2016年學術研討會(後福島改善研討會)
核二廠超越設計基準事故安全分析評估

- 國立清華大學核子工程與科學研究所
- 財團法人 核能與新能源教育研究協進會

基本資料

相片

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  清大核工所兼任副教授
- 清大核工1980級
- 1993年清大核工博士
- 曾任職核能研究所30年，專長安全分析與核能品保

大綱

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簡介: URG

- 台電公司以日本311福島事故為鑒，吸取其經驗、新創、建置擬訂了核電廠之「機組斷然處置措施」，因應電廠遭遇超出事前所預想之設計基準的複合式天災時，迅速掌握注水進入反應爐的決策時機與關鍵，將各種可能的水源(包括：生水、溪水，甚至海水)注入反應爐冷卻爐心燃料，防止爐心燃料熔毀及放射性物質外釋，及避免造成大規模民眾疏散。

- 斷然處置簡易流程

URG

資料來源-中華民國核能學會
http://archived.chns.org/s.php@page=3&id=34&id2=1857.html

程式主要模擬範圍

階段	策略	時限與目標
Phase 1	策略 CS.1-01 生水(消防水)注水入反應爐 策略 CS.1-02 廠區全黑反應爐降壓 策略 CS.1-03 廠區全黑圍阻體排氣 策略 CS.1-04 消防水車引接注水 策略 CS.1-05 RCIC手動運轉操作 策略 CS.1-06 第5部柴油發電機供電二部機 策略 CS.1-07 氣渦輪機全黑柴油發電機供電二部機	1小時內 控制與減緩事態
Phase 2	策略 CS.2-01 移動式空壓機/氮氣瓶供給SRV/ADS氣源 策略 CS.2-02 480V機動性柴油發電機引接 策略 CS.2-03 4.16kV電源車引接 策略 CS.2-04 延長直流電源供電時間 策略 CS.2-05 用過燃料池補/灑水 策略 CS.2-06 沉水泵排水操作 策略 CS.2-07 機動性水源對CST注水	8小時內 電源復原
Phase 3	策略 CS.3-01 緊急進水口垃圾清運 策略 CS.3-02 ESW馬達更換 策略 CS.3-03 替代長期冷卻	36小時內 建立長期冷卻

參考資料-網際網路
http://www.aec.gov.tw/webpage/info/files/index_04_2-22.pdf

FLEX

美國核能工業界委託美國 核能協進會於 2011 年 12 月提出了「彈性且多樣化處理策略」（Flexible and Diverse Coping Strategies， 簡稱 FLEX），計畫性且系統性地提供可攜式緊急設備(包括電源、水源、泵浦等)，協助重要安全系統 確保電廠達到最終熱沈，以減緩事件發生所帶來之後果。

（FLEX）的基本要件如下：

- 對超過基本設計外部事件可提供多一層安全保障，以避免核子燃料受 損。
- 維持爐心冷卻、用過燃料池冷卻及圍阻體完整。
- 可多重供應電源與冷卻水。
- 妥適地規劃可攜式緊急設備之存放地點。
- 力求支援設備規格之一致性，使電廠間之相互備援更順暢。
- 對 FLEX 相關設備之配置、維護、測試及人員之定期訓練等項目，應建 立良好管理，以確保 FLEX 之可行性與可靠性。
- 成立支援核電廠緊急設備之區域應變中心。

簡介: 程式介紹

- TRACE

美國核管會將RELAP5與TRAC-P以及應用在沸水式電廠的RAMONA與TRAC-B四個程式的功能發展整合成一個新的程式TRAC（TRAC/RELAP Advanced Computational Engine）。

程式介紹

- MELCOR

MELCOR是由Sandia國家實驗室開發的嚴重事故分析程式，至今已發展超過25年，主要用於分析沸水式與壓水式核能電廠的嚴重事故，特別是可模擬與分析爐心裂解、氫氣產生、fission產物釋出等現象，並使用”full two-fluid treatment”與” governing 方程式的semi-implicit formulation”之方式來處理熱流方面的計算與分析。

程式介紹

- MAAP

MAAP程式最初是在三哩島事故後才發展的一套工具，主要用於模擬輕水式核能發電廠的嚴重事故，程式發展至今，已可應用於各種方面，包括在PRA和風險為基礎的應用、嚴重事故管理評估、系統模擬等，且包括ALWR等具有被動安全系統的核能電廠。

程式介紹

- FRAPTRAN

FRAPTRAN是由美國西北太平洋國家實驗室PNNL於1997年開始研發，研究項目主要是計算燃料棒反應，如反應度引起之事故(RIAS)、沒有急停下沸水式反應器(BWR)的功率、冷卻水震盪和喪失冷卻水事故(LOCAs)的假想設計基準事故分析。

程式介紹

- RELAP

RELAP5分析程式是美國愛達荷國家工程與環境實驗室（Idaho National Engineering & Environmental Laboratory，INEEL）所發展的最佳估算分析工具，主要應用於輕水式反應器（Light Water Reactor，LWR）的暫態與冷卻水流失事故的分析評估，亦可廣泛應用於包含蒸汽、水、非凝結性氣體等核能或非核能系統的熱水流暫態模擬。

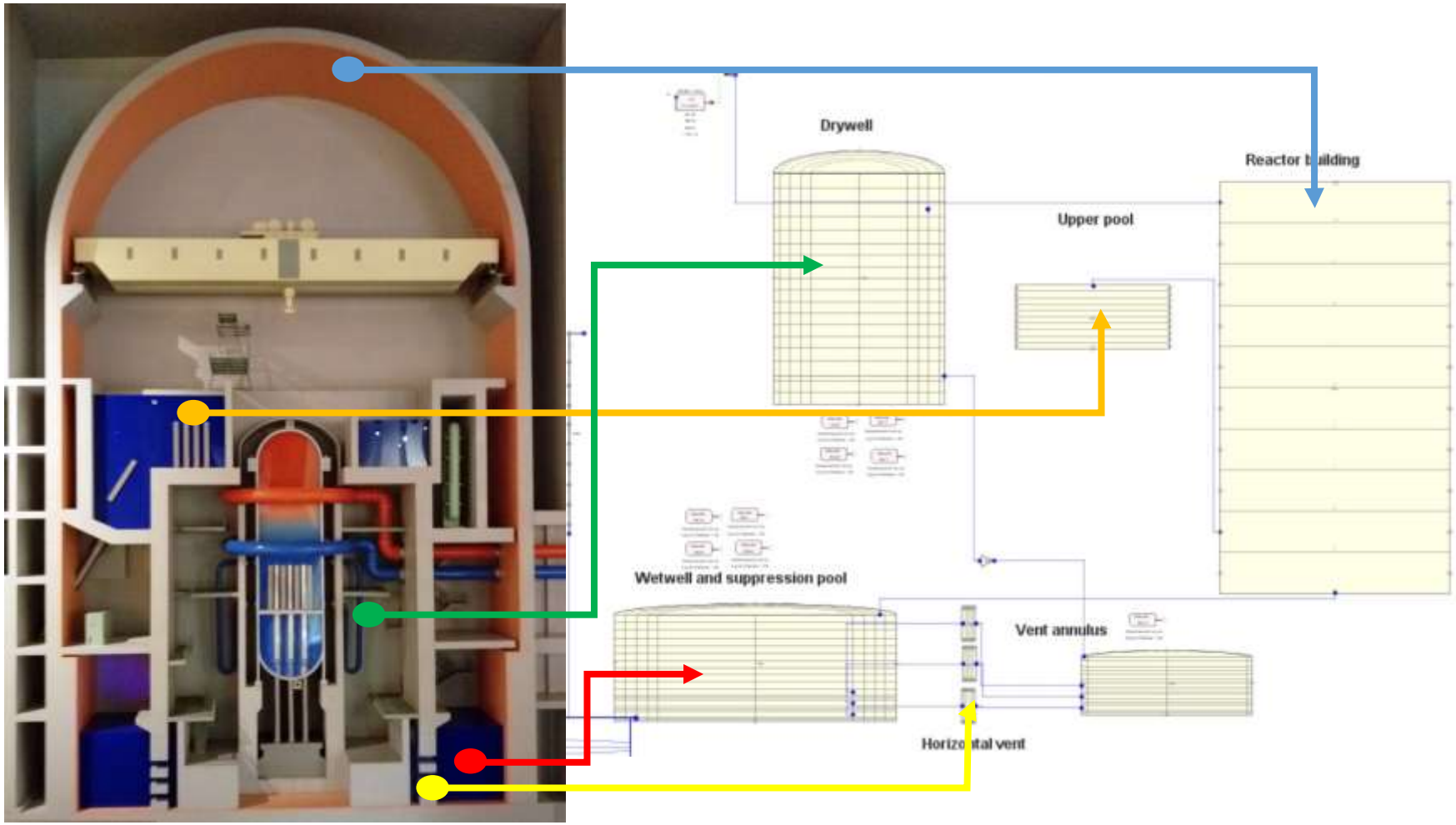
程式介紹

- PCTRAN

PCTRAN 是由台電公司和美國 MST 團隊所引進的設計的一套快速分析程式，它的功能是利用個人電腦的優越能力，來模擬核電廠的各項暫態及各種事故的評估。

模式說明與案例介紹

TRACE BWR Mark IV containment cross section



案例介紹

核二廠 TRACE initial conditions of URG

Parameter	TRACE
Power (MWt)	3001
Dome Pressure (MPa)	7.17
Feedwater Flow (kg/sec)	1626.1
Steam Flow (kg/sec)	1626.1
Core inlet flow (kg/sec)	10645

案例介紹

核二廠TRACE URG測試案例規劃：●啟動、-未動作

C$_{ontrol\ depressurization}$

A$_{DS}$

I$_{njection}$

N$_{othing}$

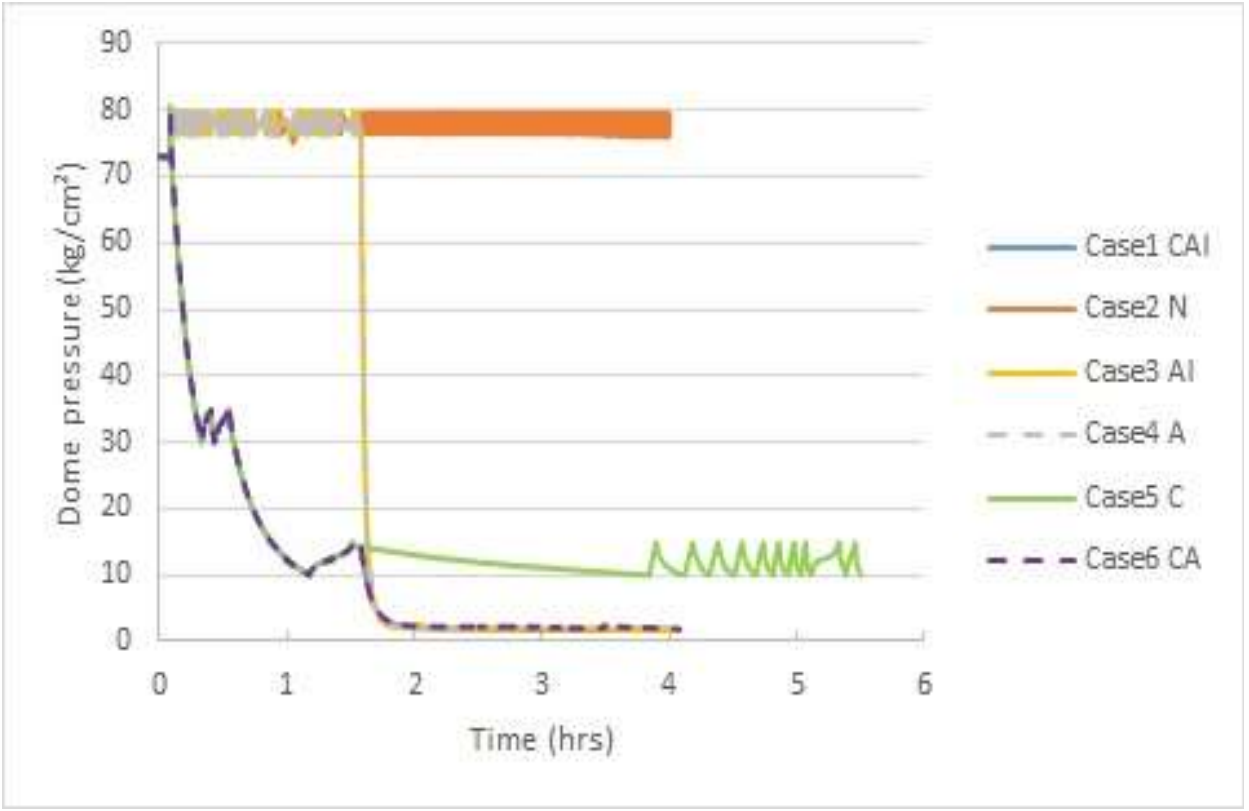
Event/Case	Case1	Case2	Case3	Case4	Case5	Case6
控制性降低反應爐壓	●	-	-	-	●	●
反應爐緊急洩壓	●	-	●	●	-	●
注水	●	-	●	-	-	-
CPU Time	236970秒	818298秒	356033秒	307438秒	313562秒	791934秒
URG動作代號	CAI	N	AI	A	C	CA

分析結果: URG案例之分析結果討論

Event	Case1	Case2	Case3	Case4	Case5	Case6
Start of simulation	0	0	0	0	0	0
Reactor Scram, MSIV Closed	300	300	300	300	300	300
Loss of Feedwater flow	305	305	305	305	305	305
Controlled De-pressure 35kg/cm²	305	-	-	-	-	305
RCIC On	306	306	306	306	306	306
SBO	2100	2100	2100	2100	2100	2100
Controlled De-pressure 15kg/cm²	2100	-	-	-	-	2100
RCIC Trip	5700	5700	5700	5700	5700	5700
Reactor pressure drop to 3kg/cm²	5700	-	5700	5700	5700	5700
Containment vent	5700	-	5700	5700	5700	5700
Low pressure water injection	6700	-	6700	-	-	-
Fuel temperature over 1088K	-	13244	-	7895	18723	13920
Fuel temperature over 1477K	-	14164	-	8536	19550	14802
End of simulation	14400	14412	14641	8688	19808	14991

URG案例之分析結果討論

TRACE



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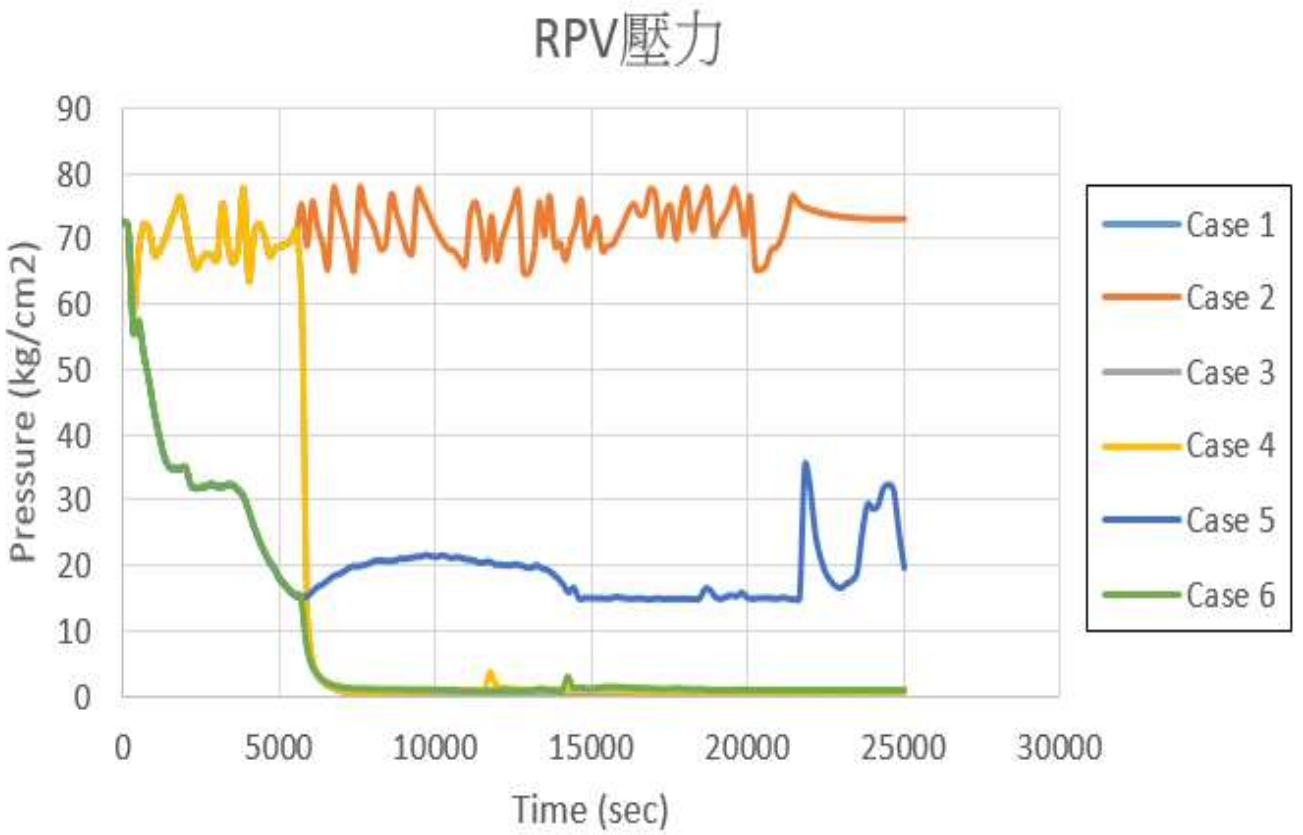

URG案例之分析結果討論

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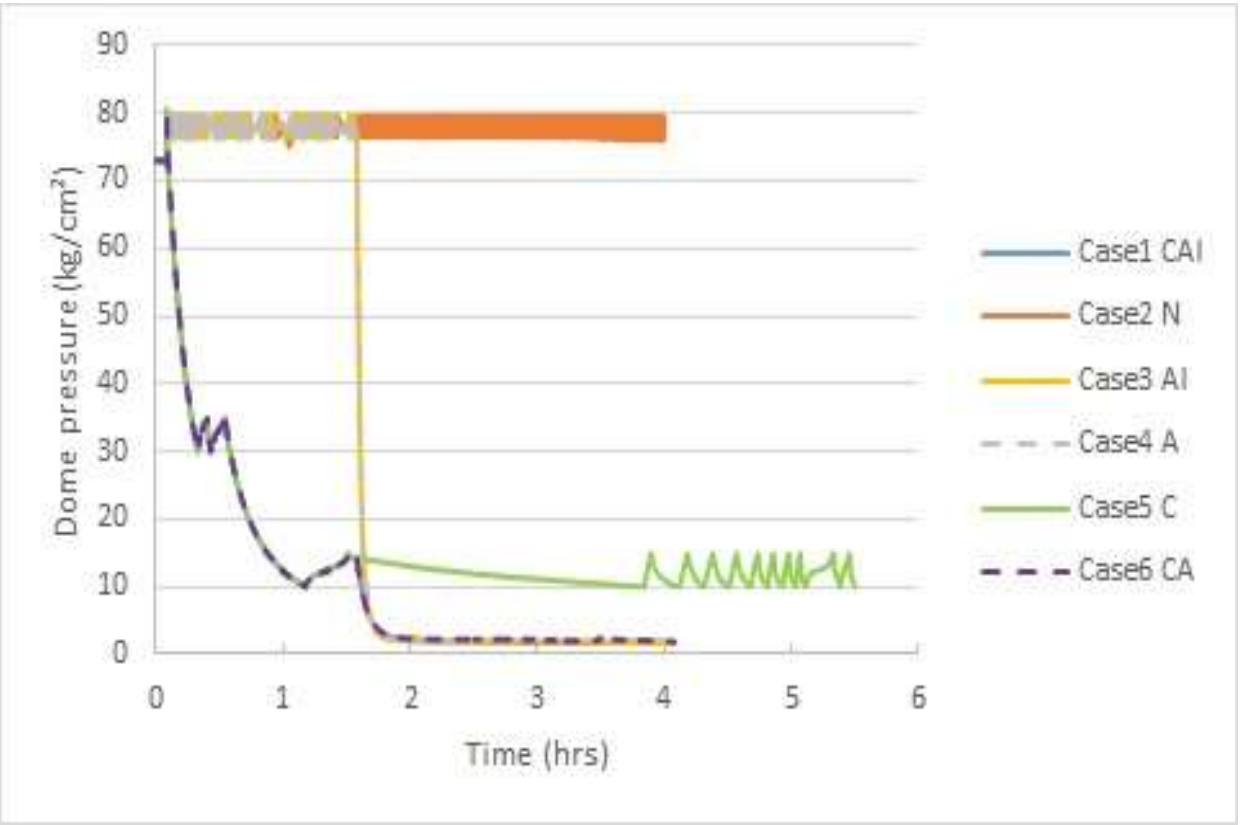
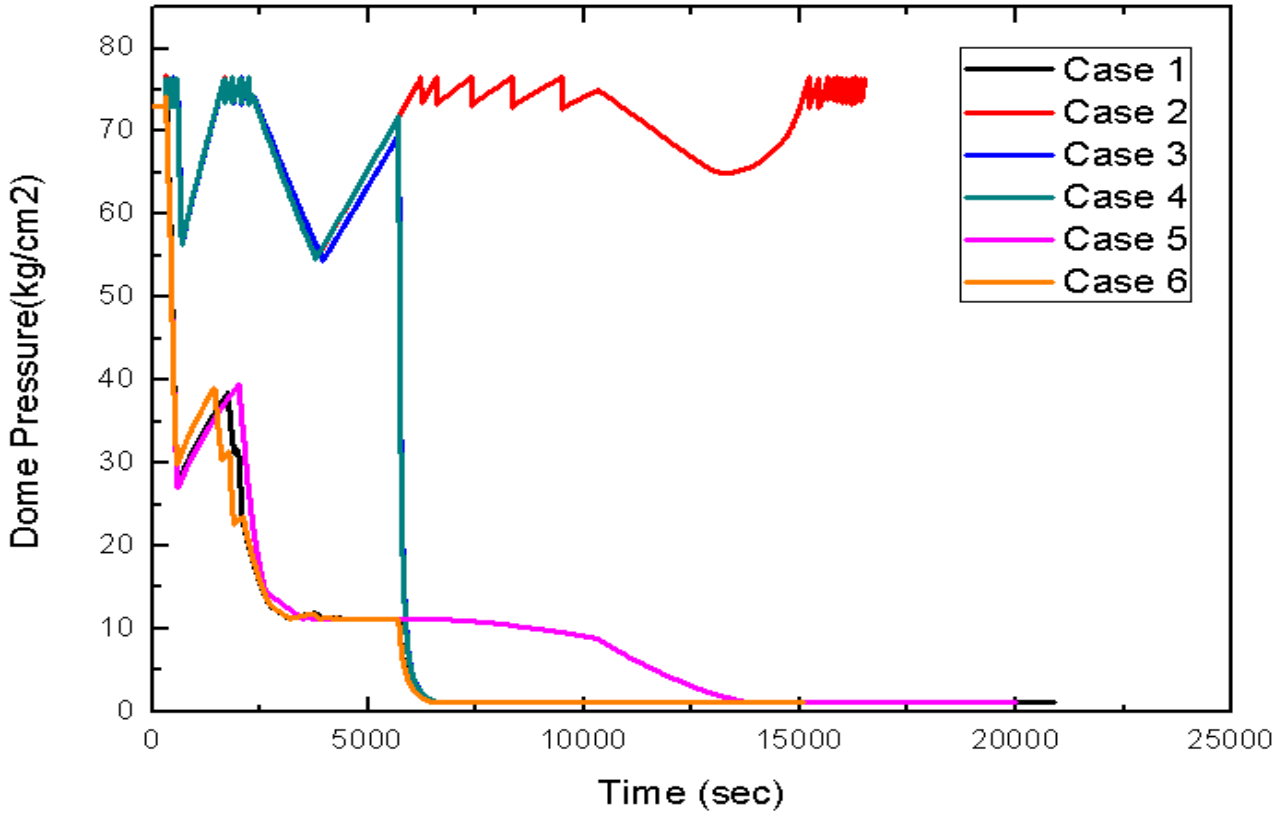


