行政院及所屬各機關出國報告
（出國類別：專題研究）

美國核能電廠老化管理

服務機關：台灣電力公司
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出國地區：美國
出國期間：92.12.16~93.4.13
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行政院及所屬各機關出國報告提要

出國報告名稱：美國核能電廠老化管理專案研究

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出國計畫主辦機關／聯絡人／電話 臺灣電力公司/人事處/02-2366-7685

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為提供美國未來能源多元化的選擇及因應全球氣候變遷--溫室效應氣體減量的準備，美國於1991年12月即公佈核能電廠延役的法規修訂，並於1995年5月確定核能電廠延役申請所須的評估範圍、評估內容、及申請程序。

而當美國第一座核電廠--Calvert Cliffs，於1998年4月將其延役申請文件送美國管制單位NRC審查，並於2000年3月獲得核准，到2004年4月為止，獲得延長運轉20年者，計有23個機組；正在申請中的，計有19個機組(兩項合計，共佔40%的機組提出)；未來幾年內會提出申請的案件，至少還有25個電廠。

本次出國主要研究美國核能電廠的老化管理評估及其延役申請的流程與相關法規的規定，做為本公司未來執行時的參考，或將其引進公司內，確保核能運轉安全。並順便瞭解目前美國核能界的重要議題與發展。

美國核能電廠老化管理

目 錄

摘 要

為提供美國未來能源多元化的選擇及因應全球氣候變遷--溫室效應氣體減量的準備，美國於 1991 年 12 月即公佈核能電廠延役的法規修訂，並於 1995 年 5 月確定核能電廠延役申請所須的評估範圍、評估內容、及申請程序。

而當美國第一座核電廠--Calvert Cliffs，於 1998 年 4 月將其延役申請文件送美國管制單位 NRC 審查，並於 2000 年 3 月獲得核准，到 2004 年 4 月為止，獲得延長運轉 20 年者，計有 23 個機組；正在申請中的，計有 19 個機組(兩項合計，佔美國所有 103 部機組的 40%)；而向 NRC 表示在未來幾年內會提出申請的案件，至少還有 25 個電廠。

本次出國主要研究美國核能電廠的老化管理評估及其延役申請的流程與相關法規的規定，做為本公司未來參考用。並順便瞭解目前美國核能界的重要議題與發展。

一、出國任務

(一)研究美國核能電廠老化管理評估與延役申請流程與相關法規規定及執行準則。

(二)利用地利之便，參加美國 NRC 的公開會議，瞭解美國 NRC 與核能工業界互動的情形，並瞭解最新的發展狀況。

(三)拜訪位於美國中部阿肯薩州的核電廠兩週，瞭解 Entergy 公司旗下的 ANO 核電廠執行老化管理評估的經驗。

(四)以本次出國研究心得，提供本公司各核能電廠有關設備老化管理的方向。

二、行程簡介

本次出國研究期間為92年12月16日至93年4月13日止，合計120天。主要是在ATL顧問公司(位於馬里蘭州Germantown)進行相關資料的研究，並順道參加美國NRC所舉行的公開會議，此期間合計參加NRC召開的5次公開會議，瞭解核電廠延役申請相關議題最新的發展現況及參加2004年共3天的NRC法規年會。最後到Entergy電力公司旗下的ANO核電廠拜訪兩星期，觀摩其執行核電廠老化管理與評估的經驗，以作為本公司未來執行相關作業的參考。

此5次NRC所召開的公開會議有3次是與核電廠延役申請有關，一次為核電廠功率提升後的議題討論；一次是PRA風險評估的品質要求發展現況。

NRC舉辦之2004年法規年會於3月10日至3月12日在華盛頓DC的Hilton飯店舉行，因地利之便，順道參加。

三、心得報告

本報告依「美國核電廠延役申請」、「美國 NRC 2004 年法規年會」、及「美國核能工業其他現況」三者的順序報告。有關美國核電廠延役申請除了研讀美國的法規、法規指引、標準審查計劃及老化管理經驗回饋(GALL report)報告外，亦以 Hatch 電廠的申請案為研讀對象，以增加研究內容的實務面，並作為本公司將來若執行核電廠延役申請時，核一廠可以參考的對象。

(一) 美國核電廠延役申請:

美國早在 1982 年的一次老化研究專題研討會中，就有人提出核能電廠延役申請的觀念，美國政府並在 1986 年提出政策聲明，決定要往核電廠延役的方向進行。為了配合本項作業，美國政府與工業界雙方均就法規修訂與老化研究等相關議題，進行討論與研究，而於 1991 年公佈核電廠延役的法規要求，即 10CFR54。

