

出國報告（出國類別：其他）

「赴加拿大參加第 19 屆太平洋盆地核
能會議(PBNC 2014)暨參訪 Pulse Energy
公司」出國報告

服務機關：核能研究所

姓名職稱：徐獻星 研究員

洪勁宇 助理工程師

派赴國家：加拿大

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摘 要

第 19 屆太平洋盆地核能會議(Pacific Basin Nuclear Conference, PBNC)為 2 年一度的國際核能會議，本屆會議於加拿大溫哥華舉行，主題為「履行 21 世紀太平洋盆地區域核能技術之承諾」，共計有來自 20 多個環太平洋地區國家、三百餘篇的論文發表。核研所核儀組組長徐獻星博士及助理工程師洪勁宇此次出國除參加 PBNC 會議並參加大會安排之技術參訪行程外，亦順道受邀前往 Pulse Energy 公司進行技術討論，有助於了解國際上核能產業相關技術之發展，並拓展國際合作機會。

此次 PBNC 會議包含 10 個不同的技術議題，例如在「強化核能安全」議題上，可採用易損性分析的方式將隨機性及不確定性納入地震易損性計算中，以計算磚牆的耐震能力；或是在「運轉改善及維護」議題中，藉由線上監視與進階圖樣辨識工具來偵測設備異常，取代傳統儀器校正的方式等，涵蓋層面甚廣。故建議持續派員參與 PBNC 會議，蒐集論文與現場相關之資料，作為後續研究參考與借鏡，並可於會議上發表論文，提升我國於國際間之能見度。本報告將分段敘述此行之過程、心得與建議。

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一、目的

第 19 屆太平洋盆地核能會議(Pacific Basin Nuclear Conference, PBNC)的主題為「履行 21 世紀太平洋盆地區域核能技術之承諾」，此會議包含了十個不同的主要議題，如「強化核電廠之安全性」、「改善運轉及維護品質」等內容，共計有來自 20 多個環太平洋地區國家、三百餘篇的論文發表，徐獻星與洪勁宇此次出國公差參加此一會議並發表論文，主要了解福島事故後，環太平洋地區國家對於核能電廠安全議題之發展。徐員也代表原能會蔡主委參加太平洋核能理事會(Pacific Nuclear Council, PNC) 2014 年第四季會議。PBNC 大會亦於會議結束後安排前往 TRIUMF 及 General Fusion 進行技術參訪，TRIUMF 為加拿大國家核能及粒子物理研究所；General Fusion 則以提供商用核融合能源為目標，兩者皆有助於了解國際上先端技術之發展，作為國內研究之借鏡。

此外，此行亦參訪 Pulse Energy 公司，進行能源相關技術討論，Pulse Energy 公司致力於能源智慧(Energy Intelligence)技術，對於降低能源花費及改善能源效率皆取得相當研究成果。本出國報告分段敘述此行之成果，以及心得與建議事項。

二、過程

核研所徐獻星、洪勁宇於 103 年 8 月 21 日自桃園國際機場出發，同日晚上抵達加拿大溫哥華。於 8 月 22 日至 Pulse Energy 公司進行能源相關技術討論，8/24 上午徐獻星代表原能會出席 PNC 會議，8 月 24 日至 8 月 28 日參加 PBNC 2014 並發表論文，並與與會學者進行經驗交流，8 月 29 日則參加 PBNC 2014 大會舉辦之技術參訪行程，至 TRIUMF 及 General Fusion 公司參觀，迄 9 月 1 日返抵國門。此次出國公差共計 12 天，行程如下：

(一) 103/8/21

徐獻星、洪勁宇由台北前往加拿大溫哥華。

(二) 103/8/22

徐獻星、洪勁宇前往 Pulse Energy 公司討論能源相關技術。

(三) 103/8/24~103/8/28

8/24 上午徐獻星代表原能會蔡主委參加 PNC(Pacific Nuclear Council) 2014 年第四季會議；8/24~8/28 徐獻星、洪勁宇參加「第 19 屆太平洋盆地核能會議(PBNC 2014)」，並發表論文。

(四) 103/8/29

徐獻星、洪勁宇參訪 TRIUMF 及 General Fusion 公司。

(五) 103/8/30~103/9/1

徐獻星、洪勁宇回程，返回台北。

三、心得

(一) 參訪 **Pulse Energy** 公司

此行由 Pulse Energy 公司事業開發部總監 Bryan Anderson 負責接待。Pulse Energy 共有員工 60 多人，客戶涵蓋了電力公司(如：加拿大 BC Hydro)、能源供應商(如：英國最大的能源供應商 British Gas)、大型企業、中小企業，甚至是地方社區(加拿大 Hartley Bay)。目前 Pulse Energy 主要服務區域為北美、英國、及澳洲。

作為一節能顧問公司，Pulse Energy 主要提供顧客能源智慧(Energy Intelligence)的解決方案，即所謂的 Pulse Platform。如圖 1 所示，Pulse Platform 提供一個視覺化的使用者介面，其採用「軟體即服務(Software as a Service, SaaS)」之雲端服務模式，使用者不須安裝任何軟體，即可使用雲端平台提供的各項服務，諸如 Pulse Check、Pulse Energy Manager 等服務。

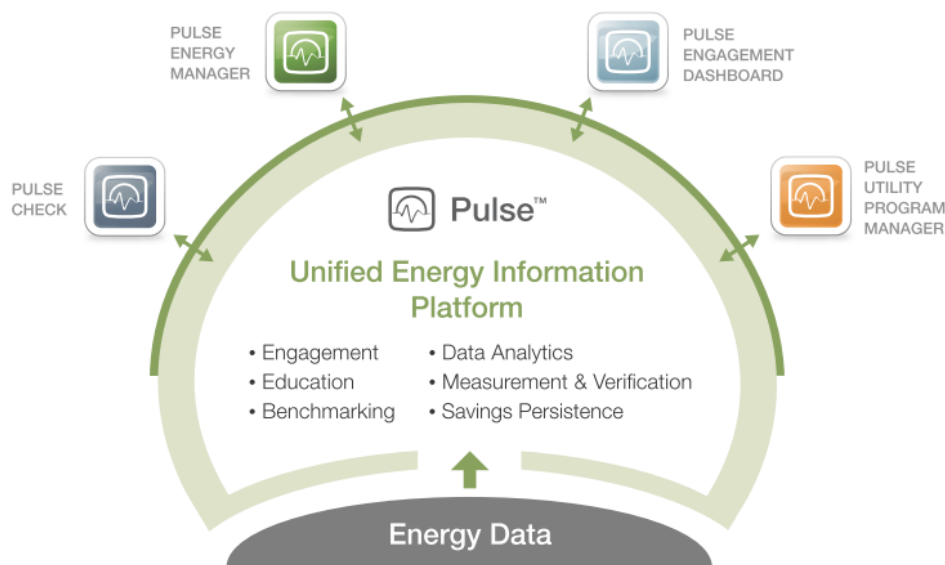


圖 1. Pulse Platform 之應用

對於中小企業(Small and Medium Enterprises, SMEs)而言，Pulse Energy 引進了 Pulse Check，針對中小企業的能源消耗數據，提供一個直觀、客制化的線上平台。該方案主要藉由中小企業的電力帳單，進行每月一次的數據蒐集。由於多數的中小企業辦公作業侷限在單一建築內，Pulse

Check 主要用於個別建築物的耗能分析，根據建築物的負載數據與平日的活動行為(例如：上班時間須開啟空調)，Pulse Check 可分析資料並建議企業主採取合適的手段以節省開銷。

藉由大量的帳單數據分析，Pulse Check 可提供企業主其他類似公司(例如：兩家大賣場的耗能模式應該類似)的數據比較，藉以瞭解企業目前的耗能情況是否超出正常的使用範圍；此分析亦可幫助企業主建立合適的能源計畫，追蹤過往的能源開銷，並預估節能之後的費用是否可符合預算需求。

不同於 Pulse Check 採用每月帳單分析的方式，對於大型企業，Pulse Energy 則提供了 Pulse Energy Manager 來實現即時耗能分析的需求，該方案透過安裝在企業內之智慧電表蒐集耗能資訊，並透過 SFTP (SSH File Transfer Protocol)的方式，將資訊上傳至資料中心，使用者可隨時使用電腦或移動式設備連上 Pulse Platform，觀看即時的耗能數據。此外，Pulse Energy 亦建立了 Pulse Adaptive Model (PAM)的能源模型，該模型結合了歷史用電資料及環境特徵(Feature)，如：溫度、季節等因素，以建立基線(Baseline)來預測耗能情況，並藉此發展節能策略。如果發生能源異常使用的情況，導致耗能超出 PAM 所估計的範圍，則會產生即時的警示來提醒使用者，如圖 2 所示。



圖 2. 預測耗能並與實際情況比較，若有異常狀況則即時警示

此行除聽取 Bryan Anderson 介紹 Pulse Energy 技術外，洪員亦以簡報

方式，介紹台灣目前發展分散式發電(Distributed Generation)及能源管理的情況，內容包含台灣的再生能源政策、核能研究所發展微電網(Microgrid)的成果、及國內資策會發展能源管理的現況等，並於簡報後針對雙方合作機會進行討論。雖然目前 Pulse Energy 主要服務區域尚未涵蓋亞洲，但 Bryan Anderson 提及亞洲地區亦為該公司未來發展之重點區域，但尚有部份技術議題仍須克服，如是否須於亞洲地區建立資料中心等，是後續雙方可繼續接洽討論的內容之一。

台灣於 2008 年通過永續能源政策綱領，希望能創造「能源、環保與經濟」三贏之局面，政策目標包含提高能源效率、發展潔淨能源、及確保能源供應穩定，其中希望全國之二氧化碳排放減量於 2025 年回到 2000 年時的排放量。為達成此目標，能源效率管理之議題越發重要。

能源效率管理涉及耗能的統計與分析，從而預測未來的耗能情況並加以改善，為了預測用戶的用電情況，建立基線模型是不可或缺的一部份。美國國家實驗室 Lawrence Berkeley National Laboratory (LBNL)發表之“Evaluation of the Predictive Accuracy of Five Whole-Building Baseline Models”報告中，利用 29 個不同環境、大小各異建築物之數據，評估五個不同基線模型之能源使用預測準確度，包括 Pulse Adaptive Model (PAM)、LBNL model、day-time-temperature model、mean-week model 及 change-point model。結果顯示：在不同的期間(Period)及預測範圍下，Pulse Adaptive Model、LBNL model、及 day-time-temperature model 的準確性是較佳的，可見 Pulse Energy 所提出的 PAM 有其獨特之處，可普遍適用於不同情境下之耗能預測。

核研所組織改造後，將隸屬於經濟能源部，並更名為能源研究所，故新能源研發及分散式能源等技術將是未來發展之重要議題。核研所目前已於所內建構再生能源園區，並設立微型電網試驗場，其中能源管理及智慧控制技術即為發展微型電網應用中不可或缺的關鍵技術。

目前國內資策會所建構之智慧綠能聯網共通平台(In-Snergy)，已在全國擁有數千台感測設備，在台北市松山區之民生社區更建立了家庭能源管

理應用之實證基地，共佈建了 1200 套家庭能源監控設備，收集 6000 多個家電資料以建立家電特徵值及家電耗能資料庫，從而實現電能管理及需量預測管理等應用，可作為核研所之借鏡。如何結合國內外技術之特色及優勢，發展出適合台灣的基線模型或節能管理應用，並與台灣之能源供應者合作，推廣至企業、社區甚至於家庭，相信是未來可繼續討論及研究之議題。

(二) 參加 PNC 會議

本次徐員代表原能會蔡主委參加之太平洋核能理事會(Pacific Nuclear Council, PNC)2014 第四季會議，與 2014 PBNC 核能會議同地召開，由本屆主席 Mr. Atsuyuki Suziki 主持，本次會議計有來自十餘國約 20 人出席。照往例，會議由各國代表自我介紹開始，接著進行會務處理、招收新成員進度、各工作小組現況、及各與會代表報告該國核能近況等、最後由即將承接 2016 PBNC 核能會議之大陸代表，報告其規劃事項並聽取與會專家建議後結束。徐員也代表報告我國近來之核能發展現況。

PNC 有鑑於日本福島事故後與民眾溝通的工作變得更為重要，為瞭解各國如何有效執行宣導核能事務，PNC 所屬之「公共訊息及宣導」工作小組製作一份問卷調查，並對民眾進行民意調查，會中也由負責人員報告調查結果。

徐員於會中與各國核能單位的主要負責成員會談並交換各國核能發展現況，經由此國際核能民間組織，把台灣核能政策及發展現況，與世界各國分享。參與此國際委員會(PNC)的成員，不少都是長期投入國際核能發展並參與不同領域工作，多半是各國核能學會的主要幹部，另有不少是大學教授等。

日本福島事件無疑是最近影響國際核能事務最重大的事件，Mr. Atsuyuki Suziki 本次會後將卸任，在其會後致詞時表達，以身為一日本人，他對福島事件對全球核能之影響深感抱歉，他特別強調，除日本外，台灣應該是受福島事件影響最深的國家，所以他也對台灣表達最大的歉

意。

(三) 參加第 19 屆太平洋盆地核能會議(PBNC 2014)

第 19 屆太平洋盆地核能會議共有來自 20 多個國家，共計三百多篇的論文發表，大會主席 Mr. Frank Doyle 於 8 月 25 號進行開場致辭，為 PBNC 2014 揭開序幕，如圖 3 所示。此次會議主題為履行 21 世紀太平洋盆地區域核能技術之承諾，共區分成 10 個不同的技術議題，論文題目涵蓋甚廣。大會每天亦有安排全體會議(Plenary Session)，並邀請各國學者專家針對下述主題進行演講：

1. 第一天

環太平洋地區的發展。

2. 第二天

面對挑戰：替代燃料及燃料供應、用過燃料之長期管理。

3. 第三天

建構未來：發展新型反應器技術及應用、新核電廠建造及生命週期管理。

4. 第四天

管制要求之趨勢。

各國學者專家演講相關照片如圖 4、圖 5 所示。我國原能會黃慶東副主委亦於 8/28 早上擔任 Plenary Speaker，介紹台灣目前管制單位的核能政策及龍門電廠遭遇之挑戰，以及福島事故後之安全再評估及放射性廢料管理等議題，如圖 6 所示。



圖 3. PBNC 2014 大會主席 Mr. Frank Doyle 為 8 月 25 號會議進行開場白



圖 4. 美國能源部 Dr. Peter Lyons 針對美國核能電廠現在之情況及未來之挑戰進行演講

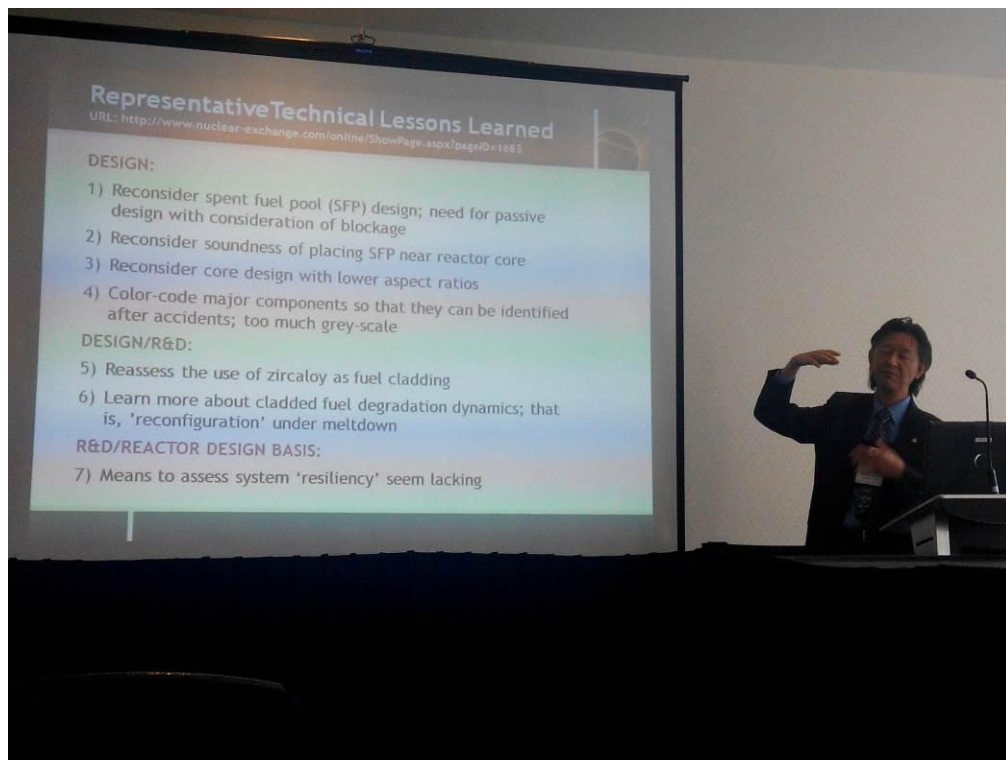


圖 5. 愛達荷大學(University of Idaho)教授 A. Tokuhiro 針對福島事故之經驗教訓進行演講

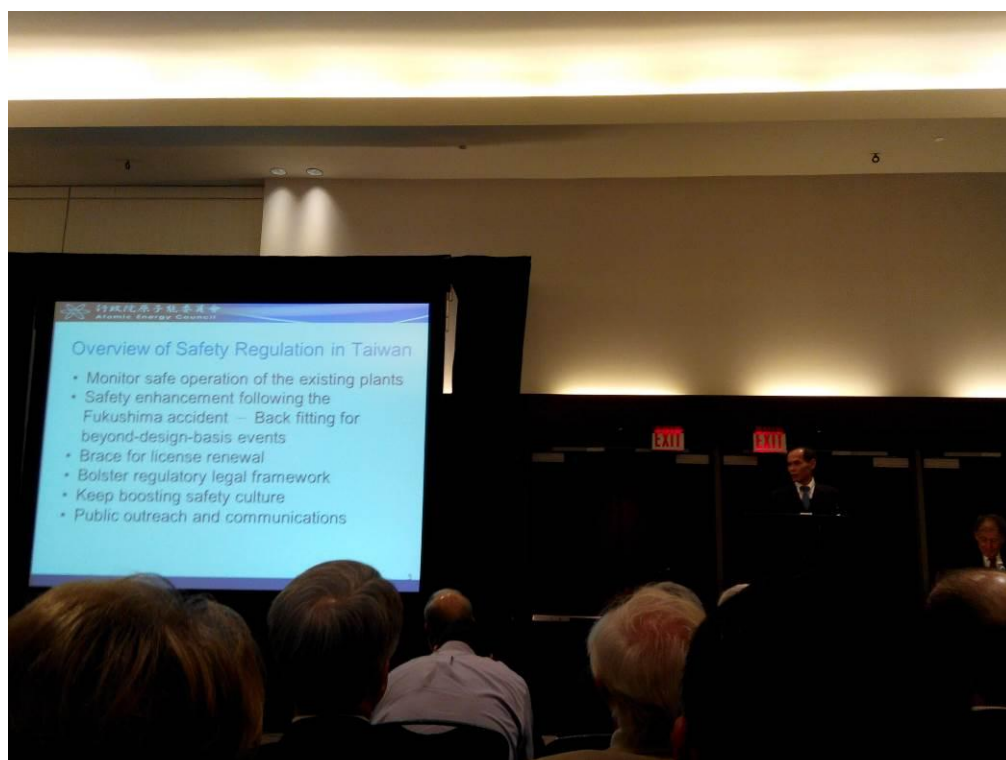


圖 6. 我國原能會黃慶東副主委介紹台灣的核能政策以及龍門電廠遭遇之挑戰

除全體會議外，本次 10 個不同的技術議題會議共分十個會議室舉行，每個議題約略為 2 到 3 小時，茲就部份演講內容介紹如下：

1. **Seismic Fragility Analysis of the Block Masonry Wall in Nuclear Power Plants**

福島事故後，核能電廠開始以系統性的方式來評估電廠的地震風險，管制單位亦制訂新的法規來防範未來的地震事件。地震安全度評估 (Seismic Probabilistic Risk Analysis, SPRA) 係用以評估核能電廠遭受地震時發生事故的機率，其中，結構的地震易損性 (Seismic Fragility) 為進行 SPRA 評估過程中不可或缺的一環。地震易損性可計算單一結構或組件，在特定地震下的條件破壞機率，以找出結構或組件之耐震強度 (Seismic Capacity)，譬如磚牆，該結構物在核能電廠中常作為屏蔽物，發生地震時卻很容易發生毀損而影響電廠安全。

計算系統、結構及組件 (System, Structure and Component, SSC) 的地震易損性分析有兩種可用的評估方法：第一種為典型計算地震易損性的方式，藉由保守性確定失效餘裕 (Conservative Deterministic Failure Margin, CDFM) 來進行評估，此方法首先確定高信心度且低失效機率 (High Confidence, Low Probability of Failure, HCLPF)，再藉由 HCLPF 計算出最大抗震能力 (Fragility Capacity) 的中值 (Median)；第二種方式則是易損性分析 (Fragility Analysis, FA)，此方式直接計算中值，並將隨機性 (Randomness) 及不確定性 (Uncertainty) 納入計算中。

最大抗震能力 (Fragility Capacity) 的中值 A (Median)，為數個安全因子 (Safety Factor, SF) 乘上設計基準地震之 g 值 (A_{ref})，可表示為：

$$A = (F_S \cdot F_\mu \cdot F_R) \cdot A_{ref}$$

其中 F_S 為強度安全 (Strength Factor) 因子， F_μ 為塑性能量吸收 (Inelastic Energy Absorption) 因子， F_R 則為反應因子，又可表示為：

$$F_R = (F_{SA} \cdot F_{\delta} \cdot F_M \cdot F_{SS}) \cdot (F_{QM} \cdot F_{SA} \cdot F_{\delta} \cdot F_M \cdot F_{MC} \cdot F_{EC})$$

第一個括號內的項目代表了主要結構的相關因子，其中 F_{SA} 為地震反應頻譜形狀(Ground Spectra Shape)因子， F_{δ} 為結構阻尼(Structure Damping)因子， F_M 為結構模型(Structure Modelling)因子，而 F_{SS} 為土壤結構互制(Soil-structure Interaction)因子；第二個括號則代表與組件相關之因子，其中 F_{QM} 為定量(Quantification Method)因子， F_{MC} 為模態組合(Modal Combination)因子，而 F_{EC} 為地震分量組合(Earthquake Component Combination)因子。

為了驗證 CDFM 和 FA 方法的差異，本篇論文給定了一個假設的磚牆並提供相關參數，包含組態、失效模式、動態行為、及各安全因子等。根據計算的結果，採用 FA 方式計算出來的磚牆耐震能力中值為 0.84g，再依據此中值，計算出磚牆的 HCLPF 值為 0.295g (失效風險為 $3.55 \times 10^{-4}/\text{yr}$)；另一方面，採用 CDFM 方法所計算出的 HCLPF 則為 0.40g，失效風險則介於 $0.88 \times 10^{-4}/\text{yr} \sim 2.47 \times 10^{-4}/\text{yr}$ 之間。與實際磚牆的情況相較，採用 CDFM 方法所計算出之 HCLPF 約略有 35% 的誤差，從而造成計算失效風險的不準確性，故本篇論文建議高地震活動帶的電廠採用 FA 方式來進行易損性分析。

由本篇論文可知：在評估 HCLPF 時，由於 CDFM 為一種簡化的近似方法，該方法僅考慮影響耐震能力最為顯著的因素，故假使有多數的不確定參數存在時，CDFM 計算出來的耐震能力可能會超出實際的 HCLPF；另一方面，由於 FA 以嚴謹、具機率性的方式考慮所有可能影響耐震能力的因素，與 CDFM 相比更具系統性，計算出的 HCLPF 會與實際值較為接近。

2. Implementation of On-line monitoring and Advanced Pattern recognition using Smart Signal

本篇論文主要介紹應用線上監視(On-Line Monitoring, OLM)與進階圖樣辨識(Advanced Pattern Recognition, APR)工具，由不同訊號之主要及關鍵成分來偵測設備異常。並且嘗試以進階圖樣辨識取得之設備狀態，做為儀器校正的依據，取代傳統於固定時間進行週期校正的方式。

進階圖樣辨識與機器學習(Machine Learning)同義，主要功能為辨識資料樣式(Patterns)與規則(Regularities)。本篇論文之進階圖樣辨識是採用 GE 公司的 Smart Signal 軟體，藉由辨識不同儀器訊號，來偵測設備異常與否。

在建模過程中，機械設備之震動訊號通常混雜太多不相關的變量，例如：溫度、壓力等，造成許多不必要的警報產生。所以，首先須將這些訊號的門檻值(Threshold)範圍設定成比較寬鬆(減少不必要的警報產生)，再從這些訊號解耦(Decouple)成數個獨立的訊號，並同時監視解耦前後的訊號。

解耦的原則採用相似性建模(Similarity Based Modeling, SBM)技術，以皮爾森積矩相關係數(Pearson Product-Moment Correlation Coefficient)度量兩個變數之間的相關程度，如圖 7 所示。

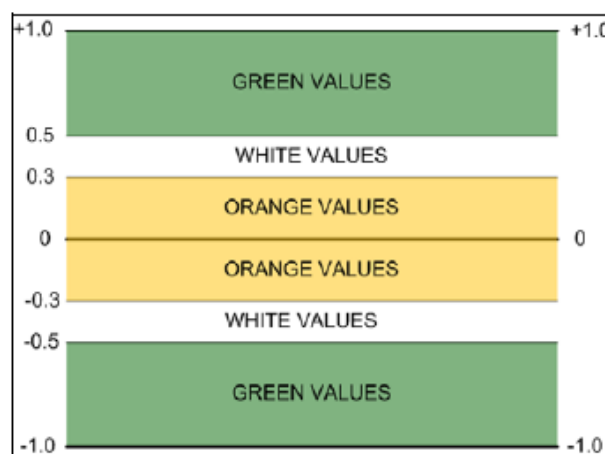


圖 7. 皮爾森積矩相關係數度量法

圖中綠色部份表示良好的相關程度；白色表示可接受的相關程度；橘色表示較差的相關程度。另外，本篇論文還整合 Smart Signal 軟體與廠內設備可靠度(Equipment Reliability, ER)程序之狀態報告(Condition Status

