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Development of a MELCOR Input Deck for Fukushima Accident: Tools and Lessons Learned Part 2 - Core

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Introduction

A preliminary study of MELCOR simulation of Fukushima Accident has been carried out, focusing on tool usage and configuration issues

- A critical problem in the input deck preparation is the availability of Plant Data
- Input data assumed for Fukushima power plant were based on public sources:
  - ✓ Report of the Japanese Government to the IAEA (contribution of NISA, JNES, TEPCO)
  - ✓ Assessments on similar plants (Peach Bottom nuclear power plant, Santa Maria de Garoña nuclear power plant)

- Input deck assumptions impact on simulation results have been evaluated
- Code computing parameters impact has been tested

Input Desk and computing parameters Sensitivity test

A preliminary study of MELCOR simulation of Fukushima Accident has been carried out, focusing on tool usage and configuration issues

	RPV Failure time	H2 Mass
Initial water Level	?	
Water Mass	?	
Lower Head water Mass	?	
Steel Mass		?
Operation Time	?	

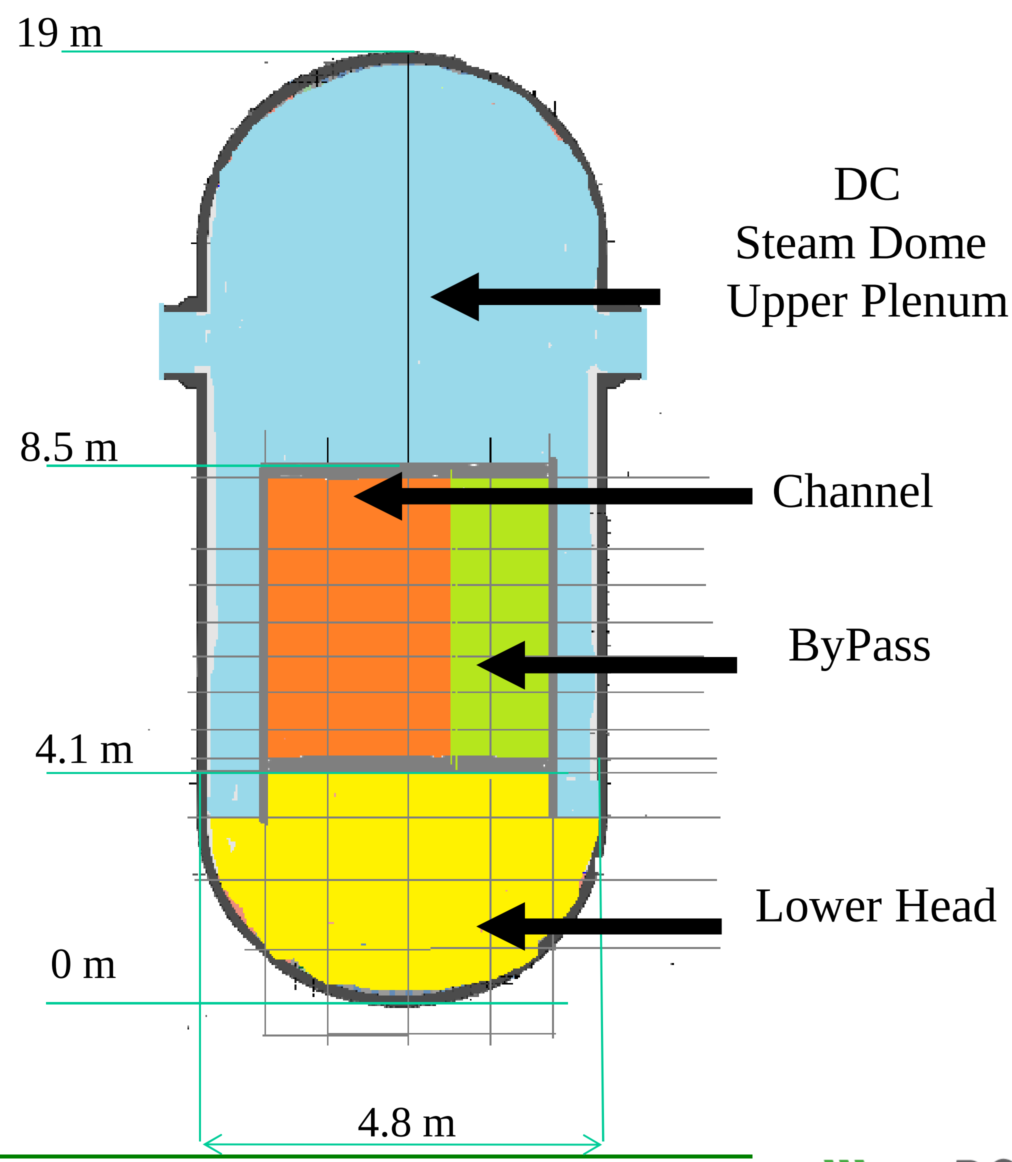
- Time evolution sensitivity with respect to simulation time steps (0.1s – 0.025s) has been tested
- Model behavior vs. Code version (MELCOR 2.1 -2010 - MELCOR 2.1-2011) has been observed

