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Preliminary Risk Assessment of a Generalized Molten Salt Reactor Off-Gas System

Recently in the nuclear industry, there has been increasing interest in molten salt reactors (MSRs). There are at least six national efforts currently developing MSR designs. In the US, the Department of Energy's (DOE) Office of Nuclear Energy (NE) is engaging the MSR sector of the advanced nuclear reactor development effort via its Gateway for Accelerated Innovation in Nuclear program and one of DOE-NE's Advanced Reactor Concept awards to support development of the Molten Chloride Fast Reactor. To achieve the enhanced safety goals for advanced reactors, such as those described by the US Nuclear Regulatory Commission (NRC), it is desirable to develop and use an incremental risk assessment approach that supports the incorporation of safety into the design from the earliest stages of development. One system within MSR designs that is especially important from a risk assessment perspective is the Off-Gas System (OGS). The OGS of an MSR will need to process fission and activation products in a way that is not a part of current commercial reactor designs, since current reactors retain essentially all radioactive materials within the fuel pellets and cladding. Furthermore, when analyzing the safety of an MSR, the OGS represents a potential interface between a large source of radioactivity and the environment. This paper describes the development and application of a risk assessment approach that is adaptable to system designs at varying levels of maturity. This method is consistent with the approaches advocated by the Generation IV International Forum and the DOE, both of which encourage the development of safety insights early in system design and the iterative incorporation of such insights. By using an industry-standard Process Hazard Analysis (PHA) methodology to generate results that can be used as input to qualitative and quantitative Fault Tree Analysis, the approach described herein is capable of providing input on how to incorporate safety into design at early stages of development. This work also builds upon prior experience gained using PHA methods to assess the early design of the Liquid Fluoride Thorium Reactor.