracy of SSDL Reference Instrumentation (Programme CARE)

The Advisory Group on Secondary Standard Dosimetry Laboratories, convened 19-23 November 1984, recommended the utilization of the ionometric method for comparison of standards within the SSDL Network. The SSDL Scientific Committee has noted that the principles and the first recommendations laid down by the Advisory Group at its 1984 meeting have been implemented. The Committee is confident that a continued improvement of the SSDL Network is possible.

The Committee has examined the SSDL Reports for 1985 during its current meeting and has noted that 37 out of 49 SSDLs submitted a report. The Committee was impressed by the work reported by a number of SSDLs. However, no report has been received from 12 SSDLs and some of the laboratories were minimally active. For these reasons the Committee recommends that a programme be initiated that could evaluate and increase the efficiency of the Network.

The Committee considers it necessary that direct traceability to the Inter- national Bureau of Weights and Measures (BIPM) be maintained with adequate accuracy. Such traceability already exists between the IAEA Dosimetry Laboratory and the BIPM. Although the BIPM cannot deal directly with all of the members of the Network, the IAEA Laboratory can provide such traceability without essential loss in accuracy. As a first step in achieving the proposed programme, the Committee recommends that the SSDLs be officially informed that membership in the Network is dependent upon periodic successful participation in performance evaluations that demonstrate adequate consistency with the international system of measurements.

If, in a given country, an SSDL organization exists, then this organization must choose one of its member laboratories to take part in such a performance evaluation.

The Committee recommends that the first performance evaluation be completed for all current SSDLs before July 1988.

The Committee proposes two methods that may be used to perform such evaluations. The IAEA Dosimetry Laboratory may send to each SSDL one of its calibrated transfer instruments so that direct comparison with the SSDL instrument is possible. Alternatively, the SSDL instrument together with the SSDL physicist responsible for calibrations may be sent to the IAEA Dosimetry Laboratory for about 2 weeks. This second method has the advantage that training of the physicist will result, in addition to the comparison.

The name "Programme CARE" has been adopted in order to emphasize the importance of Coherent and Accurate REference instrumentation, as the basis for a world-wide network of secondary calibration laboratories.

To execute the Programme CARE it is necessary to enhance the personnel of the Agency's Dosimetry Laboratory. The stability of the Laboratory team is vital to the successful execution of the programme.

The Committee expects that the Programme CARE will

(a) reinforce the SSDL Network,

(b) increase the efficient use of the excellent facilities of the IAEA Dosimetry Laboratory, and

(c) enhance the role of IAEA in the world-wide measurement system.

2. Workshop on Calibration Procedures in Dosimetry

The Scientific Committee was informed of the planned Workshop on Calibration Procedures in Dosimetry, to be held in Ecuador in October 1986. The Committee recommended for the scientific part the lecturers R. Loevinger (USA), H. Eckerl (FRG), and E. Thomasz (ARG). In case Loevinger cannot attend the workshop R.J. Shalek (USA), was proposed as alternate. The Committee expressed the opinion that the Agency should send at least 1 professional and 1 technician.

New values of the physical constants, and the new quantities used in radiation protection, should be discussed in the lectures. The Scientific Committee offered to appraise the scientific performance of the workshop, as guidance for future work- shops. The Scientific Committee does not consider this workshop to be a substitute for the periodically conducted Dosimetry Training Courses, which should be continued using the established criteria.

3. Accuracy and Traceability of Radiation Protection Instrumentation

Numerous national and international codes underline the need for and specify numerically the accuracy of dose measurements in the fields of occupational and environmental hygiene. Furthermore, the system of dose limitation depends upon reliable, accurate, and traceable dose measurements. The actions taken as a consequence of the dose limitation system have in some circumstances, as for example the recent power reactor accident in Chernobyl, a very large impact on the economic, health, and general societal factors. It is therefore essential that such actions be based on reliable data obtained with accurately calibrated instruments. In addition, the development and construction of radiation protection instruments must comply with specifications in terms of dose and/or doserate and should be tested according to such performance specifications. The behaviour of the instrumentation in environments other than the test conditions must also be investigated.

The IAEA therefore is advised to promote measures to insure worldwide reliable and traceable dose measurements in the field of radiation protection.

4. Research Contracts

The Scientific Committee is convinced that Research Contracts with members of the SSDL Network are excellent means to upgrade the technical and scientific standard of the Network. The Committee therefore offers to IAEA scientific support for the execution of those research contracts.

The Committee agreed to submit to the Secretariat, within two weeks after the Committee meeting, suggestions for appropriate research contracts to be concluded with SSDLs.

5. Technical Co-operation Programmes of the IAEA (SSDL Projects)

The Scientific Committee of the SSDL network after having examined the TC projects taken up by some of the SSDLs makes the following recommendations

5.1. Equipment

a) A more economical approach to providing equipment would be desirable.

b) For those parts that can be expected to need replacement, spares should be sent along with the original equipment.

c) Whenever feasible, radiation measuring instruments purchased by IAEA for use at SSDLs should be shipped via the Agency's Dosimetry Laboratory. It would be desirable if the eventual user of the instrument were at the Agency's Laboratory during its calibration/testing to receive training in the proper care and use of the instrument.

d) Equipment manuals, if possible in the language of the country, otherwise in English, should be made available along with the instruments. It is advisable to procure well-tried instruments to avoid lengthy down-time delays.

