

REGULATORY MODEL DEVELOPMENT FOR THE VALIDATION OF SAMGs

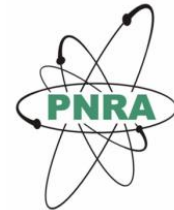
For Karachi Nuclear Power Plant (KANUPP)

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***International Experts' Meeting on Severe Accident Management in the Light of
Accident at the Fukushima Daiichi Nuclear Power Plant***

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Outline

- Objective
- Containment and Associated Systems Models
- Accident Scenario and Assumptions
- Selected Candidate High Level Actions
- Cases and Analyses Results
- Summary

Objective

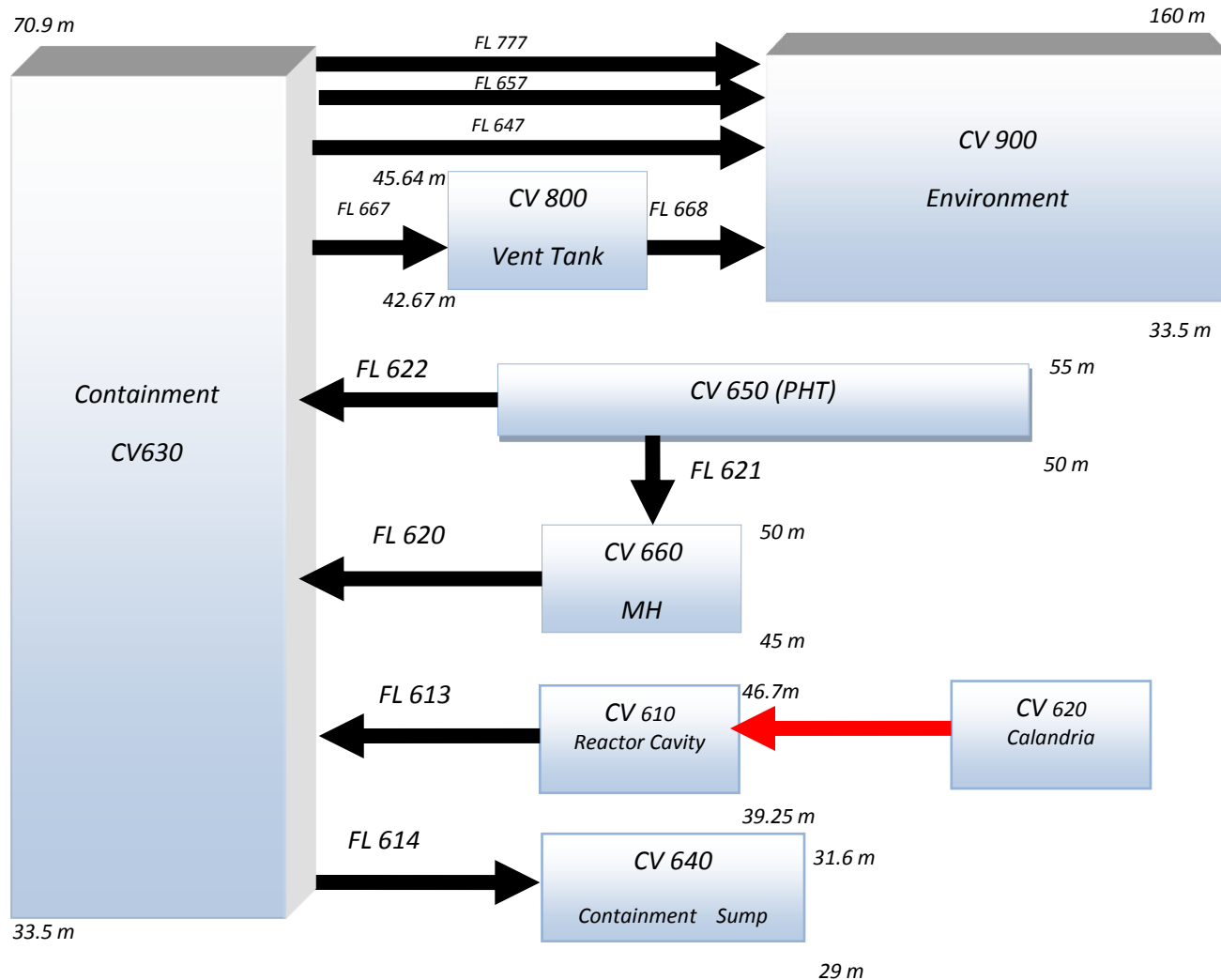
To learn lessons from the catastrophic consequences Fukushima Daiichi accident and establish a simulation model for the development, modifications and analytical enhancements in Severe Accident Management Guidelines (SAMGs)