法規公佈後，美國針對執行的可行性及執行準則與工業界討論與溝通，配合當時(1991 年)法規已要求各核電廠要在 1995 年執行維護法規(maintenance rule)，許多設備的老化現象已可由 maintenance rule 監控，因此建議在延役申請的評估作業時，即不需要再重複評估，以降低延役申請作業的複雜性與審查時間。NRC 採納該建議後，在 1995 年修訂 10CFR54，將評估範圍縮小，明訂針對 passive，long-lived 的設備進行評估。相關的執行準則與工業界討論後，以草案公佈。美國第一個核電廠 Calvert Cliffs 於 1998 年 4 月提出申請，於 2000 年 3 月獲得核准。開啟

美國其他核電廠延役申請的大門。

至2004年4月止，美國103座機組已有23部核能機組獲得延役20年的申請，在NRC審查中的有19個機組(兩者合計已佔40%)，計畫未來要提出申請的核電廠至少有25個，所有核准的資料及申請的資料，均可以在NRC政府的網站上查到。(網址為www.nrc.gov/reactor/operating/licensing/renewal.html)

美國核電廠的運轉執照核發時，一次給40年，與國內規定10年要申請換照不同。而美國核電廠提出延役申請的時機，10CFR54規定最快在電廠執照到期的20年提出，最晚需在執照到期的5年提出，以提供管制單位有充足的審查時間，及業者有時間準備相關的承諾事項。一但獲得核准延役，該機組的運轉執照一次可延長20年。美國核電廠的延役作業，依美國自己的評估(如圖一)，可以讓核能發電容量繼續延長20年，到2030年才開始減少，爭取此20年的時間，一方面可以讓美國有時間因應未來的能源變化，一方面亦可減緩美國對新建核能電廠或其他發電機組的急迫性，再者，亦可增加現有核電廠的經濟價值。

延役申請：

美國核電廠延役申請，分為兩大部分，一部份為核能安全部分，一部份為環境檢討部分，分別以10CFR54及10CFR51規定辦理，申請流程如圖二，其法規架構與下游的執行準則、審查標準、工業準則詳如表一。

NRC獨立(independently)審查通過的案件，NRC會出審查報告，並加上編號。目前公佈在網站上，讓任何有興趣的民眾或個人均可上網查到內容。因10CFR54與10CFR51所注重的焦點不同，故NRC的審查亦是分給

內部不同的專家審查，其審查報告亦分開公佈。

業者提出的申請文件內容要包括下列資料：(1)整體性電廠評估；(2)時限老化分析評估(Time-Limited Aging Analysis，簡稱 TLAA 分析)；(3)終期安全分析報告修正；(4)若運轉規範有修正亦需提出；(5)環境影響說明需依 10CFR51 的規定提出，以供 NRC 獨立審查用。以下先就環境法規說明後，再說明核能安全的部分。

10CFR51(環境法規)

美國為了讓業者及相關團體有標準可以判定環境影響是否可以接受，先由政府委託專業機構執行整體的環境影響評估研究，即 NUREG-1437。NUERG-1437 主報告是針對美國所有核能電廠的延長運轉對環境的影響所做的總研究報告，該報告已通案分析 92 項有關環境的影響分析，其結論為：有 69 項對環境的影響是小的，且適用所有的核電廠；有 23 項需要有電廠特定的資料才能決定。因此，業者提出申請案時，對已評估過的 69 項可以不用再評估，只要針對其他 23 個項目說明即可。美國將 NUERG-1437 的研究結果明訂到 10CFR51 附錄 B 內，提供一個合理及有效率的評估標準。10CFR51 所評估的 92 項環境議題結論如附件一。

美國另以法規指引 RG 4.2 supplement 1 訂出業者環境報告的標準格式及內容，共分為 9 章，分別為(1)purpose of and need for action、(2)site and environmental interfaces、(3)the proposed action、(4)environmental consequences of the proposed action and mitigating actions、(5)assessment of new and significant information、(6)summary of license renewal impacts and mitigating actions、

(7)alternatives to the proposed action、(8)comparison of environmental impact of license renewal with the alternatives、(9)status of compliance。其中第 4 章是環境報告的重點，故 RG 將電廠要執行的項目分別列出。