Reporting, CSR)軟體，由事先定義的設定值自動判斷設備狀態，包括：可接受(Acceptable)、觀察名單(Watch List)、臨界(Marginal)、以及不可接受(Unacceptable)等四類。

本論文並以 Bruce Power 電廠為例，該電廠於 2013 年 7 月 22 日發現第 8 機組鍋爐 2 號入料泵(Boiler Feed Pump, BFP)流量異常，如圖 8 所示。追查肇因，為再循環流量控制閥(Recirculation Flow Control Valve)開度超過設定值 25%，故緊急切換至 1 號入料泵並檢修 2 號入料泵之再循環流量控制閥，於問題擴大前，順利解決此問題。

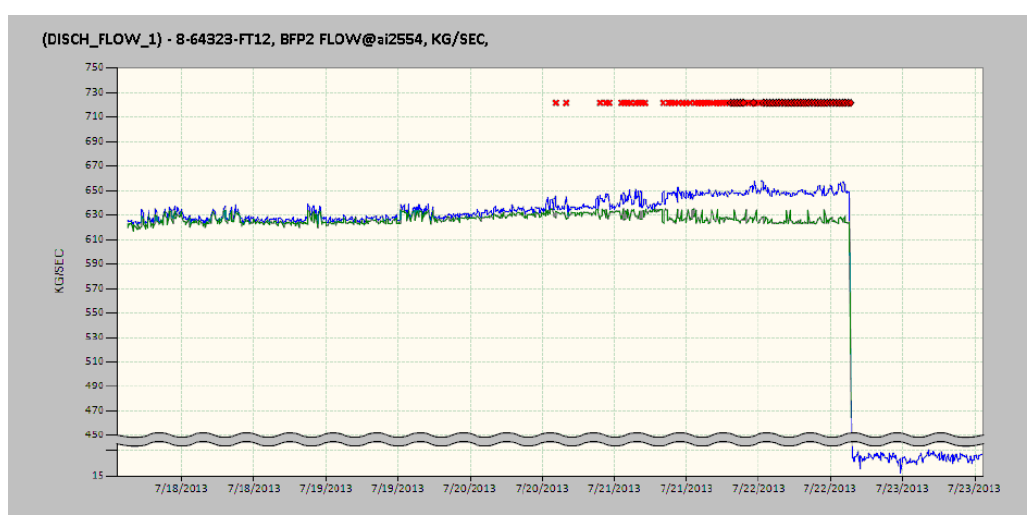


圖 8. Bruce Power 電廠第 8 機組鍋爐 2 號入料泵流量異常

另外一個案例則發生在 2013 年 11 月 6 日，該電廠發現第 4 機組主熱交換泵(Primary Heat Transport Pump) 3 號馬達之下導軸承(Lower Guide Bearing)溫度與潤滑油溫度持續上升，分別為 65° C 與 58° C(當溫度超過 75° C 時，將發出警報；超過 82° C 時，將停機)，如圖 9 與圖 10 所示。追查肇因，發現水冷卻器(Water Cooler)無法提供足夠的冷卻能力，故採用反沖洗(Back Flushing)輔助降溫，實施後結果分別為 55° C 與 45° C，也是在設備溫度超過警報或停機設定點前，成功解決該問題。

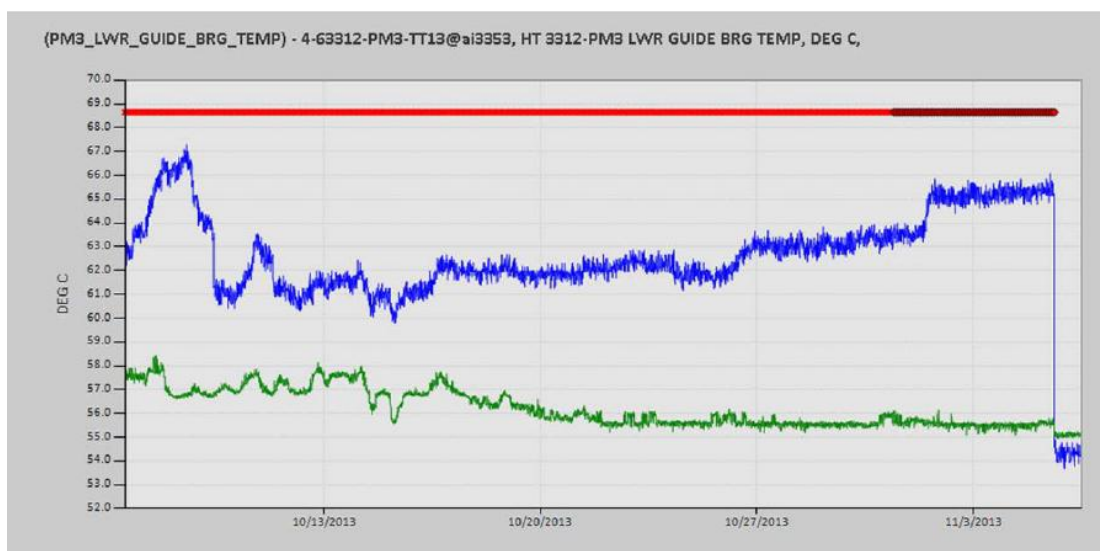


圖 9. 第 4 機組主熱交換泵 3 號馬達之下導軸承溫度異常

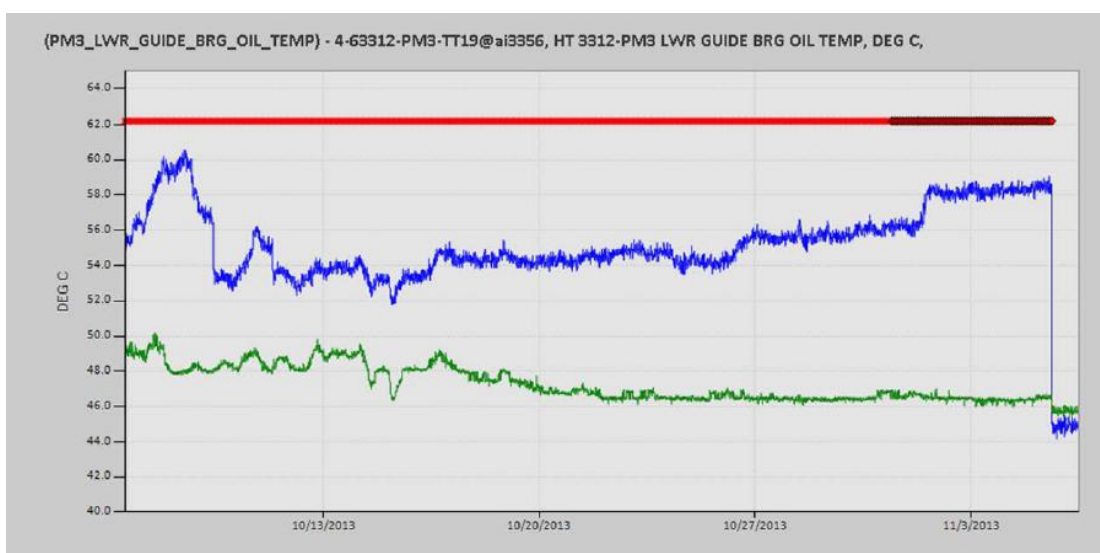


圖 10. 第 4 機組主熱交換泵 3 號馬達之下導軸承潤滑油溫度異常

此外，Bruce Power 電廠在 2012 年 6 月 28 日亦發現第 7 機組渦輪抽氣到排氣的溫度訊號偏移至 211°C 與 217°C ，如圖 11 所示。追查肇因，在渦輪滿載的狀態下，抽氣溫度應處於穩定的狀態，如圖 12 中第 8 機組之情況。藉由比較第 7 機組渦輪上游與下游抽氣到排氣的溫度，確定為溫度傳送器異常，導致訊號偏移，故提前進行校正，解決此問題。

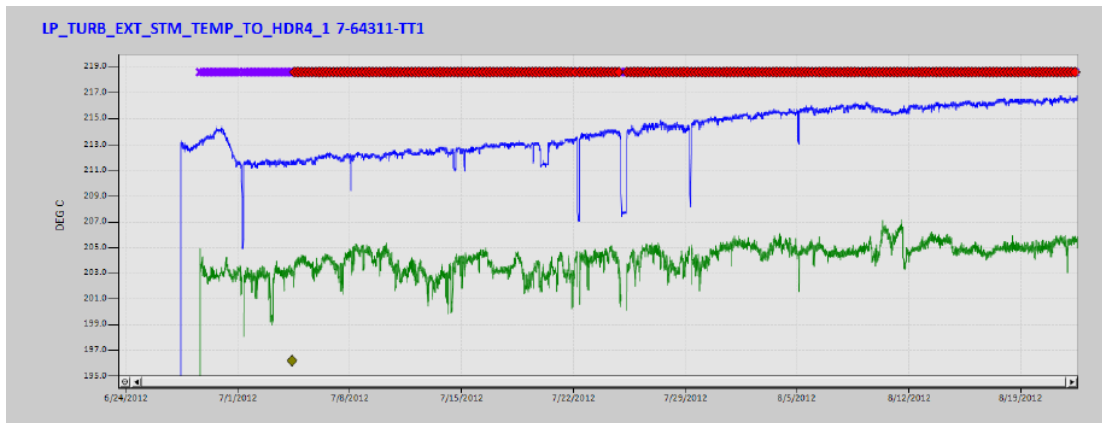


圖 11. 第 7 機組渦輪抽氣到排氣的溫度訊號偏移

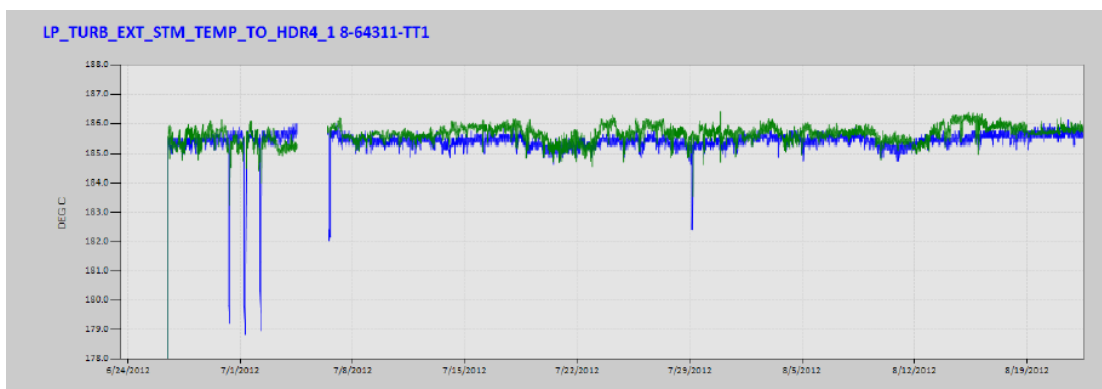


圖 12. 第 8 機組渦輪抽氣到排氣的溫度訊號

本篇論文導入線上監視與進階圖樣辨識，利用不同訊號來偵測設備異常，並利用現場經驗修正監視訊號的關聯性，最後整合廠內設備可靠度程序之狀態報告軟體，自動地判斷設備狀態，可預先警示操作人員在事故發生之前，以標準作業控制流程方式使系統回復正常運轉，免除系統產生跳脫的可能性，減少損失。由實際案例說明本文提供之方法可有效偵測設備與儀器異常。然而如何確認來源訊號的準確度(Accuracy)則為下一階段主要的挑戰。

3. **Technical Highlights of the Latest Upgrades to HITACHI's G-HIACS vSafe Functional Safety Controller**

此篇論文主要介紹 HITACHI's G-HIACS vSafe 功能安全控制器，該控制器第一版(Product Version 1, PV1)已於 2010 經 TÜV Rheinland 認證為 IEC 61508 SIL2 等級控制器，第二版(Product Version 2, PV2)也於 2013 通

過 TÜV Rheinland SIL2 認證，此論文說明兩者的差異，即第二版改良的地方。

Hitachi 最早於 1985 年推出第一代 HIACS 分散式控制系統 (Distributed Control System, DCS)，著重於系統整合與效能。由於 Hitachi 的 DCS 通常被視為整體系統的一部份，而非獨立的產品，加上過去 20 年產品技術的標準化，改變了控制系統市場的商業模式，因此，Hitachi 將 HIACS 系列的分散式控制系統導入至符合國際標準的可程式控制器 (Programmable Logic Controller, PLC) 的範疇。

G-HIACS R800FS/HSC800FS vSafe 功能安全控制器通過 TÜV Rheinland SIL2 認證，專門為安全相關應用而設計；而 G-HIACS R900FS/HSC900 通用控制器，則是為高效能、精簡化、及通用性而設計，其差異如表 1 所示。基於 HIACS 系列控制器之通用架構(Unified Architecture)設計，G-HIACS 系列的控制器可以發展成多機組(Multi-unit)之電廠架構，如圖 13 所示，其中中間區域為兩機組共用的部份，在該架構下，安全與非安全系統可以共存，並透過警告旗標(Warning Flag)相互隔離。

表 1. G-HIACS R800FS/HSC800FS vSafe 功能安全控制器與 R900FS/HSC900 通用控制器之差異

Items	R800FS/HSC800FS vSAFE	R900/HSC900
IEC 61508 Functional Safety	SIL 2 (single/duplicated system)	N/A
Supported I/O Types	FS: DI, DO, AI, AO (4 types) Non-FS: DI, DO, AI, AO, SOE, etc. (8 types)	DI, DO, AI, AO, RTD, THC, PTL, LVDT, etc. (13 types)
System	Single (SIL 2) Duplicated (SIL 2, high availability)	Single Duplicated Triple (only for HIACS)
Programming Languages	FBD, SFC, ST (IEC61131-3)	FBD, SFC, ST (IEC61131-3) FBD (Lyra HIACS [†] -type)

[†]Hitachi in-house programming language interface used in previous HIACS series; supported by R900/HSC900 for legacy customers.

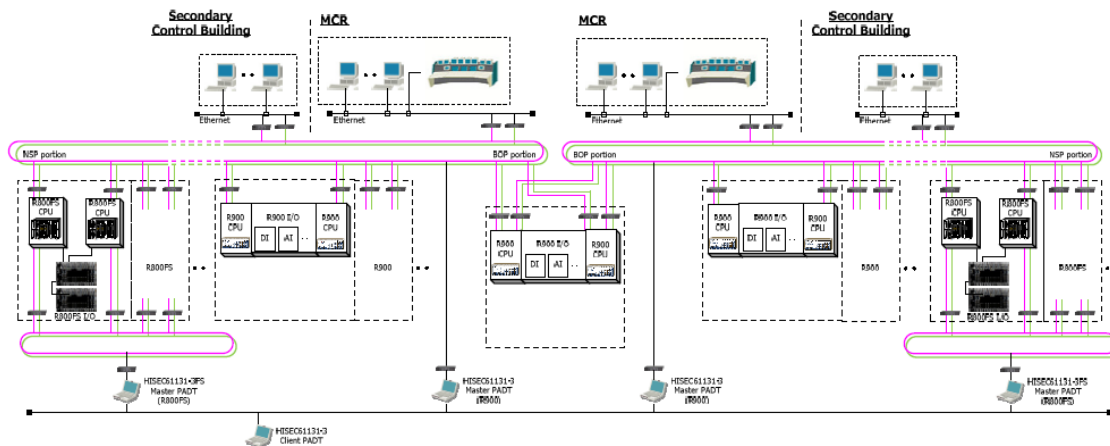


圖 13. 基於 G-HIACS 系列控制器之多機組架構

該論文著重於以下幾點：硬體效能的改善(比較第一版)、軟體使用性的改善、及符合國際標準等討論。

在硬體效能改善部份，首先提到 R800FS/HSC800FS 通訊的強化，利用循環冗餘檢查碼(Cyclic Redundancy Code, CRC)、序列編號(Sequence Numbers)、傳送/接收端鑑別、逾時監視、以及交握(Handshake)等確保通訊完整性，如圖 14 所示。

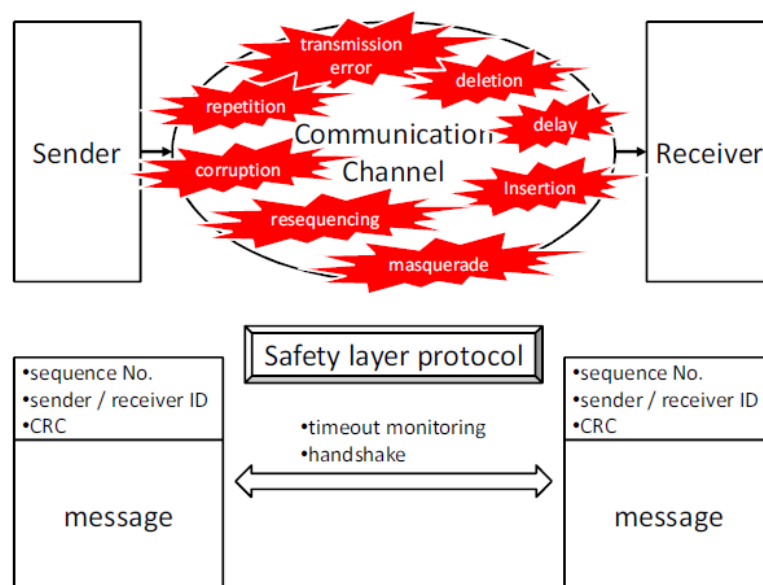


圖 14. R800FS/HSC800FS 安全通訊

再來說明 R800FS/HSC800FS 執行安全通訊的機制，由原本的軟體改

用硬體實現，如圖 15 所示。在第一版的 R800FS/HSC800FS 控制器內，所有的安全通訊皆是由軟體實現，造成系統效能大幅降低。第二版 R800FS/HSC800FS 的安全通訊設計則如圖 16 所示，安全通訊機制主要由硬體負責，消除了第一版硬體閒置(Idle)的時間，另外，軟體與硬體之間透過共用記憶體進行資料交換，也大幅提升軟體執行的效能(無須等待硬體回覆，即執行後續工作)，經實測的結果，第二版比較第一版的系統效能提升了 40%。而第一版因故障偵測導致反應時間拉長的問題，也因第二版安全通訊機制，得到了改善。

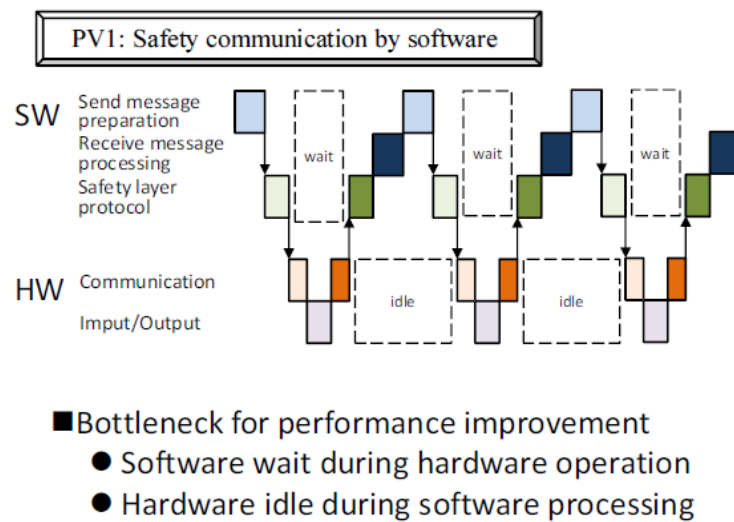


圖 15. 第一版 R800FS/HSC800FS 之安全通訊設計

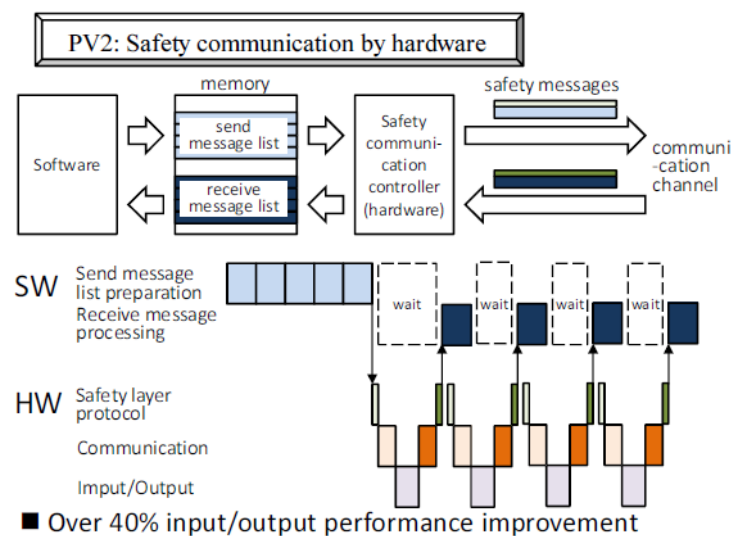


圖 16. 第二版 R800FS/HSC800FS 之安全通訊設計

在軟體使用性改善部份，Hitachi HISEC 61131-3 FS PADT 編輯工具被 TÜV Rheinland 評估為適用於組態/編輯應用邏輯的發展工具，可用於安全與非安全控制器。另外，在記憶體配置上，移除不必要的資料在比較區域(Compare Target Area)，只保留安全資料，可減少每次存取該區域資料的時間。

國內核四廠之放射性廢料處理系統(Radioactive Waste Processing System, RWPS)及棒控制資訊系統(Rod Control Information System, RCIS)係採用 Hitachi 的 HIACS-7000 型複聯式網路系統，前者負責氣體、液體放射性廢料處理系統及固體放射性廢料減容系統和固化系統等之控制；後者負責主要的功能在於提供控制棒於爐心位置的控制，藉以控制爐功率的產生與分佈，控制模式分為自動、半自動、手動三種。RCIS 能收集棒位和 RCIS 本身狀況資訊，以提供給運轉員和其他電廠系統使用。HIACS-7000 型複聯式網路系統採用的控制器為 R600，即為 R800FS/HSC800FS 的前身。

R800FS/HSC800FS 與核研所發展之三重容錯(Triple Modular Redundant, TMR)安全控制器 SCS-2000 同屬於安全級控制器，也通過 TÜV Rheinland 認證，雖然 SCS-2000 符合的安全等級 SIL3 已較 R800FS/HSC800FS 的 SIL2 高，但 Hitachi 將 HIACS 系列控制器的通用架構設計，以及第二版 R800FS/HSC800FS 針對軟硬體效能改善的技術，仍是值得參考與借鏡。

(四) 參訪 General Fusion

General Fusion 由 Michel Laberge 博士成立於 2002 年，主要業務為發展核融合(fusion)技術，以提供低成本、乾淨的能源，該公司於 2006 年完成概念驗證(proof-of-principle)的實驗，在 2010 年並獲得資金挹注，如亞馬遜(Amazon)創始人 Jeff Bezos 亦為投資者之一。不同於磁局限融合(magnetic confinement fusion)或慣性局限融合(Inertial Confinement Fusion,

ICF)技術，General Fusion 是採用磁化定位核融合(Magnetized Target Fusion, MTF)的方式，MTF 系統使用一個充滿液態鋰鉛金屬(lead-lithium)的球體，並旋轉液態金屬使其形成漩渦，在每一個脈衝時，受磁局限(magnetically-confined)的電漿將會注入漩渦內。在球體四週則有許多的活塞撞擊並產生壓力波至球體中心，並將電漿壓縮加熱，直到發生核融合。

General Fusion 的主要系統分成三個部份：

1. 電漿注入器(Plasma Injector)

在 General Fusion 系統中，位於中央球體上方及下方的錐形裝置就是電漿注入器，這些注入器讓電漿維持大概攝氏三百萬度的溫度，並形成“spheromak”，即一種類似甜甜圈形狀的電漿，並被磁場所包覆，隨後加速注入球體。目前 General Fusion 已建造出全尺寸的電漿注入器以示範 spheromak 電漿的形成，如圖 17 所示。

2. Acoustic Drivers

Acoustic Drivers(或可稱之為活塞)，用來傳遞能量並加熱氫燃料至融合反應，Acoustic Drivers 以蒸氣驅動，每一組活塞內有兩個活塞，能量由第一個活塞(Hammer)迅速傳遞至第二個活塞(Anvil)，最後轉移至液態金屬內。由於電漿進行壓縮時可能產生變形，所以需要許多電子控制系統來調整活塞運作的時間。General Fusion 亦已完成全尺寸的 Acoustic Drivers，如圖 18 所示，並證明此系統可獲得核融合所須的撞擊速度(能量)及正確的時間控制。

3. 漩渦壓縮器(Symmetric Vortex Collapse)

為 General Fusion 的核心系統，液態金屬被注入直徑 3 公尺的圓體中並形成圓柱狀的平滑漩渦，漩渦用以限制並壓縮電漿。目前 General Fusion 建造了一個直徑 1 公尺的小型球體，並具備 14 組全功能的 Acoustic Drivers 來測試液態金屬漩渦的形成及壓縮過程。

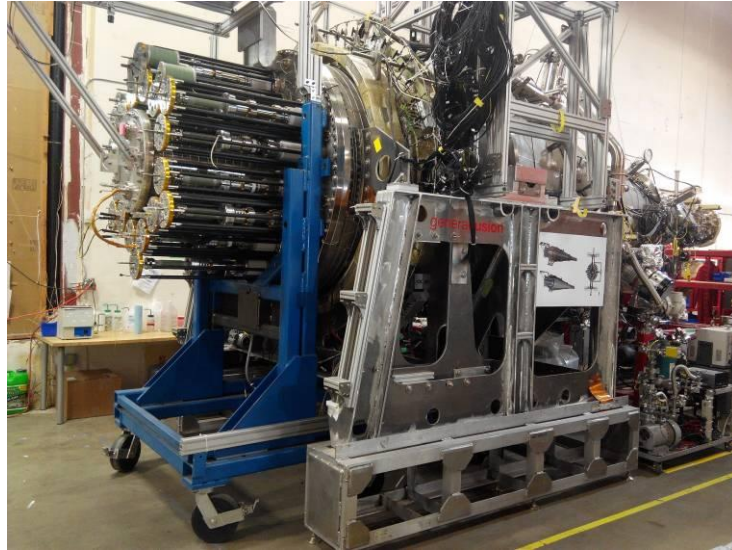


圖 17. 電漿注入器



圖 18. 小型漩渦壓縮器及 Acoustic Drivers

目前已有許多企業與研究機構著手進行磁局限融合(如:國際熱核融合實驗反應爐(ITER))或慣性局限融合(如:美國 National Ignition Facility)的研究,但對於發電廠來說,這兩種方式所花費的成本及系統的複雜性是尚待解決的問題。此外,當進行核融合時,來自電漿的高速中子可能會撞擊機器的邊緣,而造成機器損壞;另一方面,General Fusion 採用的 MTF 技術是以蒸氣推動活塞,該方式比起透過雷射或超導磁鐵來提供能量,成本是較為低廉的。而由於液態金屬會吸收所有的中子,所以不會有中子撞

