

International Atomic Energy Agency

Traceability of measurements in brachytherapy dosimetry

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Dosimetry & Medical Radiation Physics

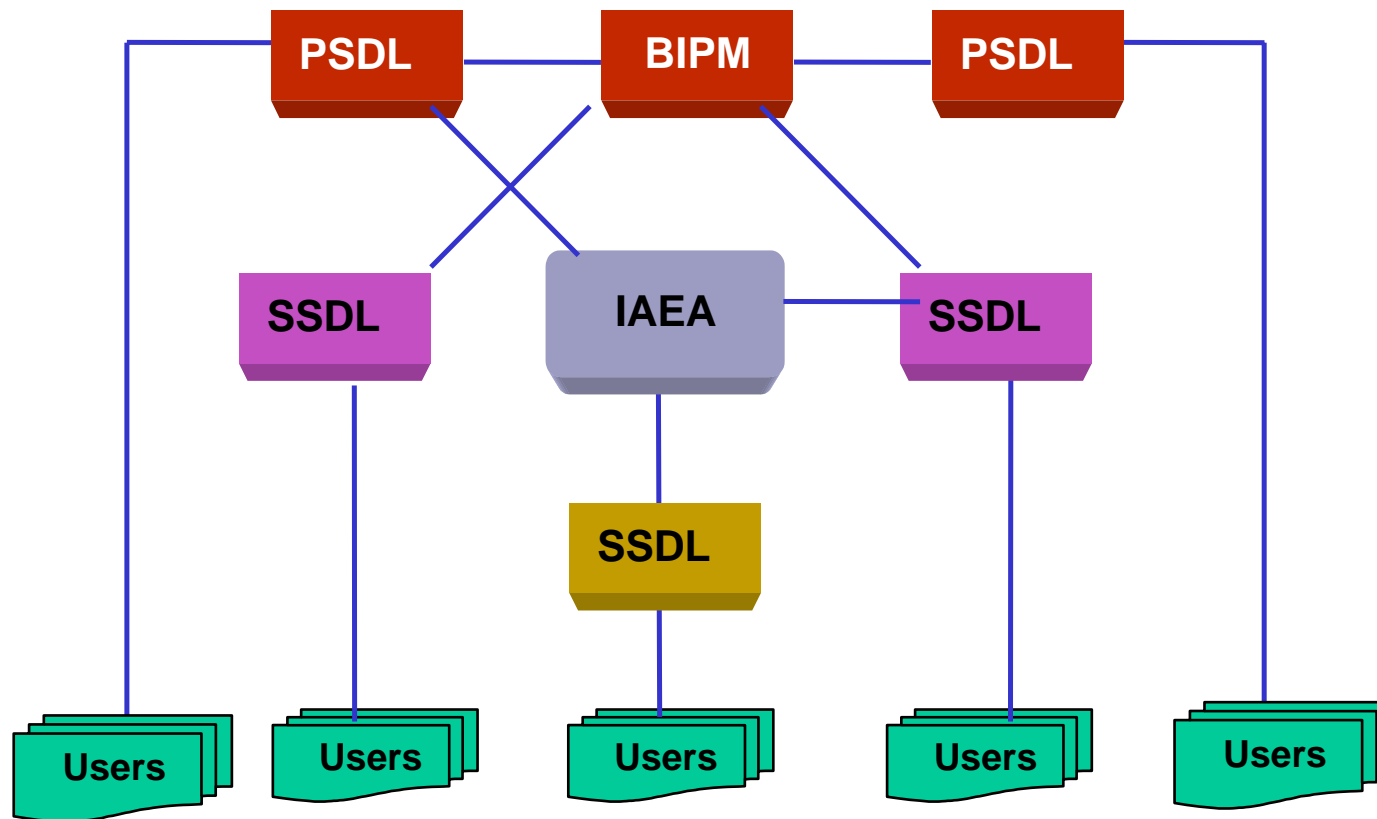
Division of Human Health

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Traceability chain in radiation dosimetry



Mutual Recognition Arrangement (MRA)

□ Objectives

- to establish the degree of equivalence of national measurement standards maintained by National Metrology Institutes (NMIs)
- to provide for the mutual recognition of calibration and measurement certificates issued by NMIs (BIPM database)

INSTITUT DU RADIUM.
LABORATOIRE CURIE.
1, rue Ponsse-Curie, Paris (5^e).

Paris, le 17 juin 1929.

CERTIFICAT. N° 5.654

DOSAGE DE RADIUM PAR LE RAYONNEMENT γ .