此 23 項目分別為：水權的衝突，魚及貝類被吸入冷凝器後的影響，較大魚類及貝類在取水口被吸入死亡的影響，heat shock，地下水使用衝突（依電廠設計不同，分成 3 項評估），地下水水質的劣化，維修工作對陸上生物的影響，對瀕臨危險生物的影響，維修工作對空氣品質的影響，對微生物的影響，電磁場的影響，房屋需求的影響，公共設施—水供應的影響，對教育體系的影響，廠外土地使用的影響，交通的影響，歷史文物資源的影響，嚴重事故的替代對應措施，輻射廢棄物的運送，及環境正義等。(此處環境正義指的是對附近低收入戶或原住民經濟上的影響)

凡是由 NRC 獨立審查同意的環境報告，均會以 NUREG-1437 的附件方式公告，每通過一件申請案，NUREG-1437 的附件就會增加一份，該附件是依申請通過的先後順序來放。

本法規屬個人過去較未接觸的範圍，加上美國環保法規與國內環保法規的要求不同，地理狀況與生物條件亦有許多不同處，故本部分僅作為參考用。但從本項法規的立法到執行來看，美國一但決定一個方向後，會進行後續的細部研究，並由政府與業者互相溝通，達成共識後，將專家研究的成果訂到法規內，訂出一個合理及有效的執行步驟與方法，供業者遵行。

Hatch 電廠的環境影響報告

- 由於 Hatch 電廠的申請文件是在 RG 4.2 Supplemental 1 公佈前送審，故其格式與 RG 4.2 Supp.1 的規定不同。共分為 5 章，依次為第 1 章-introduction，第 2 章-propose action and alternatives，第 3 章-environmental consequences and mitigation actions，第 4 章-compliance status，第 5 章-references。

- 第 2 章除了簡單介紹 Hatch 電廠的一般資料外，尚包括燃料及輻射廢料的情形、最終排熱的方式(該廠使用 cooling tower)、地上水使用的情況、地下水使用的情形、輸配電線路的現況、未來是否有重大變更改善案、員工雇用的現況、可能的替代能源(燃煤或天然氣或外購)、其他替代能源(風力、水力、太陽能等)及對空氣、土地、陸上資源及景觀的影響先簡單摘要敘述，以供後面章節使用。

- 接著於第 3 章詳細報告電廠依據 10CFR51 的規定所做的評估結果，針對 10CFR51 內歸類為 Category 1 的項目，Hatch 重新檢視一遍後，認為各項結論仍可適用於該電廠。針對其他 21 項被歸類為 Category 2 的項目，經評估後，其中 5 項在 Hatch 電廠不適用，其他 16 個項目(3.1.2 至 3.1.16)，Hatch 均一一詳細說明。其評估的結果，均屬於 10CFR51 所定義的 small effect，不會對環境造成不良影響。

- 其他替代能源對環境衝擊的情形，亦在第 3 章中說明。其結論

指出，Hatch 電廠發電屬短期利用，將來除役以後，不會影響該地區的長期生產力。

- 第 4 章則列出 Hatch 電廠目前所符合的各項環保法規情形，並將核准文號，生效日期及到期日一一列表(如 Hatch 電廠申請文件的表 4-1)。

- 除了環境說明的主報告外，亦附有六個附件。此附件係針對主報告中，有些項目需花費較長篇幅說明時，改用此附件說明。包括附件 A--10CFR51 附表 B 中的項目對應到 Hatch 電廠報告的章節編號、附件 B—對使用河水水量的評估、附件 C—該廠附近特殊生物影響的結果及與相關單位諮詢的往來文件、附件 D—對附近文物影響的評估及與相關單位諮詢的往來文件、附件 E—其他諮詢文件、附件 F--嚴重事故的替代對應措施評估結果。

- 其中讓人印象深刻的是附件 C，在諮詢對特殊生物的影響時，美國魚類及野生動物部門對該河流域內鱷魚數量的減少關切，請 Hatch 電廠說明其影響。經 Hatch 提出包括鱷魚生命的過程的說明及 Hatch 現有監視的數據、並與其他電廠比較後，該部門最後同意 Hatch 電廠的運轉與鱷魚數量的減少無重大關聯。

- 此外，附件 F 為了說明除了現行已承諾的嚴重核子事故改善事項外，Hatch 未來不會有進一步的改善措施。因此 Hatch 利用 Level 3 PRA 進行 cost-benefits 分析。使用美國 NRC 認可的 MACCS2 code，輸入電廠得特定數據，如附近的人口分佈情形，氣象資料、事故發生的機率等，分析對廠外民眾劑量的大小。計

