Creation of a Pebble Database for Material Control and Accountancy in Pebble Bed Reactors

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Program: CT-4

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ABSTRACT:

Pebble Bed Reactor **(**PBR) safeguards approaches are different from traditional large fuel assembly approaches. For example, light water reactor (LWR) fuel assemblies are large, heavy and highly radioactive, which makes theft of these used assemblies unlikely. Because of this, sites that store used LWR fuel do not need to meet the Nuclear Regulatory Commission (NRC) design basis threat theft/diversion requirement. Instead they only need to meet the sabotage requirements. This will not be the case for the PBRs whose fuel consist of relatively small, light, and lower radioactivity pebbles. These pebbles likely will have enrichments above 10%, thus requiring more stringent Category II material control and accountancy (MC&A) requirements. In addition to these challenges, PBRs are designed for their fuel (pebbles) to continuously flow through the reactor core. Item accounting of pebbles appears unfeasible with current technology due to the large number of pebbles in the reactor (~10^5), that foreign objects such as imbedded tags ideally should not be placed in the pebbles, the surface of the pebbles can rub off while traveling through the reactor, and the high heat and radiation fields created from used pebbles limit the capabilities of some nondestructive assay (NDA) techniques. To overcome this challenge, bulk material accountancy techniques can be applied, however, like all used fuel, there is no mature NDA technique to directly measure ^{235}U or plutonium content. A solution to this challenge is to use indirect assessments of nuclear material content, such as fuel burnup. Unfortunately, burnup assessment techniques are often too simplistic to capture the complex history of pebbles, with traditional LWR correlations relating ^{137}Cs's 662 keV gamma ray counts to burnup. Two pebbles can have the same burnup but significantly different plutonium content if they took different paths though the reactor. Creating a vast database of pebble histories and their NDA signatures is essential to improving methods to correlate NDA signatures to pebble content. Through the creation of this database, the methodology employed will also be documented and published for the PBR community to utilize. Not only is knowing a pebble's content vital for facility operations, but this information is also needed for safety, security, and safeguards (3S).