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Small Modular Reactor Multi-Module PSA

Nuclear power plants (NPPs) with advanced reactor technologies, particularly small modular reactors (SMRs) are planned to be built in various countries worldwide. Due to the much lower power output of these reactor types in comparison to operating NPP units, the plants with SMRs are intended to be realized by multiple modules of the same type at a given site. Based on the type of the multi-module concept, the different SMR modules may share some systems, structures and components (SSC, e.g., a joint building, or electricity supply) and/or a common team of operators. As an example, the NuScale VOYGR™-type SMR is developed to share SSC for up to twelve modules.

For analysing the risk of multiple modules at a common site, GRS has developed a multi-module Level 1 PSA for a VOYGR™ SMR plant applying the commercially available PSA code RiskSpectrum®. The model enables the analyst to compare the risk from a single module to that of multiple, up to twelve identical modules located in the same building, sharing several SSC and the operators' team. The manufacturer's PSA of NuScale has been modified by an own analysis of initiating events (i.e., common cause initiators (CCIs) affecting multiple modules) and applying reliability data for systems and components from the German operating experience regarding single and/or common cause failures (CCFs). As a result, the core damage frequencies (CDFs) for a hypothetical site with only a single SMR single module site and with twelve modules have been determined and compared. Multi-module cut sets with an important contribution to the overall risk are identified. Inter-module CCFs and human failures have been observed to be the important risk contributors. The analysis of significant contributors to the inter-module risk appears to be beneficial for quantifying the main cut sets and the safety balance of the reactor concept.

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