PCTRAN



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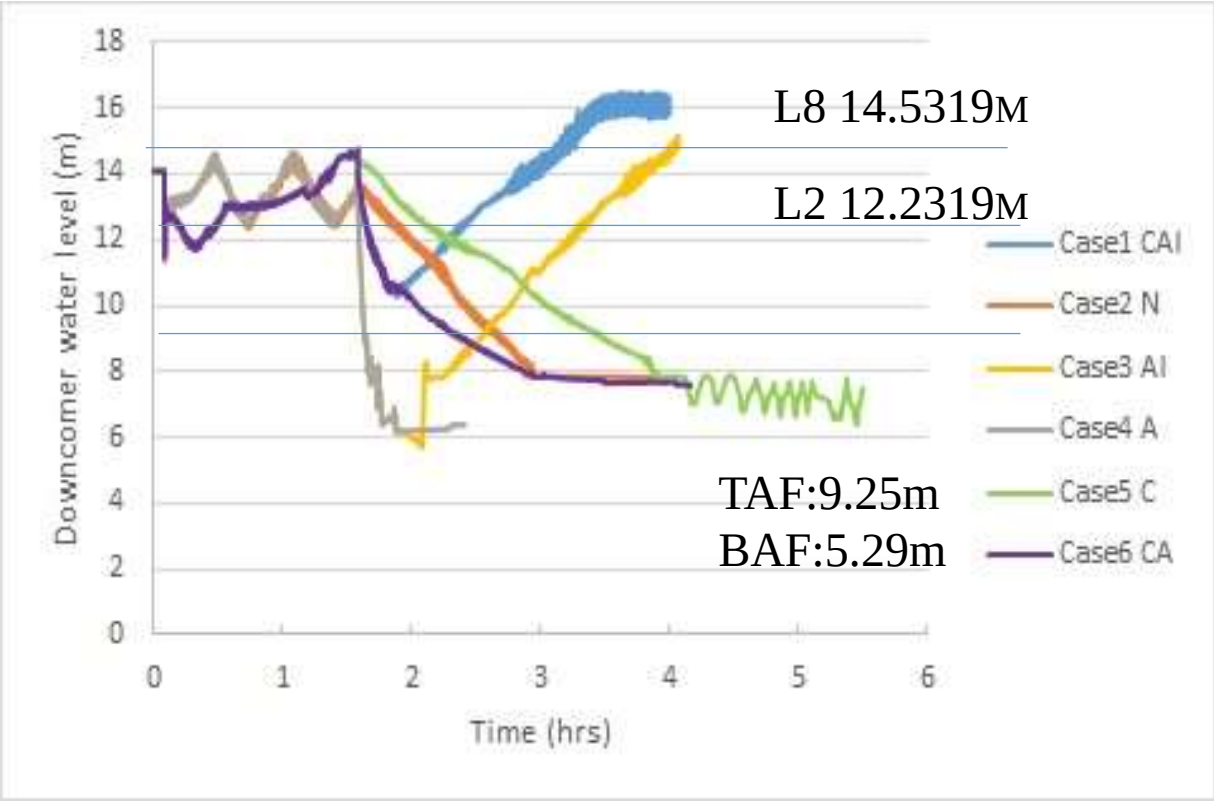

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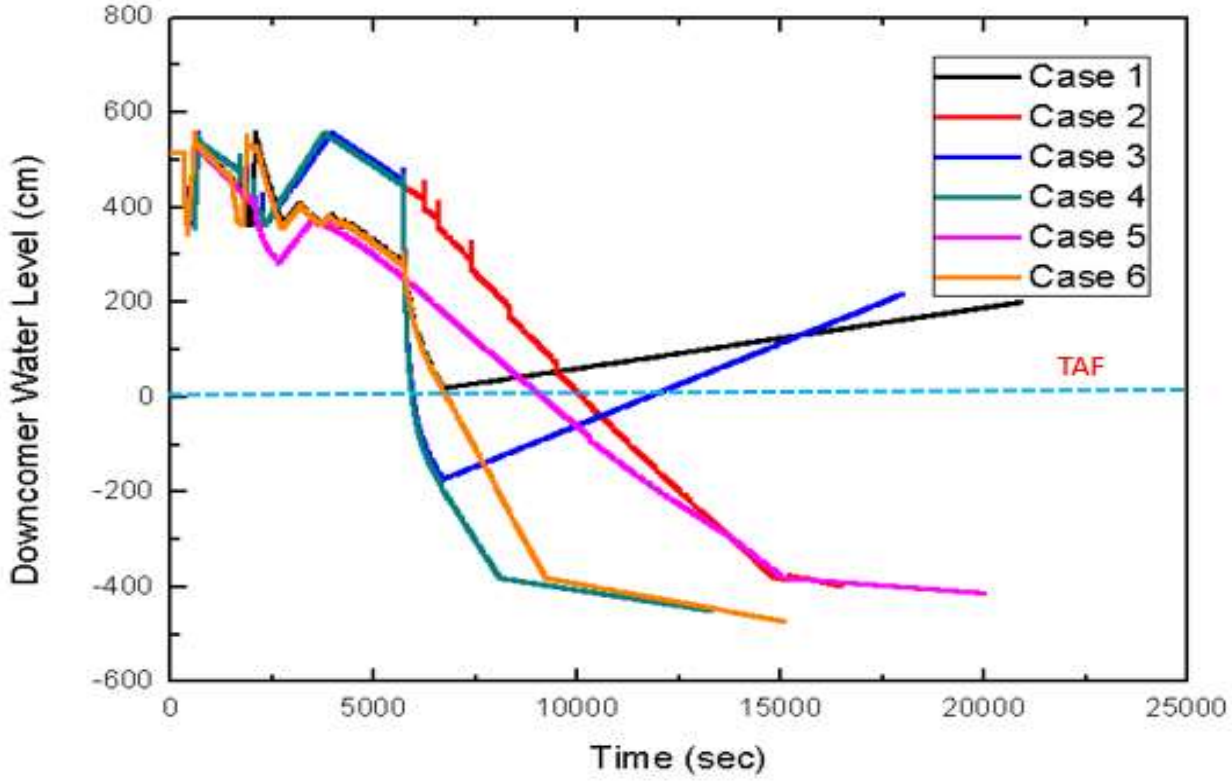

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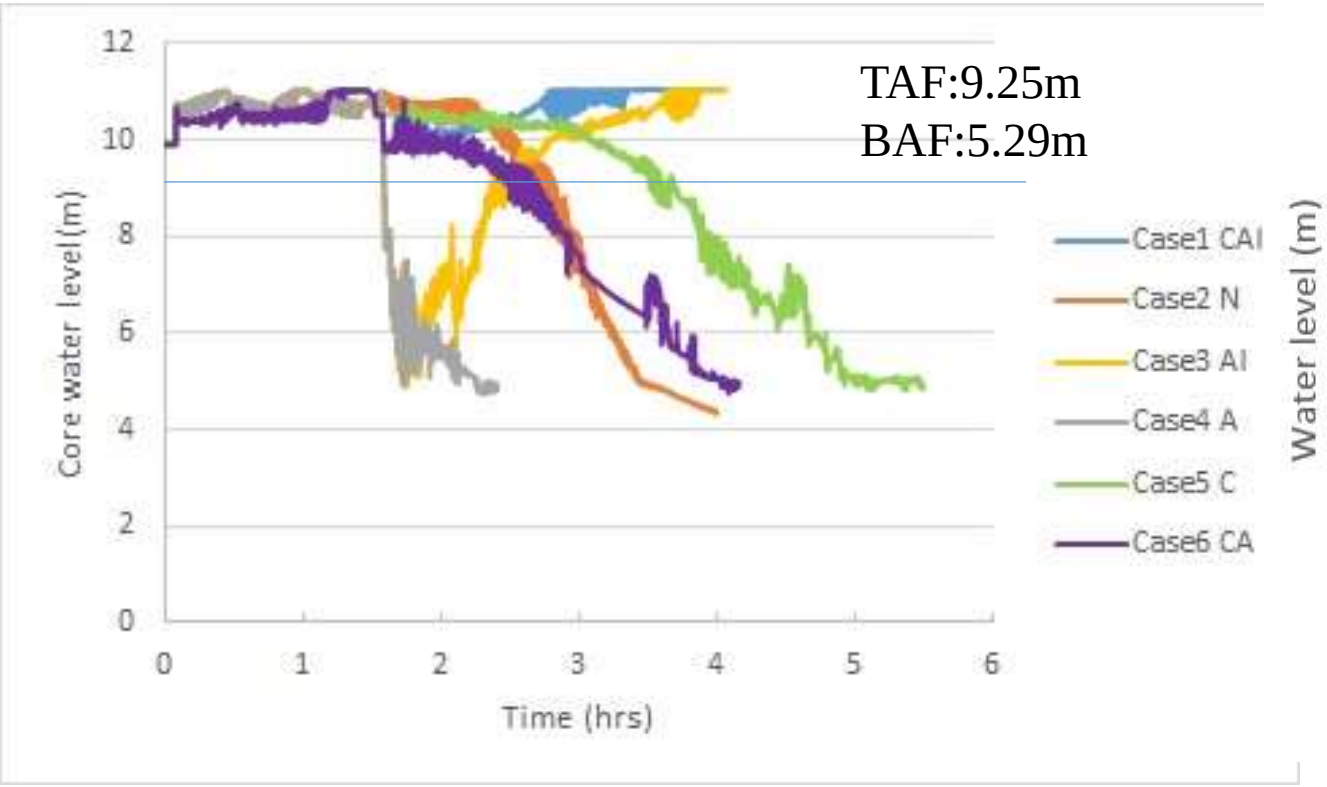

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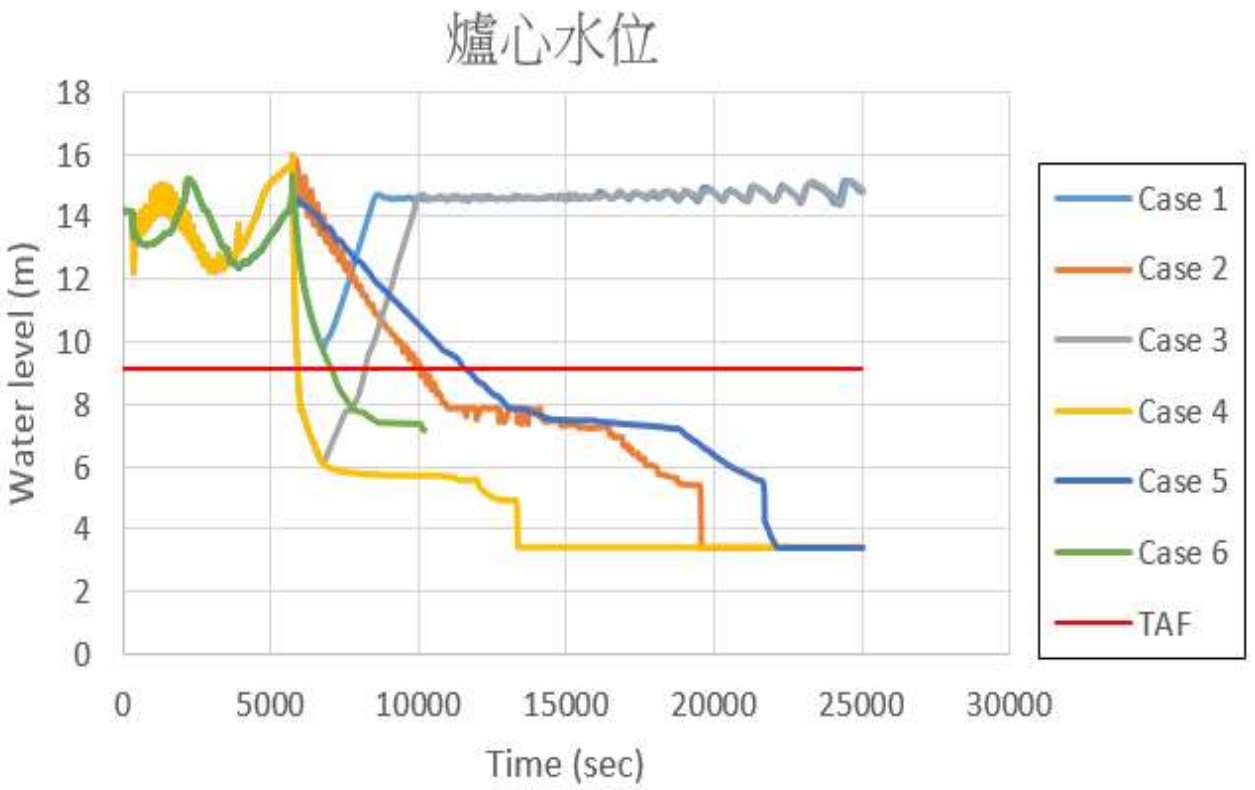

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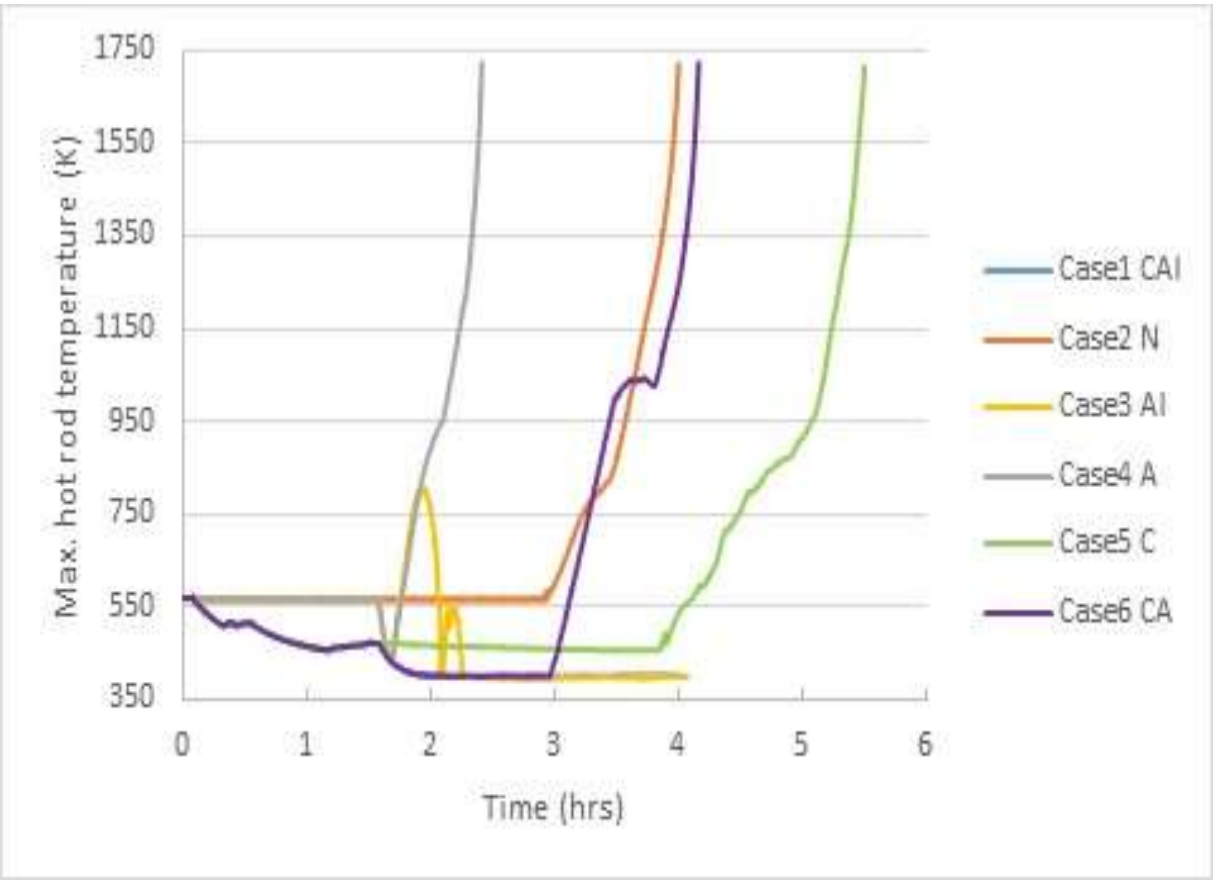

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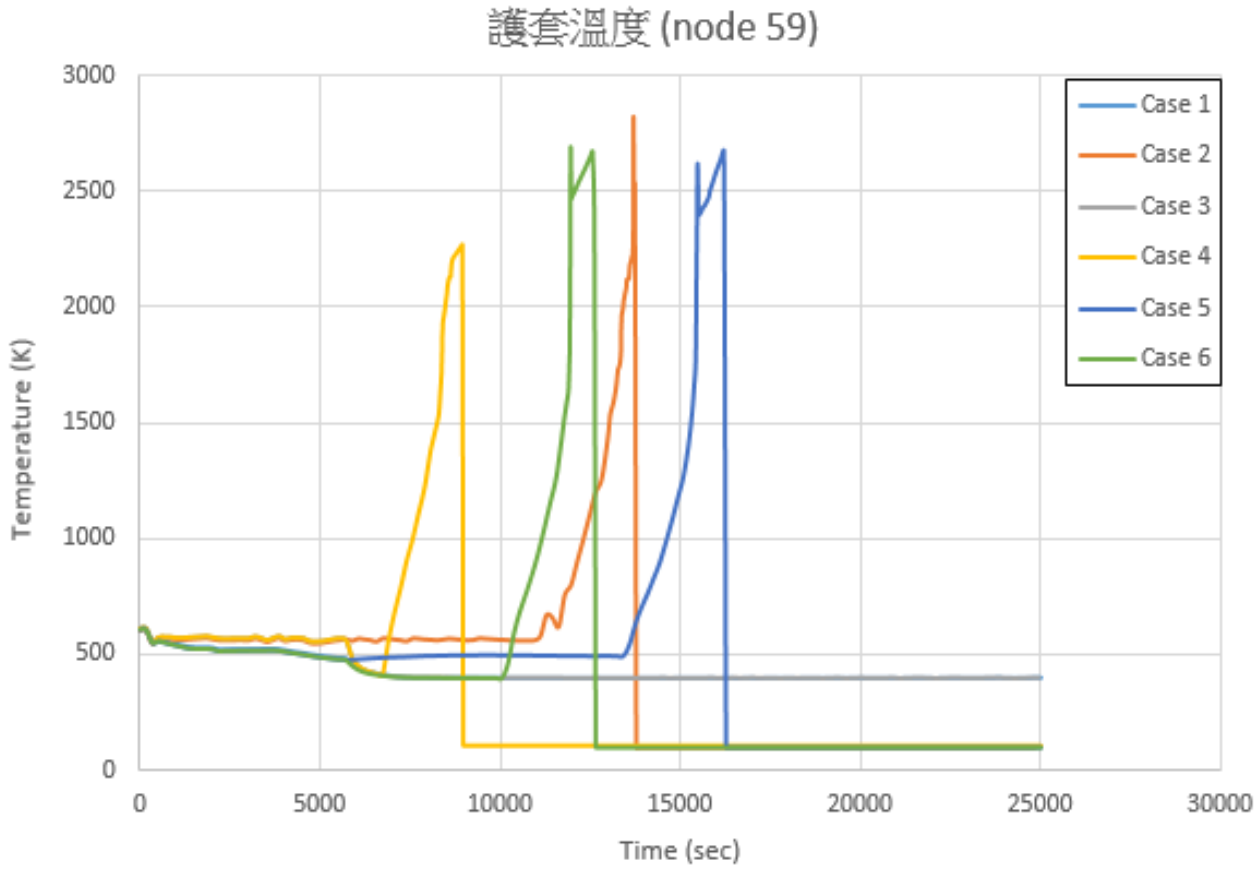

URG案例之分析結果討論

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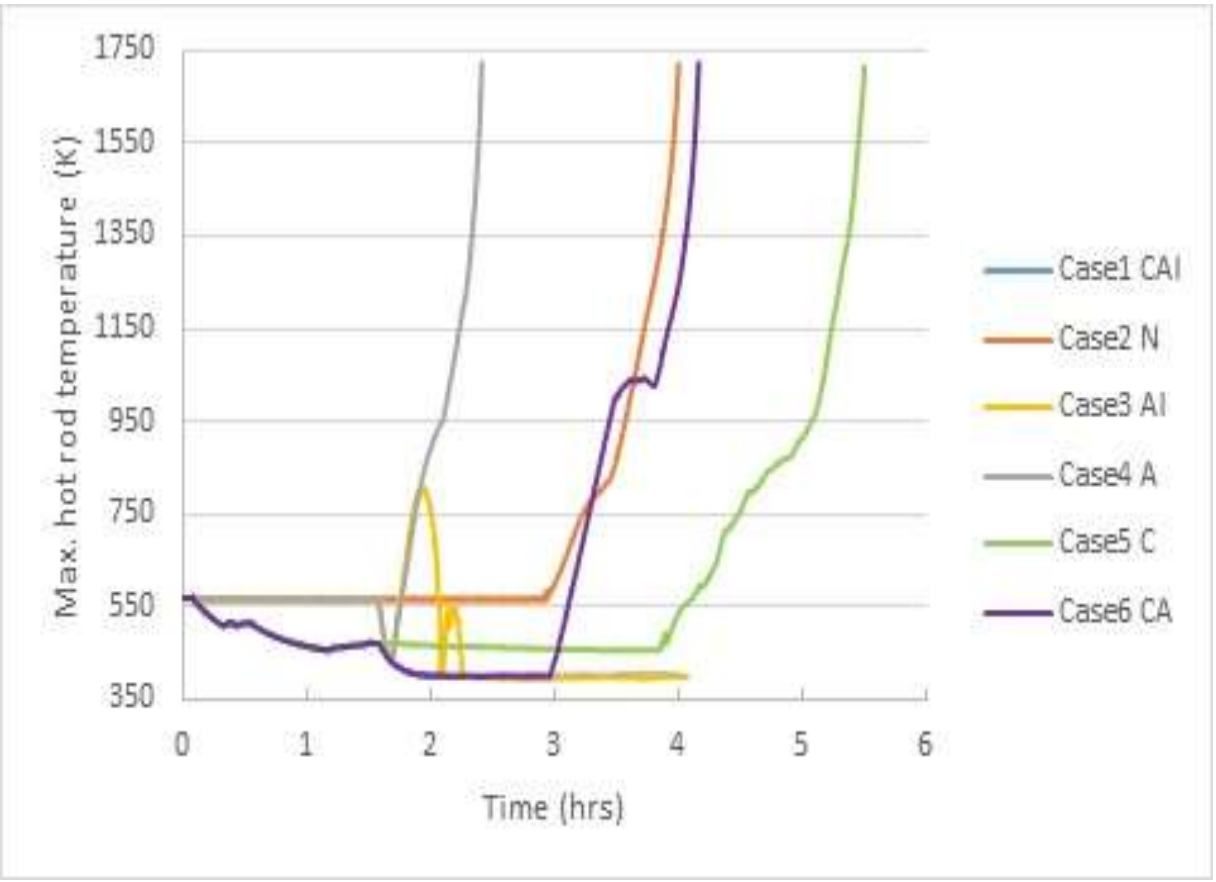