Input Data

VOLUME (m^3)	Peach Bottom	RSE
Reactor Pressure vessel	610	260
Channel	33.3	19
Bypass	25.8	7.5
Free Volume in core (Channel+Bypass)	59.1	26.5
Lower Head	103	28

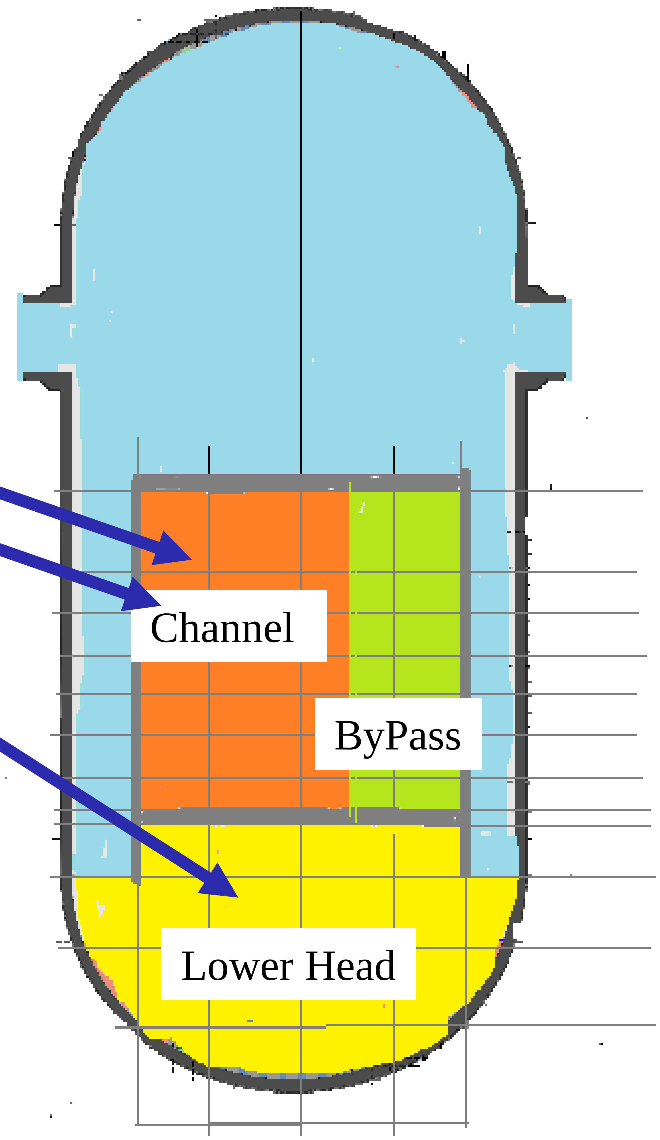
Sensitivity test:
Lower Head Volume : 28 m^3 , 34 m^3

VESSEL DATA	
Vessel Height	19 m
Vessel Inner diameter	4.8 m



Input Data

MATERIALs	Peach Bottom (3293 MW) (kg)	Scaled Peach Bottom (1380 MW) (kg)	RSE Data (1380MW) (kg)
Fuel	172500	72000	75365
Zircaloy	62600	27300	31100
NS Steel	16300	7140	7121
B4C	1150	480	480
Supporting Steel	104880	45750	45000



Failure SS for Temperature:

```
COR_SS    2 !n ia     ir      issmod     issfai      tssfai
            1   5      1-2  PLATEB     TSFAIL 1273.15
            2  1-4     1-2 COLUMN     TSFAIL 1273.15
```

H_2 production depends on amount of Zircaloy and Steel:
We can evaluate the Zircaloy mass even with geometrical consideration
For Steel mass this is more difficult

