Safety Corner

What are the Uncertainties in a Risk Assessment for Complex Engineering System?

Full scope probabilistic risk assessments (PRAs) for complex engineering systems can be categorized into levels. A three-level categorization is adopted for nuclear power plan PRA:

A Level 1 PRA estimates the frequency of damage to the nuclear core, usually with a reactor operating at full power. All systems that work to protect the reactor from core melt are modeled. Because the functions and the availabilities of the safety systems are generally well understood, the uncertainties of the result are relatively small.

A Level 2 PRA estimates the magnitude and timing of radiological releases into the environment, given a core melt has occurred. Uncertainties associated with how much radioactive materials (e.g., coolant, gases) escape from the reactor systems at various levels of release strength, as well as variations in the response of containment system, make a Level 2 PRA less precise than a Level 1 PRA.

A Level 3 PRA assesses personnel injuries/fatalities and economic losses that might result if radioactivity escaped from the containment system. Highly variable factors like wind speed and direction will affect the results, and make a Level 3 PRA having the highest uncertainties.

The uncertainties associated with a risk assessment can be due to the limitation to accurately model complex reality, the limited knowledge in applying correct data and parameters, and the randomness of the nature. These uncertainties can be somewhat reduced by refining the modeling efforts to more accurately reflect the real world, a better understanding of the physics and interactions to improve the precision of the models, and/or collecting adequate, relevant data to improve the input parametric values.

While it is convenient to summarize the numerical results of a quantitative risk assessment (QRA) using a single number or a representative value such as point estimate or mean value, the results of a PRA take more than the form of a single number by providing a spectrum of possible outcomes in terms of distributions of values to explicitly express the associated uncertainties because it is also important to understand how much larger or smaller the actual risks and the associated uncertainties are.

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