Containment and Associated Systems Models

Following are the containment and ex-vessel associated models that are used in KANUPP model development:

- a. Containment model
- b. Cavity and Containment leakage model
- c. Dousing Spray System Model
- d. Passive Hydrogen Recombiners Model
- e. Containment Vent Model
- f. Fan Cooler Model

MELCOR Nodalization



Accident Scenario and Assumptions

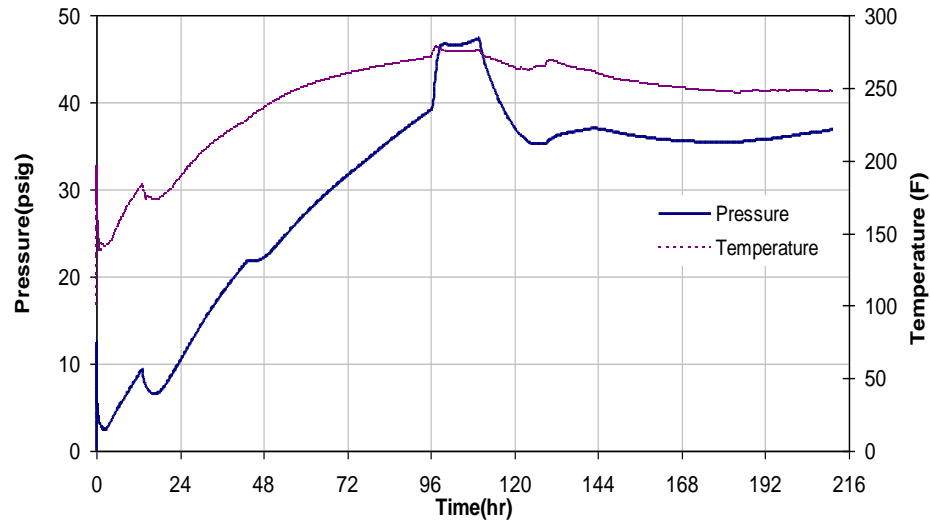
- To assess and demonstrate the applicability of the model developed, a transient has been simulated for Large LOCA coincident with loss of ECI (due to SBO – simulation covers 5-6 days of SBO)
- It is assumed that simulation starts after the core has collapsed in the lower portion (dump space) of calandria vessel at about *1000.0 sec* after initiating event
- It is assumed that the entire core comes in the dump space instantaneously and is cooled by the water outside the vessel. (some D₂O is available in dump space for direct cooling)
- In the current calculations, the containment conditions at the start of simulation (core collapse) are assumed to be normal (atmospheric) and a break discharge is input through EDF package to approximately simulate the initial conditions.

