MELCOR DB Construction for the Severe Accident Analysis DB

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1. Introduction

The Korea Atomic Energy Research Institute (KAERI) has been constructing a severe accident analysis database (DB) under a National Nuclear R&D Program. In particular, an MAAP (commercial code being widely used in industries for integrated severe accident analysis) DB for many scenarios including a station blackout (SBO) has been completed. This paper shows the MELCOR DB construction process with examples of SBO scenarios, and the results will be used for a comparison with the MAAP DB.

2. MELCOR DB Variable Design

The first step is to design DB variables that can give good information about accident progression. All output variables in MELCOR [1] code can be used as the DB variables, and some important variables to be compared with the MAAP [2] results for a basic check of the scenarios are selectively shown in Table 1. As illustrated in Fig.1, MELCOR data need to be modified in order to synchronize the data by adjusting the reference levels or by summing up the (MELCOR) volumes, which have used further subdivision.

Table 1: MELCOR DB Variable Selection

MELCOR / MAAP	Variable Description	Note
CVH-CLIQLEV.n	Collapsed liquid elevation in control volume n	UF.602 = (CVH-CLIQLEV.600) – 2.35m
ZWBS	Collapsed water level in broken S/G downcomer	
CVH-CLIQLEV.n	Collapsed liquid elevation in control volume n	UF.702 = (CVH-CLIQLEV.700) – 2.35m
ZWUS	Collapsed water level in unbroken S/G downcomer	
CVH-P.n	Pressure of control volume n	n=380(cold leg) or 500(PRZ)
PPS	Pressure in primary system	
COR-TSVC.n	Core temperature in node n	n=104(bottom, channel 1) n=114(top, channel 1)
MAX_CET	Maximum core exit temperature	
CVH-CLIQLEV.n	Collapsed liquid elevation in control volume n	n=820(inner shell) or 830(annulus)
ZWRB(2)	Collapsed water level in containment	2=lower compartment
CVH-P.n	Pressure of control volume n	n=840(dome)
CVH-P.n	Pressure of control volume n	n=382/392/482/492 : 4 tanks
PACUM	Pressure in accumulator	
CVH-CLIQLEV.n	Collapsed liquid elevation in control volume n	n=130(downcomer)/150(LP)/ 170(core)/260(UP)
ZWCPS	Collapsed water level in primary system	
COR-DMH2-TOT	Total cumulative hydrogen production in core	
MH2CR	Integrated H_2 mass generated in core	
CVH-CLIQLEV.n	Collapsed liquid elevation in control volume n	n=388
ZWRWST	(Collapsed) water level in RWST	
COR-M.m.k.n	Total mass (intact plus conglomerate) of material m in component k in cell n	n=104/105/.../113/114 /204/205/.../213/214 .../ /604/605/.../613/614 /704/705/.../713/714 COR-M.m.k.n = COR-MCRP-TOT + COR-MINC-TOT + COR-MSS-TOT + COR-MSX-TOT + COR-MUO2-TOT + COR-MZR-TOT + COR-MZX-TOT
MCR	Total mass of core material remaining in core	

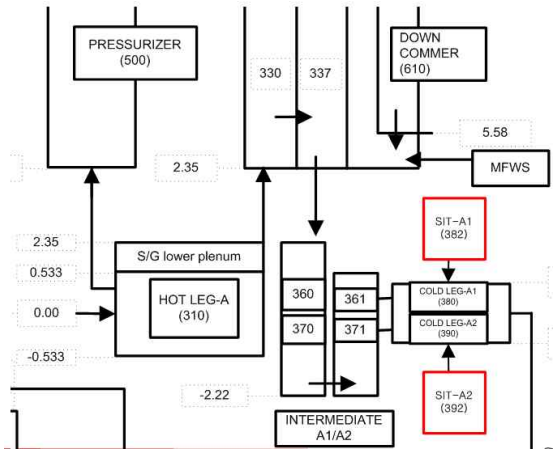
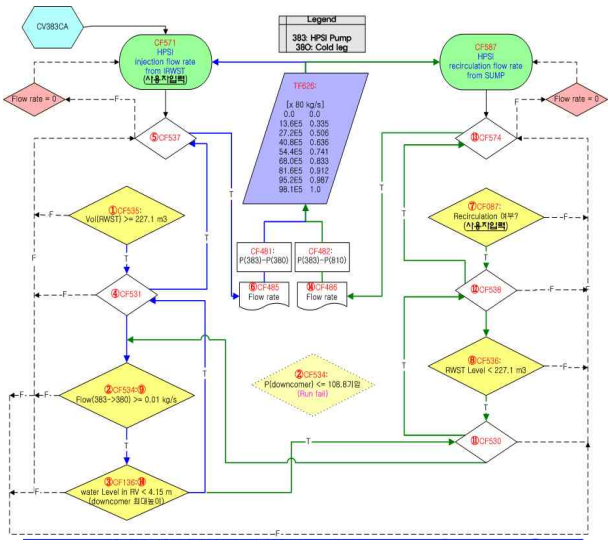
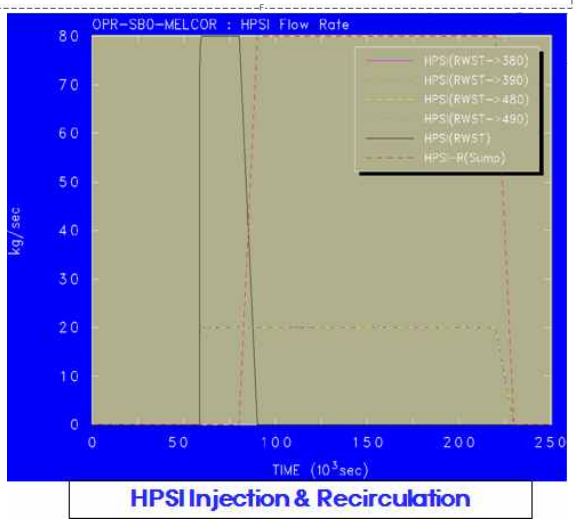