擊機器表面，亦可降低機器的損壞風險。**General Fusion** 已完成技術理論推導，並建立了各子系統的原型來測試，雖然目前 **General Fusion** 尚未將各子系統合併成完整的一套系統來驗證，但相信後續的發展仍然備受期待。

核融合技術於 1950 年代初即試驗成功，1955 年於日內瓦舉辦之原子能和平用途(**Atoms for Peace**)會議上，印度的核子物理學者 **Homi Jehangir Bhabha** 曾預測在 20 年內就可找出控制核融合反應的方法，但截至目前為止，控制核融合反應並使其具備商業化之價值，亦即，輸出的能量要大於跨越庫侖障壁(**Coulomb Barrier**)及其他產生核融合所須之能量，仍是研究核融合重要的議題。

目前世界上較廣為人知的核融合方式包含磁局限融合及慣性局限融合，在今年(2014)美國能源部所屬研究機構 **Lawrence Livermore National Laboratory (LLNL)**更取得突破性的進展，使高能量慣性局限融合所獲得之能量，首度高於投入之能量。但由於慣性局限融合的方式是採用高功率雷射來撞擊燃料球來引發核反應，高額的能量消耗仍是必須面對的問題。而 **General Fusion** 所採用的磁化定位核融合方式則提供另外一種「可能成功的機會」，而且成本更加便宜。在 **General Fusion** 研發初期，是採用蒸氣推動之活塞來壓縮球體內的液態金屬，使其溫度上升，但實際上，電漿冷卻的速度快過壓縮產生熱量的速度。為了解決此問題，**General Fusion** 改採用兩段式的活塞，第一段的活塞就類似鎚子，快速的撞擊第二段的活塞，使其能更快速的壓縮電漿。目前 **General Fusion** 各個子系統獨立運作情況良好，未來的發展仍然值得期待。

(五)參訪 TRIUMF

TRIUMF 實驗室座落於加拿大 **Vancouver** 市英屬哥倫布大學(**UBC**)南端，是全球在次原子(**Subatomic**)物理實驗室之領導地位，擁有各國物理學家及不同領域專家，並具不同技術資源及商業夥伴。其主要研究目標為人體健康與生活品質，並培植高科技產業，生產高價值特殊藥品、探究地球

環境物質、開發新物質、及探巡宇宙奧秘等。

參觀 TRIUMF 時，最先被吸引的設施是其設置在接待室內之 Cloud Chamber，如圖 19 所示。Cloud Chamber 在早期被當作核輻射探測器，也是最早的帶電粒子徑跡探測器。該裝置係利用純淨的乙醇進行絕熱膨脹，當溫度降低達到過飽和狀態時，環境中滿佈之宇宙射線射入雲室，其高能粒子引起的離子，在過飽和蒸汽中可成為蒸汽的凝結中心，圍繞著離子將生成微小的液滴，於是粒子經過的路徑上就出現一條白色的霧，在其黑室內就可看到粒子運動的徑跡。徐員當時在其黑室內，可以看見頻繁的 Gamma 射線，其軌跡為一彎曲的弧線。也偶而可看見 Alpha 射線，其軌跡就像一肥胖的直線，甚為有趣，在黑室內拍攝之照片如圖 20 所示。

徐員為核工系出身，從事輻射偵測研發工作多年，現在首次見到輻射線本尊，很有他鄉遇故知的感覺。也引發徐員的感觸，雖然核能從業者認為已盡到最大的努力，但外界大眾皆稱核能溝通不足。如果國內能由根本做起，讓大眾透過類似 Cloud Chamber 這樣簡單的設備，瞭解輻射線的模樣，也瞭解輻射線本就充斥在四周，也許反核的聲音就可較小。



圖 19. Triumf 內用以顯現宇宙射線之 Cloud Chamber



圖 20. 在 Cloud Chamber 內現形之輻射線

TRIUMF 擁有全世界規模最大的迴旋加速器(Cyclotron)，可產生 500 MeV 的正子束。在 TRIUMF 內，大部分的實驗計畫及正子治療設施(Proton Treatment Facility)皆都依賴此正子束，其圖片如圖 21 所示。該迴旋加速器藉由巨大的電極，加速在螺旋狀真空腔內之粒子，至光速之 $3/4$ 速度後，由射束管導入至實驗區。圖 22 為此迴旋加速器之模型，總重達 4000 噸，電磁鐵直徑達 18 公尺，可產生世界最強之正子束。當我們位於其上方樓層時，導覽人員示範迴紋針可輕而易舉的直立起來。

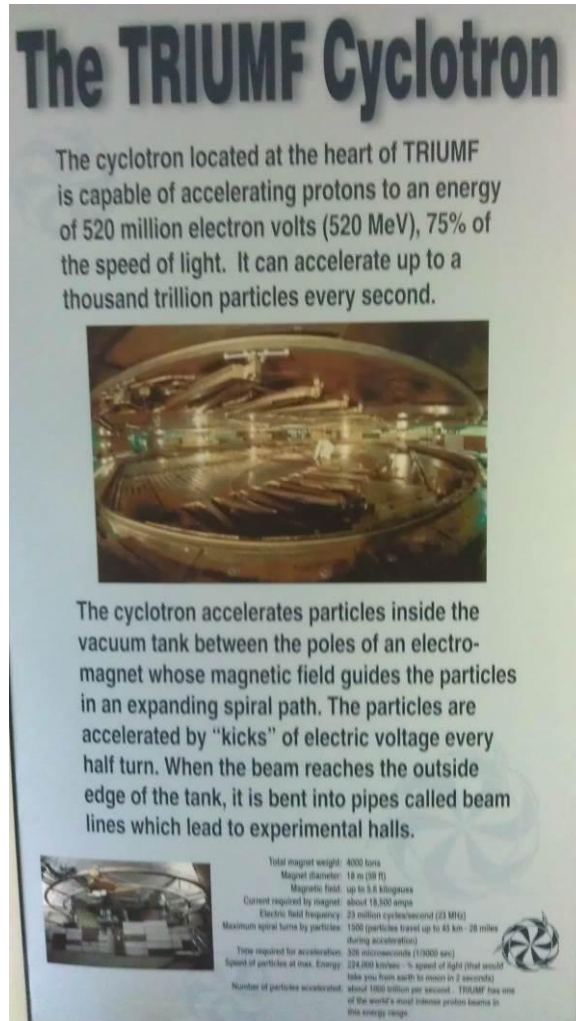


圖 21. TRIUMF 迴旋加速器的外觀圖

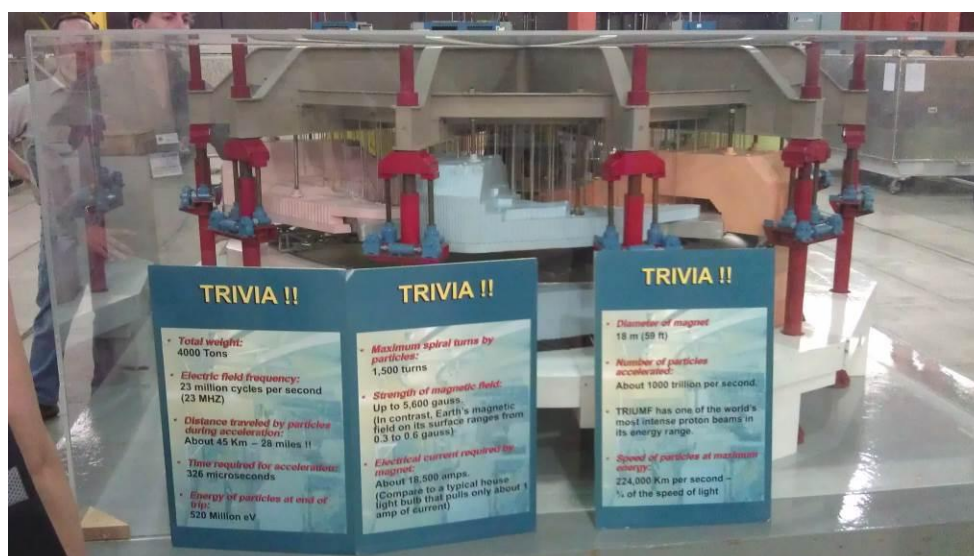


圖 22. TRIUMF 迴旋加速器的模型

TRIUMF 實驗室內也與英屬哥倫布大學(UBC)及其他研究單位合作，於 2004 年，在其實驗室內建置加拿大第一座正子攝影電腦斷層掃描器 (PET/CT Scanner)，用以定量決定活體內被正子標記物質之濃度，比 MRI 或 CT 等設備，具有更靈敏之功能，特別是在癌症的檢測上。TRIUMF 的正子攝影電腦斷層掃描器也被 UBC 應用於大腦疾病及其他之研究上，其模型如圖 23 所示。



圖 23. TRIUMF 正子攝影電腦斷層掃描器模型

四、建議事項

(一) 持續參與 PBNC 會議

此次 PBNC 會議共區分成 10 個不同的技術議題，論文題目涵蓋面甚廣，大會亦邀請許多學者專家進行專題演講，從管制單位法規要求到福島事故後電廠經驗回饋等主題皆有著墨，可提供與會人員完整的知識。太平洋盆地核能會議(PBNC)每兩年舉行一次，下一屆(第 20 屆)則預計在 2016 年於中國北京舉行，建議持續派員參與 PBNC 會議，蒐集論文與現場相關之資料，作為本所後續研究之參考與借鏡，並可於會議上發表論文，提升我國於國際間之能見度。

(二) 鼓勵國內專家或學者參加 PNC 會議

藉由參與太平洋核能理事會(PNC)會議，可與各國核能學會的主要負責成員會談並交換各國核能發展現況，我國也可以經由此國際核能民間組織，把台灣核能政策及發展現況，與世界其他各國分享，增加台灣的能見度。由過去會議資料及 ANS 網站上的資訊可知，他國參與太平洋核能理事會的成員，不少都是長期投入及參與，且多半是各國核能學會的主要幹部或是大學教授；我國則是根據會議安排之地點，由臨近同仁來代表參加，雖有地利之便，但每次參與會議者並不同，可能得重新熟悉會議的運作，也無法了解前次會議之議題與討論事項，連貫性較為不足。未來或可鼓勵國內專家或學校教授來共同參與 PNC 會議。

(三) 從根本加強核能溝通

雖然核能從業者認為已盡到最大的努力，但外界大眾皆稱核能溝通不足。如果國內能從根本做起，讓大眾透過類似 Cloud Chamber 這樣簡單的設備，瞭解輻射線的模樣，也瞭解輻射線本就充斥在四周，也許反核的聲音就可較小。

五、附錄

(一)附錄一 參考資料

(二)附錄二 PBNC 2014 議程

(三)附錄三 洪員於 PBNC 2014 會議簡報資料

(一)附錄一 參考資料

1. PBNC 2014 Program Book (PBNC 2014 議程資料), Aug. 24-28, 2014, Hyatt Regency Hotel, Vancouver, BC, Canada. (存核研所核儀組)
2. PBNC 2014 Proceedings Material with Papers Stored on a USB Memory Stick (PBNC 2014 論文集), Aug. 24-28, 2014, Hyatt Regency Hotel, Vancouver, BC, Canada. (存核研所核儀組)

(二)附錄二 PBNC 2014 議程



PBNC-2014
Vancouver, BC, Canada
2014 Aug. 24-28
Preliminary Program Outline
as of 2014 April 4



Sunday, August 24 18:00 Conference Registration 19:00 Conf. Exhibits (to Wed. Aug. 27) 19:00 Conference Reception; Guest Speaker: Mr. Duncan Hawthorne, Pres. & CEO, Bruce Power (Canada) Monday, August 25 08:00 Welcoming Remarks: Mr. Jacques Plourde, President, CNS (Canada) 08:05 Welcoming Remarks: Prof. Atsuyuki Suzuki, President, PNC (Japan) 08:10 Welcoming Remarks, Dr. John Barrett, Pres. & CEO, CNA (Canada) 08:15 Welcome Remarks and Keynote Address: The Hon. Greg Rickford, Canadian Minister of Natural Resources (Invited) 08:30 Plenary IA: Fulfilling the Promise – Developments within the Pacific Rim – Established Programs; Chair: Dr. Peter Lyons, Assistant Secretary for Nuclear Reactor Technologies, USDOE (US) 08:30 Dr. Peter Lyons, Assistant Secretary for Nuclear Reactor Technologies, USDOE (USA) 08:45 Prof. Atsuyuki Suzuki, President, JAEA (Japan) 09:00 Mr. Tom Mitchell, President & CEO, Ontario Power Generation (Canada) 09:15 Mr. Zhongzhi Ding, Senior Advisor, China Power Investment Corp. (China) 09:30 Prof. Kune Y. Suh, Seoul National University (Republic of Korea) 09:45 Questions & Answers 10:00 Break 10:30 Plenary IB: Fulfilling the Promise – Emerging Programs; Chair: Dr. Alexander Bychkov, Dep. Dir. Gen. IAEA 10:30 Dr. A. Bychkov, Dep. Dir. Gen., IAEA 10:45 Dr. Lydia Paredes, General Director, Instituto Nacional de Investigaciones Nucleares (México) 11:00 Dr. Le Chi Dung, Dep. Dir. Gen., Vietnam Agency for Radiation and Nuclear Safety (Vietnam) 11:15 Prof. Leonid Bolshov, Director, IBRAE RAN (Russian Federation) 11:30 Questions & Answers		Monday, August 25 12:00 Conference Luncheon and W.B. Lewis Lecture, Dr. S. Banerjee, DAE Homi Bhabha Chai Professor (India) 14:00 Parallel Technical Sessions – 17:00 (Break mid-afternoon) Tuesday, August 26 08:00 Parallel Technical Sessions – 12:00 (Break in mid-morning) 12:00 Honors & Awards Luncheon; Keynote Address 1; Guest Speaker: Mr. Tim Gitzel, Pres. & CEO, Cameco Corporation (Canada) 14:00 Plenary IIA: Fulfilling the Promise – Addressing the Challenges – Alternative Fuel Cycles and Fuel Supply; Chair: TBA 14:00 Mr. Derek Gross, Director Marketing Strategy, Cameco Corp. (Canada) 14:15 Mr. Sermet Kuran, Director, AFCR Technology & Fuel Cycles, Candu Energy Inc. (Canada) 14:30 Dr. Patricia Paviet, Director, Office of Systems Engineering & Integration, USDOE (US) 14:45 WNA Speaker (UK) (invited) 15:00 Questions & Answers 15:15 Break 15:45 Plenary IIB: Fulfilling the Promise – Addressing the Challenges – Long-Term Used-Fuel Management; Chair: Mr. Ken Nash, Pres., NWMO (Canada) 15:45 Mr. Ken Nash, President, NWMO (Canada) 16:00 Mr. Toru Yamaji, President, NUMO (Japan) 16:15 Dr. William Boyle, Director of Used Nuclear Fuel Disposition Research & Development, USDOE (US) 16:30 Dr. Jong In Lee, President, KORAD (Republic of Korea) 16:45 Dr. Liang Chen, Deputy Director, Environmental Engineering Division, BRIUG (China) 17:00 Roundtable/Panel Discussion 18:00 Student Posters & Wine-&Cheese Reception		Wednesday, August 27 08:00 Plenary IIIA: Fulfilling the Promise – Building for the Future – Developing New Reactor Technologies and Applications; Chair: Dr. John Kelly, Deputy Assistant Secretary for Nuclear Reactor Technologies, US DOE (US) 08:00 Dr. John Kelly, USDOE (US) 08:15 Dr. Hark Roh Kim, Senior Vice-President, Strategic R&D Program, KAERI (Republic of Korea) 08:30 Dr. Adi Paterson, CEO, ANSTO (Australia) 08:45 Mr. Doug Richardson, Chief Tech. Officer, General Fusion Inc. (Canada) 09:00 Dr. Yuliang Sun, Deputy Director, Inst. of Nuclear and New Energy Tech., Tsinghua University (China) 09:15 Questions & Answers 09:30 Break 10:00 Plenary IIIB: Fulfilling the Promise – Building for the Future – Plant Infrastructure Development and Life Management; Chair: Mr. Ken Ellis, Managing Director, WANO (Canada) 10:00 Mr. Ken Ellis, Managing Director, WANO (Canada) 10:15 Mr. Mark Elliott, Chief Nuclear Eng., Ontario Power Generation (Canada) 10:30 Mr. Ken Petrunik, Chief Program Officer, Emirates Nuclear Energy Corporation (UAE) 10:45 Mr. Garry Young, Director. License Renewal, Entergy Nuclear (US) 11:00 Mr. Frank Yee, Chief Nuclear Engineer, Candu Energy Inc. (Canada) 11:15 Mr. Len Clewett, Exec. VP & Chief Nuclear Officer, Bruce Power (Canada) 11:30 Questions & Answers 12:00 Conference Luncheon and Keynote Address 2: Guest Speaker: Dr. Bob Walker, President & CEO, AECL (Canada) 14:00 Parallel Technical Sessions – 17:00 (Break mid-afternoon) 15:00 Close of Exhibits 18:30 Conference Banquet and Entertainment		Thursday, August 28 08:30 Plenary IVA: Fulfilling the Promise – Regulatory Trends; Trends in Regulatory Requirements to Ensure Safe Operation of NPPs; Chair: Dr. Michael Binder, CNSC President 08:30 Dr. Michael Binder, President, CNSC (Canada) 08:45 Mr. William Ostendorff, Commissioner, USNRC (USA) 09:00 Dr. Tsing-Tung Huang, Deputy Minister, AEC (Taiwan) 09:15 Dr. Un Chul Lee, Chairman, NSSC, Republic of Korea 09:30 Mr. Juan Eibenschutz, Chairman, CNSNS (México) 09:45 Questions & Answers 10:00 Break 10:30-12:00 Parallel Technical Sessions 12:00 Conference Luncheon and Keynote Address 3, on Communications and Outreach; Guest Speaker: Dr. John Barrett, Pres. & CEO, CNA (Canada) 14:00 Plenary IVB: Fulfilling the Promise – Telling Our Story – Communications and Outreach Discussion; Moderator: Ms. Mimi Limbach, Managing Partner, Potomac Communic. Group, Inc. (US) 14:00 Ms. Mimi Limbach: Setting the Stage Capturing the Discussions, Recommendations and Outcomes of the Past 4 Days of PBNC-2014 14:15 Dr. Michael Brady Raap, ANS President-Elect (US) 14:30 Mr. Lixin Shen, Deputy Secretary-General, Chinese Nuclear Soc. (China) 14:45 Dr. Jeremy Whitlock, Manager Non-Proliferation & Safeguards, AECL (Canada) 15:00 Questions & Answers 15:30 Closing Ceremony: Transfer of PBNC Duties: Mr. Frank Doyle, Conf. Chair, 19th PBNC to Conf. Chair, 20th PBNC End of Conference See you at PBNC-2016! vs3 Friday, August 29 (Optional) 08:30 Tours: TRIUMF & General Fusion 12:30 Tours: TRIUMF & General Fusion	
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1. 8/25 議程內容

Welcoming Remarks	Monday August 25	Plenary Sessions	Monday August 25
WELCOMING REMARKS AND KEYNOTE ADDRESS 1 Room: Regency E & F Time: 8:00-9:00		09:00 Plenary Session Introductory Remarks: Dr. Ron Oberth, Plenary and Keynote Program Chair (Canada)	
08:00-08:05 INTRODUCTORY REMARKS: Mr. Frank Doyle, Conference Chair		PLENARY I: FULFILLING THE PROMISE – DEVELOPMENTS WITHIN THE PACIFIC RIM Room: Regency E & F Chair: Dr. Peter Lyons, Assistant Secretary for Nuclear Energy, USDOE	
08:05-08:10 WELCOMING REMARKS Mr. Jacques Plourde (President, Canadian Nuclear Society)		09:05-09:20 PAST, PRESENT, AND FUTURE OF NUCLEAR POWER IN U.S. Dr. Peter Lyons (Assistant Secretary for Nuclear Energy, USDOE)	
08:10-08:15 WELCOMING REMARKS Prof. Atsuyuki Suzuki (President, Pacific Nuclear Council)		09:20-09:35 A JAPAN'S CHALLENGE – TOWARDS CREATING A MOST ROBUST NUCLEAR ENERGY FUTURE Prof. Atsuyuki Suzuki (Senior Scientific Advisor, JAEA)	
08:12-08:20 WELCOMING REMARKS Dr. John Barrett (President & CEO, CNA)		09:35-09:50 STRATEGIES FOR ENSURING THE FUTURE OF NUCLEAR ENERGY Mr. Tom Mitchell (President & CEO, Ontario Power Generation)	
08:20-08:30 WELCOMING REMARKS AND INTRODUCTION OF THE HON. KELLY BLOCK Mr. Tim Gitzel (Honorary Conference Chair and President & CEO, Cameco)		09:50-10:20 Break: Regency A & B, Foyer, Balmoral	
08:15-08:30 KEYNOTE ADDRESS 1 The Hon. Kelly Block (M.P., Parliamentary Secretary to the Minister of Natural Resources)		10:20-10:35 THE CURRENT STATUS AND PROSPECT OF NUCLEAR POWER IN CHINA Mr. Suo Wei, Vice President, (State Nuclear Power Technology Corporation (China))	
		10:35-10:50 PRESENT AND FUTURE OF KOREAN NUCLEAR POWER Mr. Kye-Hong Min (Executive Vice Chairman, KAIF)	
		10:50-11:05 NUCLEAR ENERGY IN THE NEAR FUTURE IN MEXICO Dr. Lydia Paredes (General Director, Instituto Nacional de Investigaciones Nucleares, México), Mr. Javier Palacios (Instituto Nacional de Investigaciones Nucleares, México)	
		11:05-11:30 QUESTIONS AND ANSWERS	
		KEYNOTE ADDRESS 2: 11:30-12:00 THE GROWTH OF NUCLEAR POWER IN THE PACIFIC AND THE IAEA'S SUPPORT FOR ITS DEVELOPMENT Dr. Alexander Bychkov (Deputy Director General, IAEA)	

SESSION 1A5-1:**ESTABLISHING NEW BUILD REQUIREMENTS INCLUDING SAFETY***Track 5: Deploying New Reactors and Building to Time*

Room: Regency E

Chairs: Mike Godfrey, Westinghouse & Stephen Yu, Candu Energy Inc.

