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# Shielding Evaluation of New PET/CT Room & Uptake Rooms

**VAMC – Bay Pines**
**10000 Bay Pines Blvd**
**Bay Pines, Florida 33744**

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This report is to document the shielding required for new PET/CT and uptake rooms going in VAMC- Bay Pines. The calculations were conducted assuming the facility will treat **39** patients per week with an activity of 13 mCi F-18 in the PET/CT room. The forty patients were divided into 3 uptakes rooms The shielding calculations were performed using NCRP 147. The hallways between the control room, uptake room, and scan room were considered controlled rooms. The distance from the rooms on the second floor to the third floor is 19.5 feet. The distance from the floor below these rooms to the current floor is 23 feet. There is slightly more than 6 inches of concrete as support between these rooms and the rooms above.

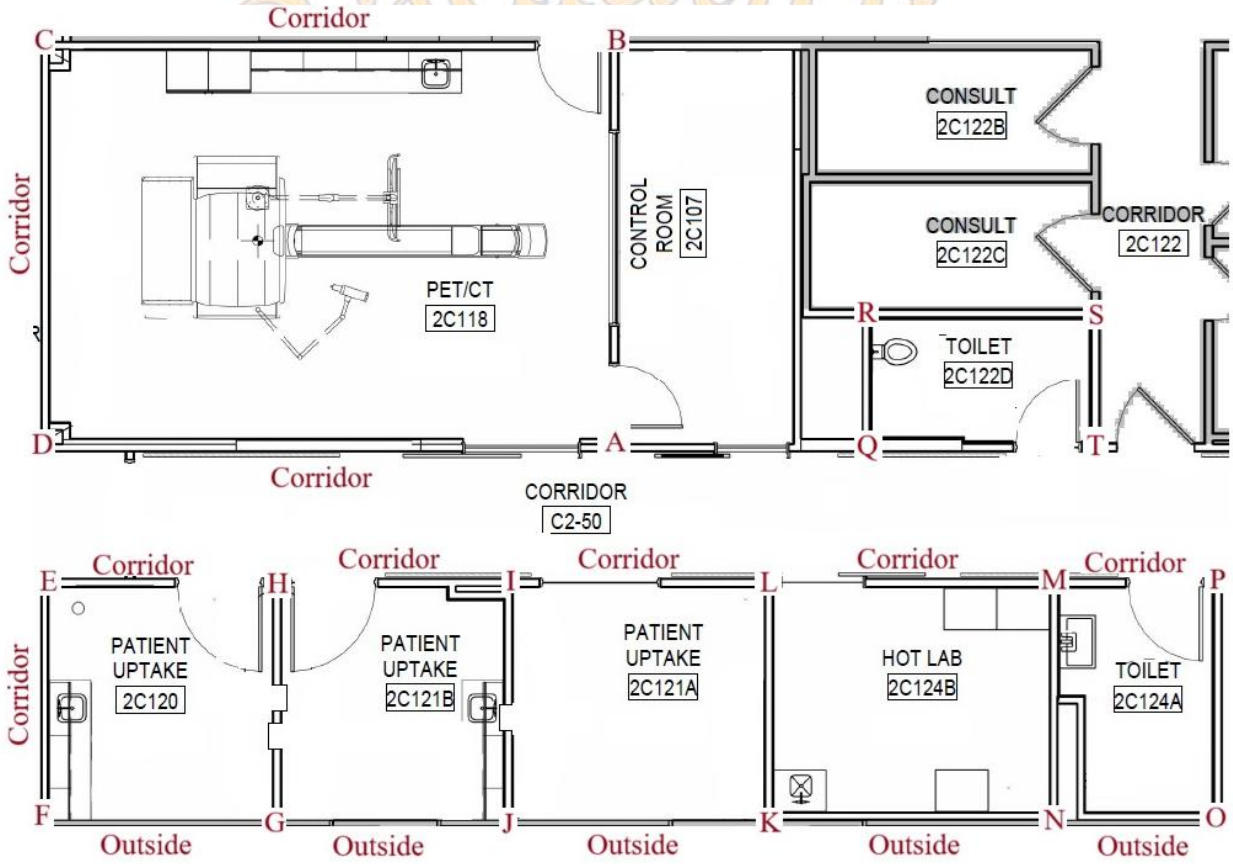



**Figure 1: PET/CT, and Uptake Rooms Layout**

# Summary of Shielding Requirements

| Barrier | Type | Recommended Shielding |
|---|---|---|
| **PET/CT SCAN ROOM** | | |
| A-B (Control Room Wall & Door) | Restricted | Recommend 1/16" lead shielding. |
| B-C (Corridor Wall) | Unrestricted | Recommend 1/16" lead shielding. |
| C-D (Corridor Wall) | Unrestricted | Recommend 1/16" lead shielding. |
| D-A (Corridor Wall) | Unrestricted | Recommend 1/16" lead shielding. |
| Floor | Unrestricted | No additional shielding required. |
| Ceiling | Unrestricted | No additional shielding required. |
| **UPTAKE ROOM 2C120** | | |
| E-F (Corridor Wall & Door) | Unrestricted | Recommend 1/8" lead shielding. |
| G-H (Uptake Room 2C121B) | Unrestricted | Recommend 1/8" lead shielding. |
| F-G (Outside Wall) | Unrestricted | No additional shielding required. |
| E-H (Corridor Wall & Door) | Unrestricted | Recommend 1/8" lead shielding. |
| Floor | Unrestricted | No additional shielding required. |
| Ceiling | Unrestricted | No additional shielding required. |
| **UPTAKE ROOM 2C121B** | | |
| H-I (Corridor Wall & Door) | Unrestricted | Recommend 1/8" lead shielding. |
| G-H (Uptake Room 2C120) | Unrestricted | **See G-H in Uptake 2C120.** |
| G-J (Outside Wall) | Unrestricted | No additional shielding required. |
| I-J (Uptake Room 2C121A) | Unrestricted | Recommend 1/8" lead shielding. |
| Floor | Unrestricted | No additional shielding required. |
| Ceiling | Unrestricted | No additional shielding required. |
| **UPTAKE ROOM 2C121A** | | |
| I-J (Uptake Room 2C121B) | Unrestricted | **See I-J in Uptake 2C121B.** |
| I-L (Corridor Wall & Door) | Unrestricted | Recommend 1/8" lead shielding. |
| K-L (Hot Lab) | Unrestricted | Recommend 1/8" lead shielding. |
