IPEM conferences

# *RPA Update 2021*

24th June 2021- Online (BST)

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|---|---|
| 10.00 – 10.10 | **Introduction** |
| 10.10 – 10.30 | **The Definition of Effective Sources. An Update on: Variation of Radiation Dose with Distance from Radiotherapy Linac Bunker Maze Entrances**<br>Matthew Gardner, formerly of University Hospitals Birmingham NHS Foundation Trust, UK. |
| 10.30 – 10.50 | **Potential Pitfalls of Linear Accelerator Bunker Refurbishment**<br>Colin Jennings, Rosemere Cancer Centre, Lancashire Teaching Hospitals, UK. |
| 10.50 – 11.00 | Questions |
| 11.00 – 11.20 | **Break** |
| 11.20 – 11.40 | **Skin Contamination in Nuclear Medicine – the 'Never Event' that unfortunately happens! – A New Model and dose estimates for a range of radionuclides, including the alpha emissions of Ra223.**<br>William Thomson, City Hospital, Birmingham |
| 11.40 – 12.00 | **Nuclear Medicine contingency plans and the practicing thereof**<br>Kat Dixon, University Hospitals Dorset, UK. |
| 12:00 – 12:10 | Questions |
| 12.10 – 12.30 | Breakout session 1 |
| 12.30 – 13.30 | **Lunch** |
| 13.30 – 13.50 | **Evaluating the practical impact of Instantaneous dose rate on designation of Controlled Areas.**<br>Andrew Bridges, University Hospitals of Leicester NHS Trust, UK. |
| 13.50 – 14.10 | **Needle stick injury in the Radiopharmacy - a Case Study**<br>Emily Seymour, Velindre Cancer Centre, Velindre University NHS Trust, Cardiff, Wales. |
| 14.10 – 14.30 | **Community Diagnostic Hubs**<br>Cathy Wybrow and Kim Robertson, NHS England and NHS Improvement. |
| 14.30 – 14.40 | Questions |
| 14.40 – 15.00 | **Break** |
| 15.00 – 15.30 | **HSE Update**<br>James Taylor, HSE |
| 15.30 – 15.50 | **CIDI** |
| 15.50 – 16.00 | Questions to the regulators |
| 16.00 – 16.20 | Breakout session 1 |
| 16.20 – 16.30 | Final questions & Closing |

*Organised by IPEM's Radiation Protection Special Interest Group*

**The Definition of Effective Sources. An Update on: Variation of Radiation Dose with Distance from Radiotherapy Linac Bunker Maze Entrances**

[1]Mike C Thorne, [2]Matthew Gardner, [3]William Mundon, [3]Thomas Pawsey, [4]Benjamin Davis, [4]Stuart Green

[1] Mike Thorne and Associates Limited, UK.
[2] formerly of RRPPS, Department of Medical Physics, University Hospitals Birmingham NHS Foundation Trust, UK.
[3] formerly of the School of Physics and Astronomy, University of Birmingham, UK.
[4] Department of Medical Physics, University Hospitals Birmingham NHS Foundation Trust, UK.

## Background

In our 2020 publication[1], the results of which were also presented at the 2020 Medical Physics & Engineering Conference (MPEC)[2], it was argued that the Inverse Square Law (ISL) should be used with caution to correct doses measured at distance from radiotherapy bunker maze entrances. Whilst no simple relationship exists, values were identified which can be used as guiding principles for distance correction. For instance it was found that the dose rate at 1m outside the maze entrance is approximately 50% that at the maze entrance to within a standard error of 5%. This was extensively tested for a range of maze designs, beam energies & linac orientations and validated at 1m using uniformity measurements.

Further analysis has since been completed on the data. Applying geometrical considerations of an effective source at some distance within the maze allows a modification to the ISL assumption to be derived which means it can be applied (although we suggest cautiously) for radiotherapy bunker maze entrances.

## Methods

Assuming an effective source at distance, a, within the maze then the appropriate normalisation factor for dose rates at distances, x, from the maze entrance becomes $(a+x)^2$, not $x^2$ as might be applied with ISL assumptions. Using this and the results of the previous study[1] (e.g. that at 3m from a maze entrance the dose rate is approximately 18% that at the maze entrance itself) it is possible to derive a quadratic equation. The solution to this equation gives the approximate position of the effective source.

The validity of this solution was tested by comparison of the ISL prediction using the effective source position to the measured data from the previous study.

## Results

The solution to the quadratic equation indicates that for radiotherapy bunker mazes the effective source is approximately 2.2m within the maze. Taking this as the position of the source and applying the ISL gives good agreement (within 3% on average) with the measured results from the previous study.

## Discussion & Conclusion

The ISL can still be used with a modification to account for the position of an effective source 2.2m within the maze entrance. But caution should be applied as of course in reality the source is not a point but is spatially extensive.