- 14:00-14:20 **81. IAEA SAFEGUARDS IN NEW NUCLEAR FACILITIES**
A. Catton (IAEA), K. Durbin (U.S. Dept of Energy), A. Hamilton (IAEA), E. Martikka (STUK, Finland), S. Poirier, J. Sprinkle, R. Stevens (IAEA), J. Whitlock (Atomic Energy of Canada Limited)
- 14:20-14:40 **235. A COMPARISON OF SAFETY CLASSIFICATION TERMINOLOGY FOR NUCLEAR POWER PLANTS**
S. Xu, A. Blahoiaru, G. Frappier (Canadian Nuclear Safety Commission)
- 14:40-15:00 **219. COOPERATION IN REACTOR DESIGN EVALUATION AND LICENSING (CORDEL)**
B. Kaufner, A. Wasylyk (World Nuclear Association)
- 15:00-15:20 **372. DESIGN REQUIREMENTS FOR NEW NUCLEAR REACTOR FACILITIES IN CANADA (FOCUS ON IMPORTANT IMPROVEMENTS FROM RD-337 VERSION 1 OF 2008)**
S. Shim, C. Harwood, M. Y. Ohn, Y. C. Liu, T. Young (Canadian Nuclear Safety Commission)
- 15:20-15:40 **196. SCIENTIFIC AND TECHNICAL INFORMATION AS A SOURCE FOR IAEA SAFEGUARDS STATE EVALUATION**
M. Barletta, Y. Feldman, M. Ferguson (International Atomic Energy Agency)

SESSION 1A10-2:**SECURING MEDICAL BENEFITS***Track 10: Acquiring Medical and Biological Benefits*

Room: Regency F

Chairs: Donald Higson, Australian Nuclear Association & Nicholas Priest, Atomic Energy of Canada Limited

- 14:00-14:20 **190. THE NRU REACTOR: PAST, PRESENT & FUTURE**
M. Floyd (Atomic Energy of Canada Limited), D. Banks (Canadian Neutron Beam Centre), J. Carver, T. Leung, W. TerMarsch, F. Van Hoof, L. Walters, N. Wang (Atomic Energy of Canada Limited)
- 14:20-14:40 **110. ACTIONS NEEDED TO ENSURE A RELIABLE SUPPLY OF 99MO AND 99MTC?**
R. Cameron, P. Peykov (OECD Nuclear Energy Agency)
- 14:40-15:00 **324. CANADA'S ONGOING ROLE IN GLOBAL MEDICAL ISOTOPE SUPPLY**
R. Wiens (Nordion (Canada) Inc.)
- 15:00-15:20 **123. DESIGN AND SIMULATION OF A SMALL DENSE PLASMA FOCUS DEVICE FOR PRODUCTION OF SHORT-LIVED RADIOISOTOPES FOR POSITRON EMISSION TOMOGRAPHY**
R. Alibazi Behbahani (University of Saskatchewan), S. Wolfe (Plasmionique, Inc.), A. Hirose, C. Xiao (University of Saskatchewan)

15:20-15:40

161. THE SYLVIA FEDORUK CANADIAN CENTRE FOR NUCLEAR INNOVATION: ADVANCING KNOWLEDGE THROUGH PARTNERSHIPS

N. Alexander, J. Root (Sylvia Fedoruk Canadian Centre for Nuclear Innovation), K. Chad (University of Saskatchewan), G. Berezna (University of Ontario Institute of Technology), M. Dalzell (Sylvia Fedoruk Canadian Centre for Nuclear Innovation)

Session 1A6-3:**MANAGEMENT, OPERATIONS AND SAFETY***Track 6: Mining, Fuel and Fuel Cycles*

Room: Plaza A

Chairs: Paul Chan, Royal Military College of Canada & Brent Lewis, University of Ontario Institute of Technology

- 14:00-14:20 **101. ADVANCED BWR FUEL DESIGNS – INCREASING RELIABILITY, OPERATING MARGIN, AND FUEL EFFICIENCY FOR GLOBAL BWR OPERATIONS**
N. Garner, S. Cole (AREVA Inc), R. Graebert, D. Bender (AREVA GmbH), N. Teboul, P. Mollard (AREVA NP)
- 14:20-14:40 **131. BWR FUEL LATTICE ANALYSIS FOR A GOOD 3D PERFORMANCE**
A. Castillo, J. J. Ortiz-Servin, J. L. Montes-Tadeo, R. Perusqui-Del-Cueto (INSTITUTO NACIONAL DE INVESTIGACIONES NUCLEARES)

14:40-15:00

135. MARGIN IMPROVEMENT INITIATIVES: REALISTIC APPROACHES

P. Chan, S. Paquette (Royal Military College of Canada), T. Cunniff (Director Nuclear Safety, Department of National Defence), C. French, H. Bonin (Royal Military College of Canada), M. Pandey (University of Waterloo), M. Murchie (Cameco Fuel Manufacturing)

15:00-15:20

163. ANALYSIS OF CS-137 TO CS-134 ACTIVITY RATIO FOR FAILED FUEL EXPOSURE ESTIMATION

R. T. Chiang (Energy Engineering Service LLC), B. C. Cheng (Electric Power Research Institute)

Session 1A1-4:**ACCIDENT MANAGEMENT - ANALYSIS (I)***Track 1: Enhancing Safety, and Security*

Room: Plaza B

Chairs: Quanmin Lei, Canadian Nuclear Safety Commission & Jong Yeob Jung, Korea Atomic Energy Research Institute

14:00-14:20

23. IMPROVEMENTS OF INTERFACIAL DRAG MODEL FOR THE RECTANGULAR NARROW CHANNEL REFLOODING SIMULATION BASED ON THE RELAP5/MOD3

S. Liu, W. Zeng (Nuclear Power Institute of China)

14:20-14:40

76. A PROBABILISTICS SAFETY ASSESSMENT OF ULTIMATE RESPONSE GUIDELINES OF MAANSHAN NUCLEAR POWER PLANT

P. Y. Wang (National Tsing Hua University), M. Lee (National Tsing Hua University), C. C. Chao (Institute of Nuclear Energy Research)

Monday August 25		Monday August 25	
Technical Sessions		Technical Sessions	
14:40-15:00	413. BRUCE NGS A LOSS OF FLOW ANALYSIS FOR EFFECTIVENESS OF LEVEL 2 DEFENCE-IN-DEPTH PROVISIONS <i>W. Won (AMEC NSS), Y. Jiang, M. Kwee, J. Xue (Bruce Power)</i>	15:00-15:20	328. IN SITU NEUTRON REFLECTOMETRY STUDY OF HYDROGEN ABSORPTION BY ZIRCONIUM DURING CATHODIC POLARIZATION <i>J. J. Noel (University of Western Ontario), J. M. Smith (Atomic Energy of Canada Limited), M. Vezvaie, Z. Tun (Canadian Neutron Beam Centre)</i>
15:00-15:20	409. COMPARISON OF FUZZY SET DEFINITION FOR HYDROGEN FLAMMABILITY DURING A SEVERE ACCIDENT <i>S. H. Park, K. I. Ahn, Y. H. Jin (Korea Atomic Energy Research Institute), E. H. Suh (Mokwon University)</i>	15:20-15:40	364. PROPERTY MEASUREMENTS AND INNER STATE ESTIMATION OF SIMULATED FUEL DEBRIS <i>S. Hirooka, M. Kato, K. Morimoto, T. Washiya (Japan Atomic Energy Agency)</i>
Session 1A1-5: ACCIDENT MANAGEMENT - EXPERIMENTS (I) <i>Track 1: Enhancing Safety, and Security</i> Room: Plaza C Chairs: Kathrin Agethen, Ruhr-Universität Bochum & Zhe (Rita) Liang, Atomic Energy of Canada Limited		Session 1A1-6: ACCIDENT MANAGEMENT - SPENT FUEL POOL SAFETY & PLANT SECURITY <i>Track 1: Enhancing Safety, and Security</i> Room: Georgia A Chairs: Thambiayah Nitheanandan, AECL & Wieland Holzer, TÜV SÜD Industrie Service GmbH	
14:00-14:20	186. STRESS ANALYSIS OF FEEDER BENDS USING NEUTRONS: NEW RESULTS AND CUMULATIVE IMPACTS <i>D. Banks, R. Donabarger (Canadian Neutron Beam Centre), B. Leitch (Atomic Energy of Canada Limited), R. Rogge (Canadian Neutron Beam Centre)</i>	14:00-14:20	43. THERMAL ANALYSES FOR THE SPENT FUEL POOL OF TAIWAN BWR PLANTS DURING THE LOSS OF COOLING ACCIDENT <i>C. Bo-Yan, Y. Chia-Lin, W. Wei-Che, C. Yen-Shu (Institute of Nuclear Energy Research, Taiwan)</i>
14:20-14:40	188. CHF ENHANCEMENT APPROACHES OF A 37-ELEMENT FUEL BUNDLE <i>J. H. Park, J. Y. Jung, E. H. Ryu (Korea Atomic Energy Research Institute)</i>	14:20-14:40	83. LOSS OF COOLING ACCIDENT SIMULATION OF NUCLEAR POWER STATION SPENT-FUEL POOL <i>M. Lee (National Tsing Hua University), K. S. Liang (National Tsing Hua University), K. Y. Lin (Taiwan Power Company)</i>
14:40-15:00	274. THE SENSITIVITY OF NEUTRON SCATTERING TO HYDROGEN IN NUCLEAR FUEL <i>M. Gharghour, R. Donabarger (Canadian Neutron Beam Centre), N. Wang, S. Hibbins (Atomic Energy of Canada Limited)</i>		
14:40-15:00	197. FINITE ELEMENT ANALYSIS OF HEAT TRANSFER BETWEEN SPENT CANDU FUEL BUNDLES IN SPENT FUEL POOLS <i>C. Krasnaji, W. Grant (Canadian Nuclear Safety Commission)</i>	15:00-15:20	200. CYBER SECURITY FOR REMOTE MONITORING AND CONTROL OF SMALL REACTORS <i>D. Trask (Atomic Energy of Canada Limited), C. H. Jung (Canadian Nuclear Safety Commission), M. MacDonald (Atomic Energy of Canada Limited)</i>
15:20-15:40	201. DISTRIBUTED SECURITY FRAMEWORK FOR MODERN WORKFORCE <i>G. Balatsky, C. Scherer (Los Alamos National Laboratory)</i>		
Session 1A2-7: AGEING MANAGEMENT <i>Track 2: Improving Operation and Maintenance</i> Room: Georgia B Chairs: Won-Pil Baek, KAERI & John Roberts, CNS		Session 1A7-9: SCWR GENERAL <i>Track 7: Developing New Technology and Applications</i> Room: Oxford Chairs: Daniel Brady, Natural Resources Canada & Thomas Schulenberg, Karlsruhe Institute of Technology	
14:20-14:40	25. OECD/NEA MULTI-LATERAL COOPERATION IN THE AREA OF STRUCTURAL INTEGRITY & AGING MANAGEMENT <i>A. Breest (OECD Nuclear Energy Agency), K. Gott (MATSAFE AB), B. Lydell (Sigma-Phase Inc., OECD), J. Riznic (Canadian Nuclear Safety Commission)</i>	15:00-15:20	164. PWSCC EXPERIENCES AND MANAGEMENT IN KOREA <i>K. Lee, S. Lee, H. S. Chung, J. Yang, J. Lee (Korea Hydro and Nuclear Power Co. Ltd.)</i>
14:40-15:00	229. CONDITION MONITORING ASSESSMENT OF RISK INFORMED THINNING RATE OF DARLINGTON FEEDERS <i>M. Li (Ontario Power Generation Inc.)</i>	15:20-15:40	418. DEVELOPMENT AND IMPLEMENTATION OF THE HEAVY WATER PROGRAM AT BRUCE POWER <i>R. Davloor, C. Bourassa (Bruce Power)</i>
14:00-14:20	363. BUILDING GENERATION FOUR: RESULTS OF CANADIAN RESEARCH PROGRAM ON GENERATION IV ENERGY TECHNOLOGIES <i>T. Anderson (Natural Sciences and Engineering Research Council of Canada), L. K. H. Leung, D. Guzonas (Atomic Energy of Canada Limited), D. Brady, J. Poupore (Natural Resources Canada), W. Zheng (CanmetMATERIALS)</i>		
14:20-14:40	107. OVERVIEW AND PROGRESS IN THE EUROPEAN PROJECT: "SUPERCRITICAL WATER REACTOR - FUEL QUALIFICATION TEST" <i>R. Mariana (Centrum vyzkumu Rez), T. Schulenberg (Karlsruhe Institute of Technology), D. Visser (NRG), C. Maraczy (MTA EK), A. Toivonen (Kemistintie), A. Kiss (BME), R. Novotny (JRC, Institute for Energy and Transport)</i>		

- 14:40-15:00 **142. REACTOR CORE AND PASSIVE SAFETY SYSTEMS DESCRIPTIONS OF A NEXT GENERATION PRESSURE TUBE REACTOR – MECHANICAL ASPECTS**
M. Yetisir, M. Gaudet, D. Rhodes, H. Hamilton, J. Pencer (Atomic Energy of Canada Limited)
- 15:00-15:20 **56. THERMALHYDRAULICS AND SAFETY RESEARCH IN SUPPORT OF PHASE-II OF THE CANADIAN GENERATION-IV NATIONAL PROGRAM**
L. K. H. Leung (Atomic Energy of Canada Limited)
- 15:20-15:40 **220. AN INTEGRATED APPROACH TO SELECTING MATERIALS FOR FUEL CLADDING IN ADVANCED HIGH-TEMPERATURE REACTORS**
C. Rangacharyulu (University of Saskatchewan), D. Guzonas, J. Pencer, A. Nava-Dominguez, L. K. H. Leung (Atomic Energy of Canada Limited)

Session 1A4-10: RADIOACTIVE WASTE MANAGEMENT (I)

Track 4: Environmental Protection and Waste Management

Room: Prince of Wales

Chairs: **K. Dormuth, CNS &
L. Dimitrovski, ANSTO**

- 14:00-14:20 **378. AN OVERVIEW OF RADIOACTIVE WASTE MANAGEMENT IN CANADA**
S. Liblong, C. F. Wong (Atomic Energy of Canada Limited)
- 14:20-14:40 **165. CANADA'S DEEP GEOLOGICAL REPOSITORY FOR USED NUCLEAR FUEL – SITE SELECTION PROCESS UPDATE**
J. A. Facella (Nuclear Waste Management Organization)

- 14:40-15:00 **150. CANADA'S DEEP GEOLOGICAL REPOSITORY FOR USED NUCLEAR FUEL –THE GEOSCIENTIFIC SITE EVALUATION PROCESS**
M. B. Belfadhel, A. Blyth, A. Desroches, S. Hirschorn, J. McKelvie, M. Sanchez-Rico Castejon, A. Parmenter, A. Urrutia-Bustos, A. Vorauer (NWMO)

- 15:00-15:20 **406. NEW CHALLENGES IN THE SAFETY ASSESSMENT OF RADIOACTIVE WASTE STORAGE AND DISPOSAL FACILITIES IN THE RUSSIAN FEDERATION**
I. Linge, S. Utkin (Nuclear Safety Institute (IBRAE RAN))

- 15:20-15:40 **265. PERFORMANCE ASSESSMENT FOR PROPOSED DISPOSAL OF NORM AT AN EXISTING LANDFILL IN NEW SOUTH WALES, AUSTRALIA**
S. Fountain (Geosyntec Consultants, Inc.), J. Jones (SITA Australia), J. Christopherson, C. Drummond (Geosyntec Consultants, Inc.), R. Bruce, D. Duffy (Geosyntec Consultants Sdn. Bhd.), J. Beech (Geosyntec Consultants, Inc.)

Session 1A8-12: PUBLIC COMMUNICATION LESSONS FROM FUKUSHIMA

Track 8: Addressing Public Concerns about Radiation Impacts

Room: Brighton

Chairs: **Jason Donev, University of Calgary &
Laura Scheele, Energy Northwest**

- 14:00-14:20 **149. MEDIA COVERAGE OF FUKUSHIMA ACCIDENT IN THE RUSSIAN PRESS - LESSONS FOR RADIATION EMERGENCY RISK COMMUNICATION**
E. Melikhova, R. Arutyunyan (Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE))
- 14:20-14:40 **291. WHAT DOES "NUCLEAR POWER VILLAGE" REPRESENT IN THE NEWSPAPER ARTICLES?**
I. Takenaka (The University of Tokyo), H. Kimura (Public Outreach, Non-Profit)
- 14:40-15:00 **289. DEVELOPMENT OF A COMMUNICATION METHOD IN WHICH EXPERTS AND CITIZENS RESPECT EACH OTHER**
H. Kimura (Public Outreach, Non-Profit), I. Takenaka (The University of Tokyo), S. Tsuchida (Kansai University)
- 15:00-15:20 **405. SOCIOLOGICAL ASPECTS OF 3.11 FUKUSHIMA DAIICHI ACCIDENT AFTERMATH AND THE GENSHIRYOKU-MURA (NUCLEAR VILLAGE, OR PRO-NUCLEAR CONCESSION SECTOR)**
T. Sawada (Tokyo Institute of Technology)

MONDAY AFTERNOON BREAK

Room: **Regency A & B, Foyer, Balmoral**
 Time: 15:20-15:50

Session 1B5-1: NEW BUILD DESIGN AND SAFETY REQUIREMENTS

Track 5: Deploying New Reactors and Building to Time

Room: Regency E

Chairs: **Stephen Yu, Candu Energy Inc. &
Milton Caplan, MZ Consulting Inc.**

- 16:00-16:20 **250. A COMPARISON OF THE DIFFERENCE OF REQUIREMENTS BETWEEN FUNCTIONAL SAFETY AND NUCLEAR SAFETY CONTROLLERS**
C. K. Chen, C. L. Lee, S. S. Shyu (Institute of Nuclear Energy Research)
- 16:20-16:40 **320. TESTING AND QUALIFICATION OF CONFIDENCE IN STATISTICAL PROCEDURES**
D. Serghiuta, J. Tholammakkil, N. Hammouda (Canadian Nuclear Safety Commission), A. O'Hagan (Sheffield University, UK)
- 16:40-17:00 **285. BARRIER EVALUATIONS FOR FIRE PROTECTION ASSESSMENTS**
G. Roach (PLC Fire Safety Solutions), L. Morrison (Professional Loss Control)
- 17:00-17:20 **423. CANADIAN AND INTERNATIONAL APPROACHES TO REGULATORY EFFECTIVENESS**
R. Lojk (Canadian Nuclear Safety Commission)

Session 1B7-2:**SODIUM FAST REACTORS***Track 7: Developing New Technology and Applications*

Room: Regency F

Chairs: Ser Gi HONG, Kyung Hee University & Guanheng Zhang, University of California Berkeley

16:00-16:20 **60. NEUTRONIC DESIGN OF ADVANCED SODIUM COOLED TRU BURNER CORES USING MODERATOR RODS AND ABSORBER REGION**D. Y. KIM, S. G. HONG
(Kyung Hee University)16:20-16:40 **66. COMPARISON OF KANEXT AND SERPENT FOR FUEL DEPLETION CALCULATIONS OF A SODIUM FAST REACTOR**R. C. López-Solis, J. L. Francois
(Universidad Nacional Autónoma de México), M. Becker, V. H. Sánchez-Espinoza (Karlsruhe Institute of Technology)16:40-17:00 **239. SODIUM FAST REACTORS WITH BREED AND BURN BLANKET**

G. Zhang, E. Greenspan, A. Jolodovsky, J. Vujic (University of California Berkeley)

17:00-17:20 **365. DEVELOPMENT OF SCIENCE-BASED FUEL TECHNOLOGIES FOR JAPAN'S SODIUM-COOLED FAST REACTORS**M. Kato, S. Hirooka, Y. Ikusawa, K. Takeuchi, M. Akashi, K. Maeda, M. Watanabe, A. Komeno, K. Morimoto
(Japan Atomic Energy Agency)17:20-17:40 **225. U.S. - ROK POSSIBLE COOPERATION IN THE DEVELOPMENT OF SODIUM FAST REACTORS**C. Braun, R. Forrest
(Stanford University)17:40-18:00 **35. BENCHMARK STUDY FOR CRITICAL EXPERIMENTS**E. Mitenkova, N. Novikov
(Nuclear Safety Institute Russian Academy of Sciences)**Session 1B6-3:****DESIGN AND REACTOR PHYSICS***Track 6: Mining, Fuel and Fuel Cycles*

Room: Plaza A

Chairs: Brent Lewis, University of Ontario Institute of Technology & Engin Özberk, IMII

16:00-16:20 **177. CANDU FLEXIBLE AND ECONOMICAL FUEL TECHNOLOGY IN CHINA**

C. Mingjun (CNNC Nuclear Power Operation Management Co.), Z. Zhenhua, M. Zhiliang (CNNC Third Qinshan Nuclear Power Co.), C. M. Cottrell, S. Kuran (Candu Energy Inc.)

16:20-16:40 **231. POWER FLATTENING AND BREEDING PERFORMANCE STUDY FOR UCFR LOADING THORIUM FUEL**

T. Tak, J. Choe, D. Lee (Ulsan National Institute of Science and Technology)

16:40-17:00 **283. CALCULATION OF THE RADIAL AND AXIAL FLUX AND POWER DISTRIBUTION FOR A CANDU 6 REACTOR WITH BOTH THE MCNP6 AND SERPENT CODES**

M. Hussein, H. Bonin (Royal Military College of Canada), B. Lewis (University of Ontario Institute of Technology)

17:00-17:20 **284. BURNUP CALCULATION OF A CANDU6 REACTOR - USING THE SERPENT AND MCNP6 CODES**

M. Hussein, H. Bonin (Royal Military College of Canada), B. Lewis (University of Ontario Institute of Technology)

17:20-17:40 **268. NON-FOURIER VERNOTTE-CATTANEO NUMERICAL MODEL FOR HEAT CONDUCTION IN A BWR FUEL ROD**

E. G. Espinosa-Martínez, A. Vázquez-Rodríguez, J. R. Varela-Ham, G. Espinosa-Paredes (Universidad Autónoma Metropolitana-Iztapalapa)

17:40-18:00 **14. RECOVERY OF PLUTONIUM FROM ANALYTICAL LIQUID WASTE IN RRP**G. Okude, H. Okunoya, S. Matsuoka, Y. Niitsu, K. Suzuki
(Japan Nuclear Fuel Limited)**Session 1B1-4:****ACCIDENT MANAGEMENT - ANALYSIS (II)***Track 1: Enhancing Safety and Security*

Room: Plaza B

Chairs: Sergei Petoukhov, Atomic Energy of Canada Limited & Won Jae Lee, Korea Atomic Energy Research Institute

16:00-16:20 **145. MODELING A BWR VENT LINE USING RELAP5**

M. Ceceñas-Falcón, R. Ovando-Castelar, J. E. Rivera-Ortega (Instituto de Investigaciones Eléctricas)

16:20-16:40 **151. A METHODOLOGY TO DEVELOP INDIVIDUAL PLANT EXAMINATION (BACK-END ANALYSIS) FOR BOILING WATER REACTORS**

J. Arellano-Gomez, R. Rea-Soto, S. Sandoval-Valenzuela, R. Calixto-Rodríguez (Instituto de Investigaciones Eléctricas)

16:40-17:00 **153. SIMILARITY ANALYSIS WITH PCCS-AP CODE SIMULATION FOR PASSIVE PWR CONTAINMENT TEST FACILITY DESIGN**

Z. Zhou (Tsinghua University), Y. Zhang (Xiamen University), Y. Yang (State Nuclear Power Technology R&D Center)

17:00-17:20 **193. NUMERICAL ANALYSIS FOR FLOW DISTRIBUTION IN ACE7 FUEL ASSEMBLIES AFFECTED BY A SPACER GRID DEFORMATION**

J. P. Park (Korea Atomic Energy Research Institute), S. W. Hwang, J. H. Jeong (Pusan National University)

17:20-17:40 **217. AN SBLOCA TEST ON THE SIS LINE BREAK WITH THE VISTA-ITL FACILITY AND ITS SIMULATION WITH THE MARS-KS CODE**

H. S. Park (Korea Atomic Energy Research Institute), D. H. Kang (System Engineering & Technology Co., Ltd.), Y. G. Jung, H. Bae, S. U. Ryu (Korea Atomic Energy Research Institute), J. S. Suh (System Engineering & Technology Co., Ltd.), S. J. Yi (Korea Atomic Energy Research Institute)

Session 1B1-5:**ACCIDENT MANAGEMENT - EXPERIMENTS (II)***Track 1: Enhancing Safety and Security*

Room: Plaza C

Chairs: Thambiayah Nitheanandan, Atomic Energy of Canada Limited & Meng Lin, Shanghai Jiaotong University

- 16:00-16:20 **211. FUEL CRACKING IN RELATION TO FUEL OXIDATION IN SUPPORT OF AN OUT-REACTOR INSTRUMENTED DEFECTED FUEL EXPERIMENT**

A. Quastel, C. Thiriet (Atomic Energy of Canada Limited),
B. Lewis, E. Corcoran (Royal Military College of Canada)

- 16:20-16:40 **290. EXPERIMENTAL STUDY ON DOWNWARD TWO-PHASE FLOW IN NARROW RECTANGULAR CHANNEL**

T. H. Kim, J. H. Jeong (Pusan National University)

- 16:40-17:00 **212. ROLES OF TEXTURE OF ZR ALLOYS IN ZRO₂ FILM FORMATION AND HYDRIDE ORIENTATION NEAR ZRO₂/ZR INTERFACE**

W. Qin, J. A. Szpunar (University of Saskatchewan), J. Kozinski (York University)

- 17:00-17:20 **294. AN OECD/NEA ATLAS INTERNATIONAL PROJECT FOR THERMAL-HYDRAULIC SAFETY IMPROVEMENT**

K. Y. Choi, K. H. Kang, J. Kim, Y. Park, B. U. Bae, C. H. Song (Korea Atomic Energy Research Institute)

17:20-17:40

- 356. PRELIMINARY TEST RESULTS AND CFD ANALYSIS FOR MODERATOR CIRCULATION TEST AT KOREA**

H. T. Kim (Korea Atomic Energy Research Institute), S. Im, H. J. Sung (Korea Advanced Institute of Science and Technology), H. Seo, I. C. Bang (Ulsan National Institute of Science and Technology)

17:40-18:00

- 276. IN-SITU NEUTRON DIFFRACTION STUDY OF ZIRCALOY 4 SUBJECTED TO BIAXIAL TENSION**

M. Gharghour (Canadian Neutron Beam Centre), D. McDonald, L. Xiao (Atomic Energy of Canada Limited)

Session 1B1-6:**ACCIDENT MANAGEMENT - SEISMIC ANALYSIS AND MATERIAL BEHAVIOUR***Track 1: Enhancing Safety and Security*

Room: Georgia A

Chairs: Engin Özberk, IMII & Ron Rogge, Canadian Neutron Beam Centre

16:00-16:20

- 69. NUMERICAL INVESTIGATIONS ON THE SEVERE LOAD CASES EARTHQUAKE AND TURBINE DISC BURST**

W. Holzer, B. Buchmeier (TÜV SÜD Industrie Service GmbH)

✓ 16:20-16:40

- 195. EARTHQUAKE RESISTANCE OF CRACKED CONCRETE EMBEDDED WITH LARGE SIZE REBARS (D43 AND D57) IN NUCLEAR CONTAINMENT**

Y. C. Kan (Chaoyang University of Technology), K. C. Pei (Institute of Nuclear Energy Research)

✓ 16:40-17:00

- 380. SEISMIC FRAGILITY ANALYSIS OF THE BLOCK MASONRY WALL IN NUCLEAR POWER PLANTS**

Z. Wang, M. D. Pandey, W. C. Xie (University of Waterloo)

17:00-17:20

- 207. AN EVALUATION OF THE INCREASE IN FEEDWATER FLOW EVENT WITH A COMMON-CAUSE FAILURE IN THE SAFETY I&C SYSTEMS**

G. c. Lee, J. J. Kim, S. W. Kim (KEPCO Engineering & Construction Company, Inc)

Session 1B2-7:**MATERIALS AND CORROSION***Track 2: Improving Operation and Maintenance*

Room: Georgia B

Chairs: Jacques Plourde, President, Canadian Nuclear Society & Joo Hwan Park, Korea Atomic Energy Research Institute

16:00-16:20

- 90. CRACK OF REACTOR VESSEL UPPER HEAD PENETRATION NOZZLES IN KOREAN NUCLEAR PLANTS**

E. DOH, T. s. LEE, J. y. KIM, C. h. LEE (KEPCO Plant Service and Engineering Co., Ltd.)

16:20-16:40

- 192. STRESS CORROSION CRACKING MITIGATION BY ULTRASOUND INDUCED CAVITATION TECHNIQUE**

C. Fong, Y. C. Lee (Industrial Technology Research Institute), T. K. Yeh (National Tsing Hua University, Taiwan)

16:40-17:00

- 143. SIMULATION OF TOTAL LIFTOFF IN RESPONSE TO PLANT OPERATIONAL PARAMETERS FOR A BWR ON OLN**

M. Pop, L. Lamanna (AREVA, Inc.), C. Gregorich (Formerly with AREVA, Inc.), A. Hoornik (AREVA, Inc.)

17:00-17:20

- 269. EFFECT OF PH AND WATER RADIOLYSIS ON CORROSION OF INCONEL ALLOY 600 AT 150°C**

A. Y. Musa (Western University), J. C. Wren (Western University, Ontario, Canada)

17:20-17:40

- 272. EFFECT OF WATER RADIOLYSIS ON CORROSION OF CO-CR ALLOY**

M. Behazin, J. Noël, J. C. Wren (Western University)

17:40-18:00

- 323. DATABASE AND PREDICTION MODEL FOR CANDU PRESSURE TUBE DIAMETER**

J. Y. Jung, J. H. Park (Korea Atomic Energy Research Institute)

Session 1B7-9:**SCWR NEUTRONIC***Track 7: Developing New Technology and Applications*