NATURE ET PROVENANCE DE L'APPAREIL.
Appareil à sel de Radium solide sur disque platine marque A. 84
Épaisseur 3 mm
Surface 4,458 cm²
apporté par la Société Nouvelle du Radium le 7 juin 1929
et rendu à le 17 - - -

CONDITIONS DE MESURES.
Le rayonnement γ de l'appareil est comparé au rayonnement γ de l'Étalon du Laboratoire
Si l'appareil n'a pas atteint son rayonnement limite, celui-ci est déduit des mesures par le calcul.
L'appareil qui fait l'objet de ce Certificat a atteint son rayonnement limite.

RÉSULTAT DES MESURES.
Le rayonnement γ limite émis à l'extérieur de l'appareil est équivalent à celui de
2,18 Milligrammes de radium élément.

QUANTITÉ DE RADIUM CONTENUE DANS L'APPAREIL.
Cette quantité est évaluée en tenant compte de l'absorption du rayonnement γ par la paroi
de l'appareil, conformément à l'épaisseur de celle-ci et à son coefficient d'absorption.
L'épaisseur indiquée par la Société Nouvelle du Radium est mm: 3.
La correction qui en résulte est évaluée à 12%
du rayonnement γ qui émane de la substance.
La quantité de radium contenue dans l'appareil est donc :

MILLIGRAMMES DE RADIUM ÉLÉMENT 26,05
six milligrammes, six centimes



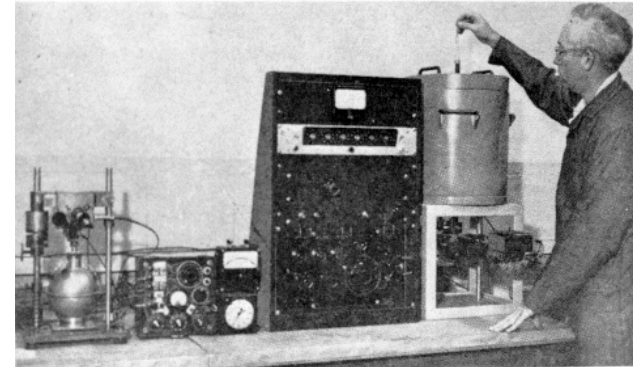
Primary standards for brachytherapy dosimetry

- Standards for ^{137}Cs , ^{60}Co and ^{192}Ir (LDR only)
 - Standards based on a series of graphite cavity ion chambers
 - Air kerma rates determined with these chambers are used to calibrate sources of ^{137}Cs and ^{60}Co (correction for air attenuation, build-up and room scatter)



Primary standards for brachytherapy dosimetry

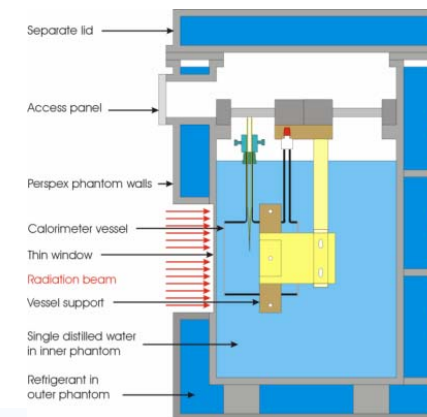
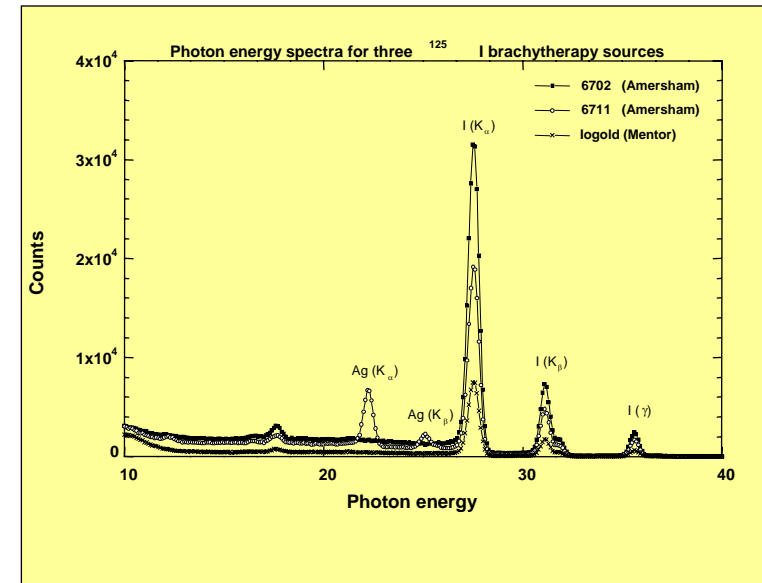
- Standards for ^{137}Cs , ^{60}Co and ^{192}Ir (LDR only)
 - Calibrated sources of ^{137}Cs and ^{60}Co are used as working standards to calibrate unknown sources of the same type (using replacement method and a large volume ion chamber)



Primary standards for brachytherapy dosimetry (cont.)