5.2. Experts

The Scientific Committee feels that it is desirable to recruit as Technical Co-operation experts persons actively working in SSDLs. This may help to solve the needs of particular SSDLs, in respect of their ongoing or future pro- grammes. The selected expert should know the needs of the SSDL project before- hand so that his stay will be more usefully utilized by the counterpart.

In the past there have been cases where the assignment reports of the experts have not been found in the SSDL files and this had impaired the usefulness of these expert services. The Scientific Committee recommends that the expert's report should be made available to the SSDL, after it has been released by the government.

There should be review of the progress of the implementation of the recommenda- tions of the expert and means should be sought for removing any bottlenecks.

6. Fellowships

The Committee, while appreciating the fellowship programme, feels that fellow- ships should fulfill the long-term plans of the SSDLs and should serve to meet specific needs and build up training resources.

7. Emphasis on Training and the CARE Programme

Based on the present status of the SSDL network and considering the efforts so far made in order to implement the SSDL network, the Scientific Committee recommends that the emphasis in the next years should be placed on the enhancement of the expertise of the SSDL staff and the quality of their

work. The Committee proposes that the expert missions be reduced and the highest priority given to training and the CARE Programme.

A long term training programme should be planned by the Secretariat of the Network and discussed in detail at the next meeting of the Scientific Committee.

8. Adoption of New Values of Physical Constants

The Scientific Committee recommends that the IAEA Dosimetry Laboratory should immediately adopt the new values of the physical constants for the calibration factors. A technical paper based on the CCEMRI (Section I 1985) resolutions should be written, explaining the implications of the changes. The paper should be presented at the workshop in Ecuador and later distributed to all SSDLs through the Secretariat.

9. Date of Next Meeting and Committee Utilization

It is recommended that the comments of the Scientific Committee be solicited between committee meetings, on matters for which this is appropriate and if time allows. It was agreed that the next Committee meeting should take place in June 1987.

ANNEX 3

GUIDELINES FOR MEMBER STATES CONCERNING RADIATION MEASUREMENT STANDARDS AND SECONDARY STANDARD DOSIMETRY LABORATORIES

INTRODUCTION

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

In order to co-ordinate the provision of guidance and assistance to such laboratories, the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) set up a Network of Secondary Standard Dosimetry Laboratories (SSDLs) under their joint aegis, as described in the IAEA booklet 'SSDLs: Development and Trends' (1985). This publication includes detailed criteria for the establishment of these laboratories. The present guidelines deal with the functions and status of SSDLs, in particular with the need for recognition and support by the competent national authorities.

THE NEED FOR MEASUREMENT STANDARDS

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

Traceability and confidence in known levels of measurement are also required for high-dose measurements, such as those delivered in sterilizing pharmaceutical products and the treatment of food.

SSDLs AND METROLOGY

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

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

PRINCIPLES AND RECOMMENDATIONS

MEASUREMENT STANDARDS

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

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

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

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

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

SSDLs AND THE NETWORK

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

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

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

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

ANNEX 4

NEW VALUES OF SOME PHYSICAL INTERACTION COEFFICIENTS FOR DOSE MEASUREMENTS

Information for SSDLs

H.H. Eisenlohr and K. Zsdánszky

1. The recommendation of CCEMRI

At its 8th meeting in 1985 Section I of the "Comité Consultatif pour les Etalons de Mesure des Rayonnements Ionisants" (CCEMRI) to the "Comité International des Poids et Mesures" (CIPM) has put forward a recommendation on new values of some physical constants to be used for exposure and absorbed dose determinations (see Annex I).

Implementation of this recommendation has some impact on the measurement of exposure, air kerma and absorbed dose, and may result in changes in calibration factors of dosimeters. This subject will be discussed in detail at the IAEA Workshop on Calibration Procedures in Dosimetry, to be held in Quito in October 1986. The following information may assist SSDLs in preparing themselves for the expected changes of calibration factors.

2. The most important changes

The recommendation has been caused by new numerical values of some physical constants which have become available recently. The two most important changes concern:

a) $s_{m,a}$, the ratio of the mean restricted collision mass stopping powers of the chamber material to that of air for electrons crossing the cavity, and

b) W_{air}/e, the mean energy required to produce an ion pair in air per electron charge, for electrons emitted by radioactive sources or produced by photon absorption.

In the past the values of $s_{m,a}$ were deduced in most cases from the data of NCRP (1961) or from Berger and Seltzer (1964). However, new stopping power data were recently published by Berger and Seltzer (1982), and in ICRU Report 37 (1984), based on new values of the mean excitation energy and the density effect.

Cavity ionization chambers with graphite wall material are generally used as primary standards of exposure and air kerma for ^{60}Co gamma radiation. The mean stopping-power ratios ($s_{C,a}$) to be applied for such graphite chambers depend on the density of the graphite, the size of the cavity and the scattered component in the incident beam. The new values of $s_{C,a}$ are about 0.7% lower than the previous ones (for graphite cavity chambers) in case of ^{60}Co gamma radiation.

The value of $W_{air}/e = 33.85 \pm 0.15$ J/C was recommended for dry air in ICRU Report 31 (1979). The new value of $W_{air}/e = 33.97 \pm 0.06$ J/C has been recommended by CCEMRI in 1985 (see Annex I). This value is based on a coherent estimation of the new $s_{C,a}$ values and is 0.35% higher than the previous one.

