EXPERIENCE IN ESTABLISHING AND OPERATING A RADIATION DOSIMETRY AND RADIOACTIVITY CALIBRATION LABORATORY IN THE REPUBLIC OF CHINA

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INTRODUCTION

Increasing public concern and more demanding legislation about radiation safety have made reliable measurement of ionizing radiation a necessity. Standardized calibration and procedures for the measurement of radiation doseage become one of the most important parts to assure measurement accuracy and hence radiation safety. The wareness of this need has led to the establishment of the Radiation Dosimetry and Radioactivity Calibration Laboratory (RDRCL) at the Institute of Nuclear Energy Research (INER). Since July 1976 the RDRCL has been operated by the Health Physics (HP) Division of INER. In setting up and operating the laboratory, several guides(1,2,3) have been followed. The experience we have gained may be of general interest to those whose concern is with the use or calibration of dosimeter.

ORGANIZATION AND RESPONSIBILITY OF THE RDRCL

The RDRCL includs two main parts namely Photon Dosimetry Calibration Laboratory (PDCL) and Radioactivity Calibration System (RCS). The operation of the RDRCL is under overall supervision of the HP Division Director of INER. For rountine calibrating services, the PDCL has two full-time senior physicists well experienced in radiation dosimetry and four full-time technicians with adequate qualification and experience to provide calibrating services. More over, for special consulation or discussion, other senior physicists or engineerers in the HP Division can readily provide help. Since most Radiotherapy centers in Taiwan are located in the northern part and are close to INER. The calibration services for them are convenient. In the past years, the PDCL in addition to discharge served the instrument calibration work for INER, has offered technical service to other public or private companies in Taiwan, e.g. Taiwan Power Company, University of Tsing-Hua, and a good many hospitals.(4)

The main responsibilities to be implemented by PRDL in the laboratory itself could include:

(1). The maintenance of a set of secondary standard (intercomparison) ion chamber and radiation sources.

(2). Calibrating radiation measuring instruments used for clinical dosimetry and radiation protection purposes, and issuing certificates.

(3). The minor repair of instruments when needed.

(4). Coordinating efforts with other HP staffs on personnel and environmental dosimetry services.

(5). Training of health physicists and medical physicists, and paritcipating in training programs sponsored by government.

(6). Providing help to radiation protection services with regard to dosimetric problems.

(7). Joining in dosimetric intercomparisons with other laboratories.

(8). Keeping up-to-date dosimetric measurement methods, and carrying out research on radiation dosimetry.

EQUIPMENT AND FACILITIES OF THE PDCL

(A) X-ray Beams

The PDCL is equipped with two X-ray generating systems. A Baltgraph CE 50/30 type X-ray machine with 50 kVcp X-ray tube incorporating a Beryllium window was installed for low energy work, and a high quality Pantak HF420c calibration type X-ray machine was used for both medium and low energy work. The later can be operated with voltage from 420 to 10 kVcp at tube current down to 50 A. The ancillary facilities include a set of high quality filters, an adjustable diaphragm, a transmission type monitor chamber, etc. The X-ray generating system is capable of generating those filtered X-ray beams as recommended by the National Bureau of Standard (NBS) or as shown in the ISO-4037 report, regarding to the effective energy and dose rate ranges.

(B) γ-ray Sources

To obtain a wide range of γ-energies and outputs, a large number of sealed radioisoiope sources, such as Ra-226, Cs-137 and Co-60, etc. were used to provide precise exposure rate.

The above-mentioned X and γ-photon sources are or can be equipped with calibration benches or stands. Devices for easy and reproducible position, such as trackes, laser beam sources, etc. are available. The remote control systems can be installed whenever necessary.

(C) Ionization Chambers

Ionization chambers calibrated against the primary standards at the NBS or the National Physical Laboratory (NPL) of the U.K. are refered to as the secondary standard chambers at the PDCL. Some secondary standard ion chambers, together with two free-air ion chambers are properly used and maintained. Redundant principle is practised whenever possible.

Ion chamber calibrated against the secondary standard ion chambers are referred to as the laboratory standard instruments which are used to calibrate the field-use dosimeters or survey meters.

(D) Electrometers

There are many feedback type high precision electrometers in the PDCL. Some of them have been calibrated traceable to NBS. Like ion chamber, the electrometers in the PDCL are classfied as secondary standard, laboratory standard and field-use.

(E) Other Equipment

Additional equipment required for ionization chamber calibration include standard charge/voltage sources, three terminal calibration capacitors, high quality barometers, thermometers, timers, humidity measurement instruments, atmospheric communication testing chamber, etc. Many self made devices are installed to position various types of chambers in optimum location with a view to meeting requirements of all radiation charactistics so that most accurate results are obtained based on which to determine the realistic condition.

OPERATION OF THE PDCL

In order to fulfill PDCL's responsibities and to provide for the soonest possible instrument calibration, a disciplined procedure is established to follow. The protocol of the PDCL has described in detail the procedures for calibrating, reporting and record keeping for each class of device. Also classes are defined into which each device will fall. These procedures have also delineated explicit steps to assure utmost accuracy in calibration. All calibrating activities have to be in conformity with laboratory protocol.

RADIOACTIVITY CALIBRATION SYSTEM

According to the characteristics of the radioactivity, e.g. radiation types, physical and chemical forms, and intensity, there are many different qualitification and quantification methods in determining the activity of a radioisotope.

The RCS has had many activity measuring systems which mainly include alpha spectrometric system, 2π-α counter, 2π-β counter liquid scintillation spectrometric system, gamma spectrometric system, 4π-γ ionization chamber, and 4π-β, γ coincidence counting system.(5)

EXPERIENCE WITH THE RDRCL

Experiences gained from establishing and operating the RDRCL

in these years show that the calibration of radiation measuring instruments is a high-tech endeavor and rather costly work. It is important that the personnel selected for establishing and operating the RDRCL are adequately qualified and are given adequate status and remuneration. It also needs to invest large fund for equipment and site preparation. A rigid protocol and a list of operational procedures must be clearly defined and strictly followed. The supports from other relevant high technical industries and the close contact with other national laboratories are essential parts to elevate the level of the laboratory.

Reference:

1. J.G. Holt, "Design and Operation of Standard Laboratories for Radiation Dosimetry". Victoreen Instrument (1977)

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3. ISO "X and γ-reference Radiations for Calibrating Dosimeters and Dose Ratemeters and for Determining Their Response as a Function of Photon Energy" Report 4037 (1979)

4. W.L. Chen and S.C. Chang, "The Use of Ferrous Sulphate Dosimeter for Intercomparison of Absorbed dose from Electron Beams". Med. Phys. 11(3): 335-337 (1984)

5. T.Y. Chang, G.S. Chiou, W.L. Chen and C.M. Tsai, "The Absolute Counting of Complex Decaying Nuclides" Nucl. Sci. J. 17(1): 39-43 (1980)