Volume 6 Number 1 1990

Medical Physics World

Bulletin of the International Organization for Medical Physics

President's Message

The number of countries that are members of the IOMP continues to grow. Recently Yugoslavia and Korea have applied and met the requirements and have been accepted. On behalf of the IOMP I welcome them.

In May of this year one of our largest members, the Peoples Republic of China (it is certainly the largest in terms of population, but not in terms of Medical Physicists) hosted a very successful meeting. It was co-sponsored by the Chinese Association of Radiation Physics (CARP) and the Chinese Society of Medical Physics (CSMP), the International Affairs Committee of the IOMP and the American Association of Physicists in Medicine (AAPM). I had the honour and distinct pleasure, to be a co-president of the meeting.

The meeting, called the Beijing International Congress (BICMRP) was, and I quote Hu Yi Min, Executive Chairman and our ever busy host, "the first of its kind in this century on an international scale in Medical Radiation Physics." It was held in a hotel with excellent conference facilities in downtown Beijing and was attended by more than 150 Chinese participants and well over 50 from other lands. Three full days of papers and discussion followed. Meetings like this where people can easily talk to each other, are exceedingly important for the development of science. The members of the Organizing Committee are to be congratulated on a job superbly done.

Quite in addition to the BICMRP, a somewhat impromptu meeting was organized in Hong Kong by our Hong Kong members to take advantage of the presence of several international physicists in that city on their way to China. The Hong Kong physics society is to be congratulated and thanked for their timely action.

A "before the meeting tour," to a number of locations in China was also organized. The Chinese are known to be good hosts and they amply proved it to those of us who were fortunate enough to take advantage of this opportunity to visit the country that contains nearly a quarter of the worlds population.

We can now look forward to visiting East Asia again next year, for then, early in July (7-12), Japan will host the 9th International Conference on Medical Physics and the 16th International Conference on Medical and Biological Engineering. This will be our next main meeting and I sincerely hope many readers of this bulleting will be able to attend.

J. R. Cunningham, Ph.D., President, IOMP

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IOMP Corporate Members

The following corporations are Corporate Members in the IOMP for 1990:

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IOP Publishing, Ltd. Bristol, England	**Varian** Palo Alto, CA, USA

Funding derived from these sources is allocated to the support of hospital physicists in developing countries. Corporations wishing to receive more information about Corporate Membership should contact: Colin G. Orton, Ph.D., Prof., IOMP Secretary-General, address on page 2.

Announcement

IOP Publishing, Ltd. — Corporate Membership

The Institute of Physics Publishing Ltd. of Bristol, England has recently become a corporate subscriber to IOMP. IOP Publishing, Ltd. is the publisher of Physics in Medicine and Biology which is an official journal of the IOMP. IOP Publishing, Ltd. is the publishing arm of the British Institute of Physics and is a not-for-profit organization which currently publishes about 25 research journals in physics and related fields. They also have a list of about 40 books in medical physics and biomedical engineering, which are published under the Adam Hilger imprint. The company is always keen to seek out new authors in these fields.

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Announcement

Linac Quality Assurance

The French Society of Hospital Physicists (SFPH) edited and published a document on "Quality Control of Electron Accelerators for Medical Use" in July 1989. This document was the result of an SFPH working group under the chairmanship of Miss G. Marnello, and is available both in French and English from:

Genevievè Gaboriaud
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Institut Curie
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Secretary-General's Report

Kyoto World Congress

Plans for the July 7-12, 1991 World Congress on Medical Physics and Biomedical Engineering in Kyoto, Japan, are progressing well. Prof. Hiroshi Abe, President of the Congress, and his colleagues on the Organizing Committee are to be congratulated. Most of you will have received a Brochure announcing the Congress and will shortly be receiving a Call-for-Papers. Please write directly to Prof. Abe at the address given in the Calendar of Events if you need further information.

I have been informed about several other conferences to be held just before or just after the Kyoto Congress in countries fairly close to Japan. Attendees in Kyoto might plan a stop-over in these countries. At this time I believe that plans for none of these conferences have been completed, but the following information is probably close to being correct:

Venue	Topic(s)	Approximate Dates
Xian, Peoples Republic of China	Mainly Biomedical Engineering	15-18 July
Guangzhou, Peoples Republic of China	Mainly Medical Physics	18-21 July
Sydney, Australia	Medical Physics and Biomedical Engineering	Near 21 July
Seoul, Korea	Magnetic Resonance Imaging	Near 5 July

I should know more details on these conferences soon, so please feel free to write to me for more information.

PMB Agreement

I am pleased to announce that we are about to sign a formal agreement with the Institute of Physical Sciences in Medicine (IPSM) and IOP Publishing, Ltd. which, amongst other things, will result in the provision of 10 free annual subscriptions to libraries in developing countries. I need to notify IOP Publishing, Ltd. of recipients for 1991 by November 1 of this year, so those interested in applying for one of these free subscriptions should write to me, with a justification for your application, by October 1.

Libraries Program

We have received several offers of donation of books and sets of journals and several requests to establish libraries in developing countries. Our Developing Countries Committee has authorized me to start to make allocations and arrangements have just begun to establish the first group of libraries. A list of donors and recipients will appear in the next issue of MPW.

Corporate Members

A complete list of Corporate Members appears elsewhere in this Issue, but here I would like to welcome new Members: Computerized Imaging Reference Systems, IOP Publishing, Ltd., Multidata Systems International Corporation and Oldelft and Varian. I also want to specially note that three of our Corporate Members have provided additional funding to establish special programs: Nucleton Corporation have provided $1000 to continue with the Nucletron Travel Grants this year, Gammex has established a $2000 Gammex Companies Fund, and Nuclear Associates has given $1000 for a Nuclear Associates Library. Application forms for these and other IOMP grants are available from my office.

Nominations

The IOMP Council has to elect two Officers during the Kyoto Congress: Vice-President and Secretary-General. Only the Secretary-General is eligible for re-election but, even then, at least two condidates must be nominated for each position. The Nominating Committee is seeking recommendations from the Membership. Any Member wishing to recommend a candidate for nomination for either of these two positions should notify Nominating Committee Chairman, Dr. Cunningham (Address on page 2). Proposals should include all appropriate documentation, plus a letter from the candidate agreeing to be considered for nomination. Deadline for receipt of proposals is October 1, 1990.

