MELCOR2.2/SNAP Analysis of Oxidation Response during Spent Fuel Pool Quenching

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Outline

- Introduction
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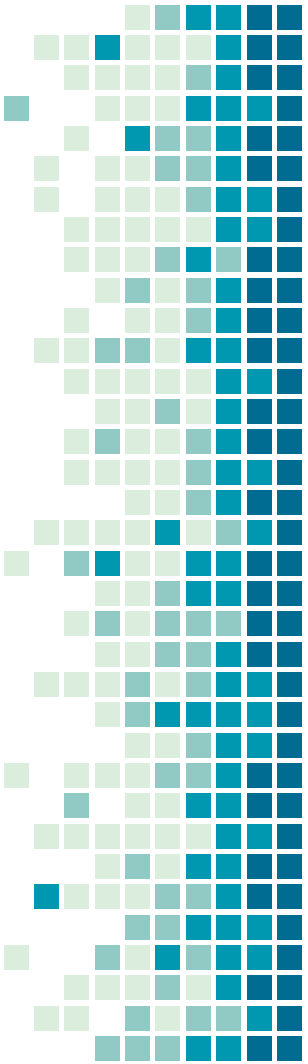

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Introduction

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Introduction

Origin

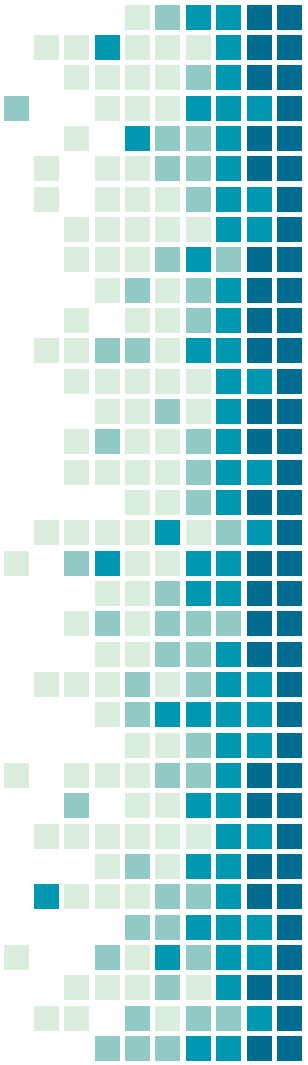
After Fukushima event, the safety analysis of the nuclear power plant spent fuel pool become one of the safety concern in Taiwan.

