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出國報告（出國類別：其他）

赴美國參加第十二屆 EPRI 國際電廠銲接修補技術研討會及前往加拿大 LAI 公司討論設備改善事項出國公差報告

服務機關：核能研究所
姓名職稱：鄭勝隆　副研究員
派赴國家：美國、加拿大
出國期間：106 年 6 月 19 日~106 年 6 月 28 日
報告日期：106 年 8 月 9 日

摘要

此次公差主要為參加第十二屆 EPRI 國際電廠銲接修補技術研討會，發表本所覆銲工作論文,並藉此收集國外核能電廠組件破損修補案例及銲接修補技術資訊，以作為本所計畫執行及後續研發工作之擬定參考。

在大會演講後,此屆研討會論文分為核能電廠及火力電廠兩個議題場地舉行。核能電廠議題涵蓋組件銲接修補案例、Alloy 52M 銲接缺陷、應力腐蝕防治、模擬軟體使用、自動化銲接設備整合、其他材料與技術應用等類別。

研討會後，前往加拿大拜訪 Liburdi Automation Inc (LAI) 公司，討論本所覆銲設備的改善議題，參觀新開發的銲接影像監視系統，並了解 LAI 公司的積層製造技術發展與銲接修補業務。

經過此次參訪，個人認為本所可以學習國外研發機構，以特定計畫為題，定期舉辦研討會，發表計畫成果、收集業界需求，並引導學界研發。

此外，弧銲積層製造研究及運用案例日益增加，其特性與覆銲技術相近，在工作轉型上，可將大尺寸積層製造列為技術發展的方向；同時，製程規劃、參數調整、銲道品質管理及銲接瑕疵監測評估等自動化銲接技術正發展中，本所可以在既有基礎上，順勢發展相關技術，以協助國內產業升級。另外，力學及材料模擬軟體已運用於產業多年，且本所已具多年經驗，但在製程模擬上，仍無力學及冶金性質關係(耦合)模擬，若可開發軟體評估瑕疵發生，將對弧銲積層製造的參數設定有重大改善。

雙相不銹鋼已用於核能產業中，此類材料亦適用於海洋環境，可考慮用於本所風機及未來海洋環境相關的計畫中。

目次

一、目　的

此次公差主要為參加第十二屆 EPRI 國際電廠銲接修補技術研討會，發表本所覆銲工作論文，並藉此收集國外核能電廠組件破損修補案例及銲接修補技術資訊，以作為本所計畫執行及後續研發工作之擬定參考。

研討會後，前往加拿大拜訪 Liburdi Automation Inc 公司，討論本所覆銲設備改善議題，參觀其新開發的銲接影像監視系統，並了解該公司在積層製造的最新技術與銲接修補業務的拓展。

二、過　程

106 年 06 月 18 日~06 月 20 日　　去程（台北－美國 洛杉磯－美國 奧蘭多）

06 月 20 日~06 月 23 日　　第十二屆國際電廠銲接修補研討會

06 月 24 日(星期六)　前往加拿大 多倫多市

06 月 25 日(星期日)　整理資料

06 月 26 日~06 月 26 日　　參訪加拿大 LAI 公司

06 月 27 日~06 月 28 日　　返程（加拿大 多倫多－台北）

(一)　第十二屆國際電廠銲接修補研討會

本屆 EPRI 銲接修補研討會於 6 月 21 日至 23 日在佛羅里達的奧蘭多舉行，圖 2 為大會現場，本屆會議的核能議題論文涵蓋組件銲接修補案例、Alloy 52M 銲接缺陷、應力腐蝕防治、模擬軟體使用、自動化銲接設備整合、其他材料與技術應用等類別，會議議程如及附件 1 所示。此行除發表論文外，亦藉此收集國外的銲接研究，以用於後續計畫規劃之參考，論文發表過程及相關研究摘要敘述如下。

1.論文發表

論文發表為此次公差的主要工作，論文發表被安排在第一天的下午(圖 3)，發表簡報檔如附件 2 所示。會後與 EPRI 銲接修補技術中心(Welding and Repair Technology Center)的計畫經理 Greg Frederick 先生短暫交談，Frederick 先生表示，將邀請我們出席它們的工作會議，用以交流研究現況，並歡迎我們去參觀 EPRI 在北卡的銲接實驗室。

2.大會演講

本次大會邀請俄亥俄州立大學材料系 A. Ramirez 教授、國際原子能總署

(IAEA)核能工程師 Harri Varjonen 先生及 Structural Integrity Associates (SIA)公司 Richard E. Smith 博士進行專題演講；另外，安排 Stan Gingrich 及 D. Borel 兩位專家講述雙相不銹鋼用於石化電廠的現況及數值分析用於電廠修補的工作。

Ramirez 教授以整合同步輻射及 Gleeble 試驗機為設備(設置情形如圖 4 所示)，執行材料的高溫相變態、機械性質的關聯性研究，由同步輻射的晶格資料推算相變化過程或程度，並比對 Gleeble 試驗機顯示的高溫機械性質資料，用以連結兩者間的關聯性，並驗證現今數值計算及相圖的準確性，以利後續熱處理製程開發。

IAEA 的 Harri Varjonen 先生則針對國際核能使用現況發表演講。他指出，目前約有 333 座的反應爐運轉超過 30 年，超過 40 年的則有 81 座，因材料老化管理、頁岩油開採降低的石化原料價格…等因素，已有 6~7 座可繼續運轉的反應爐(運轉超過 40 年)宣布除役，同時，還有 10 座未達 40 年運轉年限的電廠宣佈提前除役。

Smith 博士為 SIA 的銲接專家，具有 50 年以上的工作經驗。在會中以破壞力學、數值模擬、體積非破壞檢測…等工程技術運用於核能電廠重大事件(應力腐蝕及 PWSCC 異質銲道劣化)的演講，其演講也提到工程技術人力的老化對電廠營運的影響，並提出多項解決建議。

Stan Gingrich 為 AECOM 的材料與銲接工程部門的專案經理，主要負責發電設備的排氣脫硫設備(Flue-Gas Desulfurization，FGD)，他發表雙相不銹鋼(Duplex Stainless Steel)用於 FGD 的演講。雙相不銹鋼為沃斯田鐵及肥粒鐵兩相各占一半的材料，具有良好的抗孔蝕及間隙腐蝕能力及優異的銲接性及機械性質，目前北美地區約有 20%的 FGD 使用雙相不銹鋼，然而，因銲道研磨及熱量控制等製程問題，常使銲道的抗腐蝕性不佳。

Stan Gingrich 提醒一些銲接過程的重要細節，用以避免雙相不銹鋼銲件的耐蝕性劣化，相關細節包括控制入熱量及層間溫度、選用適當銲材、避免冷卻速度過慢…等。

D. Borel 先生則是 ESI 集團的銲接模擬專家，他在會中發表銲接修補過程中的物理現象及冶金變化的模擬研究，並運用相關模擬結果於預測修補組件時的銲接熱裂發生。

3.核能組件修補

本次會議有數個銲接修補案例發表，其中包含 Susquehana 1 號機的小管徑覆銲、比利時壓水式電廠調壓槽的 Alloy 52MSS 覆銲經驗及 James A. FitzPatrick 電廠的餘熱移除管路覆銲，其他修補案例則包含 EDF 的 BMI 修補。

Susquehana 1 號機的小管路銲道為 304 材質，經確認破損原因為沿晶應力腐蝕(IGSCC)，破損位置曾經修補過，雖然該廠已執行加氫水化學的防治措施，但仍發生 IGSCC。

與前案類似，James A. FitzPatrick 電廠的餘熱移除管路的破損原因也是 IGSCC，但此破損的異質銲道連接 304 管路及碳鋼鑄造閥，因修補處兩邊的幾何形狀不一致而具挑戰性。除碳鋼鑄造閥處發現裂紋外，執行不銹鋼緩衝層覆銲時，發現 304 管路有爐水滴漏，而需以 Alloy 182 進行止漏。

此外，James A. FitzPatrick 電廠的飼水加熱器(Feedwater Heater)因沖蝕(flow accelerated corrosion, FAC)而執行修補或更換，為節省數百萬美元以上的費用，最終採用修補方案。此修補採用機械式 Gas Metal Arc Welding (GMAW)製程，用以減少人力(約節省 450 小時人力)，並可獲得較均一厚度的修補銲層。

AZZ WSI 公司執行比利時 Doel Unit 3、Doel Unit 4 及 Tihange Unit 2 等 3 個機組調壓槽的安全釋壓閥及噴灑管嘴的覆銲，並對安全釋壓閥進行重新對位(realignment)。執行期程自 2015 年秋季至 2017 年春季，覆銲材料為 Alloy 52MSS，過程顯示 Alloy 52MSS 有較好的抗微小裂紋(micro-fissure)的能力，此工作應為 Alloy 52MSS 第一個應用案例。

4.銲接設備自動化

在設備發展研究上，本次大會焦點之一為運用感測器於銲接製程，主要計畫

執行單位為田納西大學。計畫以人機介面整合運動(機器手臂)及銲接製程為目標，運用感測器(sensor)資料於銲接程序與路徑之規畫與調整，監測並控制熔池及熱影響區，最終希望能達到調整銲珠及研判融合不良、夾渣…等銲接缺陷發生。

製程規劃以使用影像及輪廓儀等資料為主，熔池監控則以影像、熱影像及聲音等擷取資料為依據，影像、熱影像及輪廓儀等 3 項資料則做為銲接缺陷的研判依據。

5.軟體運用

此次會議的工程軟體使用上，包含 Sysweld、Thermal Calc 及 DIC 等三項軟體的運用。其中，Sysweld 為銲接專用的模擬軟體，已用於 James A. FitzPatrick 電廠的飼水加熱器(Feedwater Heater)的修補尺寸之設計；此外，EDF 的銲接修補案例採用 Sysweld，顯示此軟體已被國外核管單位及核能工業界所接受。

Thermal Calc.為材料冶金評估軟體，可配合多項模組進行凝固、相變化、相析出…等多項工作的預測及評估。此次會議中，其所屬公司發表銲接熱裂及不銹鋼敏化的新評估應用。

Digital Image Correlation (DIC)為一種影像軟體，可以於評估材料受力過程的細部應變變化，已常見於目前的銲接研究中。此次會議中，橡樹嶺國家實驗室發表照射過材料的摩擦攪拌銲接論文，論文運用紅外線攝影機影及 DIC 軟體進行銲接的應變評估與量測。

6.其他

除上述研究外，此次會議亦有多個單位提出應力腐蝕的防治措施，其中包含 AREVA 的 Ultra High Pressure (UHP)、MRP Associates 的 Internal Mechanical Stress Improvement (IMSI)及和 Young-Sik Pyun1 教授提出的 Ultrasonic nanocrystal Surface Modification(UNSM)。

UHP 將用於 Byron 電廠 2 號機及 Braidwood 電廠 1 號機，IMSI 則是類似機械應力改善製程(Mechanical Stress Improvement Process, MSIP)，對接及 J 型銲道

皆可使用，其應力改善深度較表面應力改善高。UNSM 則是採用以珠擊的概念，進行表面應力改質，目前相關申請法規已獲得同意。

SIA 公司發表雙相不銹鋼在核電產業的使用情況，使用範圍包括新建電廠的燃料貯存廠房的水池(In-containment Refueling Water Storage Tank)與用過燃料池(Spent fuel pools)，以及核電廠的用過燃料乾式貯存桶。其中，San Onofre 電廠已向美國核管會申請使用雙相不銹鋼製作的用過燃料貯存桶。

EPRI 的 D. Gandy 先生發表新製程用於未來新反應器製造，以便降低成本及製造時程。該方法結合粉末冶金及熱均壓兩製程製作反應器模塊，以電子束進行模塊的對接銲，運用二極體雷射執行組件的表面披覆，相關技術將可用於 SMRs、ALWRs、Gen IV 等反應器的製造。

(二)　參訪加拿大 Liburdi Automation Inc.(LAI)公司

此次公差另一個重點是參訪 LAI 公司，觀看它們新銲道監視系統展示，同時了解 LAI 公司在積層製造及 MIG 銲接修補的技術發展現況，相關參訪過程摘要如下。

1.新銲道監視系統展示

本所使用軌道銲接機執行覆銲工作已近十年，日前接到 LAI 公司通知，將停產銲道監視系統的視訊轉換盒，屆時將無備用零件維護本所設備。本次參訪目的為參觀其新型銲道監視系統，並與該公司技術人員討論本所設備的維護方案，以作為本所軌道銲接機設備的維護及更新參考。