Selected Candidate High Level Actions(CHLAs)

For SAMGs progression of accidents may be represented by plant damage condition (PDCs) or descriptors and corresponding mitigating actions are designated as Candidate high level actions (CHLAs)

- **Case 1:** The accident has progressed to failure of the calandria vessel; debris has been discharged to vault and no containment heat removal system is available
- **Case 2:** Containment Spray System is available
- **Case 3:** Passive Hydrogen Recombiners are available
- **Case 4:** Containment Venting System is available
- **Case 5:** Fan Coolers are available

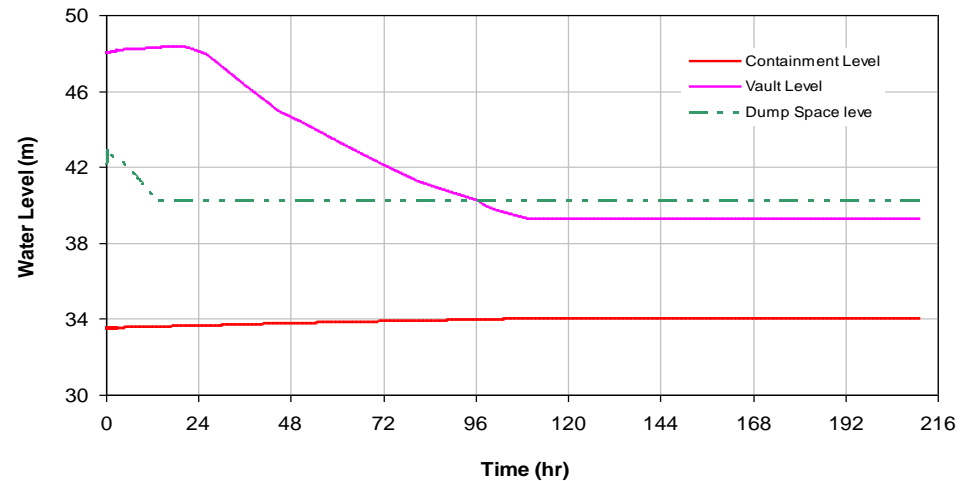
Case 1: The accident has progressed to failure of the calandria vessel; debris has been discharged to vault