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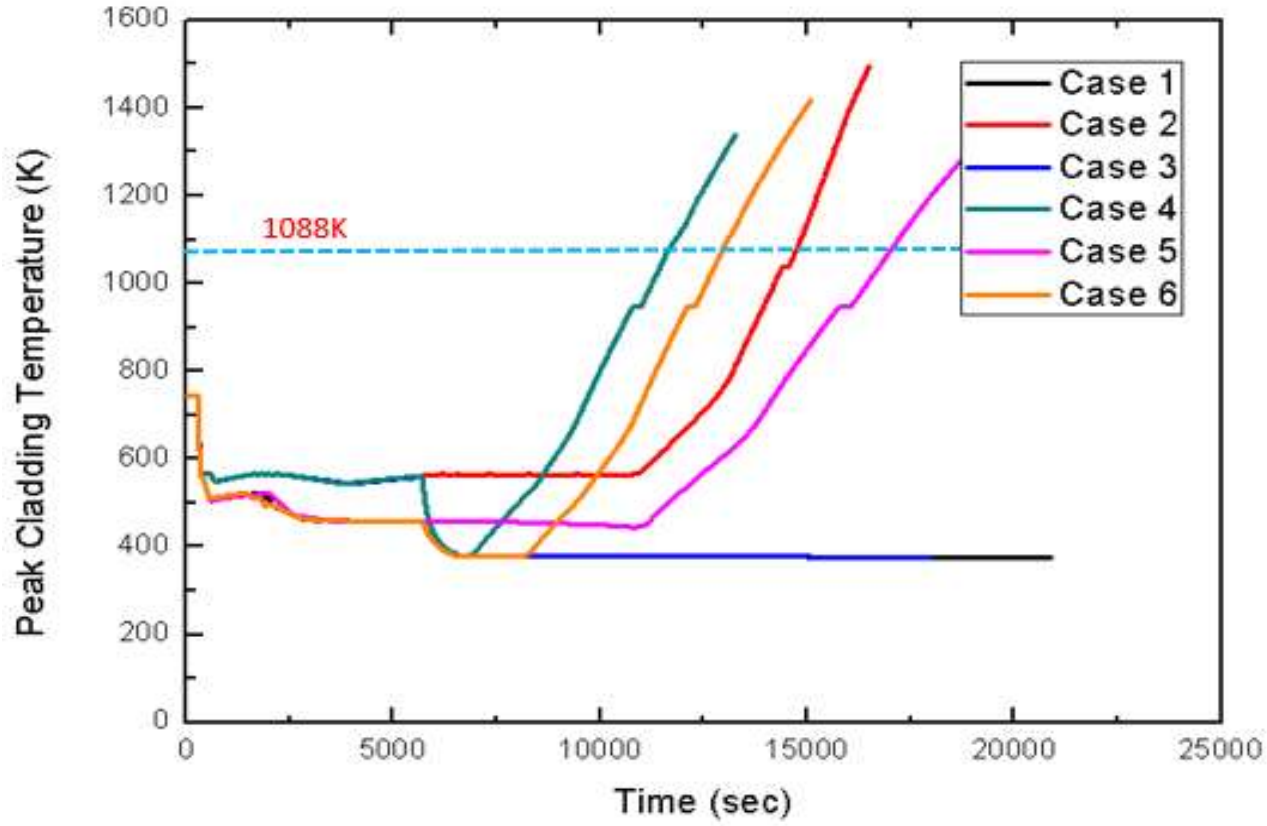

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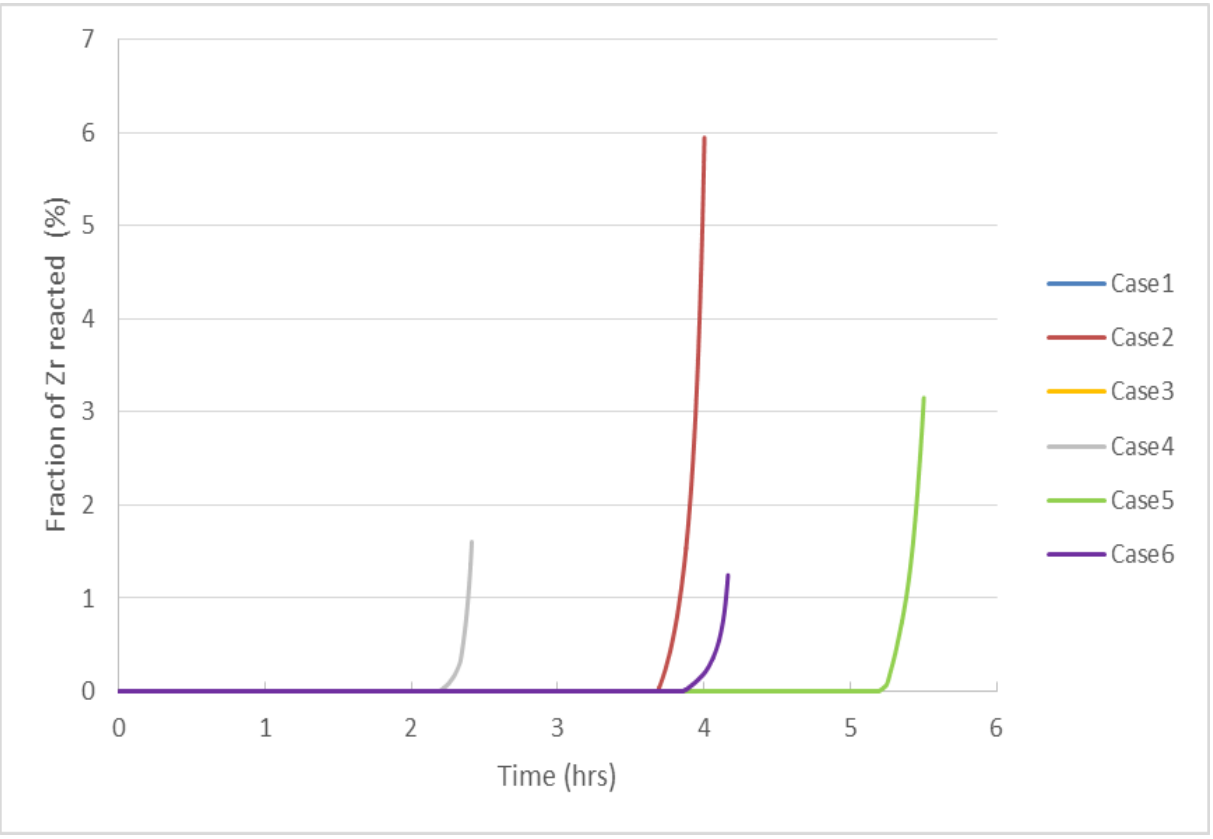

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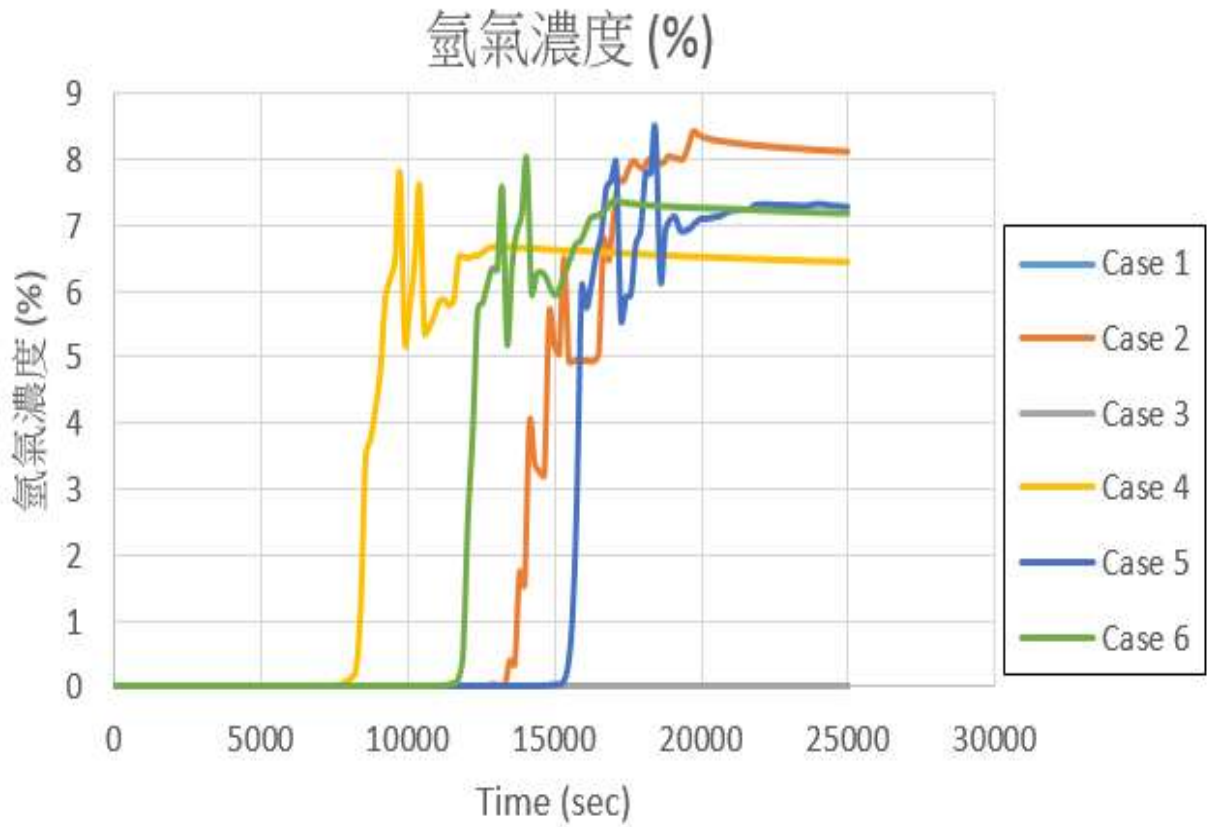

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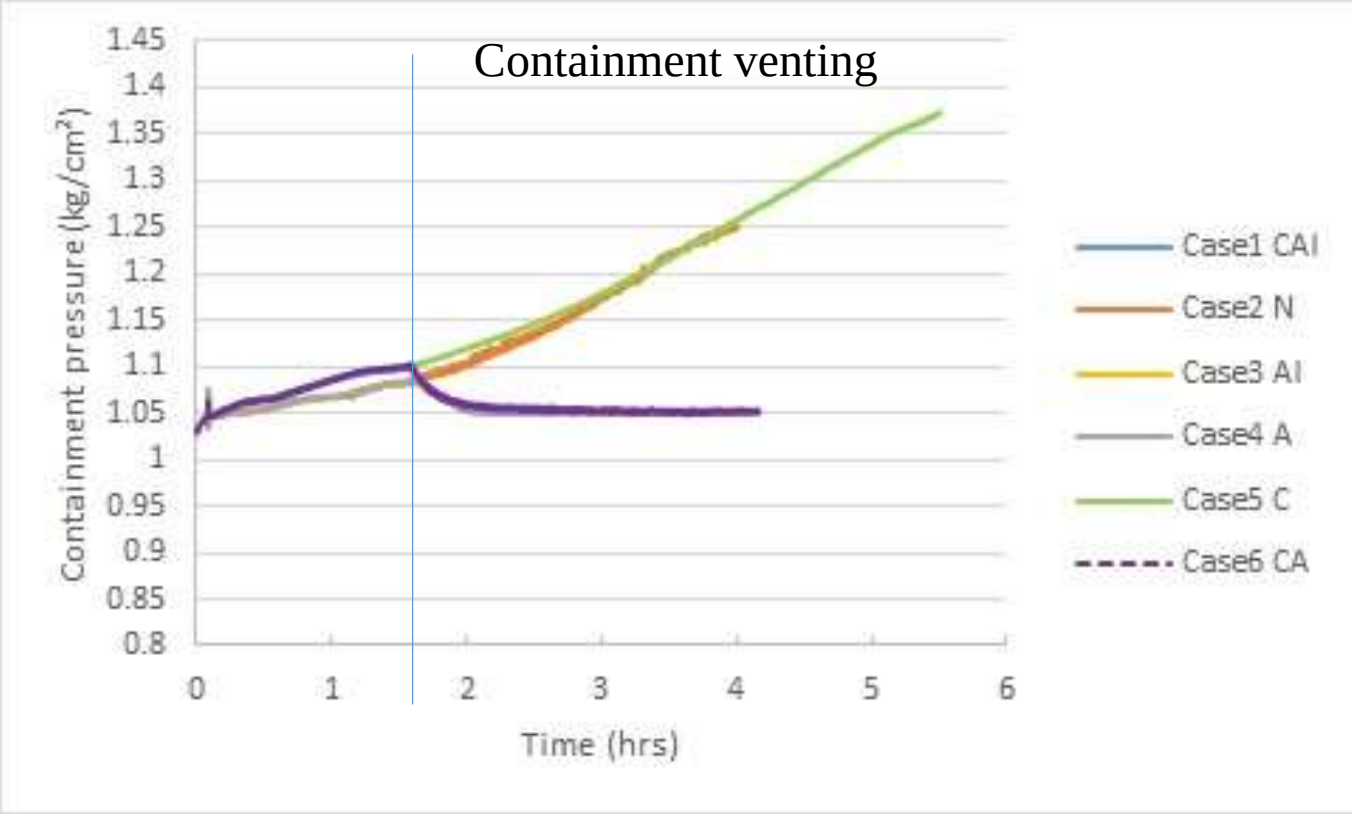

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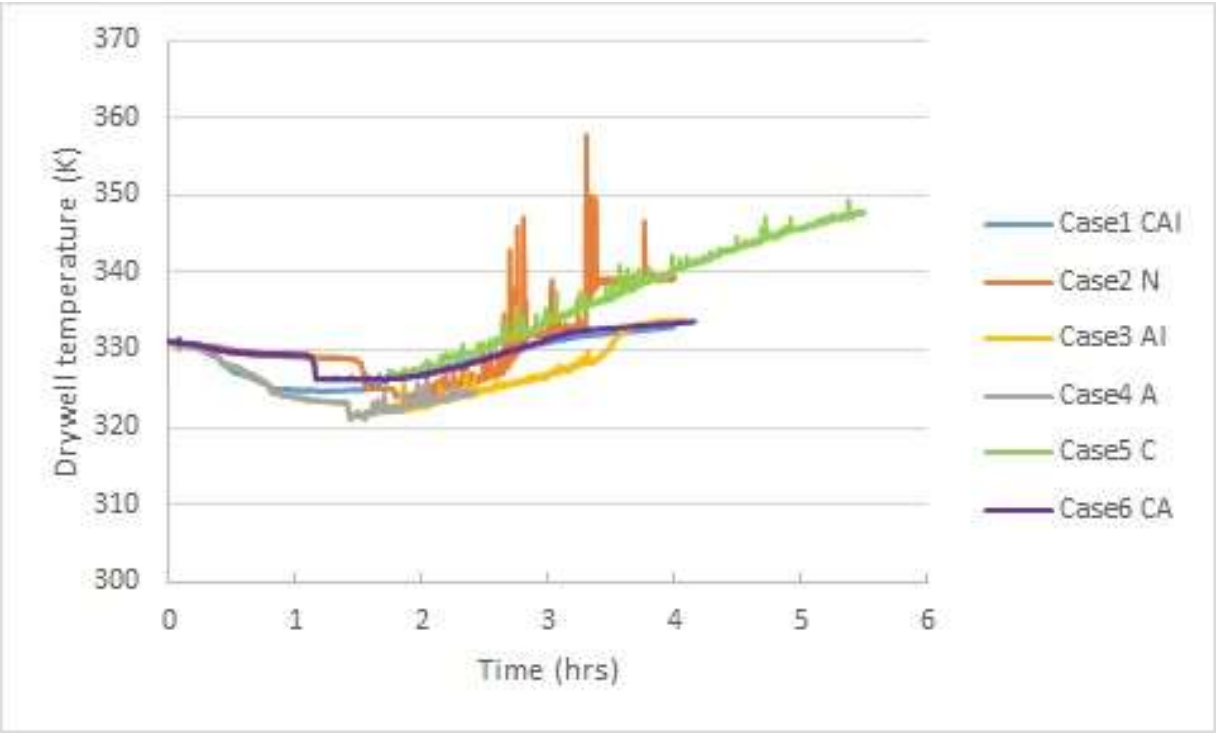

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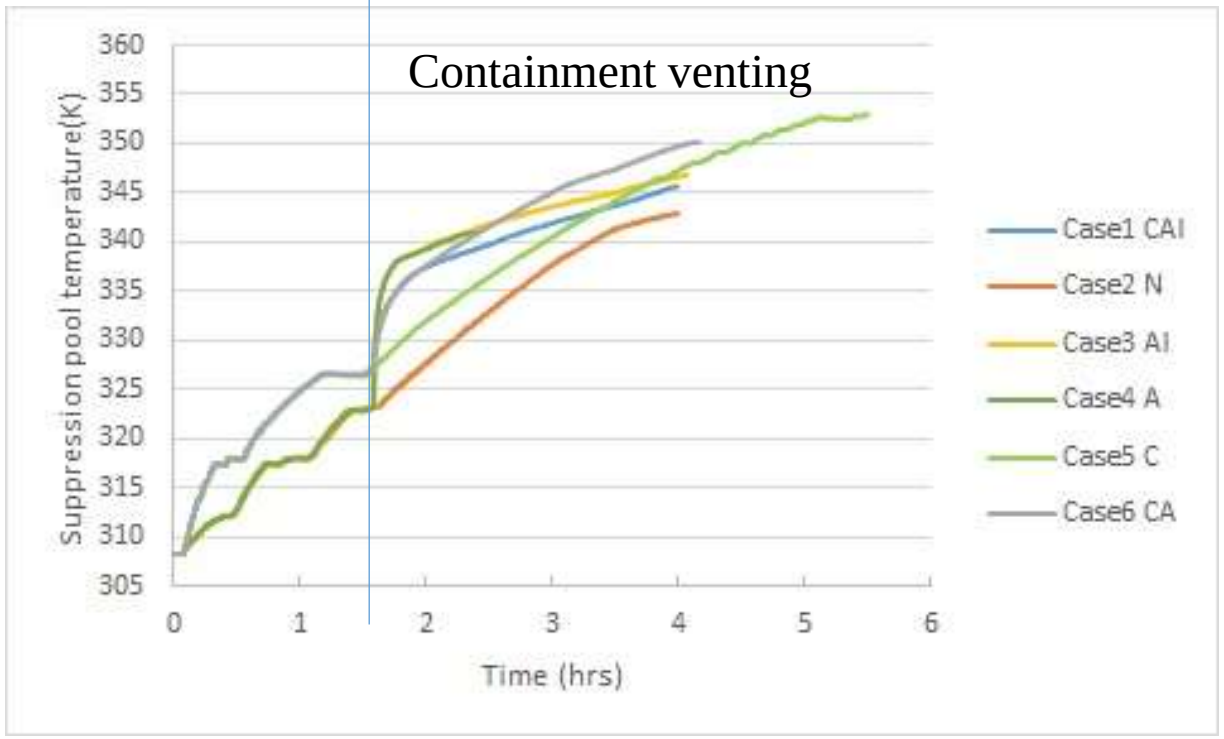

URG案例之分析結果討論

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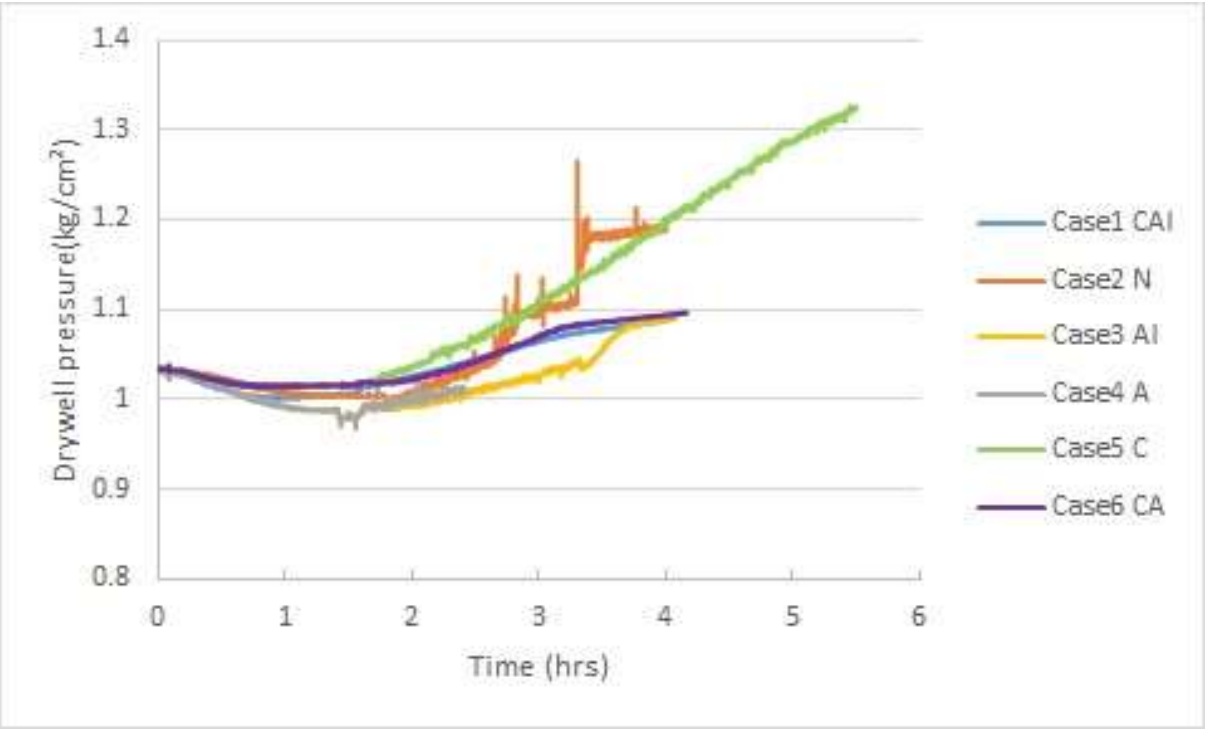