Code

TRACE : Thermal-hydraulic

MELCOR : Severe accident

SNAP : Graphic user interface



Introduction

STEP1

Data collection and model establishment of Maanshan NPP SFP

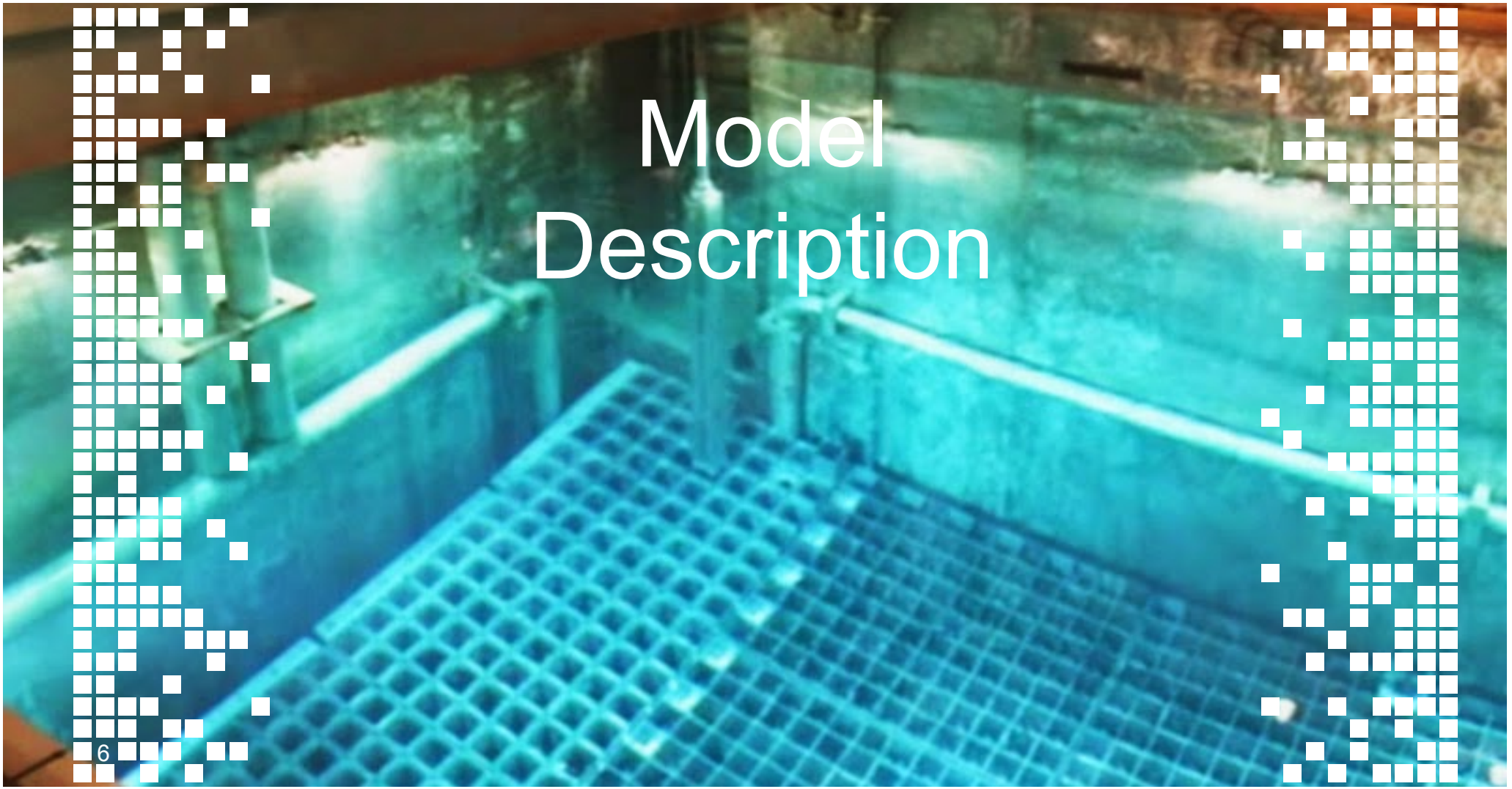
STEP2

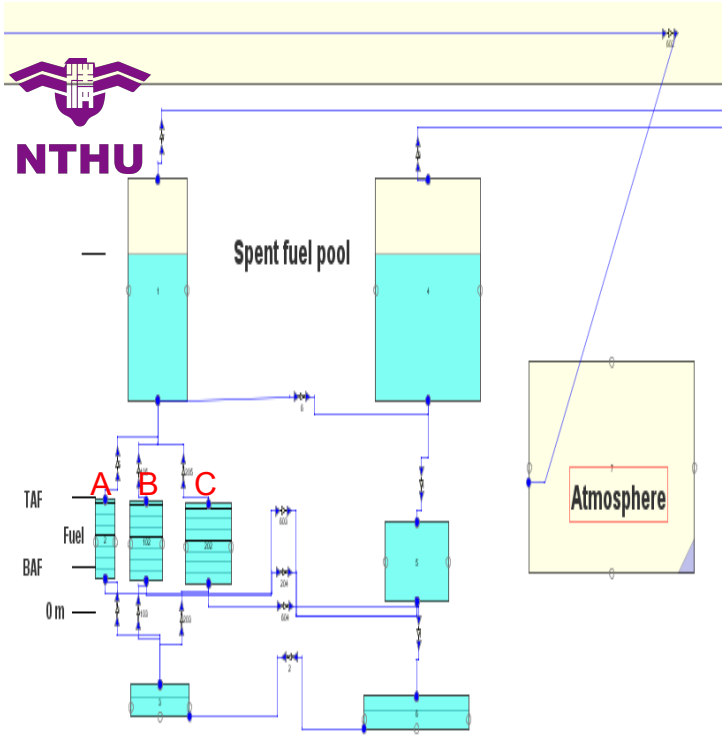
Comparison of TRACE in previous work* and MELCOR in the case of SBO

