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Quantifying Aerosol Deposition Mechanisms in Model Dry Cask Storage Systems

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ABSTRACT:

The objective of this work is to measure aerosol deposition and resuspension rates in laboratory models of dry cask storage systems. We will address this objective in two main ways: 1) we will build a laboratory experiment to mimic the geometry and boundary conditions of a dry cask storage system and conduct experiments to directly measure the deposition/resuspension rates of bulk aerosol in the system and 2) we will conduct small-scale fundamental experiments (in parallel) to isolate and quantify individual deposition mechanisms and resuspension rates, with a focus on those sensitive to variable humidity and surface temperature, thereby improving our understanding and parameterization of those processes unique to the dry cask storage system. With this 2-pronged approach, we will quantify aerosol deposition mechanisms and resuspension rates both separately and as combined effects. Working with PNNL scientists, we will integrate our results with the DOE aerosol deposition model to calibrate and validate the model against particulate deposition and resuspension mechanisms, including aerosol droplet evaporation, Brownian diffusion, aerodynamic deposition, gravitational settling, thermophoresis, turbophoresis, Saffman Lift, diffusiophoresis, Stefan Flow, and electrophoresis. This work will be accomplished by first conducting a scoping study to determine the mechanisms and parameters that are most likely to have the biggest influence on aerosol deposition and resuspension behavior in dry storage casks.

This work is driven by the following hypotheses:

1. Not only are not all aerosol deposition mechanisms equally important, but over the life of a DSC, the relative importance of each mechanism will change as well.
2. Dimensionless similitude can be achieved in our laboratory scale experiments.

The outcomes of this project will advance the knowledge used to develop strategies that support meeting the federal government's responsibility to manage and dispose of the nation's commercial used nuclear fuel. Specifically, our results will inform long-term storage options and enhance the safety of waste management and storage of spent nuclear fuel.

The specific deliverables include:

- Experimental results of aqueous aerosol evaporation and deliquescence at boundary conditions relevant to spent nuclear fuel dry storage canisters.
- Deposition/resuspension rates in a lab-scale dry storage cask model for both dry and wet aerosol at a range of relevant boundary conditions.
- Validation of aerosol deposition models currently employed at PNNL by coordinating experimental setups with ongoing aerosol deposition modeling activities.