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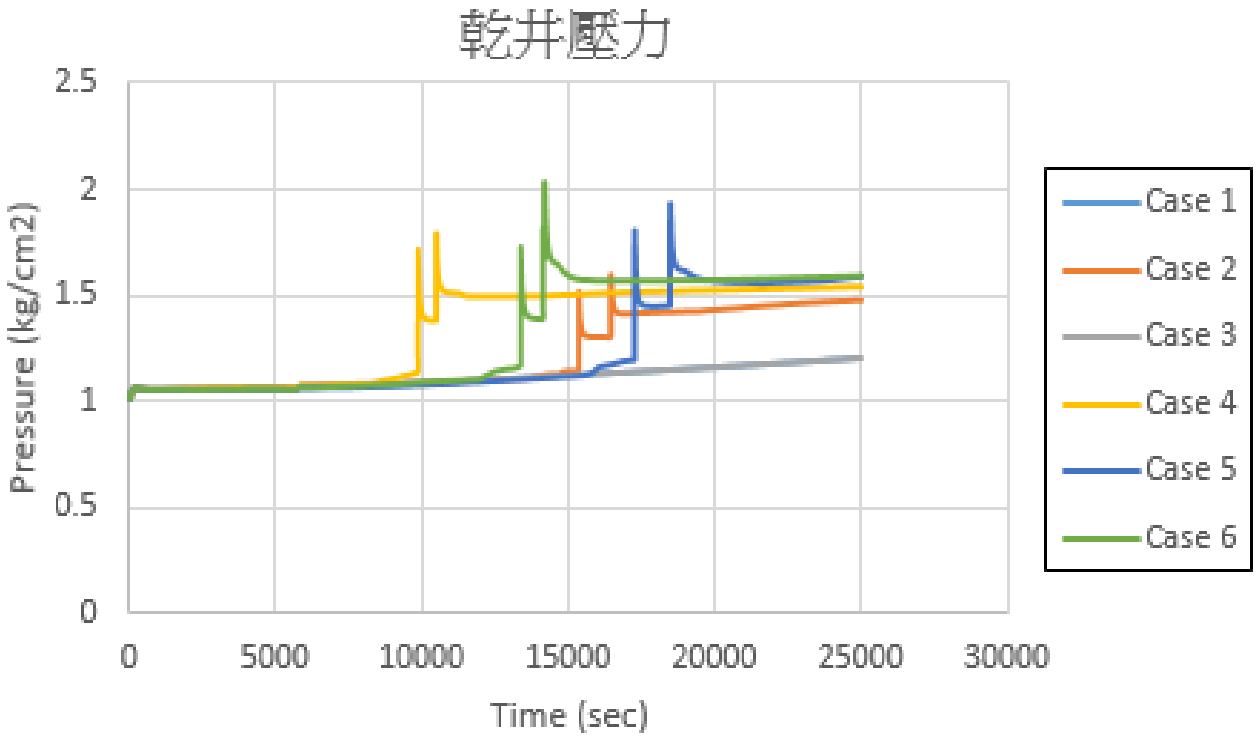

URG案例之分析結果討論

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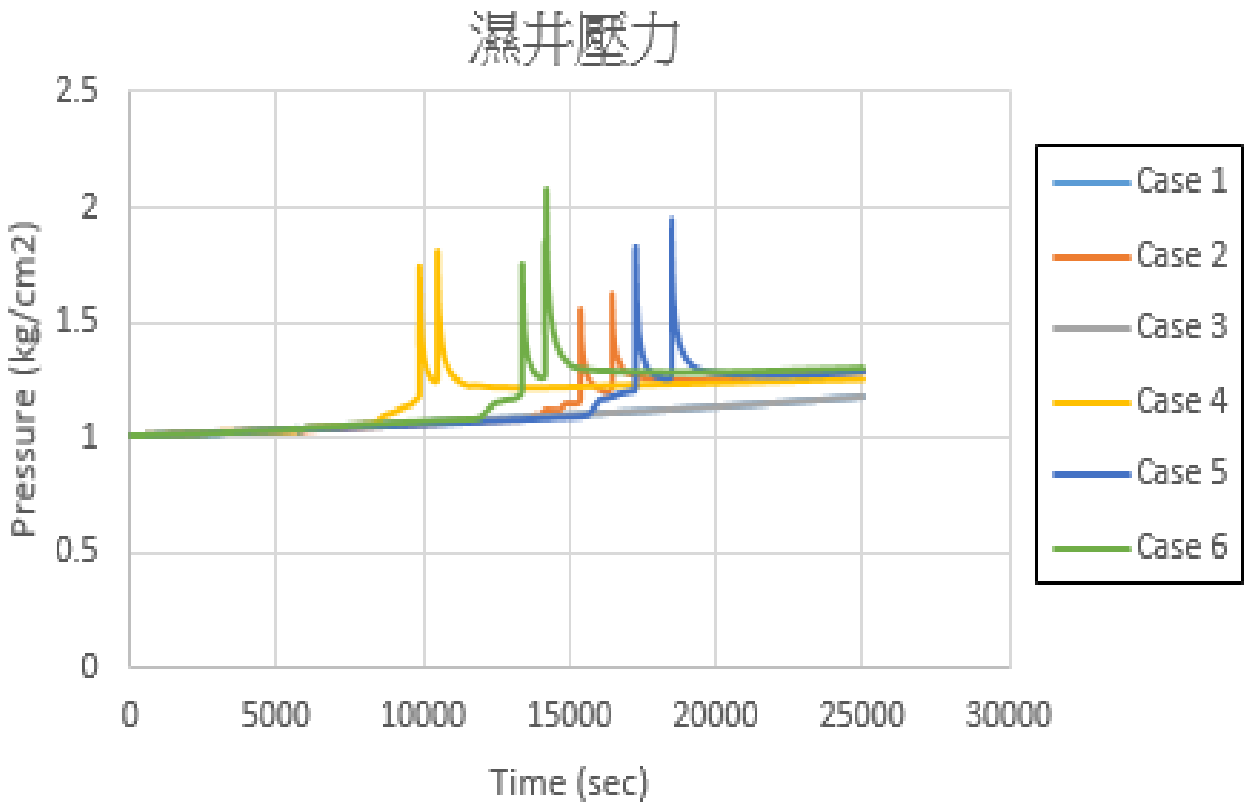
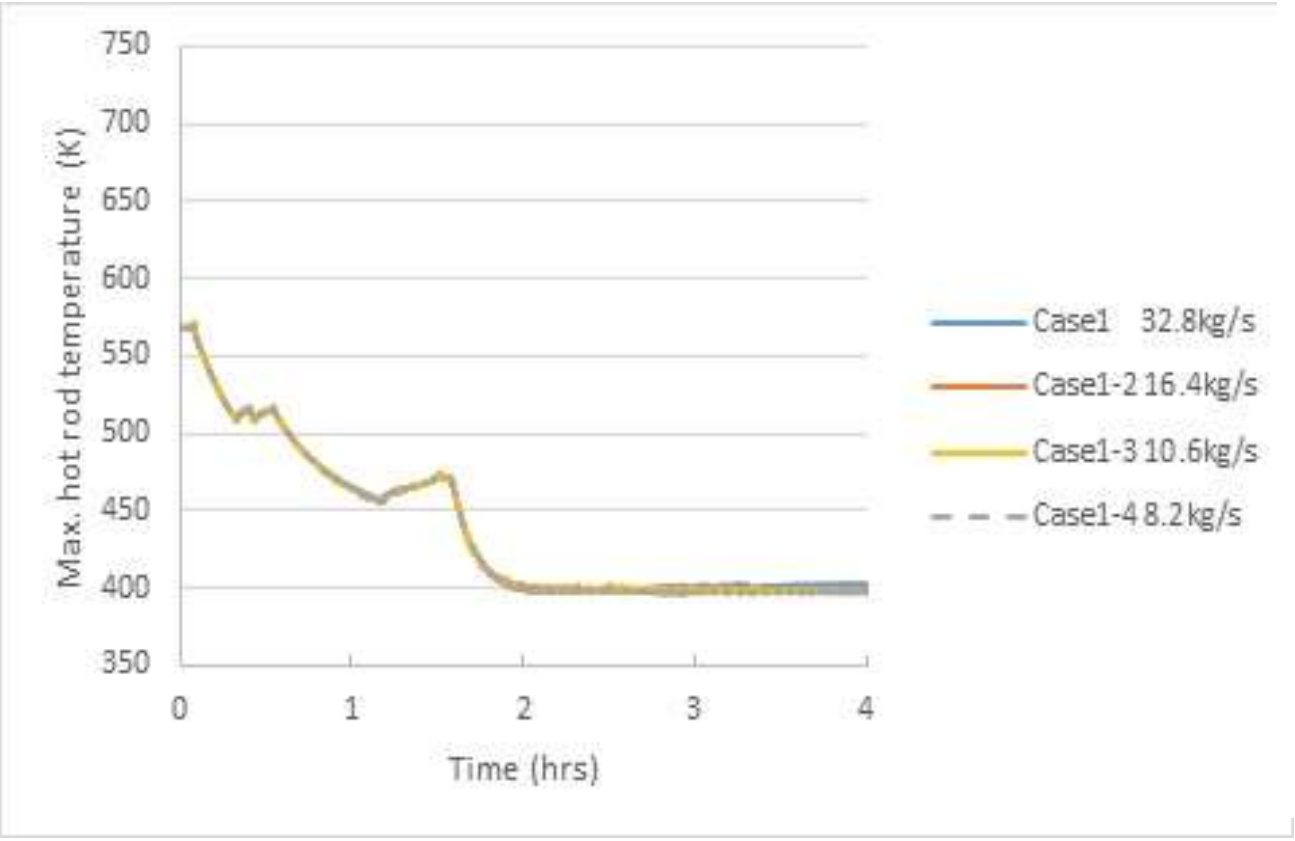
MAAP



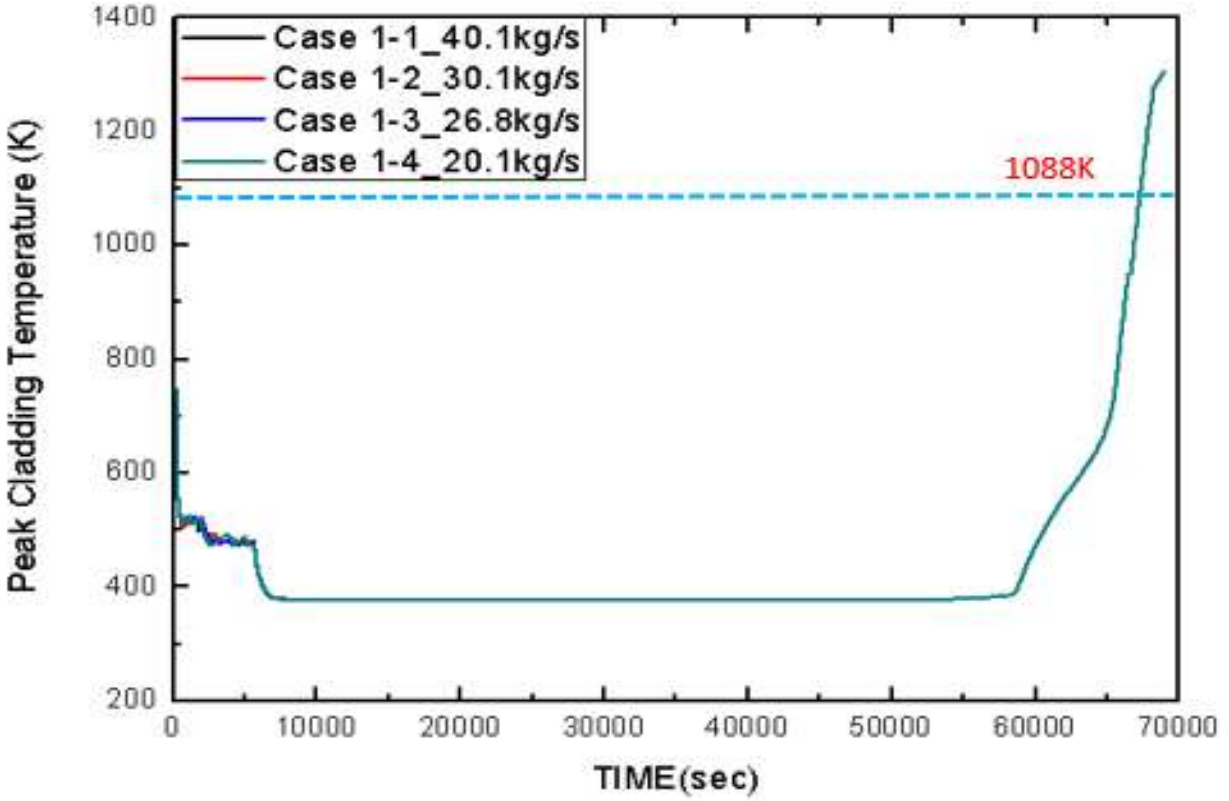
URG案例之分析結果討論

URG程序下所需最小生水量

TRACE



PCTRAN



URG案例之分析結果討論

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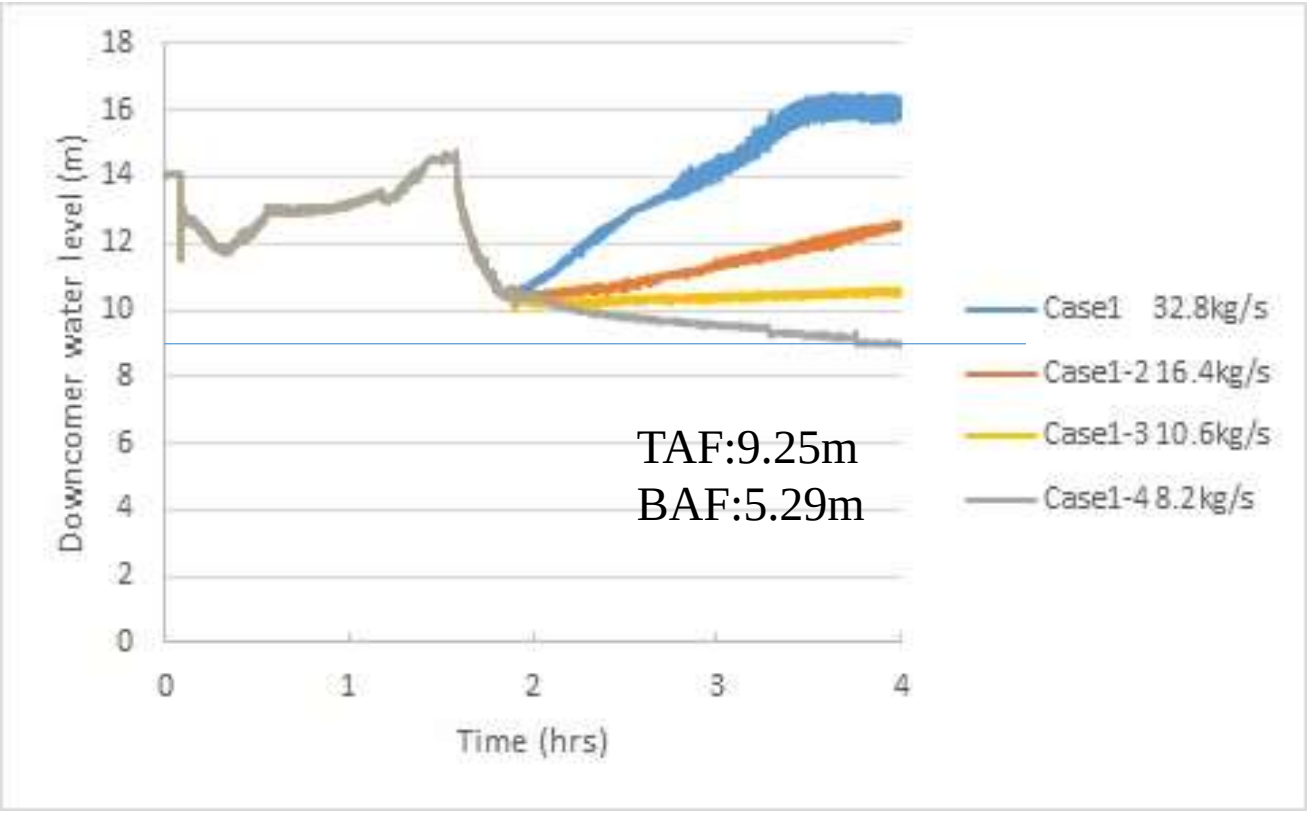

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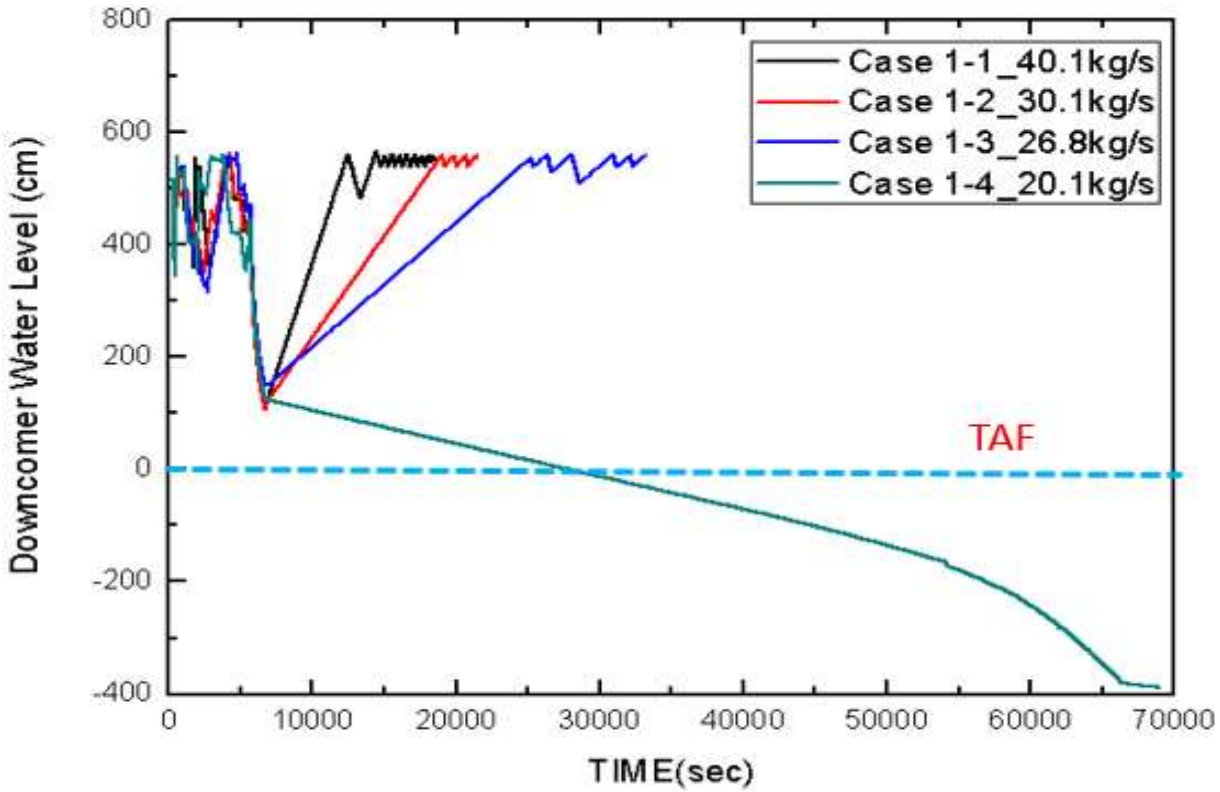
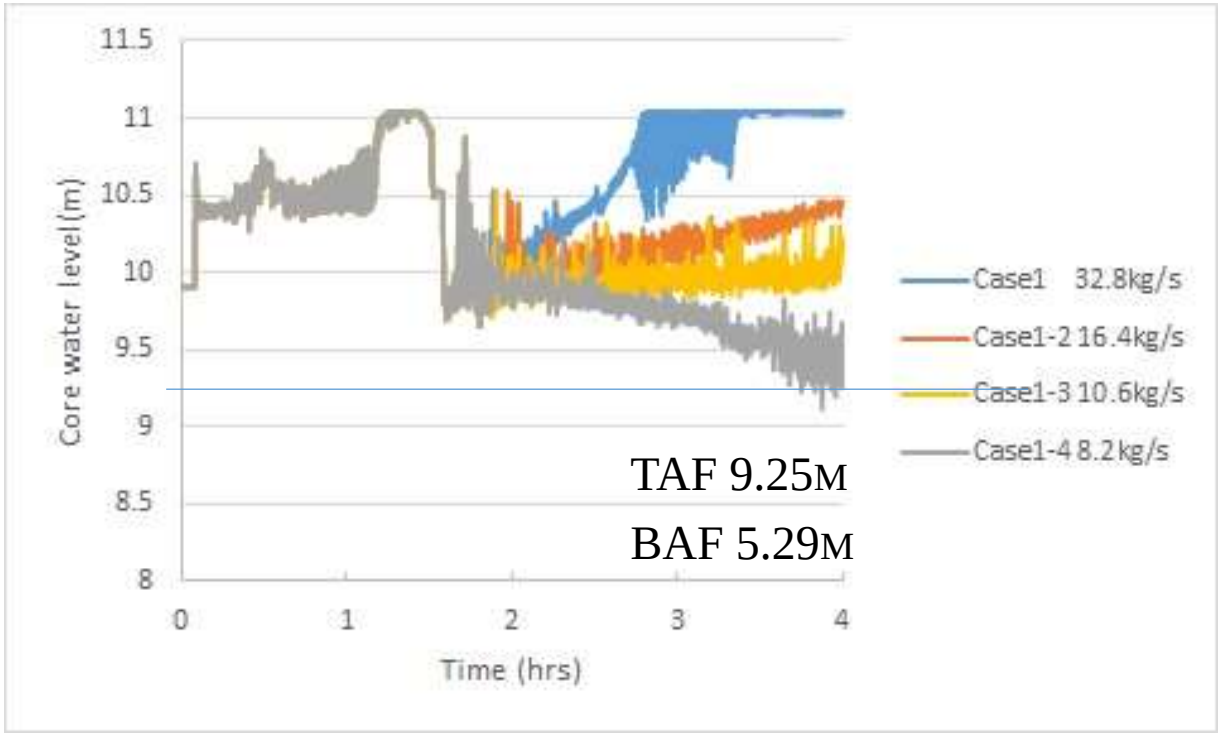