Room: Oxford

Chairs: Adriaan Buijs, McMaster U. & Gilberto Espinosa-Paredes, Universidad Autónoma Metropolitana-Iztapalapa

16:00-16:20

- 166. THERMAL NEUTRON SCATTERING CROSS SECTION MEASUREMENTS OF NORMAL AND SUPERCRITICAL WATER**

G. Bentoumi, G. Li, L. Li, B. Sur (Atomic Energy of Canada Limited)

- 16:20-16:40 **403. PARAMETERS FOR TRANSIENT RESPONSE MODELING FOR THE CANADIAN SCWR**
J. Pencer, M. McDonald, V. Anghel (Atomic Energy of Canada Limited)
- 16:40-17:00 **204. A SIMPLIFIED 3D DRAGON SIMULATION OF AN INCLINED REACTIVITY CONTROL DEVICE FOR THE CANADIAN-SCWR**
H. Raouafi, G. Marleau (École Polytechnique de Montréal)
- 17:00-17:20 **266. TEMPERATURE FEEDBACK EFFECTS IN A SUPERCRITICAL WATER REACTOR CONCEPT WITH MULTIPLE HEAT-UP STEPS**
A. Barragán-Martínez (Universidad Nacional Autónoma de México), G. Espinosa-Paredes (Universidad Autónoma Metropolitana-Iztapalapa), A. Vázquez-Rodríguez, C. Martin-del-Campo, J. François (Universidad Nacional Autónoma de México)
- 17:20-17:40 **411. PRELIMINARY SPACE-TIME KINETICS SIMULATION OF A COOLANT VOIDING-INDUCED TRANSIENT FOR A SUPERCRITICAL WATER COOLED REACTOR WITH RE-ENTRANT FUEL CHANNELS**
P. Schwanke, E. Nichita (University of Ontario Institute of Technology)

Session 1B4-10: RADIOACTIVE WASTE MANAGEMENT (II)

Track 4: Environmental Protection and Waste Management

Room: Prince of Wales

Chairs: K. Dormuth, CNS &
L. Dimitrovski, ANSTO

- 16:00-16:20 **31. POSTCLOSURE SAFETY ASSESSMENT OF A USED FUEL REPOSITORY IN SEDIMENTARY ROCK**
M. Gobien, F. Garisto, N. Hunt, E. Kremer (Nuclear Waste Management Organization)
- 16:20-16:40 **263. CURRENT ISSUES IN THE TRANSPORT OF RADIOACTIVE WASTE AND SPENT FUEL: WORK BY THE WORLD NUCLEAR TRANSPORT INSTITUTE**
H. J. Neau, B. Bonnardel-Azzarelli (World Nuclear Transport Institute)
- 16:40-17:00 **114. FINITE ELEMENT MODELING OF COPPER COATED USED FUEL CONTAINERS FOR LONG-TERM STORAGE IN A DEEP GEOLOGICAL REPOSITORY**
C. Boyle (Nuclear Waste Management Organization), S. Meguid (University of Toronto)
- 17:00-17:20 **32. IMPACT OF COLLOID FORMATION ON SAFETY ASSESSMENT OF WASTE DISPOSAL IN BRINE**
S. Nagasaki (McMaster University)
- 17:20-17:40 **394. ASSESSING THE EFFECTS OF COOLING WATER DISCHARGES TO THE ENVIRONMENT**
D. Kim, N. Ali, J. Moreno-Colacci (Environment Canada)

Session 1B8-12: PUBLIC ACCEPTANCE

Track 8: Addressing Public Concerns about Radiation Impacts

Room: Brighton

Chairs: Mimi Limbach, Managing Partner,
Potomac Communications Group, Inc.
& Jeremy Whitlock, Atomic Energy of
Canada Limited

- 16:00-16:20 **58. IT TAKES A COMMUNITY TO ENGAGE A COMMUNITY: A MODEL FOR PUBLIC ENGAGEMENT ABOUT THE IMPACTS OF NUCLEAR RESEARCH AND DEVELOPMENT**
M. Dalzell, M. Main, J. Root (Sylvia Fedoruk Canadian Centre for Nuclear Innovation)
- 16:20-16:40 **59. NUCLEAR 101, A COURSE ON THE NUCLEAR SECTOR FOR WORKERS IN THE NUCLEAR SECTOR**
J. M. K. C. Donev (University of Calgary), D. Boreham, S. Day (McMaster University), R. Dranga (Atomic Energy of Canada Limited), J. Krasznai, R. Matthews (retired), J. Whitlock (Atomic Energy of Canada Limited)
- 16:40-17:00 **155. THE UNIQUE ROLE OF A PUBLIC POWER AGENCY IN NUCLEAR COMMUNICATIONS**
L. Scheele, J. Dobken (Energy Northwest)
- 17:00-17:20 **6. NUCLEAR KNOWLEDGE, TRUST, AND PUBLIC ACCEPTANCE OF NUCLEAR DEVELOPMENTS**
L. Berdahl, S. Bell, M. Bourassa, J. Fried (University of Saskatchewan)

- 17:20-17:40 **10. SMALL MODULAR REACTORS (SMRS) –THE KEY TO INCREASED SOCIAL ACCEPTANCE OF NUCLEAR POWER?**

H. Sam-Aggrey (Atomic Energy of Canada Limited)

2. 8/26 議程內容

Technical Sessions		Tuesday August 26		Tuesday August 26		Technical Sessions	
Session 2A1-1:		Session 2A1-2:		Session 2A1-3:		Session 2A1-4:	
EMERGENCY PLANNING (I)		SEVERE ACCIDENTS (I)		ACCIDENT MANAGEMENT - UNCERTAINTY ANALYSIS		ACCIDENT MANAGEMENT - ANALYSIS (III)	
<i>Track 1: Enhancing Safety and Security</i>		<i>Track 1: Enhancing Safety and Security</i>		<i>Track 1: Enhancing Safety and Security</i>		<i>Track 1: Enhancing Safety and Security</i>	
Room: Regency E		Room: Regency F		Room: Plaza A		Room: Plaza B	
Chairs: Alexander Barzilov, U. Nevada & Quanmin Lei, Canadian Nuclear Safety Commission		Chairs: Mark Elliott, Ontario Power Generation & Ondrej Beneš, European Commission Institute for Transuranium Elements		Chairs: John Luxat, McMaster University & Arun Nayak, Bhabha Atomic Research Centre		Chairs: Miguel Ceceñas-Falcón, Instituto de Investigaciones Eléctricas & James J. Noel, University of Western Ontario	
08:00-08:20	13. THE ULTIMATE EMERGENCY MEASURES TO SECURE NPPS UNDER AN ACCIDENTAL CONDITION WITH NO DESIGNED POWER OR WATER SUPPLY <i>L. C. Wang, S. C. Chiang (Taiwan Power Company), T. K. S. Liang, Y. F. Hsu, H. J. Young (National Tsing Hua University)</i>	08:20-08:40	51. VALIDATION OF MCCI MODELS IMPLEMENTED IN ASTEC MEDICIS ON OECD CCI-2 AND CCI-3 EXPERIMENTS AND FURTHER CONSIDERATION ON REACTOR CASES <i>K. Agethen, M. Koch (Ruhr-Universität Bochum)</i>	08:00-08:20	111. THE ROLE OF MICROSCOPIC AND MACROSCOPIC TREATMENT OF ERROR SOURCES IN BEST ESTIMATE AND UNCERTAINTY ANALYSIS <i>D. Novog (McMaster University), C. Frepoli (FPoliSolutions, LLC)</i>	08:00-08:20	109. APPLICATION OF THE TRACE THERMAL HYDRAULIC CODE TO MODEL RD-14M FUEL CHANNEL VOIDING DURING LOCA <i>A. Oussoren, A. Delja (Canadian Nuclear Safety Commission)</i>
08:20-08:40	92. ADVANCES IN THE SIMULATION OF PERSONAL PROTECTIVE EQUIPMENT FOR THE MITIGATION OF EXPOSURE TO RADIOACTIVE PARTICULATES <i>M. Roeterink, D. Kelly, E. Dickson, E. Corcoran (Royal Military College of Canada)</i>	08:40-09:00	53. SIMULATION OF BUOYANCY INDUCED GAS MIXING TESTS PERFORMED IN A LARGE SCALE CONTAINMENT FACILITY USING GOTHIC CODE <i>Z. R. Liang, Y. S. S. Chin (Atomic Energy of Canada Limited)</i>	08:20-08:40	319. A STOCHASTIC-DETERMINISTIC APPROACH FOR EVALUATION OF UNCERTAINTY IN THE PREDICTED MAXIMUM FUEL BUNDLE ENTHALPY IN A CANDU POSTULATED LBLOCA EVENT <i>D. Serghiuta, J. Tholammakkil, W. Shen (Canadian Nuclear Safety Commission)</i>	08:20-08:40	172. ACHIEVEMENTS AND LESSONS LEARNED FROM THE HIGH ENERGY LINE BREAK ASSESSMENT OF BRUCE A UNITS <i>X. Duan, M. Kozluk (Candu Energy Inc.), J. Beaton, R. McLean (Bruce Power)</i>
08:40-09:00	160. MANAGING THE 'GAPS' IN A REGIMEN OF CONTROL – OPERATIONAL DECISION MAKING IN NUCLEAR POWER <i>S. J. McDougall (Leading Safety Culture Inc.)</i>	09:00-09:20	391. CANADIAN NUCLEAR POWER PRINCIPLES FOR BEYOND DESIGN BASIS EVENTS - SUPPORTING RATIONALE <i>M. Elliott (Ontario Power Generation), G. Newman (Bruce Power), A. Bhaloo (New Brunswick Power)</i>	08:40-09:00	251. OPTIONS FOR IMPROVEMENT OF THE REACTOR POWER MEASUREMENT SENSITIVITY DURING TRANSIENTS <i>V. Ponomarev, P. Ponomarev (Megawatt Solutions Inc.)</i>	08:40-09:00	322. CLAD THICKNESS EFFECT ON THE CANDU FUEL FAILURE FOLLOWING DESIGN BASIS ACCIDENT <i>J. Y. Jung, J. H. Bae (Korea Atomic Energy Research Institute)</i>
		09:20-09:40	400. EXTERNAL HAZARDS ASSESSMENT FOLLOWING FUKUSHIMA – BRUCE POWER EXPERIENCE <i>R. McLean, J. Higgs, E. Chan (Bruce Power)</i>			09:00-09:20	327. MONTE CARLO EVALUATION OF THE POWER COEFFICIENT OF REACTIVITY IN 3-D CANDU REACTOR <i>M. Motalab, Y. Kim (Korea Advanced Institute of Science and Technology)</i>
						09:20-09:40	353. SUMP WATER USABILITY ANALYSIS FOLLOWING LB LOCA OF CANDU 6 REACTOR <i>M. S. Jang (Nuclear Engineering Service & Solution), S. M. Kim (Korea Hydro and Nuclear Power Co. Ltd.), B. J. Moon, S. R. Kim (Nuclear Engineering Service & Solution)</i>

Session 2A2-5:**INSPECTION / I&C***Track 2: Improving Operation and Maintenance*

Room: Plaza C

Chairs: Paul Spekkens, OPG & Juan Arellano-Gomez, Instituto de Investigaciones Electricas

08:00-08:20 **159. ISOLATED PHASE BUS DUCT SYSTEMS – INSPECTION AND MAINTENANCE BEST PRACTICES**
G. Whitehead (Electrical Builders, Inc.)

08:20-08:40 **375. NON-INTRUSIVE ACCURATE AND TRACEABLE FLOW MEASUREMENTS IN NUCLEAR POWER PLANT SYSTEMS**
A. Gurevich, V. Kanda, B. Sharp, A. Lopez (Advanced Measurement and Analysis Group Inc.), Y. Gurevich (Daystar Technologies Inc.)

08:40-09:00 **104. EVOLUTION OF CANDU PLANT DIGITAL INSTRUMENTATION AND CONTROL**
M. Kattan (Candu Energy Inc.)

09:00-09:20 **103. TECHNICAL HIGHLIGHTS OF THE LATEST UPGRADES TO HITACHI'S G-HIACS V SAFE FUNCTIONAL SAFETY CONTROLLER**
D. Tan, K. Ishii, Y. Otsuka, K. Uemura, M. Suenaga (Hitachi, Ltd.), T. Koyamada (Hitachi Canada)

09:20-09:40 **117. EXPERIENCES AND FIRST RESULTS OF THE OL3 INNER CONTAINMENT IN-SERVICE-INSPECTION SYSTEM**
B. Wienand (AREVA GmbH)

Session 2A5-6:**NEW DEVELOPMENT & DESIGNS INCLUDING FUEL***Track 5: Deploying New Reactors and Building to Time*

Room: Georgia A

Chairs: Sang Shim, Canadian Nuclear Safety Commission & Francesco Venneri, Ultra Safe Nuclear Corporation

08:00-08:20 **54. DYNAMIC THERMO-CHEMO-MECHANICAL STRAIN OF ZIRCALOY-4 SLOTTED RINGS FOR EVALUATING STRATEGIES THAT MITIGATE STRESS CORROSION CRACKING**
G. Ferrier, J. Metzler, M. Farahani, P. Chan, E. Corcoran (Royal Military College of Canada)

08:20-08:40 **332. THE USE OF FULLY CERAMIC MICROENCAPSULATED (FCM) FUEL IN CANDU REACTORS**
F. Venneri (Ultra Safe Nuclear Corporation), W. J. Lee (Korea Atomic Energy Research Institute), C. K. Jo (KAERI)

08:40-09:00 **152. FAST: A COMBINED NOC AND TRANSIENT FUEL PERFORMANCE MODEL USING A COMMERCIAL FEM ENVIRONMENT**
A. Prudil, J. Bell, A. Oussoren, P. Chan (Royal Military College of Canada), B. Lewis (University of Ontario Institute of Technology)

09:00-09:20 **318. A STYLIZED APPROACH FOR EVALUATION OF INCREMENTAL CHANGE IN CANDU ROP/NOP TRIP FUNCTIONAL FAILURE PROBABILITY UNDER AGING CONDITIONS**
D. Serghiuta, J. Tholammakkil (Canadian Nuclear Safety Commission)

09:20-09:40 **307. ENGINEERING JUDGEMENT AND BRIDGING THE FIRE SAFETY GAP IN EXISTING NUCLEAR FACILITIES**
G. Qamheiah, D. Wu (PLC Fire Safety Solutions)

09:40-10:00 **262. A STUDY OF THE PLANNED VALUE ESTIMATION METHOD FOR DEVELOPING EARNED VALUE MANAGEMENT SYSTEM IN THE NUCLEAR POWER PLANT CONSTRUCTION PROJECT**
S. H. Lee (Korea Hydro & Nuclear Power Co., Ltd), B. S. Moon (Korea Hydro & Nuclear Power Co., Ltd), J. Lee (Kong Kwan Protech Co)

Session 2A7-7:**LEAD-COOLED FAST REACTORS AND MOLTEN SALT REACTORS***Track 7: Developing New Technology and Applications*

Room: Georgia B

Chairs: Janne Wallenius, Kungliga Tekniska Högskolan & Imre Pázsit, Chalmers University of Technology

08:00-08:20 **321. A CONCAVE INITIAL CORE TO OPTIMIZE THE REACTIVITY OF BREED-AND-BURN FAST REACTOR (B&BR)**
D. Hartanto, Y. Kim (Korea Advanced Institute of Science and Technology)

08:20-08:40 **24. SEALER-3: A VERY SMALL LEAD FAST REACTOR FOR THE CANADIAN MARKET**
J. Wallenius, J. Ejenstam, P. Szakalos (Kungliga Tekniska Högskolan)

08:40-09:00 **316. DYNAMIC BEHAVIOUR AND NEUTRON NOISE IN MOLTEN SALT REACTORS WITH CIRCULATING PERTURBATIONS**

I. Pázsit, V. Dykin (Chalmers University of Technology)

09:00-09:20 **292. THE DUAL FLUID REACTOR - A NEW CONCEPT FOR A HIGHLY EFFECTIVE FAST REACTOR**

A. Huke, G. Ruprecht, D. Weissbach, S. Gottlieb (Institute for Solid State Nuclear Physics), A. Hussein (University of Northern BC), K. Czernski (Uniwersytet Szczeciński, ul.)

Session 2A7-9:**SCWR MATERIALS AND CHEMISTRY (I)***Track 7: Developing New Technology and Applications*

Room: Oxford

Chairs: Wenye Zheng, CanmetMATERIALS & Sami Penttilä, VTT Technical Research Centre of Finland

08:00-08:20 **129. GRAIN BOUNDARY ENGINEERING IN INCOLOY 800H/HT VIA THERMO-MECHANICAL PROCESSING**
H. Akhiani, M. Nezakat, J. Szpunar (University of Saskatchewan)

08:20-08:40 **154. LITERATURE REVIEW ON THE APPLICATION OF THE INCOLOY 800 FAMILY OF ALLOYS FOR USE AS FUEL CLADDING IN SCW NUCLEAR REACTORS**
Q. Nazarali, X. Huang (Carleton University), D. Guzonas (Atomic Energy of Canada Limited)

08:40-09:00 **275. MICROSCOPY INVESTIGATION ON THE CORROSION OF CANADIAN GENERATION IV SCWR MATERIALS**

J. Li (CanmetMATERIALS), X. Huang (Carleton University), Y. Zeng, W. Zheng (CanmetMATERIALS), O. I. Woo (Atomic Energy Canada Limited), D. Guzonas (Atomic Energy of Canada Limited)

09:00-09:20 **350. OXIDATION RESISTANCE OF THERMO-MECHANICALLY PROCESSED AUSTENITIC STAINLESS STEEL 316L IN SUPER CRITICAL WATER**

M. Nezakat, H. Akhiani (University of Saskatchewan), S. Penttilä (VTT Technical Research Centre of Finland), J. Szpunar (University of Saskatchewan)

09:20-09:40 **354. STRESS-CORROSION CRACKING PROPERTIES OF CANDIDATE FUEL CLADDING ALLOYS FOR THE CANADIAN SCWR: A SUMMARY OF LITERATURE DATA AND RECENT TEST RESULTS**

W. Zheng, Y. Zeng (CanmetMATERIALS), J. Luo (University of Alberta), R. Novotny (JRC, Institute for Energy and Transport), J. Li, B. S. Amirkhiz (CanmetMATERIALS), D. Guzonas (Atomic Energy of Canada Limited), M. Matchim, J. Collier, L. Yang (CanmetMATERIALS)

Session 2A1-10:

SAFETY CULTURE (I)

Track 1: Enhancing Safety and Security

Room: Prince of Wales

Chairs: Kathleen Smith, Atomic Energy of Canada Limited & Ioan Arimescu, AREVA Inc.

08:00-08:20 **184. AREVA CONTRIBUTIONS TO ADVANCED CODES AND DESIGN/LICENSING METHODOLOGIES FOR LWR FUEL**

I. Arimescu (AREVA Inc.), C. Garnier, P. Mailhe (AREVA NP), P. Bellanger, M. H. Smith (AREVA Inc.)

08:20-08:40 **187. SAFETY CULTURE IMPROVEMENTS IN A NUCLEAR LABORATORY SETTING**

K. Smith, J. McKenna (Atomic Energy of Canada Limited)

08:40-09:00 **191. ENHANCED CANDU 6 SAFETY DESIGN IMPROVEMENTS**

S. Yu, A. Lee, M. Soudard (Candu Energy Inc.)

✓ 09:00-09:20 **329. LESSONS LEARNED AND IMPLICATIONS OF THE FUKUSHIMA NPP ACCIDENTS**

A. Tokaihiro (University of Idaho)

09:20-09:40 **379. NRU LICENCE EXTENSION VIA INTEGRATED SAFETY REVIEW**

N. Mantifel (Atomic Energy of Canada Limited)

Session 2A7-12:

SMALL MODULAR REACTORS

Track 7: Developing New Technology and Applications

Room: Brighton

Chairs: Metin Yetisir, Atomic Energy of Canada Limited & Daniel Ingersoll, NuScale Power

08:00-08:20 **88. AN EXPERIMENTAL STUDY ON THE HEAT LOSSES OF THE SMART-ITL FACILITY FOR THE SMART DESIGN BY THREE METHODS**

S. U. Ryu, H. Bae, D. E. Kim, Y. C. Shin, H. S. Park, S. J. Yi (Korea Atomic Energy Research Institute)

08:20-08:40 **209. EXTENDING NUCLEAR ENERGY TO NON-ELECTRICAL APPLICATIONS**

D. Ingersoll, Z. Houghton (NuScale Power), R. Bromm (Fluor Corporation), C. Desportes (Aquatech International), M. McKellar, R. Boardman (Idaho National Laboratory)

08:40-09:00 **227. DESIGN STUDY ON THE EFFECTS OF RELATIVE DIAMETERS IN THE REACTOR VESSEL AND RISER ON THE PERFORMANCE CHARACTERISTICS OF A SMALL MODULAR REACTOR DRIVEN BY NATURAL CIRCULATION**

Y. Kim, K. Yi, S. Hong, B. Lee, S. Baik, Y. Choe, C. Chung (KEPCO Engineering and Construction Company, INC.)

09:00-09:20 **73. PRELIMINARY ANALYSIS OF CREST TEST FACILITY USING CATHARE CODE**

C. Peng, Y. Zan, Y. Zhang, Z. Huang, W. Zhuo, X. Yan (Nuclear Power Institute of China)

09:20-09:40 **382. BALANCE OF PLANT DESIGN ISSUES FOR SMALL REACTORS IN CANADA**

G. Harvel, D. Meneley (University of Ontario Institute of Technology)

Tuesday Morning Break

Room: Regency A & B, Foyer, Balmoral

Time: 09:40-10:10

Session 2B1-1:**RISK ASSESSMENT (I)***Track 1: Enhancing Safety and Security*Room: **Regency E**Chairs: **Dave Trask, Atomic Energy of Canada Limited & Donald Higson, Australian Nuclear Association**

- 10:20-10:40 **29. STRESS TEST OF THE NUCLEAR POWER PLANTS PERFORMED IN TAIWAN**
C. H. Wu, W. C. Teng, S. Chang, Y. B. Chen (Atomic Energy Council, Taipei, Taiwan)

- 10:40-11:00 **97. A RISK-INFORMED FRAMEWORK FOR ESTABLISHING A BEYOND DESIGN BASIS SAFETY BASIS FOR EXTERNAL HAZARDS**
P. Amico, R. Anoba, B. Najafi (Hughes Associates, Inc.)

- 11:00-11:20 **236. MUON TOMOGRAPHY WITH MOMENTUM MEASUREMENTS FOR FAST DETECTION OF NUCLEAR MATERIALS AT PORTS OF ENTRY**

A. Erlandson, V. Anghel (Atomic Energy of Canada Limited), J. Armitage (Carleton University), F. Baig, K. Boniface (Atomic Energy of Canada Limited), J. Botte (Carleton University), K. Boudjemline (Canada Border Services Agency), D. Bryman, J. Bueno (Advanced Applied Physics Solutions), E. Charles (Canada Border Services Agency), T. Cousins (International Safety Research), P. L. Drouin (DRDC), G. Gallant (Canada Border Services Agency), R. Gazit (Advanced Applied Physics Solutions), D. Godin, V. V. Golovko (Atomic Energy of Canada Limited), C. Howard, R. Hydromako (Defense Research and Development Canada), C. Jewet, G. Jonkmans (Atomic Energy of Canada Limited),

Z. Liu (Advanced Applied Physics Solutions), S. Noel (International Safety Research), A. Robichaud (Carleton University), T. J. Stocki (Health Canada), M. Thompson (Atomic Energy of Canada Limited), D. Waller (Defense Research and Development Canada)

- 11:20-11:40 **310. NON - DESTRUCTIVE NUCLEAR FORENSICS OF RADIOACTIVE SAMPLES**
R. Rogge (Canadian Neutron Beam Centre), Q. Alexander (Atomic Energy of Canada Limited), G. Bentoumi (Atomic Energy of Canada Limited), I. Dimayuga (Atomic Energy of Canada Limited), R. Flacau (Canadian Neutron Beam Centre), G. Li, L. Li, B. Sur (Atomic Energy of Canada Limited)

- 11:40-12:00 **157. FEAR OF NUCLEAR POWER GENERATION**
D. Higson (Australian Nuclear Association)

Session 2B1-2:**SEVERE ACCIDENTS (II)***Track 1: Enhancing Safety and Security*Room: **Regency F**Chairs: **Smain Yalaoui, Canadian Nuclear Safety Commission & Arun Nayak, Bhabha Atomic Research Centre**

- 10:20-10:40 **70. MAAP4-CANDU SIMULATION RESULTS FOR CANDU 6 ACCIDENT MANAGEMENT MEASURE: STEAM GENERATOR SECONDARY SIDE WATER MAKE-UP FROM DOUSING TANK FOR THE STATION BLACKOUT SCENARIO**
S. Petoukhov (Atomic Energy of Canada Limited)

- 10:40-11:00 **72. ANALYSIS METHOD FOR THE DESIGN OF A HYDROGEN MITIGATION SYSTEM WITH PASSIVE AUTOCATALYTIC RECOMBINERS IN OPR-1000**
C. H. KIM, J. J. Sung, S. J. Ha (Korea Hydro and Nuclear Power Co. Ltd.), I. S. Yeo (KEPCO Engineering and Construction Co. Ltd.)