Containment pressure and temperature

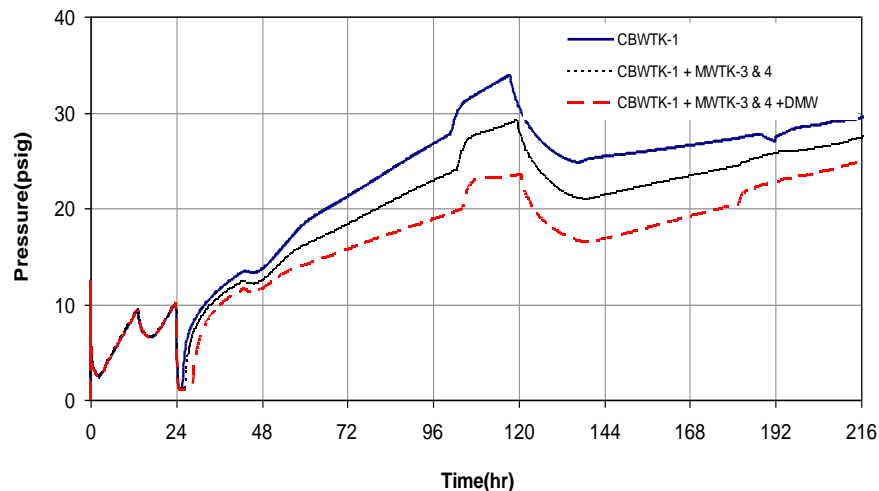


Dump Space, Vault and Containment water levels

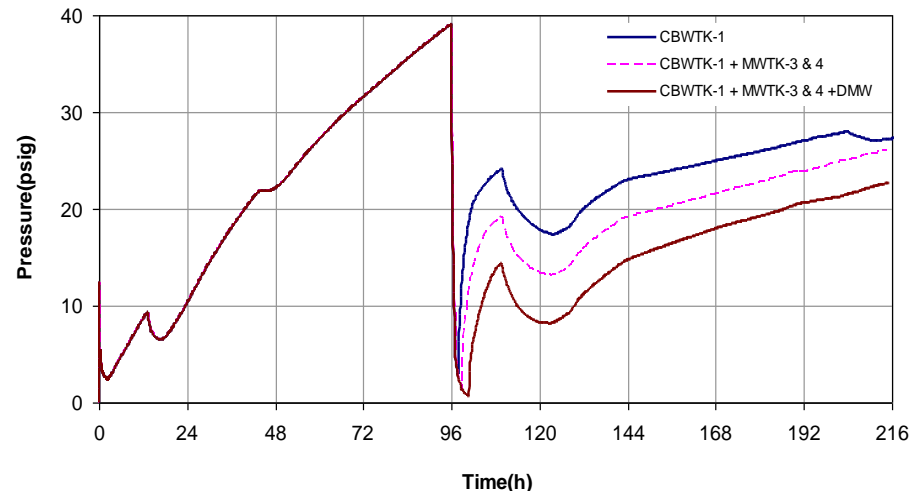


Case 2: Containment spray system (DSW) is available

- MELCOR Containment Spray system model is utilized to observe the containment response against the two severe accident core damage descriptors
- During first condition, it is assumed that all the fuel bundles got melted and reside in calandria vessel which is intact and DSW is made available during this period
- For the second condition, it is assumed that containment spray system is made available when calandria vessel is failed and debris has just fallen into the vault



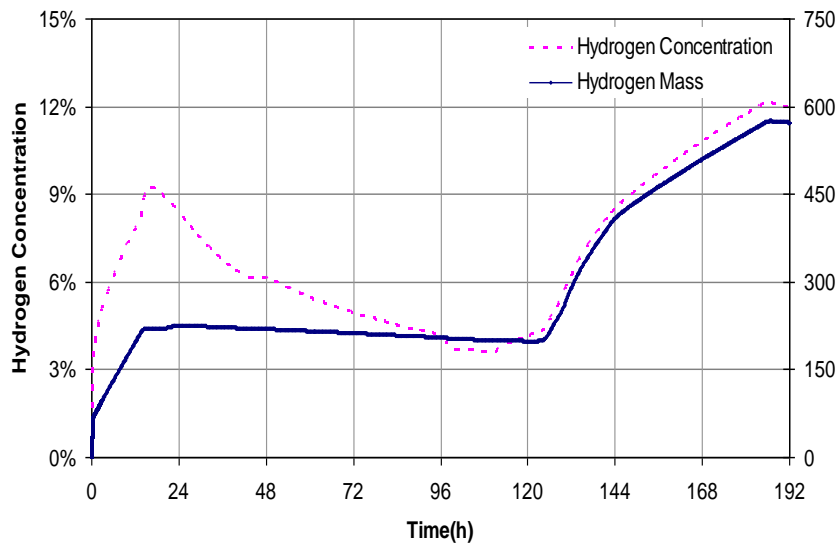
Condition 1: Containment Pressure with spray available before calandria fails



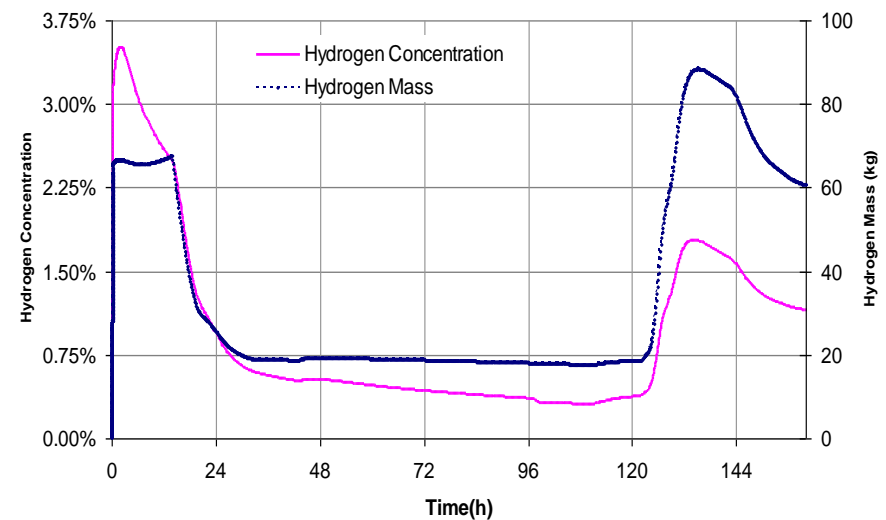
Condition 2: Containment Pressure with spray available after calandria fails

