SESSION IV: APPLICATIONS TO UNCERTAINTY ASSESSMENT IN LEVEL 2 PSA

SESSION CHAIRS: MESSRS AHN (KAERI) AND LAJTHA (VEIKI)

Mr. *Lajtha* presented the first phase of effort to determine the uncertainties in the level 2 PSA for the Paks NPP, whose main objective was to quantify uncertainties in containment failure state and release category frequencies. He stated that the uncertainty analysis for the level 2 PSA of NPP Paks has been performed by a combination of multiple severe accident simulations and the use of dedicated probabilistic methods and tools to express uncertainties of accident phenomena and, consequently, containment states.

Their study started with the propagation of uncertainties from the level 1 analysis to the level 2 PSA. First the important severe accident phenomena were determined then the model parameters were chosen for the uncertainty calculations. The samples from the range and distribution of the selected model parameters were produced by the Latin hypercube sampling method. 200 calculations were performed for each branch of a plant damage state by the MAAP4/VVER code.

Ms. *Siltanen* presented the development of a comprehensive SAM strategy for the Loviisa NPP and its implementation. She stated that the strategy ensures reliable prevention and mitigation of containment-threatening phenomena. The development of the SAM scheme for Loviisa NPP was an Integrated ROAAM application. Her presentation focused on the treatment of phenomenological uncertainties according to the Integrated ROAAM approach. In addition, she presented about PSA level 2 studies carried out for Loviisa NPP.

Her conclusion was that while the integrated ROAAM ensures a balanced SAM concept and a credible treatment of phenomenological uncertainties, particularly when hardware modifications of the plant are involved. She also pointed out that PSA level 2 allows us to understand the source term and the uncertainties involved in radioactive release modeling.

Mr *Kress* presented an assessment of the phenomenological uncertainties associated with Level 2 PRA. This assessment is based on the results NUREG-1150 and the Individual Plant Examination (IPE) Insights Program. Also, it reflects the more recent technical knowledge and understanding of severe accident phenomena. While a formal propagation of the uncertainty is the best way to account for model uncertainties, under certain circumstances, he demonstrated that the model uncertainties associated with many phenomenological issues are not important to the overall risk. Risk importance measures for phenomenological issues can be useful for directing any needed sensitivity analysis (in the absence of any formal model uncertainty analysis), as well as for developing research priorities to reduce the overall model uncertainty.

Mr. *Raimond* gave an outline of the Method implemented by the IRSN for the evaluation of uncertainties in level 2 PSA including an example of release calculation and perspectives of application. The main objective of this was to present the methodological approach of IRSN for uncertainties assessment in level 2 PSA, with more details on release assessment. The method implemented for the Accident Progression Event Tree (APET) in IRSN was briefly described:

- A detailed interface with a large number of PDS,
- Physical modules in APET for each severe accident phenomena,
- Uncertainties evaluation with ‘state’ and ‘uncertain’ variables as entries of physical APET,
- Modules and ‘response surfaces’ method for the link with severe accident codes results.

With that method, the results of level 2 PSA can be expressed with more than a thousand release categories and associated source terms. In practice, the results are presented in a more synthetic way by suitably grouping these release categories.

Mr. *Chaumont* summarised the activities carried out in the frame of the Severe Accident Research Network (SARNET), focusing on the Level 2 PSA work package and on the comparison of partners' methods for uncertainties assessment. The PSA2 work package (PSA2 WP) is a part of the SARNET Joined Programme Activity related to level 2 PSA methodologies. The general objectives of this work package is to provide a comparison of the different methodologies used or under development for level 2 PSA application by the partners involved and to promote their harmonization. Attention is paid on the methodologies used so far by the different partners to assess the uncertainties in their level 2 PSA. First conclusions of the comparison were given in terms of improvement needs and then of perspectives of the work for the following period of work.

Mr. *Brown* presented the results of a scoping study, conducted to investigate the influence of the input parameter VFSEP on the dryout (void) time of the upper level fuel channels in a generic CANDU 6 reactor core, during a postulated Large Loss-of-Coolant Accident with complete loss of emergency core cooling (LLOCA+LOECC). He stated that a code-to-code comparison between MAAP4-CANDU (v4.05A) and CATHENA (a detailed thermal-hydraulic code used design basis accident analyses of a CANDU plant).was performed to evaluate the values of the parameter VFSEP appropriate for a given LLOCA, with generic CANDU 6 plant data. His conclusion is that results of the scoping analyses demonstrated the input parameter for phase separation onset in the PHTS (primary heat transport system) is important for predicting the timing of events of accident progression.

Mr. *Kawabata* discussed the uncertainty analysis of containment failure frequencies performed for each failure mode as a part of level 2 PSA projects at JNES, for a Japanese 4-loop PWR plant with a pre-stressed concrete containment. For this, the LHS method was applied with a sample size of 200 to each PDF and the uncertainties in the CET were then combined and propagated by the PREP/SPOP code in which credit was given for statistically correlated parameters.

His conclusion is that uncertainties addressed in the late containment failure modes (such as containment bypass, and late over-pressurization excluding base-mat melt-through) were not so great and early containment failure modes (i.e., in-vessel and ex-vessel steam explosion, and hydrogen detonation failure) subjected to large uncertainties did not contribute much to the total containment failure frequency.

Mr. *D'Auria* presented about an 'IAEA TECDOC' whose purpose is to address the use of a best estimate approach in licensing type accident analysis with evaluation of uncertainties. He stated that the document should outline the current issues and future trends in BE accident analysis and share experience and guidance for performing accident analysis based on present good practice worldwide. Through his presentation, he recommended that best-estimate applications of complex thermal-hydraulic system codes be supported by uncertainty evaluation for the relevant output quantities. He also recommended (1) the development of consistent procedures for the application of uncertainty methods within the licensing process, (2) the reproducibility and traceability of the results, (3) training and certification of users of the systems codes, in particular for licensing calculations.