→ Sensitivity on Steel mass

Accident sequence

Sensitivity

Time		Time (h)	Events	Assumption for the analysis
11/03	14:46	0	Earthquake	
	14:46	0	Reactor scram	Reactor Scram
	14:52 . .. 15:34	0.10	IC starts/IC work	It was assumed the IC was able to remove the decay heat during the first hour after the reactor scram.
	15:37	0.85	Tsunami SBO	Start of the simulation. Function of IC was lost End of the analysis: vessel failure

Initial reactor power	1380MWt
Initial reactor pressure	6.93 MPa
Initial reactor water level	(4.0m above the top active fuel, TAF)
Burn –up	2 year, 80% capacity factor (5.05E7 s)
Shut Down	Time = 0 Earthquake (Simulation: Time= -3600 s)
IC	NO
Simulation time	t_{start} = 0, SBO t_{end}= RPV failure

	Base Case	***DUS** w-level,mass*
Water level	12.5 m	*10.5 m*
Water mass (DSU)	79600 kg	*56500 kg*
Water mass (LP)	21800 kg	21800 kg

Decay Heat for first hour about 8 10^{10} J
= evaporation 51000 kg of water

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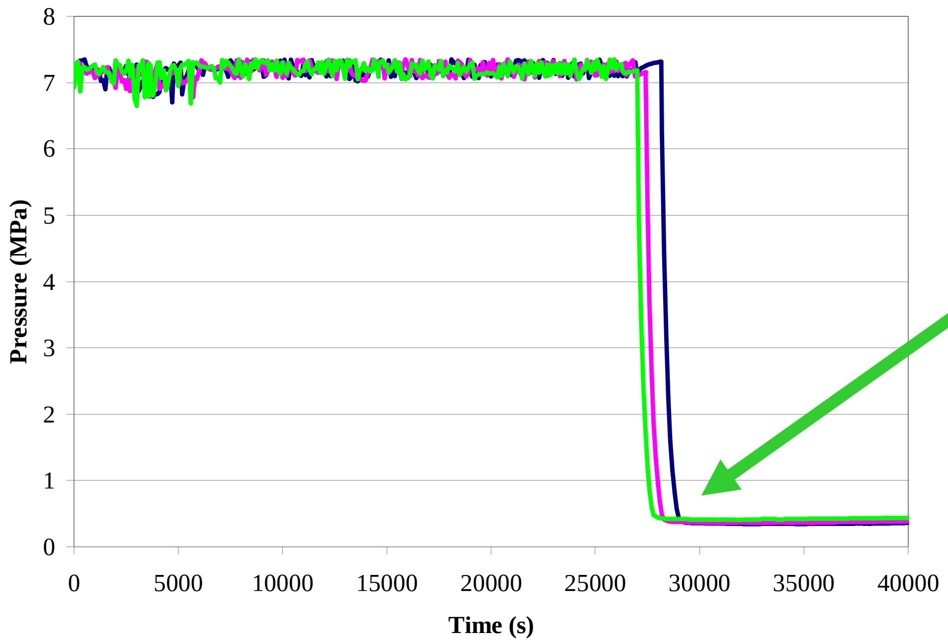
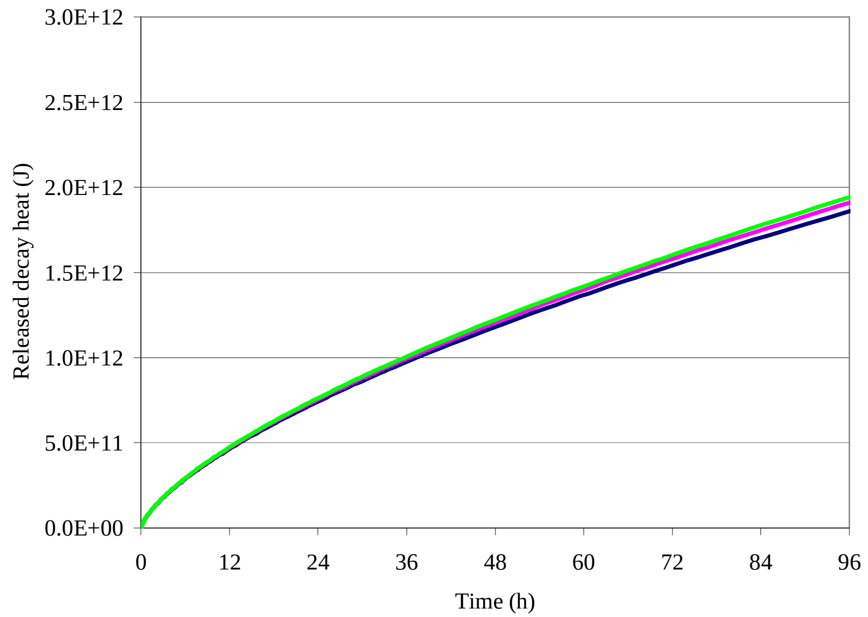
Sensitivity on data: Operation time