若依據PCTRAN的結果，生水量20.1 kg/s將不足以冷卻衰變熱，造成爐心水位持續下探。
建議生水的最小注入量應為26.8 kg/sec以上

URG案例之分析結果討論

TRACE



若依據TRACE的結果，生水量8.2kg/s將不足以冷卻衰變熱，造成爐心水位持續下探。
生水量10.6kg/s約維持水位為一水平狀態，
但基於安全與保守的考量，建議生水的最小注入量應為16.4 kg/sec以上

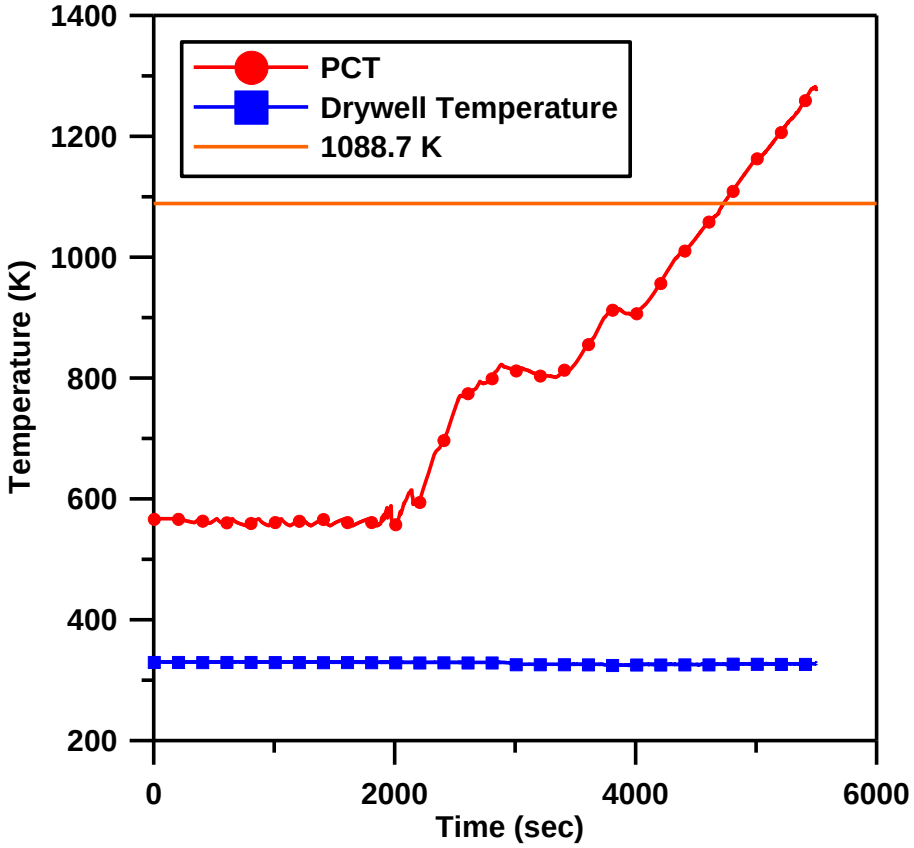
極端案例分析

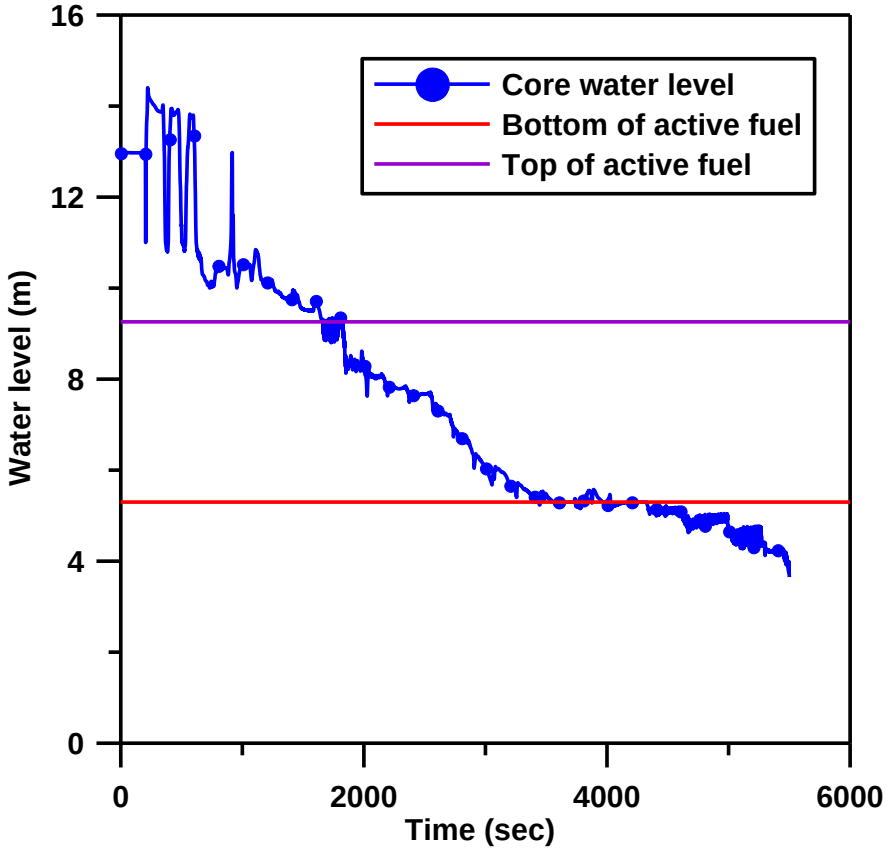
核二廠TRACE SBO+LOCA with FRAPTRAN

Event(sec)	3.2.1	3.2.2	3.2.3
	SBO	SBO+LOCA	SBO+LOCA
Transient start	0	0	0
Reactor Scram	200.1	200.1	200.1
MSIV Close Recirculation pumps trip feedwater flow trip	200.2	200.2	200.2
LOCA (steam line*1)	-	200.2	200.2
Water level →TAF	357	700	369
RCIC stop	-	-	485
Fuel temp >1088K	4730	1900	2200
Raw water injection	-	-	800
Water level →BAF	-	-	-
End of Analysis (water level back to TAF)	5500	2500	3910

核二廠 SBO(no water injected)

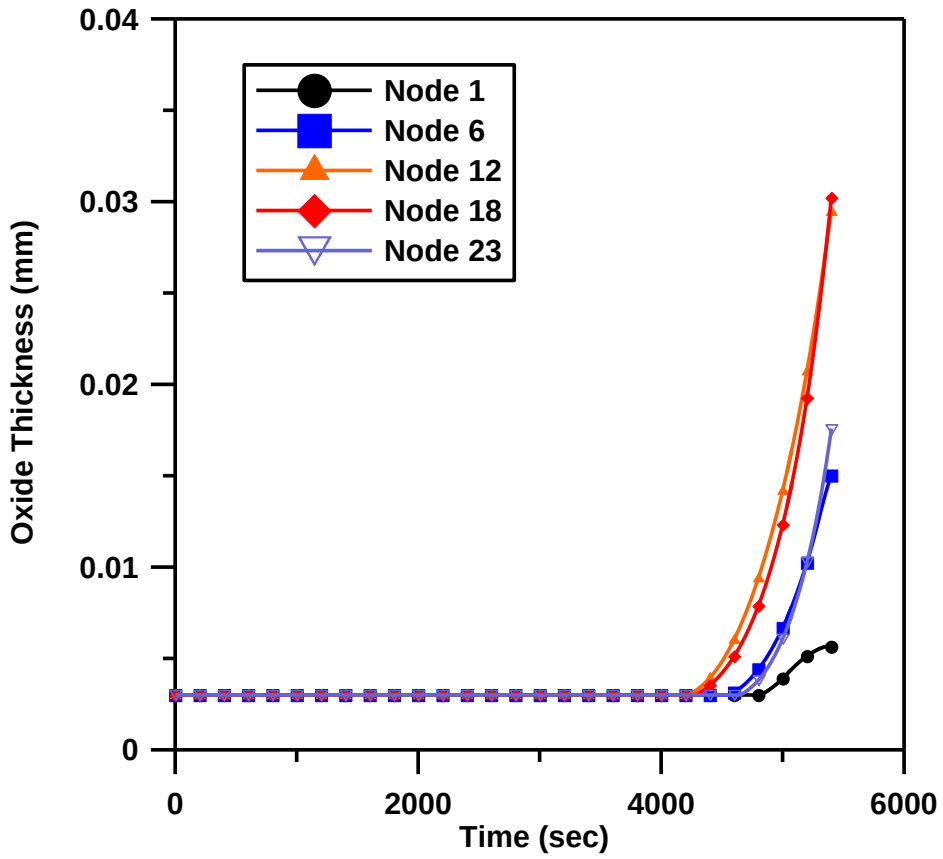
TRACE results



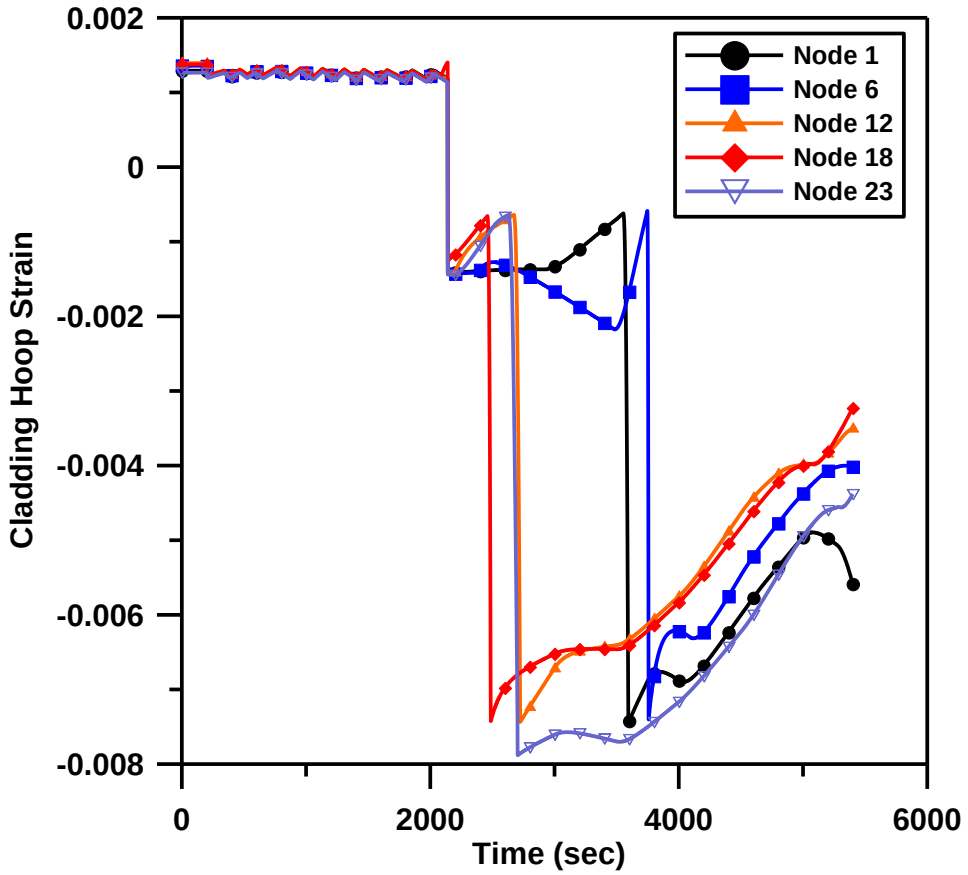


核二廠 SBO(no water injected)

FRAPTRAN results

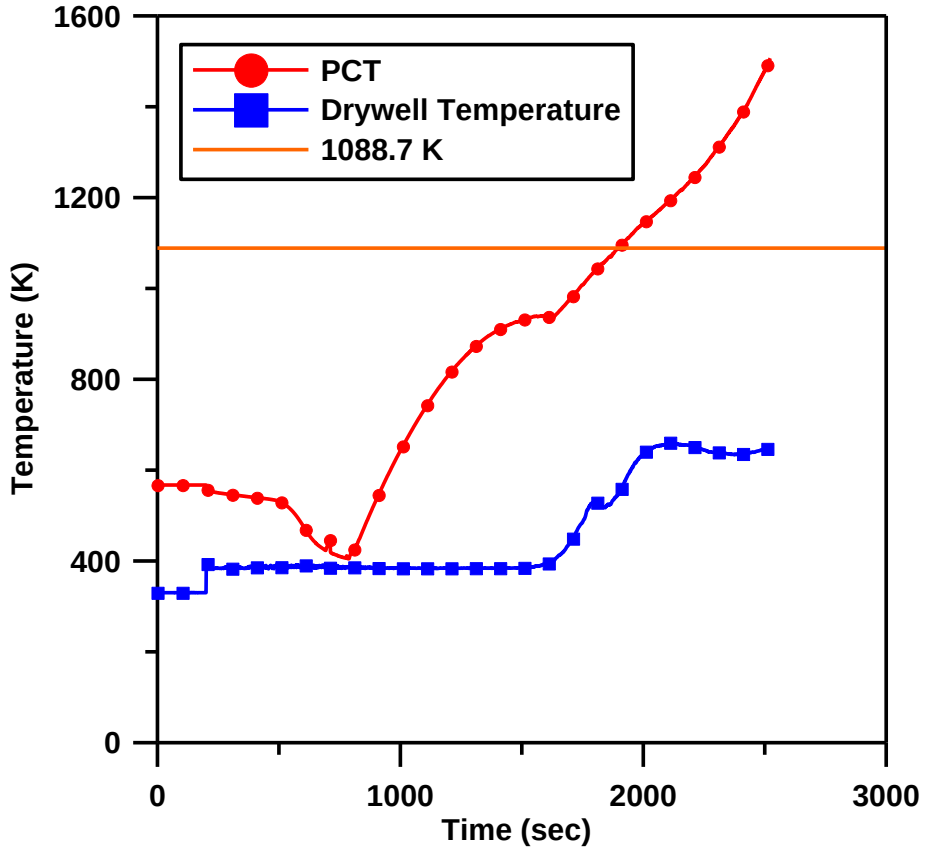


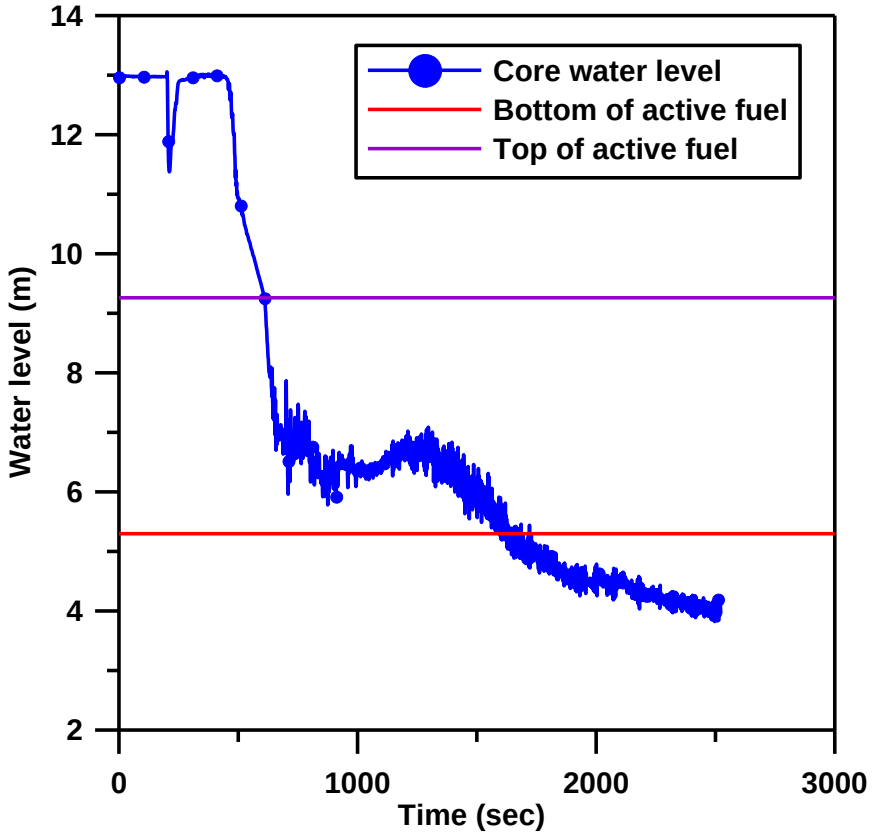
發生鋯水反應



核二廠 SBO+LOCA(no water injected)

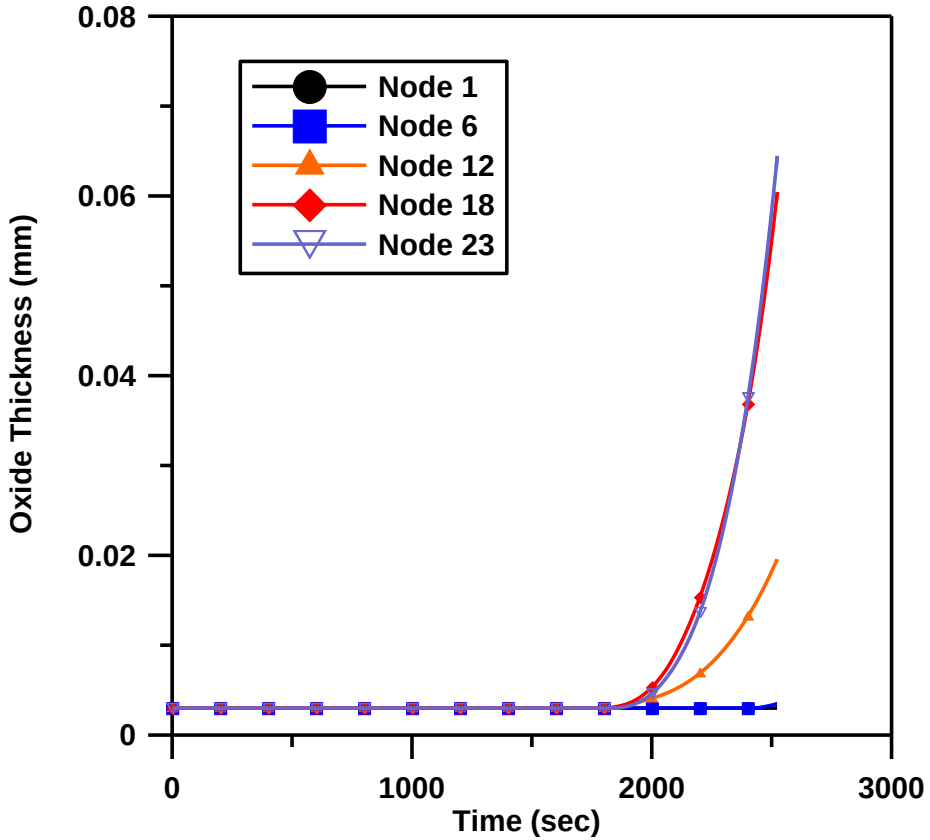
TRACE results



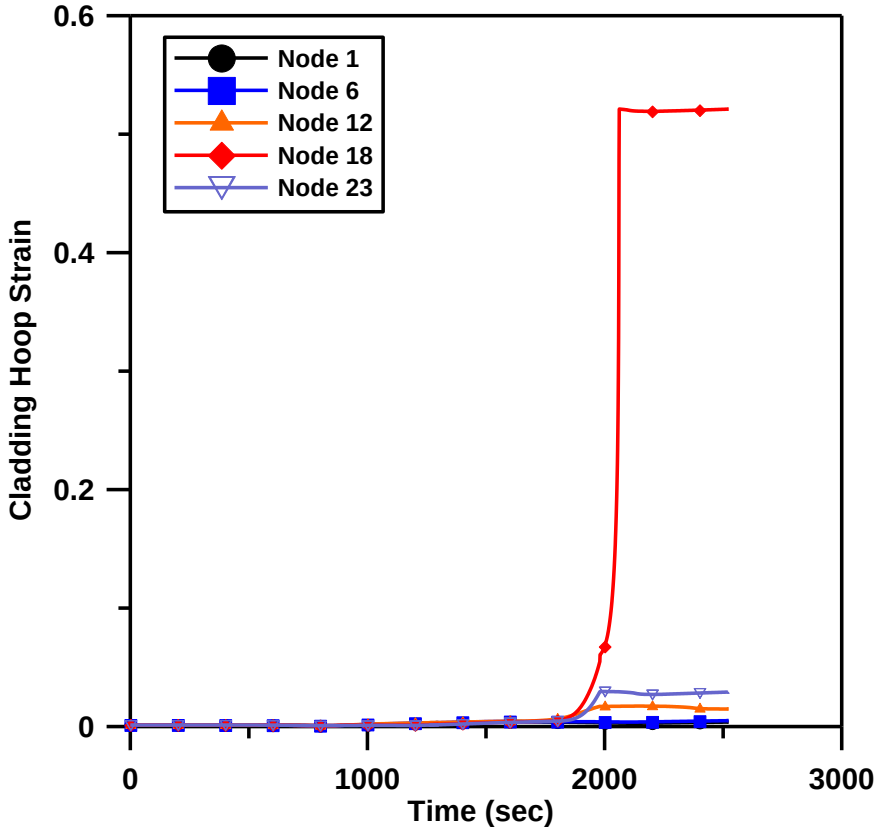


核二廠SBO+LOCA(no water injected)