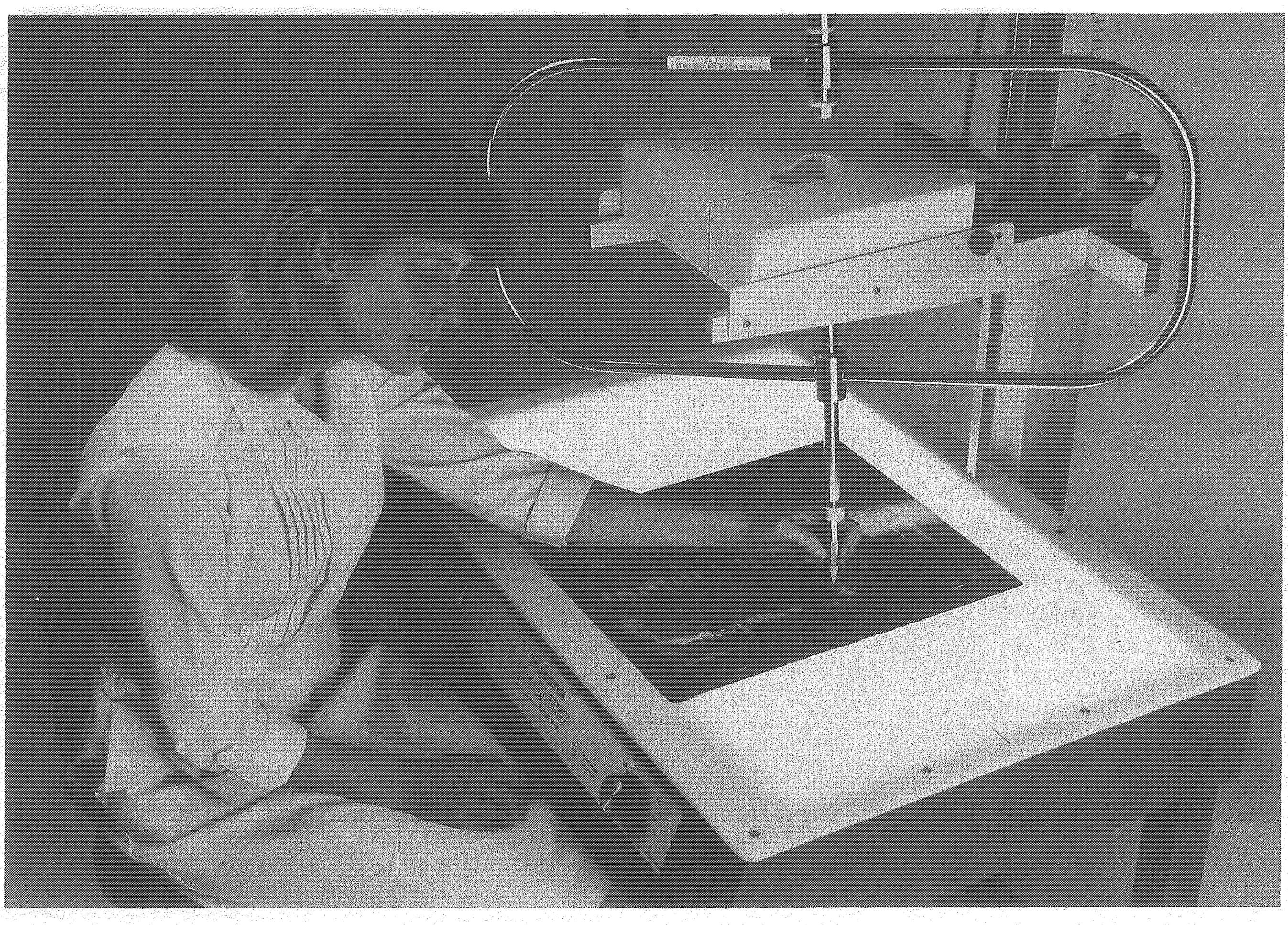
Colin G. Orton, Ph.D.
Secretary-General

Announcement

X International Conference on the Use of Computers in Radiation Therapy

1. In order to help developing countries improve cancer treatment services and follow-up of patients, relevant PC based software is solicited from individual medical physicists. Floppy diskettes accompanied by a two page write-up on the programme may be sent to Dr. P. S. Iyer, Convenor, Scientific Programme Committee, X ICCR, DRP, BARC, Bombay 400085, India. Display facilities and free exchange of softwares will be allowed with due acknowledgement to the contributing authors.

2. Limited funds are available to support delegates' participation from developing countries. Those desirous of availing these may send a brief biodata to the Organizing Secretary, Dr. S. Hukku, Dept. of Radiotherapy, Sanjay Gandhi PGI, P.O. Box 375, Rae Bareli Road, Lucknow-226 001, India as soon as possible. Nominations by National Medical Physics Societies will also be considered.



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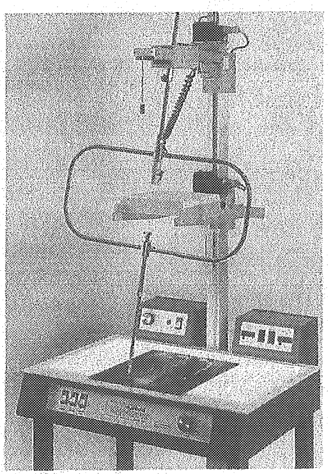

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Comparison of Absorbed Dose Determinations Using the IAEA Dosimetry Protocol and the Ferrous Sulphate Dosimeter

Olof Mattsson
Radiation Physics Department
University of Gothenburg, Sweden

Introduction

In 1985 a comparison of different revised protocols for the dosimetry of high-energy 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 cobaly-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 $e_m G$ of $332 . 10^{-6}\ m^{-2}\ kg^{-1}\ Gy^{-1}$ was used for all beam qualities, see Svensson 1988.

Results

The recalculated absorbed dose values are given in Table 1. The agreement between the two dosimetry methods is within about ±1 percent 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
10 MeV Electron[1]	1.986	2.008	−1.1
10 MeV Electron[2]	1.986	1.964	+1.1
18.1 MeV Electron	1.983	2.002	−1.0

1) Thick scattering foil, applicator scattered electrons
2) Thin scattering foil, no applicator scattered electrons

Conclusions

It can be concluded that the ionization chamber dosimetry using a graphite chamber are 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.

Announcement

1989 Nucletron Travel Scholarships

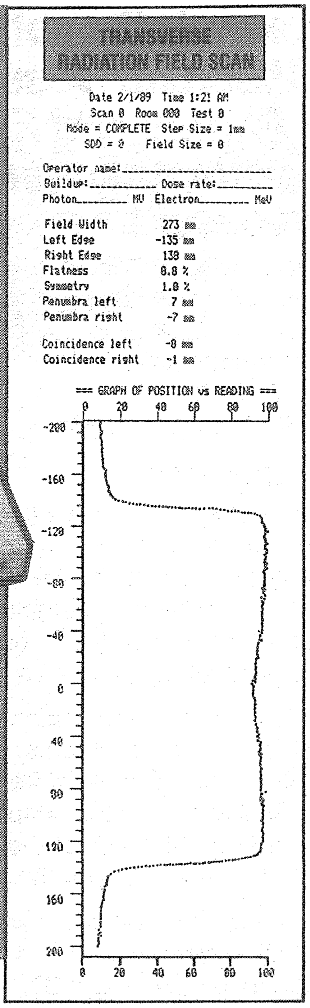
Nucletron Trading BV provided the IOMP $1000 U.S. to support Travel Scholarships as payment of their 1989 Corporate Members dues. The IOMP used this money to provide two scholarships for attendance at the May 1990 International Congress in Beijing. The awardees were:

Dr. Udipi Madhvanath and Mr. Oskar Chomicki

These are both members of our Developing Countries Committee and used this opportunity to meet with Committee Chairman Prof. Xie Nan-Zhu and President Prof. Jack Cunningham to discuss our program of support for developing countries.

Members interested in applying for these scholarships in the future should contact me, preferably at least 6 months before they need the support.

Colin G. Orton



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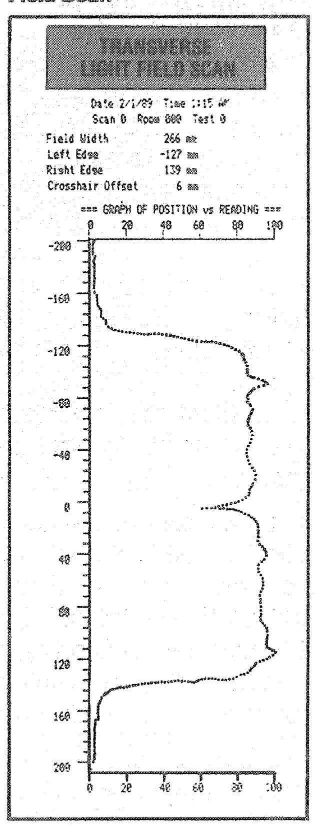

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Presentation of TRS No. 277 *"Absorbed Dose Determination in Photon and Electron Beams. An International Code of Practice"*

Hans Svennson
Head, Dosimetry Section
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A-1400 Vienna, Austria

I. 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 coordinated 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.

II. 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.

Ionization chamber specific factors are then applied to determine the absorbed dose to air chamber factor (or more strictly, the quotient of mean absorbed dose to air in the chamber cavity and the meter reading for the device), N_D. This factor is defined by:

(1)

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

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.

(2)

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

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.

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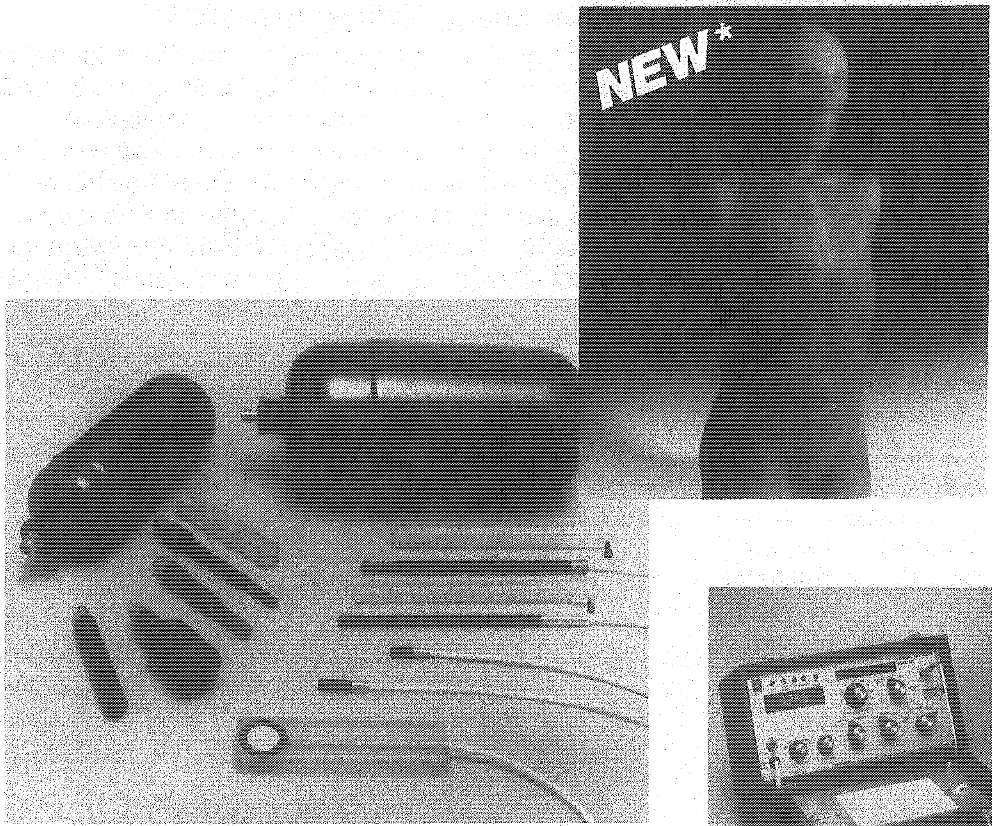

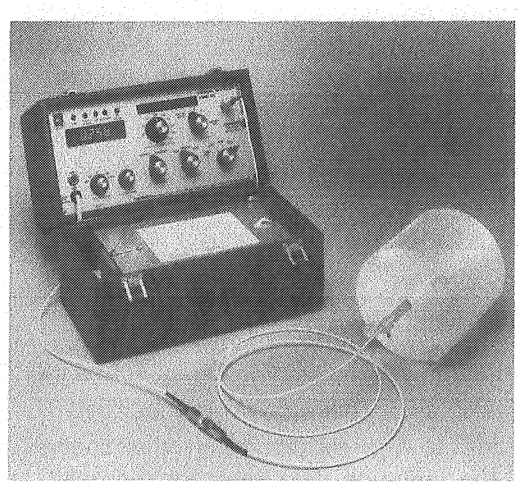

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Some errors in these constants will cancel out if the same set of data is applied throughout the calibration chain, see Andreo et al. (1987).[3]

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[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

$$TPA^{20}_{10} \text{ or } D_{20} / D_{10}$$

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 ±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.