•Sensitivity Cases : OT. 12 months – 18 months -24 months



Differences of few minutes in RPV Failure Time



Operation time: 80% of 24 months

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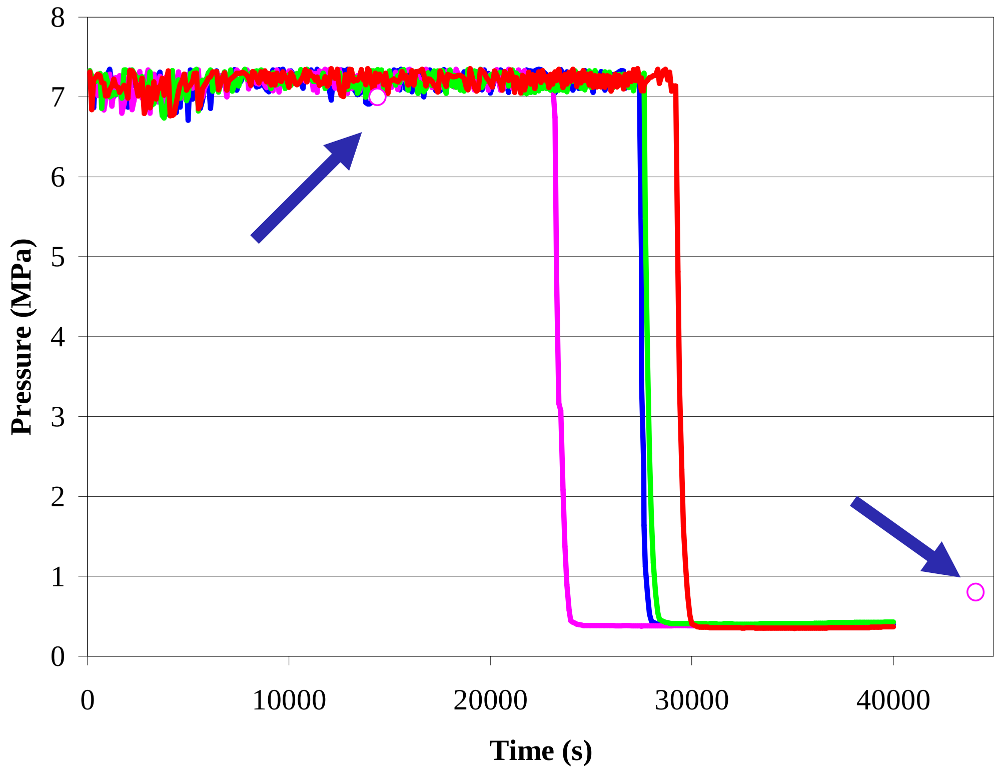
Sensitivity on data: Water Mass