圖 5 為 LAI 公司的軌道式氬銲機展示現場。展示使用架於管路模擬件上的 G 型銲頭 (圖 6(a))，除銲頭攝影機不同外，銲頭構型及銲機控制面板皆與本所設備相同(如圖 6(c))，整個展示過程採用冷送線的銲接製程模式。新銲道監視系統的體積縮小，採用外掀式觸控螢幕(如圖 6(b))，整體操作除可採觸控外，亦可以使用 USB 插槽外接搖桿控制。

圖 7(a)為熔池前方及後方的影像。因新型攝影機不需調整光圈，已取消原控制系統上的光圈控制，還一併取消鎢棒位置校正。在銲接過程中，操作員可以同時監看熔池並確認銲接參數，如圖 7(b)所示。整個排線連接如圖 7(c)所示。

整體來說，新銲接監視系統使用的新型攝影機，可免除光圈濾鏡(dot filter)及光圈調整機構，進一步更新監控軟體，免除鎢棒位置的調整步驟，使用上更為便利。

2.積層製造

LAI 公司除有銲機製造及設計的能力外，其業務還包含渦輪葉片維修、核電廠組件修補…等，該公司主要使用雷射銲接與電漿銲接等兩種製程修補渦輪葉片，修補程序與覆銲製程相近。

圖 8 為該公司的積層製造測試件，使用冷送線的雷射銲接製程，測試項目包含不銹鋼材質管路及管嘴、鈦合金錐形體及鎳基合金葉片等等。該公司使用葉片修補技術於鎳基合金的積層製造上，以送粉式的雷射銲接製程為主，圖 9 為該公司的 6KW 雷射銲接機台。另外，該公司亦常以電漿銲接製程修補葉片，圖 10 為該公司的微電漿銲接系統，配合送粉機構執行葉片修補。

該公司技術人員表示，送粉方式主要用於微小裂紋的精確修補，可藉由不同粉末的比例來調配銲道材質；相對的，送線方式有利於大面積修補，同時銲線存放較為容易，特別是針對親氧性極高的鈦金屬。上述為送粉及送線的選用依據。

現場另有衛星用的鈦合金槽體組件樣品(如圖 11)，其原製程為旋壓成形(spinning)，須預留大體積材料以用於邊槽加工。新製程仍採較薄板件旋壓成桶狀槽體，再以積層製造方式做出邊槽，較原先製程省工及省料，該產品已獲選用於實際衛星。

3.HY-80 鋼板修補及 MIG 銲接技術

除原先業務外，公司應加拿大海軍需求執行 HY-80 鋼板的潛艇外殼修補研發。圖 12 為 HY-80 的原材及修補試片，該公司開發手工電焊及機械式 MIG 銲接等兩種修補製程(圖 13(a))，圖 13(b)與圖 13(c)為修補完成後的彎曲測試及 X-ray 測試樣品，該公司製程亦通過加國海軍的爆炸測試。

此外，LAI 公司亦發展石化廠組件修補的 MIG 銲接製程，該公司 MIG 技術已達到可單道次對接半吋厚鋼板，如圖 14 所示。圖 15 為其軌道式 MIG 銲接設備，整體設備與本所軌道式 TIG 銲接設備相近。

除相關銲接技術外，該公司的銲接場地皆裝置排氣設備(圖 16)，有利於排放銲接產生的有害氣體，可供本所實驗室設置或改善之參考。

三、心　得

關於此次國外公差，相關心得條列如下:

1. 國外研發機構(如 EPRI)常自辦國際研討會，除用以發表計畫成果並宣傳工作成效外，亦藉此收集業界需求，，引導學界研發。
2. 在論文簡報後，與 EPRI 的 WRTC 計畫經理 Greg Frederick 先生短暫交談，Frederick 先生邀請本所出席其計畫工作會議，分享研究成果，此點說明本所研究仍符合業界需求。
3. 近年來，弧銲的積層製造的研究日益增加，實務運用案例越來越多，本所覆銲技術為堆銲型態的銲接，只要改變製程參數及程序控制，即可達到積層製造要求。在考量本所的轉型上，可將大尺寸積層製造列為未來技術發展的方向。
4. 機器人及機器手臂早已運用於銲接產業中，目前已有多款整合 TIG 跟 MIG 的市售銲接設備，在短缺技術純熟的銲工、勞動條件增加及工業化 4.0 的產業發展趨勢下，從製程規劃、參數調整、銲道品質管理及銲接瑕疵監測評估等工作的自動化正逐步發展，本所在既有基礎上可以順勢發展相關技術，以其運用於國內相關產業，以協助國內產業升級。
5. 力學及材料模擬軟體已運用於產業多年，但在製程模擬上，仍無力學及冶金性質關係(耦合)模擬，若可開發軟體評估瑕疵發生，將對弧銲積層製造的參數設定有重大改善。
6. 雙相不銹鋼已用於核能產業中，此類材料亦適用於海洋環境，可考慮用於本所風機…等計畫。

四、建 議 事 項

(一) 持續派員參加此類銲接修補技術會議，收集弧銲積層製造相關資訊，以作為本所覆銲技術發展參考。

(二) 持續注意銲接設備的自動化發展現況，逐步更新本所設備並累績整合經驗，以利推展後續研發工作。

(三) 建置本所在材料力學及冶金性質的整合模擬能力，開發銲接程序規劃、瑕疵監測及評估機制，以加速本所研發計畫。

(四) 與國內廠家密切合作，共同進行銲接技術研發計畫，以符合國內產業需求。

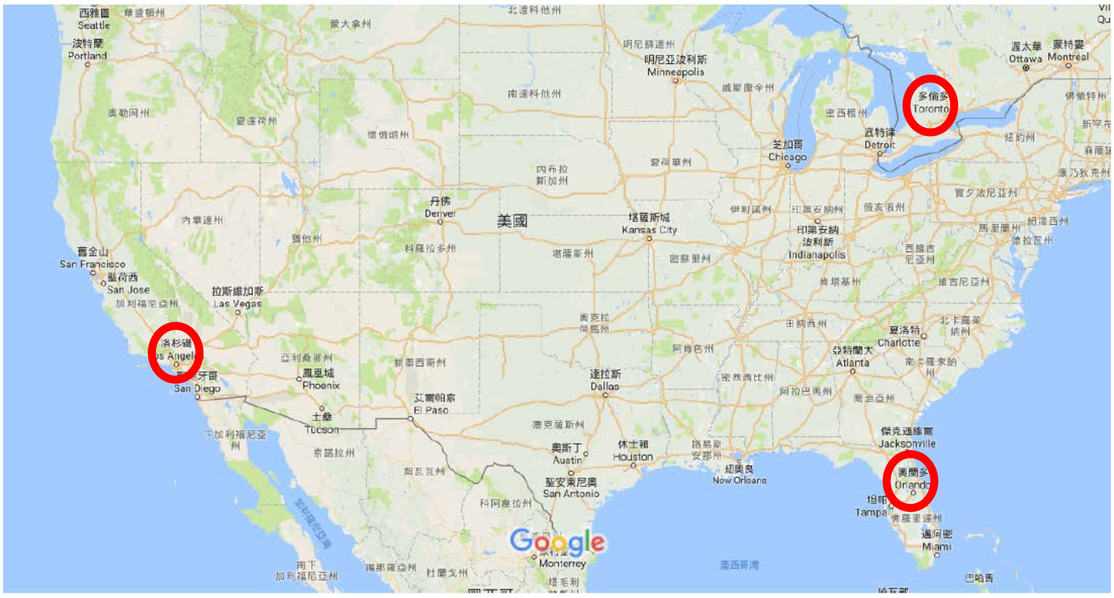


圖 1 EPRI 會議與 LAI 公司的位置。

圖 2 第 12EPRI 國際電廠銲接修補研討會會場。

圖 3 研討會論文簡報情況。

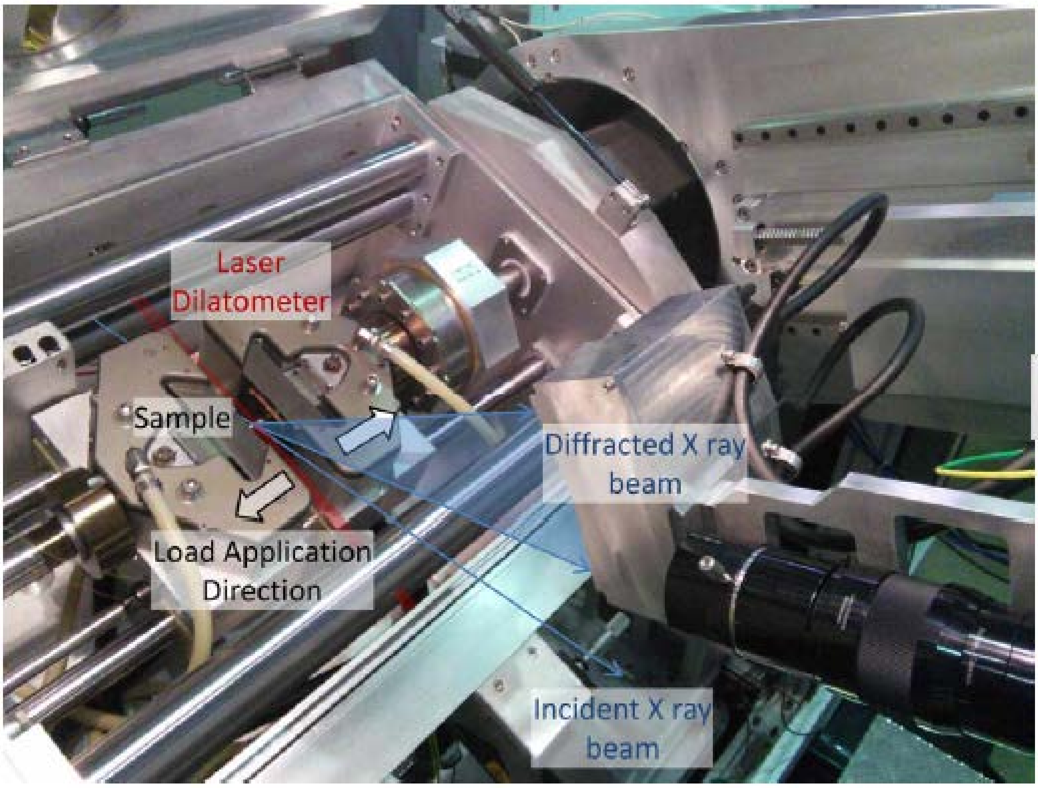


圖 4 同步輻射與 Gleeble 試驗機的整合。

圖 5 LAI 軌道式氬銲機展示現場。

圖 6 LAI 軌道式氬銲機: (a)銲頭；(b)銲道監視系統及(c)銲機。

(a)	(b)
	

(c)