III. 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)

$$D_W = M_u N_K k_u (\mu_{en}/\rho)_{w,air} p_u$$

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 × 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 $k_u p_u$ (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 data on p_u for different types of chambers are needed.

IV. 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.

V. Check of the Code

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

Mattsson had participated in several absorbed dose intercomparisons at the ^{60}Co-gamma rays 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 $\varepsilon_m G$ was assumed to be 353×10^{-6} $m^2 kg^{-1} Gy^{-1}$

Mattsson had also determined values of $\varepsilon_m G$ with a water calorimeter, (Mattsson 1984).[10] His values on $\varepsilon_m G$ for ^{60}Co-gamma rays, high energy X-rays and electrons were all between 349×10^{-6} and 354×10^{-6} $m^2 kg^{-1} Gy^{-1}$. No energy dependence could be proven. The total uncertainty was estimated to ± 1 percent (L.S.D.)

Pettersson 1967 used a water calorimeter of a different construction to determine the G-value for ^{60}Co-gamma rays and 20 MeV electrons. He reported within 0.1% the same $\varepsilon_m G$ for these two qualities. A very recent experimental work by Berkvens gave a constant $\varepsilon_m G$, within parts of one percent 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

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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 $\varepsilon_m G$ could be used for ^{60}Co-gamma rays, high-energy x-rays and electrons. An $\varepsilon_m G$ equal to 352×10^{-6} $m^2 kg^{-1} Gy^{-1}$ was recommended by the ICRU report 35, which is thus is in good agreement with recent investigations. This value is therefore applied for all beam qualities by Mattsson in the separate Note in this newsletter for the test of the Code.

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

Futher experiments to check the Code will be carried out. A special coordinated research project was started including 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).

VI. 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 of 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 percent, 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 percent 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.

VII. 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).

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 today 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 "coordinated research project." It might be that some changes will be necessary after this evaluation.

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CALENDAR OF EVENTS

Geoffrey S. Ibbott, Editor

1990

September

Inter-regional Seminar on Radiotherapy Dosimetry, Leuven, Belgium (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

September 4 - 7

3rd International Conference on "Applications of Physics in Medicine and Biology, Medical Diagnostic Imaging," sponsored by International Centre for Theoretical Physics (ICTP), Istituto Nazionale di Fisica Nucleare (INFN), and Societa Italiana di Fisica (SIF), Miramare, Trieste, Italy, (ICTP, Conf. on Appl. of Phys. in Med. and Biol., P.O. Box 586, I-34100 Trieste, Italy).

September 5 - 7

6th International Selection Users' Meeting, Montecatini, Italy (Rosemarie Warshowsky, Marketing Manager, Nucletron Corporation, 9160 Red Branch Road, Columbia, Maryland 21045, [Tel: 301-964-2249, FAX: 301-964-0912]).

September 9 - 11

ESTRO Teaching Course on "New Trends in the Management of Malignant Lymphomas," "The Molecular Biology of Cancer," "Quality Control Procedures in Radiotherapy Departments," Firenze, Italy (ESTRO Secretariat, U.Z. St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

September 9 - 14

Congress Ampere on Magnetic Resonance, Stuttgart, FRG (J.U. von Schutz, 3, Physikalisches Instiut, Pfaffenwaldring 57 FRG).

September 10 - 13

9th Annual Meeting of the European Society for Therapeutic Radiology and Oncology, Including Sessions on Biology and Quality Assurance, Centro Congressi, Montecatini, Italy (ESTRO Secretariat, University Hospital St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Austria).

September 12 - 15

4th Congress of the South African Society of Nuclear Medicine, Kruger National Park, South Africa (Jan Esser, Department of Nuclear Medicine, Area 559, Johannesburg Hospital, P.O. Box 39, Johannesburg, 2000, South Africa).

September 12 - 16

Institute of Physical Sciences in Medicine Annual Conference, Oxford, England (Institute of Physical Sciences in Medicine, 2 Low Ousegate, York YO1 1QU, United Kingdom).

September 13 - 17

6th Regional Conference of Asia and Australia of the International Society of Radiographers and Radiological Technicians, Christchurch, New Zealand (Miss V. Crown, 38 High Ashton, Kingston Hill, Kingston, Surrey KT2 7QL, United Kingdom).

September 14 - 19

Asian Oceanian Congress of Radiology, New Delhi, India (Dr. Sudarshan K. Aggarwall, Indian Radiological and Imatging Association, Dr. Dewan Chand Aggarwal X-ray Clinic, 10-B, Kasturba Gandhi Marg., New Delhi 110 001, India).

September 17 - 20

11th Conference of the European Society for Hyperthermic Oncology, Latina, Italy (G. Arcangeli, M.D., Chairman of the Organizing Committee, G. Porfiri Oncology Centre, S. Maria Goretti Hospital, 04100 Latina, Italy [0773-662177]).

September 19 - 21

EULEP International Symposium on the Clearance of Inhaled Particles, (CEC, Dr. W. G. Dreyling, GSF-P1, Ingolstadter Landstr. 1, D-8042, Neuherberg, F R Germany).

September 19 - 22

Annual Meeting of the Royal College of Radiologists, Edinburgh, Scotland, United Kingdom (The Conference Officer, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG, United Kingdom).

September 21

ALARA, London, UK (INE Mrs. S. Blackburn, Institution of Nuclear Engineers, 1 Penerley Road, London, SE6 2LQ, UK).

September 21 - 22

International Symposium on Remote Afterloading & Brachytherapy, (Dattatreyudu Nori, M.D. [718-670-1500]).

September 23 - 28

23rd Annual Meeting of the European Society for Radiation Biology, Trinity College, Dublin, Ireland (ESRB Secretariat, Nuclear Energy Board, Clonskeagh Square, Dublin 14, Ireland [353-1-697766]).

September 24 - 27

Joint Annual Conference of the Australian Radiation Protection Society and the Australasian College of Physical Scientists and Engineers in Medicine, Adelaide, Australia (Dr. A. H. Beddoe, Conference Secretariat, SAPMEA, GPO Box 4-98, Adelaide, South Australia 5001 [Tel: 61-8-232-0918]).

September 25 - 28

International Conference on Monte Carlo Methods in Neutron and Photon Transport, Budapest, Hungary (Dr. L. Koblinger, Central Research Institute for Physics, P.O. Box 49, H-1525, Budapest, Hungary).

September 30 - October 3

4th International Evoked Potentials Symposium, Toronto, Ontario, Canada (Colin Barber, Ph.D., Symposium Co-Director, Medical Physics Department, Queen's Medical Centre, Nottingham NG7 2UH, England [44 602 421421 Ext. 3531]).

October 7 - 12

5th Latin American Conference on Medical Physics, Ribeiraro Preto, Sao Paulo, Brazil (Thomaz Ghilardi, Netto, CIDRA-FFCRP-USP, AV. Bandeirantes 3900).

October 16 - 19

29th Hanford Symposium on Health and the Environment, "Indoor Radon and Lung Cancer: Reality or Myth?" Tower Inn Richland, Washington, D.C., U.S.A. (Ray W. Baalman, Manager, Planning & Communications, MS K4-14 Life Sciences Center, Battelle, Pacific Northwest Laboratories, Richland, WA 99352 [509-376-3655]).

October 22 - 26

ESTRO Teaching Course on "The Role of Radiotherapy in the Management of Cancer," Copenhagen, Denmark (ESTRO Secretariat, U.Z. St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

November 4 - 7

14th Symposium on Computer Applications in Medical Care, Sheraton Washington Hotel, Washington, D.C., U.S.A. (The George Washington University Medical Center, Office of Continuing Education, 2300 K Street, N.W., Washington, D.C. 20037, U.S.A.).