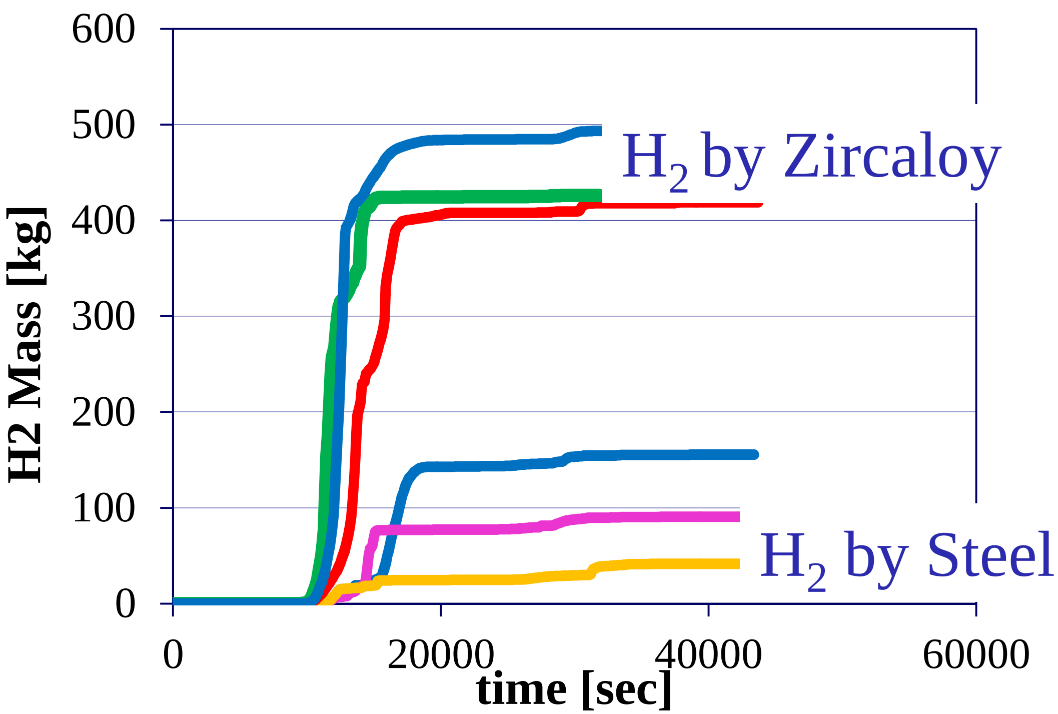


RPV Failure (s)	
Base	26800
DUS level	23500
DUS mass	27600
LP	29200
Δ	**1.5 h**

[s]	**RPV Failure**
TEPCO	50400
NISA	14400

	Base Case	***DUS** w-level,mass*	**DUS** w-mass	**LP** w-mass
Reactor water level	12.5 m	*10.5 m*	12.5 m	12.5 m
Water mass (DSU)	79600 kg	*56500 kg*	*87900 kg*	79600 kg
Water mass (LP)	21800 kg	21800 kg	21800 kg	*25700 kg*

Sensitivity on H_2 Production by Steel and Zr in core



	Base Case	Low Zircaloy	Low Sup Zircaloy
Zircaloy	31100 kg	15500 kg	31100 kg
Zircaloy Sup	5400 m2	5400 m2	2700 m2

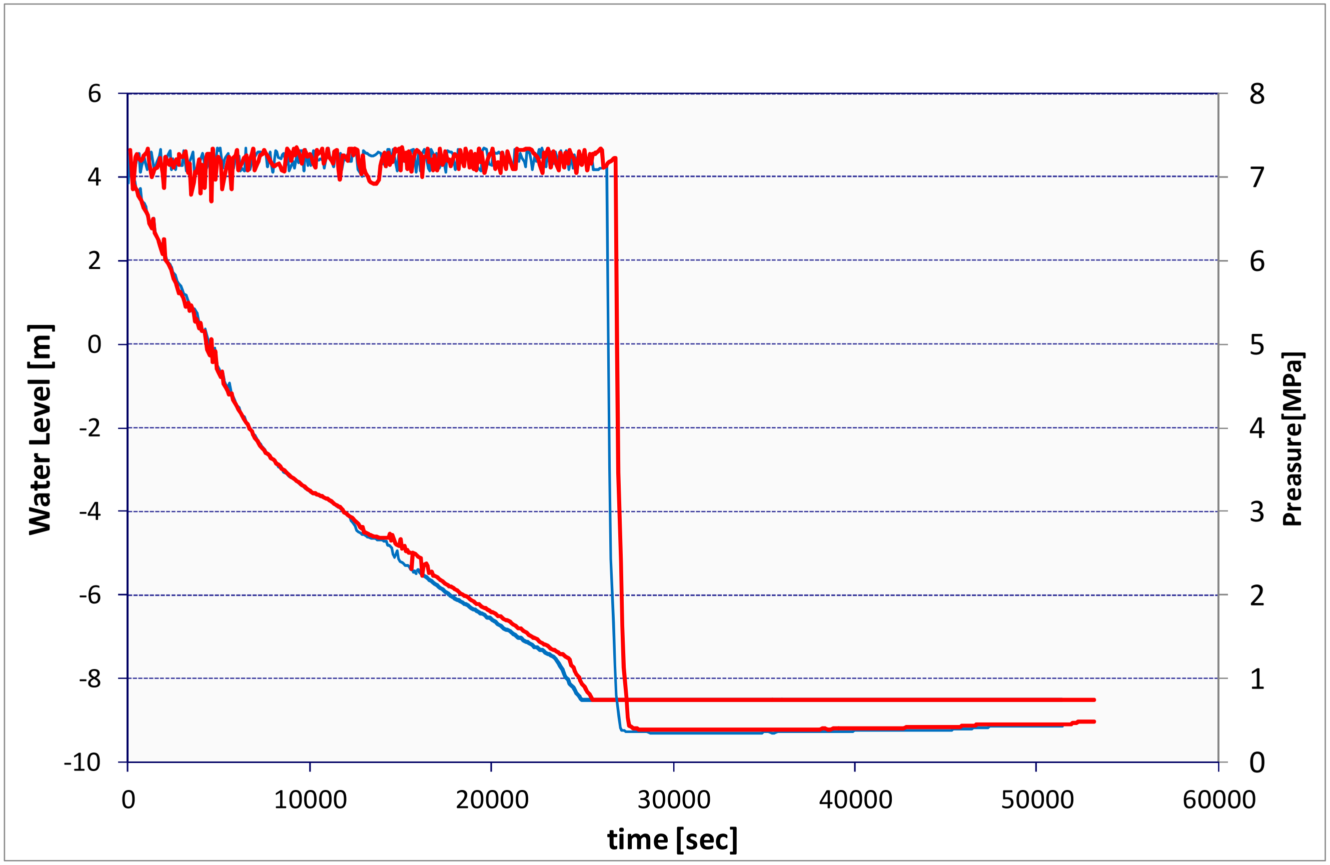
	Base Case	Low Steel	Low Sup Steel
Steel	7100 kg	3550 kg	7100 kg
Steel Sup	1300 m2	1300 m2	650 m2