算每一個改善措施可以降低多少劑量，並以 1man-rem 值 2000 美元為計算基礎，算出效益(benefits)，並換算成目前價值。接著評估該改善措施的費用(cost)，若 cost 大於 benefits，則法規同意不須改善。

- 經電廠評估 9 項 SAMA 報告內，Hatch 電廠可能適用的改善方案後，每一項分析結果均是成本大幅高過效益(如 Hatch 電廠申請文件的附件 F 表 7)，故 Hatch 在未來並不會有新增加的嚴重核子事故改善方案。

10CFR54(核能安全法規)

為了確保核能安全，其延役申請設計邏輯為：確定業者的老化管理計劃可以在設備完全喪失安全功能前，及早發現設備的劣化，進行設備更新或修理。因此 10CFR54 法規規定業者要做**整體性電廠評估**。整體性電廠評估包括三大評估過程，第一是進行範圍界定(scope)的判斷，決定那些系統要納入延役申請的範圍；第二是進行篩選(screening)說明，決定系統內的那些設備或組件要進行老化效應評估；第三是證明業者可以有效管理設備的老化效應(稱為 aging management review，簡稱 AMR)。其評估流程如圖三，以下分別說明三個評估過程：

範圍界定(scope)的判斷：

凡是符合下列標準的系統(即與核能安全相關的設備)，均要納入老化管理評估的範圍：(詳細的系統範圍可再參考 NEI 95-10 的說明)

(1)安全相關的設備(safety-related SSCs)；

(2)非安全設備(nonsafety-related SSCs)，但故障會使安全相

關設備故障者；

(3)為證明符合特定法規要求的系統，如：防火評估(10CFR 50.48)系統、環境驗證法規(EQ，10CFR50.49)所要求的設備、pressurized thermal shock(10CFR50.61，僅適用 PWR 電廠)、預見暫態未急停(ATWS，10CFR50.62)所要求的設備、電廠全黑(Station Blackout，10CFR50.63)要求的設備等。

篩選(screening)說明：

10CFR54 在制定時，認為若屬動力(active)的組件，電廠會利用定期測試的方法確認設備的功能，故其老化效應在早期即可發現，並及早採取改正措施，防止進一步劣化，屬正常作業的一部分，亦即在 10CFR50--現有的管制法規要求內，可不須在延役申請時另外再提出；而對已訂有定期更換的設備(即設備在未真正喪失其特定功能時，或在預定的使用壽命前，即予更換），亦代表電廠正常的維護管理作業，亦不須再另外評估。

因此當系統選定後，接著依系統的組件功能進行篩選，其篩選準則為：(1)設備執行該特定功能時，沒有移動的組件或改變狀態(此處一般稱為 passive component)；且(2) 該設備通常在運轉期間不打算更換(此處通稱為 long-lived component)。符合此兩要項的設備，須進行延役的老化管理評估。

例如：反應爐、RCS piping、蒸氣產生器、調壓槽、pump casing、valve bodies、圍阻體、廠房結構；電纜線等，此類即屬延役申請文件要評估的項目。而例如馬達、發電機、風扇、蓄電池、電驛、開關等，屬 active 組件，現有的偵測試驗及維護法規已可有效監測老化效應，在延役期間繼

續有效，不須再特別提出。

老化管理評估:

在篩選完設備後，電力公司即須將各項設備進行老化管理評估，看現有的維護計劃是否可以監測該設備的所有老化現象。若無法在現有的老化管理計畫內涵蓋，電力公司則視性質，決定新增一個老化管理計畫或加強現有的老化管理計畫。一般而言，80%以上的老化管理計畫屬已在執行的計畫，少數屬於要加強或新增項目。

老化管理計畫可分為 4 類，(1)預防(prevention)類，如 coating 計畫可防止一般腐蝕；(2)減輕(mitigation)類，如水質管理計畫可降低應力腐蝕(SCC)現象；(3) 情況監視(condition monitoring)類，如檢查與檢驗(inspect and examine)，大部分的老化管理屬此類；(4)性能監視(performance monitoring)類，如測試(test)。

大部份老化效應可以用一個老化管理計畫監視，少部份需要多種老化管理計畫監視，如應力腐蝕(SCC)，除了要有水質管理計畫外，亦要定期目視檢查或作非破壞性檢查，才能有效瞭解設備的使用狀態。