Fig.1 MELCOR Illustration of subdivision

3. MELCOR Data Validation





In order to compare the results with the MAAP code, input data validation should be made, particularly regarding the operation logics of the safety systems, for which an illustration is shown, for HPI (High Pressure Injection) success in the upper two figures.

4. Scenario Selection

The developing strategy of the MELCOR code is the same with that of the MAAP DB. For the generation of the data set, the Korean standard nuclear power plant (KSNP) has been selected as a reference plant, and eight SBO scenarios are chosen to be analyzed based on the PSA [3] results (these eight scenarios accounted for 99 percent of the occurrence frequency of a total of 197 SBO scenarios). Table 2 shows the selected scenarios and their definitions. Both thermal hydraulics and source term analysis have been performed using MELCOR version 1.8.5 for the chosen scenarios.

Scenario	Frequency	Cumulated	Note
SBO			
SBO-33	1.329E-08	1.33E-08	
SBO-41	2.350E-09	1.56E-08	
SBO-45	4.173E-07	4.33E-07	Most Probable
SBO-78	2.126E-09	4.35E-07	
SBO-86	8.120E-10	4.36E-07	
SBO-90	2.788E-08	4.64E-07	
SBO1-90	1.004E-08	4.74E-07	
SBO1-94	6.224E-09	4.80E-07 (누적≥99%)	Most Conversative

Scenario	AFW Delivery	Secondary Steam Removal	Restore AC Power	HPSI operation (Inj & Rec)	CSS operation (Inj & Rec)
SBO-33	TDP	ADV	before RV fail	Success	Success
SBO-41	TDP	ADV	before CMT fail	Fail	Success
SBO-45	TDP	ADV	N/A	Fail	Fail
SBO-78	TDP	MSSV	before RV fail	Success	Success
SBO-86	TDP	MSSV	before CMT fail	Fail	Success
SBO-90	TDP	MSSV	N/A	Fail	Fail
SBO1-90	N/A	N/A	before CMT fail	N/A	Success
SBO1-94	N/A	N/A	N/A	N/A	N/A

Table 2: Scenario Selection

5. Results Comparison

As illustrations, the results of MELCOR are shown for the pressure in the containment in Fig.2, and concrete ablation depths in the cavity in the MAAP and MELCOR codes are compared, respectively, in Table 3. Furthermore, a data conversion program [4] from the MELCOR output data format into that of the MAAP is developed to help users easily compare the output data in the same plotting frame.

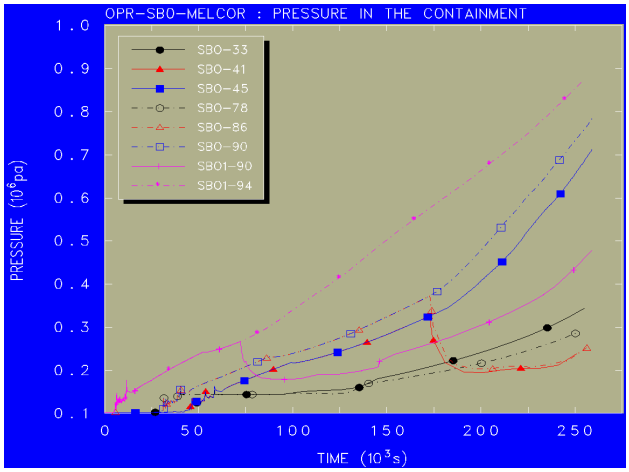


Fig.2 Containment Pressure in MELCOR

Scenario	Code	Depth [m]
SBO-33	MELCOR	0.92
	MAAP	Negligible
SBO-41	MELCOR	1.37
	MAAP	Negligible
SBO-45	MELCOR	1.68
	MAAP	0.89
SBO-78	MELCOR	Negligible
	MAAP	Negligible
SBO-86	MELCOR	1.57
	MAAP	0.41
SBO-90	MELCOR	1.78
	MAAP	1.56
SBO1-90	MELCOR	2.0
	MAAP	Negligible
SBO1-94	MELCOR	1.8
	MAAP	2.32

Table 3: Comparison of Concrete Erosion Depth

6. Conclusions

The MELCOR DB methodology together with SBO results will be used as inputs for the construction of a general DB, and special value will be found in the complimentary process of comparison with the MAAP DB. The results are extended from the preliminary results [5], and the DB will make the Severe Accident Management (SAM) supporting system, under development in KAERI, be more applicable to the base of an MAAP-MELCOR dual evaluation.

ACKNOWLEDGMENTS

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