FRAPTRAN results

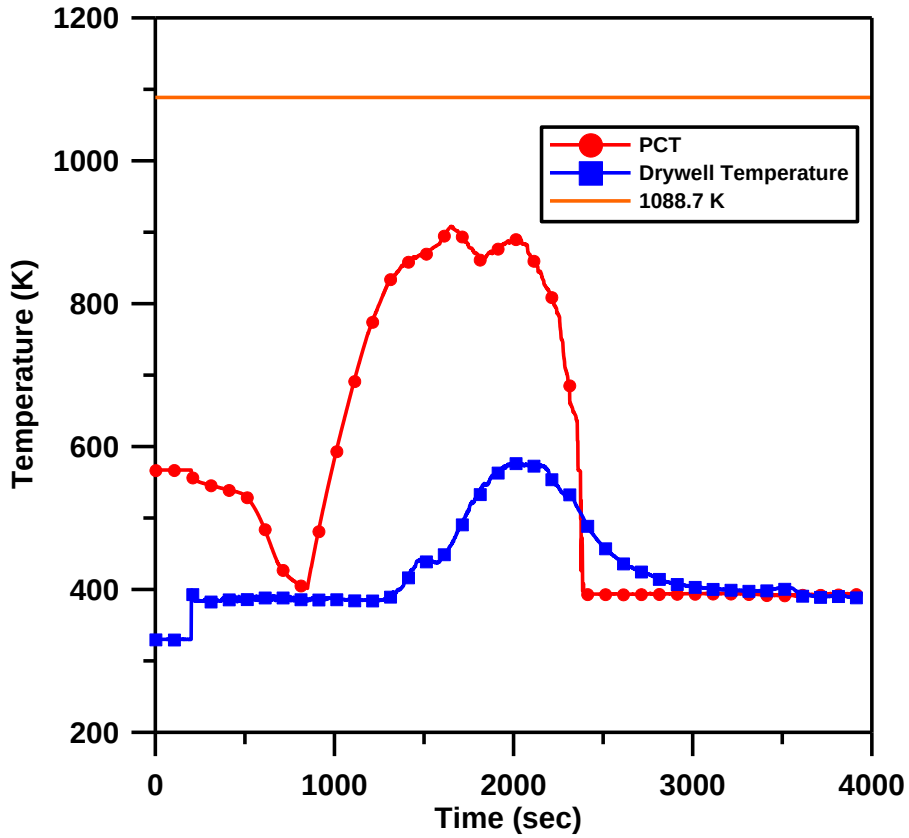


發生鋯水反應，護套於**node 18**破損

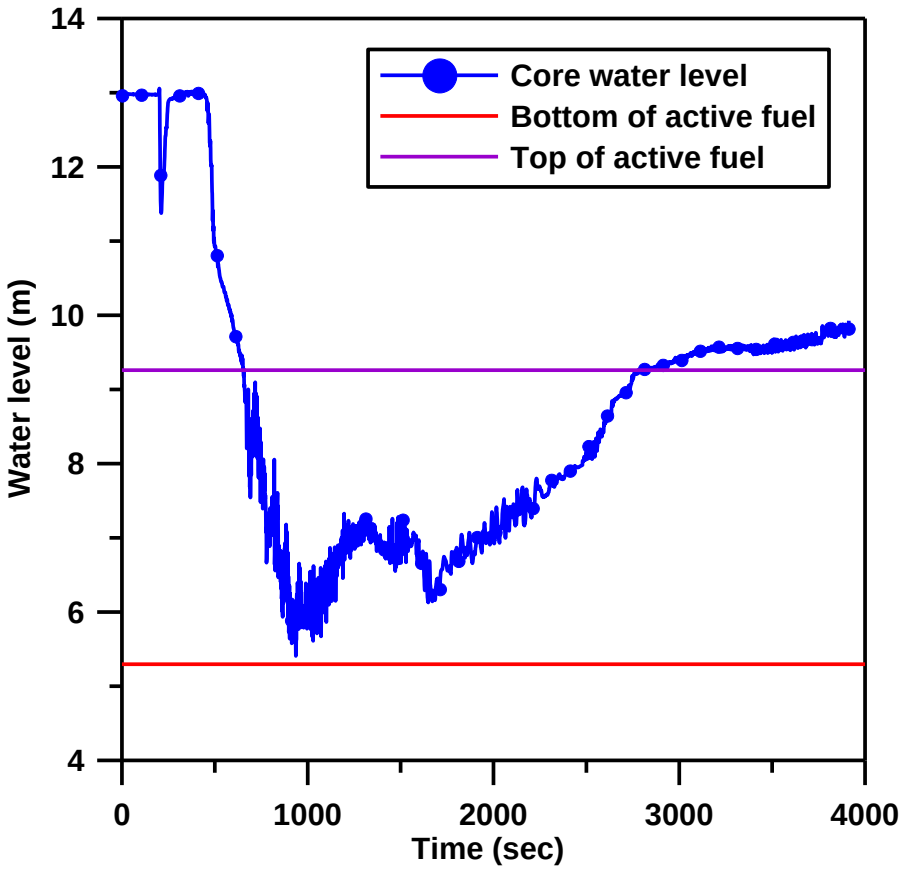


核二廠SBO+LOCA(fire water injected)

TRACE results



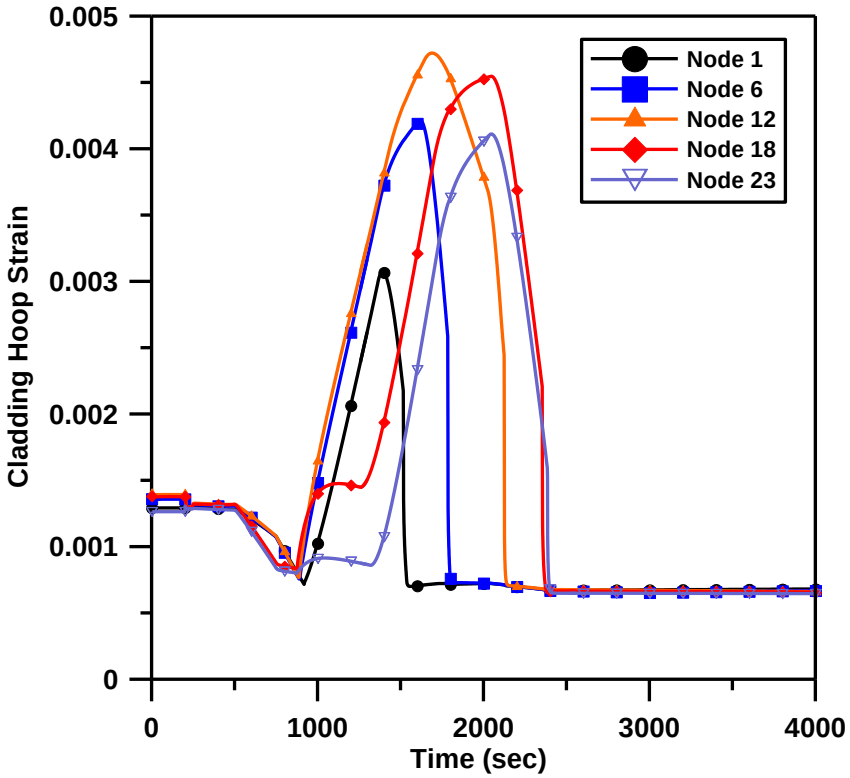
於800sec時注入生水

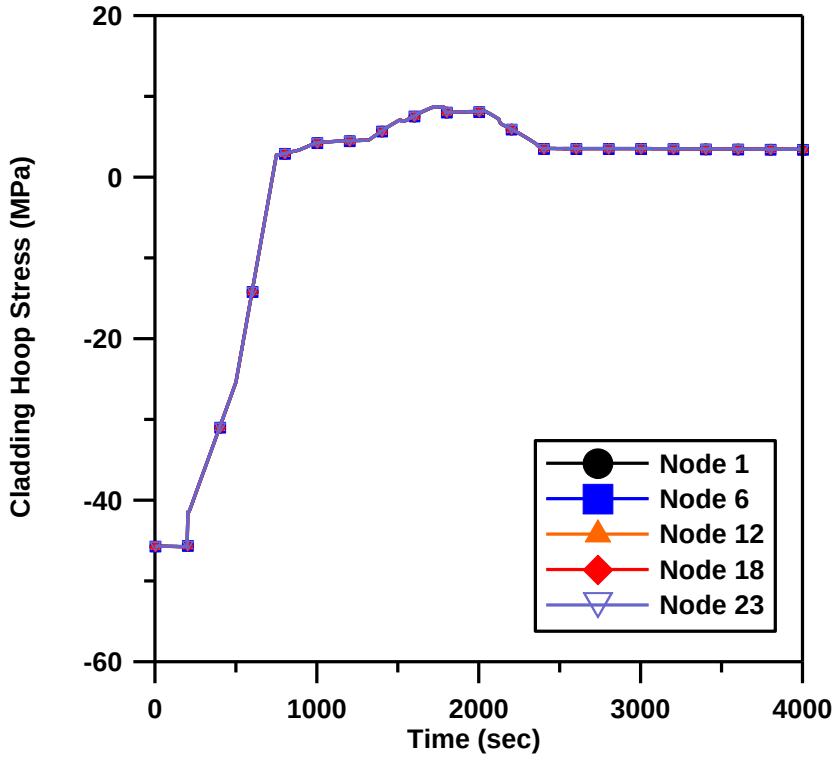


核二廠SBO+LOCA(fire water injected)

FRAPTRAN results

無錯水反應發生





FLEX案例介紹

核二廠TRACE FLEX測試案例規劃：●啟動

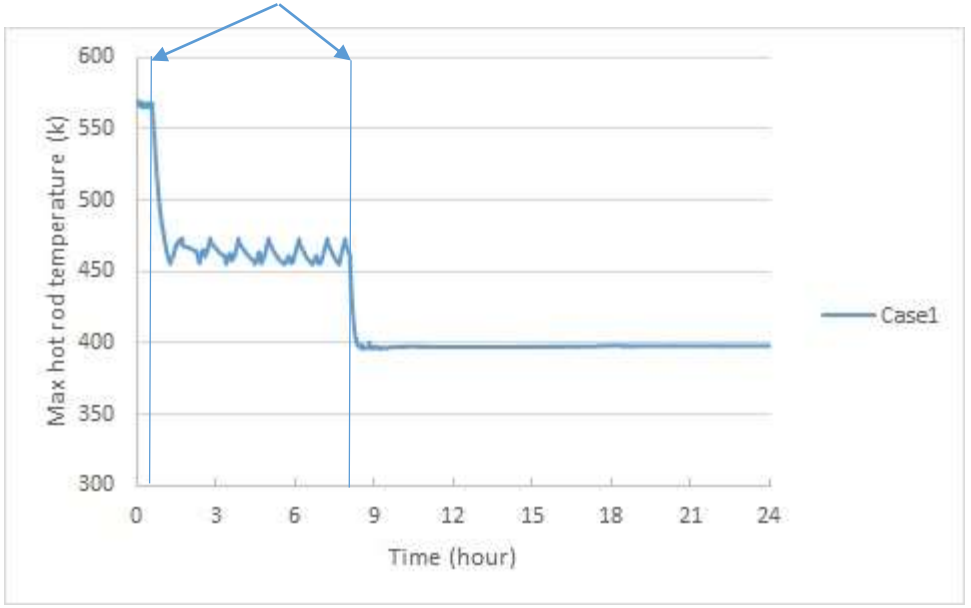
Event/Case	Case1
控制性降低反應爐壓	●
反應爐緊急洩壓	●
注水	●

分析結果: FLEX案例之分析結果討論

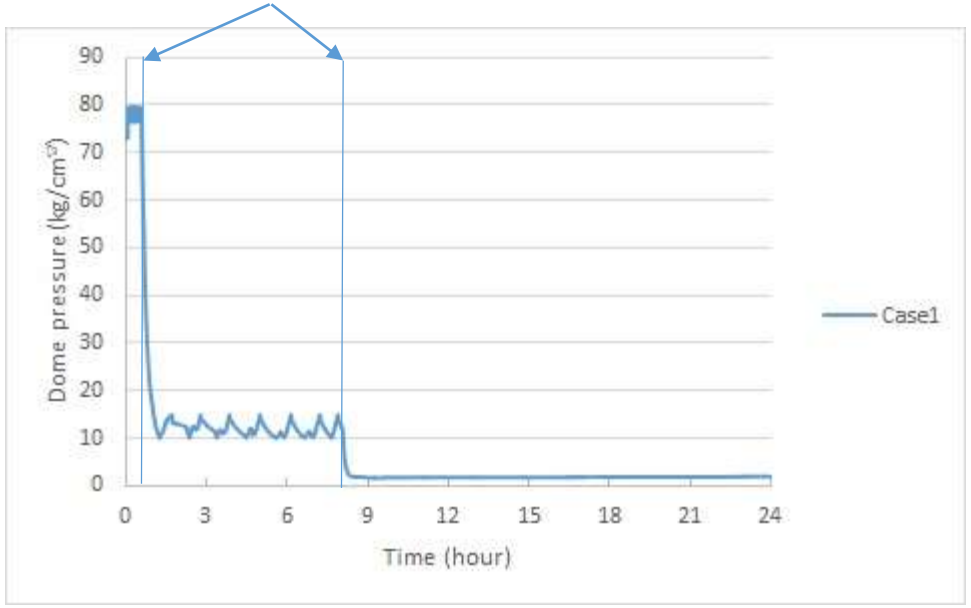
Event	Case1
Start of simulation	0
Reactor Scram, MSIV Closed	300
Loss of Feedwater flow	305
Controlled De-pressure 35kg/cm^2	305
RCIC On	306
SBO	2100
Controlled De-pressure 15kg/cm^2	2100
RCIC Trip	28800
Reactor pressure drop to 3kg/cm^2	29100
Containment vent	29100
Low pressure water injection	29100
Fuel temperature over 1088K	-
Fuel temperature over 1477K	-
End of simulation	86400

FLEX案例之分析結果討論

RCIC運轉

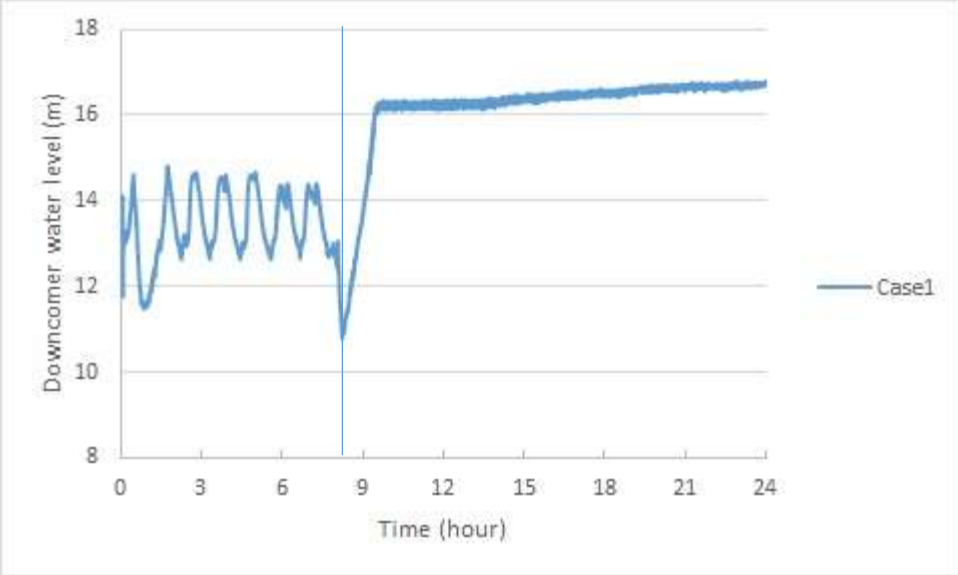


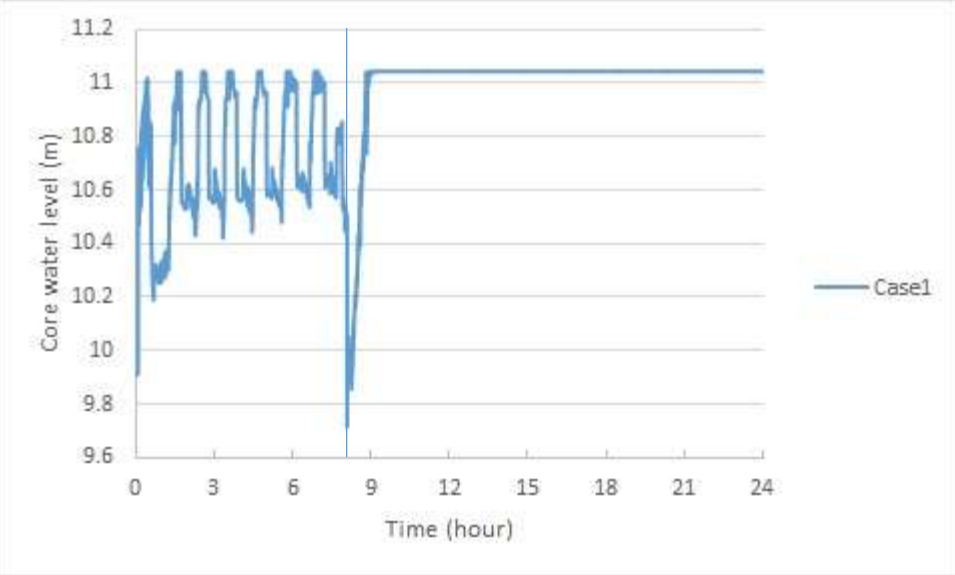
調控SRV開關保持壓力維持RCIC運轉



FLEX案例之分析結果討論

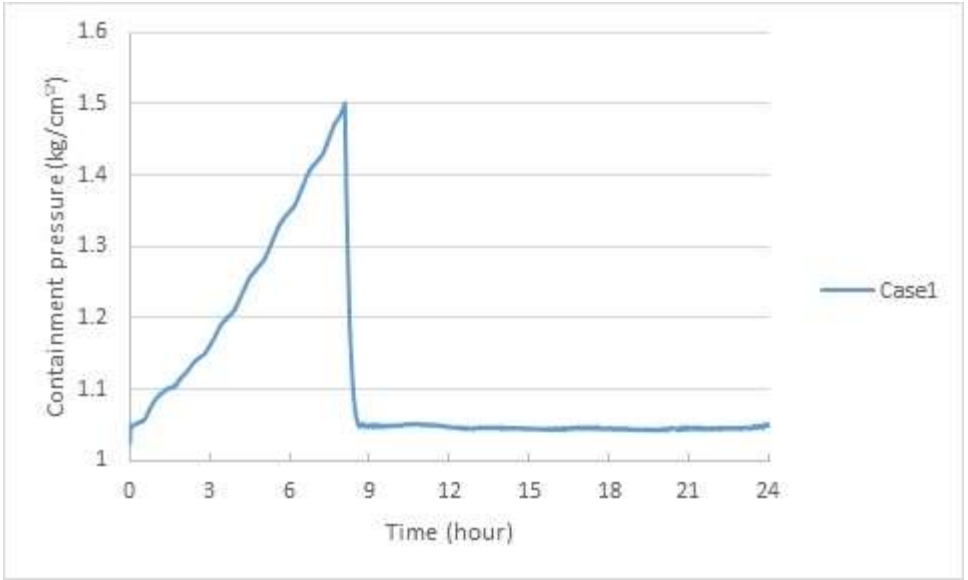
RCIC設定L8高水位時關閉，L2低水位時啟動，運轉8小時後失效，緊急降壓到3kg/cm^2，以可攜式緊急設備進行補水動作。





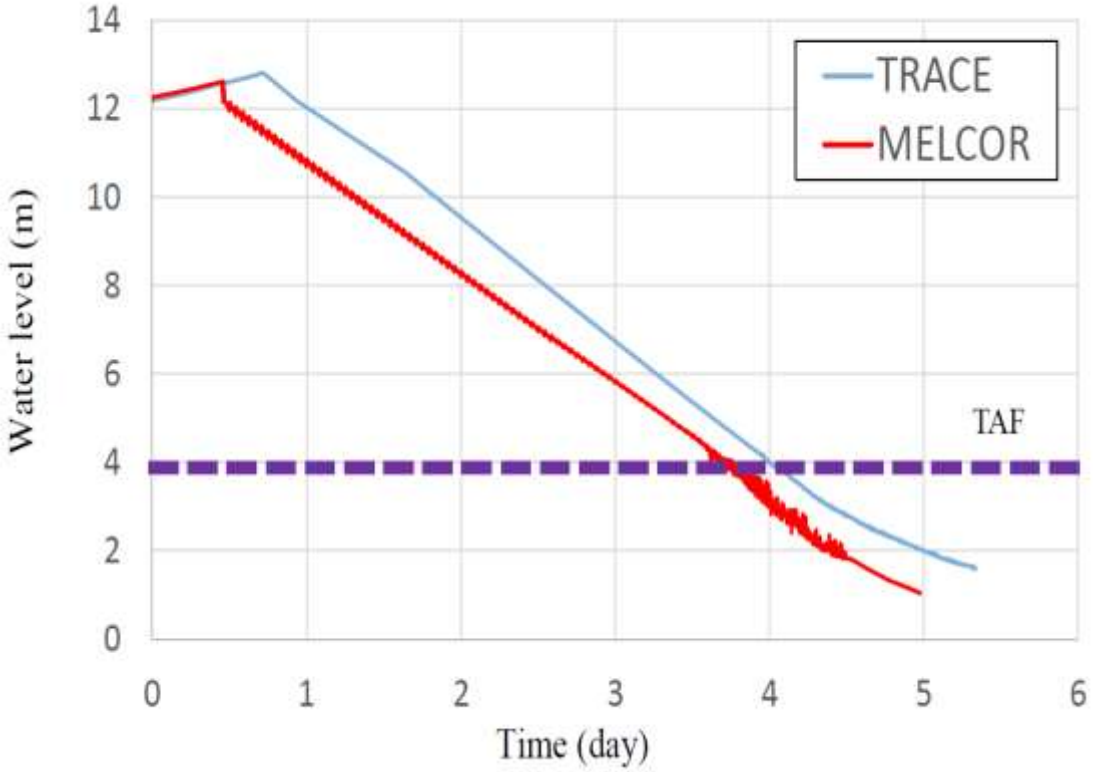
FLEX案例之分析結果討論

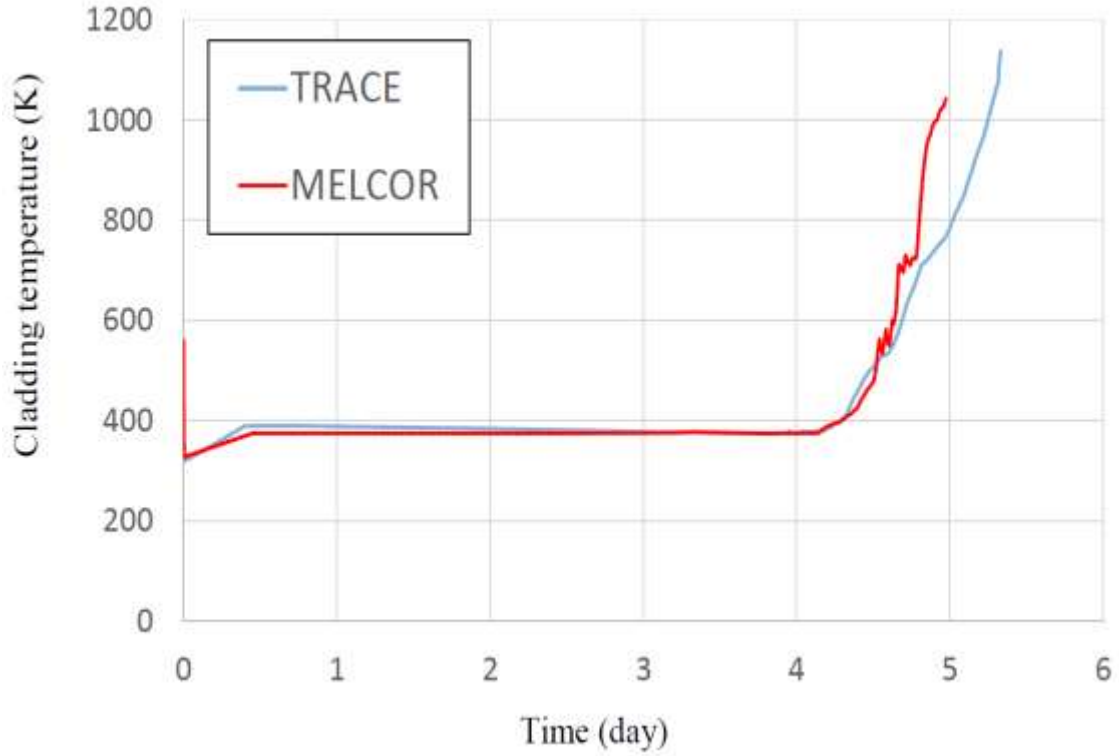
圍阻體壓力最高峰值達到1.5kg/cm^2，執行排氣洩壓後回復到初始值。



核二廠用過燃料池(喪失冷卻系統，無補水案例)