| J-K (Outside Wall) | Unrestricted | No additional shielding required. |
| Floor | Unrestricted | No additional shielding required. |
| Ceiling | Unrestricted | No additional shielding required. |

| | | |
|---|---|---|
| **Hot Toilet 2C124A** | | |
| M-N (Hot Lab) | Restricted | Recommend 1/16" lead shielding. |
| M-P (Corridor Wall & Door) | Unrestricted | Recommend 1/16" lead shielding. |
| P-O (Thyroid Room Wall) | Unrestricted | Recommend 1/16" lead shielding. |
| N-O (Outside Wall) | Unrestricted | No additional shielding required. |
| Floor | Unrestricted | No additional shielding required. |
| Ceiling | Unrestricted | No additional shielding required. |
| **Hot Toilet 2C122D** | | |
| Q-R (Open Space/Control Room) | Restricted | No additional shielding required. |
| R-S (Consultation Room Wall) | Unrestricted | Recommend 1/16" lead shielding. |
| S-T (Corridor Wall) | Unrestricted | Recommend 1/16" lead shielding. |
| T-Q (Corridor Wall & Door) | Unrestricted | Recommend 1/16" lead shielding. |
| Floor | Unrestricted | No additional shielding required. |
| Ceiling | Unrestricted | No additional shielding required. |

In general, calculated shielding is often overestimated due to assumptions on workload, use factors, and occupancy factors. I have attempted to provide more realistic factors based on information from the facility and modified occupancy estimates.

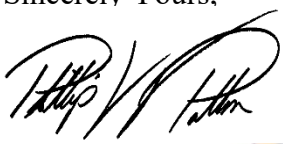
For the PET/CT room, calculations were made using a one (1) hour uptake and a half (1/2) hour scan time. Calculations are on Page 5.

For the Hot Lab it is recommended to shield the sources and the cabinets as is common practice. Therefore, no additional shielding will be needed. If you want to add shielding, 1/16" will help reduce the rare times the sources are not behind an L shield or in a shielded drawer.

For the uptake, the patient is assumed to be located in the center of the room toward the outside wall unless otherwise noted on the diagram. This will allow for the best protection to the population outside of the nuclear medicine area. The patient is assumed to be seated and alone during the hour of uptake. Calculations are on Page 5.

All lead sheeting should extend to a height of at least 7 feet above floor level. Nail heads do not need to be overlapped. **Doors and windows require the same amount of lead or lead equivalent shielding as the wall it is part of. Additionally, any outlets or cutouts in the walls will need the same shielding as the wall placed behind the outlet or cutout.** Overlying drywall seams should be offset and great care should be exercised in taping and plastering seams. No gaps in drywall are acceptable. If you have any questions, please contact me at (702) 336-3004.