Some less significant changes concern the g values (the fraction of electron energy expended for bremsstrahlung) and the mass energy absorption coefficient ratio. The new g value in air is 3.2×10^{-3} for ^{60}Co gamma rays which is about 1×10^{-4} less than the old one (Boutillon, 1985). The change is still less for medium and low energy X-rays. The new ratio of the mass energy absorption coefficients for air and graphite is about 0.1% less than the earlier one for ^{60}Co gamma rays (Hubbell 1969 and 1982).

The use of the new values leads to some changes in the determination of exposure and air kerma with primary standards. Consequently, the calibration factors of secondary standards and field instruments will also be changed.

3. Changes in the determination of exposure and air kerma by primary standards

3.1. Primary standards of exposure

3.1.1. Free-air chambers are the primary standards of exposure for X-rays in the range from a few to several hundred kV tube potential. The exposure determined by a free-air chamber is given by

$$X = \frac{Q}{V \varrho} \prod K_i \qquad (1)$$

where

X is the exposure

Q is the electric charge collected by the chamber

V is the volume of the chamber in which the charge is collected

ϱ is the mass density of the air

$\prod K_i$ is the product of dimensionless correction factors.

As it may be seen, there is no change in the determination of exposure by free-air chamber because the relevant physical constants are not included in equation (1).

3.1.2. Graphite cavity chambers are generally used as primary standards of exposure for ^{60}Co gamma rays. The exposure determined by a graphite cavity chamber is given by

$$X = \frac{Q}{V} \; s_{C,a} \; \frac{(\mu_{en}/\varrho)_a}{(\mu_{en}/\varrho)_C} \; \prod K_i \qquad (2)$$

where

$\frac{(\mu_{en}/\varrho)_a}{(\mu_{en}/\varrho)_C}$ is the ratio of the mean mass energy absorption coefficients and graphite, and

the other symbols are as defined above.

In equation (2) the new values of $s_{C,a}$ and the mass energy absorption coefficient ratio effect a decrease of the exposure determined by a graphite cavity chamber of about 0.8% for ^{60}Co gamma rays.

3.2. Primary standards of air kerma

Primary standards of exposure may also be used as primary standards of kerma in air for photon energies between several keV and a few MeV, according to the relation between these quantities. The kerma in air may be calculated from the exposure:

$$K_{air} = X \frac{W_{air}/e}{1 - g} \qquad (3)$$

3.2.1. The air kerma of X-rays determined by a free-air chamber is 0.35% higher because of the new value of W_{air}/e. The influence of the new g values is negligible for medium and low energy X-rays.

3.2.2. The air kerma of ^{60}Co gamma rays determined by a graphite cavity chamber is given by

$$K_{air} = \frac{Q}{V} \; s_{C,a} \; \frac{(\mu_{en}/\varrho)_a}{(\mu_{en}/\varrho)_C} \; \frac{W_{air}/e}{1 - g} \; \prod k_i \qquad (4)$$

and is about 0.55% lower than earlier because of the new values of the physical constants included in equation (4).

4. Changes in the calibration factors of secondary standards of exposure and air kerma

Secondary standards calibrated before the introduction of the new values of interaction coefficients can be adjusted to the changes outlined above by correcting the old calibration factors. The changes of the calibration factors depend on the

TABLE I

APPROXIMATE CHANGES OF CALIBRATION FACTORS OF EXPOSURE AND AIR KERMA SECONDARY STANDARDS*

Physical quantity:	Exposure		Air kerma	
Primary standard (used for calibration)	Free-air chamber	Graphite cavity chamber	Free-air chamber	Graphite cavity chamber
Radiation	X-rays (medium and low energy)	^{60}Co	X-rays (medium and low energy)	^{60}Co
Influence of the new values of the relevant physical constants on the calibration factor (in percent):				
$s_{C,a}$	-	-0.7	-	-0.7
W_{air}/e	-	-	+0.35	+0.35
g	-	-	-	-0.1
$(\mu_{en}/\rho)_{a,C}$	-	-0.1	-	-0.1
Total change of calibration factor:	-	-0.8%	+0.35%	-0.55%

* More accurate data depend on the density of the graphite chamber-wall, the size of the cavity and the scattered component in the incident beam.

type of primary standard against which the calibration was performed and to some extend on the radiation beam. Approximate data are listed in Table I which can be used for the correction of the calibration factors of secondary standards before obtaining a new calibration. The uncertainty of this correction is estimated to be less than $\pm$0.1%.

5. Determination of absorbed dose

5.1 The primary standards of absorbed dose

The conceptually simplest method of measuring absorbed dose is the calorimetric method (Domen, 1974).

The ionization method can also be used for the measurement of absorbed dose (BIPM, 1975). If the mean energy W, needed to produce a pair of ions is known, the ionization produced in a cavity ionization chamber permits calculation of the dose absorbed in the air of the cavity, and from this the absorbed dose in graphite can be derived with the help of the ratio of stopping powers of graphite and air (the CCEMRI has chosen graphite as the reference material for absorbed dose measurements).