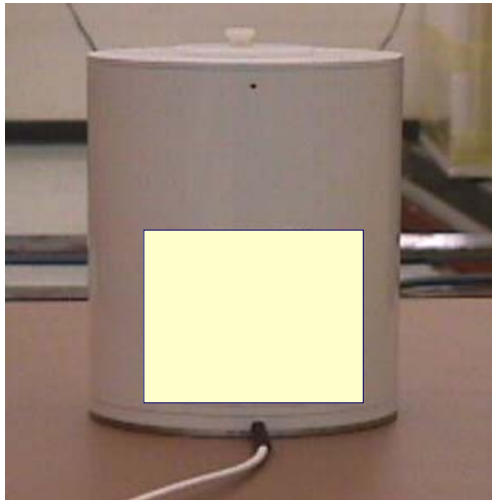
□ High dose rate ^{192}Ir

- At present, primary standards are not available.
- Traceability is assured through an interpolated air kerma calibration factor (250kV & $\text{HVL} \sim 3\text{mm Cu}$ and $^{137}\text{Cs}/^{60}\text{Co}$)
- Trend: development of standards in terms of absorbed dose to water



Calibrations at SSDLs

- ❑ Recommended transfer instrument for the calibration of all photon sources used in brachytherapy: well type ion chamber with its electrometer



Calibrations at SSDLs

Low dose rate ^{137}Cs

- ❑ SSDL acquires a secondary standards brachytherapy dosimetry system (well chamber, electrometer and non calibrated ^{137}Cs sources similar to IAEA sources)
- ❑ Well type ion chamber calibrated at a IAEA or a PSDL (in mGy/nC) using reference sources traceable to the International Measurement System



Calibrations at SSDLs

Low dose rate ^{137}Cs (Cont.)

- ❑ SSDL measures reference air kerma rate of its source using its IAEA calibrated well chamber
- ❑ SSDL calibrates users' sources and well type chambers using its well type chamber
- ❑ Uncertainty on the calibrations: 1.5-2.5% (k=1)

Calibrations at SSDLs

High Dose Rate Brachytherapy ^{192}Ir

- ❑ IAEA is currently not providing calibrations for HDR ^{192}Ir
- ❑ **SSDL calibrates a well type ion chamber at the ADCL-Wisconsin for HDR ^{192}Ir**
- ❑ **SSDL uses calibrated well chamber to calibrate hospitals sources (at the hospital)**



Calibrations at SSDLs

High Dose Rate Brachytherapy ^{192}Ir (Cont.)

□ SSDL “calibrates” a Farmer type ion chamber for ^{192}Ir based on ^{137}Cs (or ^{60}Co) and 250 kV beam quality (ISO narrow series) IAEA-TECDOC-1274

□ ^{137}Cs and 250kV x-rays

$$N_{K, 192\text{Ir}} = (1+x)[N_{K,250\text{kV}}+N_{K,\text{Cs}}]^{1/2}, \text{ where } x = f(\text{chamber wall})$$

□ ^{60}Co and 250kV x-rays

$$N_{K, 192\text{Ir}} = (0.8 \cdot A_{w,250\text{kV}} N_{K,250\text{kV}} + 0.2 \cdot A_{w,\text{Co}} N_{K,\text{Co}}) / A_{w,\text{Ir}}$$



Calibrations at SSDLs

High Dose Rate Brachytherapy ^{192}Ir (Cont.)

- ❑ IAEA is conducting an international comparison (4 institutions) to assess the uncertainty of the “free in air” methodology
- ❑ In the comparison, 4 Farmer type ion chambers are calibrated at 4 laboratories for HDR ^{192}Ir
- ❑ Preliminary results show an agreement within 1%



Quality control

□ Safety and lessons learned

Accident caused by	Number of cases
Dose calculation error	6
Error in quantities and units	2
Incorrect source strength	7
Equipment failure	4
Other	13
Total	32



Quality control- calibrations

- Stability of reference ionization chamber with check source measurements**
- Current/charge measurements**
- Working standards stability**
- Temperature and pressure measurements (open chambers)**
- Participation in external audits/comparisons**