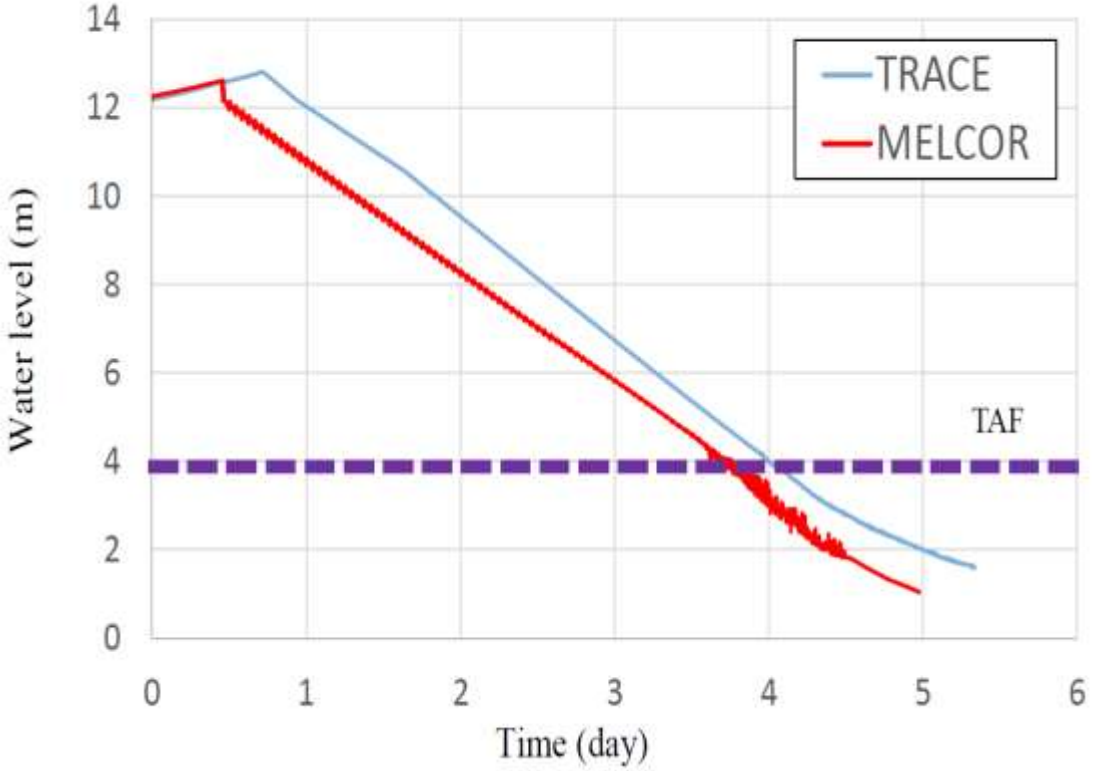
11.16 m × 11 m × 12.19 m; the initial condition was 311 K (water temperature) / 1.013 × 10^5 Pa. The total power of the fuels was roughly 10.26 MWt initially

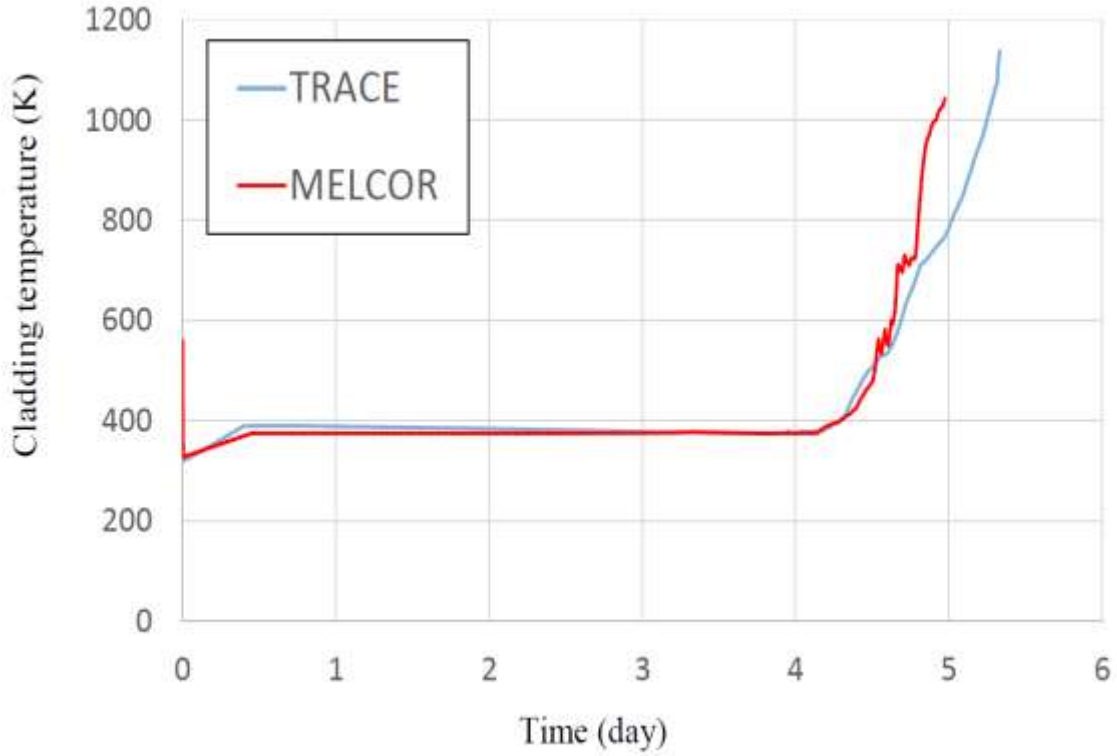




核二廠用過燃料池(喪失冷卻系統，無補水案例)

11.16 m × 11 m × 12.19 m; the initial condition was 311 K (water temperature) / 1.013 × 10^5 Pa. The total power of the fuels was roughly 10.26 MWt initially





Modeling and verification with RELAP5 code for Kuosheng (BWR/6) nuclear power plants

- The Kuosheng power plant, the second nuclear power plant, is located on the northern coast of Taiwan. Its nuclear steam supply system (NSSS) is a type of boiling water reactor (BWR/6) designed and built by General Electric on a twin unit concept.
- Each unit includes two loops of recirculation piping and four main steam lines
- The operating power is 3030 MWt after SPU.

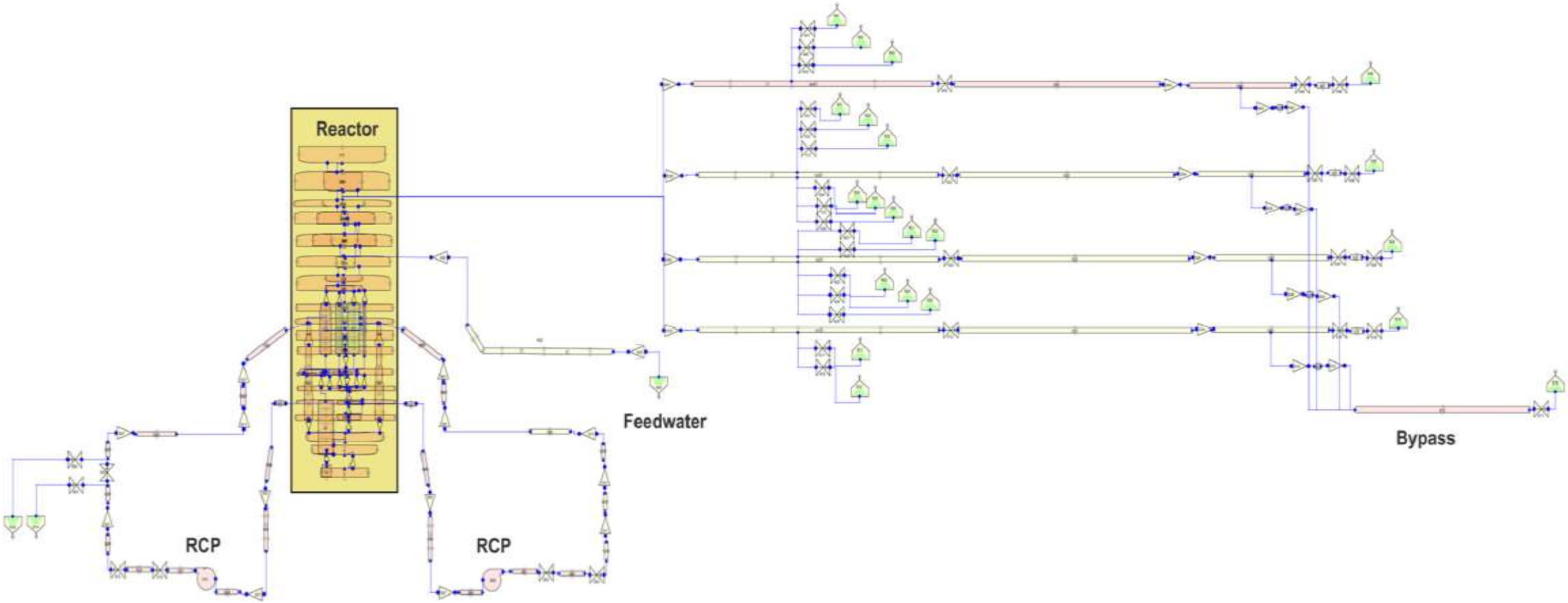
Startup tests cases

- Generator Load Rejection with Bypass (2016, NUREG/IA-0464)
- One Feedwater Pump Trip(2016, NUREG/IA-0464)
- Main steam line isolation valves closure with bypass(2016, NUREG/IA-0464)

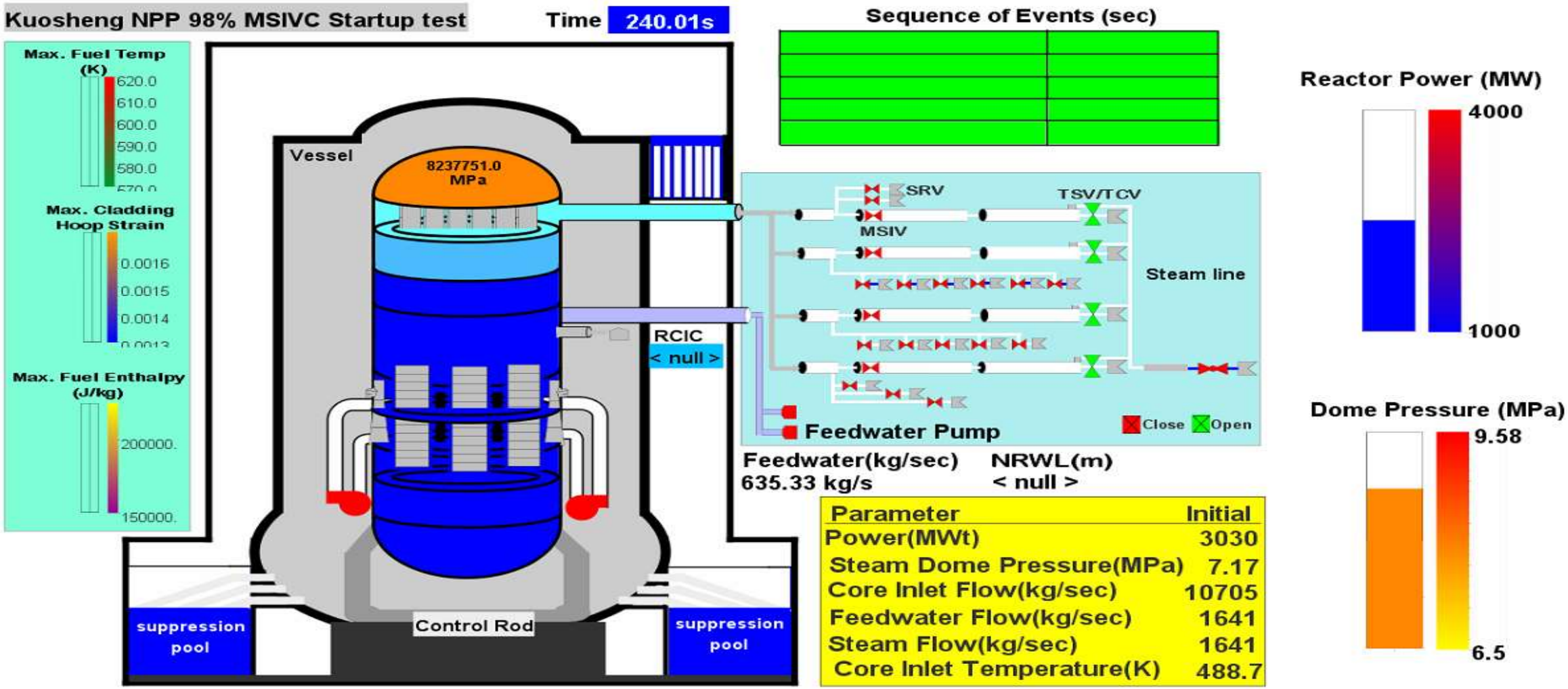
Hypothetical accidents (SPU)

- Main steam line isolation valves closure with bypass failure(2016, NUREG/IA-0464)
- Turbine trip with bypass failure(2016, NUREG/IA-0464)
- Generator Load Rejection with bypass failure(2016, NUREG/IA-0464)

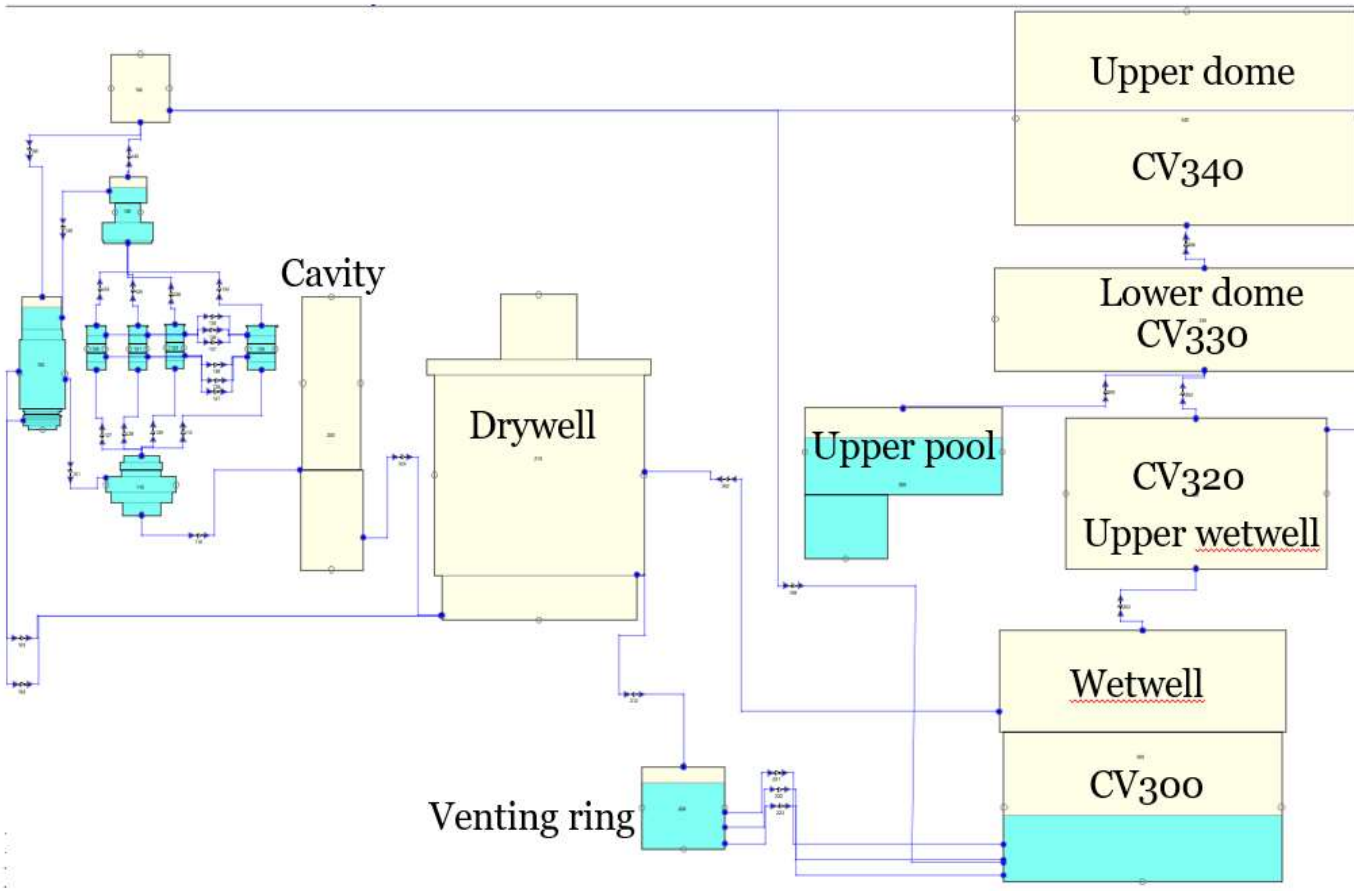
The chart of Kuosheng RELAP5/MOD3.3 model