There are some national metrology laboratories (PSDLs) maintaining a calorimeter as a primary standard of absorbed dose for ^{60}Co gamma radiation(e.g. Pruitt J.S., 1981) and providing absorbed-dose calibrations for ^{60}Co gamma rays in water. The secondary standard or the user's ionization chamber may be calibrated at the point of interest in a water phantom where the absorbed dose to water has been determined by the PSDL. In such cases the PSDL should be asked for the correction of the calibration factor resulting from the new values of the physical constants in question. The change, if any, will be very small.

5.2 Absorbed dose derived from exposure or air kerma

The determination of absorbed dose may be performed by using ionization chambers with exposure or air kerma calibration factors calibrated in a ^{60}Co gamma beam. Procedures, conversion and correction factors are published in several national or international protocols advising the user how to obtain absorbed dose from a measurement of exposure or another appropriate quantity (e.g. NACP 1980, HPA 1983, AAPM 1983, SEFM 1984). It should be noted that the procedures for obtaining the absorbed dose and the calibration factor of the ionization chamber should be consistent, i.e. both should be derived from the same set of values of physical

interaction coefficients. A "Code of practice for absorbed dose determination in photon and electron beams" will be published by the IAEA soon. The purpose of the IAEA code of practice is to describe in detail the measurement procedure and to provide the current best values for physical constants and correction factors. It is not possible to discuss here the procedure in detail; however, the determination of absorbed dose in a ^{60}Co gamma beam is outlined briefly.

The mean absorbed dose to air inside the air cavity of the ionization chamber at the calibration radiation quality , $\bar{D}_{air,c}$ may be evaluated from the air kerma. The relation between $\bar{D}_{air,c}$, and $K_{air,c}$ is given by

$$\bar{D}_{air,c} = K_{air,c} (1-g) k_{att} k_m \qquad (5)$$

where

$K_{air,c}$ is the kerma in air at the centre of the ionization chamber in the absence of the chamber at the calibration radiation quality,

k_{att} is a factor, correcting for attenuation (absorption and scattering) in the ionization chamber material at the calibration, and

k_m is a chamber material dependent factor correcting for lack of air equivalence of the ionization chamber material.

As it may be seen, a change of g value works in the opposite direction in equation (5) than in equations (3) and (4).

The relation between $\bar{D}_{air,c}$ and the exposure X, expressed from equations (3) and (5) is:

$$\bar{D}_{air,c} = X (W_{air}/e) k_{att} k_m \qquad (6)$$

Thus, the absorbed-dose-to-air chamber factor of a cavity ionization chamber will be reduced by about 0.45% for ^{60}Co gamma rays, if it was calibrated against a graphite cavity primary standard chamber before the change of the relevant physical constants became effective.

The absorbed-dose-to-air chamber factor, at the calibration radiation quality, $N_{D,c}$, may be derived from the air kerma calibration factor, N_K, using equation (5):

$$N_{D,c} = N_K \, (1-g) \, k_{att} \, k_m \tag{7}$$

or from the exposure calibration factor, N_X, using equation (6):

$$N_{D,c} = N_X \, k_{att} \, k_m \, (W_{air}/e) \, k_1 \tag{8}$$

where

$k_1 = 1.00$ if N_X is given in C kg^{-1} C^{-1}, or

$2.58 \; 10^{-4}$ if N_X is given in R C^{-1}.

According to the Bragg-Gray equation one obtains for the determination of the absorbed dose to water at the effective point of measurement of the chamber, D_w, in the absence of the chamber:

$$D_w = \bar{D}_{air,c} \, (s_{w,air})_u \, p_u \tag{9}$$

where

$(s_{w,air})_u$ is the ratio of the mean mass stopping powers, water to air, at the reference point at the user's radiation quality, and

p_u is the perturbation correction factor of the ionization chamber.

Assuming that the energy dependence of W is negligible in a ^{60}Co beam, the absorbed dose to air calibration factor is given by

$$N_D = \bar{D}_{air,c}/M_c = \bar{D}_{air,u}/M_u \tag{10}$$

where

M_c is the meter reading at the calibration quality c, and

M_u is the meter reading at the user's quality u.

Using this assumption, the absorbed dose to water at the effective point of measurement may be obtained from:

$$D_w = N_D M_u \, (s_{w,air})_u \, p_u \tag{11}$$

where the meter reading, M_u, should be corrected for temperature, pressure, recombination, humidity etc.

Recommended values of correction factors (k_{att}, k_m, p_u) for a large number of commercial ionization chambers and the new values for physical interaction coefficients will be provided in the Code of Practice to be published by the IAEA.

6. Conclusions

The use of the new values of some physical constants is important for primary standards where the highest possible accuracy is needed. The changes will be performed according to the recommendation of CCEMRI (1985).

The calibration factors of secondary standards should be corrected for either by a new calibration against a primary standard, or by correcting the calibration factors by using the approximate data listed in Table I.

The change is not significant for users of field instruments. Even in the case of radiation therapy, the change is one order of magnitude lower than the accuracy required in the determination of the radiation dose delivered to the patient. Dosimeters with calibration factors adjusted to the new values should be used for absorbed dose determination according to a procedure which is consistent with the new recommended values of physical constants (e.g. the "Code of practice for absorbed dose determination in photon and electron beams" to be published by the IAEA).