November 11 - 14

10th International Conference on the Use of Computers in Radiotherapy, Sanjay Gandhi Post-Graduate Institute of Medical Sciences, Lucknow, India (Scientific Programme Contact Dr. P. S. Iyer, Head, MPSC, Division of Radiological Protection, Bhabha Atomic Research Centre, Bombay 400 085, India [Tel. 022-5514910, Ext. 2623]).

November 11 - 15

ESTRO Teaching Course in "Basic Clinical Radiobiology," Granada, Spain (ESTRO Secretariat, U.Z. St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

November 11 - 16

Winter Meeting of the American Nuclear Society, Washington, D.C., U.S.A. (Meetings Department, American Nuclear Society, 555 North Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

November 12 - 15

3rd International Symposium on Intraoperative Radiation Therapy, Kyoto, Japan (Mitsujuki Abe, M.D., Professor and Chairman, Department of Radiology, Faculty of Medicine, Kyoto University, Shogoinkawaharacho, Sakyo-ku, Kyoto 606, Japan).

November 25 - 30

Joint Meeting of AAPM with the Radiological Society of North America, Chicago, Illinois, U.S.A. (AAPM Executive Officer, 335 East 45th Street, New York, New York 10017, U.S.A. [212-661-9404]).

1991

Vienna, Austria

International Symposium on Health Effects of Ionizing Radiations: Radiation Protection Implications, (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

Goettingen, F.R. Germany

Joint Congress on Radiation Protection in Medicine, (Mr. H. Brunner, Abt. SU, EIR, CH-5503, Wurenlingen, Switzerland).

January 21 - 24

American Association of Physics Teachers Annual Winter Meeting, San Antonio Marriott Rivercenter, San Antonio, Texas, U.S.A. (American Association of Physics Teachers, 5112 Berwyn Road, College Park, Maryland 20740, U.S.A.).

February 17 - 20

1st European Conference on Biomedical Engineering, Nice, France (E.C.B.E./SEPFI, Bernard Leon, 8, rue de la Michodiere, 75002, Paris, France [33.1 47 42 92 56, TELEX: 33.1 42 66 14 28]).

March 11 - 15

Annual Conference and Summer School of the South African Association of Physicists in Medicine and Biology: "Biophysical Aspects of Therapy Beams," Cape Town, South Africa (Dr. D. T. L. Jones, National Accelerator Centre, P.O. Box 72, 7131 Faure, South Africa).

April 11 - 13

ART 91 — International Symposium on Treatment Planning and Tumor Response Monitoring, Munich, Federal Republic of Germany (Peter Kneschaurek, Ph.D., or Andreas Heuck, M.D., Institut fur Radiologische Onkologie, Technische Universitat Munchen, Ismaninger Str. 15, D-8000 Munchen, Fed. Rep. of Germany. [Tel: 49-89-41-40-43-04 or 49-89-41-40-43-01, Fax: 49-89-41-40-43-96]).

April 30 - May 4

Conference on Occupational Exposure, Guernsey, Channel Islands (Mr. G. A. M. Webb, National Radiological Protection Board, Chilton, Didcot, Oxon, OX11 ORQ, UK).

May 2 - 4

Radiology 91, 49th Annual Congress of the British Institute of Radiology, Brighton, United Kingdom (Programme Office, The British Institute of Radiology, 36 Portland Place, London W1N 4AT, United Kingdom [01-580-4805]).

May 16 - 19

8th Annual Meeting of the American College of Medical Physics, Lake of the Ozarks, Missouri, U.S.A. (American College of Medical Physics, 1891 Preston White Drive, Reston, Virginua 22091).

June 2 - 6

Annual Meeting of the American Nuclear Society, Orlando, Florida, U.S.A. (Meetings Department, American Nuclear Society, 555 North Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

June 10 - 14

5th IRPS International Symposium on Radiation Physics, (ATLAS — Congress Department, ISRP-5 Lastovska, 23, Yugoslavia, [(41) 525-333 or (41) 231-555, Telex: 22413, Fax: (41) 335-977]).

June 17 - 20

Canadian Organization of Medical Physicists Annual Meeting with Canadian College of Physicists in Medicine and Canadian Radiation Protection Association, (Dr. Walter Huda, Medical Physic, 100 Olivia St., Winnipeg, Manitoba R3E 0V9, Canada [204-787-4191, FAX: 204-783-6875, ENA: WHUDA@UPFMCC]).

July 5 - 6

2nd International Symposium on Biophysical Aspects of Auger Processes, University of Massachusetts, Amherst, Massachusetts, U.S.A. (Dandamudi V. Rao, Ph.D., Professor of Radiology, University of Medicine and Dentistry of New Jersey, 185 South Orange Avenue, Newark, New Jersey 07103-2757, U.S.A.).

July 7 - 12

9th International Congress of Radiation Research, Sheraton Center, Toronto, Ontario, Canada (Ms. Meg Keiser, Radiation Research Society, 1101 Market Street, 14th Floor, Philadelphia, Pennsylvania 19107, U.S.A. [215-574-3153]).

July 7 - 12

World Congress on Medical Physics and Biomedical Engineering: the 9th International Congress of Medical Physics and the 16th International Conference on Medical and Biological Engineering, (Dr. Hiroshi Abe, President 9th International Congress of Medical Physics, C/O Japan Convention Services, Inc., Kansai Branch, Sumitomo Seimei Midosuji Bldg., 4-14-3 Nishitemma, Kita-ku, Osaka 530, Japan).

July 21 - 25

Health Physics Society Annual Meeting, Columbus, Ohio, U.S.A. (Health Physics Society, 8000 Westpark Drive, Suite 400, McLean, VA 22101, U.S.A.).

July 21 - 25

American Association of Physicists in Medicine, 33rd Annual Meeting, San Francisco, California, U.S.A. (AAPM, 335 East 45th Street, New York, New York 10017, U.S.A.).

July 21 - 26

35th Annual International Technical Symposium on Optical and Optoelectronic Applied Science and Engineering, San Diego, CA (SPIE, P.O. Box 10, Bellingham, WA 98227-0010, U.S.A. [206-676-3290]).

September 2 - 5

5th Breast Cancer Working Conference, EORTC Breast Cancer Cooperative Group, Pauscollege Leuven, Belgium (Department of Radiotherapy, University Hospital St. Rafael, Capucijnenvoer 33, 3000 Leuven, Belgium, [32-16-21-22-11]).

September 2 - 6

6th Meeting World Federation for Ultrasound in Medicine and Biology, Copenhagen, Denmark (Soren Hanke, Ultralydlaboratoriet, Kobenhavns Amts Sygehus, Gentofte, DK-2900 Hellerup, Denmark).

September 2 - 6

Leuven, Belgium, Inter-Regional Seminar on Radiotherapy Dosimetry, (Conference Service Station, IAEA, P.O. Box 100, A-1400 Vienna, Austria).

September 8 - 14

International Conference on Magnetism, United Kingdom (The Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX, United Kingdom [01 235 6111]).

September 9 - 13

Dosimetry Course, Jointly Organized by the ESTRO and the International Atomic Energy Agency (IAEA), Vienna. Leuven, Belgium (ESTRO Secretariat, U.Z. St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

September 15 - 20

ECR '91; 7th European Congress of Radiology, Austria Center, Vienna, Austria (Mrs. Sylvia Altermann, Vienna Medical Academy, Alser Strasse 4, 1090 Vienna, Austria [Tel. 43-222 421383, Telex: 134743 medak a]).

September 16 - 20

ESTRO Teaching Course on Radiation Physics for Clinical Radiotherapy, Leuven, Belgium (ESTRO Secretariat, U.Z. St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

September 18 - 21

Annual Meeting of the Royal College of Radiologists, Warwick, United Kingdom (The Conference Officer, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG, United Kingdom).

October 27 - 31

ECCO 6/ESTRO 10, Firenze, Italy (ESTRO Secretariat, U.Z. St. Rafael, Department of Radiotherapy, Capucijnenvoer 35, 3000 Leuven, Belgium).

November 10 - 15

Winter Meeting of the American Nuclear Society, San Francisco, California, U.S.A. (Meetings Department, American Nuclear Society, 555 Kensington Avenue, LaGrange Park, Illinois 60525, U.S.A.).

November 17 - 20

15th Symposium on Computer Applications in Medical Care, Sheraton Washington Hotel, Washington, D.C., U.S.A. (The George Washington University Medical Center, Office of Continuing Education, 2300 K Street, N.W., Washington, D.C. 22037, U.S.A.).

December 1 - 6

Joint Meeting of AAPM with the Radiological Society of North America, Chicago, Illinois, U.S.A. (AAPM, 335 East 45th Street, New York, New York 10017, U.S.A. [212-661-9404]).

December 14 - 18

6th Asian Oceanian Congress of Radiology, New Delhi, India (Dr. Diwan Chand Aggarwal , Imaging Research Centre, 10-B, Kasturba Gandhi Marg, New Delhi-110 001, India [3329887, Telex: 3165141, Fax: 3324652]).

1994

August 20 -26

World Congress on Medical Physics and Biomedical Engineering: 10th International Congress of Medical Physics and 17th International Conference on Medical and Biomedical Engineering, Rio de Janeiro, Brazil.