## References

1) Gardner, M., Mundon, M., Pawsey, T., Davis, B. & Green, S. (2020). *Variation of Radiation Dose with Distance from Radiotherapy Linac Bunker Maze Entrances*. Journal of Radiological Protection 40(4), 1039-1047. https://doi.org/10.1088/1361-6498/aba99a.
2) Gardner, M., Mundon, M., Pawsey, T., Davis, B. & Green, S. (2020). *Variation of Radiation Dose with Distance from Radiotherapy Linac Bunker Maze Entrances*. Medical Physics & Engineering Conference (MPEC), September 2020, Online.

**Potential Pitfalls of Linear Accelerator Bunker Refurbishment**

[1]Jennings C,
[1]Radiotherapy Physics, Rosemere Cancer Centre, Lancashire Teaching Hospitals, UK.

**Background**.

Linear accelerator (linac) replacement can often provide unique and unforeseen Radiation Protection challenges for the RPA. These include changes in room use, equipment type, energies, treatment techniques, room access, dose rates, isocentre positions etc. Each of these changes will require individual consideration with respect to compliance with regulations and the ALARP principle (1). This talk gives some examples of situations encountered during linac bunker refurbishments and the solutions employed.

**Methods**

The Rosemere Cancer Centre opened in 1997 with 2 linear accelerators. Over the past 23 years the centre has expanded massively, adding an additional 6 linac bunkers and also replacing linacs that have reached their end of life. As the linac bunkers have been introduced in different phases with different designs this has led to a set of unique challenges for each linac bunker refurbishment. Issues encountered include:

- Upgrade of linac to high dose rate (FFF) beams
- Use of Magnetite concrete and high density blocks for shielding
- Movement of linac isocentre
- Upgrade of maximum linac field size
- Connection of external interlock (eg Castell key) systems

**Results**.

For each linac bunker upgrade the design team have worked closely with the local MPE and department RPA to ensure all clinical needs are met whilst complying with Regulations and national recommendations (2,3). Often close collaboration with the equipment supplier is also required, especially where non-standard connections to linacs are required eg External Interlock systems. Solutions to the problems encountered will be presented which will be common to many other Radiotherapy centres.

**Conclusion.**

Close collaboration has led to successful upgrades and refurbishments of linac bunkers in a cost effective and timely manner, overcoming numerous problems using radiation protection advice. This advice has been used to influence equipment manufacturer install procedures to improve their documentation and make safer their future intsalls and refurbishments.

**Key references**.

1. The Ionising Radiations Regulations 2017, https://www.legislation.gov.uk/uksi/2017/1075
2. Design and Shielding of Radiotherapy Treatment Facilities, IPEM Report 75 2nd Edition, 2017
3. NCRP Report No. 151 – Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities (2005)

**Skin Contamination in Nuclear Medicine – the 'Never Event' that unfortunately happens! – A New Model and dose estimates for a range of radionuclides, including the alpha emissions of Ra223.**

**Thomson WH, James G**
**Physics and Nuclear Medicine Department , City Hospital , Birmingham**

**Background**

At the RPA Update 2020, I presented new data on skin contamination doses Hp(0.07) from a range of radionuclides. The cumulative dose values were based on activity that resides on the skin surface. However, there is published data showing percutaneous absorption of radiopharmaceuticals through the epidermal layer and the basal layer into the dermal layers of skin (1). From the dermal layer there is vascular clearance into the bloodstream. The concern is that such flow through the basal layer might lead to larger doses.

This dynamic process of percutaneous absorption has been modelled using VARSKIN and also GEANT4 monte Carlo to give new values for skin contamination. In particular, the Monte Carlo process allows data for alpha emitters , which are not modelled in VARSKIN.

**Methods**

The model assumes a cylindrical system through the skin, with a diameter of 1cm2. There is an epidermal cylinder , 70um thick, and a dermal cylinder assumed 1mm thick. Using VARSKIN, the basal cell doses were calculated for 1MBq content in each of the epidermal and dermal cylinders. EXCEL was used to give a 1st order model for percutaneous flow, with 100% activity in the epidermal layer flowing to 100% in the dermal layer. 5% step changes were used. The timescale was based on published data of 95% of Tc99m pertechnetate being in the dermal layer after 1 hour (2).

There is then vascular clearance from the dermal layer. Published data for Tc99m and F18 show this to have a biological half-life of 8hrs (range 5 - 13hr) (1). A conservative 10hr was used.

For Ra223 ,an alpha emitter, similar model data was obtained but using GEANT4 , since VARSKIN does not include alpha dosimetry data.

**Results**

The new model data is shown in Table 1, together with the standard values based on surface contamination. Despite flowing through the basal layer, the new model generally shows lower dose estimates (except I123 and Ra223). This is due to the lower dose values when in the dermal layer, with its greater depth.