- 11:00-11:20 **78. MINIMUM STEAM COOLING WATER LEVEL OF BOILING WATER REACTORS**
M. T. Huang, B. M. Lee (National Tsing Hua University)

- 11:20-11:40 **82. EXPERIMENTAL RESULTS OF IN-VESSEL MELT POOL BEHAVIOUR WITH SURFACE INSULATION AND SURFACE COOLING CONDITION FROM LIVE-3D AND LIVE-2D FACILITIES**
X. Gaus-Liu (Karlsruhe Institute of Technology), A. Miassodov (Karlsruhe Institute of Technology), B. Fluhrer, T. Cron (Karlsruhe Institute of Technology)

- 10:40-11:00 **125. FEASIBILITY OF FULLY CERAMIC MICROENCAPSULATED (FCM) REPLACEMENT FUEL ASSEMBLY FOR OPR-1000 CORE FULLY LOADED WITH FCM FUEL ASSEMBLIES**

W. J. Lee, K. H. Lee, H. Kwon, J. H. Chun, Y. M. Kim (Korea Atomic Energy Research Institute), F. Venneri (Ultra Safe Nuclear Corporation)

- 11:00-11:20 **132. DEVELOPMENT OF A THREE-DIMENSIONAL THERMO-MECHANICAL DEFORMATION MODEL OF A HORIZONTAL NUCLEAR FUEL ELEMENT**
K. Gamble (Royal Military College of Canada), A. Williams (Atomic Energy of Canada Limited), P. Chan (Royal Military College of Canada)

- 11:20-11:40 **205. TOTAL MONTE-CARLO METHOD APPLIED TO THE ASSESSMENT OF UNCERTAINTIES IN A REACTIVITY-INITIATED ACCIDENT**
D. F. da Cruz, D. Rochman, A. Koning (Nuclear Research and Consultancy Group NRG)

Session 2B1-3:**ACCIDENT MANAGEMENT - REACTOR PHYSICS (I)***Track 1: Enhancing Safety and Security*Room: **Plaza A**Chairs: **Dumitru Serghiuta, Canadian Nuclear Safety Commission & Dirceu F. da Cruz, Nuclear Research and Consultancy Group NRG**

- 10:20-10:40 **84. STATUS OF REACTOR CORE DESIGN CODE SYSTEM IN COSINE CODE PACKAGE**
Y. Chen, H. Yu, Z. Liu, C. Wang, S. Li, Z. Liu, X. Hu, S. Wang, G. Qian, Y. Sun, Y. Yan, Y. Hu (State Nuclear Power Software Development Center)

Session 2B1-4:**EMERGENCY PLANNING (II)***(Track 1: Enhancing Safety and Security)*

Room: Plaza B

Chairs: **Thambiayah Nitheanandan, AECL**
& **Masanori Naitoh, Institute of Applied Energy**

- 10:20-10:40 **218. COMBINED ANALYSIS OF FIRE MODEL UNCERTAINTY AND INPUT PARAMETER UNCERTAINTY FOR NUCLEAR POWER PLANT FIRE SCENARIOS**
K. Overholt (National Institute of Standards and Technology), M. Clouthier (Fauske & Associates)
- 10:40-11:00 **226. ANALYSIS OF EVACUATION PROCEDURE AFTER THE ACCIDENT OF THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT**
T. Murayama, F. Iizuka, H. El-Asaad (Tokyo Institute of Technology)
- 11:00-11:20 **241. STUDY ON THE IMPLEMENTATION OF THE FULL SCOPE SEVERE ACCIDENT MANAGEMENT**
D. Huang, Z. Zou, M. Zhang (Nuclear Power Institute of China)
- 11:20-11:40 **246. REQUIREMENT DEVELOPMENT OF A PWR SEVERE ACCIDENT MANAGEMENT SUPPORT SYSTEM BASED ON A SEVERE ACCIDENT SIMULATOR**
H. Wang, Y. Yang, Y. Xiong, G. Chen (State Nuclear Power Software Development Center), Y. Chen (State Nuclear Power Software Development Center)

Session 2B7-5:**GAS-COOLED FAST REACTORS, HIGH TEMPERATURE REACTORS AND VERY HIGH TEMPERATURE REACTORS***Track 7: Developing New Technology and Application)*

Room: Plaza C

Chairs: **Sung-Deok Hong, Korea Atomic Energy Research Institute & Hongxing Yu, NPIC**

- 10:20-10:40 **33. ANALYSIS OF THREE DBAS OF HTR-10GT (I)**
M. Lang, Y. Dong (Tsinghua University)
- 10:40-11:00 **80. STATUS OF VHTR-RELATED THERMAL HYDRAULIC EXPERIMENTAL RESEARCH AT KAERI**
S. D. Hong, C. S. Kim, J. H. Kim, M. H. Kim (Korea Atomic Energy Research Institute)
- 11:00-11:20 **22. ADVANCED NUCLEAR REACTOR DESIGN TECHNOLOGY RESEARCH IN NPIC**
Y. Hongxing (Nuclear Power Institute of China)
- 11:20-11:40 **416. LARGE-SCALE HYDROGEN PRODUCTION USING NUCLEAR REACTORS**
D. Ryland, L. Stolberg, A. Kettner, N. Gnanapragasam, S. Suppiah (Atomic Energy of Canada Limited)

Session 2B5-6:**NEW DEVELOPMENT & DESIGNS***Track 5: Deploying New Reactors and Building to Time*

Room: Georgia A

Chairs: **Frank Yee, Chief Nuclear Engineer, Candu Energy Inc. & Ron Brewer, Professional Loss Control**

- 10:20-10:40 **253. DESIGN CHARACTERISTICS OF EU-APR1400 ON-SITE POWER SYSTEM**
Y. Kim, D. Kim, Y. S. Kim (KHNP)
- 10:40-11:00 **330. STRESSES IN TRANSITION REGION OF VVER-1000 REACTOR VESSELS**
I. Namgung (KEPCO International Nuclear Graduate School), T. L. Nguyen (National Research Institute of Mechanical Engineering)
- 11:00-11:20 **273. FPGA-BASED I&C SYSTEMS IN NPP NEW BUILDS AND MODERNIZATION PROJECTS**
S. Russomanno, O. Glocker (SunPort S.A.)
- 11:20-11:40 **270. FIRE PROTECTION FOR ELECTRICAL CABLING SYSTEMS**
R. Brewer, L. Morrison, L. Hamre (Professional Loss Control)

Session 2B7-7:**SCWR T/H & SAFETY (I)***Track 7: Developing New Technology and Applications*

Room: Georgia B

Chairs: **Metin Yaras, Carleton University & Xiaojing Liu, Shanghai Jiao Tong University**

- 10:20-10:40 **41. THERMAL-HYDRAULIC ANALYSIS OF SWAMUP FACILITY USING ATHLET-SC CODE**
Z. Wang, Z. Cao, X. Liu (Shanghai Jiao Tong University), X. Cheng (Karlsruhe Institute of Technology)
- 10:40-11:00 **44. CFD SIMULATION OF FLOW AND HEAT TRANSFER IN CANADIAN SCWR BUNDLES**
K. Podila, Y. Rao (Atomic Energy of Canada Limited)
- 11:00-11:20 **61. THERMAL-HYDRAULIC ANALYSES FOR IN-PILE SCWR FUEL QUALIFICATION TEST LOOPS AND SCWR MATERIAL LOOP**
A. Vojacek, G. Mazzini, J. Zmitkova, M. Ruzickova (Research Centre Rez)
- 11:20-11:40 **315. OPTIMIZED CHANNEL INLET ORIFICE SIZING FOR THE PRESSURE TUBE TYPE SUPERCRITICAL WATER-COOLED REACTOR**
D. Hummel, D. Novog (McMaster University)
- 11:40-12:00 **417. CFD STUDY OF OSCILLATORY INSTABILITY IN A VERTICAL PIPE WITH SUPERCRITICAL WATER**
E. Ebrahimi, V. Chatoorgoon, S. Ormiston (University of Manitoba)

Technical Sessions	Tuesday August 26	Plenary Sessions	Tuesday August 26
Session 2B4-9: ENVIRONMENTAL EFFECTS OF NUCLEAR ACCIDENTS <i>Track 4: Environmental Protection and Waste Management</i> Room: Oxford Chairs: M. Garamszeghy, NWMO & S. Liblong, Atomic Energy of Canada Limited		Session 2B10-10: RADIOLOGICAL PROTECTION CHALLENGES (I) <i>Track 10: Acquiring Medical and Biological Benefits</i> Room: Prince of Wales Chairs: Juan Arellano-Gomez, Instituto de Investigaciones Electricas & N. Priest, Atomic Energy of Canada Limited	
10:20-10:40	48. ENVIRONMENTAL IODINE VOLATILITY IN THE AFTERMATH OF THE FUKUSHIMA DAICHI NUCLEAR ACCIDENT <i>L. Lebel, R. Dickson, G. Glowa (Atomic Energy of Canada Limited)</i>	10:20-10:40	71. CURRENT STATUS OF SECURING CATEGORY 1 AND 2 RADIOACTIVE SOURCES IN TAIWAN <i>Y. F. Cheng, C. H. Tsai (Atomic Energy Council of Taiwan)</i>
10:40-11:00	118. AN OFFSITE DOSE EVALUATION CODE FOR RADIOACTIVE MATERIAL RELEASE ACCIDENTS <i>S. H. Chen (National Tsing-Hua University), J. R. Wang (Atomic Energy Council, Taiwan), C. Shih (National Tsing Hua University)</i>	10:40-11:00	282. A PRACTICAL PROCESS FOR LIGHT-WATER DETRITIATION AT LARGE SCALES <i>H. Boniface (Atomic Energy of Canada Limited), J. Robinson (Tyne Engineering), N. Gnanapragasam, I. Castillo, S. Suppiyah (Atomic Energy of Canada Limited)</i>
11:00-11:20	384. SIMULATING AIR DOSE RATE OF RADIOACTIVITY IN SELECTED AREA OF FUKUSHIMA BY PHITS <i>T. Saito, M. Yamaguchi, T. Kato, Y. Oda, A. Kitamura (Japan Atomic Energy Agency)</i>	11:00-11:20	362. TRITIUM (HTO AND OBT) UPTAKE WITHIN THE ENVIRONMENT AND THE POTENTIAL RISKS TO MAN <i>S. B. Kim, M. Stuart, C. Shultz (Atomic Energy of Canada Limited)</i>
11:20-11:40	383. SIMULATING SOIL AND CESIUM-137 LOSSES FROM LAND SURFACE OF EASTERN FUKUSHIMA PREFECTURE <i>A. Kitamura, M. Yamaguchi, H. Kurikami, H. Sato, M. Yui (Japan Atomic Energy Agency)</i>	11:20-11:40	371. OVERVIEW OF APPLICATIONS OF RADIATION PROCESSING IN COMBINATION WITH CONVENTIONAL TREATMENTS TO ASSURE FOOD SAFETY <i>M. Lacroix, M. Turgis (INRS-Institut Armand-Frappier), R. Severino (INRS-Institut Armand-Frappier, University of Salerno), K. D. Vu (INRS-Institut Armand-Frappier), F. Donsi (University of Salerno), S. Salmieri (INRS-Institut Armand-Frappier), G. Ferrari (University of Salerno)</i>
11:40-12:00	213. APPLICATION OF CANDU FAILED FUEL INSPECTION SYSTEM AND TECHNOLOGY <i>Y. Kim, J. Shin, S. Woo, T. Choi (Kepco Nuclear Fuel), J. Park (Korea Hydro & Nuclear Power Co., Ltd.)</i>	PLENARY IIA: FULFILLING THE PROMISE - ADDRESSING THE CHALLENGES - ALTERNATIVE FUEL CYCLES AND FUEL SUPPLY Room: Regency E & F Chair: Dr. Sermet Kuran, Candu Energy Inc.	
		14:00-14:15	CANDU FUEL-CYCLE FLEXIBILITY <i>Dr. Sermet Kuran (Candu Energy Inc.)</i>
		14:15-14:30	URANIUM SUPPLY AND MARKET UPDATE <i>Mr. Derek Gross (Director Marketing Strategy, Cameco Corporation)</i>
		14:30-14:45	DOE ACTIVITIES PROMOTING UNDERSTANDING OF ADVANCED NUCLEAR FUEL CYCLES <i>Dr. Patricia Paviet (Director, Office of Systems Engineering & Integration, USDOE), Dr. R. Wigeland, Dr. T. Talpo, Dr. B. Singh (USDOE)</i>
		14:45-15:00	RECYCLING AND ADVANCED FUEL CYCLES AT AREVA <i>Mr. Jean-François Bêland (Executive Vice President, AREVA Canada Inc.)</i>
		15:00-15:30	QUESTIONS AND ANSWERS
TUESDAY AFTERNOON BREAK Room: Regency A & B, Foyer, Balmoral Time: 15:30-16:00			

**PLENARY IIB:
FULFILLING THE PROMISE - ADDRESSING THE
CHALLENGES - LONG-TERM USED-FUEL MANAGEMENT**

Room: Regency E & F

Chair: **Mr. Ken Nash, President, Nuclear Waste Management Organization (Canada)**

16:00-17:00 PRESENTATIONS BY:

Mr. Ken Nash (President, Nuclear Waste Management Organization (Canada)), Dr. Shunsuke Kondo (President, NUMO (Japan)), Dr. William Boyle (Director of Used Nuclear Fuel Disposition Research & Development, USDOE), Dr. Liang Chen (Deputy Director, Environmental Engineering Division, BRIUG (China))

17:00-17:30 ROUND-TABLE DISCUSSION

KEYNOTE ADDRESS 4

Room: Regency E & F

17:30-18:00 KEYNOTE ADDRESS 4

The Hon. Robert Norris (Member of Saskatchewan Legislative Assembly, Saskatoon-Greystone)

3. 8/27 議程內容

Plenary Sessions	Wednesday August 27	Plenary Sessions	Wednesday August 27
PLENARY IIIA: FULFILLING THE PROMISE – BUILDING FOR THE FUTURE – DEVELOPING NEW REACTOR TECHNOLOGIES AND APPLICATIONS Room: Regency E & F Chair: Dr. John Kelly, Deputy Assistant Secretary for Nuclear Reactor Technologies, US DOE		PLENARY IIIB: FULFILLING THE PROMISE – BUILDING FOR THE FUTURE – PLANT INFRASTRUCTURE DEVELOPMENT AND LIFE MANAGEMENT Room: Regency E & F Chair: Mr. Ken Ellis, Managing Director, WANO	
08:00-08:15	ADVANCED REACTOR PROGRAM IN THE UNITED STATES <i>Dr. John Kelly (Deputy Assistant Secretary for Nuclear Reactor Technologies, US DOE)</i>	10:15-10:30	PLANT INFRASTRUCTURE DEVELOPMENT AND LIFE MANAGEMENT <i>Mr. Ken Ellis (Managing Director, WANO)</i>
08:15-08:30	STATUS OF ADVANCED NUCLEAR REACTOR DEVELOPMENT IN KOREA <i>Dr. Hark Roh Kim (Vice-President, Strategic R&D Program, KAERI), Dr. K.K. Kim (KAERI), Dr. Y.W. Kim, Dr. H.K. Joo (KAERI)</i>	10:30-10:45	SAFELY EXTENDING CANDU LIFE <i>Mr. Mark Elliott (Ontario Power Generation)</i>
08:30-08:45	NEW TO NUCLEAR COUNTRIES: CONSIDERATIONS FOR ADOPTION OF SMALL MODULAR REACTORS - A GUIDE TO FUTURE ADOPTERS <i>Dr. Adi Paterson (CEO, ANSTO), Mr. Mark Ho (ANSTO), Dr. Greg Storr (ANSTO)</i>	10:45-11:00	BARAKAH PROJECT IN UAE <i>Mr. Ken Petrunik (Advisor to the CEO Nuclear Power, Emirates Nuclear Energy Corporation)</i>
08:45-09:00	NUCLEAR FUSION: NO LONGER 30 YEARS AWAY - HOW RECENT PROGRESS IN FUSION TECHNOLOGY IS CHANGING THE TIMESCALES FOR COMMERCIAL FUSION ENERGY <i>Dr. Michel Laberge (General Fusion)</i>	✓ 11:00-11:15	STATUS OF LONG TERM OPERATION OF NUCLEAR POWER PLANTS IN THE US <i>Mr. Garry Young (Director, License Renewal, Entergy Nuclear)</i>
09:00-09:15	DEVELOPMENT OF HTGR IN CHINA AS AN ADVANCED NUCLEAR POWER TECHNOLOGY <i>Dr. Yuliang Sun (Deputy Director, Institute of Nuclear & New Energy Technologies, Tsinghua University), Dr. Zuoyi Zhang (Institute of Nuclear and New Energy Technology, Tsinghua University)</i>	11:15-11:30	INFRASTRUCTURE NEEDED FOR SUCCESS – AN OEM/NSP DESIGNER'S PERSPECTIVE <i>Mr. Frank Yee (Chief Nuclear Engineer, Candu Energy Inc.)</i>
09:15-09:45	QUESTIONS AND ANSWERS	11:30-12:00	QUESTIONS AND ANSWERS
Wednesday Morning Break Room: Regency A & B, Foyer, Balmoral Time: 09:45-10:15			

Session 3A1-1:**SAFETY CULTURE (II)***Track 1: Enhancing Safety and Security*

Room: Regency E

Chairs: Paul Spekkens, Ontario Power Generation & Xiaoyang Gaus-Liu, Karlsruhe Institute of Technology

- 14:00-14:20 **3. KEY CONSIDERATIONS AND SAFETY ISSUES FOR THE STRETCH POWER UPRATE AT CHINSHAN NUCLEAR POWER STATION**
P. H. Huang (Taiwan Power Company)
- 14:20-14:40 **36. BASIS FOR THE DERIVATION OF THE SAFETY GOALS AND CHALLENGES FOR APPLICATION TO MULTI-UNIT STATIONS**
S. Yalaoui, Y. Akl, G. Frappier (Canadian Nuclear Safety Commission)
- 14:40-15:00 **108. CERTIFICATION OF CANADIAN NUCLEAR POWER PLANT PERSONNEL**
F. o. Newbury (Canadian Nuclear Safety Commission)
- 15:00-15:20 **167. STUDY ON TEAM CHARACTERISTICS INFLUENCING ON NUCLEAR SAFETY CULTURE IN KOREA BASED ON BAYESIAN NETWORKS**
K. Young-gab, S. Chan-ho, P. Jeong-jin (Korea Hydro & Nuclear Power Co. Central Research Institute)

Session 3A1-2:**SEVERE ACCIDENTS (III)***Track 1: Enhancing Safety and Security*

Room: Regency E

Chairs: Stephen Yu, Candu Energy Inc. & Joerg Starflinger, University of Stuttgart

- 14:00-14:20 **85. EFFECTIVENESS OF SHOCK ATTENUATION BY SIMPLE GEOMETRICAL MEANS IN MITIGATING SEVERE ACCIDENT EXPLOSIVE LOADS**
J. W. Park, J. S. Kim, J. Bae, W. C. Seol, A. R. Choi (Dongguk University)
- 14:20-14:40 **94. UNDERSTANDING AND EVALUATION OF SEVERE ACCIDENT MITIGATION ACTIONS**
Q. Lei, C. French, P. Devitt, A. Viktorov (Canadian Nuclear Safety Commission)
- 14:40-15:00 **113. ANALYSIS OF STATION BLACKOUT MITIGATION STRATEGY IN LUNG MEN ABWR WITH PCTAN**
Y. Hsu (National Tsing Hua University), J. R. Wang (Atomic Energy Council, Taiwan), J. H. Yang, C. Shih (National Tsing Hua University)
- 15:00-15:20 **127. EXPERIMENTAL STUDY ON TRIGGERING OF THERMAL FRAGMENTATION PROCESS IN A VAPOR EXPLOSION**
M. Lin (Shanghai Jiaotong University), Y. Zhou (Shanghai Jiaotong University), M. Zhong, Y. Li, Y. Yang (Shanghai Jiaotong University)
- 15:20-15:40 **128. CRITICAL HEAT FLUX MODEL AT REACTOR PRESSURE VESSEL OUTER SURFACE**
X. Cheng, R. Guo, B. Kuang (Shanghai Jiao Tong University)

Session 3A9-3:**FACING COMPETITORS AND REDUCING COST***Track 9: Facing Competitors and Reducing Cost*

Room: Plaza A

Chairs: Frank Yee, Chief Nuclear Engineer, Candu Energy Inc. & Milt Caplan, MZ Consulting Inc.

- 14:00-14:20 **91. ECONOMIC CASE FOR CANDU LIFE EXTENSION PROJECTS**
S. Qureshi, T. Tenev, M. Lewis (Candu Energy Inc.)
- 14:20-14:40 **122. UPDATES TO THE ESTIMATED COST OF URANIUM RECOVERY FROM SEAWATER**
E. Schneider, H. Lindner (University of Texas)
- 14:40-15:00 **230. CLIMATE CHANGE: ASSESSMENT OF THE VULNERABILITY OF NUCLEAR POWER AND COST OF ADAPTATION**
H. Paillere (OECD/Nuclear Energy Agency), R. Cameron (OECD Nuclear Energy Agency), J. Y. Caneill (EDF Group), S. Syri (Aalto University)
- 15:00-15:20 **240. NEW NUCLEAR PLANT DEVELOPMENT - BALANCING LOCALIZATION WITH COMPETITIVENESS**
M. Caplan (MZ Consulting Inc.), T. S. Thompson (MZ Consulting Inc.)

Session 3A4-4:**CHARACTERIZATION OF ENVIRONMENTAL STRESSORS***Track 4: Environmental Protection and Waste Management*

Room: Plaza B

Chairs: B. Belfadhel, NWMO & K. Dormuth, CNS

- 14:00-14:20 **65. THE OFFICIAL WEBSITE OF THE U. S. DEPARTMENT OF ENERGY'S NUCLEAR CRITICALITY SAFETY PROGRAM**
B. Koponen, D. Heinrichs, C. Lee (Lawrence Livermore National Laboratory), L. Scott (SAIC)
- 14:20-14:40 **121. PRELIMINARY SOURCE TERM ANALYSIS FOR WOLSONG UNIT 1 USING MCNP/ORIGEN-2**
K. Noh, C. Hah, C. Kim (KEPCO International Nuclear Graduate School)
- 14:40-15:00 **194. POLYMER-INORGANIC COMPOSITE RESINS FOR RECOVERY OF RADIOACTIVE CESIUM FROM ACIDIC MEDIA**
J. I. Park, J. S. Kim, A. Jo, E. S. Jang, Y. J. Park (Korea Atomic Energy Research Institute)
- 15:00-15:20 **366. SAMPLING, CHARACTERIZATION AND DISPOSAL OF SPENT ION EXCHANGE RESINS**
K. Krishnaswamy, K. Choi, S. Kenny (Atomic Energy of Canada Limited)
- 15:20-15:40 **381. THE ANALYSIS OF RADIATION LEVELS FOR DAILY SUPPLIES MADE IN KOREA**
H. R. Kim (Ulsan National Institute of Science and Technology)

Session 3A7-5:**RESEARCH REACTORS**

Track 7: Developing New Technology and Applications

Room: Plaza C

Chairs: Tim Leung, Atomic Energy of Canada Limited & Ashok Khanna, Indian Institute of Technology

- 14:00-14:20 **1. A COMPREHENSIVE APPROACH TO DELAYED-NEUTRON RELATED DATA FOR SAFE OPERATION OF INNOVATIVE REACTORS**
S. Chiba (Tokyo Institute of Technology), K. Nishio (Japan Atomic Energy Agency), Y. Aritomo (Tokyo Institute of Technology), H. Koura, O. Iwamoto, T. Kugo (Japan Atomic Energy Agency)
- 14:20-14:40 **99. THE COMET METHOD FOR REACTOR PHYSICS CALCULATIONS**
F. Rahnama, D. Zhang, K. Connolly (Georgia Institute of Technology)
- 14:40-15:00 **281. MONTE CARLO APPLICATIONS TO CORE-FOLLOWING OF THE NATIONAL RESEARCH UNIVERSAL REACTOR (NRU)**
T. S. Nguyen, X. Wang, T. Leung (Atomic Energy of Canada Limited)
- 15:00-15:20 **298. THERMAL HYDRAULICS OF ACCELERATOR DRIVEN SYSTEM: VALIDATION AND ANALYSIS**
I. Kumari, A. Khanna (Indian Institute of Technology)

Session 3A5-6:**ADVANCED FUEL FOR NEW BUILD**

Track 5: Deploying New Reactors and Building to Time

Room: Georgia A

Chairs: Paul Chan, Royal Military College of Canada & Kwang-Won Lee, KEPCO E&S

- 14:00-14:20 **130. VERIFICATION OF HIPER16(TM) FUEL DESIGN FOR 16X16 CE-NSSS TYPE NUCLEAR POWER PLANTS**
S. Y. Jeon, J. M. Suh, J. I. Kim, K. L. Jeon (KEPCO Nuclear Fuel)
- 14:20-14:40 **176. THE EFFECT OF ACTINIDE COMPOSITION ON TRANSURANIC MIXED OXIDE FUEL LATTICE PHYSICS PARAMETERS IN CANDU**
A. C. Morreale (Atomic Energy of Canada Limited), J. C. Luxat (McMaster University)
- 14:40-15:00 **169. THERMAL ANALYSES FOR THE RACK DESIGN WITH SPEN FUEL POOL DURING THE LOSS OF COOLING ACCIDENT**
C. L. Yeh, Y. S. Chen, B. Y. Chen, Y. S. Tseng, W. C. Wei (Institute of Nuclear Energy Research)
- 15:00-15:20 **144. THE AQUEOUS SYNTHESIS OF UMOO6 AND ITS SIGNIFICANCE TO NUCLEAR FUEL**
R. A. Barry, J. Scott (Royal Military College of Canada), I. Korobkov (University of Ottawa), J. Deveau, E. C. Corcoran (Royal Military College of Canada)

