Accident Sequences Management in Severe Accident Risk Database

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1. Introduction

In terms of an accident management, the cases causing severe core damage need to be analyzed and arranged systematically for an easy access to the results since the Three Mile Island (TMI) accident. The objectives of this paper are to explain how to identify the plant response and cope with its vulnerabilities using the PSA quantified results and severe accident database SARDB (Severe Accident Risk Data Bank) based on sequences analysis results.

2. SARD DB Results and Application Method

In this section the methodology of how to use PSA results and database in managing accidents occurring in a nuclear power plant is described.

2.1 SARD Main structure

At present, KAERI is calculating the severe accident sequences intensively for various initiating events and generating a database for the accident progression including thermal hydraulic and source term behaviours. The developed Database (DB) system includes a graphical display for a plant and equipment status, previous research results by knowledge-base technique, and the expected plant behaviours. For an efficient management, each of the three modules takes charge of (1) specification of the target information for the data allocation and the retrieval, (2) automatic allocation of the severe accident risk data sets into the database, and (3) fast prediction and intelligent retrieval of the user-specified scenario-based plant response.

2.2 Data Bank of Severe Accident Sequences Analyses

Once the initial information setting module is prepared, the SARD Database is structured to capture the various elements of the severe accident risk information by allocating a separate Access Database table to each element.
-Base Case:
As an Example, according to the Level 2 PSA results for the large LOCA initiators, seven scenarios have been determined for analyses based on the probabilistic safety analysis of the KSNP as shown Table 1. These scenarios account for 99.6 % of the occurrence frequency of the 30 large LOCA scenarios. [1]. In medium LOCA, contribution of the six sequences out of 20 plant damage state event tree end points takes about 99.8%. Also, contribution of the nine sequences from PDS event tree end points takes about 97.4% in small LOCA.

I.E	Basic Event	Frequencies	Characteristics
LLOCA	LLOCA-2	17.01	/SIT*/LPI*/HPR*/HPH*CSS
	LLOCA-3	19.25	/SIT*/LPI*/HPR*HPH*/CSS
	LLOCA-5	11.50	/SIT*/LPI*HPR*/LPR/*HPH*/CSS
	LLOCA-8	5.9	/SIT*/LPI*HPR*LPR*HPH*CSS
	LLOCA-9	45.36	/SIT*LPI*/HPI*/HPR*/CSS
	LLOCA-15	0.46	/SIT*LPI*HPI*HPR*LPR*HPH*CSS
	LLOCA-17	0.15	SIT*/LPI*/HPR*/CSS
	total	99.63 %	
MLOCA	ML2	28.15	/HPI*/HPR*/HPH*CSR
	ML3	31.87	/HPI*/HPR*HPH*/CSR
	ML5	10.07	/HPI*HPR*/LPR*/CSR
	ML8	9.0	/HPI*HPR*LPR*CSR
	ML9	19.1	HPI*/LPI*/LPR*/CSI/*/CSR
	ML19	0.76	HPI*LPI*CSI
	toatl	98.95 %	
SLOCA	SL11	0.05	/HPI*/AFW*/ADV*HPR*LPR*/CSS
	SL12	57.79	/HPI*/AFW*/ADV*HPR*LPR*CSS
	SL13	0.27	/HPI*/AFW*/ADV*HPR*/LPR*/CSS
	SL21	0.08	/HPI*/AFW*ADV*/MSSV*/HPR*BDL*/CSS
	SL26	0.14	/HPI*/AFW*ADV*/MSSV*HPR*LPR*CSS
	SL45	0.19	/HPI*AFW*/LPR*BDE*/CSS
	SL55	1.19	HPI*/AFW*ADV*/MSSV*/HPR*BD*/CSS
	SL57	5.12	HPI*/DPI*LPI*CSI
	SL59	32.6	HPI*DPI*/LPI*/CSI
	total	97.43 %	

Table 1. Summary of the initial and boundary conditions of LOCA sequence with its frequency.

- Sensitivity Case:
Though some sensitivity runs were done in the PSA study, they do not show the effect of safety parameters on accident progression systematically. In terms of accident management, this information can be useful to anticipate how the accident goes in the end. The following shows the information examples of parameters for the base case and the sensitivity runs for a LOCA sequence.

1) Break Sensitivity: Break Location (Cold-leg, Hot-leg) Break Size (0.4 ,0.8 ,10.02 ft2)
2) Phenomena Sensitivity: Ex-vessel Cooling (off, on), MCCI Heat Transfer Coefficient
3) System Sensitivity (availability):Charging Pump Flow (0, 88, 132 gpm)

2.3 SARD DB Searching Modules

Searching module takes charge of fast prediction and intelligent retrieval of the user-specified scenario-based plant response and of the symptom-based event sequence information from the database. For this, the SARD menu system provides a user-friendly interface for the user to explore the contents of the database and to obtain answers to various questions. The present database management system is very useful in a number of applications including a support of the Level 2 PSA, a comparison of severe accident analysis results, training and understanding of the severe accident phenomenology, and an assistance in a severe accident management.