一般而言，土木結構類會有的老化效應或機制為混凝土龜裂、穿孔性、腐蝕及強度下降等；而機械類設備會有龜裂、腐蝕、疲勞、脆化與沖腐蝕造成管路薄化等現象；儀電類的包覆材料或接頭可能因熱或輻射線或濕度等因數引起電纜線包覆材料的脆化、龜裂、融化或氧化等現象。

美國電力公司為了進行各項設備的老化效應評估，委託 EPRI 針對核能電廠的各類設備，依設備的材質，及其使用的環境，一一列出已知的老化效應。EPRI 整理過去的老化研究及電廠的使用經驗後，完成三份研究報

告，分別為土木結構類—EPRI-1002950、機械類—EPRI-1003056 及儀電類--EPRI-1003057。電力公司再使用該份文件，比對電廠自己設備的材質及使用環境後，可以用查表的方式，直接判斷該設備的老化效應。再由評估者決定電廠是否有對應的老化管理計畫。若無，可以參考前面已獲核准核電廠的執行計畫，比照辦理。本公司因為有參加 EPRI 專案，可以使用該項技術報告，EPRI 技術報告的內容案例摘要如附件二。

核電廠全部系統的評估結果，依系統章節特性，依序放在評估報告的 3.1 節--反應器、3.2 節—緊要安全系統(ESF)、3.3 節--輔助系統、3.4 節--蒸氣系統、3.5 節--圍阻體、廠房及結構系統、及 3.6 節--儀電系統。

老化管理經驗回饋(GALL)報告

除了 EPRI 的技術報告外，NRC 亦將前面兩個電廠所核准的內容，整理成一份文件—NUREG-1801（簡稱 GALL 報告），提供審查準則給 NRC 審查者使用。該報告依系統章節列出各系統常見的設備、使用的材質、所處環境、會有的老化機制、與應該有的老化管理計畫。若是業者提出的老化管理計畫與 GALL 報告的老化管理計畫相同，NRC 即可同意業者可以有效管理設備的老化；相反的，與 GALL 報告不同的，業者需提出說明，以讓 NRC 可以判斷業者的偏離是否可以接受。若發現有不在 GALL 報告內的老化機制，或不同材質時，NRC 會要求審查者對該項進一步審查（即由審查小組轉會 NRC 內部其他技術部門審查）。而在 GALL 報告的第 11 章中，整理出 NRC 已認可的 45 項老化管理計畫，分別為**機械類 34 項計畫、結構類 8 項計畫、儀電類 3 項計畫**，標題詳細如下：