圖 7 銲道監視系統: (a)銲接時的熔池監視畫面;(b)銲接時的實際銲接參數與熔池監視畫面;(c)背面接線情況。

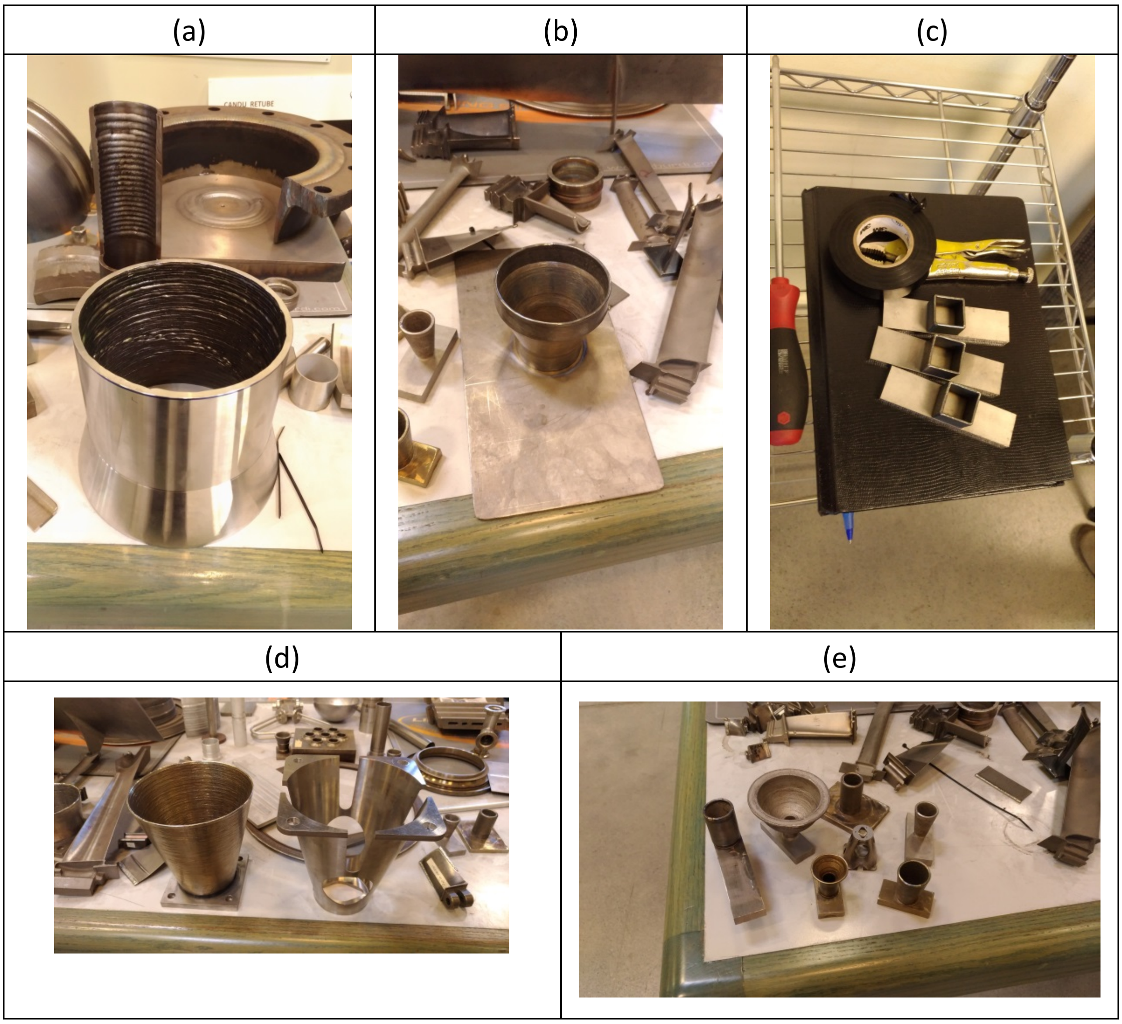


圖 8 積層製造成品: (a)不銹鋼材質管路及管嘴;(b)鈦合金錐形體及鎳基合金葉片；(c)鈦合金小方形體；(d)鈦合金錐形體及其成品；(e)鈦合金小圓錐及小圓形體。

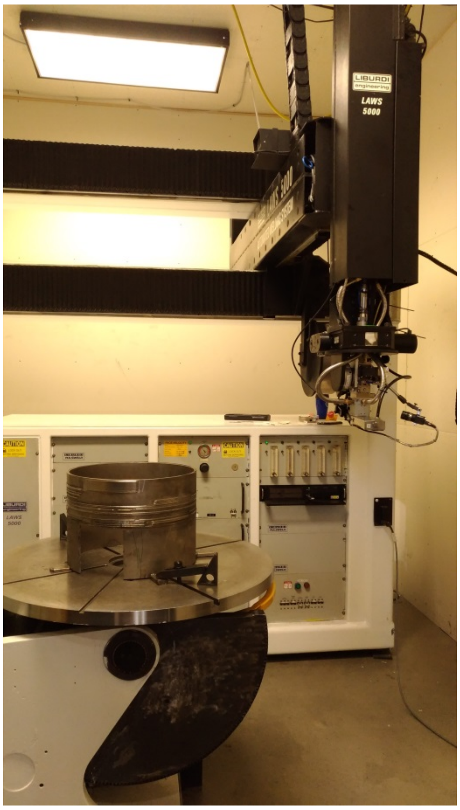
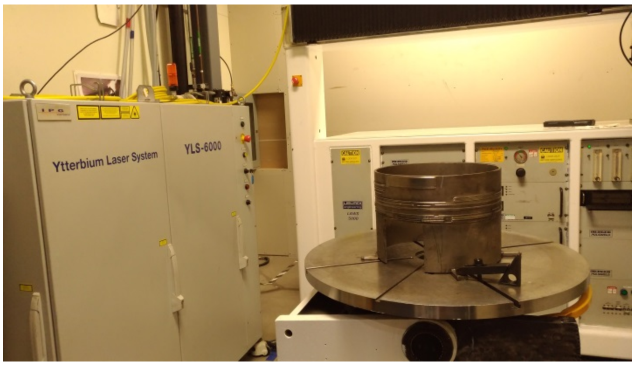
(a)	(b)
	 (c) 

圖 9 雷射銲接系統：(a)機構外觀；(b)銲接頭；(c)旋轉台與雷射源。

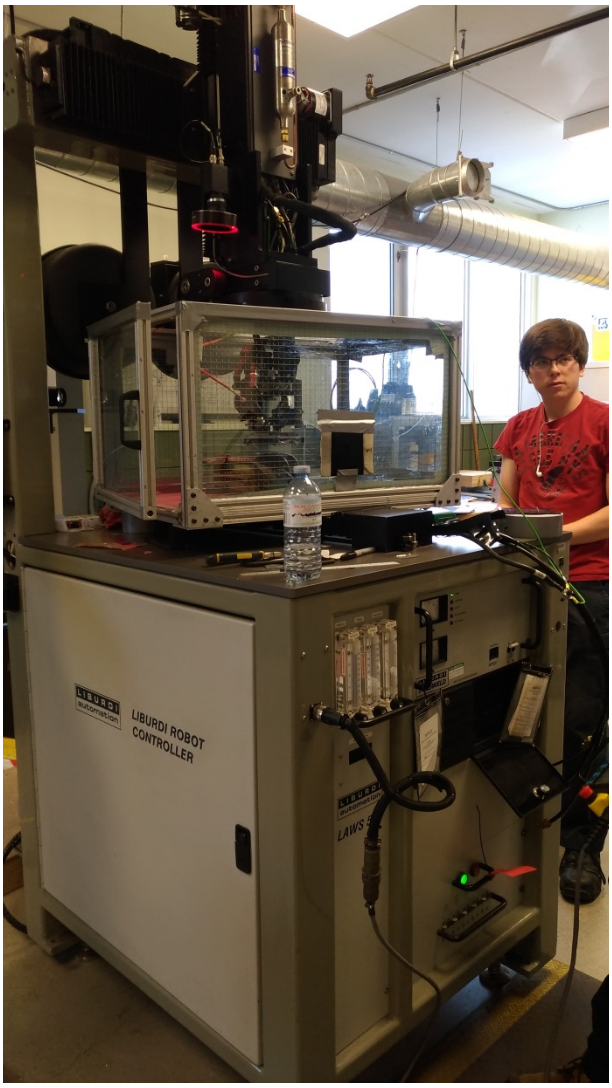


圖 10 微電漿銲接系統。

(a)	(b)
	

圖 11 部份積層之鈦合金槽體: (a)槽體剖面；(b)積層製造部位。

(a)	(b)
	

圖 12 (a)HY-80 鋼板原材及(b)模擬修補試片。

(a)

(b)

(c)

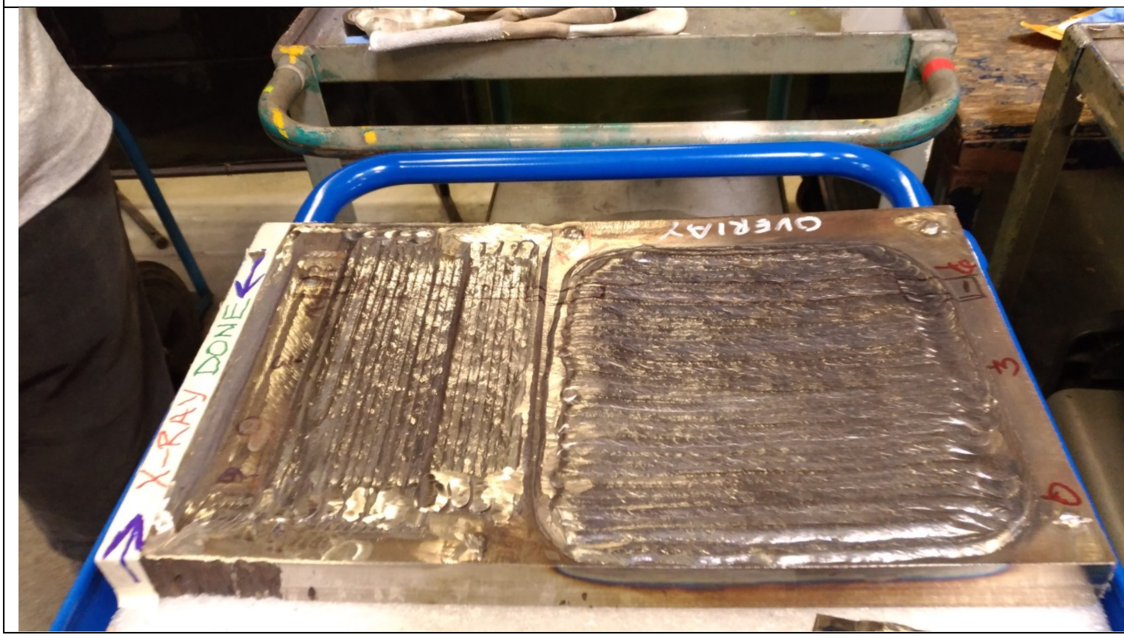


圖 13 (a)HY-80 鋼板修補測試試片；(b)彎曲測試結果；(c)執行 X-ray 檢測。

(a)	(b)
	
(c)	
	

