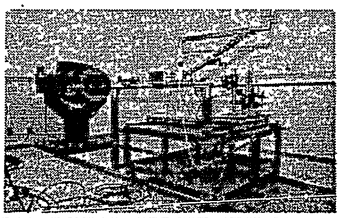
CALIBRATION

OF SOURCES AND EQUIPMENT

Secondary Standard Dosimetry Laboratoty

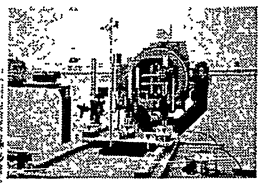
- The laboratory which has been designated by competent authorities to undertake the duties of providing the necessary link in the traceability of radiation dosimetry to national/international standards for users within that country

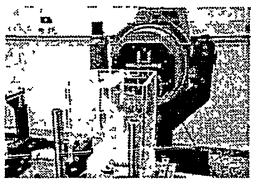


Traceability to Secondary Standard Dosimetry Laboratory

Secondary Standard Dosimetry Laboratoty

Secondary Standards: traceable to the primary standards of laboratories participating in the international measuring system (PSDLs)





International Traceability I

- ✓ External beam Radiation Therapy
- ✓ Sealed Source Brachytherapy (HDR)
- ✓ Unsealed Source Therapy (Radioiodine)

The outcome of treatment is highly dependent on the radiation dose delivered to the patient

International Traceability II

- ✓ Radiation Protection for patients in:
  - Diagnostic Radiology
  - Diagnostic Nuclear Medicine
- ✓ Occupational Radiation Protection

All of these applications relate directly or indirectly to human health, emphasizing the importance of traceability of dosimetry to avoid unintended radiation exposures of individuals

Measurement Traceability

The chain of traceability should ensure that radiation doses are being delivered as intended at the end point. In practice, the SSDL may be the only centre available in the country to provide support on quality audit and expertise on quality assurance.

The SSDLs are similary audited at an international level (by IAEA).

The quality of radiation calibration is assured throughout the measurement chain to the point of radiation.

Classification of instruments

Primary Standard

An instrument of the highest metrological quality that permits determination of the unit of a quantity from its definition, the accuracy of which has been verified by comparison with the comparable standards of other institutions at the same level.

Secondary Standard

An instrument calibrated by comparison with a primary standard.

Classification of instruments

National Standard

A standard recognized by an official national decision as the basis for fixing the value in a country of all other standards of the given quantity.

Reference Instrument

An instrument of the highest metrological quality available at a given location, from which measurements at that location are derived.

Field Instrument

A measuring instrument used for routine measurements whose calibration is related to the reference instrument.

Calibration of radiotherapy equipment

Although many different types of measuring systems exist, the use of an ionization chamber is the most satisfactory.

It is essential for every radiotherapy center to possess a dosemeter which has been calibrated over the whole range of radiation qualities to be used.

If a wide range of qualities is involved then probably more than one kind of ionization chamber will be required.

For each ionization chamber there should be also available a radiation source (of known half-life)with which to check the constancy of the instrument.

Formalism I

Air kerma calibration (TPR 277)

The air Kerma or exposure standard at the PSDL is used in order to determine calibration factors for the secondary standard of the SSDL in terms of air kerma per meter reading or charge.

This Standard is used in the calibration of the user's instrument at the SSDL to yield the factor Nk.

The calibration of users chamber be made free in air in a Co-60 gamma beam.

Absorbed dose to water (TPR 398)

The calibration of the chamber is made at a point of interest in a water phantom where the absorbed dose to water could be determined by the PSDL.

This Standard is used in the calibration of the user's instrument at the SSDL to yield the factor Nw.

The calibration of users chamber be made free in a water phantom in a Co-60 gamma beam.

Formalism II

Advantages

- **Absorbed dose to water is the quantity of main interest in radiation therapy since this quantity relates closely to the biological effects of radiation.**
- **The new formalism will reduce the uncertainty in determining the absorbed dose to water in radiotherapy beams.**
- **Measurements based on calibration in air (Kair) require chamber dependent conversion factors to determine absorbed dose to water (which do not account for differences between individual chambers of a particular type).**

Formalism III

The absorbed dose to water at the reference depth z_{ref} in water for a reference beam of quality Qo and in the absence of the chamber is given by:

$$D_{wQo} = M_{Qo} N_{DwQo}$$

Where M_{Qo} = the reading of the dosimeter under the reference conditions used in the standards laboratory

N_{DwQo} = the calibration factor in terms of absorbed dose to water of the dosimeter obtained from a standard laboratory

Formalism IV

Calibration Factor: Ratio of the conventional true value of the quantity to be measured conditions to the indicated value.

Reference conditions: a set of values of influence quantities for which the calibration factor is valid without further correction factor.

(the geometrical arrangement, distance and depth, the field size, the material and dimensions of the irradiated phantom, and the ambient temperature, pressure and relative humidity)

Formalism V

For these influence quantities can not be kept under control during calibration appropriate correction factors must be applied

The measurements in a different quality require a correction factor $k_{Qo,Q}$ which corrects for the effects of the difference between the reference beam quality (usually Co-60 beam) and the actual user quality.

Equipment I

Cylindrical ionization chambers: may be used for the calibration of radiotherapy beams of medium energy X rays above 80 kV (HVL=2 mm), Co-60 beams, high energy photon beams, electron beams with energy above 10 MeV approximately.

The chamber cavity volume should be between about 0,1 and 1 cm^3 (compromise between the need of sufficient sensitivity and the ability to measure dose at a point).

The chamber must be aligned in such a way that the radiation fluence is approximately uniform over the cross section of the chamber cavity (the cavity length sets a lower limit on the size of the field in which measurements may be made).

Equipment II

Plane-parallel ionization are recommended to be used at all electron and below 10 MeV their use is mandatory. For photon beams they are suitable for reference dosimetry measurements only when a calibration in terms of absorbed dose to water is available at the user quality.

One of the main advantages of plane-parallel chambers for electron beam dosimetry is the possibility of minimizing perturbation effects (the contribution of electrons through the side walls being negligible).

This design justifies taking the effective point of measurements of the chamber p_{eff} to be on the inner surface of the entrance window, at the centre of the window for all beams qualities and depths (reference point of the chamber).

Equipment III

Ionization chambers for measuring low energy X-rays must also be of plane-parallel type.

When used in beams above 50 kV an additional plastic foil added to the window to provide full buildup of the primary beam must be added.

The measuring assembly includes an electrometer and a power supply for the polarizing voltage of the ionization chamber.

When possible the electrometer and the ionization chamber may be calibrated separately.

Equipment IV

Water is recommended as the reference medium for measurements of absorbed dose for both phantom and electron beams.

The phantom should extent to at least 5 cm beyond all four sides of the largest field size employed at the depth of measurement.

There must be also a margin of 5gr/cm^2 beyond the maximum depth of measurement (10 gr/cm^2 in medium X rays).

The use of plastic phantoms is not recommended for absolute dosimetry as in general they are responsible for the largest discrepancies in the determination of absorbed dose for most beams types (density variations, scaling depths).

Equipment V

Plastic phantoms can be used for routine quality assurance measurements, provided the relationship between dosimeter readings in plastic and water for the user beam at the time of calibration.

Calibration

Every two or three years or whenever the user suspects that the chamber has been damaged.

Chambers used in low and medium energy X rays must recalibrated at all relevant qualities each time.