Sincerely Yours,



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**References**


(1) National Council on Radiation Protection and Measurements (NCRP) Report 147, Structural Shielding Design for Medical X-ray Imaging Facilities, NCRP, 2004

(2) Madsen, M.T., Anderson, J.A., Halama, J.R., Kleck, J., Simpkin, D.J., Votaw, J.R., Wendt, R.E., III, Williams, L.E. and Yester, M.V. (2006), AAPM Task Group 108: PET and PET/CT Shielding Requirements. Med. Phys., 33: 4-15. https://doi.org/10.1118/1.2135911


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# Calculations

## CT Component of PET/CT Room

Shielding requirements:

| Barrier | Design Dose (mrem/wk) | T | P/T (mrem/wk) | Dist (ft) | Unshielded Dose (mrem/wk) | Required Transmiss | Required Pb (mm) | Required Pb (inches) | Required Concrete (mm) | Required Concrete (inches) |
|---|---|---|---|---|---|---|---|---|---|---|
| AB Control Room | 10 | 1.000 | 10 | 13.0 | 477.4 | 0.02094 | 0.908 | 1/28 | 100.1 | 3.94 |
| BC Corridor | 2 | 0.200 | 10 | 10.0 | 806.9 | 0.01239 | 1.093 | 1/23 | 115.0 | 4.53 |
| CD Corridor | 2 | 0.200 | 10 | 13.0 | 477.4 | 0.02094 | 0.908 | 1/28 | 100.1 | 3.94 |
| DA Corridor | 2 | 0.025 | 80 | 10.0 | 806.9 | 0.09915 | 0.439 | 1/58 | 57.0 | 2.24 |
| Ceiling (Office) | 2 | 1.000 | 2 | 19.0 | 1.2 | 1.67776 | None | None | -10.9 | -0.43 |
| Floor (Corridor & Open Space) | 2 | 0.200 | 10 | 22.0 | 0.9 | 11.24703 | None | None | -42.6 | -1.68 |

Floor/ceiling too thin: Determine how much Pb to add. OK

HVL in lead= 0.1 mm Pb , HVL in concrete= 1.5 cm concrete per NCRP 49, 150 kVp.

Present floor/ceiling consists of 4.5 inches concrete= 11.43 cm conc= 7.6 HVLs thick

Required ceiling transmission= 1.67776 or -0.7 HVLs, so must add -8.4 HVLs. This is -0.84 mm Pb to add.

Required floor transmission= 11.24703 or NA HVLs, so must add NA HVLs. This is NA mm Pb to add.

## PET Component of PET/CT Room

**PET Shielding Calculations**
**PET/CT Scan Room**

| | Patient Dose Rate Constant (uSv-m$^2$/MBq-h) | Dose Rate Constant (uSv-m$^2$/MBq-h) | Dose Reduction Factor over time Uptake | Dose Reduction Factor over time Imaging |
|---|---|---|---|---|
| **FDG** | **0.092** | **0.143** | **0.83** | **0.91** |

| | |
|---|---|
| **Typical Dose (MBq)** | **481** |
| **Typical Patients/week** | **40** |
| **Uptake Time (hr)** | **1** |
| **Imaging Time (hr)** | **0.5** |
| **Percentage of activity secreted prior to scan** | **15%** |

**Important: see summary for final recommendations**

| Barrier | T | Distance (m) | Weekly Dose Equiv. | Transmission Factor | Required Shielding |
|---|---|---|---|---|---|
| A-B Control Room | 1 | 4.10 | 27.9 | 3.585 | **None mm Pb** |
| B-C Corridor | 0.2 | 2.89 | 56.1 | 1.781 | **None mm Pb** |
| C-D Corridor | 0.2 | 4.10 | 27.9 | 3.585 | **None mm Pb** |
| D-A Corridor | 0.2 | 2.89 | 56.1 | 1.781 | **None mm Pb** |
| Ceiling (Office) | 1 | 5.40 | 0.4 | 49.747 | **None mm Pb** |
| Floor (Corridor & Open Space) | 0.2 | 6.30 | 0.3 | 338.553 | **None mm Pb** |