圖 14 單道次 MIG 對接試片：(a)銲道正面；(b)銲道背面；(c)銲道側面。

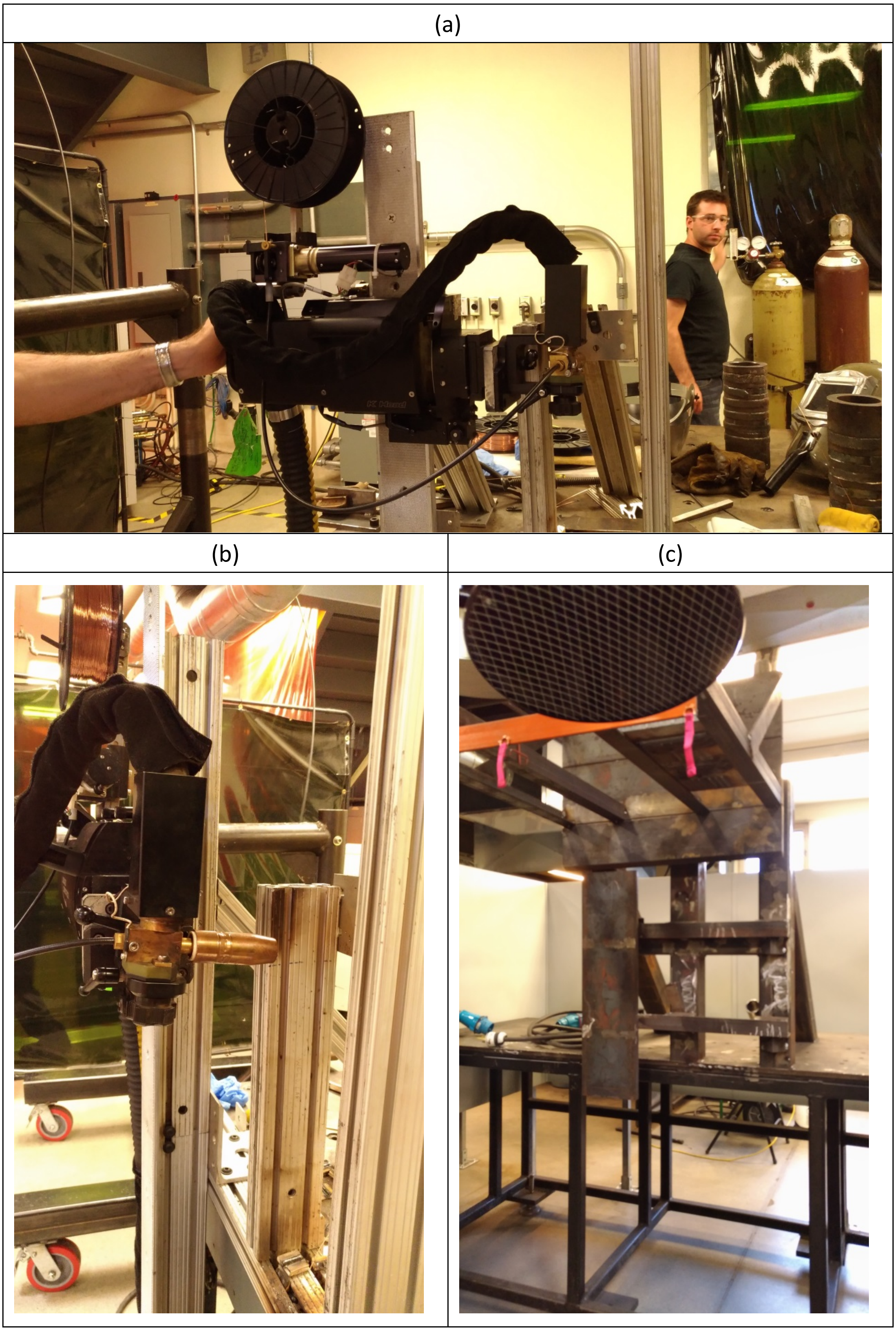


圖 15 軌道式 MIG 銲接系統：(a)銲頭正面；(b)銲頭側面；(c)銲接模擬器。

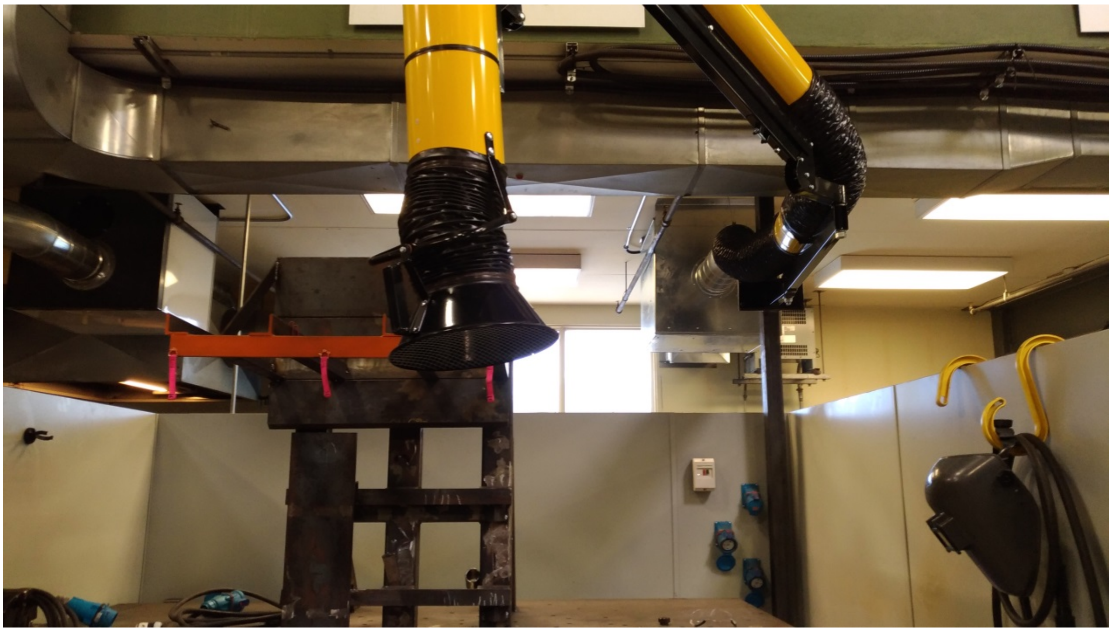


圖 16 廠房內排氣系統。

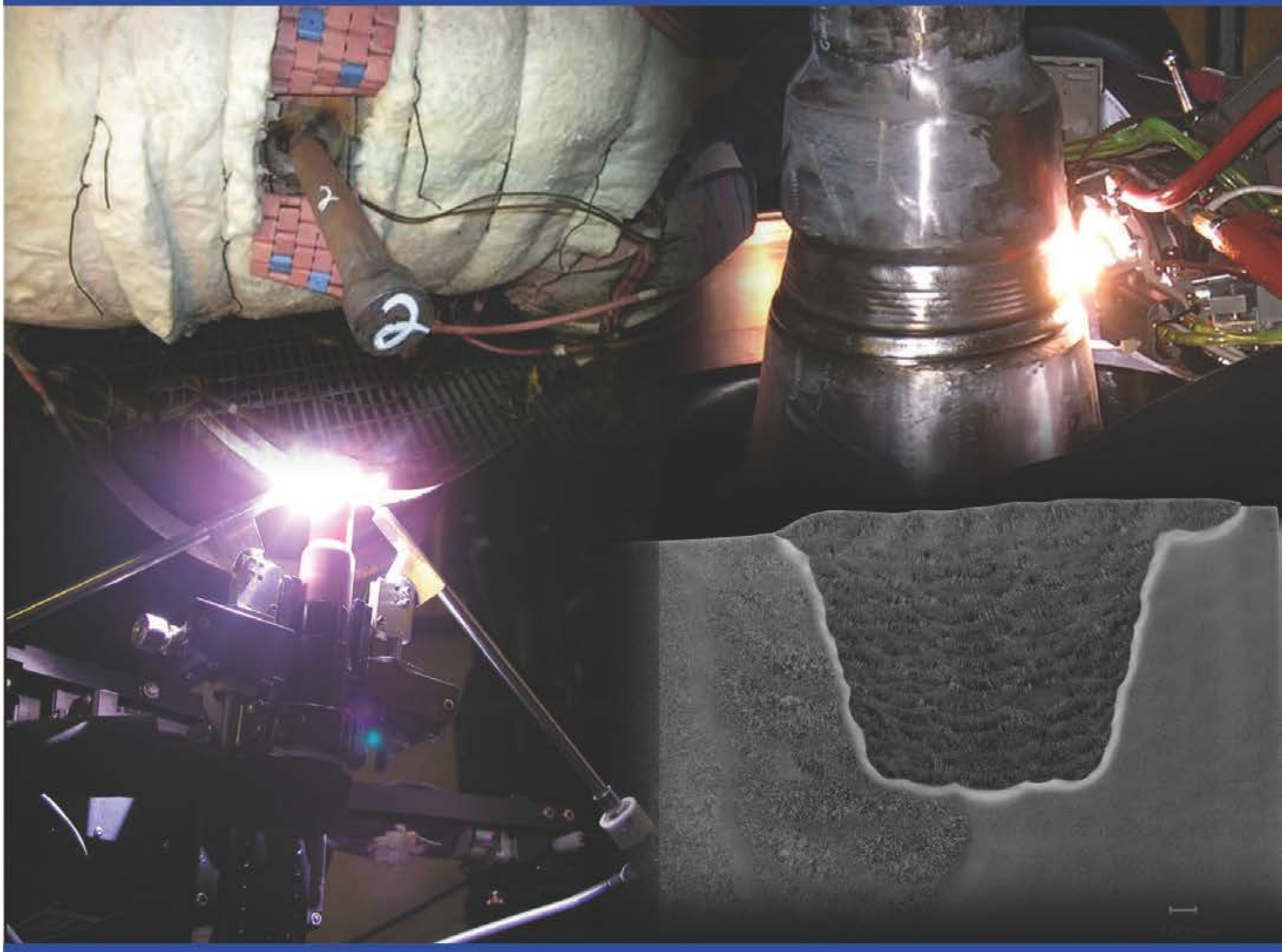
五、附　錄

(一)附錄 1

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Welding and Repair Technology for Power Plants
12th International EPRI Conference

Program



June 21–23, 2017
Reunion Resort, Orlando, Florida

Background

Previous Electric Power Research Institute (EPRI) conferences on welding and repair technology highlighted emerging repair technologies and reviewed many established methodologies for repairing power plant components, including reactor pressure vessels, steam generators, vessel nozzles, piping, headers, valves, and pumps. The 2017 conference will capture emerging and advanced welding and repair technologies for nuclear and fossil pressure retaining components, rotating equipment, and other engineering structures.

Today, emerging issues such as life expectancy of repaired components; avoidance of time-consuming post-weld heat treatments; repair guidelines for aging components; on-line repair options; use and application of advanced alloys; and repair procedures for critical power plant components such as rotors, blades, headers, and piping are increasingly important. EPRI, utilities, original equipment manufacturers, and vendors worldwide have been carrying out related research and application activities. As a result of these issues and efforts, there exists a need to consolidate this experience and identify current limitations and future needs.

Conference Sponsor

Structural Integrity Associates, Inc.®

Technical Scope

The Welding and Repair Technology for Power Plants Twelfth International EPRI Conference will address the repair of nuclear, fossil, heat recovery steam generator (HRSG), and steam turbine power plant components. Topics for discussion will include repair methods, performance, prior service effects, repair and welding qualifications, materials properties, advanced repair technology, corrosion, and case histories. Although repair and welding technology for the maintenance of existing power plants will be the primary focus of this conference, with the emergence of new nuclear and fossil plant construction, advanced fabrication and welding technologies for new plants will be included. The program—designed for technical exchange among participants—will highlight utility needs and current industry capabilities and experience.

As a part of this conference, the fossil session will highlight a special one-day session highlighting recent developments in the application of alternative weld repair methods for the creep strength enhanced ferritic steel Grade 91. This special one day session will be open to all attendees of the Conference, but the selected lectures given over the 1 day session will be by invitation only. Topics covered will include perspectives from entities involved in the repair process, end-use application examples, recent data development and supporting analysis of in-service performance.

EPRI Program Sponsors

- EPRI Welding and Repair Technology Center (WRTC)
- EPRI Fossil Materials and Repair Program (P87)

Use the QR code to access meeting information and connect with EPRI Social Media.

Event Code: 1227-4933

APP

Keynote Speakers

The Use of Advanced In-Situ Testing Techniques to Address Real World Welding Challenge

Antonio J. Ramirez
Professor, Welding Engineering Program, Materials Science and Engineering Department
The Ohio State University

Prof. Antonio J. Ramirez, received his degree in Mechanical Eng. (1993) from the National University of Colombia, M.Sc.(1997) and Ph.D.(2001) in Materials Science from São Paulo University (Brazil). After a postdoc at OSU (2001-2003), continued his scientific career at the Synchrotron Light National Laboratory (LNLS) and Nanotechnology National Laboratory (LNNano) in Brazil (2004–2015) as researcher, group leader and deputy-director. He joined the Welding Engineering Program at the Materials Science and Engineering Dept. at OSU in 2015, where he teaches welding metallurgy and leads the Manufacturing and Materials Joining Innovation Center (Ma2JIC). His research ranges from joining of structural materials to exploring fundamental aspects of bulk and nanostructured materials down to the atomic scale. He has worked with the technological and fundamental aspects of welding metallurgy and has a vast experience in materials modeling and characterization. In recent years, he has devoted his efforts to the study of friction stir welding and the development and application of advanced in-situ techniques associated with electron microscopy and synchrotron x-ray diffraction to unveil the fundaments of phase transformations on structural and functional materials

Outage Related Statistic and Ongoing Optimization Projects in IAEA

Harri Varjonen
Nuclear Engineer
International Atomic Energy Agency IAEA

Harri Varjonen was born in Finland 1968. He received the Engineer's degree in Satakunta University of Applied Sciences a.k.a. Porin Teknillinen Oppilaitos in Finland in 1995. He has more than 20-years experience in maintenance in different positons in paper-, and nuclear industry. Harri Varjonen began his nuclear career in Olkiluoto Nuclear Power Plant in Finland in 2002 as a maintenance engineer and worked there twelve years. Past two and half years he has worked as a Nuclear Engineer of the International Atomic Energy Agency,(IAEA) headquarter in Vienna, Austria. His main responsibilities and duties are to develop instructions and guidelines for the maintenance areas in nuclear industry. At the moment he is preparing and developing technical documents which are related to Outage Optimization Strategies-, Improvement of In-Service Inspection Effectiveness-, and Dissimilar Metal Welding Inspection, Monitoring and Repair Approaches in Nuclear Power Plants.