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*Readers are invited to send to the **Calendar of Events** Editor, Geoffrey S. Ibbott, M.S. (address on page 2), information on any events not listed in this issue of MPW and also additions or corrections to the items that are listed. Officers of national societies are especially encouraged to submit information on their future national meetings.*

Continued from page 12

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.
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Editorial Policy

Medical Physics world welcomes correspondence from medical physicists around the world. We are especially interested in receiving articles which review the status of medical physics in countries where "medical physics" is still a developing profession, such as the article on page 20. Please send all correspondence intended for publication typed, double spaced to the Editor. The deadline for the next issue is October 1, 1990.

The International Union of Physical and Engineering Sciences in Medicine: *A Communication*

Lawrence H. Lanzl, Ph.D.
President, IUPESM
and
Robert L. Clarke, Ph.D.
Secretary-General, IUPESM

Our fields of science, i.e., physical and engineering sciences in medicine, progress through steps of discovery, measurement, theory and finally, consensus.

For arriving at consensus, mechanisms of communication are imperative. In the area of communication, the International Union of Physical and Engineering Sciences in Medicine (IUPESM) has evolved to a position of world importance in just about a decade since its formation in 1982. This has occurred because IUPESM is, in part, an umbrella organization made up at present of two member organizations, the International Organization for Medical Physics (IOMP) and the International Federation for Medical and Biological Engineering (IFMBE). Both of these had a history of successful national and international meetings held independently of each other.

There were early attempts by IFMBE and IOMP to join forces, related to one of the authors (RLC) by Val Mayneord (U.K.), one of the founders of IOMP. The earliest attempt, made when both organizations were in their formative stages, were perhaps premature, and truth to tell, encountered some personality problems. At the time of the meetings of 1976, held contiguously but separately in Ottawa, the time seemed ready for a renewed attempt. The credit for the success of the resulting negotiations should go largely to Jack Hopps (Canada) of IFMBE and John Mallard (U.K.) of IOMP. It is to the work of Jack Hopps that we owe the support of the Canadian National Reserach Council. Starting in 1979 in Jerusalem, Israel joint international medical physics and biomedical engineering conferences have been held.

Today, the joint meetings are designated as the "World Congress of Medical Physics and Biomedical Engineering," sponsored by IUPESM, IFMBE and IOMP. The next two Congresses will take place in Kyoto, Japan (1991), and Rio de Janeiro, Brazil (1994).

The General Assembly of IUPESM held in San Antonio, Texas, in 1988 made a number of important decisions which its council was empowered to carry out. The following action on these decisions is being taken:

A. Statutes

The statutes of IUPESM were to be divided and reorganized into Statutes and By-Laws. The statutes can be amended, but amendments require two thirds of the delegates' votes for approval; the by-laws on the other hand, require only a majority vote for amendments. The redrafting of the statutes and by-laws is essentially

Continued on page 18

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Continued from page 16

complete. The objectives of the statutes remain very much the same, namely:

The aims for the IUPESM are:

(a) To contribute to the advancement of physical and engineering sciences in medicine;

(b) To organize international cooperation and promote communication among those engaged in health care science and technology;

(c) To coordinate activities of mutual interest to engineering and physical science within the health care field: international and regional scientific conferences, seminars, working groups, regional support programs and scientific and technical publications; and

(d) To represent the professional interests and views of engineers and physical scientists in the health care community.

The redrafted statutes also clarify the various types of membership in the Union. In addition to the founding constituent organizations of the Union (IFMSE and IOMP), any country having adherence with the Union may be represented at a General Assembly by a National Member. The National Member in each case is to be the National Academy of Science, the National Research Council or similar authority, OR a scientific or engineering society or group of societies, or other national body specifically constituted for adherence with the Union.

B. Membership in The International Council of Scientific Unions

We received Associate Status with the International Council of Scientific Unions in 1982. The 1988 General Assembly of IUPESM gave the Council a mandate to pursue full membership in the International Council of Scientific Unions (ICSU). Among the advantages of full membership is the increased recognition of the physical and engineering sciences in medicine by national government. In addition, recognition and funding for third-world activities in our fields of science is enhanced because of the relationship of ICSU with the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Another advantage is the possibility for medical physicists and engineers to be appointed to the General Committee of ICSU. ICSU is the most important non-governmental international body worldwide that addresses scientific concerns, many of which are global in nature. ICSU has had the leading role in worldwide interdisciplinary research programs such as the International Geophysical Year, the International Biological Programme, as well as the International Geosphere-Biosphere Programme: A Study of Global Change.

IUPESM has launched a campaign to gain full membership in ICSU in the year 1991 and has made a commitment to achieve this goal.

C. Venue of the World Congress

It was obvious at the 1988 World Congress on Medical Physics and Biomedical Engineering that IUPESM needed to improve the method of selecting the venue for future Congresses. In 1988, the Council began to develop criteria for Congress site selection for prospective hosts. This document specifies that the IUPESM Congress Coordinating Committee represents the IFMBE and IOMP. An application to host a Congress must be submitted by both the biomedical engineering and the medical physics organization in the host country.

The procedures to be used by the Congress Coordinating Committee in selecting a site for a World Congress have also been drafted, and they are being submitted to the executives of the IFMBE and IOMP for consideration and possible revision.

D. IUPESM Award of Merit

The IUPESM Award of Merit is to be presented at the World Congresses in recognition of a medical physicist or a biomedical engineer who has established a distinguished career in medical physics and/or biomedical engineering. The criteria for the award have been established, and the first Award was presented in 1988 in San Antonio. The Award Committee will consists of the Vice-President of the IUPESM as the Chairman, together with two representatives each from IFMBE and IOMP.

E. Young Investigators' Award

During the 1988 World Congress a young investigators award was inaugurated. For the 1991 World Congress, IUPESM is planning to hold a Young Investigators Symposium. An announcement concerning the selection of presenters as well as the awarding of several prizes to young investigators has been completed. Announcements of the Symposium will be circulated through the IFMBE and the IOMP, as well as the Japanese Organizing Committee.

F. Support for IUPESM

Over the past several formative years of the IUPESM, the National Research Council of Canada has very generously supported the work of IUPESM by providing direct financial help as well as allowing us to share with the Canadian Medical and Biological Engineering Society (with whom we share staff). The officers and other council members of the Union wish to thank the National Research Council of Canada for this much needed assistance.

G. IUPESM Council Members

The Council of IUPESM for the years 1988-1991 comprises of the following individuals:

IUPESM COUNCIL

IUPESM OFFICERS

Lawrence L. Lanzl (USA) — President
Oivind Lorentsen (Norway) — Past-President
Nandor Richter (Hungary) — Vice-President
Robert Clarke (Canada) — Secretary-General
Sally Chapman (Canada) — Executive Secretary

MEMBERS OF COUNCIL

IFMBE		IOMP
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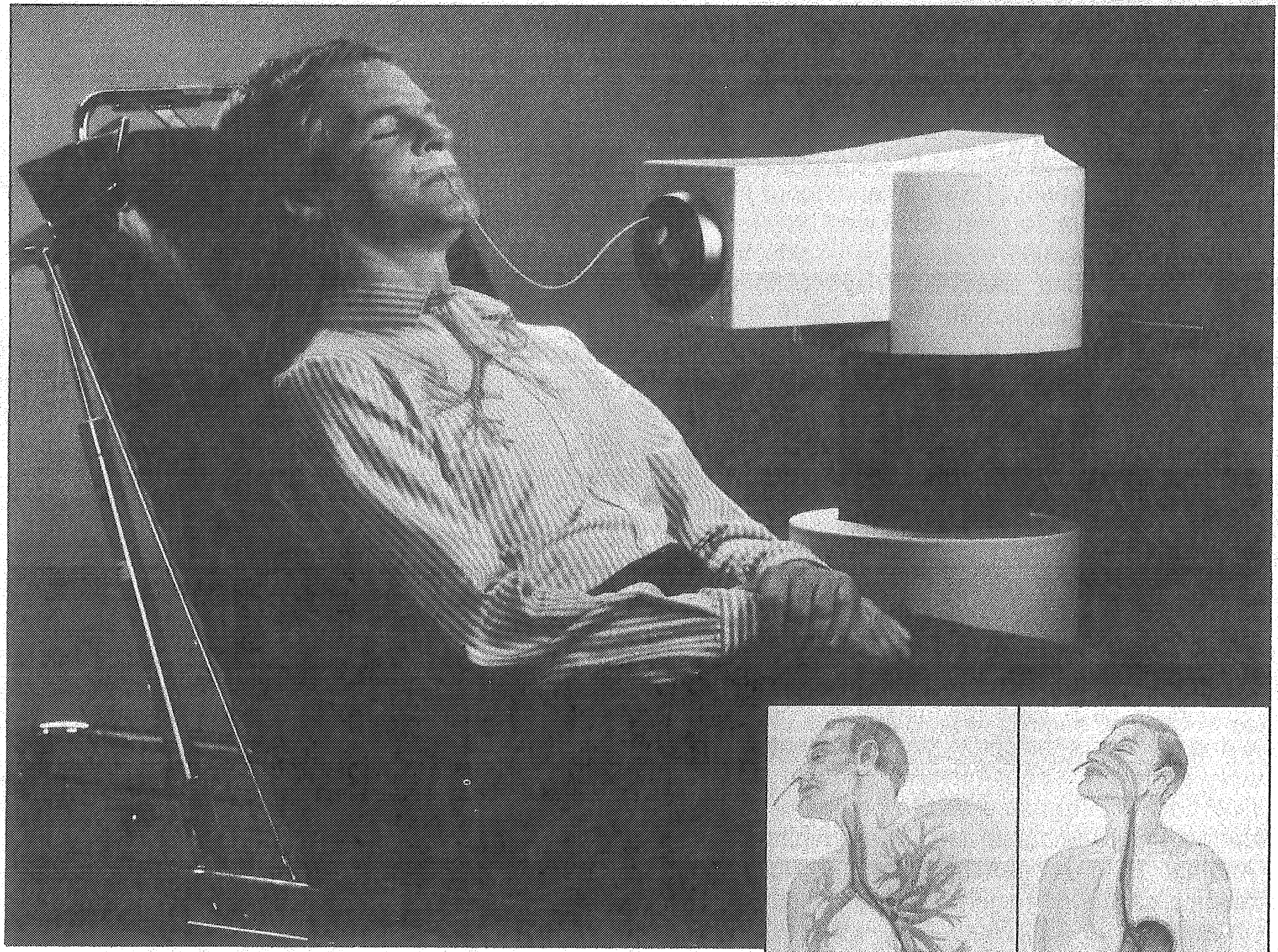