STEP3

Mitigation strategy** and quenching analysis***

* Y. Chiang, ''The Mitigation Strategy Analysis of Maanshan Nuclear Power Plant Spent Fuel Pool Using TRACE/ FRAPTRAN/SNAP. ''
** The water injection referenced by NEI06-12
*** The water injection started when cladding temperature reached 1200K, 1400K, 1500K, 1600K, 1700K and 1800K


Model
Description



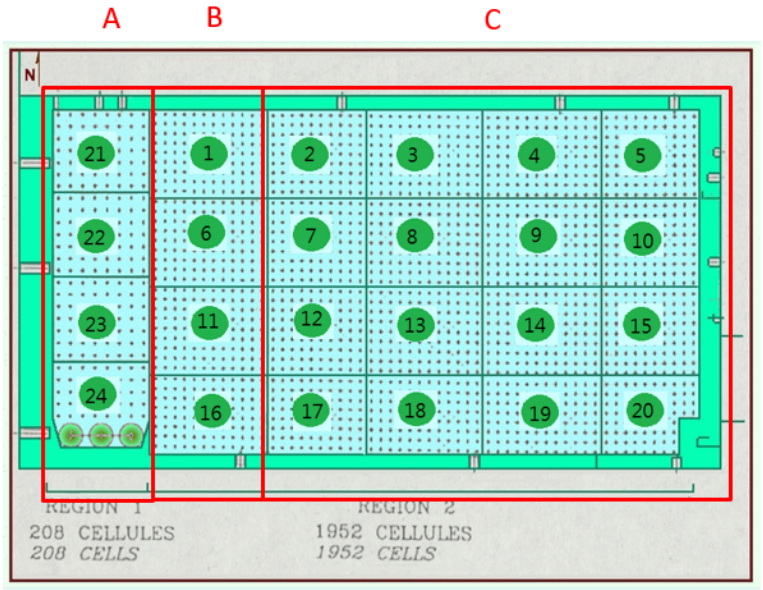
Model Description

The latest version MELCOR2.2 was used and combined with Symbolic Nuclear Analysis Package (SNAP) 2.5.1.

The size of Maanshan NPP SFP was **16.56 m * 8.73 m** and water level was **13.77 m** initially. The initial condition of water temperature was **311K** and the pressure was **1.013*10^5 Pa**.

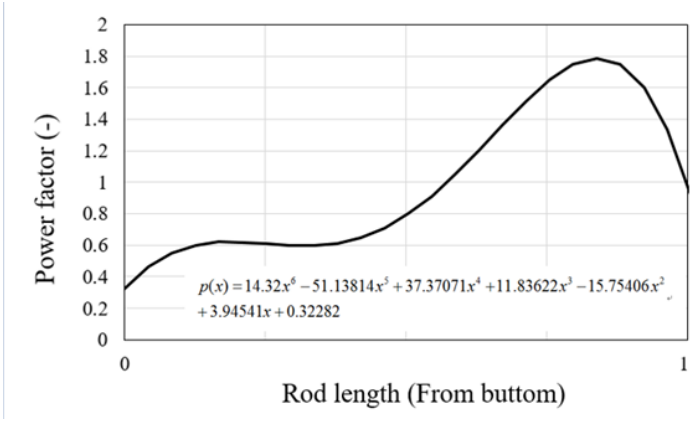
Model Description

The total power of the fuels was roughly **10.5411 MWt** initially. The fuel of SFP separated into three regions and the SFP was assumed to be “Full-core off-load’’ situation.