Keynote Address

Paradigm Shifts in Welding Technology for the Nuclear Power Industry

Richard E. Smith
Senior Associate/Chief Welding Engine
Structural Integrity Associates

Dr. Smith is a Materials Engineer having worked more than 50 years in the electric power industry. He is a graduate of Virginia Tech having received his BS and MS in Metallurgical Engineering and PhD in Materials Engineering Science. His work experience covers large component fabrication, electric utility equipment research, then engineering support on materials, corrosion, and welding related issues primarily for electric power utilities. He has supported ASME B&PV Code development, and has been associated with Structural Integrity Associates for the past 18 years where he currently serves as Senior Associate/ Chief Welding Engineer. Welding issues have dominated his work experiences for his entire career and in recent years has focused on the many issues encountered with welding Alloy 52 type filler materials including the evolution of temper bead technology. He is a Fellow of the American Welding Society and has actively participated on the ASME Boiler and Pressure Vessel Code.

Contacts

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Agenda at a Glance

Tuesday, June 20, 2017			
5:00–7:00	**Welcome Reception** (Location: Grande Lobby)		
Wednesday, June 21, 2017			
8:30	**Keynote Addresses** (Location: Grande ABCD)		
10:30	**Break**		
11:00	**General Session** (Location: Grande ABCD)		
12:00	**Lunch** (Location: Grande Pavilion and Forte)		
1:00	**Nuclear Session - Operating Experience** (Location: Grande D)	1:00	**Fossil Session - Repair and PWHT** (Location: Grande ABC)
2:30	**Break**	2:30	**Break**
3:00	**Nuclear - Student Session** (Location: Grande D)	3:00	**Fossil - Student Session** (Location: Grande ABC)
5:00—8:00	**Vendor Expo** (Location: Grande Pavilion)	5:00—8:00	**Vendor Expo** (Location: Grande Pavilion)
Thursday, June 22, 2017			
8:30	**Nuclear Session - Operating Experience** (Location: Grande D)	8:30	**Fossil Session - Introduction to Alternative Weld Repairs** (Location: Grande ABC)
10:00	**Break**	10:00	**Break**
10:30	**Nuclear Session - Residual Stress** (Location: Grande D)	10:30	**Fossil Session - Supporting Research for Grade 91 Steel Repair** (Location: Grande ABC)
12:00	**Lunch** (Location: Grande Pavilion)	12:00	**Lunch** (Location: Grande Pavilion)
1:00	**Nuclear Session - Codes and Standards** (Location: Grande D)	1:00	**Fossil Session - Grade 91 Steel Repair Case Studies** (Location: Grande ABC)
3:00	**Break**	3:00	**Break**
3:30	**Nuclear Session - Weldability** (Location: Grande D)	3:30	**Fossil Session - Grade 91 Steel Repair Case Studies** (Location: Grande ABC)
5:30	**Adjourn**	5:00	**Adjourn**
Friday, June 23, 2017			
8:30	**Nuclear Session - Advanced Manufacturing and Fabrication** (Location: Grande D)	8:30	**Fossil Session - Dissimilar Metal Welds** (Location: Grande ABC)
10:00	**Break**	10:00	**Break**
10:30	**Nuclear Session - Advanced Welding Techniques** (Location: Grande D)	10:30	**Fossil Session - Advanced Materials and Inservice Monitoring** (Location: Grande ABC)
12:00	**Adjourn**	12:00	**Adjourn**

Agenda

Wednesday, June 21, 2017	
General Session Chairs: Greg Frederick and John Shingledecker / EPRI Representatives: Greg Frederick and John Shingledecker	
8:30	WRTC/Program 87 Introduction, *G. Frederick and J. Shingledecker*, Electric Power Research Institute (EPRI)
9:00	Keynote Address: The Use of Advanced In-Situ Testing Techniques to Address Real World Welding Challenges, *A. Ramirez*, The Ohio State University
9:30	Keynote Address: Outage Related Statistic and Ongoing Optimization Projects in IAEA, *H. Varjonen*, International Atomic Energy Agency
10:00	Keynote Address: Paradigm Shifts in Welding Technology for the Nuclear Power Industry, *R. Smith*, Structural Integrity Associates
10:30	**Break**
11:00	Duplex Stainless Steels for Power Generation Applications, *S. Gingrich*, AECOM Corporation
11:30	Use of Numerical Simulation for Welding and Repair Qualification, *D. Borel, J. Delmas, K. Dorogan, S. Hendili, and V. Robin*, Electricité de France
12:00	**Lunch**

Wednesday, June 21, 2017 (continued)			
Nuclear Session - Operating Experience Chair: R.C. Folley / EPRI Representative: Nick Mohr		**Fossil Session - Repair and PWHT** Chair: Darrell Wisner / EPRI Representative: Dan Purdy	
1:00	First-of-a-Kind Full Structural Weld Overlay on a Small Instrument Housing, *M. Comstock*, Talen Energy *and S. McCracken*, Electric Power Research Institute (EPRI)	1:00	Improving Through Wall Temperature Gradients During Pipe to Valve Post Weld Heat Treatment, *J. Hainsworth*, WR Metallurgical
1:20	Reactor Vessel Bottom Mounted Instrumentation Nozzle Repair at EDF's Gravelines 1 Nuclear Power Plant, *D. Barton*, Westinghouse *and B. Delaunay*, EDF	1:30	Repairs of Fossil Boilers Versus HRSG's: Field Experience, Insights and Recommendations, *P. Kasik and G. Lawrence*, Alliant Energy
1:40	The Progress of Weld Overlay Service for Nuclear Power Plant by INER, *S. Jeng*, The Institute of Nuclear Energy Research		
2:00	Alloy 52MSS Structural Weld Overlays and Safety Relief Valve Piping Realignment Lessons Learned, *P. Lester, D. Barborak*, AZZ WSI *and S. Vanduysen*, Tracetebel Engie	2:00	Simulations of the Post-Weld Heat Treatment of Thickness Transitions, *D. Purdy*, Electric Power Research Insittute (EPRI)
2:30	**Break**	2:30	**Break**
Nuclear - Student Session Chair: Adam Hope / EPRI Representative: Ben Sutton		**Fossil - Student Session** Chair: Rich Lynch / EPRI Representative: John Shingledecker	
3:00	Development of an Integrated Sensor Suite for Adaptive Wide Groove Welding, *S. Robertson and W. Hamel*, University of Tennessee	3:00	Microstructural Evolution of Grade 91 Dissimilar Metal Welds, *S. Orzolek, J. DuPont*, Lehigh University *and J. Siefert*, Electric Power Research Institute (EPRI)
3:30	Quantification of the Susceptibility to Ductility Dip Cracking in Weld Overlays of Ni-Based Alloy, *S. Luther and B. Alexandrov*, The Ohio State University	3:30	Stress Relief Cracking of High Temperature Alloys, *R. Kant and J. DuPont*, Lehigh University
4:00	System Architecture of Adaptive Welding in V-Groove Welding, *J. Penney and W. Hamel*, University of Tennessee	4:00	Temper Bead Welding for Weld Overlays, *J. Stewart and B. Alexandrov*, The Ohio State University
4:30	Microstructural Evolution of Graded Transition Joints for Nuclear Applications, *J. Galler, J. DuPont*, Lehigh University, *M. Subramanian and S. Babu*, University of Tennessee	4:30	Microstructural Evolution at the Damage Region of Grade 91 Steel Dissimilar Metal Weld, *M. Kuper, B. Alexandrov*, The Ohio State University, *and J. Burgess*, Alstom
5:00–8:00	**Vendor Expo**	5:00–8:00	**Vendor Expo**

Agenda (Continued)

Thursday, June 22, 2017			
Nuclear Session - Operating Experience Chair: R.C. Folley / EPRI Representative: Nick Mohr		**Fossil Session - Introduction to Alternative Weld Repairs** Chair: Michael Crichton / EPRI Representative: John Siefert	
8:30	Watts Bar Nuclear Plant Unit 2 Start-Up Fatigue Failures, *K. Dietrich*, TVA	8:30	Challenges of Implementing Alternative Weld Repair Methods in the National Board Inspection Code, *G. Galanes*, Diamond Technical Services
8:50	Development and Implementation of Automated Gas Metal Arc Welding Technology for Large-Scale Weld Overlay Heat Exchanger and Pressure Vessel Applications, *J. Mansfield*, Exelon; *J. Tatman, D. Couch, and G. Frederick*, Electric Power Research Insitute (EPRI); *B. Shula*, Formerly with ESI-Group; *and N. Chapman*, Formerly Westinghouse	9:00	An Insurer's Perspective on Alternative Weld Repairs, *B. Wiegloszinski*, HSBCT
9:10	GTAW Filler Metals for Repair of Piping Systems Damaged by Flow Accelerated Corrosio, *L. Bouffier, M. Lelong, and C. Bonan*, EDF		
9:30	St. Lucie Unit 1 Reactor Coolant Pump Seal Cooler Return Tubing Leak Repair, *C. Webb*, Nextera	9:30	A State Chief's Perspective on Alternative Weld Repairs, *R. Troutt, State Chief of Texas*
10:00	**Break**	10:00	**Break**
Nuclear Session - Residual Stress Chair: Trevor Hicks / EPRI Representative: Jon Tatman		**Fossil Session - Supporting Research for Grade 91 Steel Repair** Chair: Tim Bacha / EPRI Representative: Kent Coleman	
10:30	Residual Stress Measurement for Nuclear Components, *M. D. Olson, A. T. DeWald, and M. R. Hil*, Hill Engineering, LLC	10:30	Recent Developments and On-Going Assessment of Repair for Creep Strength Enhanced Ferritic Steels, *J. Siefert*, Electric Power Research Institute (EPRI)
11:00	Internal Mechanical Stress Improvement (IMSI) Method to Mitigate Stress Corrosion Cracking in Welds, *A. Kepple*, MPR Associates	11:00	Analysis Supporting the Integrity of Alternative Weld Repairs in Grade 91 Steel, *I. Perrin*, Structural Integrity Associates
11:30	Mechanical and Corrosion Properties of Dissimilar Metal Welds Before and After UNSM Treatment, *Y. Pyun, A. Amanov*, Sun Moon University; *N. Hardwick, J. Su*, AEROPROBE CORP; *G. Frederick, N. Mohr, and S. McCracken*, Electric Power Research Institute (EPRI); *V. K. Vasudevan*, University of Cincinnati	11:30	Open Panel Discussion, *All*
12:00	**Lunch**	12:00	**Lunch**

Agenda (Continued)

