A Method for Risk-Informed Safety Significance Categorization Using the Analytic Hierarchy Process (AHP) and Bayesian Belief Networks (BBN)

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Abstract

A risk-informed safety significance categorization (RISSC) is to categorize structures, systems, or components (SSCs) of a nuclear power plant (NPP) into two or more groups, according to their safety significance using both probabilistic and deterministic insights. In the conventional methods for the RISSC, SSCs are quantitatively categorized according to their importance measures for the initial categorization. The final decisions (categorizations) of SSCs, however, are qualitatively made by an expert panel through discussions and adjustments of opinions by using the probabilistic insights compiled in the initial categorization process and combining the probabilistic insights with the deterministic insights. Therefore, owing to the qualitative and linear decision-making process, the conventional methods have the demerits that they are very costly in terms of time and labor; that it is not easy to reach the final decision, when the opinions of the experts are in conflict; and that they have an overlapping process due to the linear paradigm: the categorization is performed twice first, by the engineers who propose the method, and second, by the expert panel. In this work, a method for RISSC using the AHP and BBN is proposed to overcome the demerits of the conventional methods and to effectively arrive at a final decision (or categorization). By using the AHP and BBN, the expert panel takes part in the early stage of the categorization (that is, the quantification process) and the safety significance based on both probabilistic and deterministic insights is quantified. According to that safety significance, SSCs are quantitatively categorized into three categories such as high safety significant category (Hi), potentially safety significant category (Po), or low safety significant category (Lo). The proposed method was applied to the components such as CC-V073, CV-V530, and SI-V644 in Ulchin Unit 3. By using this method, we could categorize the components quantitatively on the basis of experts'knowledge and experience in an early stage.