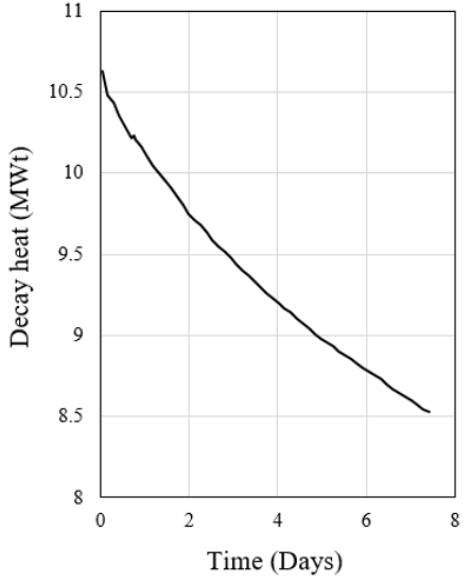


MELCOR Area	Power Fraction(%)	Thermal Power(MWt)
A	**80.9**	**8.5356**
B	**3.82**	**0.4011**
C	**15.28**	**1.6044**

Model Description



Power shape used in MELCOR

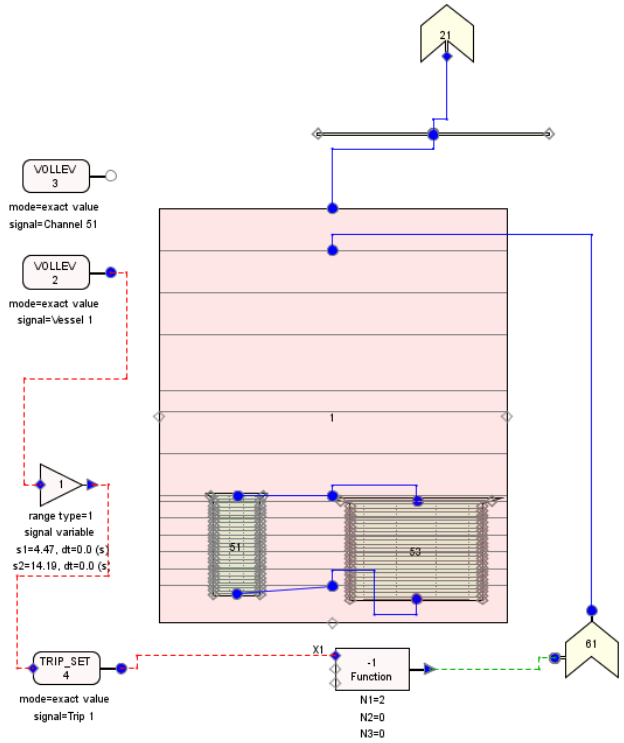


Decay heat used in MELCOR

These two pictures show the decay heat and power shape settings of MELCOR model.

Model Descriptic

TRACE model was used in the paper ”**The Mitigation Strategy Analysis of Maanshan Nuclear Power Plant Spent Fuel Pool Using TRACE/FRAPTRAN/ SNAP**”, SDEWE2017.



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Result

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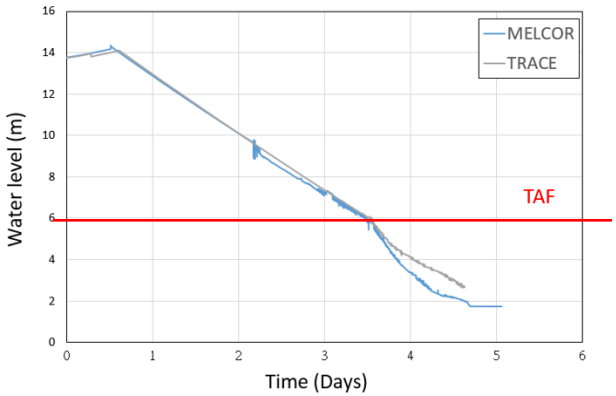
Result

Fukushima-like condition

In this case, all water injection of Mannshan NPP SFP was set to be failed. The pool water level kept going down due to the evaporation. The cladding temperature rose over 1088.7K when the water level below Top of Active fuel.