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**PET Shielding Calculations**
**Uptake Room 2C120**

| | Patient Dose Rate Constant (uSv-m²/MBq-h) | Dose Rate Constant (uSv-m²/MBq-h) | Dose Reduction Factor over time Uptake | Dose Reduction Factor over time Imaging |
|---|---|---|---|---|
| FDG | 0.092 | 0.143 | 0.83 | 0.91 |

| | |
|---|---|
| Typical Dose (MBq) | 481 |
| Typical Patients/week | 14 |
| Uptake Time (hr) | 1 |
| Imaging Time (hr) | 0.5 |

| Barrier | T | Distance (m) | Weekly Dose Equiv. | Weekly Limit (uSv) | Transmission Factor | Required Pb (mm) | Required Pb (inches) |
|---|---|---|---|---|---|---|---|
| E-F Corridor | 0.2 | 1.91 | 141.0 | 20.0 | 0.709 | **2.797** | **1/9** |
| G-H Uptake 2C121B | 0.2 | 1.98 | 131.2 | 20.0 | 0.762 | **2.250** | **1/11** |
| F-G Outside | 0.025 | 1.91 | 141.0 | 20.0 | 5.676 | **None** | **None** |
| E-H Corridor | 0.2 | 1.98 | 131.2 | 20.0 | 0.762 | **2.250** | **1/11** |
| Ceiling (Office) | 1 | 5.40 | 17.6 | 20.0 | 1.134 | **None** | **None** |
| Floor (Storage) | 0.05 | 6.30 | 13.0 | 20.0 | 30.875 | **None** | **None** |

**PET Shielding Calculations**
**Uptake Room 2C121B**

| | Patient Dose Rate Constant (uSv-m²/MBq-h) | Dose Rate Constant (uSv-m²/MBq-h) | Dose Reduction Factor over time Uptake | Dose Reduction Factor over time Imaging |
|---|---|---|---|---|
| FDG | 0.092 | 0.143 | 0.83 | 0.91 |

| | |
|---|---|
| Typical Dose (MBq) | 481 |
| Typical Patients/week | 13 |
| Uptake Time (hr) | 1 |
| Imaging Time (hr) | 0.5 |

| Barrier | T | Distance (m) | Weekly Dose Equiv. | Weekly Limit (uSv) | Transmission Factor | Required Pb (mm) | Required Pb (inches) |
|---|---|---|---|---|---|---|---|
| H-I Corridor | 0.2 | 1.91 | 130.9 | 20.0 | 0.764 | **2.233** | **1/11** |
| G-H Uptake 2C120 | 0.2 | 1.98 | 121.8 | 20.0 | 0.821 | **1.669** | **1/15** |
| G-J Outside | 0.025 | 1.91 | 130.9 | 20.0 | 6.112 | **None** | **None** |
| I-J Uptake 2C121A | 0.2 | 1.98 | 121.8 | 20.0 | 0.821 | **1.669** | **1/15** |
| Ceiling (Office) | 1 | 5.40 | 16.4 | 20.0 | 1.221 | **None** | **None** |
| Floor (Storage) | 0.05 | 6.30 | 12.0 | 20.0 | 33.250 | **None** | **None** |

**PET Shielding Calculations**
**Uptake Room 2C121A**

| | Patient Dose Rate Constant (uSv-m²/MBq-h) | Dose Rate Constant (uSv-m²/MBq-h) | Dose Reduction Factor over time Uptake | Dose Reduction Factor over time Imaging |
|---|---|---|---|---|
| FDG | 0.092 | 0.143 | 0.83 | 0.91 |

| | |
|---|---|
| Typical Dose (MBq) | 481 |
| Typical Patients/week | 13 |
| Uptake Time (hr) | 1 |
| Imaging Time (hr) | 0.5 |

| Barrier | T | Distance (m) | Weekly Dose Equiv. | Weekly Limit (uSv) | Transmission Factor | Required Pb (mm) | Required Pb (inches) |
|---|---|---|---|---|---|---|---|
| I-L Corrdor | 0.2 | 1.91 | 130.9 | 20.0 | 0.764 | **2.233** | **1/11** |
| I-J Uptake 2C121B | 0.2 | 1.98 | 121.8 | 20.0 | 0.821 | **1.669** | **1/15** |
| J-K Outside | 0.025 | 1.91 | 130.9 | 20.0 | 6.112 | **None** | **None** |
| K-L Hot Lab | 0.5 | 1.98 | 121.8 | 100.0 | 1.642 | **None** | **None** |
| Ceiling (Office) | 1 | 5.40 | 16.4 | 20.0 | 1.221 | **None** | **None** |
| Floor (Storage) | 0.05 | 6.30 | 12.0 | 20.0 | 33.250 | **None** | **None** |