- H2 production between 550-700 kg
- Oxidation 50% Zircaloy mass
- If Oxidation Zircaloy 100% : max 1300 kg H

- Not closely linear dependence of H2 production for mass and surface of Steel and Zircaloy

Base	DUS level	DUS mass	LP	Low Steel	Low sup steel	TEPCO	NISA
650 kg	690 kg	710 kg	550 kg	590 kg	520 kg	750 kg	1000 kg

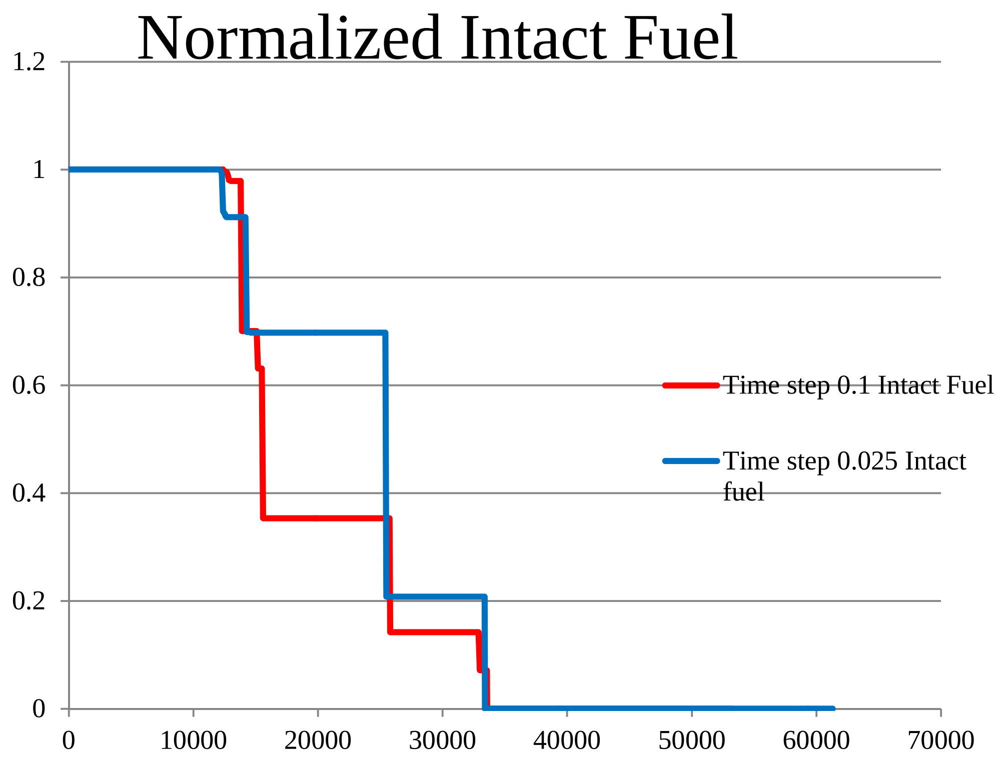
Sensitivity with Melcor 2.1 : Time Step



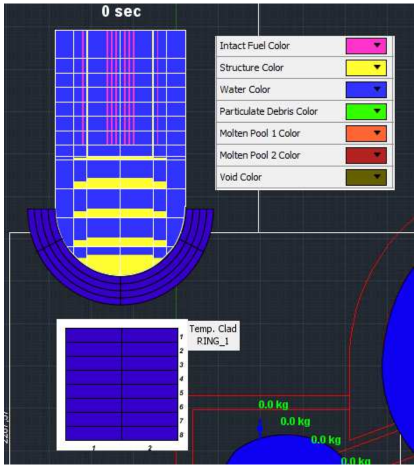
Case time step
0.1 sec
0.025 sec

- same RPV Failure time (few 100 sec)
- same TAF-BAF -Vessel Dryout time

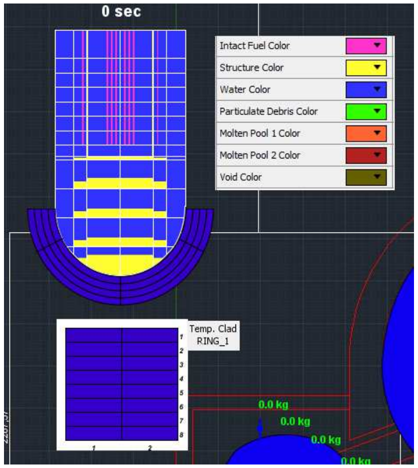