Water level results of MELCOR and TRACE

Event	Time (day)
SBO	**0**
Water level dropped to TAF	**3.5**
Mitagation strategy	**4~4.3**

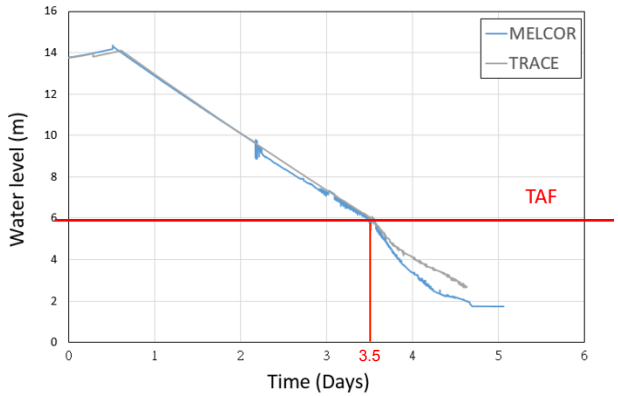
Sequence of event

Result

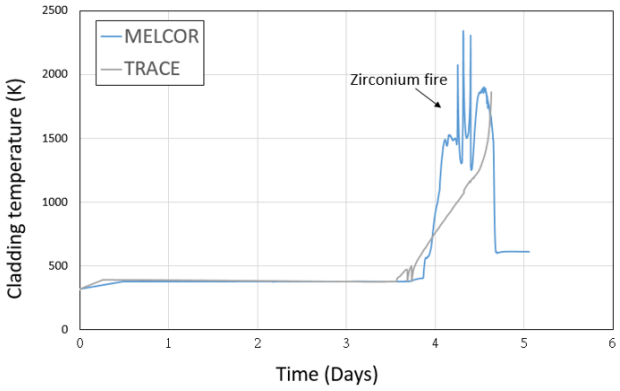
Fukushima-like condition

The result of the peak cladding temperature shows that because of the oxidation heat, temperature of MELCOR rose more rapidly.

And the irregularity of the curve means the zirconium-fire happened.



Water level results of MELCOR and TRACE



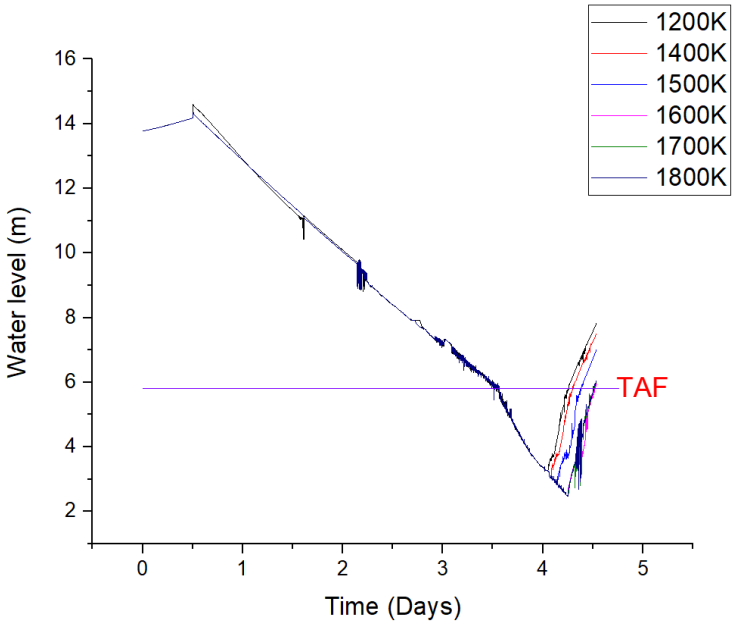
Peak cladding temperature results of MELCOR and TRACE

Result

Mitigation Strategy

The following research tried to find out the phenomenon may happened after 3.5 days.

The water injection was assumed to be 200GPM (12.61kg/s). It was the lowest flow rate of the NEI06-12 suggestion for a SFP accident.