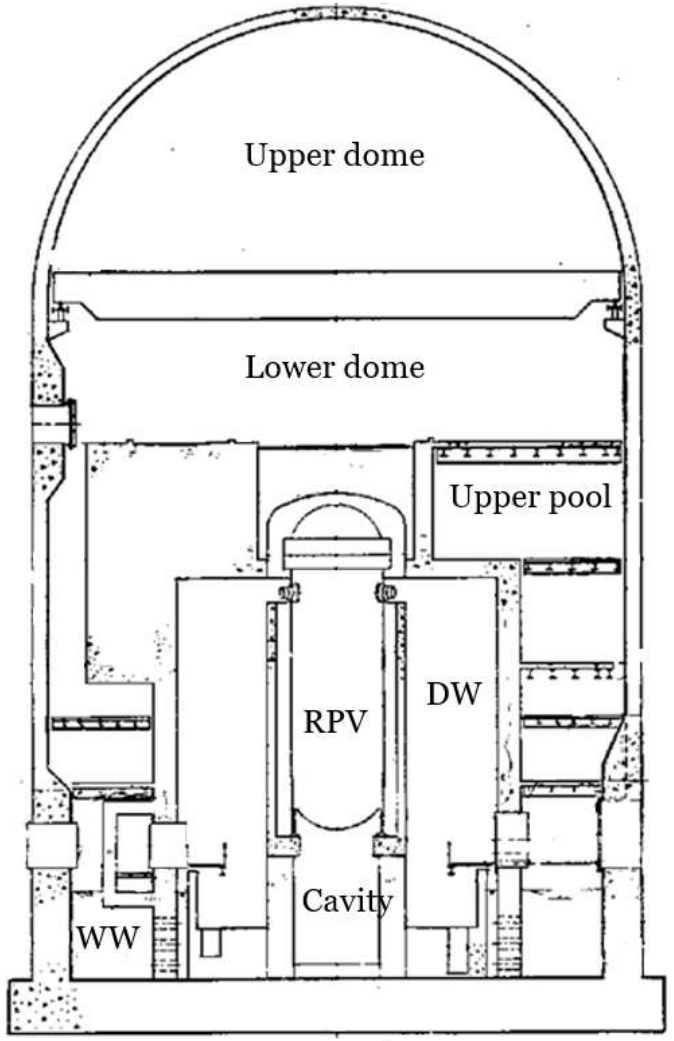


The animation model of RELAP5

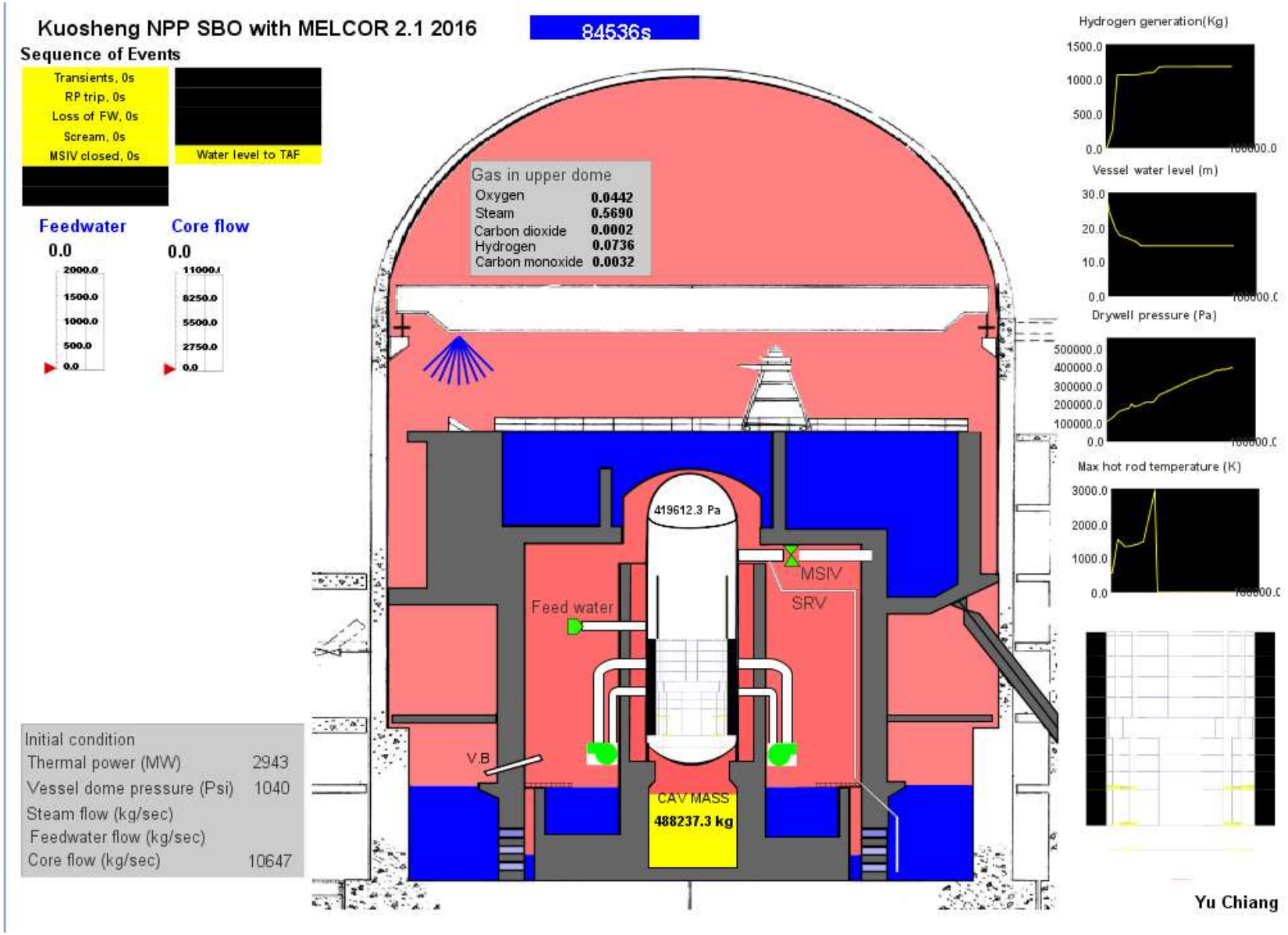


The Kuosheng model of MELCOR2.1/SNAP

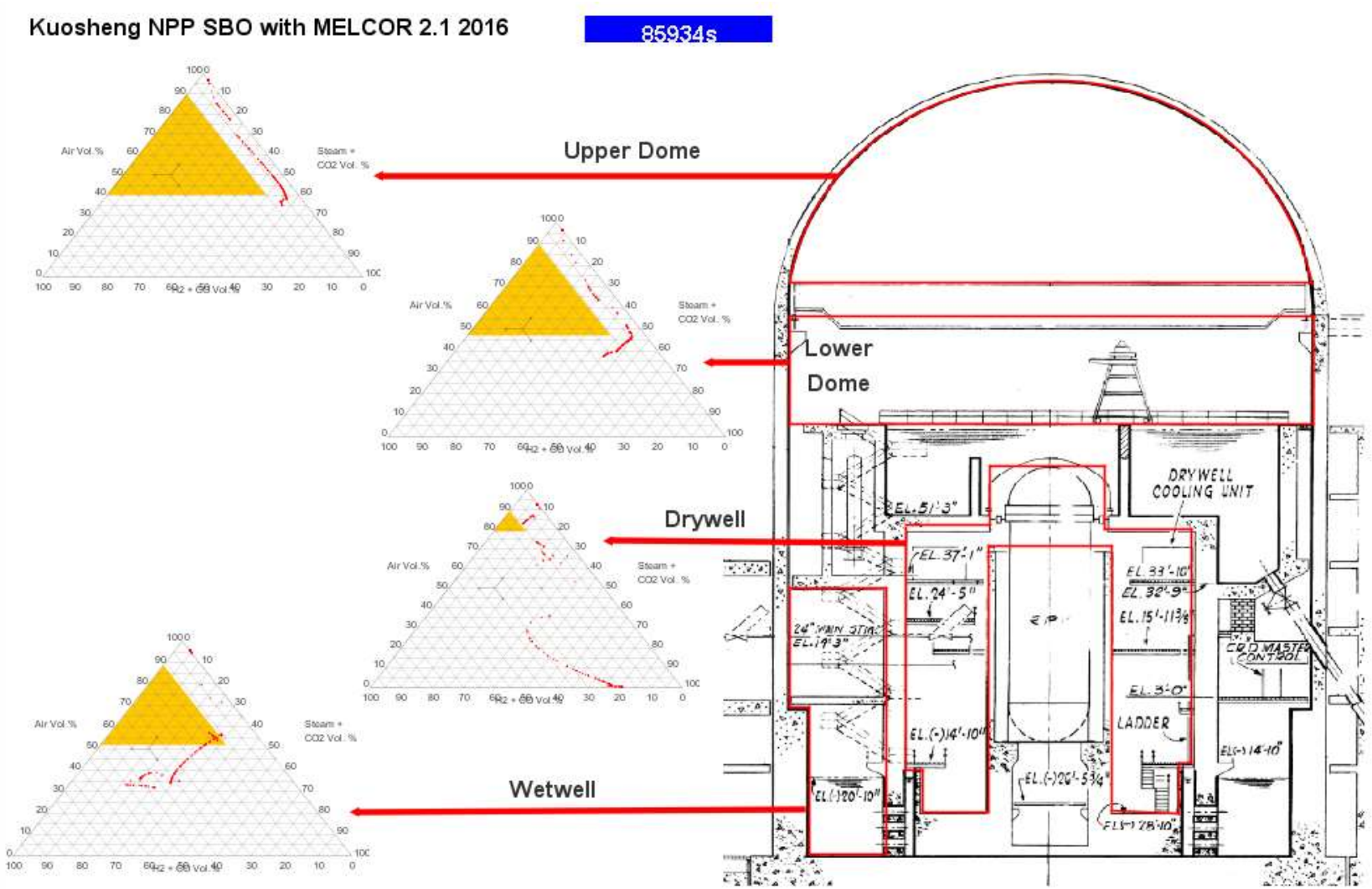




The animation model of MELCOR2.1/SNAP



The animation model of MELCOR2.1/SNAP



Yu Chiang

結論

本研究已成功地建立TRACE、MELCOR、MAAP、PCTRAN、RELAP、FRAPTRAN、FRAPCON等分析模式。為了驗證斷然處置程序及FLEX在類福島事故之條件下的有效性，本研究利用上述模式去模擬斷然處置程序及FLEX。TRACE的分析結果顯示斷然處置程序及FLEX可以有效地確保核二廠的安全，使PCT小於1088.7 K(1500°F)的限值。另外本研究也進行控制降壓、緊急降壓與低壓注水的相關靈敏度分析研究，其分析結論如下:

- 在無補水的案例，有控制降壓與緊急降壓之案例，其PCT上升的速率會大於無降壓之案例。
- 生水的製備應越快完成越好。一旦RCIC不可用時，即可立刻將反應爐降壓，然後注入生水，來確保反應爐的水位。
- 在緊急降壓之前，應先執行控制降壓的步驟。如此在進行緊急降壓時，可減緩水位下降的程度。
- 若依據TRACE的結果，生水的最小注入量應為16.4 kg/sec以上。
- MAAP及PCTRAN的結果與TRACE相似

相關論著

SCI paper

- Hao-Tzu Lin, Shu-Ming Yang, Jong-Rong Wang, Shao-Wen Chen, Chunkuan Shih, The ultimate response guideline simulation and analysis by using TRACE for Lungmen ABWR nuclear power plant, KERNTECHNIK, Vol. 80, pp. 214-231, 2015.
- Hao-Tzu Lin; Jong-Rong Wang; Kai-Chun Huang; Chunkuan Shih; Show-Chyuan Chiang; Chia-Chuan Liu, Station Blackout Mitigation Strategies Analysis for Maanshan PWR Plant Using TRACE, Annals of Nuclear Energy, Vol. 89, pp.1-18, 2016.
- Chun-Yu Chen, Chunkuan Shih, Jong-Rong Wang, “The Alternate Mitigation Strategies on the Extreme Event of the LOCA and the SBO with the TRACE Chinshan BWR4 Model”, Nuclear Engineering and Design, Vol. 256, pp. 332-340, 2013.
- Che-Hao Chen, Jong-Rong Wang, Hao-Tzu Lin, Shao-Wen Chen and Chunkuan Shih, Analysis of SBO ATWS for Maanshan PWR, Kerntechnik, Vol. 80, pp. 431-439, 2015

EI paper

- J. R. Wang, W.Y. Li, H.T. Lin, B.H. Lee,C. Shih, and S.W. Chen, “The Analysis of TRACE/PARCS in the Simulation of Ultimate Response Guideline for Lungmen ABWR”, World Academy of Science, Engineering and Technology, Vol. 85, pp. 58-63, 2014.
- J. R. Wang, H.T. Lin, H. C. Chen, C. Shih, S. W. Chen, S. C. Chiang, C. C. Liu, The Analysis and Simulation of TRACE in the Ultimate Response Guideline for Chinshan BWR/4 Nuclear Power Plant, World Academy of Science, Engineering and Technology, International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering Vol. 9, No:6, pp.703-707, 2015.
- Jong-Rong Wang, Hao-Tzu Lin, Hsiung-Chih Chen and Chunkuan Shih, “The SBO/LOCA Transient Analysis of SNAP/TRACE for Kuosheng Nuclear Power Plant”, World Academy of Science, Engineering and Technology Vol.8, No.7, pp. 361-366, 2014.

會議論文

- J. R. Wang, H. T. Lin, Y.T. Lee, A. L. Ho, S. W. Chen, and C. Shih, The Analysis of TRACE/FRAPTRAN in Ultimate Response Guideline for Lungmen ABWR Nuclear Power Plant, NURETH-16, August 30-September 4, Hyatt Regency Chicago, 2015.
- Che-Hao Chen, Kai-Chun Huang, Shao-Wen Chen, Jong-Rong Wang, Chunkuan Shih, Hao-Tzu Lin, Show-Chyuan Chiang, Chia-Chuan Liu, Assessment of Station Blackout Mitigation Strategy Applying The Ultimate Response Guideline to Maanshan PWR, NURETH-16, August 30-September 4, Hyatt Regency Chicago, 2015.
- Jong-Rong Wang, Yung-Shin Tseng, Wan-Yun Li, Jung-Hua Yang, Hao-Tzu Lin, Hsiung-Chih Chen, Shao-Wen Chen, Chunkuan Shih, Show-Chyuan Chiang, Tzu-Yao Yu, The Ultimate Response Guideline Simulation and Analysis by Using TRACE/FRAPTRAN for Chinshan Nuclear Power Plant, TOP FUEL 2016, SEPTEMBER 11-16, BOISE CENTRE, BOISE, IDAHO, U.S.A., 2016.
- Chunkuan Shih, Jong-Rong Wang, Te-Chuan Wang, Hao-Tzu Lin, Hsiung-Chih Chen, Yu Chiang, Shao-Wen Chen, Show-Chyuan Chiang, Tzu-Yao Yu, Wen-Sheng Hsu, The Establishment and Simulation of TRACE/FRAPTRAN/MELCOR /SNAP Model for Chinshan Nuclear Power Plant Ultimate Response Guideline, PBNC 2016, Beijing, China, Apr. 5-9, 2016.
- Ting-Yi Wang, Yu-Ting Hsu, Jong-Rong Wang, Chun-Kuan Shih, Shao-Wen Chen, Applications of PCTRAN for URG Evaluations Under SBO Conditions in Chinshan BWR/4, ANS Transactions, November 8-12, 2015, Washington, DC, USA, 2015.
- Yu-Tzer Lee, S. W. Chen, J. R. Wang, C. Shih, 2015, “The SBO Analysis with URG Procedure fror Lungmen ABWR using TRACE/FRAPTRAN Codes”, ANS Transactions, Washington, DC. , USA. November 8 - 12, 2015.

- HUANG Chun-Fu, CHANG Ching, YANG Jung- Hua, WANG Jong-Rong, SHIH Chunkuan, CHEN Shao-Wen, “Analysis of a Exercise Script of Ultimate Response Guideline in Maanshan NPP by TRACE Code”, PBNC, Beijing, China, April 5-9, 2016.
- Yu Chiang, Jong-Rong Wang, Ting-Yi Wang, Hao-Tzu Lin, Te-Chuan Wang, Wen-Sheng Hsu, Jyh-Tong Teng, Shao-Wen Chen, Chunkuan Shih, “The Ultimate Response Guideline Simulation and Analysis by using MELCOR2.1/SNAP for Chinshan BWR/4 Nuclear Power Plant”, ICAPP, San Francisco, USA, April 17-20, 2016.
- Chunkuan Shih, Tsong-Sheng Feng, Kai-Chuen Huang, Chin-Cheh Chang, Jong-Rong Wang, 2011, “On RPV Depressurization Strategy and Alternate Water Systems in SBO of Nuclear Power Plants”, ANS Winter Meeting, Washington, DC, USA, Oct. 30 – Nov. 3, 2011.
- C. Y. Chen, C. Shih, R. Y. Lin, J. R. Wang, 2012, “The Extreme Event of the LOCA and Extended SBO with the TRACE Model of Chinshan BWR4 NPP”, ICONE 20 and POWER 2012, Anaheim, CA., USA, July 30 – Aug. 3, 2012.
- Chin-Cheh Chang, Tsung-Sheng Feng, Jong-Rong Wang, Kai-Chun Huang, Chunkuan Shih, 2012, “Analysis of RPV Depressurization and Alternate Water Injection Strategy in SBO of BWR-6 Nuclear Power Plants”, Int. Top. Mtg. on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-9), Kaoshiung, Taiwan, Sept. 9-13, 2012.
- Chun-Yu Chen, Chunkuan Shih, Jong-Rong Wang, Hao-Tzu Lin, 2012, “Sensitivity Studies on Early HPCI Injection and Increased RCUC Flow in the SBLOCA Combined SBO Accident with TRACE Chinshan Mode”, ENC 2012, Manchester, UK, 9-12 Dec., 2012.
- K.C. Huang, J.R. Wang, H.T. Lin, and C. Shih, 2013, “TRACE Simulation of SBO accident and Mitigation Strategy in Maanshan PWR”, CAMP Spring Meeting, Pisa, Italy, May 7-10, 2013.
- J. R. Wang, H. T. Lin, H. C. Chen, W. C. Wang, C. Shih, 2012, “Station Blackout Analysis of Lungmen ABWR Using TRACE”, ICONE 20 and POWER 2012, Anaheim, CA., USA, July 30 – Aug. 3, 2012.
- Y. T. Hsu,J. H. Yang,S. C. Chiang, T. Y. Yu, C. Shih, “ANALYSIS OF ELAP AND MITIGATIONSTRATEGIES IN MAANSHAN PWR WITHPCTRAN,” ANS 2016 winter meeting.
- H.C. Chang,C. Shih,J. R. Wang, S.C. Chiang,T.Y. Yu, “FUEL ROD THERMO-MECHANIC ANALYSIS OFKUOSHENG NPP IN MSIVC TRANSIENT WITHRELAP5 MOD3.3/FRAPTRAN/PYTHON CODEIN SNAP INTERFACE,” ,” ANS 2016 winter meeting.

- Wen-Jie Chang, Chunkuan Shih, Jong-Rong Wang, Hao-Tzu Lin, 2012, “TRACE Analysis of Station Blackout Transient in Chinshan BWR/4”, Int. Top. Mtg. on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-9), Kaoshiung, Taiwan, Sept. 9-13, 2012.
- Wen-Hsiung Wu, Jong-Rong Wang, Chunkuan Shih, 2012, “Station Blackout Analysis for Lungmen ABWR with RETRAN Assessment”, Int. Top. Mtg. on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-9), Kaoshiung, Taiwan, Sept. 9-13, 2012.
- Kai-Chun Huang, Jong-Rong Wang, Hao-Tzu Lin, Chunkuan Shih, 2013, “TRACE Code Analysis for Station Blackout Mitigation Strategy in PWR Nuclear Power Station”, The 15th Int. Top. Mtg. on Nuc. Thermal-Hydraulics, NURETH-15, Pisa, Italy, May 12-17, 2013.
- Che-Hao Chen, Jong-Rong Wang, Hao-Tzu Lin, and Chunkuan Shih, “Pressure Estimation of SBO ATWS for Maanshan PWR”, ICAPP 2015, May 3 – 6, 2015, Nice, France.
- Yu Chiang, Jong-Rong Wang, Hao-Tzu Lin, Shao-Wen Chen and Chunkuan Shih, Methodology Using MELCOR2.1/SNAP to Establish An SBO Model Of Chinshan BWR/4 Nuclear Power Plant, NURETH-16, August 30-September 4, 2015, Hyatt Regency Chicago, 2015.
- 王仲容、林浩慈、陳雄智、陳紹文、施純寬, 核一廠之TRACE斷然處置措施的模擬與分析, 中國機械工程學會第三十二屆全國學術研討會, 2015.
- 王仲容、林浩慈、陳雄智、陳紹文、施純寬, 核一廠用過燃料池之TRACE/FRAPTRAN/SNAP模式建立, 中國機械工程學會第三十二屆全國學術研討會, 2015.
- 陳雄智、王仲容、楊融華、施純寬, MAAP程式進行核三廠斷然處置程序分析評估, 中國機械工程學會第三十二屆全國學術研討會, 2015.
- 張靖、陳紹文、楊融華、王仲容、施純寬、林唯耕, 核三廠假設性冷卻水流失事故之TRACE圍阻體模式分析, 中國機械工程學會第三十二屆全國學術研討會, 2015.
- 黃俊富、陳紹文、楊融華、王仲容、施純寬, TRACE模擬馬鞍山電廠核安三號演習劇本及斷然處置之分析, 中國機械工程學會第三十二屆全國學術研討會, 2015.
- 王亭懿、徐鈺婷、陳雄智、王仲容、陳紹文、施純寬, 應用金山電廠PCTRAN模式進行斷然處置措施有效性分析, 中國機械工程學會第三十二屆全國學術研討會, 2015.

- Yu Chiang, Jong-Rong Wang, Te-Chuan Wang, Wen-Sheng Hsu, Jyh-Tong Teng, Shao-Wen Chen and Chunkuan Shih, “MELCOR2.1/SNAP Analysis of Fukushima-Like Accident for Chinshan BWR/4 NPP”, in NUTHOS-11. 2016: Korea.
- Yu Chiang, Jong-Rong Wang, Ai-Ling Ho, Wen-Sheng Hsu, Jyh-Tong Teng, Shao-Wen Chen and Chunkuan Shih, “MELCOR Analysis on Hydrogen Behaviors of Chinshan NPP Spent Fuel Pool”, in PSAM-13. 2016: Korea.
- Yu Chiang, Jong-Rong Wang, Ai-Ling Ho, Wen-Sheng Hsu, Jyh-Tong Teng, Jing Chang and Shao-Wen Chen and Chunkuan Shih, “Extended Loss of AC Power (ELAP) Analysis of Kuosheng BWR/6 Using MELCOR2.1/SNAP”, in PSAM-13. 2016: Korea.
- Wen-Hsiung Wu,Lih-Yih Liao, Jong-Rong Wang, Chunkuan Shih, Shao-Wen Chen, “Temperature and Pressure Analysis of LOCAfor Kuosheng MARK III Containment UsingTRACE/CONTAN,” in NUTHOS-11. 2016: Korea.
- Jung-Hua Yang, Shao-Wen Chen, Ailing Ho,Jong-Rong Wang, Chunkuan Shih, “Establishment of TRACE containment modeland Maanshan ELAP analysis,” in NUTHOS-11. 2016: Korea.
- Wan-Yun Li,Jong Rong Wang, Yung-Shin Tseng, Wan-June Chiu, Hao-Tzu Lin,Jung-Hua Yang, Shao-Wen Chen, Chunkuan Shih, “THE FUEL INTEGRITY ANALYSIS OF TRANSFERPROCESSES FOR CHINSHAN DRY-STORAGESYSTEM BY FRAPTRAN/CFD,” Light Water Reactor (LWR) Fuel Performance Meeting.
- Jong-Rong Wang, Yung-Shin Tseng, Wan-Yun Li, Hao-Tzu Lin, Hsiung-Chih Chen, Shao-Wen Chen, Chunkuan Shih, Show-Chyuan Chiang, Tzu-Yao Yu,” The Ultimate Response Guideline Simulation and Analysis by Using TRACE/FRAPTRAN for Chinshan Nuclear Power Plant,” Light Water Reactor (LWR) Fuel Performance Meeting.
- C. Shih, J. R. Wang, H. C. Chang, S. W. Chen, S. C. Chiang, T. Y. Yu,” The Establishment of RELAP5/SNAP Model forKuosheng Nuclear Power Plant,” WASET, London, 2016.

NUREG report

- Jong-Rong Wang, Kai-Chun Huang, Hao-Tzu Lin, Chunkuan Shih, TRACE Simulation of SBO Accident and Mitigation Strategy in Maanshan PWR, NUREG/IA-0430, 2013.
- Jong-Rong Wang, Chun-Yu Chen, Hao-Tzu Lin, Chunkuan Shih, The Alternate Mitigation Strategies Study of Chinshan BWR/4 by Using the LOCA and SBO Analysis of TRACE, NUREG/IA-0440, 2014.
- Chunkuan Shih, Jong-Rong Wang, Hao-Tzu Lin, Yu Chiang, The Establishment and Assessment of Kuosheng (BWR/6) NPP Dry-storage System TRACE/SNAP Model, NUREG/IA-0451, 2015.
- Chunkuan Shih, Jong-Rong Wang, Hao-Tzu Lin, Hui-Chen Wang, Show-Chyuan Chiang, Chia-Chuan Liu, Spent Fuel Pool Safety Analysis of TRACE in Chinshan NPP, NUREG/IA-0452, 2015.
- Chunkuan Shih, Ai-Ling Ho, Jong-Rong Wang, Hao-Tzu Lin, Show-Chyuan Chiang, Chia-Chuan Liu, Analysis of the control rod drop Accident (CRDA) for Lungmen ABWR, NUREG/IA-0455, 2015.
- Chunkuan Shih, Jung-Hua Yang, Jong-Rong Wang, Hao-Tzu Lin, Show-Chyuan Chiang, Chia-Chuan Liu, BEPU Analysis and Benchmark with IIST 2% SBLOCA Experiment Using TRACE/DAKOTA, NUREG/IA-0456, 2015.
- Chunkuan Shih, Hao-Chun Chang, Jong-Rong Wang, Shao-Wen Chen, Hao-Tzu Lin, Show-Chyuan Chiang, Tzu-Yao Yu, Fuel Rod Properties and Uncertainty Analysis during Overpressurizarion Transient for Kuosheng Nuclear Power Plant with TRACE/FRAPTRAN/DAKOTA codes in SNAP interface, NUREG/IA-0465, 2016.
- Chunkuan Shih, Hao-Chun Chang, Jong-Rong Wang, Shao-Wen Chen, Hao-Tzu Lin, Show-Chyuan Chiang, Tzu-Yao Yu, RELAP5/MOD3.3 Model Assessment and Hypothetical Accident Analysis of Kuosheng Nuclear Power Plant with SNAP Interface, NUREG/IA-0464, 2016.
- Chunkuan Shih, Jung-Hua Yang, Jong-Rong Wang, Shao-Wen Chen, Show-Chyuan Chiang*, Tzu-Yao Yu, Fuel Rod Behavior and Uncertainty Analysis by FRAPTRAN/TRACE/DAKOTA Code in Maanshan LBLOCA, NUREG/IA-0471, 2016.

CSARP meeting

- Applications of MELCOR2.1/SNAP for Chinshan BWR/4 Spent Fuel Pool Safety Analysis, Washington DC, 2014.
- Overview of Severe Accident Research Activities in Taiwan, Albuquerque, 2015.
- The Ultimate Response Guideline simulation and analysis by using MELCOR2.1 for Chinshan BWR/4 nuclear power plant, Albuquerque, 2015.
- MELCOR/GOTHIC/FLACS Analysis on Hydrogen Behaviors of Chinshan NPP MK-I Containment, Washington DC, 2016.

CAMP meeting

- Status of CAMP Activities in Taiwan(自2014年後, URG模式建立)