Safety Corner

Uncertainty Analysis versus Sensitivity Analysis

Risk is defined as the effect of uncertainty on objectives, according to ISO 31000 and ISO Guide 73. Thus, an effective risk management system must formally address uncertainly. General public often simply define risk as the product of likelihood and consequence, and mistakenly think that the likelihood term is addressing uncertainty. However, uncertainty exists in both likelihood and consequence of risk calculations, as well as in the risk models. The likelihood calculation yields the occurrence frequency of the accident scenarios but it cannot tell how likely the frequency is.

Safety engineers use probability distributions to address uncertainty in a risk assessment. For example, safety engineers would model the failure rate, λ, of a component as a random variable and use a probability distribution $\lambda(t)$ to address its uncertainly. The output of the risk assessment would also be a probability distribution, which is often represented by its mean value. If the uncertainty is large, the corresponding probability distribution will show a wide band. If the band is unacceptably wide, safety engineers would identify the sources of uncertainty and refine the analysis. This dimension of a risk assessment cannot be addressed by merely evaluating the likelihood of the accident scenarios.

An uncertainty analysis aims to propagate the uncertainties in the input parameters to the output through the risk models in a risk assessment, where sampling methods such as Monte Carlo or Latin Hypercube are often used.

The aim of sensitivity analysis is to compute the effect of changes in input parameter on the output of a risk assessment. A sensitivity analysis cannot replace an uncertainly analysis but plays a complementary role as it can rank-order by importance the strength and relevance of the inputs in determining the variation in the output. Such knowledge allows safety engineers to determine which parameters require a more accurate values or a narrower uncertainty, and understand the behavior of the system being modeled.

Sophisticated risk assessment software includes standard modules for uncertainty analysis and sensitivity analysis, making these analyses straightforward.

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