Water level results of sensitivity study

Result

Mitigation Strategy

These two equation show the zirconium-water calculation of MELCOR. The oxidation rate may speed up after the temperature over 1853K.

$$\mathbf{K(T) = 29.6\ exp\left(\frac{-16820.0}{T}\right)\ for\ T < 1853.0\ K}$$

$$\mathbf{K(T) = 87.9\ exp\left(\frac{-16610.0}{T}\right)\ for\ T \geq 1853.0\ K}$$

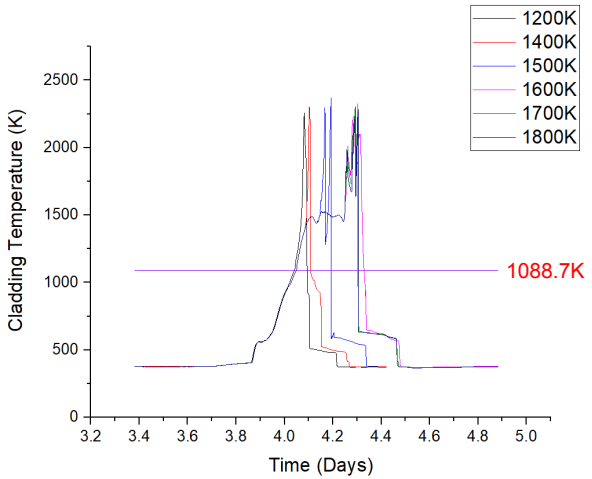
It was call "**Breakaway oxidation**."

Result

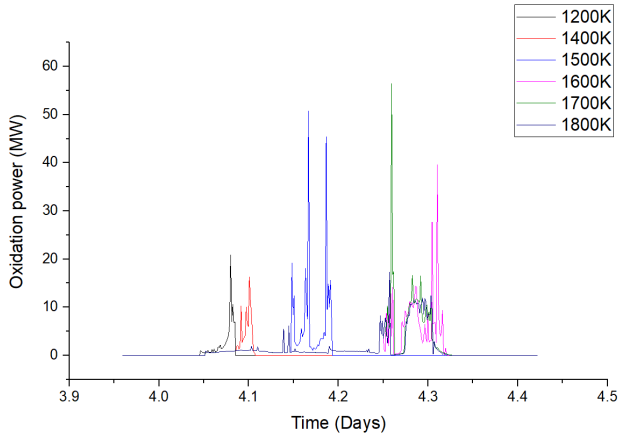
Mitigation Strategy

First peak of each curve was cause by oxidation heat.

In the case that water injection started at over 1500K, there were more than one peak.



Peak cladding temperature results of sensitivity study



Oxidation heat results of sensitivity study

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Conclusion

3.5 Conclusion

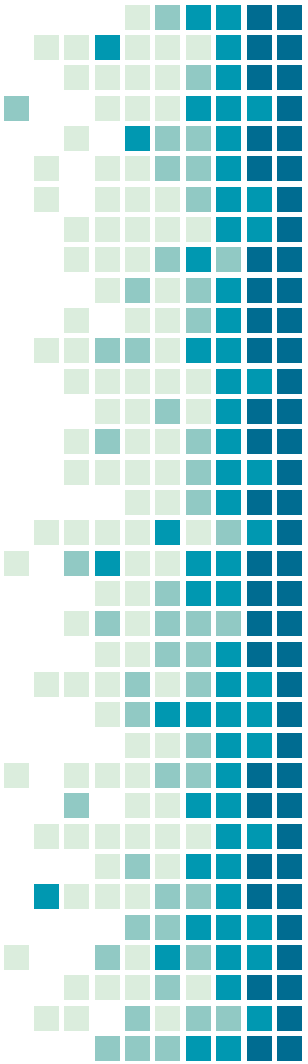
4.1 Days

The water level dropped to TAF

Days

The cladding temperature over 1500K

It is the best way to start the water injection before 3.5days. However, if the extra water cannot be prepared before 3.5 days, the water injection must start before 4.1days to prevent the severe accident from making more oxidation heat.



THANKS!

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