The overall change in the calibration of the TLDs used for the IAEA/WHO postal dose intercomparison service for ^{60}Co gamma radiation amounts to no more than 0.5% (see 5.1) which is well within the uncertainty of the method.

ANNEX I

Extract from the report of the "Comité Consultatif pour les Etalons de Mesure des Rayonnements Ionisants" to the "Comité International des Poids et Mesures".

Section I - Rayons X et gamma, electrons
8th Meeting (April 1985)

4. Physical quantities for radiation measurement standards

At its 7th meeting, Section I discussed the implications of changes in stopping power ratios on exposure and absorbed dose determinations. At that time, data from a draft ICRU report on stopping powers were used to estimate that values of exposure determined with the BIPM's exposure standard, a carbon cavity chamber, in ^{60}Co radiation would be reduced by about 0.75%. A similar decrease would apply to exposure standards of the national laboratories. That meeting also discussed how new stopping power ratios would affect the value of W obtained from most previous measurements. It was decided then to postpone a decision on changing primary standards at least until the ICRU report became available.

A paper (85-8) presented by BIPM to the 8th meeting reconsidered the W values compiled by the ICRU in its Report 31 (1979). Most evaluations of W had been based on measurements of the product $W.s_{m,a}$, where $s_{m,a}$ is the mean ratio of the restricted stopping powers of the material and air. The re-evaluations by BIPM used the new ICRU stopping power data (ICRU Report 37), and took account of spectral changes due to scattered photons. In addition, two recent determinations were included, one being that by the BIPM (85-5). The weighted mean value of W/e obtained for dry air was (33.97 ± 0.06) J C^{-1}.

The meeting was reminded that this new value of W and the new stopping power ratios form a consistent set. That is, adopting one implies that the other also should be adopted, owing to their linkage through the product $W.s_{m,a}$.

The meeting noted that there are thus new values available for the following quantities:

1. Stopping powers for electrons (ICRU Report 37),
2. W/e (quoted above, and 85-8),
3. (1 - g) (85-18),
4. Energy-absorption coefficients (Hubbell, IJARI 33 (1982) p. 1269).

Considering that exposure, air kerma and absorbed dose standards should be based on current best values of physical constants, Section I recommended that use of the important values listed above be initiated in the existing system of radiation

measurement standards from 1986-01-01. It was further recommended that, although changes in standards should be made as infrequently as possible, further adjustments should be considered as the values of physical constants continue to be refined.

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ANNEX 5

EXCERPT FROM:

TESTING OF RADIOTHERAPY DOSIMETERS IN ACCORDANCE WITH SPECIFICATIONS GIVEN BY IEC PUBLICATION 731 (1982)

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PREFACE

In their position as centres for expertise in radiation dosimetry and its applications, the Secondary Standard Dosimetry Laboratories (SSDLs) are expected to advise the radiation users, the radiotherapy centres in particular, in selection and use of the most suitable dosimetric equipment. Various dosimeters are commercially available, but objective information on their fundamental technical characteristics is lacking. Such information would be valuable and necessary for the SSDLs to be able to judge the accuracy and reliability of the many choices which exist for a given application. The results of systematic evaluations of dosimeters in a recognized SSDL (or SSDLs) could be helpful supplementary information to the other SSDLs and to the radiation users.

In 1983 The Finnish Centre for Radiation and Nuclear Safety (STUK; old name: Institute of Radiation Protection) and the International Atomic Energy Agency (IAEA) made a research contract, the purpose of which was to test selected dosimeters for use in radiotherapy in accordance with the specifications by the International Electrotechnical Commission (IEC).

Two commonly used dosimeters (chamber, measuring assembly and radioactive check device) were selected:

- PTW, Physikalisch Technische Werkstätten, FRG: Measuring assembly type IQ 764, S/N 040 with two chambers type M233332, S/N B330 and B391 (B391 was replaced by S/N 001 for part of the tests when it was accidentally broken) and check device type 119, S/N 23261-409.

- Nuclear Enterprises Ltd., UK: Measuring assembly NE 2570, S/N 305 with two chambers type NE 2571, S/N E002 and 182 and check device type NE 2503/3, S/N 1265.

Note: The original purpose was to test a PTW chamber which by construction would be comparable with the NE 2571 chamber. By mistake, however, a chamber type PTW M233332 was supplied for testing. This chamber has a wall thickness larger than that used for ordinary chambers (e.g. NE 2571), and was specially designed (by P. Almond) to minimize the perturbation effect for measurements in a phantom in a ^{60}Co beam. The use of this chamber is limited to measurement in ^{60}Co beams, and the large energy dependence found at lower photon energies is, therefore, not of importance.

Table I gives a summary of the tests carried out and the results. The marking on the dosimetes and the instruction for use were checked in accordance with the requirements by the IEC publication 731 and stated in form of a check list.

Table I. Summary of the tests carried out and the results. Yes/No: Meets/does not meet the IEC requirements.

