A Baseline Confirmation for MELCOR DB Construction

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1. Introduction

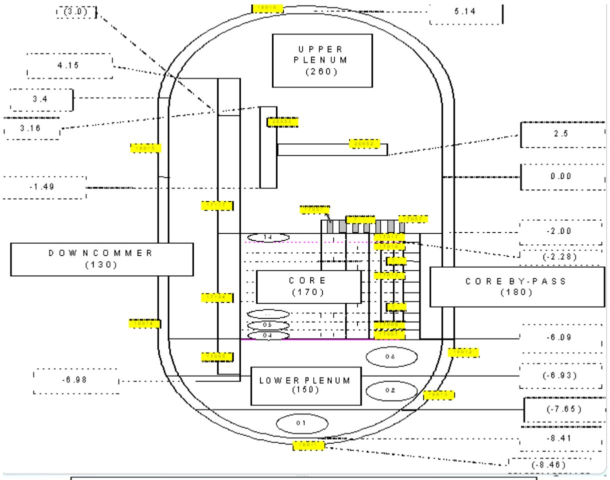
A baseline calculation for MELCOR database (DB) is confirmed for OPR-1000 as a target plant. This is an essential process to provide firm ground before all calculations and analysis are to be made for DB extension in the next stage.

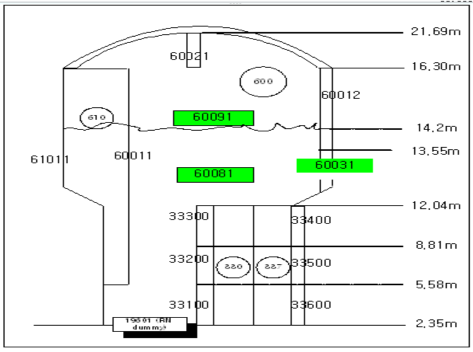
For this study, MELCOR major input is checked and assessed via comparing the system behavior between MELCOR[1] and MAAP4[2] codes for station blackout (SBO) scenarios as a typical high pressure sequence. The following variables in core, primary system (RCS) and steam generator (SG) until reactor vessel failure time are selected for the system behavior confirmation.

- Core: fuel temperature
- RCS: primary pressure
- SG: pressure/temperature and mass inventory

2. MELCOR Input Preparation

The MELCOR nodalization schemes for core (upper figure) and steam generator (lower figure) are illustrated in the following two figures.





3. MELCOR/MAAP Power Synchronization

In order to check the accident progression and the system behavior, consistent data are used between two codes especially for decay power distribution in core as shown in the following table.