Session 3A6-7:**MINING AND WASTE MANAGEMENT**

Track 6: Mining, Fuel and Fuel Cycles

Room: Georgia B

Chairs: Steven Krahn, Vanderbilt University & Engin Özbek, IMI

- 14:00-14:20 **116. MANAGING ENVIRONMENTAL AND HEALTH IMPACTS OF URANIUM MINING**
R. Vance, R. Cameron (OECD Nuclear Energy Agency)
- 14:20-14:40 **138. DISPOSING HIGH-LEVEL TRANSURANIC WASTE IN FUSION FISSION REACTORS**
Y. Shen (Institute of Applied Physics and Computational Mathematics)
- 14:40-15:00 **238. ANALYSIS OF BACK-END FUEL-CYCLE ISSUES IN THE ROK**
R. Forrest, C. Braun (Stanford University)
- 15:00-15:20 **373. AN UPDATE ON THE ATTRIBUTES AND STATUS OF THORIUM FUEL CYCLES**
S. Krahn, A. Croff, T. Ault (Vanderbilt University)
- 15:20-15:40 **374. USE OF TECHNOLOGY READINESS LEVELS TO FACILITATE NUCLEAR FUEL CYCLE RESEARCH, DEVELOPMENT, AND DEPLOYMENT**
S. Krahn, A. Croff, T. Ault (Vanderbilt University)

Session 3A3-9:**CONSIDERATIONS IN NUCLEAR POLICY**

Track 3: Facilitating Energy Policy and Global Consensus

Room: Oxford

Chairs: Mimi Limbach, Managing Partner, Potomac Communications Group, Inc. & Gerry Frappier, Canadian Nuclear Safety Commission

- 14:00-14:20 **415. AN OVERVIEW OF ONTARIO'S 2013 LONG TERM ENERGY PLAN**
C. Jobe (Ontario Ministry of Energy)
- 14:20-14:40 **189. MULTI-CRITERIA PLANNING OF NUCLEAR CONTRIBUTION TO THE GOALS OF CLEAN ELECTRICITY IN MEXICO**
C. Martín del Campo (Universidad Nacional Autónoma de México)
- 14:40-15:00 **346. A HISTORICAL REVIEW OF NUCLEAR CONTRIBUTION TO THE ONTARIO ENERGY MIX**
T. Nitheanandan, M. Brown (Atomic Energy of Canada Limited)
- 15:00-15:20 **137. EVALUATION OF THE EFFECTIVENESS OF THE IMPLEMENTATION OF POWER PLANS IN KENYA**
N. Ruwah (KEPCO International Nuclear Graduate School Ulsan, Republic of Korea), C. K. Chang (KEPCO International Nuclear Graduate School)

Session 3A7-10:**SCWR MATERIALS AND CHEMISTRY (II)***Track 7: Developing New Technology and Applications*

Room: Prince of Wales

Chairs: Xiao Huang, Carleton University & Radek Novotny, JRC, Institute for Energy and Transport

- 14:00-14:20 **120. EFFECT OF SURFACE PREPARATION ON CORROSION RESISTANCE OF NICR, NIAL, NICRAL AND NICRALY ALLOYS IN SUPERCRITICAL WATER**
R. Garcia, A. Qian, X. Huang (Carleton University), D. Guzonas (Atomic Energy of Canada Limited)
- 14:20-14:40 **286. OXIDE SCALES FORMED ON AUSTENITIC FE-CR-NI ALLOYS EXPOSED TO SUPERCRITICAL WATER: ROLE OF ALLOYING ELEMENTS**
S. Mahboubi, G. Botton, J. Kish (McMaster University)
- 14:40-15:00 **249. DEVELOPMENT OF YTTRIA STABILIZED ZIRCONIA COMPOSITES FOR THERMAL INSULATION IN NUCLEAR REACTORS**
J. Lo, R. Zhang, R. Santos (CanmetMATERIALS, NRCan)
- 15:00-15:20 **302. OXIDATION BEHAVIOR OF AUSTENITIC IRON-BASE ODS ALLOY IN SUPERCRITICAL WATER**
Y. Behnamian, Z. Dong, R. Zahiri, A. Kohandehghan, D. Mitlin (University of Alberta), Z. Zhou (University of Science and Technology Beijing), W. Chen, J. L. Luo (University of Alberta), W. Zheng (CanmetMATERIALS), D. Guzonas (Atomic Energy of Canada Limited)

Wednesday Afternoon BreakRoom: Regency A & B, Foyer, Balmoral
Time: 15:40-16:00**Session 3B1-1:****SEVERE ACCIDENTS (IV)***Track 1: Enhancing Safety and Security*

Room: Regency E

Chairs: Masanori Naitoh, Institute of Applied Energy & John Luxat, McMaster University

- 16:00-16:20 **175. RECENT EXPERIMENTS AND NUMERICAL SIMULATIONS ON COOLABILITY OF DEGRADED CORES IN THE LATE PHASE OF SEVERE ACCIDENTS OF LIGHT WATER REACTORS**
J. Starflinger, M. Buck, R. Kulenovic, S. Rahman, A. Hartmann, M. Rashid, S. Leininger (University of Stuttgart)
- 16:20-16:40 **206. INVESTIGATION ON COOLING POSSIBILITIES OF A DEGRADED CORE IN A MBLOC SCENARIO FOR A GERMAN PWR WITH ATHLET-CD**
A. Trometer, M. Buck, J. r. Starflinger (University of Stuttgart)
- 16:40-17:00 **214. A STUDY OF RPV DEPRESSURIZATION AND CONTAINMENT VENT STRATEGY IN FUKUSHIMA LIKE ACCIDENT OF CHINSHAN NPP BY USING MAAP5**
S. Y. Fan, S. J. Wang (Institute of Nuclear Energy Research)
- 17:00-17:20 **224. ANALYSIS OF ACCIDENT PROGRESSION OF FUKUSHIMA DAICHI NPP BY THE SAMPSON CODE**
M. Naitoh, H. Suzuki, H. Mizouchi, M. Pellegrini (Institute of Applied Energy)

Session 3B2-2:**IMPROVED OPERATIONS AND SAFETY***Track 2: Improving Operation and Maintenance*

Room: Regency F

Chairs: Brian Fehrenbach, Candu & Dirceu F. da Cruz, Nuclear Research and Consultancy Group NRG

- 16:00-16:20 **170. THE THIRD QINSHAN NUCLEAR POWER PLANT OUTAGE INTERVAL EXTENSION PROJECT (NON-INSTRUMENTATION SURVEILLANCE REQUIREMENTS JUSTIFICATION)**
X. Peng, C. Zeng, Z. Wu, M. Chen (CNNC Nuclear Power Operations Management Co. Ltd)
- 16:20-16:40 **264. PROCESS IMPROVEMENT OF THE EMERGENCY OPERATING PROCEDURES FOR EMBALSE NUCLEAR POWER PLANT**
A. D. Mariotti, M. Pomerantz (Embalse Nuclear Power Plant), C. Moreno (Embalse Nuclear Power Plant)
- 16:40-17:00 **303. USE OF FIRE HAZARD ANALYSIS TO COST EFFECTIVELY MANAGE FACILITY MODIFICATIONS**
K. Krueger, R. Cronk (PLC Fire Safety Solutions)
- 17:00-17:20 **178. DESIGN MODIFICATION AND TECHNICAL IMPROVEMENT OF QINSHAN PHASE III NPP**
M. Chen (CNNC Nuclear Power Operations Management Co. Ltd), G. Yao (CNNC Nuclear Power Operation Management Co. Ltd)

- 17:20-17:40 **202. REDUCING RADIATION EXPOSURES AT NUCLEAR POWER PLANTS USING VIRTUAL JOB PLANNING**
Y. Verzilov (Kinectrics Inc.), A. Husain (Kinectrics Inc.)

Session 3B2-3:**IMPROVED COMPONENTS AND EQUIPMENT***Track 2: Improving Operation and Maintenance*

Room: Plaza A

Chairs: Jacques Plourde, President, Canadian Nuclear Society & Won-Pil Back, KAERI

- 16:00-16:20 **96. NFC BASED EQUIPMENT QUALIFICATION MANAGEMENT (NEQM) SYSTEM PREVENTING COUNTERFEIT AND FRAUDULENT ITEM**
C. K. Chang (KEPCO International Nuclear Graduate School), K. J. Lee (Kyung Hee University)
- 16:20-16:40 **171. IMPROVED RPV STUD HOLE PLUG**
J. Hedtke (Sciencetech)
- 16:40-17:00 **397. IMPLEMENTATION OF ON-LINE MONITORING AND ADVANCED PATTERN RECOGNITION USING SMART SIGNAL**
G. Dardona (Bruce Power)
- 17:00-17:20 **38. DESIGN AND APPROVAL OF E P S DIESEL SYSTEMS IN GERMAN NPP**
A. A. Kollmer (TÜV SÜD Industrie Service GmbH)
- 17:20-17:40 **396. FUNDAMENTALS OF ASSET MANAGEMENT IN AN AGEING NUCLEAR POWER STATION**
B. Crook (Bruce Power)

- 17:40-18:00 **388. ESTABLISHMENT OF THE TECHNICAL BASIS TO APPLY THE VISCOUS DAMPER IN NUCLEAR POWER PLANT**
J. Nakajima, N. Suetono, T. Higuchi, H. Katayama (Toshiba Corporation)

Session 3B4-4:

RADIATION IN THE ENVIRONMENT

Track 4: Environmental Protection and Waste Management

Room: Plaza B

Chairs: M. Garamszeghy, NWMO & B. Belfadhel, NWMO

- 16:00-16:20 **299. EXTRACTION OF METAL IONS THROUGH LIGAND ASSISTED IONIC LIQUIDS**
P. Kumar (Indian Institute of Technology), T. Vincent (BARC), A. Khanna (Indian Institute of Technology)

- 16:20-16:40 **21. HIGH THROUGHPUT SALT SEPARATION FROM URANIUM DEPOSITS WITH MULTILAYER POROUS CRUCIBLES**
S. W. Kwon, K. M. Park, J. G. Kim, I. T. Kim, S. B. Park (Korea Atomic Energy Research Institute)

- 16:40-17:00 **407. INTERCOMPARISON OF NUMERICAL SIMULATIONS ON OCEANIC DISPERSION OF THE RADIOACTIVE CESIUM RELEASED BECAUSE OF THE FUKUSHIMA DISASTER**
H. Kawamura, T. Kobayashi, A. Furuno (Japan Atomic Energy Agency), N. Usui, M. Kamachi (Japan Meteorological Agency), S. Nishikawa, Y. Ishikawa (Japan Agency for Marine-Earth Science and Technology)

- 17:00-17:20 **112. SPECTRUM ANALYSIS IN LEAD SPECTROMETER FOR ISOTOPIC FISSION ASSAY IN USED FUEL**
Y. Lee, C. J. Park, H. d. Kim, K. C. Song (Korea Atomic Energy Research Institute)

- 17:20-17:40 **385. PRELIMINARY ANALYSIS OF DIPOLE TRACER MIGRATION EXPERIMENTS IN FRACTURED SEDIMENTARY ROCK AT HORONOBÉ URL OF JAPAN**
H. Yokota, S. Tanaka (Japan Atomic Energy Agency)

Session 3B7-5:

FUSION REACTORS

Track 7: Developing New Technology and Applications

Room: Plaza C

Chairs: R. Fedosejevs, U Alberta & Michel Laberge, General Fusion

- 16:00-16:20 **234. SPHEROMAK COMPRESSION EXPERIMENTS AT GENERAL FUSION**
A. Fraese, S. Howard, V. Saponitsky, J. Zimmermann, M. Reynolds, S. Barsky, J. McCone, R. Ivanov, D. Parfeniuk, P. O'Shea, D. Richardson, M. Delage, M. Laberge (General Fusion)

- 16:20-16:40 **139. FUSION FISSION HYBRID REACTOR FOR ENERGY (FFHR-E): A POTENTIAL WAY TO MAKE USE OF NATURAL URANIUM WITHOUT SEPARATION OF PLUTONIUM**
X. m. Shi, X. j. Peng (Institute of Applied Physics and Computational Mathematics, Beijing)

- 16:40-17:00 **179. THE LOFA ANALYSIS OF FUSION-FISSION HYBRID REACTOR**
Z. c. Yu, H. Xie (Tsinghua University)

- 17:00-17:20 **257. PRELIMINARY NEUTRONIC ANALYSIS OF FUSION FISSION HYBRID TEST BLANKET MODULE**
M. T. Siddique, S. H. Hong, M. H. Kim (Kyung Hee University)

- 17:20-17:40 **313. THE USE OF SPIN POLARIZED FUEL TO GIVE INCREASED YIELD FOR LASER FUSION ENERGY**
R. Fedosejevs (University of Alberta)

- 17:40-18:00 **420. EXPERIMENTAL PRESSURE DROP AND HEAT TRANSFER IN SQUARE ARRAY ROD BUNDLE FOR FUSION-FISSION HYBRID SYSTEM**
J. A. Shamim, P. K. Bhowmik (Seoul National University), K. Y. Suh (Seoul National University, PhiloSophia Inc.)

Session 3B5-6:

ADVANCED SIMULATIONS FOR NEW BUILD

Track 5: Deploying New Reactors and Building to Time

Room: Georgia A

Chairs: Mamoud Kattan, Candu Energy Inc. & Ihn Namgung, KEPCO International Nuclear Graduate School

- 16:00-16:20 **301. POWER—FEEDWATER ENTHALPY OPERATING DOMAIN FOR SBWR APPLYING MONTE CARLO SIMULATION**
S. Quezada-García, E. G. Espinosa-Martínez (Universidad Autónoma Metropolitana-Iztapalapa), A. Vázquez-Rodríguez (Universidad Nacional Autónoma de México), J. R. Varela-Ham, G. Espinosa-Paredes (Universidad Autónoma Metropolitana-Iztapalapa)

- 16:20-16:40 **140. APPLICATION OF THE RISK-INFORMED METHODOLOGY FOR APRI400 P-T LIMITS CURVE**
K. Kim, I. Namgung (KEPCO International Nuclear Graduate School)

- 16:40-17:00 **336. DEVELOPING A BRANCH AND BOUND METHOD FOR LARGE POST EVENT STATE SPACES UNDER DYNAMIC PRA ASSESSMENT USING LENDIT METRICS AND S2R2 SETS**
A. Tokutomi, J. Nielsen, J. Khatri (University of Idaho)

Session 3B6-7:**MATERIALS, SUPPLY AND MANUFACTURING***Track 6: Mining, Fuel and Fuel Cycles*

Room: Georgia B

Chairs: Robert Wham, Oak Ridge National Laboratory & Barbara Szpunar, University of Saskatchewan

16:00-16:20 62. THE PLUTONIUM-238 SUPPLY PROJECT*R. Wham, K. Felker, E. Collins, D. Benker, S. Owens, R. W. Hobbs, D. Chandler, R. Vedder (Oak Ridge National Laboratory)***16:20-16:40 124. THORIA VERSUS URANIA COMPARISON***B. Szpunar, J. Szpunar (University of Saskatchewan)***16:40-17:00 182. PYROPROCESS INTEGRATED INACTIVE DEMONSTRATION FACILITY FOR PYROPROCESSING TECHNOLOGY DEVELOPMENT***K. Kim, I. Cho (Korea Atomic Energy Research Institute)***17:00-17:20 424. NUCLEAR POWER NEW TECHNOLOGICAL PLATFORM WITH CLOSING FUEL CYCLE***V. Pershukov (State Atomic Energy Corporation «Rosatom»), V. Rachkov (ITC "PRORYV" Project)***Session 3B3-9:****NUCLEAR ENERGY POLICY AND HUMAN RESOURCE DEVELOPMENT***Track 3: Facilitating Energy Policy and Global Consensus*

Room: Oxford

Chairs: Cedric Jobe, Ontario Ministry of Energy & Gerry Frappier, Canadian Nuclear Safety Commission

16:00-16:20 401. STRENGTHENING CANADA'S NUCLEAR LIABILITY REGIME*D. McCauley, J. Hénault (Natural Resources Canada)***16:20-16:40 331. IMPACT OF NUCLEAR POWER PLANT CONSTRUCTION RELATIVE TO DECOMMISSIONING FOSSIL FUEL PLANTS IN ORDER TO REDUCE CO₂ EMISSIONS USING A MODIFIED NORDHAUS VENSIM DICE MODEL***A. Tokuhito, J. Colpetzer (University of Idaho)***16:40-17:00 27. DELAYED PARTICLES FROM SPECIAL NUCLEAR MATERIALS AND THEIR NUCLEAR FORENSICS APPLICATIONS***M. Andrews, D. Kelly, E. Corcoran (Royal Military College of Canada)***17:00-17:20 133. HUMAN RESOURCE DEVELOPMENT (HRD) WITH THE INTRODUCTION OF NUCLEAR/RESEARCH REACTORS IN KENYA***A. Shadrack (Radiation Protection Board Kenya)***Session 3B7-10:****SCWR T/H & SAFETY (II)***Track 7: Developing New Technology and Applications*

Room: Prince of Wales

Chairs: David Novog, McMaster University & György Hegyi, Centre for Energy Research, Hungarian Academy of Sciences

16:00-16:20 183. CFD STUDY OF CONVECTIVE HEAT TRANSFER TO CARBON DIOXIDE AND WATER AT SUPERCRITICAL PRESSURES IN VERTICAL CIRCULAR PIPES*F. Zhou, D. Novog (McMaster University)***16:20-16:40 45. RIA ANALYSIS OF THE SCWR-FQF FACILITY IN THE LVR-15 RESEARCH REACTOR***C. Marácz, G. r. Hegyi, I. n. Trosztel, G. b. Hordósy, r. Brolly (Centre for Energy Research, Hungarian Academy of Sciences)***16:40-17:00 106. SAFETY ANALYSES FOR AN IN-PILE SCWR FUEL QUALIFICATION TEST LOOP***T. Schulenberg, M. Raqué (Karlsruhe Institute of Technology)***17:00-17:20 115. INDIRECT CONSEQUENCES OF PRESSURE TUBE RUPTURE DURING SCWR FUEL QUALIFICATION TEST***T. Zeiger, T. Schulenberg, M. Flad, M. Raqué (Karlsruhe Institute of Technology)***17:20-17:40 74. BUBBLE DEPARTURE DIAMETER IN NARROW RECTANGULAR CHANNEL UNDER ROLLING CONDITION***T. Xié, B. Chen, X. Yan, J. Xu, Y. Huang, Z. Xiao (Nuclear Power Institute of China)***CONFERENCE BANQUET AND ENTERTAINMENT**

Room: Regency D & E

19:00-19:15 PACIFIC NUCLEAR COUNCIL (PNC) PRESIDENT PROF. A. SUZUKI WILL UPDATE PNC ACTIVITIES AND INTRODUCE INCOMING PNC PRESIDENT MS. MIMI LIMBACH**20:15-21:00** FIRST NATIONS ARTISTS MUSIC AND DANCE SHOW: DRUMMING, SINGING AND VARIOUS COLOURFUL NATIVE DANCES

4. 8/28 議程內容

Plenary Sessions

Thursday August 28

PLENARY IVA:

FULFILLING THE PROMISE – TRENDS IN REGULATORY REQUIREMENTS TO ENSURE SAFE OPERATION OF NPPS

Room: Regency E & F

Chair: Michael Binder, President, CNSC, Canada

08:30-08:40	CANADIAN PERSPECTIVE ON CANADA'S REGULATORY ACTIVITIES <i>Dr. Michael Binder (President, CNSC, Canada)</i>
08:40-08:50	SAFETY ENHANCEMENT EFFORTS AFTER FUKUSHIMA ACCIDENT IN KOREA <i>Dr. Un Chul Lee (Chairman, NSSC, Korea)</i>
08:50-09:00	SELF TRUST, A MAJOR CHALLENGE FOR NUCLEAR REGULATORS <i>Mr. Juan Eibenschutz (Director General, CNSNS, México)</i>
09:00-09:10	REGULATORY OVERSIGHT ON NUCLEAR SAFETY IN TAIWAN <i>Dr. Tsing-Tung Huang (Deputy Minister, AEC, Taiwan)</i>
09:10-09:20	REGULATORY PERSPECTIVE OF AN NRC COMMISSIONER <i>Mr. William Ostendorff (Commissioner, USNRC, USA)</i>
09:20-10:00	QUESTIONS AND ANSWERS

Thursday Morning Break

Room: Regency A & B, Foyer, Balmoral

Time: 10:00-10:30

Technical Sessions

Thursday August 28

Session 4A1-1:

RISK ASSESSMENT (II)

Track 1: Enhancing Safety and Security

Room: Regency E

Chairs: François Newbury, Canadian Nuclear Safety Commission & Erik-G. Espinosa-Martinez, UAM

10:20-10:40	387. FISSION PRODUCT RELEASE FROM IRRADIATED NUCLEAR FUEL AT ACCIDENTAL CONDITIONS <i>O. Beneš, J. Y. Colle, R. J. M. Konings, T. Wiss (European Commission Institute for Transuranium Elements)</i>
✓ 10:40-11:00	389. THE ROLE OF SAFETY ANALYSIS IN ADDRESSING ENVIRONMENTAL QUALIFICATION OF THE NRU REACTOR SAFETY SYSTEMS <i>M. Karam (Atomic Energy of Canada Limited)</i>
11:00-11:20	392. PROBABILISTIC MODELING OF MATERIAL RESISTANCE TO CRACK INITIATION DUE TO HYDRIDED REGION OVERLOADS IN CANDU ZR-2.5%NB PRESSURE TUBES <i>L. Gutkin, D. Scarth (Kinectrics Inc.)</i>

Session 4A1-2:

SEVERE ACCIDENTS (V)

Track 1: Enhancing Safety and Security

Room: Regency F

Chairs: Martin Clouthier, Fauske & Associates & Zhiwei Zhou, Tsinghua University

10:20-10:40	248. DEVELOPMENT OF CSA N1600-14: GENERAL REQUIREMENTS FOR NUCLEAR EMERGENCY MANAGEMENT PROGRAMS <i>C. Sellar (CSA Group), J. Coles (Ontario Power Generation)</i>
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10:40-11:00	361. CANDU SEVERE ACCIDENT MANAGEMENT GUIDANCE UPDATE <i>L. Jones (Ontario Power Generation), N. Popov (SNC Lavalin Nuclear), L. Gilbert (Bruce Power), J. Weed (CANDU Owners' Group)</i>
11:00-11:20	305. REACTOR SAFETY RESEARCH AND DEVELOPMENT IN CHALK RIVER LABORATORIES <i>T. Nitheanandan (Atomic Energy of Canada Limited)</i>
✓ 11:20-12:00	414. SAFETY IMPROVEMENTS AT CANADIAN NUCLEAR POWER PLANTS IN THE AFTERMATH OF FUKUSHIMA ACCIDENT <i>G. Rzentkowski, H. Khouaja (Canadian Nuclear Safety Commission)</i>
11:20-12:00	425. GUIDANCE ON THE IMPLEMENTATION OF MODIFICATIONS TO MITIGATE BEYOND DESIGN BASIS ACCIDENTS <i>S. Harris, J. Marczak, M. O'Neill (Ontario Power Generation)</i>

Session 4A4-3:

ENVIRONMENTAL CHEMISTRY (II)

Track 4: Environmental Protection and Waste Management

Room: Plaza A

Chairs: M. Garamszeghy, NWMO & L. Dimitrovski, ANSTO

10:40-11:00	228. BULK MONITORING AND SEGREGATION OF RADIOACTIVE WASTES <i>H. Beddow, I. Adsley, I. Pearman, A. Sweeney, M. Davies (Nuvia Limited)</i>
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11:00-11:20 **258. SOLIDIFICATION OF METAL CHLORIDE WASTE FROM PYROCHEMICAL PROCESS VIA DECHLORINATION-CHLORINATION REACTION SYSTEM**
H. S. Park, I. H. Cho, K. R. Lee, J. H. Choi, H. C. Eun, I. T. Kim, G. I. Park (Korea Atomic Energy Research Institute)

11:20-11:40 **358. IMPLEMENTATION OF A PERMEABLE REACTIVE BARRIER FOR TREATMENT OF GROUNDWATER IMPACTED BY STRONTIUM-90**
A. Przepiora, D. Bodine, P. Dollar (Geosyntec Consultants), P. Smith (Quantum Murray LP Remediation Services)

11:40-12:00 **376. EFFLUENT AND ENVIRONMENTAL MONITORING OF CHALK RIVER LABORATORIES**
T. Pilgrim, C. De Waele, C. Gallagher (Atomic Energy of Canada Limited)

**Session 4A7-4:
SCWR MATERIALS AND
CHEMISTRY (III)**
Track 7: Developing New Technology and Applications

Room: Plaza B

Chairs: David Guzonas, Atomic Energy of Canada Limited & Peter Tremaine, University of Guelph

10:20-10:40 **359. EXTREME WATER CHEMISTRY – HOW GEN IV WATER CHEMISTRY RESEARCH IMPROVES GEN III WATER-COOLED REACTORS**
D. Guzonas (Atomic Energy of Canada Limited)

10:40-11:00 **308. OVERVIEW ON INVESTIGATION OF METAL SPECIATION UNDER SUPERCRITICAL WATER-COOLED REACTOR COOLANT CONDITIONS BY AB INITIO CALCULATIONS, SPECTROSCOPY AND CONDUCTIVITY MEASUREMENTS**
C. Pye, L. Cheng (St. Mary's University), P. Tremaine (University of Guelph)

11:00-11:20 **309. BOILING POINTS AND SPECIATION OF AQUEOUS ELECTROLYTE SOLUTIONS UNDER "HIDEOUT" CONDITIONS IN SUPERCRITICAL WATER-COOLED REACTOR COOLANT BY RAMAN SPECTROSCOPY**
L. Applegarth, P. Tremaine (University of Guelph)

11:20-11:40 **355. EXTRAPOLATION OF RATE CONSTANTS OF REACTIONS PRODUCING H₂ AND O₂ IN RADIOLYSIS OF WATER AT HIGH TEMPERATURES**
R. Leblanc, K. Ghandi, B. Hackman, G. Liu (Mount Allison University)

11:40-12:00 **421. RADIOCHEMICAL REACTION OF D-T/ TRITIUM AND CARBON MONOXIDE**
L. Wenhua, X. Yifu, S. Jiangfeng, S. Yan, B. Jingwen, J. Wenyong, H. Mingming (China Academy of Engineering Physics)

**Session 4A10-5:
RADIOLOGICAL PROTECTION
CHALLENGES (II)**
Track 10: Acquiring Medical and Biological Benefits

Room: Plaza C

Chairs: Donald Higson, Australian Nuclear Association & Nicholas Priest, Atomic Energy of Canada Limited

10:20-10:40 **30. WHITHER LNT?**
D. Higson (Australian Nuclear Association)

10:40-11:00 **210. LOW DOSE RADIATION AND ALARA: THE POTENTIAL RISKS TO PATIENTS AND STAFF FROM ALPHA-THERAPY**
N. Priest (Atomic Energy of Canada Limited)

11:00-11:20 **408. LOW DOSE DIAGNOSTIC RADIATION DOES NOT INCREASE CANCER RISK IN CANCER PRONE MICE**
D. Boreham (Northern Ontario School of Medicine), N. Phan (University of Ottawa), J. Lemon (McMaster University)

11:20-11:40 **221. GENETIC AND EPIGENETIC RESPONSES TO LOW DOSE IONIZING RADIATION: A DRIVE TOWARDS THE CONCEPT OF PERSONALIZED RADIOLOGICAL PROTECTION**
D. Klokov, M. Flegat (Atomic Energy of Canada Limited)

11:40-12:00 **426. RADICON: RADIATION EXPOSURE AND CANCER INCIDENCE (1990 TO 2008) AROUND NUCLEAR POWER PLANTS IN ONTARIO, CANADA**
E. Dagher, R. Lane, J. Burt, P. Thompson (Canadian Nuclear Safety Commission)

**Session 4A9-6:
NEW BUILD APPLICATIONS AND
MARKETS**
Track 9: Facing Competitors and Reducing Cost

Room: Georgia A

Chairs: Frank Yee, Chief Nuclear Engineer, Candu Energy Inc. & Milt Caplan, MZ Consulting Inc.