However the values for Ra223 are significantly greater, since the surface model assumes that alphas do not reach the basal layer.

| Radionuclide | Tc99m | I123 | F18 | I131 | Y90 | Lu177 | Ra223 |
|---|---|---|---|---|---|---|---|
| surface model mSv/MBq | 1170 | 2440 | 3350 | 17880 | 17970 | 16290 | 6620 |
| New percutaneous mSv/MBq | 380 (33%) | 3720 (150%) | 2300 (69%) | 9650 (54%) | 15290 (85%) | 6800 (42%) | 709900 0 (1840%) |
| Activity for 500mSv | 1.3MBq | 0.13MBq | 0.22MBq | 0.05MBq | 0.033MBq | 0.073MBq | 70Bq |

**Discussion**

The new percutaneous model gives reduced contamination values (except I123). However these still result in highly significant doses from low activities retained on the skin. For Ra223, the new model gives much higher values due to the alpha dose, which also has a QF of 20 applied. It is unclear if Ra223, and other radionuclides , have similar percutaneous absorption characteristics. However the Ra223 value shows that any skin contamination of an area of skin with any scratch, wound or skin damage could lead to extremely high dose values.

**Conclusion**

The message remains – the potential for any skin contamination in nuclear medicine needs to be essentially a 'never event'. "Bare below the elbow" cannot take precedence for radioactive work.

Ref 1 P Covens et al 2013 J. Radiol. Prot. 33: 381

Ref 2 MA Bolzinger et al 2010 Int. J. Pharm. 402: 44

**Nuclear Medicine contingency plans and the practicing thereof**

[1]Dixon KL

[1]Nuclear Medicine Department, University Hospitals Dorset (formally known as Poole Hospital), UK.

**Background**. Contingency plans for nuclear medicine departments are generally quite complex and lengthy affairs. The requirement to practice them at regular intervals is understood but perhaps how to set up such practices is less often discussed.

**Methods.** The nuclear medicine team at Poole Hospital practice contingency plans on an annual basis and have given permission for photos from their recent 'acting' exploits to be shared. The set up and design of each practice scenario will be presented.

Scenarios include:

- a lost Se-75 capsule,
- a vehicle fire while transporting radioactivity,
- a significant radioactive spill, and
- a fire starting in nuclear medicine reception.

**Results and discussion.** Learning outcomes from these sessions, the good, the bad and the ugly, will also be disclosed.

**Evaluating the practical impact of Instantaneous dose rate on designation of Controlled Areas.**

Bridges A
Dept. of Medical Physics, University Hospitals of Leicester NHS Trust, UK.

**Background**.

Regulation 17(1) Ionising Radiation Regulations[1] informs Employers' that they should establish Controlled Areas where employees are likely to receive an effective dose greater than 6 mSv a year, this regulation forms the basis for designing facilities where ionising radiation is to be used to effectively restrict the Controlled Area to a room. As the majority of facilities have the possibility of members of the public being present outside of the rooms during the use of ionising radiation, these facilities are generally designed to ensure that annual doses outside are below 0.3 mSv.

Paragraph 297 of the Approved Code of Practice (ACOP), Working with Ionising Radiation[2], states that 'in addition an area should be designated as a controlled area if the dose rate (averaged over a minute) exceeds 7.5 uSv/hr and employees untrained in radiation protection area likely to enter the area…' .The ACOP was updated in 2017 with this additional constraint; therefore this talk will explore this for both existing installations and room designs.

The aim of this talk is to look at the practical implementation of Paragraph 297 and the impact the use of Instantaneous Dose Rate (IDR) has on designation of Controlled Areas compared to a time-averaged approach.

**Methods.**

Review of multiple scenarios covering Healthcare and Veterinary facilities will be presented for both existing installations and room designs since the publication of the ACOP.

- For existing installations, the IDR were measured and then converted to annual doses, taking account of workload and occupancy.
- For room designs, the shielding and design requirements using annual and IDR constraints were assessed.

For all scenarios, the differences in shielding requirement or other methods of compliance are investigated.

**Results & Discussion**

The results of these scenarios showed that when implementing the IDR constraint, additional shielding was required compared to working to an annual dose constraint. For existing facilities, the use of IDR meant that building modifications would be required or the Employer would need to change working practices. For room designs, the IDR meant that additional shielding was required or facility size would need to be modified. These results open up a discussion about the limits of IDR; other guidance provided by Medical & Dental Guidance Notes[3] (Appendix 11) suggests a staged approach with IDR forming the initial part of the evaluation, but with a time-averaged approach managing the complexities of the scenarios discussed.

**Conclusion.**

The aforementioned scenarios indicate that the use of IDR alone may not be suitable. As such it is suggested that TADR presents a more practicable method for maintaining radiation safety in Healthcare and Veterinary practice.

**Key references**.

[1] SI 2017. *Ionising Radiations Regulations 2017 SI 2017/1075 Health and Safety* (The Stationery Office Limited, London)
[2] HSE (Health & Safety Executive) 2018. Working with Ionising Radiation: IRR 17 *Approved Code of Practice and Guidance (ACOP)* (The Stationary Office Limited, London)
[3] IPEM (Institute of Physics and Engineering in Medicine) 2002. *Medical and Dental Guidance Notes: A Good Practice Guide on all Aspects of Ionising Radiation Protection in the Clinical Environment* (IPEM)