A. Tests for the chamber assembly

IEC 731 clause	Test (FS: field size, RQ: radiation quality)	NE 2571 E002	182	PTW M233332 B330	B391	001
4.4.1	Leakage current without irradiation	1)	1)	1)	1)	
4.4.2	Stabilization time	Yes		Yes		
4.4.3	Post-irradiation leakage (at ^{60}Co, max FS)	Yes		Yes		
4.2.2	Field size					
.1	Stem scatter (at 4 RQ, 3 FS)	Yes		Yes		
.2	Stem leakage (at ^{60}Co, 3 FS)	Yes		Yes		
4.2.3	Chamber orientation					
.1	Chamber rotation (at 2 RQ, min FS)	Yes	Yes	Yes		Yes
.2	Chamber tilt (at 2 RQ, min FS)	Yes	Yes	Yes		Yes
4.2.1	Radiation quality (at 7 RQ)	Yes[2)]	Yes	5)	5)	
4.4.4	Exposure-rate dependence	Yes[3)]		Yes[3)]		
4.4.6	External fields	4)		4)		
4.4.7	Guard electrode insulation	1)	1)	1)		1)
4.4.9	Cable strain	1)		1)		
4.4.10	Cable connectors	1)		1)		
4.6.2	Pressure equilibration	Yes	Yes	Yes		Yes
4.6.3	Temperature	Yes		Yes		

B. Tests for the measuring assembly

IEC 731 Clause	Test	NE Farmer 2570 305	PTW IQ4 type 764 040
5.7	Repeatability	Yes	Yes
5.8	Zero drift and zero shift	Yes	Yes
5.9	Charge leakage	1)	1)
5.10	Stabilization time	Yes	Yes
5.11	Non-linearity	Yes	Yes
5.12	Range changing	Yes	
5.16	Temperature	No	Yes[2)]
5.19	Battery power supply	Yes	
5.20	Supply mains		Yes

C. Tests for the stability check device

IEC 731 clause	Test	NE 2503/3 1265	PTW 119 23261-409
6.4	Repeatability	Yes	Yes

1) Not possible to compare with the requirement 2) Marginal 3) At the exposure rate used 4) No requirement in IEC 731 5) See Note on preceding page.

Check list in regard to markings on the dosimeters and the instruction for use

The check results are marked in accordance with the relevant pages of IEC 731 using the notations:

```
 + :   information supplied
(+):   information supplied, but not exactly as required
 - :   information not supplied
 0 :   information not relevant or not checked
```

PTW IQ4
NE Farmer 2570

7. Markings

All markings and attached labels shall be clear and permanent.

7.1 *CHAMBER ASSEMBLY*

7.1.1 The following information shall be clearly marked on the CHAMBER ASSEMBLY or on a firmly attached label:

+ + — the serial number of the device;

- - — an indication of whether the chamber is sealed;

0 0 — a warning that the CHAMBER ASSEMBLY shall not be used in contact with a patient if it does not meet the requirements of Type B, BF or CF equipment as defined in IEC Publication 601-1.

0 0 — if it has ACCESSIBLE CONDUCTIVE PARTS, a warning that it shall not be used in contact with a patient unless it is connected to a MEASURING ASSEMBLY which is designed so that the complete instrument meets the requirements of Type B, BF or CF equipment as defined in IEC Publication 601-1.

(This may require the specification of particular models of MEASURING ASSEMBLIES.)

7.1.2 The following information should be clearly marked on the CHAMBER ASSEMBLY or on a firmly attached label:

+ + — the manufacturer's name, trade mark or other recognized marking;

+ + — the type number of the device.

7.1.3 The following information may be given by markings on the CHAMBER ASSEMBLY or on a firmly attached label:

– + – an engraved mark so that the REFERENCE POINT of the chamber can be accurately positioned during calibration;

0 0 – the nominal full scale reading when the chamber is supplied specifically for use with one MEASURING ASSEMBLY (especially for a condenser chamber);

– – – the RATED RANGE of radiation qualities.

7.2 *MEASURING ASSEMBLY*

7.2.1 The following information shall be clearly marked on the MEASURING ASSEMBLY:

+ + – the manufacturer's name, trade mark or other recognized marking;

+ + – the type number and serial number of the device;

0 + – the legend "uncorrected" on or adjacent to the display if this is scaled in radiation units;

– + – the function of each socket, operating control and indicator;

0 0 – in the case of a multi-range instrument with an analogue display, the range-changing controls shall be marked with the INDICATED VALUE at full-scale for each position.

Range-changing controls shall not be marked with scale multiplying factors;

0 0 – a warning that a CHAMBER ASSEMBLY connected to the MEASURING ASSEMBLY shall not be used in contact with a patient, if the MEASURING ASSEMBLY is not designed to meet the requirements of Type B, BF or CF equipment as defined in IEC Publication 601-1;

0 0 – if the MEASURING ASSEMBLY meets the requirements of Type B, BF or CF equipment as defined in IEC Publication 601-1, an indication of Types or models of CHAMBER ASSEMBLY with which the MEASURING ASSEMBLY makes a complete instrument which also meets these requirements, and a warning that a CHAMBER ASSEMBLY connected to this MEASURING ASSEMBLY shall not be used in contact with a patient, if the complete instrument does not meet these requirements;

+ 0 – the mains voltages and frequencies for which it is designed.

0 + 7.2.2 If the MEASURING ASSEMBLY is supplied with more than one chamber, the chambers may be identified by markings on the MEASURING ASSEMBLY.

+ + 7.2.3 If graphical symbols are used they should be those given in Appendix D.

7.3 *STABILITY CHECK DEVICE*

7.3.1 The following information shall be clearly marked on the STABILITY CHECK DEVICE:

+ + – the manufacturer's name, trade mark or other recognized marking;

+ + – the type number and serial number of the device.