- Sequence based Search Approach

The following is an example showing initial conditions and result: 1) Initial and Boundary Condition (a) event-LOCA (b) Sequence - Plant Damage State ; All Safety System Fail) 2) Goal (a)Finds Progress of Accident sequence at an Initiating Event (b)Provides Operator Recovery Action for Accident Management (Ex. RV Failure time)

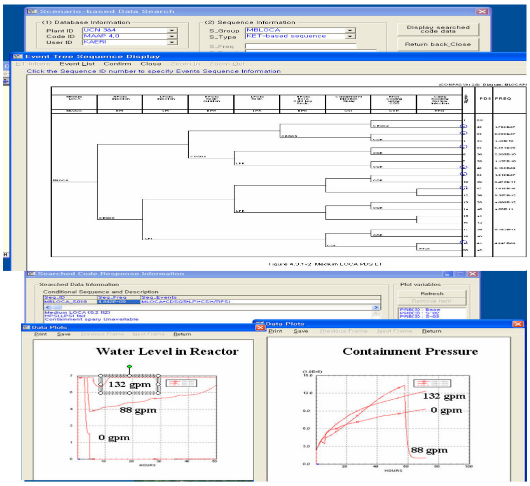

Figure 1. Display of Scenario Based Searched results in Computer Monitor

- Symptom based Search Approach

An illustrative sample is employed in the present database system as bellows. 1) Initial and Boundary Condition (a)30 Min. ~ 1Hr After Event Occurs (EOP Considered) may play a central role as an information) (b) Water Level ; 6m – 7m (Before Reactor uncover) (c)RCS Pressure < 100 atm. 2)Goal (a)Shows Possible Progress of Accident sequence under condition for OPR-1000 and (b)Provides Operator Recovery Action for Accident Management (Ex. RV Failure time)

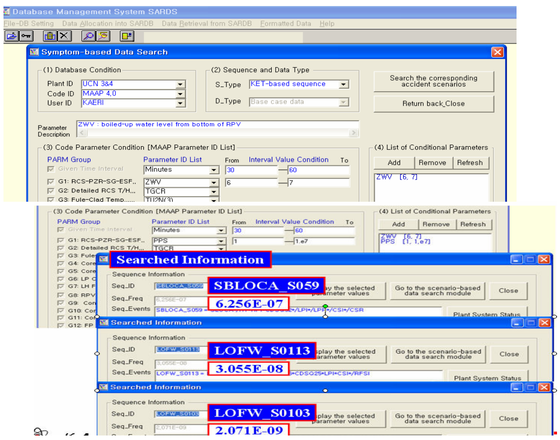

Figure 2. Display of Symptom Based Searched results in Computer Monitor

2.4 Display of Optimal Success Path

The developed system includes the graphical display for the plant and equipment status, previous research results by a knowledge-base technique, and the expected plant behavior using PSA. Also the suggested paths can be checked by monitoring the plant status using display support system such as the Severe Accident Training Simulator (SATS) [2]. The support system for a decision-making with a severe accident management provides plant parameters to monitor plant status. The path monitor checks the status of the safety system selected by the maintenance status and displays the optimal success path based on each component with a mimic display of a system drawing. An example display of optimal success path selected from the integrated reliability rules is shown in Figure 3.

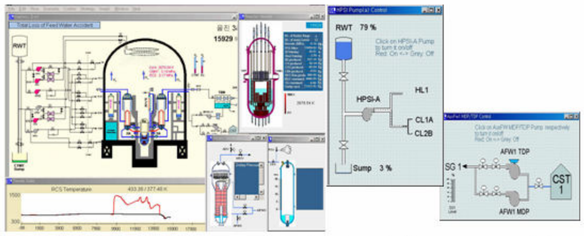

Figure 3. Display of an Optimal Success Path in Computer Monitor

3. Conclusion

Database has been effectively tested through a set of DBs whose elements are plant specific status, scenarios and parameters. Therefore analysis of severe accident may play a central role as an information source for the decision-making for severe accident management, and will be used as a training tool for a severe accident management. In particular, our approach of applying PSA results to accident management is based on back-end analyses, i.e., level-2 PSA results, because the current emergency operating procedures (EOPs) do not properly cover the severe accident regime involving core damage. The results of back-end analyses help to identify plant vulnerabilities and appropriate plant responses to a specific challenge. [3]

Acknowledgements

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