Case 3: Passive Hydrogen Recombiners(PARs) are available

- The model was analyzed without PARs and with twelve PARs
- With no PAR, **600 kg** of hydrogen is produced resulting in **12%** concentration by volume
- With **12** PARs, the hydrogen concentration remains below **4%** limit

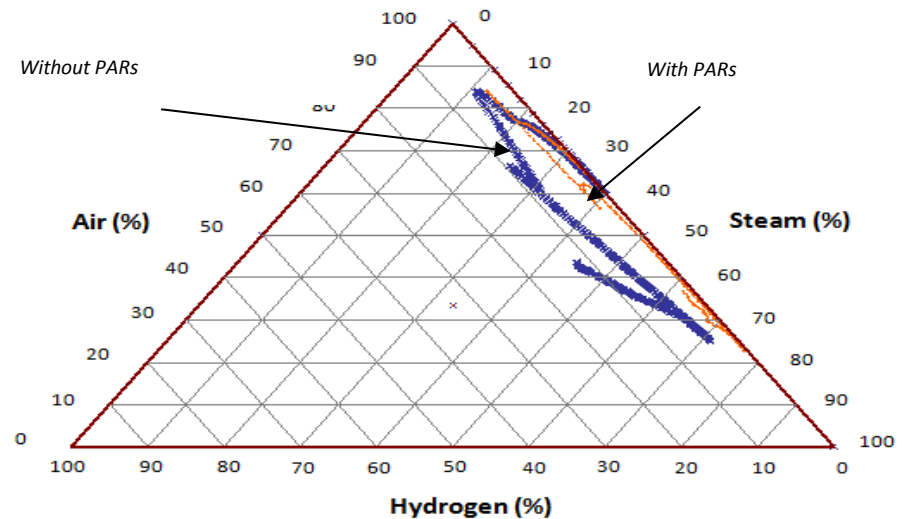
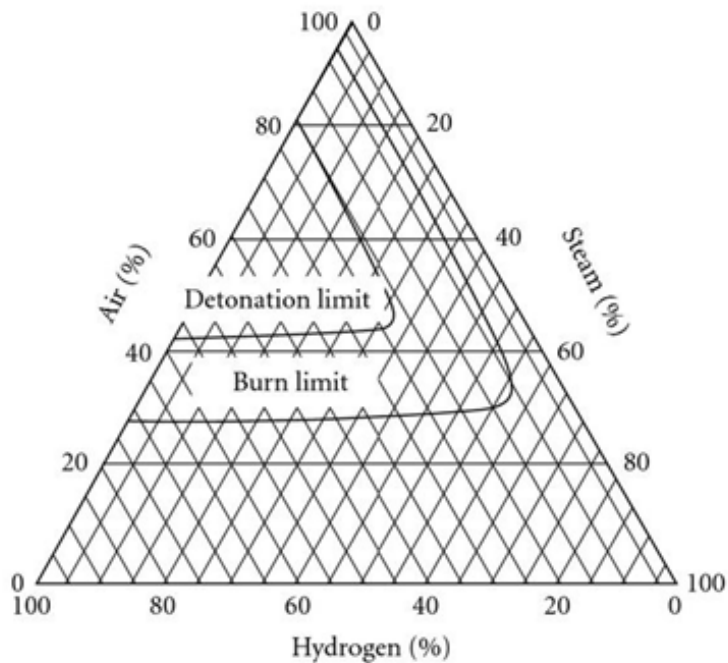