Sensitivity with Melcor 2.1 : Time Step



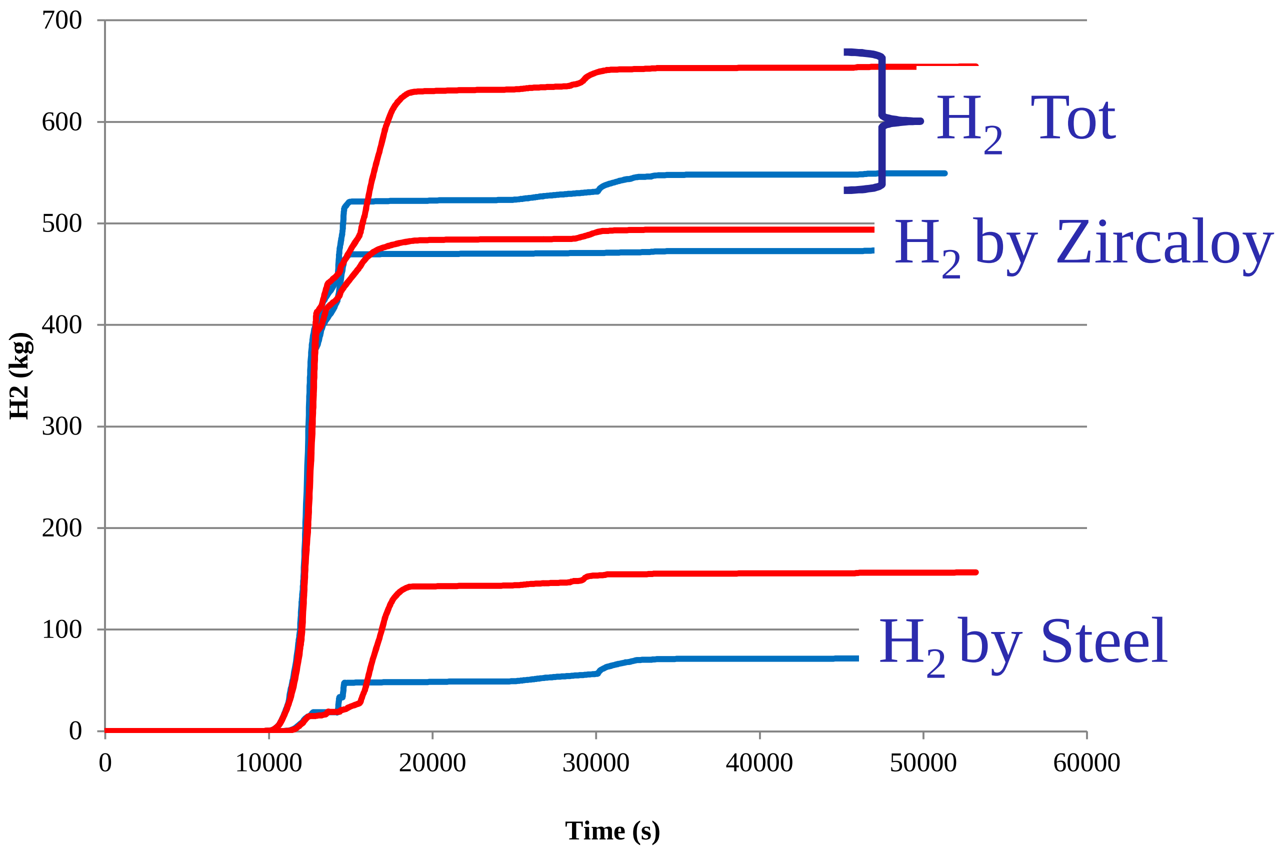
0.025 s



0.1 s



Sensitivity with Melcor 2.1 : Time Step



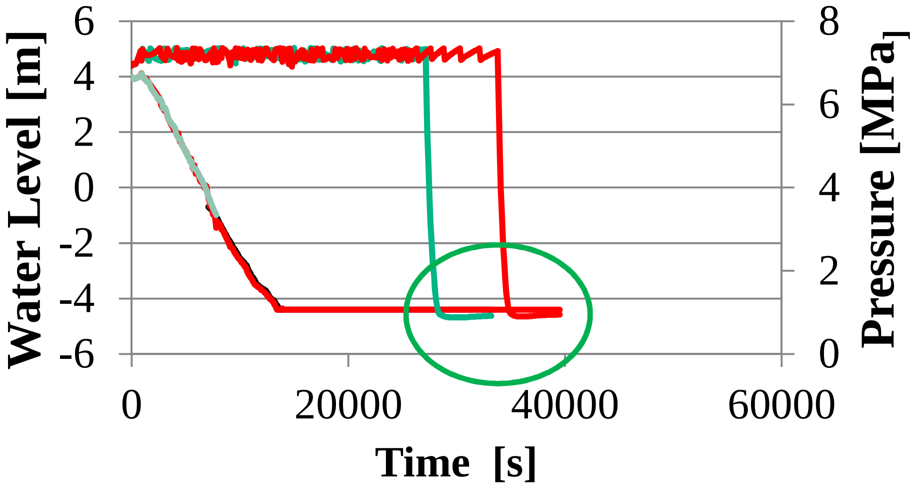
Case time step
0.1 sec
0.025 sec

Δ = 100 kg H_2 tot

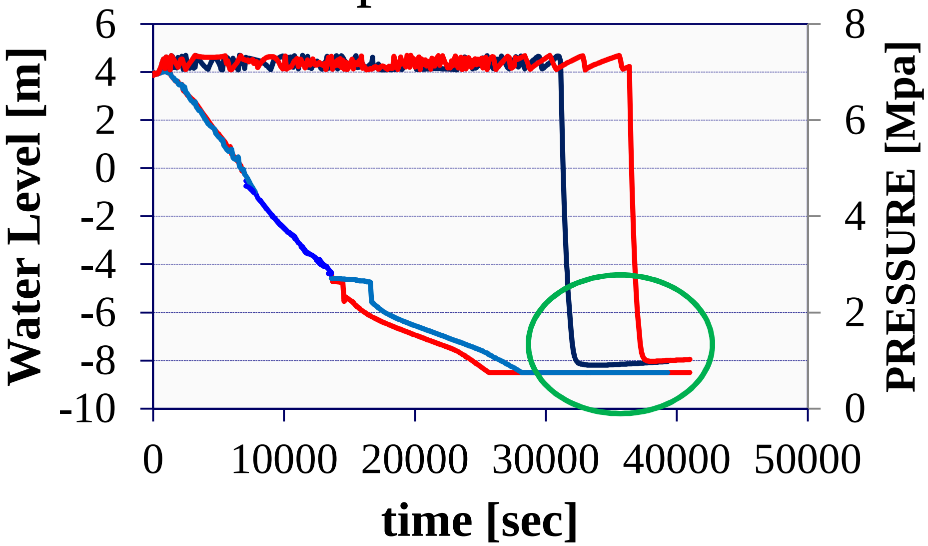
If there are rapid phenomena such as oxidation it could be useful use low time step

Sensitivity with Melcor 2.1 : Version

Time step 0.1



Time step 0.025



MELCOR 2.1 JAN-2010

MELCOR 2.1 SEP 2011

- Time difference for Failure Vessel more than 1.5 h

CONCLUSION

- Uncertainty on input data does not affect the main phenomena involved in the accident progression: evolution and timing is substantially conserved.

- Time step can influence code simulation.
  Small time step should be used to describe some rapid phenomena such as oxidation.

- Dependence on code version observed

Max Value – min value	RPV Failure time	Vessel Dry out time	H2 mass
Mass water	**1.3 h**	**1.5 h**	**150 kg**
Steel Mass			**150 kg**
Operation Time	**Few min**		
Time step (0.1- 0.025)	**Few min**		**100 kg**

Thank you for your attention

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