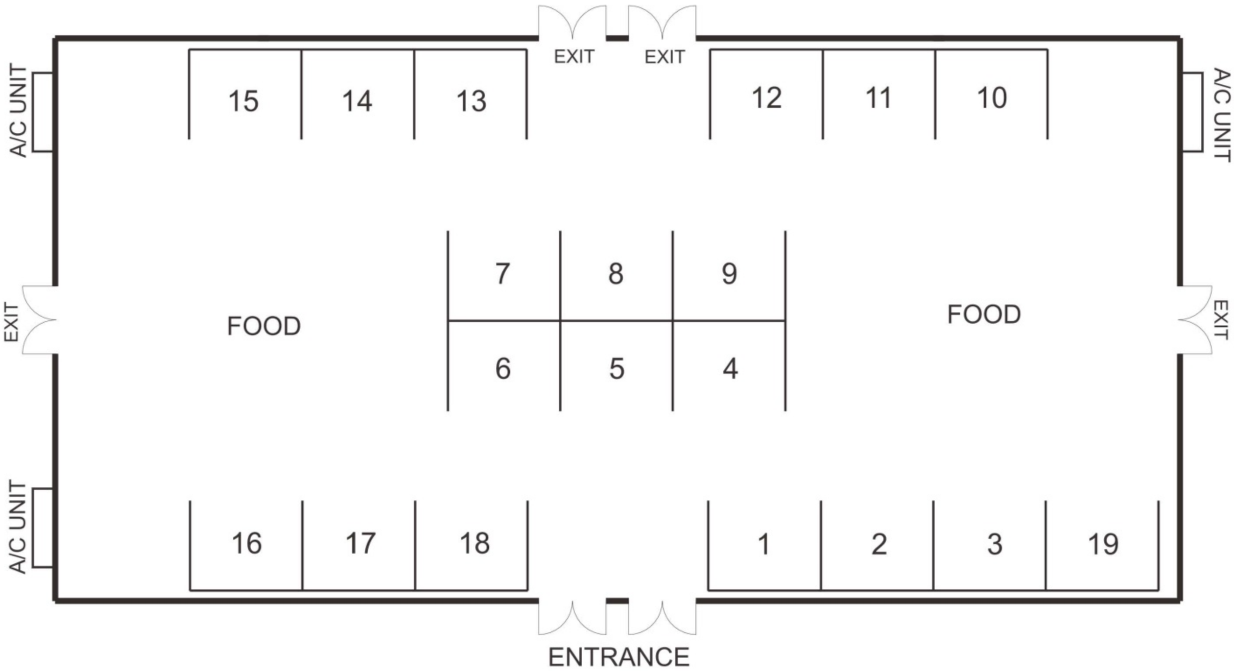
Thursday, June 22, 2017 (continued)			
Nuclear Session - Codes and Standards Chair: Joe Weicks / EPRI Representative: Steve McCracken		**Fossil Session - Grade 91 Steel Repair Case Studies** Chair: Nathan Huster / EPRI Representative: John Siefert	
1:00	B31P Standard for Preheat and Heat Treatment, *J. Swezy*, Boiler Tech Code, LLC and *P. Flenner*, Flenner Engineering	1:00	Welding Method 6 and Beyond – Perspective from a U.S.-Based Utility, *M. Crichton*, American Electric Power
1:30	Repair of Nuclear Class Piping Using Carbon Fiber Reinforced Composites, *J. O'Sullivan*, Procon	1:30	Replacement of Dissimilar Metal Weld Tube Sections in Finishing Superheater at Dominion's Virginia City Hybrid Energy Center, *F. Timmons and B. Shelton*, Dominion Energy
2:00	Structural Weld Overlay of Dissimilar Metal Weld on "A" Residual Heat Removal Low Pressure Coolant Injection Loop at James A. Fitzpatrick Plant, *J. Weicks*, Entergy; *D. Barborak*, AZZ WSI; and *J. Mansfield*, Exelon	2:00	FPL Case Histories Using Alternate Grade 91 Repairs Outside the Boiler, *K. Rapkin and A. Mayorca*, Florida Power & Light
2:30	Code Case N-865 for Pad Reinforcement Repair of ASME Class 2 and 3 Atmospheric Storage Tanks, *E. Gerlach*, Gerlach Engineering	2:30	Alternative Weld Repair of Grade 91 Hot Reheat and Main Steam Stop Check Valves, *N. Goldsmith and E. DuPont*, Xcel Energy
3:00	**Break**	3:00	**Break**
Nuclear Session - Weldability Chair: Carolin Fink / EPRI Representative: Ben Sutton		**Fossil Session - Grade 91 Steel Repair Case Studies** Chair: Scott Bowes / EPRI Representative: Ian Perrin	
3:30	Addressing Weldability Challenges in the Nuclear Power Industry with Computational Materials Engineering Tools, *A. Hope*, ThermoCalc, Inc. *and B. Sutton*, Electric Power Research Institute (EPRI)	3:30	Development and Application of T91 Cold Weld Repair Techniques, *K. Mitchell*, RWE
4:00	Welding Duplex Stainless Steel for Nuclear Applications, *B. Auvil, D. Segletes and R. Smith*, Structural Integrity Associates, Inc.	4:00	Future Activities in the Development of Alternative Weld Repairs for Creep Strength Enhanced Ferritic Steels, *J. Siefert*, Electric Power Research Institute (EPRI)
4:30	Effect of Nitrogen on the Solidification Cracking Susceptibility of ERNiCr-3 (FM82) Weld Metal, *C. Fink, M. R. Orr, J. C. Lippold*, The Ohio State University, *and F. Argentine*, BWX Technologies, Inc.	4:30	Open Panel Discussion, *All*
5:00	Development of Screening Test for High Nickel Based Alloy, *D. Abe*, IHI	5:00	**Adjourn**
5:30	**Adjourn**		

Agenda (Continued)

Friday, June 23, 2017			
Nuclear Session - Advanced Manufacturing and Fabrication Chair: TBD / EPRI Representative: David Gandy		**Fossil Session - Dissimilar Metal Welds** Chair: John Alice / EPRI Representative: John Siefert	
8:30	SMR Reactor Vessel Manufacture/Fabrication/Demonstration Project, *D. Gandy, C. Stover,* Electric Power Research Institute (EPRI), *K. Bridger and S. Lawler,* Nuclear ARMC	8:30	TBD
9:00	Ultra High Pressure (UHP) Cavitation Peening of Reactor Vessel Head Penetration Nozzles, *D. Waskey,* Areva	9:00	Microstructural Evolution of Dissimilar Metal Weld Failures Involving Grade 91, *J. DuPont,* Lehigh University *and J. Siefert,* Electric Power Research Institute (EPRI)
9:30	Piping and RPV Welding Automation Through Sensor and Model–Based Adaptive Control, *W. Hamel,* University of Tennessee	9:30	Investigation and Comparison of Good Practice and Alternative Welded T23 to T91 Ferritic Dissimilar Metal Welds after Creep Exposure, *F. Dittrich, P. Mayr,* Chemnitz University of Technology; *J. Siefert and J. Parker,* Electric Power Research Institute (EPRI)
10:00	**Break**	10:00	**Break**
Nuclear Session - Advanced Welding Techniques Chair: Darren Barborak / EPRI Representative: Jon Tatman		**Fossil Session - Advanced Materials and Inservice Monitoring** Chair: Greg Stanko / EPRI Representative: Mike Gagliano	
10:30	Hot Cell Low Heat Input Laser Welding of Highly Activated Neutron Irradiated 304 Stainless Steel, *P. Freyer, F. Gift,* Westinghouse Electric Company LLC; *J. Tatman, G. Frederick, and B. Sutton,* Electric Power Research Institute (EPRI); *and F. Garner,* Radiation Effects Consulting LLC	10:30	Microstructural Evolution and Creep-Rupture Behavior of Fusion Welds In Candidate A-USC Alloys, *D. Bechetti, J. DuPont,* Lehigh University, *J. Siefert and J. Shingledecker,* Electric Power Research Institute (EPRI)
11:00	High Integrity High Productivity Weldments Produced by the Hot Pulse™ GTA Welding Process, *D. Barborak and T. Ratchford,* AZZ WSI	11:00	A Test Method on the Creep Deformation Field of Weld Joint, *M. Song, C. Sun, Y. Sun, X. Zhang, and T. Xu,* China Special Equipment Inspection and Research Institute
11:30	Development of Auxiliary Beam Stress Improved Laser Welding for Repair of Highly Irradiated Light Water Reactor Components, *J. Chen, Z. Feng, and Z. Chen,* Oak Ridge National Laboratory; *J. Tatman and G. Frederick,* Electric Power Research Institute (EPRI)	11:30	Benefits of Long-Range-Ordered (LRO) High-Chromium Weld Overlays for Resistance to Corrosion-Fatigue Cracking in Fossil-Fired Boilers, *S. Kiser,* Special Metals Welding Products Company
12:00	**Adjourn**	12:00	**Adjourn**

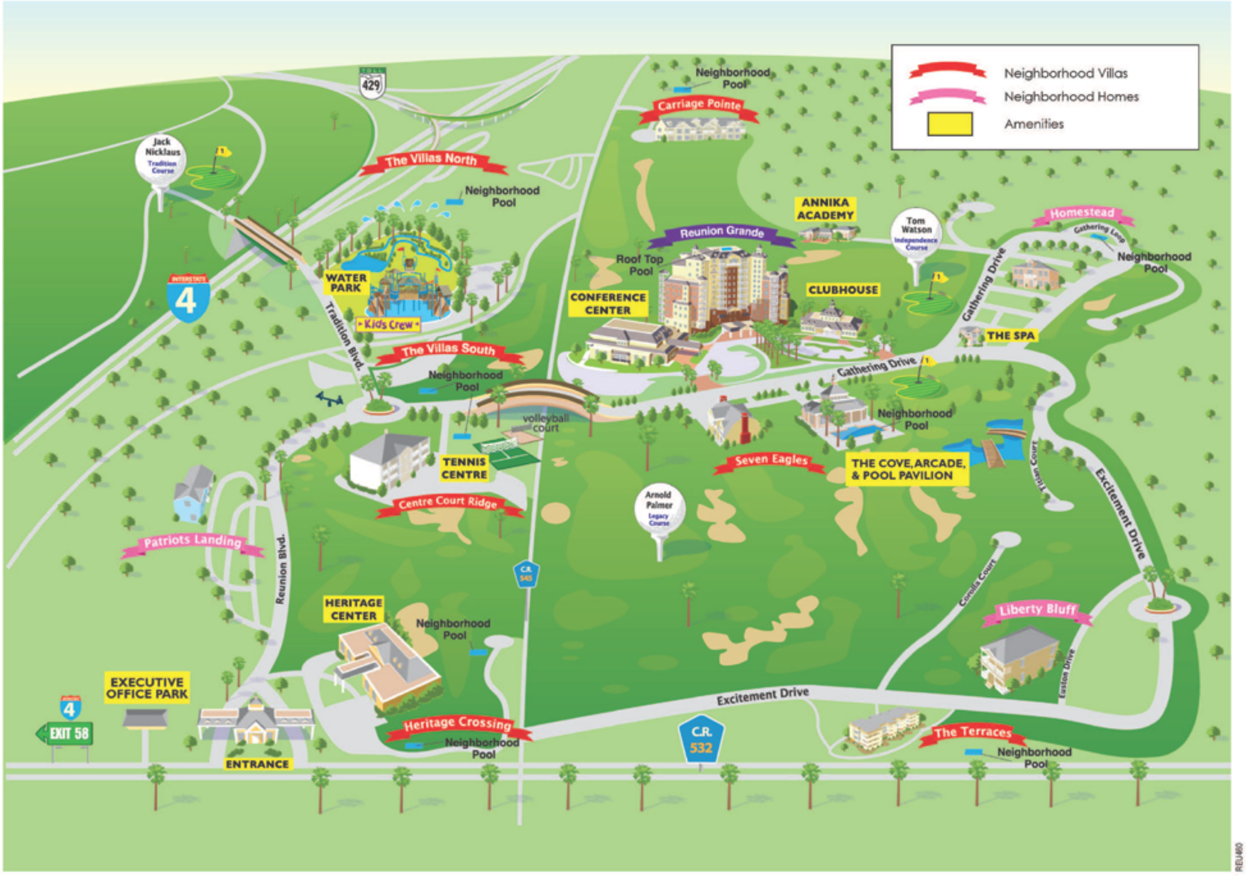
Exhibitor Map: Reunion Resort

Welding and Repair Technology for Power Plants 12th International EPRI Conference



Booth Number	Company	Email Address
1	*Euroweld, Ltd.*	bill@euroweld.com
2	*Arc Machines, Inc.*	doug.lay@arcmachines.com
3	*Lincoln Electric Co.*	matt_fleming@lincolnelectric.com
4	*Airco Welding*	steve.yoos@airco-inc.com
5	*Superheat FGH, Inc.*	glewis@superheatfgh.com
6	*Analytic Stress Relieving, INC.*	dan@analyticstress.com
7	*Proto Manufacturing*	tthompson@protoxrd.com
8	*Weldstar Company*	bdecker@weldstar.com
9	*Liburdi Dimetrics Corp.*	jbialach@liburdi.com
10	*Continental Field Systems*	kfloyd@cfsusa.net
11	*AZZ Nuclear WSI*	craigherbster@azz.com
12	*Structural Integrity Associates, Inc.*	dsegletes@structint.com
13	*BHI Energy*	bob.johnson@bhienergy.com
14	*SciAps, Inc.*	dsackett@sciaps.com
15	*Altran US Corp.*	aaron.kelley@altran.com
16	*True North Consulting, LLC*	cjb@tnorthconsulting.com
17	*Consolidated Power Supply*	ed.robertson@consolidatedpower.com
18	*Tioga Pipe Supply Co., Inc.*	jshaw@tiogapipe.com
19	*Iddeal Concepts*	patrick@iddeal.com

Reunion Hotel — Resort Map



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3002011360 June 2017

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(二)附錄 2


The Status of Weld Overlay Service for Nuclear Power Plants in Taiwan
Presented by
Sheng-Long Jeng
Institute of Nuclear Energy Research(INER)
June 21, 2017
行政院原子能委員會
核能研究所
Institute of Nuclear Energy Research
Atomic Energy Council, Executive Yuan