+ + 7.3.2 For a device using a radioactive source, a permanent label shall be affixed to the surface of the shielded container and, if the device is structurally part of the MEASURING ASSEMBLY, on the surface of the control panel, and on the surface of the carrying case, if one is supplied. This label shall include the international trefoil symbol and should include the name of the radionuclide, the activity of the radionuclide and the date for which the stated activity is applicable.

– – 7.3.3 If any part of the device which contributes to protection against ionizing radiation has to be detached in order to insert the chamber, this part shall bear a warning about the loss of protection and the necessity for replacing it after the reading.

8. Instructions for use

The instructions for use are considered to be part of the accompanying documents.

8.1 *General*

1) + + 8.1.1 In order to ensure correct use of the instrument, a manual of instructions for use shall be
2) – + provided. Measuring assembly[1], Ionization chamber[2]

0 0 8.1.2 This manual should comply in general with the requirements contained in IEC Publication 278: Documentation to be Supplied with Electronic Measuring Apparatus.

+ + 8.1.3 Sufficient information shall be given in the instructions for use to ensure unambiguous identification of the instrument to which they apply.

0 0 8.1.4 All warnings and essential requirements should be written in the vernacular of the purchaser or in a language mutually agreed between the manufacturer and the purchaser.

1) – + 8.1.5 For the MEASURING ASSEMBLY[1], each IONIZATION CHAMBER[1] and each STABILITY CHECK
2) – – DEVICE[2], information shall be supplied on construction, method of operation and specified performance.

0 0 8.1.6 If the instrument is claimed to comply with the requirements of this standard, it shall be stated whether the instrument (or component if supplied separately) is a REFERENCE-CLASS or a FIELD-CLASS INSTRUMENT.

0 0 8.1.7 For an instrument intended to operate under special conditions and which does not fulfil all the requirements of this standard, information shall be provided about those clauses with which it does not comply.

0 0 8.1.8 For an instrument incorporating a cable-connected small thimble chamber, which does not meet the requirements of Type B, BF or CF equipment as defined in IEC Publication 601-1, a warning shall be given that the instrument shall not be used in contact with a patient.

8.2 *Specified performance – General points*

0 0 8.2.1 Data derived from TYPE TESTS shall be given in the instructions for use, even if also given in test sheets.

0 0 8.2.2 Data derived from individual tests may be given in the instructions for use, but if they are not, then reference should be made to appropriate test sheets.

8.3 *CHAMBER ASSEMBLY*

8.3.1 *Construction*

The following information shall be provided:

– + *a)* the size and shape of the IONIZATION CHAMBER, both internal and external;

– + *b)* the thickness, density and material of the IONIZATION CHAMBER wall;

– – *c)* the electrical connections between each external conducting part of the CHAMBER ASSEMBLY and the cable connector;

– + *d)* the dimensions and material of the build-up cap, if any;

+ + *e)* the position of the REFERENCE POINT of the IONIZATION CHAMBER in relation to a recognizable point (e.g. the tip of a thimble chamber) or a mark;

– + *f)* whether the IONIZATION CHAMBER is guarded or unguarded;

– + *g)* whether the IONIZATION CHAMBER is sealed or unsealed.

8.3.2 *Method of operation*

The following information shall be provided:

0 0 *a)* for a CHAMBER ASSEMBLY supplied independently of MEASURING ASSEMBLY, guidance about the type of MEASURING ASSEMBLY for which it is suitable and about the method of connection, and a warning if a current-limiting resistor is necessary;

– + *b)* appropriate methods of supporting the CHAMBER ASSEMBLY, and a warning about inappropriate methods;

– + *c)* whether the chamber is suitable for use in a phantom;

– + *d)* the recommended orientation in the useful beam and information about the dependence of RESPONSE on orientation in the useful beam;

+ + *e)* the RATED RANGE of polarizing voltages;

– + *f)* the maximum polarizing voltage that may be applied without damage and without charge multiplication;

g) guidance about the time to be allowed before making a measurement after the chamber has been subjected to the following:

+ + — switching-on of polarizing voltage;
– + — connection of electrical fittings;
– – — movement of cable;
– – — sudden change of pressure or temperature;
+ – — effects of transport.

– – *h)* recommended methods of checking that the RESPONSE is not being affected by stray radiation or external fields;

– – *i)* a warning that frequent checking with a STABILITY CHECK DEVICE is advisable, especially for a sealed IONIZATION CHAMBER;

– (+) *k)* a warning where applicable that long exposure to high humidity may have an adverse effect;

– + *l)* recommended methods of correcting the INDICATED VALUE of unsealed chambers for changes in air density;

– – *m)* permissible methods of cleaning the CHAMBER ASSEMBLY;

– + *n)* a warning against damaging fragile parts, for example the window of thin-window chambers;

– + *o)* the type of radioactive STABILITY CHECK DEVICE (if any) to be used with the dosimeter;

– (+) *p)* a warning that leakage currents should be checked.

8.3.3 *Specified performance*

Data derived from TYPE TESTS on any of the following INFLUENCE QUANTITIES, about their RATED RANGE and the VARIATION of RESPONSE and leakage current within the RATED RANGE shall be provided:

– + *a)* radiation quality;

– – *b)* field size;

– – *c)* source-chamber distance (under consideration);

– + *d)* exposure rate;

0 0 *e)* exposure (for a condenser chamber);

– – *f)* temperature;

– – *g)* humidity;

– – *h)* long-term stability of RESPONSE.