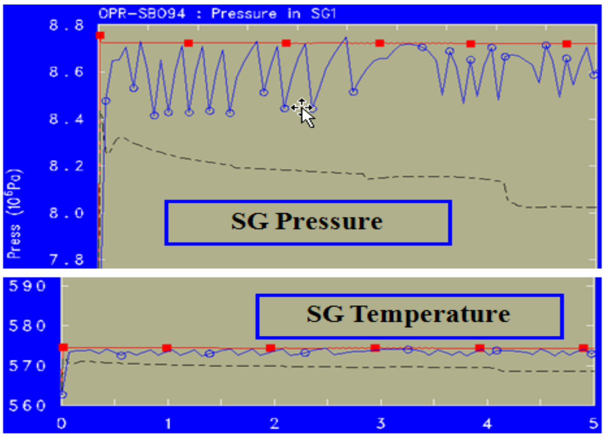
node	1		2		3		4		5		6		7		Σ
	Fuel	clad	Fuel	clad	Fuel	clad	Fuel	clad	Fuel	clad	Fuel	clad	Fuel	clad	
13	6,43E+05	8,43E+04	1,00E+06	1,43E+05	1,63E+06	2,14E+05	1,88E+06	2,47E+05	2,15E+06	2,82E+05	2,40E+06	3,15E+05	2,13E+06	2,79E+05	1,35E+07
12	8,98E+05	1,18E+05	1,54E+06	2,03E+05	2,31E+06	3,03E+05	2,67E+06	3,50E+05	3,06E+06	4,01E+05	3,42E+06	4,49E+05	3,04E+06	3,98E+05	1,92E+07
11	8,90E+05	1,17E+05	1,53E+06	2,01E+05	2,29E+06	3,00E+05	2,65E+06	3,47E+05	3,03E+06	3,97E+05	3,39E+06	4,44E+05	3,01E+06	3,94E+05	1,90E+07
10	8,66E+05	1,14E+05	1,49E+06	1,95E+05	2,22E+06	2,92E+05	2,57E+06	3,38E+05	2,94E+06	3,86E+05	3,29E+06	4,32E+05	2,92E+06	3,83E+05	1,84E+07
9	8,58E+05	1,13E+05	1,47E+06	1,93E+05	2,20E+06	2,89E+05	2,55E+06	3,34E+05	2,91E+06	3,82E+05	3,26E+06	4,28E+05	2,89E+06	3,80E+05	1,83E+07
8	8,66E+05	1,14E+05	1,49E+06	1,95E+05	2,22E+06	2,92E+05	2,57E+06	3,38E+05	2,94E+06	3,86E+05	3,29E+06	4,32E+05	2,92E+06	3,83E+05	1,84E+07
7	8,82E+05	1,16E+05	1,52E+06	1,99E+05	2,27E+06	2,97E+05	2,62E+06	3,44E+05	3,00E+06	3,93E+05	3,36E+06	4,40E+05	2,98E+06	3,91E+05	1,88E+07
6	9,14E+05	1,20E+05	1,57E+06	2,06E+05	2,35E+06	3,08E+05	2,72E+06	3,57E+05	3,11E+06	4,08E+05	3,48E+06	4,57E+05	3,09E+06	4,06E+05	1,95E+07
5	9,54E+05	1,25E+05	1,64E+06	2,15E+05	2,46E+06	3,22E+05	2,85E+06	3,73E+05	3,25E+06	4,27E+05	3,64E+06	4,78E+05	3,23E+06	4,24E+05	2,04E+07
4	7,22E+05	9,47E+04	1,23E+06	1,62E+05	1,84E+06	2,41E+05	2,13E+06	2,79E+05	2,43E+06	3,19E+05	2,72E+06	3,57E+05	2,41E+06	3,16E+05	1,53E+07
Σ	8,49E+06	1,11E+06	1,46E+07	1,91E+06	2,18E+07	2,86E+06	2,52E+07	3,31E+06	2,88E+07	3,78E+06	3,23E+07	4,23E+06	2,86E+07	3,75E+06	1,35E+07
	9,61E+06		1,65E+07		2,47E+07		2,85E+07		3,26E+07		3,65E+07		3,24E+07		1,01E+08W (6,41%) 1,84E+08W (6,53%)

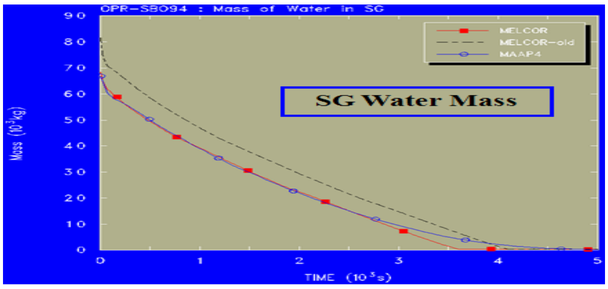
4. System Behavior Analysis

The following two SBO scenarios (SBO1-94 and SBO-45) are chosen from the Ulchin3/4 PSA[3].

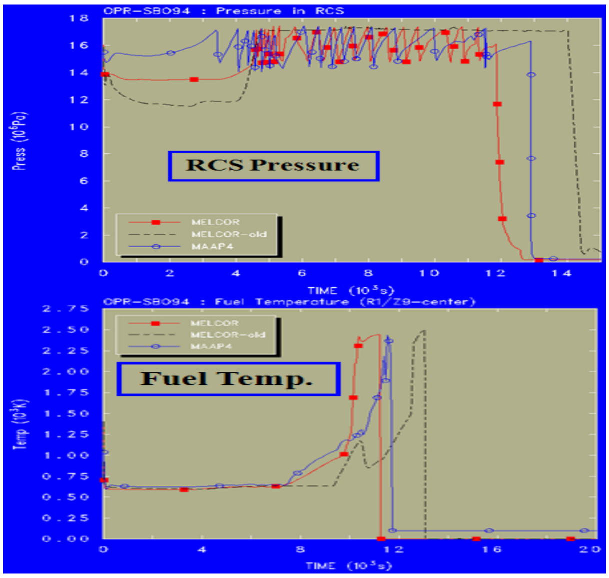
Sequence	AFW Delivery	Secondary Steam Removal	Restore AC power	HPSI operation (Inj & Rec)	CSS operation (Inj & Rec)	Frequency
SBO1-94	N/A	N/A	N/A	N/A	N/A	6.22E-9
SBO-45	TDP	ADV	N/A	Fail	Fail	4.17E-7

The first one (SBO1-94) is the most conservative scenario in which only passive systems such as safety injection tank (SIT) are available. The following figures (■: new MELCOR, O: MAAP, --: old MELCOR) show that the SG behavior is very similar in pressure and temperature except no cycling behavior in MELCOR. The decreasing mass inventory behavior in SG is almost same until small mass (< 10 ton) of water is left.

