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Application of human reliability analysis in the design stage of multi-unit small modular reactors

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It is recommended that probabilistic safety assessment (PSA) should be involved in licensing Generation-IV reactors. Human reliability analysis (HRA) is an important component of PSA process. In the existing PSA models, consideration is being taken for actions of operator recovery and accident management for the plant recovery from a degraded state or core damage situation. As happened in Fukushima event, these actions can be strictly prohibited by releases at other facilities. The HRA models for single units do not consider such a scenario. There is necessity for the HRA of a multi-unit site to consider situation where the site is contaminated with radioactive materials and accident management action required to be conducted in this environment.

In general, HRA is an area of high uncertainty, as compared to PSA inputs that are derived from plant-specific data. Quantification of operator reliability in severe conditions further increases the uncertainties due to the conditions and stresses the operators might be likely to work under. The impact on PSA model refers to that techniques for estimating human reliability in extreme conditions are still developing and the quantitative estimates have large uncertainties. In some situations, conservative biases are used. In other cases, “best estimates” are employed.

Assumed conservative human errors can present a conservative bias in the computed risk results and should be assessed for masking effects. In cases where “best estimate” values are employed, sensitivity studies on the mean unreliability values are required to examine the effect of a change in failure probability on key risk metrics.

This paper highlights the unique issues that have to be considered in applying HRA for a multi-unit SMR. It presents a holistic framework for conducting HRA in the context of PSA in order to examine the hazards that threaten a multi-unit nuclear site.

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