10:20-10:40 **326. ASSESSMENT OF TARGET MARKETS FOR DEPLOYMENT OF MODULAR HTGRS**
M. Richards, C. Hamilton, F. Venneri (Ultra Safe Nuclear Corporation)

10:40-11:00 **402. POTABLE WATER COGENERATION USING NUCLEAR POWER**
G. Alonso, J. R. Ramirez (Instituto Nacional de Investigaciones Nucleares), E. Del Valle (Instituto Politecnico Nacional)

11:00-11:20 **419. KNOWLEDGE GAPS IN ECONOMIC ANALYSES OF ADVANCED REACTOR CONCEPTS**
M. Moore, J. Pencer, L. K. H. Leung, R. Sadhankar (Atomic Energy of Canada Limited)

Session 4A8-7:**NUCLEAR EDUCATION**

*Track 8: Addressing Public Concerns about
Radiation Impacts*

Room: **Georgia B**

Chairs: **R. Dranga**, Atomic Energy of Canada
Limited & **Scott Peterson**, Senior
Vice President-Communications,
Nuclear Energy Institute

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| 10:20-10:40 | 146. A COMPREHENSIVE PROGRAM OF NUCLEAR ENGINEERING AND SCIENCE EDUCATION
<i>G. Bereznai, B. Lewis (University of Ontario Institute of Technology)</i> |
| 10:40-11:00 | 5. RESEARCH-BASED APPROACHES TO NUCLEAR EDUCATION
<i>J. Donev (University of Calgary),
Y. y. Carpenter (University of Colorado at Boulder)</i> |
| 11:00-11:20 | 98. AN ENERGY LITERACY STRATEGY FROM THE UNIVERSITY OF CALGARY FOR THE ENTIRE ENERGY SECTOR
<i>J. Donev, B. Heffernan, J. Jenden,
E. Lloyd, J. Toor, J. Williams
(University of Calgary)</i> |
| 11:20-11:40 | 386. NUCLEAR POWER AS A BASIS FOR FUTURE ELECTRICITY GENERATION
<i>I. Pioro (University of Ontario Institute of Technology)</i> |

PLENARY IVB:**FULFILLING THE PROMISE - TELLING OUR STORY –
COMMUNICATIONS AND OUTREACH DISCUSSION**

Room: **Regency E & F**

Chairs: **Mimi Limbach**, Managing Partner, Potomac Communications Group, Inc. &
Kune Y. Suh, Professor, Seoul National University

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|-------------|--|
| 14:00-14:15 | TELLING OUR STORY
<i>Ms. Mimi Limbach (Managing Partner, Potomac
Communications Group, Inc.)</i> |
| 14:15-14:30 | KOREA'S PROMISE--A TALE OF TWO CITIES
<i>Prof. Kune Y. Suh (Professor, Seoul National University)</i> |
| 14:30-14:45 | CHANGING THE CONVERSATION: HOW ANS
IS TELLING A DIFFERENT STORY ABOUT
NUCLEAR SCIENCE AND TECHNOLOGY
<i>Dr. Michael Brady Raap (President, American Nuclear Society)</i> |
| 14:45-15:00 | THE ROLE OF NGO IN NUCLEAR PUBLIC
COMMUNICATION AND THE PRACTICES
OF THE CHINESE NUCLEAR SOCIETY
<i>Mr. Lixin Shen (Deputy Secretary-General
(Chair), Chinese Nuclear Society)</i> |
| 15:00-15:15 | ACHIEVING SUCCESS THROUGH
TRUST AND ENGAGEMENT
<i>Mr. Scott Peterson (Senior Vice President-
Communications, Nuclear Energy Institute)</i> |
| 15:15-15:30 | THE PROMISE AND PERIL OF PUBLIC
NUCLEAR COMMUNICATION
<i>Dr. Jeremy Whitlock (Atomic Energy of Canada Limited)</i> |
| 15:30-15:45 | QUESTIONS AND ANSWERS |

PBNC-2014 CLOSING CEREMONY

Room: Regency E & F

Chair: Frank Doyle, Executive Chair, PBNC-2014

15:45-15:50 TRANSFER OF PBNC DUTIES FROM MR. FRANK DOYLE
TO 20TH PBNC (PBNC-2016), MR. LIXIN SHEN, DEPUTY
SECRETARY GENERAL OF CHINESE NUCLEAR SOCIETY

15:50-15:55 PRESENTATION ON PBNC-2016 BY
CHINESE NUCLEAR SOCIETY

15:55-16:00 CLOSING REMARKS BY MR. FRANK DOYLE



The 19th Pacific Basin Nuclear Conference (PBNC 2014)
Hyatt Regency Hotel, Vancouver, British Columbia, Canada, August 24-28, 2014.

A COMPARISON OF THE DIFFERENCE OF REQUIREMENTS BETWEEN FUNCTIONAL SAFETY AND NUCLEAR SAFETY CONTROLLERS

Authors: C.K. Chen, C.L. Lee and S.S. Shyu

Presenter: Chin-Yu Hung

August 25, 2014

*Nuclear Instrumentation Division,
Institute of Nuclear Energy Research
No. 1000, Wenhua Rd., Chiaan Village, Lungtan, Taoyuan, Taiwan, R.O.C.*





Introduction

- ❖ A joint effort known as **Taiwan's Nuclear I&C System (TNICS)** project had been established by Institute of Nuclear Energy Research (INER) to achieve self-reliant capabilities for design, application and licensing of nuclear I&C systems in Taiwan.
- ❖ Several key tasks including
 - Generic digital platform development,
 - Test and qualification,
 - Safety analysis,
 - System application,
 - Promotion, and
 - Licensing



Introduction

- ❖ A Triple Modular Redundant (TMR) safety controller (SCS-2000) has been completed and gone through the IEC 61508 Safety Integrity Level 3 (SIL3) certification of Functional Safety for industries.
- ❖ Based on the certification processes, the difference of requirements between Functional Safety and Nuclear Safety controllers in term of hardware and software are addressed in this study.
- ❖ Generally, sufficient diagnostics and test capability must be implemented in both safety controllers so that all failures can be detected by a combination of self-diagnostics and proof/surveillance test that assure the safety controller shall well perform its intended safety function.



SCS-2000 Safety Control System

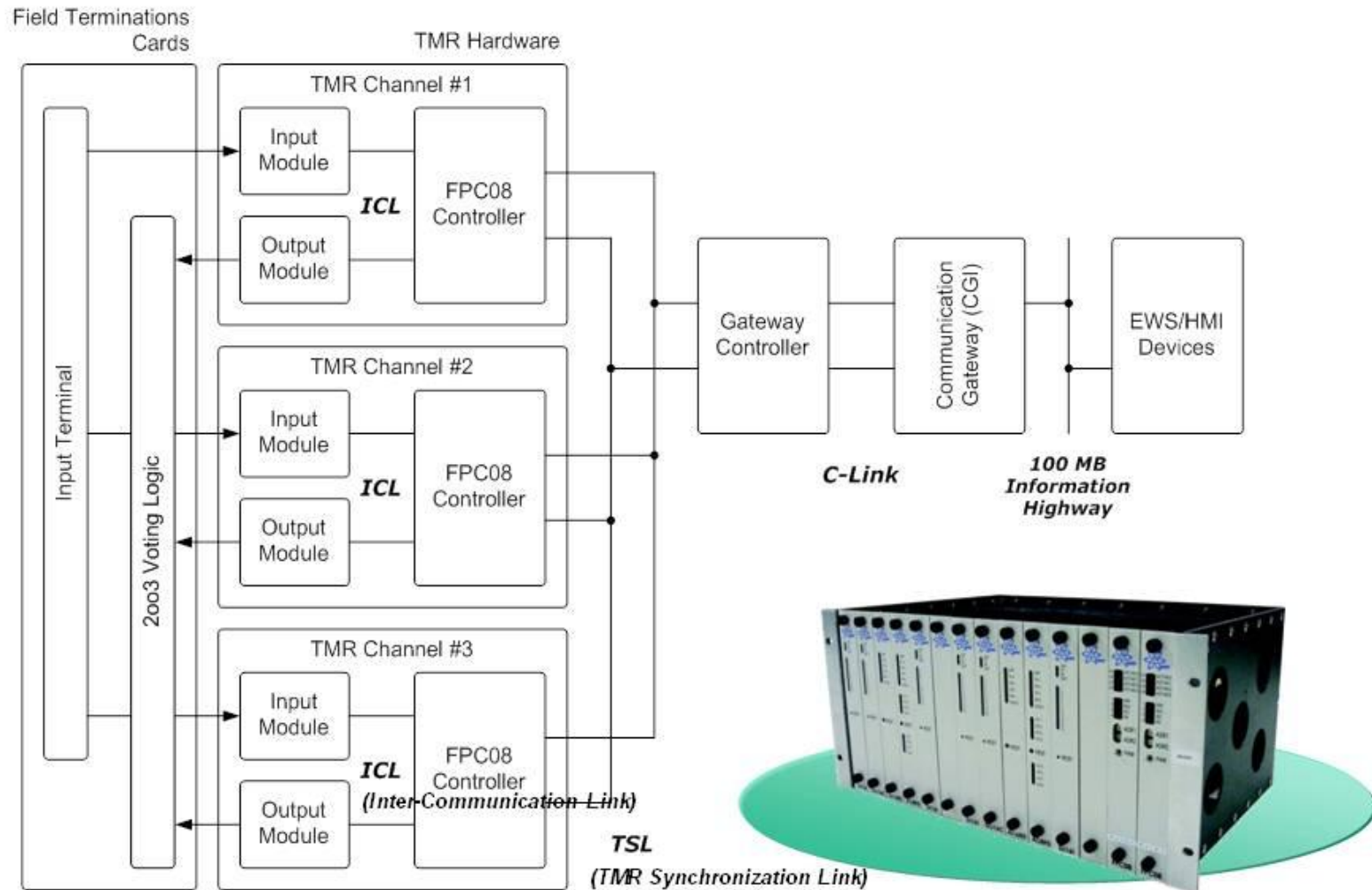


Figure 1. SCS-2000 safety control system architecture



Fault Category of SCS-2000

- ❖ The design objective of SCS-2000 with TMR architecture is to prevent any Single Point Of Failure (SPOF) from disabling the function of such configuration.

- ❖ Loss of TMR safety control system (fatal fault):
 - the failure of two sets of critical input signals;
 - the failure of two sets of trip output signals;
 - the failure of entire TSL.

- ❖ Loss of one controller (non-fatal fault):
 - loss communication of one controller;
 - the failure of one set of TMR controllers;
 - the failure of one set of critical input signals;
 - the failure of one set of trip output signals.

- ❖ Loss of partial function of controller (non-fatal fault):
 - the failure of one or more input signals;
 - the failure of hardware components of one controller;
 - TSL communication errors;
 - ICL communication errors.



Fail Safe Transitions of SCS-2000

- ❖ Analog Input (AI) module will be surrendered if calibration error, over range, and under range conditions are detected and then it will trigger an alarm and be inhibited into the control logic.
- ❖ Digital Input (DI) module will be reported when detects a fault in an input channel and then it will trigger an alarm and inhibit into the control logic.
- ❖ The I/O modules will be indicated at offline status if the watchdog timeout on any module. In such condition, any input channels from that module will become questionable.
- ❖ The controller will force DO modules enter fail safe mode, which is programmable if the corresponding input module occurs watchdog timeout or ICL timeout.
- ❖ Since AO module usually picks up stray noise or suffers from a loose or corroded connection, it doesn't recommend to use in fail safe transition for safety system.



Fault Detection of SCS-2000

❖ Online Diagnostic:

A hardware watchdog timer is used as the main diagnostic manner for SCS-2000 safety controller to report the hardware status.

❖ Quality Information of I/O Channel:

SCS-2000 uses single word and double words of quality information (status, alarm condition, operating mode and questionable status) for digital and analog I/O channels respectively.

❖ Controller Status / Dynamic Database Broadcast:

Both operational status of SCS-2000 safety controller and Dynamic Database (DDB) are periodically broadcasted over the TSL. Any predefined failure of SCS-2000 safety controller can be detected and reported.

❖ Communication Status Monitoring:

The logged communication error rate is used to identify the quality of communication links by communication errors counts.



The Objectives of Functional Safety and Nuclear Safety Controllers

- ❖ Functional Safety controller shall be complied with the international standard, [IEC 61508](#), “Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems”.
- ❖ A main objective of IEC 61508 is to facilitate the development of product and application based on its serial approaches which covers the complete safety life cycle.
- ❖ Nuclear Safety controller shall be complied with the requirements of [EPRI TR-107330](#).
- ❖ A main objective of EPRI TR-107330 is to evaluate a particular programmable logic controller (PLC) product line as a platform for safety related applications, founding a suitable qualification test program, and confirming that the manufacturer has a sufficient quality assurance program for safety related applications.



The Fault Control Measures for Random Hardware Failure of Safety Controllers

- ❖ According to TR-107330, the availability requirement of nuclear safety controller is that average probability of failure shall be less than 10^{-2} .
- ❖ The requirement of Functional Safety, the average unavailability is defined as average probability of dangerous failure on demand (PFDavg) within four Safety Integrity Levels (SILs).
- ❖ Based on the survey of related standards around the nuclear application, SIL3 is selected as our development target.

Safety Integrity Level (SIL)	Average probability of a dangerous failure on demand of the safety function (PFDavg)
4	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-2}$ to $< 10^{-1}$



The Fault Control Measures for Random Hardware Failure of Safety Controllers

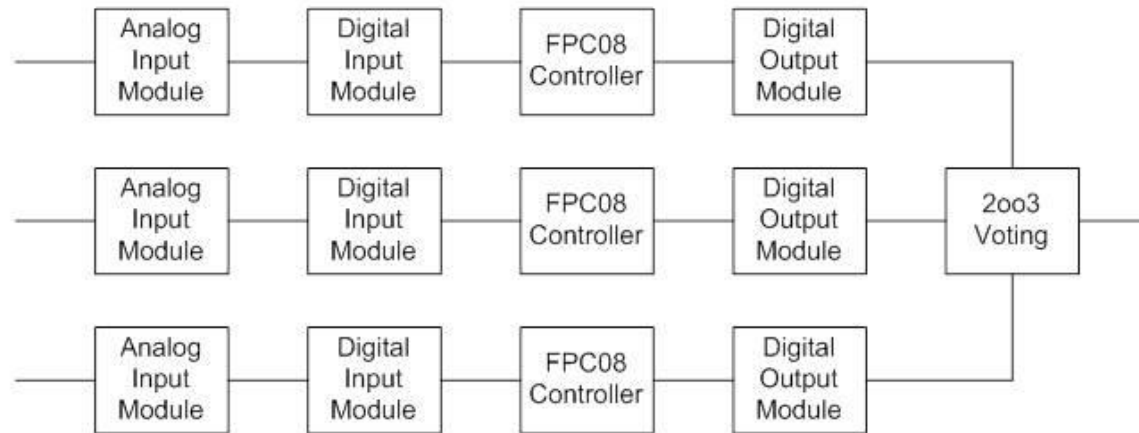
- ❖ The reliability of overall system is highly influenced by the choice of configuration and architecture design. IEC 61508 utilize the combination of Safe Failure Fraction (SFF) and Hardware Fault Tolerance (HFT) as an alternative significant assessment measure.
- ❖ Because of any failure of the safety control system results potentially dangerous consequences, the HFT is presented to eliminate the failure of the safety control system by the compensation of individual failures.
- ❖ A hardware fault tolerance of N means that N+1 is the minimum number of faults that could cause a loss of the safety function.

SFF	HFT		
	0	1	2
<60%	Not allowed	SIL1	SIL2
60% to <90%	SIL1	SIL2	SIL3
90% to <99%	SIL2	SIL3	SIL4
≥99%	SIL3	SIL4	SIL4



An Example for The Typical SCS-2000 Safety Controller

- ❖ The safety calculation shall be done for each individual safety loop. For this example, 1 analog input, 1 digital input (2-channel) and 1 digital output are included in each safety loop.



- ❖ Based on IEC 61508, the results of the calculations are given as follows:
 - Average Probability of dangerous Failure on Demand (PFDavg), $PFD_{avg} = 10^{-4}$
 - Safe-Failure-Fraction (SFF), $SFF > 90\%$ with $HFT = 1$
- ❖ The SIL3 requirements are fulfilled for SCS-2000 safety controller.



The Fault Control/Avoidance Measures for Systematic Failures of Safety Controllers

- ❖ Unlike random hardware failures, the probability of systematic failures in either hardware or software is hardly to be estimated.
- ❖ Regarding of the control and avoidance of systematic faults, the approach of the design of the hardware and software is recommend by IEC 61508.
- ❖ The Functional Safety Management (FSM) measure is used in Functional Safety for avoidance of faults concerning design, development, production, setting into operation.
- ❖ In Nuclear Safety the reliability of hardware is maintained by 10 CFR50 App. B quality assurance program, and the confidence of software life cycle is achieved by V&V process.
- ❖ Both measures between Functional safety and Nuclear safety are similar, but Functional safety has more complete guides for user to approach.



Environmental Withstand Tests for SCS-2000

- ❖ SCS-2000 had been tested and verified in different kinds of environment tests to approve its reliability for environmental withstand. Those tests include temperature, humidity, power source, radiation, ElectroMagnetic Compatibility (EMC) and seismic withstand.
- ❖ Proper Functioning Verification Procedure (PFVP) is used to assure its reliability for the required tests developed in accordance with Functional Safety and Nuclear Safety.
- ❖ The following criteria are adopted for validating the PFVP functionality of SCS-2000 system:
 - Accuracy of Analog I/O (Not vary more than 3%)
 - Response Time (Not more than 100ms)
 - I/O Operability
 - Communication Operability



Climate Tests for SCS-2000

❖ A complete set of environmental withstand test is generated for this SIL3 certification via the comparison between Functional Safety and Nuclear Safety.

- C1 – cold withstand test ($-40^{\circ}\text{C} \pm 3^{\circ}\text{C}$);
- C2 – dry heat withstand test ($70^{\circ}\text{C} \pm 2^{\circ}\text{C}$)
- C3 – variation of temperature withstand test ($-40^{\circ}\text{C} \pm 3^{\circ}\text{C}$ and $70^{\circ}\text{C} \pm 2^{\circ}\text{C}$)
- C4 – variation of temperature immunity ($-5^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $55^{\circ}\text{C} \pm 2^{\circ}\text{C}$)
- C5 – cyclic damp heat withstand test ($55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with humidity 95-100%)

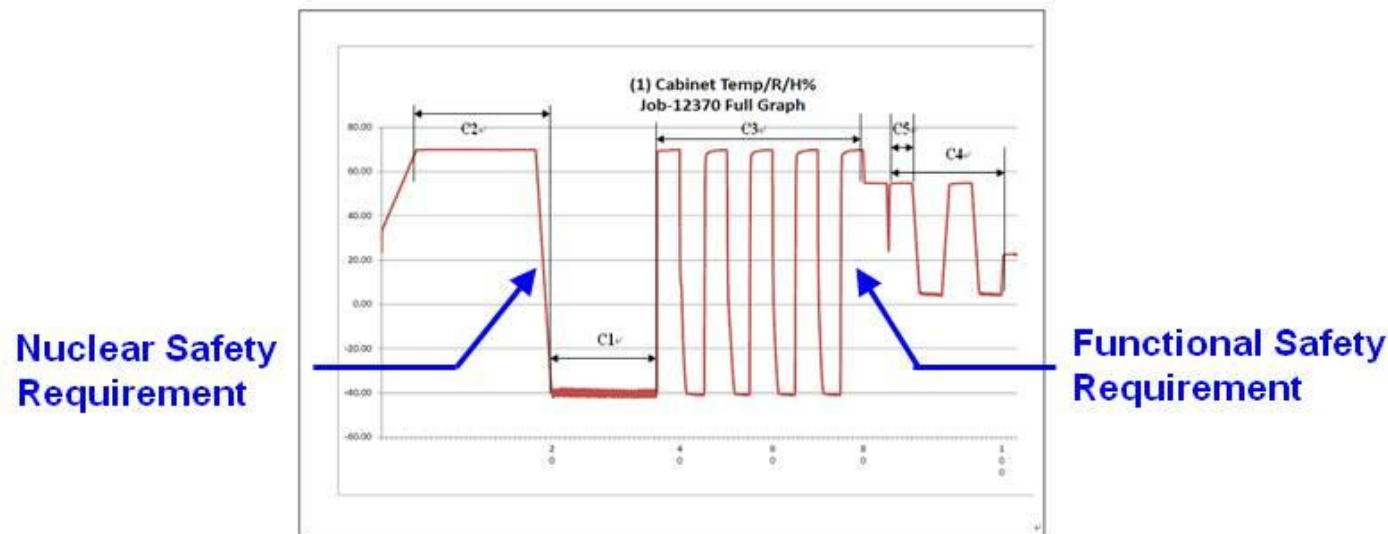
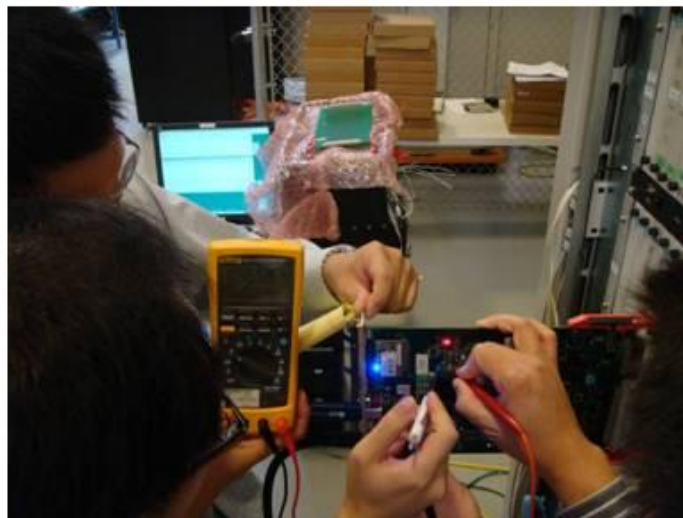
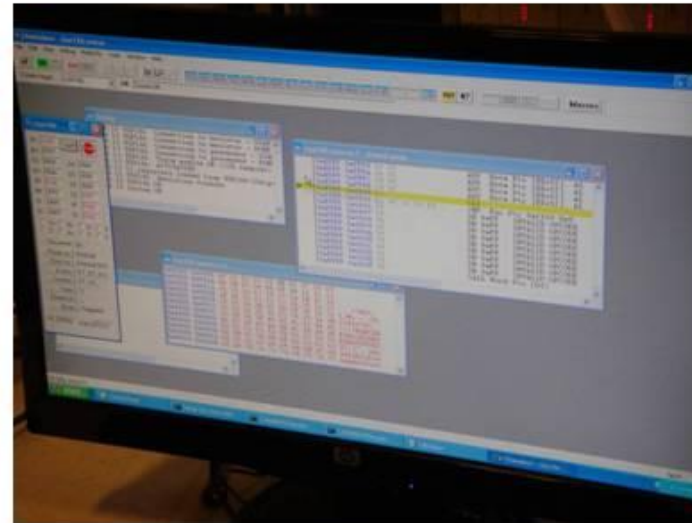


Figure 3. The testing periods of five climate tests

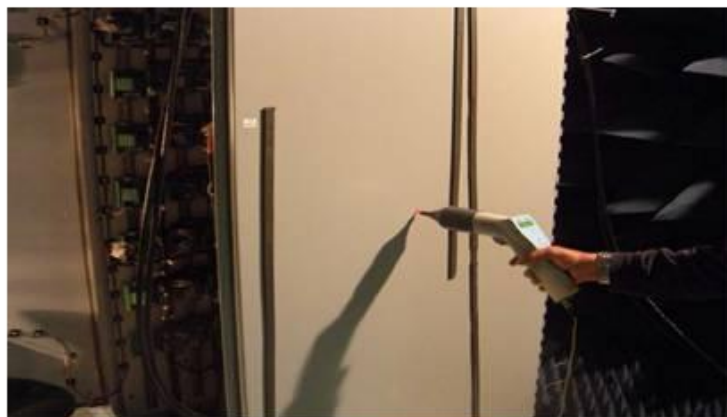


Conclusion

- ❖ Requirements of Nuclear Safety controller present the main scope for the overall lifecycle in nuclear application.
- ❖ Requirements of Functional Safety controller provide **detail designs and proper measures** of hardware and software for implementation to supplement ambiguous requirements of Nuclear Safety controller.
- ❖ Per the accumulated experience, we hope TNICS can support the required domestic self-reliant capability for the design and maintenance of digital I&C system in Taiwan.



The Fault Insertion Test (FIT) of SCS-2000



TMR configuration of SCS-2000

Environmental tests of SCS-2000



The Exhibition of SCS-2000



Thanks for your attention