Probabilistic risk analysis (PRADA)

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Human reliability analysis (HRA)

The main activity has been participation in the international EXAM-HRA project.

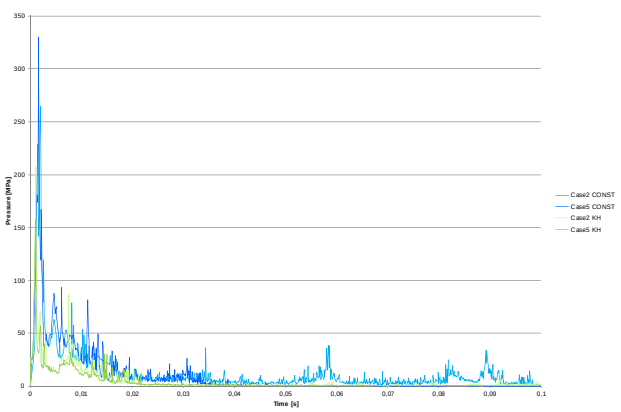
A framework for identifying discrepancies in existing HRA applications was created. A survey, on operator actions in existing PSA studies, resulting in information on appr. 420 operator actions from 6 PSA studies, was conducted, and a screening process for operator actions was created. Case studies were performed, resulting in observations that enable improvements of both plant features and HRA. An evaluation guide on how to perform HRA case studies was created. An application guide was created. It provides guidance on the scope of human failure events to be included in HRA.

Level 2 PSA

Analysis of passive safety systems focused mainly on the effectiveness of a passive autocatalytic hydrogen recombiner (PAR) in preventing hydrogen explosions in a severe accident. A simplified failure modes and effects analysis was conducted, and a general framework of combining PAR reliability reliability analysis with containment event tree was developed. The main result of the analyses was that in the computational experiments, PARs didn't work effectively in preventing hydrogen explosions, in the positions that were tried. The main reason for this ineffectiveness seems to be that PAR starts slowly, giving hydrogen time to accumulate and explode, and that it isn't efficient if installed on a wall. A better position for a PAR is likely to be the highest point(s) of the containment.

A pilot study of simulating a passive containment cooling system (PCCS, a safety system) was conducted using MELCOR code. Analysis results revealed that drywell to wetwell differential pressure, noncendencible gas mole fraction, and pressure in the drywell have the greatest impact on the heat transfer capability of the PCCS. Steam explosions were studied in the IDPSA framework, with two case studies. A literature study on debris bed coolability was performed. Information on pressure loads was obtained. The model used in these was one of the Olkiluoto 1 and 2 power plant.

Figure 1. Maximum explosion pressures of a level 2 study.



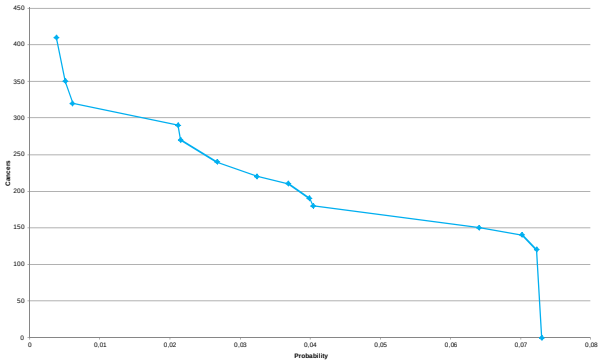


Figure 2. Farmer's curve of the level 3 pilot study. The number of cancers vertically, probability horizontally.

Risk analysis of emergency operations

A modeling framework for emergency operations, such as recovery from a LOCA accident, was developed. The operations are represented as activity networks; this is combined with Monte Carlo simulation (with probability distributions attached to the nodes of the network) to estimate the schedule risk of the operation. Another basis of the framework is fault trees. Within the framework, schedule risks, end product quality risks, and operation side effect risks cam be analysed. The framework also allows the analysis of safety risks and cost risks, although these are not relevant within the nuclear safety context.

Two case studies were conducted. The first concerned the prevention of oil spills from entering the feedwater system of the Hästholmen power plant. The other concerned the clearing of logs from roads leading to the Hästholmen power plant.

Level 3 PSA

A software requirements specification, reflecting modern level 3 analysis needs and possibilities, was created. Also an information interface between levels 2 and 3 was specified.

A pilot, using event trees, atmospheric dispersion and dose calculation was constructed to model and analyse an alternative version of the Fukushima Daiichi nuclear accident. The main result of the analyses is that that the nearly nonexistent radiological consequences of the actual accident were not the outcome of good luck but were to be expected.

Imprecise probabilities in reliability

Methods for analysing the impact of epistemic uncertainties in fault trees have been developed. The probabilities used in the fault tree are expressed as number intervals.

Also a portfolio optimization model for resource allocation in risk management was constructed., and computational performance of solution methods improved.

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