Contents

- The Nuclear Power Plants in Taiwan
- The Weld Overlay Services by INER
- The WOL preparation for the Hot-Leg DM Welds
- Conclusions

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The Locations of Nuclear Power Plants in Taiwan

NO.	Power Plant	Unit	type	MWe net	Start up*	Licensed to
1	Chinshan	1	BWR	604	1978	12/2018
		2	BWR	604	1979	07/2019
2	Kuosheng	1	BWR	948	1981	12/2021
		2	BWR	948	1983	03/2023
3	Maanshan	1	PWR	900	1984	2024
		2	PWR	923	1985	2025
4	Lungmen	1	ABWR	1300	deferred	deferred
		2	ABWR	1300	deferred	deferred

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The Weld Overlay Services by INER

Year	Work Contents	Partners	Experiences
2000	**Weld Overlay for the Stainless Steel Welds**	**Taipower**	**3 SS WOLs (Kuosheng)**
2008 ~ 2011	Pre-emptive Weld Overlay for the Dissimilar Metal Welds of Pressurizer	ITRI CTCI LAI (Liburdi)	12 DM WOLs (Maanshan)
2009 ~	Contingency Weld Overlays Service	CTCI LAI (Liburdi)	1 DM WOLs (Kuosheng)

- to repair the austenitic stainless steel welds with IGSCC

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The WOL for the Stainless Steel Welds

Year: 2001
Power Plant: Kuosheng NPP
Location: Recirculation Water System

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The Weld Overlay Services by INER

Year	Work Contents	Partners	Experiences
2000	Weld Overlay for the Stainless Steel Welds	Taipower	3 SS WOLs (Kuosheng)
2008 ~ 2011	**Pre-emptive Weld Overlay for the Dissimilar Metal Welds of Pressurizer**	**ITRI** **CTCI** **LAI (Liburdi)**	**12 DM WOLs (Maanshan)**
2009 ~	Contingency Weld Overlays Service	CTCI LAI (Liburdi)	1 DM WOLs (Kuosheng)

- **NRC issued the CALs No.07-034**

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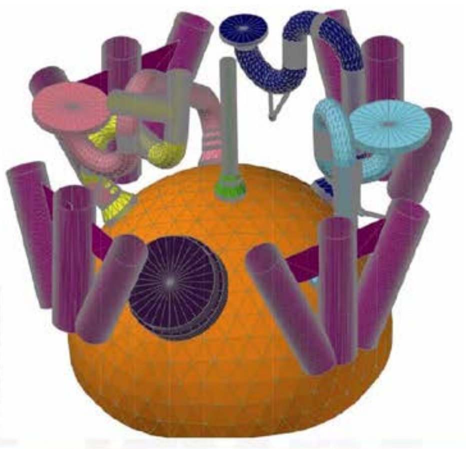
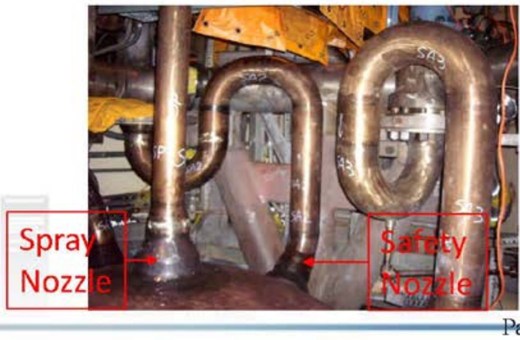
The On-site Photos and the Schematic Drawing of the Pressurizer

Year: 2008
Power Plant: Maanshan NPP





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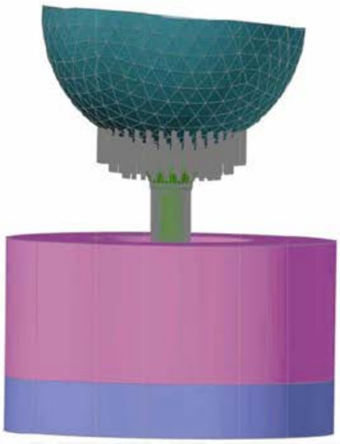
The On-site Photos and the Schematic Drawing of the Pressurizer (Continue)

Year: 2008
Power Plant: Maanshan NPP



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The Mockups for the Pressurizers

Year: 2008
Power Plant: Maanshan NPP

The upper part of pressurizer:
- Spray Nozzle
- Safety Nozzle
- Relief Nozzle

The lower part of pressurizer:
- Surge Nozzle

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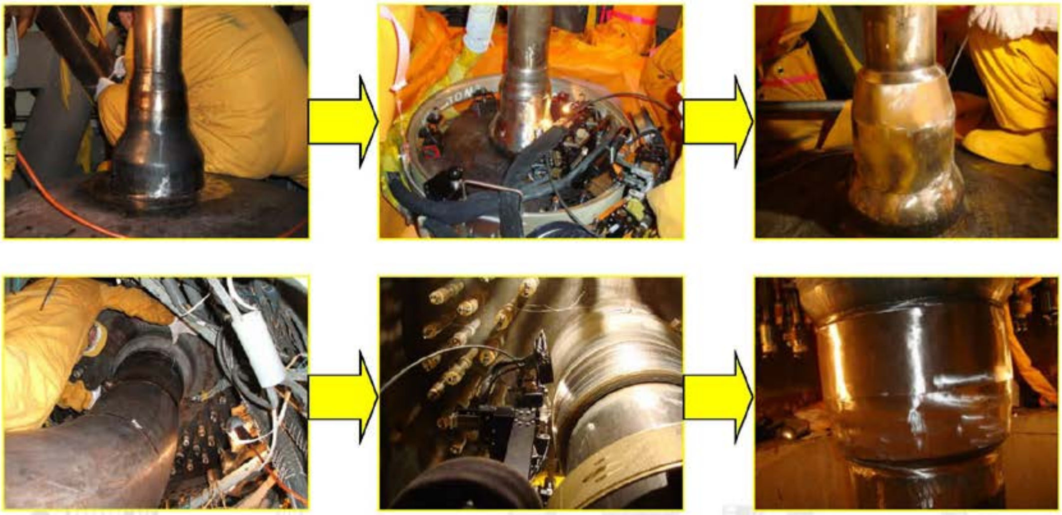
The PWOL on the DM Welds of the Pressurizers

Year: 2008
Power Plant: Maanshan NPP



Spray Nozzle

Surge Nozzle

Before welding | **During welding** | **After grinding**

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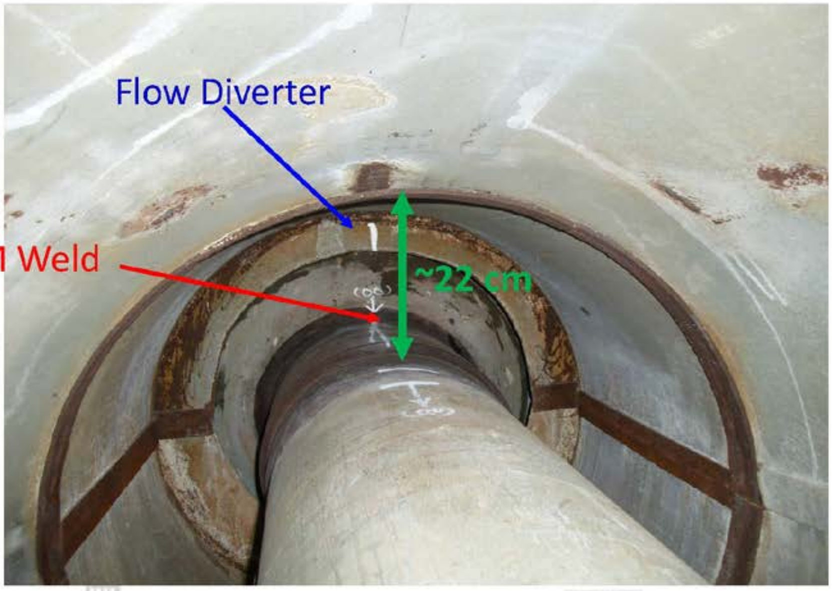
The Weld Overlay Services by INER

Year	Work Contents	Partners	Experiences
2000	Weld Overlay for the Stainless Steel Welds	Taipower	3 SS WOLs (Kuosheng)
2008 ~ 2011	Pre-emptive Weld Overlay for the Dissimilar Metal Welds of Pressurizer	ITRI CTCI LAI (Liburdi)	12 DM WOLs (Maanshan)
2009 ~	**Contingency Weld Overlays Service**	**CTCI LAI (Liburdi)**	**1 DM WOLs (Kuosheng)**

The On-site Photos of the N4B-F1 DM Weld



Year: 2010
Power Plant: Kuosheng NPP
DM Weld: N4B-F1 (Feed Water Nozzle)

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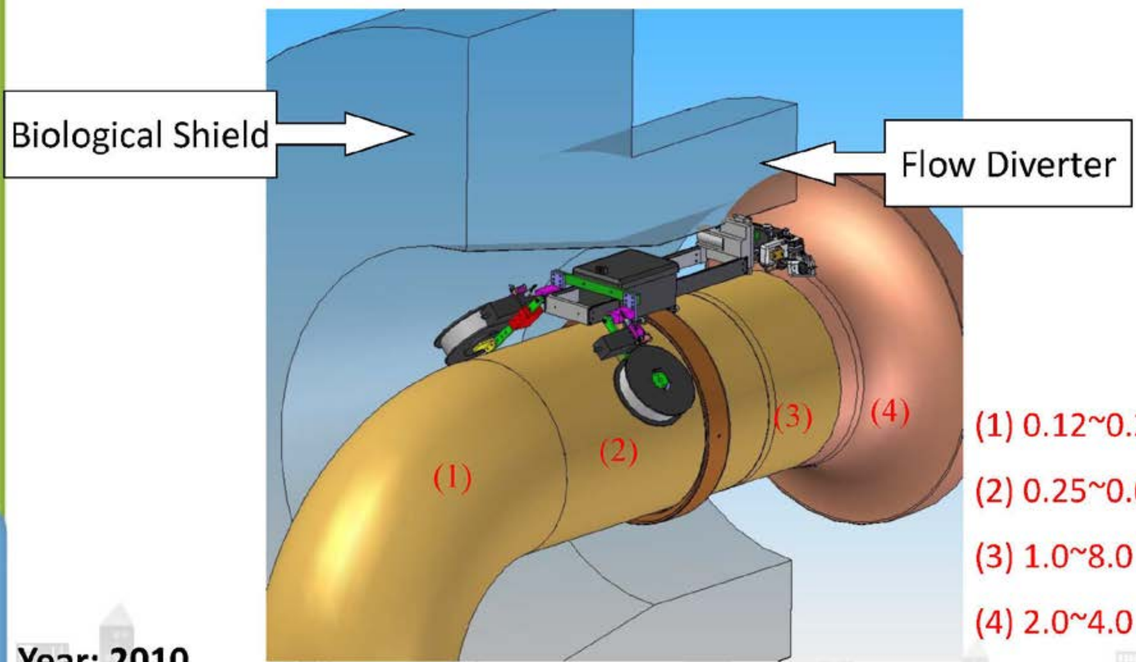
The Schematic for the Welding Head Set-up



(1) 0.12~0.25 mSv/hr

(2) 0.25~0.60 mSv/hr

(3) 1.0~8.0 mSv/hr

(4) 2.0~4.0 mSv/hr

Year: 2010
Power Plant: Kuosheng NPP
DM Weld: N4B-F1 (Feed Water Nozzle)

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The On-site Photos of the WOL

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The On-site Photos of the WOL on Feed Water Nozzle

- Total Manpower: 49 people
- Total Working time: 14 days
- Total Radiation Dose: 74.3 mSv

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The WOL preparation for the Hot-Leg DM Weld

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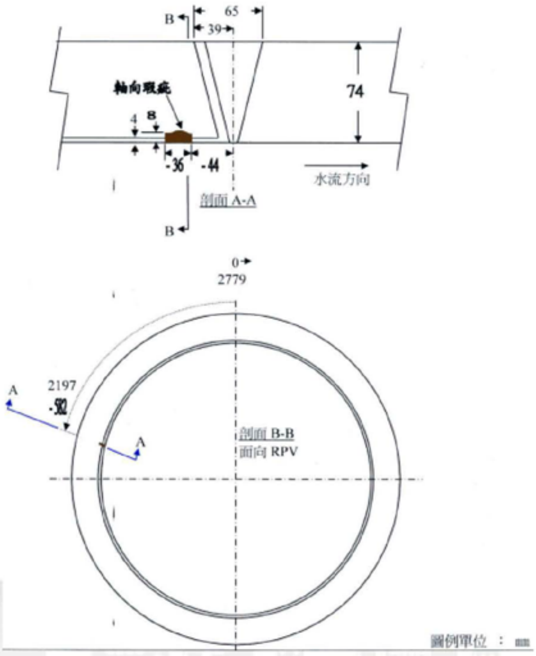
Background

- An indication was found near the Reactor Hot-Leg DM Welds of Unit 2 by AUT during the EOC-19 Outage (2010).
- The indication details:
  - depth: 8 mm (10.8% total depth)
  - Axial length: 36 mm
  - Circumferential length: 0 mm
- It has been confirmed to be a manufacture defect.



