

THEHANFORDSITE

The Radiological Risk of Internal Exposure from the Natural Environment to the Workplace

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- Fundamentals of Internal Exposure
- Historical Occurrences
- Natural Background
- Hanford Concerns





THE HANFORDSITE | Internal pathways

Pathways that a contaminant can enter the body?







THE HANFORDSITE | Internal Dose Risk

Radionuclides that emit alpha particles pose the greater risk



 Alpha radiation can cause double strand breaks in the DNA leading to cancer





THE HANFORD SITE | DOE Radionuclides

- DOE is required to protect workers from ionizing radiatic resulting from the conduct of DOE activities.
- Background radiation and radiation due to medical procedures are excluded.

(10 CFR 8







HEHANFORDSITE Historical Occurrences

Radium Dial Painters – 1917 to 1926

Dial painters tipped their brush with their lips

>50 had died by 1927 due to radium ingestion

Ra-226 targets bone volume.

Malignancies observed were **mostly bone tumors**



Source: https://en.wikipedia.org/wiki/Radium_Girls





THE HANFORDSITE Fate of Some Radium Dial Painters









Assassination of Alexander Litvinenko

- Ingested Po-210
- Poisoned on 11/1/06
- Died 11/23/06
- 700 rad to whole body over 3 weeks

Former Russian spy that had sought asylum in the UK

Po-210 is also in tobacco One pack a day = 36 mrem/y whole body (NCRP-160) Lung dose = ~ 5 rem/y (1 pack/day)

(www.radiation-dosimetry.org)

Source: http://www.elmundo.es/elmundo/2006/11/25/obituarios/1164449771.html





THE HANFORD SITE | Principle Targets

- Radon (α) \rightarrow Lungs
- Ra-226 (α)
- Plutonium (α)
- Sr-90 (β)
- I-131 (β,γ)
- Cs-137 (β,γ)

- \rightarrow Bones
- \rightarrow Bones
- \rightarrow Bones
- \rightarrow Thyroid
- \rightarrow Soft Tissue



MIRD Phantom





THE HANFORDSITE Background Contributors







THE HANFORDSITE Dissection of Background







THE HANFORD SITE Dissection of Background







THE HANFORDSITE Dissection of Background







THE HANFORDSITE Dissection of Background







THE HANFORDENTE Dissection of Background



Radon accounts for about 90% of internal dose from background.

EPA estimates 20,000 deaths per year due to lung cancer caused by radon.





THE HANFORDSITE | Internal Exposure

- Radon/Thoron: 228 mrem/y Lungs
- Internal (background)
 29 mrem/y
 - Cosmogenic: C-14 (1 mrem)
 - Primordial: U-238*, Th-232* (13 mrem)

*includes decay chain (Ra-226, Po-210...)

• K-40 (15 mrem)



- bananas contain potassium, where 0.012% is K-40.
- Thumb rule: 100 bananas = 1 mrem
- Total Internal Exposure 257 mrem/y

National Average!

















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THE HEADERDENTE | Internal Dose due to Radon

Dose from radon is primarily at home (~85-90%?)

- Office buildings ~ 3 times lower better ventilation.
- Outdoors ~ 3 times lower.
- NCRP 160 assumes: 70% at home, 20% at work, 10% outdoors or in transit

Radon dose can vary at home (includes thoron):

- 1.25 pCi/L ≈ 200 mrem/y (national average)
- 2 pCi/L ≈ 320 mrem/y
- 3 pCi/L ≈ 480 mrem/y
- 4 pCi/L ≈ 640 mrem/y (EPA action level)





THE HANFORDSITE | Radon at home









Radon concentration varies during the day



Aumento F. Radon tides on an active volcanic island: Terceira, Azores. Geofisica Internacional 41(4): 499-505; 2002.





Radon is a heavy noble gas and will enter and accumulate at low points in the house.

Exhausting low points to outside above the eaves is a common practice.

Active mitigation uses a fan to ventilate.

Ventilation is important to reducing Radon concentration!



A Physician's Guide to Radon | Radon | US EPA





THE HANFORDSITE | Radon Detection at Home

Radon monitoring is not required in Washington but may be required as part of a home inspection when buying or selling.

Several testing methods are available.





Ecosense EB100 Ecoblu, Digital Radon Detecto...



0.6 pCi/L 5.4 to 10.6 pCi/L* 0.3 pCi/L

*Opened windows for 3 hours, reduced to 1.2 pCi/L





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9-13-22: Room 4J filter change at HLMI Laboratory

•	nitial air concentration:	18.8 DAC (based	d on Pu-239)
• 4	l0-min decay:	9.1 DAC	
• 1	1.5-hour decay:	3.1 DAC	
• 2	20.5-hour decay:	0.12 DAC	(depost <0.2 DAC)
• 1	week decay:	0.0 DAC	

Note: Breathing 1 DAC for 2,000 hours = 5 rem

If we knew this was Radon, then the initial DAC level would have been about 10,000 times lower, not requiring an airborne posting.

Radon is important due to its interference with detecting DOE radionuclides of concern, where plutonium is highest concern.





Hanford Soil Background (RC-TE-RC-60761; 2021)

Radionuclide	Off-Site (pCi/g)	On-Site (pCi/g)	Onsite/Offsite	Threshold (dpm/100 cm ²)
Cs-137	0.13	1.2	10x	6
Sr-90	0.0003	0.11	400x	2
Pu-238	0.0004	0.004	10x	0.1
Pu-239/240	0.005	0.07	14x	0.5
Am-241	not measured	0.04		0.5
<mark>U-234</mark>	0.61	0.4	0.7x	24
<mark>U-235</mark>	0.066	0.037	0.6x	4
<mark>U-238</mark>	0.63	0.4	0.6x	24
<mark>K-40</mark>	15	14.4	~1x	n/a

Equivalent or less than off-site.





THE HENFORDSITE | Potential Dose from Soil at Hanford

The 2021 report concluded that External dose from Cs-137 dominated the internal dose from all radionuclides based on pathway modeling.

Nuclide	Median (mrem/y)	Upper 95% (mrem/y)
Cs-137	0.1	11
Sr-90	0	0.023
Plutonium	0	0.35
Am-241	0.0014	0.225

Measured air concentrations were well below 10 mrem/y.

This verified that bioassay monitoring was not required for routine work.

222-S Laboratory takes outside air samples to ensure there is no potential dose from soil resuspension.





- Alpha emitters are the primary concern for internal dose.
- Radon is the largest contributor to natural background radiation in the home environment.
- Radon progeny interferes with assessing radionuclides of concern.
- Plutonium is the largest concern for internal exposure at most DOE sites.