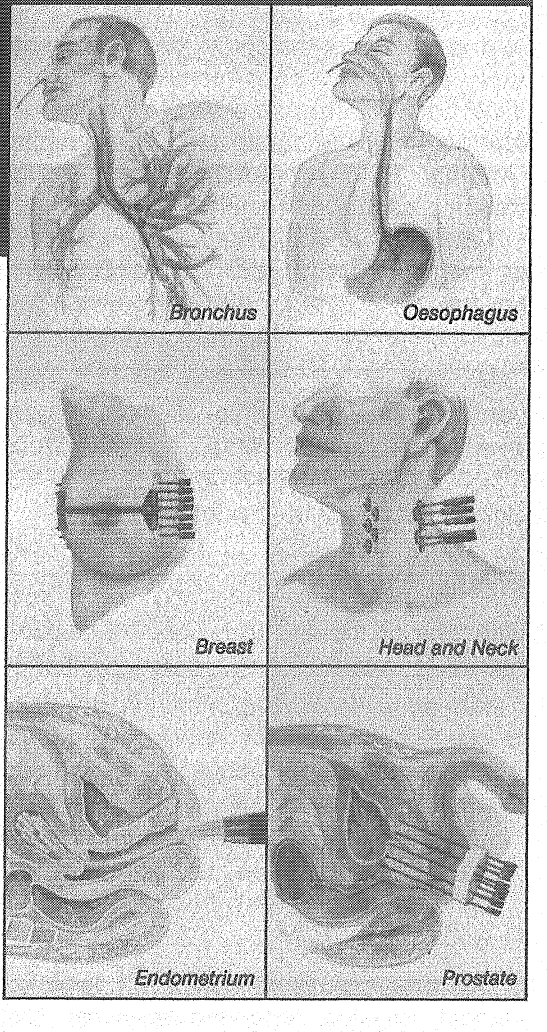

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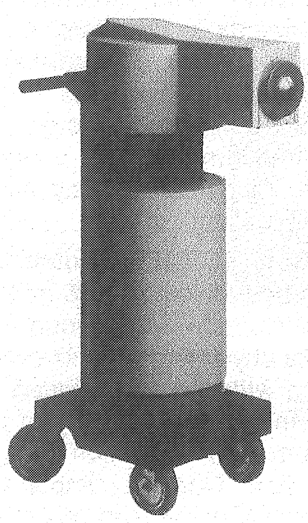

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The Greek Association of Medical Physicists

S. Xenofos, Ph.D.
Past President
Greek Association of Medical Physicists

The history of Medical Physics in Greece started in 1962 with the employment of a small number of physicists in the hospitals to deal with work related to radiotherapy with Cobalt-60 teletherapy machines and in vivo diagnostic and therapeutic applications of unsealed radioactive substances.

The Greek Association of Medical Physicists was founded in 1969 by 22 Physicists. Since then this number has increased considerably and there are today 85 medical physicists in our country, the vast majority of which work in the field of medical applications of ionizing radiations in hospitals.

Training and education of medical radiation physicists has taken place in the Nuclear Research Centre Democritos under the supervision of the Greek Atomic Energy Commission (GAEC). Courses have been organized in 1961, 1963, 1968, 1973 and 1981 and a total of 56 physicists have been graduated. The course in 1981 lasted for 18 months and included 467 lectures, 37 laboratory exercises, and 4 months practical work in hospitals. Each student also had to prepare a written dissertation under the supervision of a hospital physicist. Another 25 physicists have been educated in medical physics abroad mainly in the U.K. and France through appropriate M.Sc. or D.E.A. courses. Seven of our members have Ph.D. degrees from abroad, two are full professors of medical physics and 4 are assistant professors at the Greek Universities (Faculty of Medicine).

In order that a Radiation Medical Physicist be employed in a hospital and assume responsibility (Ministerial Act 1978) he must have:

1. University Degree in Physics.
2. An M.Sc. Degree or equivalent in Radiological Physics.
3. One year of training in a hospital Department of Medical Physics.
4. Certification from the Ministry of Health and Social Security of his competence obtained after written examinations on the following fields:

   Physics of Radiotherapy; Physics of Nuclear Medicine; Physics of Diagnostic Radiology; and Radiation Protection, with emphasis on subjects of day to day involvement in hospital work.

The board of assessors consist of two Professors of Medical Physics, one Professor of Diagnostic Radiology, a representative from the Greek Atomic Energy Commission, a representative from our Association and a representative from the Ministry of Health.

Medical Radiation Physicists were involved in 1970's in the preparation of the Greek Radiation Protection Regulations which became effective in 1978. Two of our members, Mr. Tsialas from GAEC and Professor Proimos from St. Savvas Hospital at that time, have had a leading role in this work.

Through the above legislation, Radiotherapy and Nuclear Medicine Departments must be served by a medical radiation physicist responsible for radiation protection, dosimetry, equipment calibration and quality control. In diagnostic radiology however, this is not compulsory and physicists are involved in this field only in hospitals where there are large Radiotherapy and Nuclear Medicine Departments and therefore an adequate number of Physicists are employed. It is hoped, however, that, through the EEC Directive 84/466 and proposals made by our Association to the Greek Atomic Energy Commission, quality control will become compulsory for all radiological installations. This will considerably increase the number of measurements related with image quality and radiation protection in an area which contains approximately 1,000 diagnostic x-ray machines all over Greece. Today there are fourteen Medical Physics Departments, which cover the workload of 17 cobalt units, 10 accelerators, 10 brachytherapy systems, 20 gamma cameras, 20 x-ray therapy machines and 20 linear scintiscanners. A number of Co-60 units and gamma x-cameras also exist in private clinics and laboratories.

Our Association (GAMP) have been involved in several professional and scientific matters such as:

1. The preparation of several reports which were submitted to the Ministry of Health, concerning the importance, organization and structure of Medical Physics Departments in hospitals. As a result it is now possible that Physics Departments can be formally established in hospitals if required (Presidential Act 1986). It is however unfortunate that such departments are usually under-staffed and the only personnel they have are medical radiation physicists.
2. The revision of the existing Radiation Protection Regulations, which was undertaken in 1985 by the Greek Atomic Energy Commission. Though a large number of medical physicists were involved in the early stages, and with the undersigned in the nine member steering committee formed by GAEC, important views of our Association are not reflected in the final draft. One very important issue has been the ambiquity of the term "qualified expert" mentioned in the Directive 80/836. We believe that EFOMP and if possible IAEA should

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clearly state that with reference to medical applications of ionizing radiations, the qualified expert mentioned in Directive 80/836 must be a Medical Radiation Physicist.

3. The preparation and realization of appropriate course structure for the education and training of Medical Radiation Physicists in collaboration with the Radiation Protection Department and the Institute for Radiation Physics, Nuclear Research Centre "Democritos." In 1987 our Association also proposed to the Education Committee, Ministry of Health, a period of three years (paid) hospital training, instead of the one year mentioned before, but this has not been resolved yet.

4. The preparation of a report submitted in 1988 to the Ministry of Health and the Greek Atomic Energy Commission, about the implementation of a periodic Radiation Protection and Quality Control Program for Diagnostic Radiological Installations (both public and private). We have proposed that every diagnostic installation should be checked periodically for radiation protection and image quality by a medical radiation physicist, who will also prepare and submit a report to the Radiation Protection Department of GAEC.

   Regional Physics Departments should be established which would undertake the above responsibility of all the hospitals belonging to the same region, whereas private radiological installations should be inspected either directly from GAEC or on a private basis by authorized Medical Radiation Physicists.