Hydrogen concentration and mass without PARs



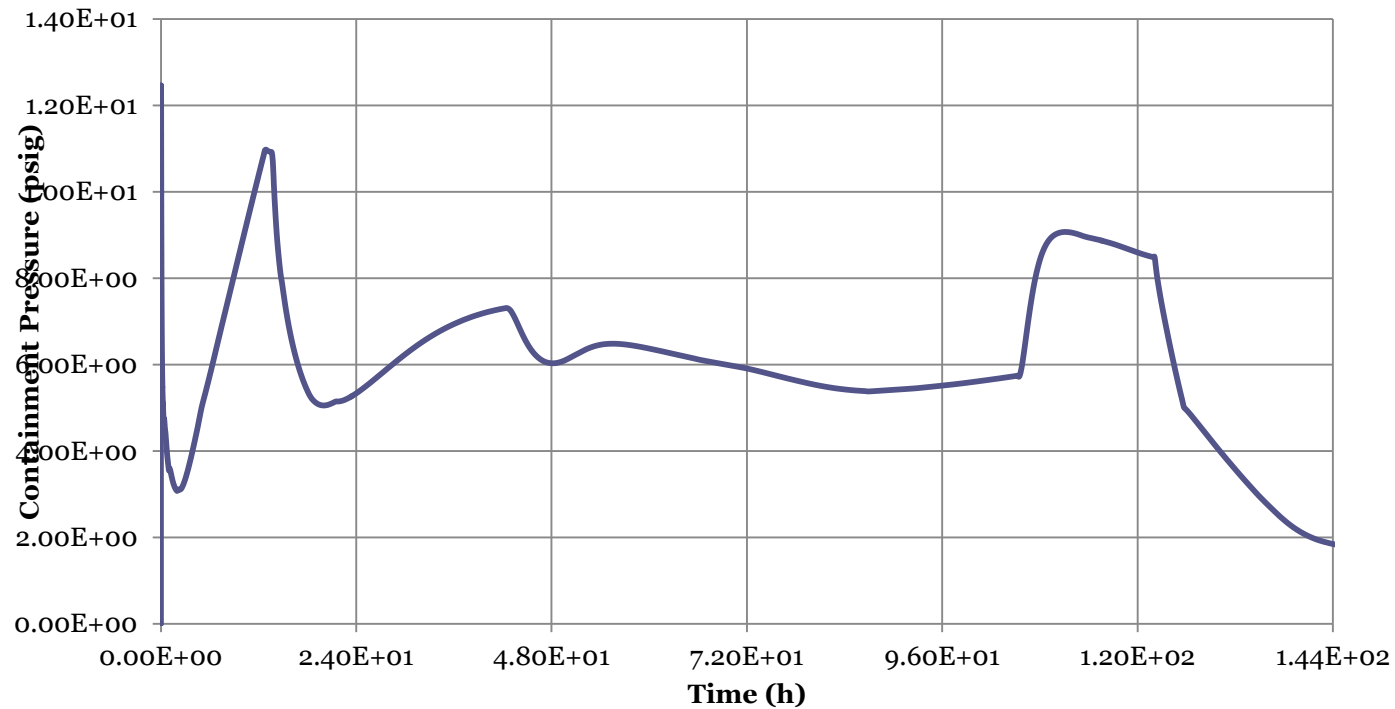
Hydrogen concentration and mass with twelve PARs

