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Activation of Insulation in Low Power Nuclear Experiments

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Changing the World's Energy Future

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Idaho National Laboratory

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Activation of Insulation in Low Power Nuclear Experiments

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Introduction

Nuclear experiments differ from conventional reactors in many ways including their scale, lifespan, and amount of operator interaction. These experiments are used to test new materials, configurations, procedures, operating regimes, and unique designs. A wealth of information can be obtained from experiments and can contribute to the design and production of higher power reactor systems. However, these features impose substantial changes to operations and maintenance procedures compared to that of conventional reactors.

Not unlike conventional reactors, a challenge that arises in experiments is the possible exposure of workers to activated materials. Thus, this analysis was performed with consideration to the possibility of a worker inhaling the activated dust from insultation material.

Problem

Depending on the experiment and design, the insulation may receive a wide range of fluence. In an experimental campaign such that the insulation does not receive a large fluence, the activation may be minimal. However, even lightly activated material can become a hazard if it is inhaled or ingested. Many insulation composites are made of materials that can or will create dust when being handled. As such, decommissioning or maintenance workers may be subject to unexpected radiation exposure if precautions are not taken. It's therefore important to understand what materials are being used, production activation products, and the amount of dust they produce when being handled.

Solutions

- **Prioritize low activation materials**
- **Allow activated materials to cool**
- **Avoid materials that produce dust**
- **Wear proper PPE, particularly respirators**
- **Minimize cutting and aggressive handling**
- **Ventilate the experiment area**
- **Minimize disturbance of settled material**
- **Prioritize remote operations / cleanup.**

Method

1) Identify potential insulating materials for use in advanced reactor experiments.
2) Model the irradiation of identified materials in various flux spectrums and identify sources of activation.

Alpha Decay:

Beta- (Electron):

Beta+ (Positron):

Electron Capture:

3) Compute conservative dose values from exposure to activated material using the NUREG-1400 dose approximation.

- Fraction of annual intake limit (I_f),
- Total unencapsulated radioactive material (Q) in Ci,
- Inhalation conversion factor (10^{-6}),
- Fractional material release (R),
- Confinement factor (C),
- Dispersibility factor (D),
- Annual Limit of Intake (ALI)

4) Identify contamination control and exposure prevention methods.

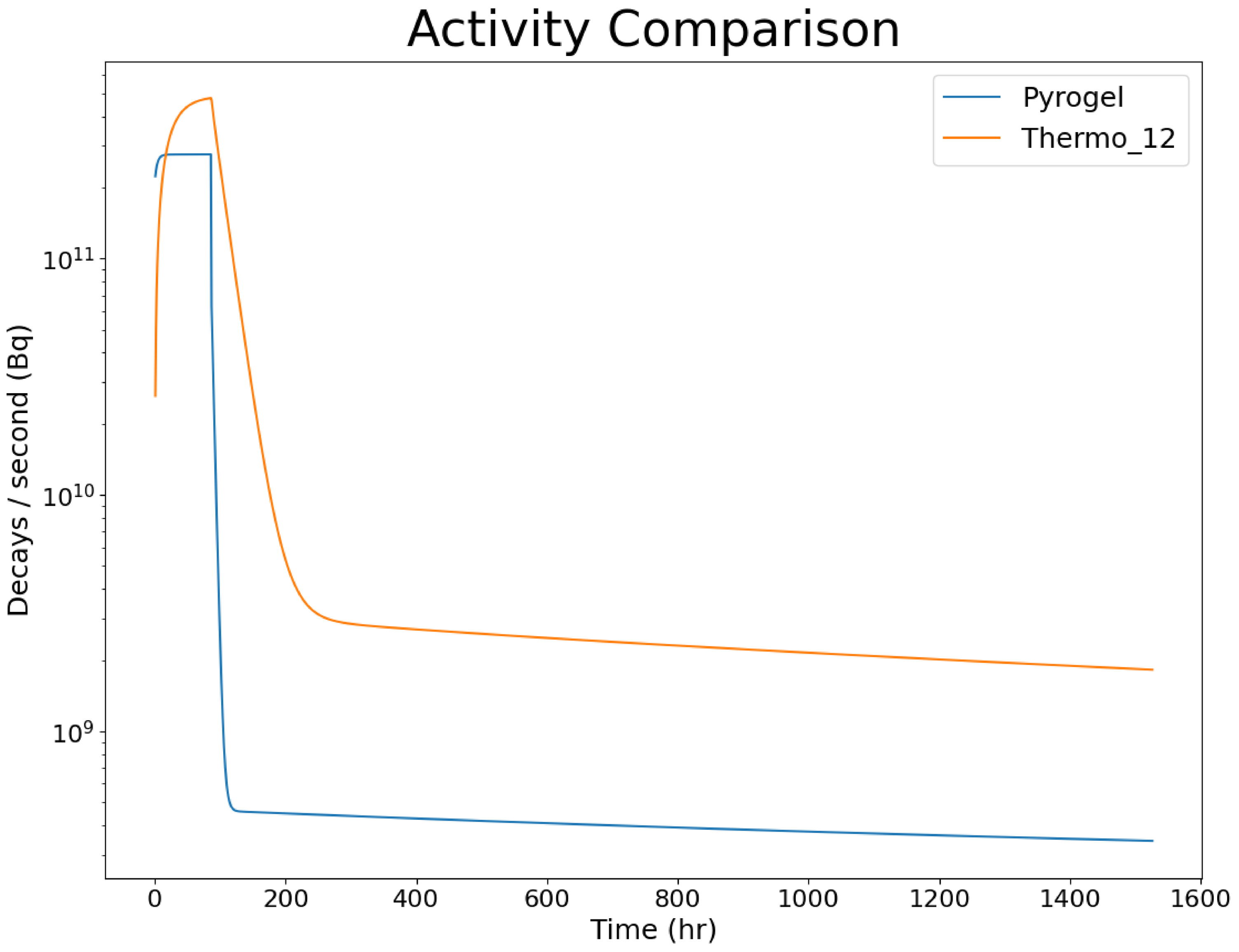
Results

Two industrial grade insulations were identified for potential use in reactor experiments – Aspen Aerogel's Pyrogel XTE, and Johns Manville's Thermo-12 Gold. Bounding dose rates to workers were computed using conservative values for the fractional intake parameters. With the allotted cooling period, both materials fall well below the 5-rem annual dose limit for workers. Na-24 and Si-31 both have relatively high radioactivity and cooling allowed these isotopes to decay away. Note that the dose in Thermo-12 is dominated by Ca-45 (not present in Pyrogel) - this example highlights the importance of material selection in experiments.

Bounding Dose Rate Estimates

	Pyrogel (μrem)	Thermo-12 (μrem)
H3	< 0.001	< 0.001
C14	< 0.001	< 0.001
Na24	-	0.0
Si31	0.0	0.0
Ca41	-	< 0.001
Ca45	-	2.437
Ca47	-	< 0.001
Sc47	-	< 0.001
Fe55	0.185	0.024
Fe59	0.312	0.040
Total	**0.497**	**2.500**

Activity Comparison



Pyrogel Activity Contributions