5. The Chernobyl incident in 1986, by informing the public through letters to the newspapers, lectures in hospitals, etc. about basic terms and physical quantities of interest and the possible implications of the above incident on the Greek population. The latter was based on preliminary measurements made in hospitals as well as those available from the Greek Atomic Energy Commission and bibliography.

6. GAMP has also organized (in cooperation with the Greek Society of Biomedical Engineering) two Conferences on Medical Physics and Biomedical Engineering in 1984 and 1986. We also organized a Seminar on Quality Control and Radiation Protection of Diagnostic Radiological Installations and Equipment which was held in Athens from 25-28 November 1987.

The Greek Association of Medical Physicists is a member of IOMP and EFOMP, and we believe they have a very important role to play in professional, scientific and educational matters and can strengthen the status of our profession.

Quality Control In Diagnostic Radiology

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I. Introduction

This paper will address the evaluation of radiological equipment used in diagnostic x-ray departments including conventional radiography, fluoroscopy with associated film devices for photospot films, conventional spot films and cinefluorography, digital subtraction angiography, computed tomography, conventional tomography, mammography, and film processing systems. Evaluation of shielding barriers, which has received extensive discussion by the NCRP[1], ICRP[2] and others and performance evaluation of non x-ray imaging systems, including nuclear magnetic resonance and ultrasound systems, will not be discussed.

The additional question of a more encompassing program of **quality assurance,** which includes training of personnel and implementation of various administrative procedures in an attempt to guarantee production of high quality images and correct interpretation of those images, has been discussed, along with quality control recommendations, in a recent report of the NCRP[3].

II. Motivations

There are many reasons to test the imaging equipment: to observe the equipment performance at installation in order to determine that it is working properly, to determine that it is currently working as well as it did at the time of installation, or to determine that repairs or modifications have improved recent improper performance. Testing may be required to satisfy requirements of regulatory agencies of the national or local government. The testing program may have been instituted according to the recommendations of international or national advisory bodies such as ICRU[4], ICRP, IEC[5], NCRP, AAPM[6], CDRH[7] and SMPTE[8].

III. Program Goals

Before the test program is instituted, the goal of the program must be defined. Possible motivations might be: to evaluate carefully the operation of the imaging equipment and to recommend changes which will improve performance; to satisfy limited requirements of regulatory agencies; or merely to generate impressive written test reports without addressing the correction of problems — an avenue which has all too often been taken. Obviously, the first approach will provide the greatest benefit to the patients and staff. Different levels of testing include sophisticated, elaborate and lengthy tests, routine periodic quality control tests, and specific problem solving tests.

IV. Choice of Test Equipment

Test equipment should be chosen on the basis of accuracy, precision, suitability for the specific measurement task, general applicability to a variety of measurements, ease of use, and acceptable cost. There are many additional aspects of the equipment which influence the choice of purchase, particularly if it is to be transported to a number of radiological facilities. These include size, shape, weight, electrical power requirements, and ruggedness of construction.

For certain measurements on the x-ray generator, including those of tube potential and current, a choice must often be made between invasive (voltage divider) and non-invasive devices (electronic kVp meter, clamp on ammeter). The decision may be based not only on those considerations mentioned above but also on the basis of hazard to personnel and time and effort required for connection of the device to the generator circuit, high-voltage transformer or x-ray tube. In addition, invasive devices often significantly affect the operation of the equipment being tested, which may require extensive corrections to the measurement data.

V. Radiographic Equipment

The following items should be tested on the radiographic system:

A. Generator

The incoming voltage levels from the power supply, which may be either an AC line or batteries, can be measured with a suitable multi-meter. The peak tube potential (kVp) applied to the x-ray tube may be determined with an invasive voltage divider system, a non-invasive electronic kVp meter, or the non-invasive Ardran-Crooks film cassette.[9] In addition to determining the kVp, it is desirable to observe the voltage waveform for a variety of kVp, mA and time settings. These observations require a storage oscilloscope and either a voltage divider or a non-invasive meter with an oscilloscope output. (One should note that the oscilloscope output from many of the electronic meters is not proportional to kVp).

The length of the exposure, or exposure time (sec or msec) can be measured with a variety of methods. These include measuring the length of the high voltage pulse on a calibrated oscilloscope trace, using a variety of electronic timers which contain a diode detector and a digital output meter, electronic or manual (single-phase wave forms only) spinning tops.

The tube current (mA) or tube current-exposure time product (mAs) may be measured with suitable multimeters. These quantities may also be available from the digital readouts of a voltage divider system.

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B. X-Ray Tube

The focal spot sizes for small and large focal spots (mm) must be determined. This measurement may be of either the geometric size as determined by the pinhole camera ot slit camera methods, or the effective focal spot size as determined from the star pattern method. [10] [11] The pinhole and slit methods require more expensive equipment, more precise alignment of the devices and long exposure times, possibly multiple exposures for adequate film density. The star pattern is a more practical testing device but provides a measurement of the convolution of the focal spot size and intensity distribution. Note that a 2° star pattern is not suitable for measurements on focal spots smaller than a nominal size of 0.3 mm. All focal spot measurements should be performed with non-screen film technique when practical. High resolution screen-film systems, such as those designed for mammography or extremity radiography, may be used when focal spot sizes and geometric magnification factors are large enough so that the screen unsharpness can be ignored.

Tube housing leakage (mR in 1 hour at 1 meter) may be measured with a "cutie-pie" type ionization survey meter; however, this method requires exposure times of a few seconds because of the relatively long response time of the meter. An integrating, high sensitivity exposure measurement system comprised of a very large ion chamber (—1000 cm^3) and a charge measuring electrometer is more suitable.

In order to prevent accidental damage to the target of the x-ray tube, settings of the technique interlocks for instantaneous exposures, and continuous exposures (if available), should be compared to the information on tube rating charts, which the manufacturers supply with the x-ray tubes.

The inherent filtration (mm Al) of the tube housing should be noted from the literature supplied with the tube. Beryllium window, rather than glass window, x-ray tubes should be used for low voltage applications such as screen-film mammography.

Cable integrity, tightness of cable connections, and adequacy of insulating gels or oils on connectors should be checked.

Linearity, consistency and typical values of exposure (mR or mR/mAs) must be measured. The ionization chamber used should have an energy response which is relatively flat for the beam qualities generated and a sensitive volume large enough to provide a reasonably large charge or current for the exposures or exposure rates being measured. The electrometer should be operated with a bias voltage high enough to collect almost all the charge produced in the relatively large active volume of the ionization chamber being used.

C. Collimation Assembly

On the collimator assembly, the accuracy of field size (cm), target distance (cm) and tube angulation (°) scales should be determined. Lead rulers and film of fluorescent screens with opaque markings may be employed.

Beam quality should be determined from half-value layer (HVL - mm Al) measurements. High purity aluminum filters (type 1100 or purer) should be used, particularly for measurements at the low voltage end of the diagnostic range. The light and radiation field alignment may be determined by comparing the position of opaque markers placed at the edge of the light field with the position of the edge of the x-ray field following a short exposure.

Operation of automatic collimators (positive beam limitation - PBL) should be checked by placing the various size film cassettes into the Bucky tray and measuring the size of the light field produced at the table top. Suitable corrections should be made for the differences in distances from the focal spot to the table and to the film tray.

The mechanical interlocks which determine the centering and angulation of the tube and collimator to the film tray and grid should be tested. Visual inspection should be performed along with actual film exposures.

D. Image Receptors — Intensifying Screens, Films, Grids, Cassettes

Image receptors should be inspected on a regular basis. Intensifying screens should be checked with a direct, long distance "flood" exposure for uniformity of light output. Their speed relative to other screens or non-screen exposure (intensification factor) should be measured with known x-ray exposure and a densitometer. Resolution of the screen-film system (line pairs/mm) can be determined from contact images of lead bar test patterns. Screens should be cleaned and coated with anti-static solutions on a regular basis. For films the speed (R^{-1} for a net optical density of 1.0), contrast (average gradient) and resolution (line pairs/mm) should be tested. A daily processor quality control program should be implemented (see below). Cassettes must be visually inspected periodically for integrity. Areas of poor screen - film contact can be determined from inspection of film images of a fine grain wire mesh placed on the surface of the cassette.

Anti-scatter grids should be chosen on the basis of scatter rejection properties (grid ratio: r), contrast enhancement factor (k), uniformity and exposure requirements (Bucky factor (B)). The Bucky factor, uniformity and alignment can be tested on site.[12] The tests must be performed with a phantom which properly simulates the body parts which will be imaged with the grid.

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E. Automatic Exposure Control

Automatic exposure control devices (AEC - phototimers, ionization timers) must be tested for variations with beam quality, patient thickness, exposure rate and thickness, exposure rate and detector element selection. The minimum exposure time must be determined and operation of a back up timer must be verified. Testing of these devices requires the use of a phantom which simulates not only the attenuation but also the scatter properties of the patients. Blocks of acrylic 20 to 30 cm on a side with thickness of 5 cm are suitable, as are water filled, thin-walled acrylic containers. The largest phantom thickness which can be reached should be at least 30 cm.