8.4 *MEASURING ASSEMBLY*

8.4.1 *Construction*

The following information shall be provided:

0 + *a)* number and types of batteries required;

– 0 *b)* type and rating of fuses required;

1) – + *c)* potential differences from earth of the polarizing supply[1] and the guard terminal;[2]
2) – –

– + *d)* if access to the inside is permitted, a circuit diagram with layout, and the means of access;

– 0 *e)* if access to the inside is not permitted, a warning to this effect;

+ + *f)* whether the MEASURING ASSEMBLY is sealed against the effect of high humidity;

– + *g)* method of maintaining desiccator.

8.4.2 *Method of operation*

The following information shall be supplied:

1) + 0 2) – 0 *a)* for a mains-powered instrument, the RATED RANGE of mains voltages[1] and frequencies;[2]

– 0 *b)* means of adjusting instrument to accept the mains voltage available;

0 + *c)* for a battery-powered instrument, the method of testing whether the batteries need replacing and the method of replacement;

+ + *d)* the function and method of operation of each control, the purpose of each socket and the meaning of each indication;

– + *e)* the correct operating position of the MEASURING ASSEMBLY and the necessity for, and method of levelling;

f) guidance on the time to be allowed, before making a measurement after the MEASURING ASSEMBLY has been subjected to the following:

+ + — switching on (STABILIZATION TIME),
+ – — connection of electrical fittings,
– + — sudden changes of temperature or humidity,
– + — effects of transport;

– – *g)* recommended methods of checking that the RESPONSE is not being affected by high humidity, stray radiation or external fields;

+ + *h)* guidance about suitable types of associated IONIZATION CHAMBERS, and types of plugs required;

– – *i)* the value of any limiting resistor in the polarizing voltage supply, or a warning if such a resistor is not incorporated;

– + *k)* for a MEASURING ASSEMBLY that has a scale marked in radiation units, a warning about the need to apply CALIBRATION FACTORS to the INDICATED VALUES.

8.4.3 *Specified performance*

Information derived from TYPE TESTS shall be provided about the following points unless it is provided in accompanying test sheets:

+ + *a)* the RESOLUTION of the display device;

– – *b)* the repeatability of successive measurements;

+ + *c)* EFFECTIVE RANGE;

– + *d)* NON-LINEARITY;

0 + *e)* uncertainty of range changing;

0 0 *f)* RESPONSE TIME (of an exposure-rate meter);

– – *g)* for exposure meters the RATED RANGE of input currents or exposure rates and the VARIATION of RESPONSE in the RATED RANGE;

– – *h)* the RATED RANGE of temperature and humidity and the VARIATION of RESPONSE and of ZERO-DRIFT and ZERO-SHIFT in the RATED RANGES;

1) 0 + 2) 0 – *i)* expected useful life of specified batteries, in use[1] and in storage;[2]

– 0 *k)* VARIATION of RESPONSE in the RATED RANGE of mains voltage;

– + *l)* expected long-term stability.

8.5 *Electrical STABILITY CHECK DEVICE*

Information shall be provided on the method of operation and the repeatability to be expected when it is operated in accordance with the instructions for use.

8.6 *Radioactive STABILITY CHECK DEVICE*

– – 8.6.1 *Construction*

Information shall be provided about the construction of the device, the strength and type of source(s) and the exposure rate at 2 cm or 10 cm from the surface of the housing so that suitable precautions can be taken for storage and in case of mechanical damage or fire.

8.6.2 *Method of operation*

– (+) For an overall STABILITY CHECK DEVICE, instructions shall be provided on the correct positioning of the IONIZATION CHAMBER and the method of assessing the temperature at the position of the IONIZATION CHAMBER. Guidance should be given as to how often and in what manner the instrument should be checked, and what precautions have to be taken in order to achieve the specified performance. A warning shall be given not to leave the chamber in the radioactive STABILITY CHECK DEVICE for unnecessarily long periods of time, if this is likely to have an adverse effect on the performance of the chamber.

– + 8.6.3 *Specified performance*

Information shall be given on the repeatability to be expected when the device is operated in accordance with the instructions for use.

9. Test sheets

The test sheets are considered to be part of the accompanying documents.

9.1 *General*

9.1.1 If an instrument is supplied by the manufacturer with a calibration, test sheets shall be provided giving CALIBRATION, and CORRECTION FACTORS by which the INDICATED VALUE of the instrument (or the RESPONSE of the IONIZATION CHAMBER) may be corrected to give the exposure or exposure rate at the REFERENCE POINT of the chamber.

9.1.2 If an instrument is supplied without a calibration, information about CALIBRATION and CORRECTION FACTORS of a typical instrument shall be provided either in the instructions for use or on separate test sheets.

9.1.3 It shall be stated on each test sheet whether the data have been derived from a TYPE TEST or a ROUTINE TEST.

9.2 *Calibration conditions*

9.2.1 If CALIBRATION FACTORS are provided by the manufacturer they shall be given over the RATED RANGE of radiation qualities; alternatively the range of radiation qualities shall be given for which the CALIBRATION FACTORS fall within stated limits.

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