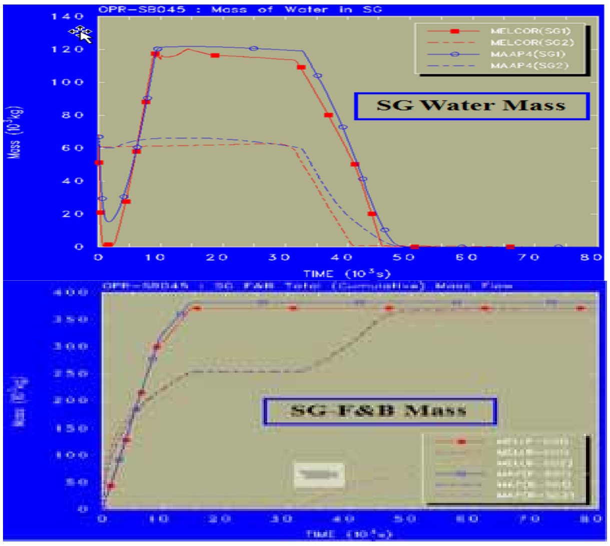




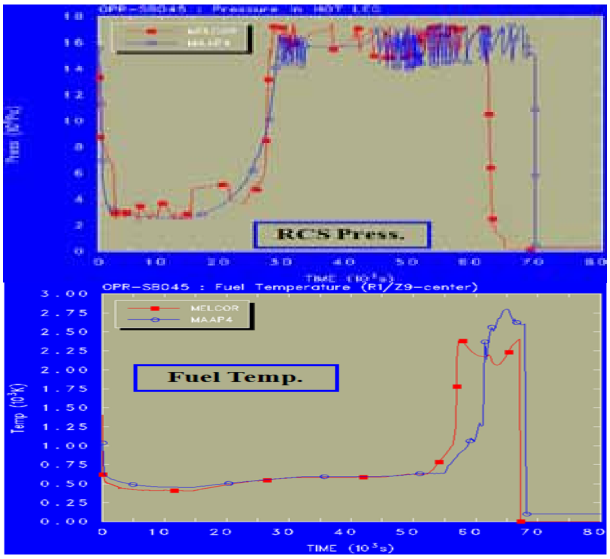
The RCS pressure shows consistent behavior after SG dryout and the fuel temperature is almost same in trend but the increasing rate of temperature is a little faster in MELCOR.



The second scenario (SBO-45) is the most probable scenario in which secondary feed and bleed is available using turbine-driven auxiliary feedwater (TDP-AFW) and atmospheric dump valves (ADV). The following figures show that the SG behavior is similar both in water inventory and in SG feed and bleed mass and rate.



The RCS pressure shows consistent behavior and the fuel temperature is almost same in trend but a little higher in MAAP.



5. Results

EVENT	MELCOR 1.8.5		MAAP 4.0.4	
	SBO1-94	SBO-45	SBO1-94	SBO-45
Core Uncovery	6,861	51,574	7,126	53,993
Core Depleted	9,007	54,908	9,459	56,328
RV Fail (penetration)	11,855	67,961	12,900	69,275

The accident progression is quite similar based on both primary and secondary system behavior and event timing (see the above table) for selected two scenarios. The results from these baseline calculations confirm the credibility on the MELCOR DB (SARDB-OPR-MEL) which is being extended from old one [4]. The DB emphasizing robust and stable run reflect the experience and necessity accumulated over the past decade and SAM supporting system (SAMEX) developing in KAERI will be more applicable on the base of MAAP-MELCOR dual evaluation.

ACKNOWLEDGMENTS

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REFERENCES

[1] SNL, MELCOR computer code manuals (Version 1.8.5), NUREG/CR -6119, SAND2005-5713, 2005.
[2] FAI, "Modular Accident Analysis Program (MAAP4) User's Manual," 2000.
[3] KEPCO, "Ulchin 3&4 Final Probabilistic Safety Analysis Report"
[4] Y.M. Song, "A Demonstration of Level-2 Risk Uncertainty Decreasing Efforts for a Phenomenological Accident Progression Prediction," Transactions of the KNS spring, 2007.