VI. Fluoroscopy, Cinefluorography, Photospots

A. Image Intensifiers

There are many parameters which can be checked on an x-ray image intensifier. These include the conversion factor ((candela/m^2)/(mR/s)), contrast ratio, resolution (line pairs/mm) for both live viewing and filming (100 or 35 mm), image lag and distortion. Furthermore the automatic brightness control system (ABC) must be tested for maximum exposure rate (R/min), typical entrance exposure rates, image intensifier input exposure rates (mR/s), variation of exposure rate with thickness, variation of exposure rate with rate settings (low, medium, high), cine pulse widths (ms) and cine pulse consistency. The fluoroscopic collimators must be tested for alignment to the image receptor during automatic operation, and beam quality must also be determined. Proper operation of cine projectors and video tape systems should also be verified.

Fluoroscopic exposure rates should be measured with a suitable ionization chamber as described above under **X-Ray Tube** and an electrometer operating in the current or rate mode. A large flat ionization chamber, approximately 100 cm^3 in volume and no more than 2 cm thick, should be used for measuring exposure to the input surface of the intensifier. The contrast ratio can be measured with a lead sheet which blocks at least 10% of the intensifier input area. A technique for measurement of contrast ratio using film has been described by Rossi and Bromberg.[13] Image lag which occurs in the observation of moving structures can be evaluated according to the method of Gray *et al.*[14]

VII. Mammography

The tests described above for the general radiographic equipment also apply to the dedicated mammography x-ray unit. Special test equipment may be required for the testing of tube potential in the low voltage range used for screen-film mammography (22-36 kVp). The focal spot provided on certain units for magnification mammography is as small as 0.1 mm; therefore, it can not be accurately measured with either the conventional 0.03 mm pinhole or the 2° star pattern. The slit camera or ½° star pattern must be employed.

Image quality in mammography should be tested with a phantom containing test objects which simulate the structures found in the cancerous breast: fibrilar structures, calcific specks simulating microcalcifications, and circular masses with diffuse edges. The patient dose parameter which is commonly reported for mammography is mean glandular dose, which may be calculated from the results of measurements of the in-air surface exposure and the half-value layer of the beam exiting the breast compression plate, as well as a knowledge of the thickness and composition of the breast being imaged. Tables for the calculation of mean glandular dose from the measured data are available from the NCRP.[15] If a significant amount of mammography is performed in the imaging department, it is desirable to have a dedicated film processor. Illuminators used for reading mammograms should be masked with black paper so that the bright light area is not larger than that of the exposed area of the mammography films.

VIII. Computed Tomography

A variety of quantities should be measured on computed tomography units for both head and abdomen modes of operation. They include noise (standard deviation of a large region of interest of a water phantom scan), CT number calibration (normally in Hounsfield units), number constancy, high contrast resolution, low contrast sensitivity, linearity of CT number with attenuation coefficient, artifacts due to misalignment, patient dose (normally Computed Tomography Dose Index - CTDI[16]), table positioning and indexing, and scout view accuracy.

IX. Film Systems

Automatic film processors, darkroom storage facilities and illuminators in the radiology department should be subject to a rigorous program of quality control.[17] With the aid of a sensitometer and densitometer, processors can be monitored on a daily basis for variations in film base-fog level. Speed (mid-range density) and contrast (gradient). An accurate thermometer should be available for periodic evaluation of processing fluid temperatures. Additional tests which might be performed on the processors on a regular basis include measurement of replenishment rates, fluid levels, film transit time (drop time), and cleanliness of machine components. Illuminators should be checked for uniformity, brightness, consistency with other boxes, and cleanliness.

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X. Conventional Tomography

Conventional tomography units, which produce film images of various planes within the patient, should be evaluated periodically for the following: proper indication of the level of the focal plane, the thickness of cut for various tomographic motions and tomographic angle settings, focal plane resolution, tomographic motion uniformity and alignment of moving or rotating grids. A procedure for performing these tests with simple test tools has been described in AAPM Report No. 4.[18]

XI. Digital Subtraction Angiography (DSA)

The generator and image intensifier assembly used for digital subtraction angiography should be tested according to recommendations given above. In addition a special phantom should be available to measure linearity, high contrast resolution, low contrast sensitivity, and registration of subtracted images. The test objects in the phantom should simulate vessels filled with iodine contrast medium.[19] A dynamic phantom which simulates the blood flow within the vessels is desirable.

XII. Video Systems

The video systems which provide the final images on many radiological systems: computed tomography (CT), digital subtraction angiography (DSA), nuclear magnetic resonance imaging (MRI), ultrasound, etc., must be tested with suitable test pattern such as that available from the SMPTE.[20] This pattern may be provided as part of vendor software or can be purchased by the user on tape or floppy disk.

XIII. Computers

The computers which are integral components of many modern radiological systems must be tested, both as part of overall system evaluation and individually with appropriate software packages.

XIV. Phantoms

Many different phantoms have been employed in various aspects of radiological testing. The ICRU will soon issue a report providing information on most of these phantoms. The report will recommend size, shape, composition, and dosimeter locations for standard phantoms for general radiology, mammography and computed tomography. In addition a detailed catalogue of existing phantoms, both commercial and non-commercial will be provided.[21]

XV. Frequency of Testing

Recommendations for the frequency of various tests have been made by many organizations and regulatory agencies. These have been summarized in Reports of the American College of Medical Physics.[22] Table 1 presents these recommendations.

XVI. Less Costly Systems

A full set of the equipment described above for testing of radiological systems would be expensive to purchase, in the range of $20,000 - 30,000. Because each laboratory, imaging department or quality control service may not be able to afford such equipment, it is necessary that the equipment be shared by several groups, purchased and distributed on a loan basis by a national or regional governmental agency, or that less expensive equipment be employed.

Cameron[23] has proposed and constructed a multipurpose test device employed in conjunction with a plastic water tank (18 cm × 18 cm × 18 cm). The equipment is inexpensive, can be used without extensive training of personnel and will allow performance of many of the important quality control tests: focal spot size, contrast, latitude, iodine concentration, image receptor speed, tomographic depth and width of cut, and high contrast resolution.

XVII. Summary

A proper quality control program for diagnostic radiology includes periodic testing, with a wide variety of devices, of all equipment associated with the production and viewing of patient images. An effective program will produce reduced overall operating costs, decreased patient exposure, decreased repeat examinations and, therefore, increased departmental efficiency and quality.

TABLE 1 — RECOMMENDED MINIMUM TEST FREQUENCIES

SYSTEM	PARAMETER	FREQUENCY
General Physical Inspection	Mechanical Components	Annually
	Electrical Components	Annually
Radiographic Equipment	X-Ray Tube	Annually
	Generator	Annually
	Radiation Exposure	Annually
	Beam Quality	Annually
	Collimation	Annually
	AEC (Phototimer)	Annually
Radiographic Imaging System	Film Processor	Daily
	Darkroom Lighting	Annually
	Intensifying Screens	Annually
	Cleanliness	Monthly
	Film Repeat Rate	Monthly
	Illuminators	Annually
	Grids	Annually
Mammography Equipment (In addition to Radiographic Above)	Beam Quality	Semi-annually
	Patient Dose	Semi-annually
	Image Quality	Monthly
	Image Receptor Transmission	Initially
Mobile Mammography w/Remote Film Processing	Line Voltage Spot Check	Daily
	Beam Quality Spot Check	Daily
	Output Spot Check	Daily
	Image Quality	Daily
	AEC Function	Daily
Fluoroscopic Equipment	Exposure Rates	Annually
	Beam Quality	Annually
	Collimation	Annually
	Image Intensifier	Annually
Computed Tomography	Mechanical Function	Annually
	Dose	Annually
	Image Quality	Annually
	Noise - Water Bath	Daily
	Water Value	Monthly
	Uniformity	Monthly
	Linearity	Monthly
	Slice Thickness	Monthly
	Multi-format Camera	Weekly
Protection	Personnel - General	Annually
	Patient Protection - General	Annually

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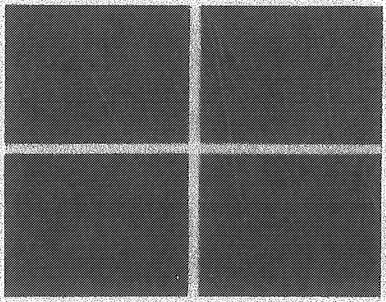

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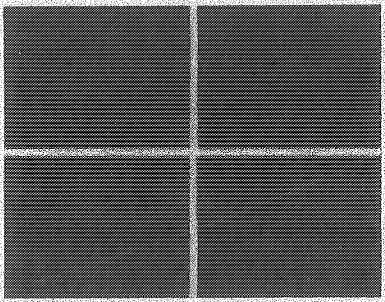

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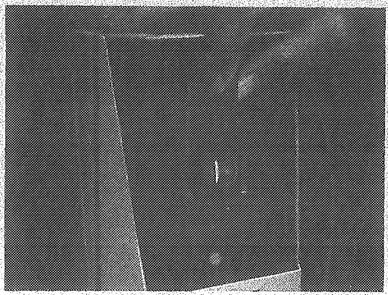

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