Hydrogen risk in Containment with and without PARs



Hydrogen risk in containment with and without PARs

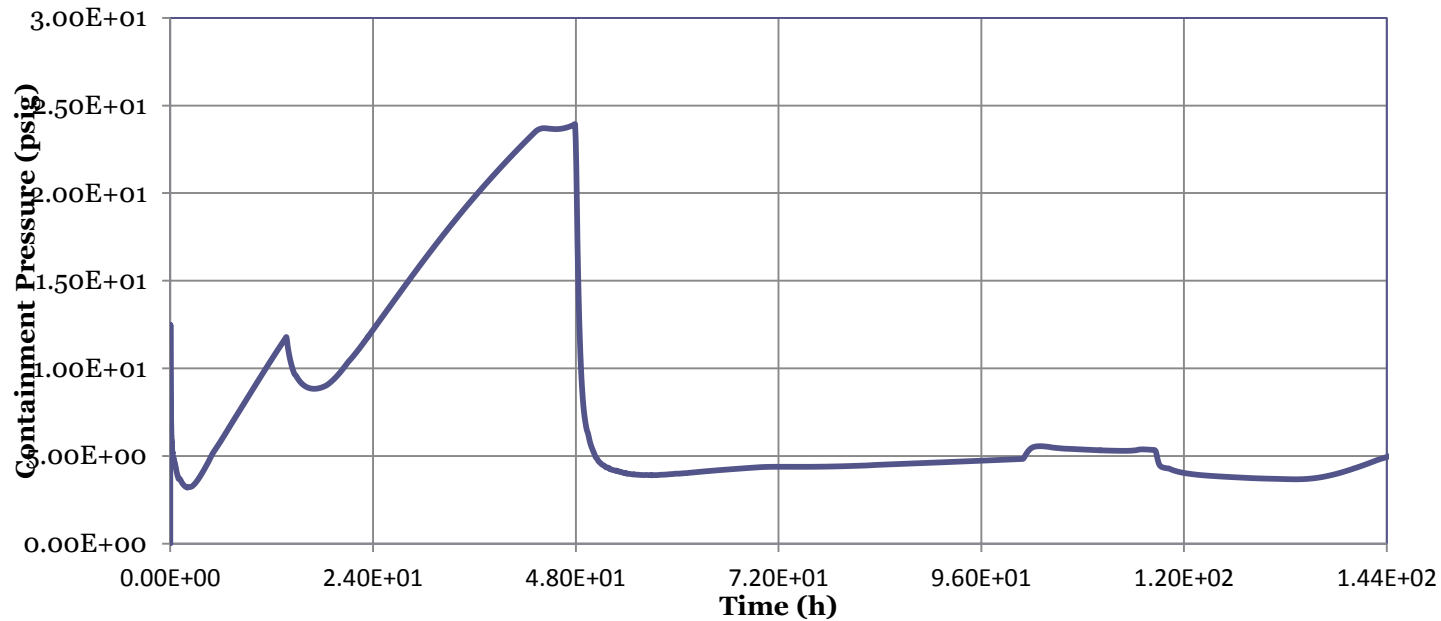
Case 4: Containment Venting System is available



Containment Pressure with venting

Case 5: Fan Coolers (FCs) are available

- Total 7 Fan Coolers (2.1 MW + 30 kW)
- Secondary coolant source for FC are assumed to be at room temperature



Containment Pressure with Fan Coolers

Summary

- Analyses were performed for Large LOCA in coincident with LOECI in KANUPP Plant
- The purpose was to demonstrate the containment response under postulated accident and effectiveness of four candidate high level. Analyses were performed using MELCOR 1.8.5
- Containment pressure reaches to 46 psig at about 97 hrs when the vault level crosses the lowest level of dump space and subsequent calandria vessel rupture and corium quenching in dump space.
- Total 600 kg of Hydrogen is produced resulting in 12% concentration by volume. However, with PARs, the hydrogen concentration remains below 4% limit.
- Venting and Fan coolers provide significant pressure suppression, especially fan coolers are more practically realizable as they are already installed in KANUPP
- Overall the study produces as a preliminary model for evaluating and validating severe accident management guidelines. Further enhancements including multiple core/containment damage descriptors and their relevant candidate high level actions will strengthen the model.

Thank You all