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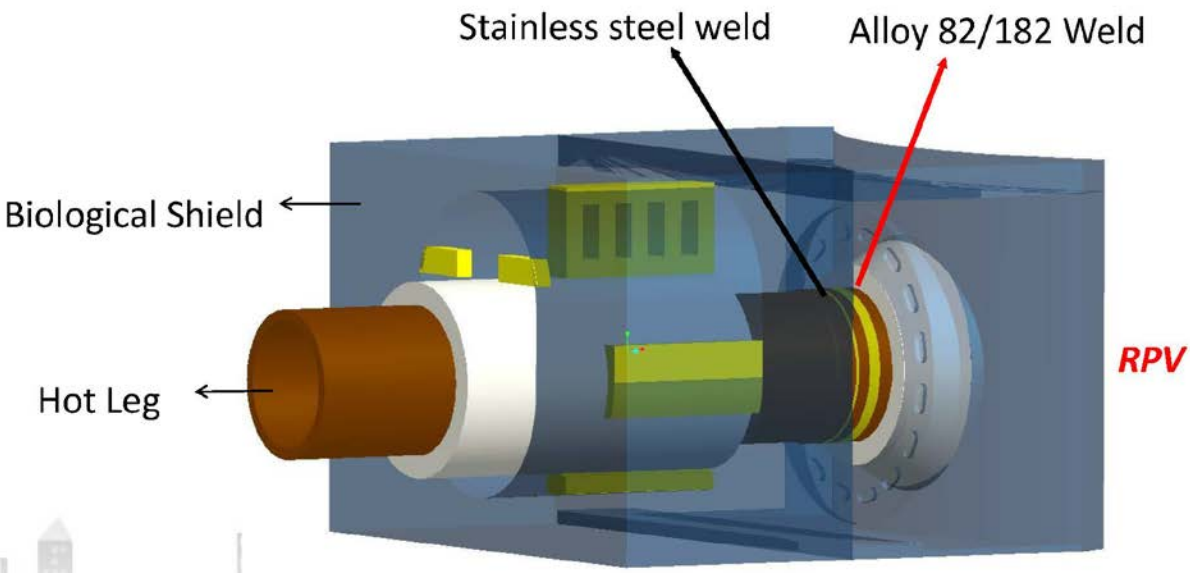
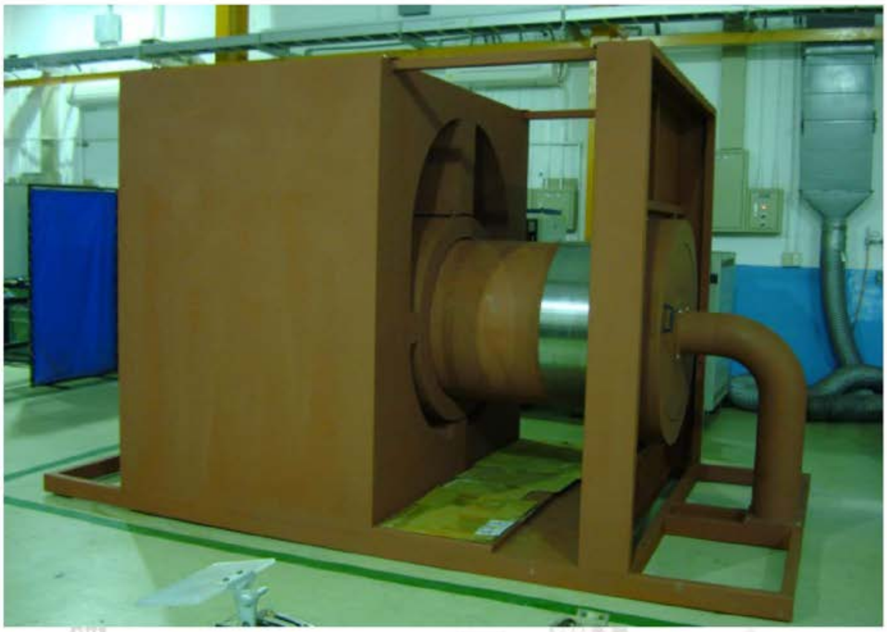
The Schematic Drawing of the Reactor Hot-Leg DM Weld



The Mockup for the Reactor Hot-Leg DM Weld



The Chemical Compositions of the pipes for the Mockups

			C	Mn	P	S	Si	Cr	Ni	Mo
Pipes (30")	316L	Report	0.027	0.95	0.037	0.014	0.56	16.34	11.00	2.12
		Exp.	0.032	0.90	0.054	0.014	0.37	16.38	10.30	2.01
	CF8A	Report	0.063	0.76	0.034	0.039	1.43	20.64	8.67	0.03
		Exp.	0.050	0.57	0.048	0.037	1.17	20.97	8.41	0.01

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The Chemical Compositions of the weld metals

			C	Mn	P	S	Si	Cr	Ni
308L	Specifications		0.03	1.0~ 2.5	0.03 Max.	0.03 Max.	0.30~ 0.65	19.5~ 22.0	9.0~ 11.0
	New heat	Report	0.012	1.67	0.023	0.011	0.35	19.74	9.67
		Exp.	0.019	1.72	0.033	0.012	0.34	19.84	10.11
	Old heat	Report	0.020	1.94	0.010	0.003	0.54	20.30	10.30
		Exp.	0.019	2.07	0.022	0.003	0.48	20.68	10.87
309L	Specifications		0.12	1.0~2.5	0.03 Max.	0.03 Max.	0.30~ 0.65	23.0~ 25.0	12.0~ 14.0
	Report		0.03	2.04	0.020	0.001	0.51	23.4	13.60
	Exp.		0.29	2.10	0.026	0.001	0.49	23.6	14.16
Alloy 52M	Specifications		0.04	1.00	0.02	0.15	0.5	28.0~ 31.5	Bal.
	Report		0.03	0.75	0.001	0.0006	0.13	29.94	59.35
	Exp.		0.03	0.78	<0.012	0.0010	0.14	30.80	63.46

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The First WOL Mockup (with PT Indications)

Pipe: CF8A
Weld Metals: two 308L layers (new heat) and one Alloy 52M layer

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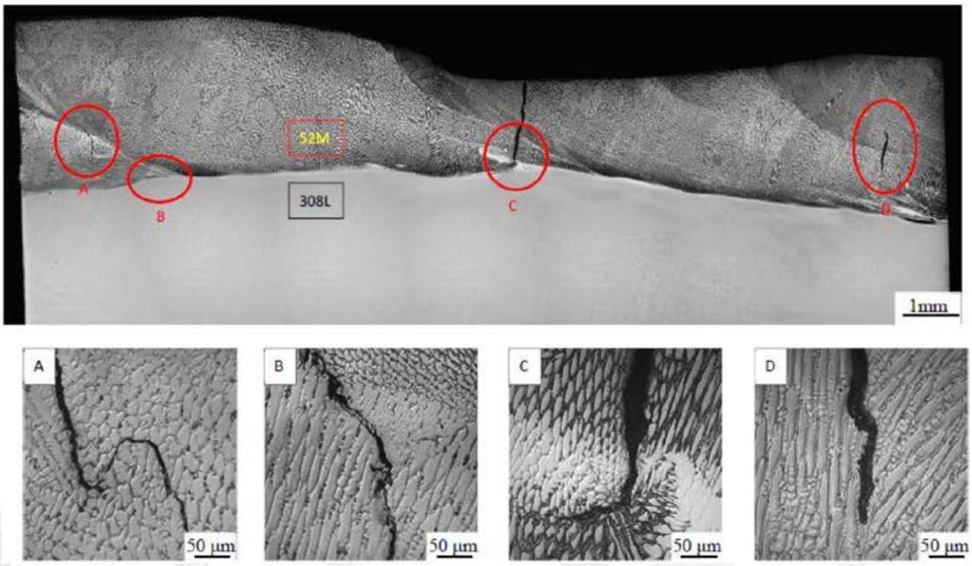
The OM Images of the Hot Cracks



Pipe: 316L
Weld Metals: two 308L layers(new heat)and one Alloy 52M layer

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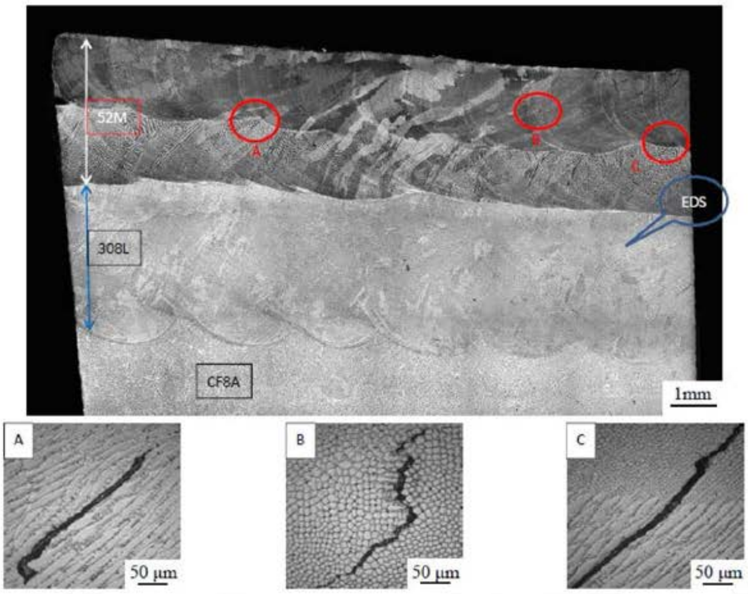
The OM Images of the Hot Cracks



Pipe: CF8A

Weld Metals: two 308L layers (new heat) and one Alloy 52M layer

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The Second WOL Mockups (without PT Indications)

銲線：308L+308L+52M	銲線：308L+309L+52M

Pipe: CF8A

Weld Metals: two stainless steel layers (old heat) and one Alloy 52M layer

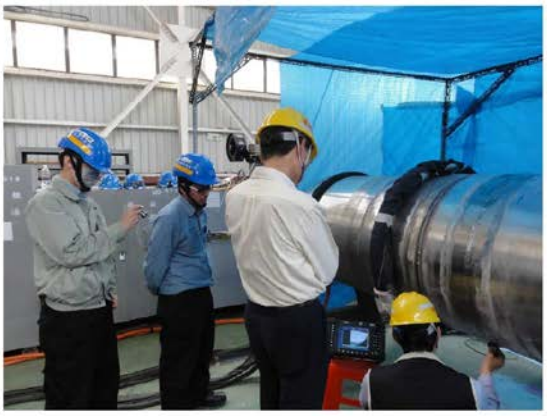
The Second WOL Mockups (without PT Indications)

	
第三層(308L+308L+52M)	第五層(308L+309L+52M 三層)

Pipe: CF8A

Weld Metals: two SS layers and one Alloy 52M layer (Left)；two stainless steel layers and three Alloy 52M layers (Right)

The Phased Array UT Examination



- By the strict control of the chemical compositions of the stainless steel filler metals, the mock-up weld overlay had passed the Phased Array UT examination by the Taipower.

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Conclusions

- INER had conducted several DM WOLs successfully in the past years. No welding defect needed to be repaired.
- By the strict control of the chemical compositions of the stainless steel filler metals, the mock-up weld overlay conducted by INER had passed the Phased Array UT examination in the WOL by the Taipower.
- The S, P, and Mn contents of the stainless steel filler metals are the crucial factors for a successful WOL process.

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