M1—營運期間檢測計畫(ASME SEC. XI ISI ，IWB，IWC，IWD)、

M2--水質管理計畫、

M3--反應爐蓋螺栓管制計畫、

M4--BWR 反應爐內管路焊接計畫、

M5--BWR Feedwater Nozzle 計畫、

M6--BWR CRD return line nozzle 計畫、

M7--BWR SCC 計畫、

M8--BWR 穿越管計畫、

M9--BWR 爐內組件計畫、

M10--硼酸腐蝕計畫、

M11--鎳合金 nozzle 及穿越器計畫、

M12--CASS 熱應力脆化管理、

M13--CASS 熱應力即中子脆化管理、

M14--loose parts 監測計畫、

M15--中子雜訊監測計畫、

M16--PWR 爐內組件計畫、

M17--流體加速腐蝕（管路薄化）計畫、

M18--螺栓完整性計畫、

M19--SG 管束完整性計畫、

M20—開放式冷卻水系統(open-cycle cooling water system)、

M21—封閉式冷卻系統(closed-cycle cooling water system)、

M22—硼酸釋出監測計畫(Boraflex Monitoring)、

M23--燃料吊車檢查計畫、

M24--空壓機檢查計畫、

M25--BWR RWCU 檢查計畫、

M26--消防系統檢查計畫、

M27--消防水系統檢查計畫、

M28--埋管或地下槽監測計畫、

M29--地面槽檢查計畫、

M30--燃油化學檢查計畫、

M31--反應爐試片檢測計畫、

M32—一次檢測計畫(one-time inspection，新增)、

M33--selective leaching of material、 及

M34--埋管或地下槽檢查；

S1--ASME SEC.XI subsection IWE、

S2--ASME SEC. XI subsection IWL、

S3--ASME SEC. XI subsection IWF、

S4—圍阻體洩漏測試計畫(10CFR50 App. J)、

S5--磚牆監測計畫、

S6--結構監測計畫、

S7--RG 1.127 渠道結構檢測計畫、及

S8--protective coating 監測維護計畫；

E1--不在環境驗證(EQ)範圍內的電纜線及接頭檢測計畫、

E2--不在環境驗證(EQ)範圍內而使用在儀控線路的電纜線檢測計畫、

E3--不在環境驗證(EQ)範圍內且無法接近的中電壓(2KV 到 15KV)電纜線檢測計畫)。

每項計畫在 GALL 報告內會先說明相關的背景後，提出 NRC 認可的工業標準或技術文件，有時會大略描述執行的方法。因此個人認為此章是目前本公司各核能電廠可以率先參考的地方。此章節亦是目前美國核電廠老化管理計畫的總整理，若本公司將目前的維護作業提升至與美國相同，對目前的維護品質及日後的延役申請應有很大的幫助。大部分的老化管理計畫屬於電廠現有的計畫，僅有少數屬於新增項目。以下簡單報告個人過去較不熟悉的計畫：

M4--BWR 反應爐內管路焊接計畫及 M9--BWR 反應爐內部組件檢測計畫：為了對反應爐內部組件的老化進行監測，除了依 BWRVIP-29 做水質的管理外，本報告列出許多 BWRVIP 專案報告的內容，包括針對反應爐內管路焊接檢測計畫依 BWRVIP-48、或 BWRVIP-62(適用飼水加氫電廠的檢測計畫)進行；core shroud：依 BWRVIP-7，-63，-76 檢查，依 BWRVIP-2 rev. 2 做為 repair 的準則；core plate 依 BWRVIP-25 檢查，依 BWRVIP-50 修理；shroud support 分別依 BWRVIP-38 及-52 檢查及修理；LPCI coupling 依 BWRVIP-42 及-56 檢查及修理；top guide 依 BWRVIP-26 及-50 檢查及修理；core spray 依 BWRVIP-18 及-16，-19 檢查、更換及修理；jet pump assembly 依 BWRVIP-41，-51 檢查及修理；CRD housing 依 BWRVIP-47，-58 檢查及修理；lower plenum 依 BWRVIP-47，-57 檢查及修理；而 BWRVIP-44 針對 nickel 合金的焊道提供修理的準則；BWRVIP-45 則對中子照射的結構組件焊接提供準則。由於 BWRVIP 對某些組件建議更嚴格的檢查方法，如 enhanced visual VT-1 檢查或超音波 volumetric 檢查，因此 NDE 的檢查人員及其設備要符合 BWRVIP-03 的標準。本計畫因參考非常多 BWRVIP 的內容，故本公司應繼續參加各項 BWRVIP 專案，以使用其研究結果。

M22--Boraflex Monitoring：本計畫起因於有電廠發現用過燃料儲存池的Boraflex panels在使用12年後，有 2個格架的硼酸濃度僅剩下原來的40%（長期經gamma射線照射和池水作用，使得Boraflex panels變形，並釋放出silica到池水中，漸漸造成硼酸也一起流失），此情形有可能造成臨界分析不能符合要保留5%次臨界margin的要求，因此NRC以IN 93-70及IN 95-38通知，並以GL 96-04要求業者對用過燃料池儲存格架進行定期的檢查、監測。其監測週期依boraflex的狀況而定，最長為每5年檢查一次。決定boraflex狀況的方法包括：(1)執行中子衰減測試，以得知panels內部gap形成的情況；(2)定期對池水取樣分析，對氧化矽(silica)做趨勢分析，並使用EPRI發展的電腦程式RACKLIFE，預測預期壽命。

M28--埋管或地下槽監測計畫與M34--埋管或地下槽檢查，此兩個計畫是針對平常無法監測的地下管路或地下槽的老化情形進行管理，由於M28的計畫內容包括原始設計的external coating,wrappings及cathodic protection system(陰極保護系統），並依NACE standard RP-0285-95及RP-0169-96執行surveillance，因此NRC認為在60年的使用期間內，此計畫可以有效保護管路。而M34的計畫針對僅有一般的coating及wrappings的設備，無陰級保護系統，需增加定期的檢視管路表面的情形，其設計不若M28的措施完善，因此NRC會對M34的計畫內容進一步審查。

M32---一次檢測計畫，此計畫是驗證水質管理計畫的有效性，以確定老化效應與預期的一致。本項計畫需在40年運轉期限前完成一次，以抽樣檢查的結果決定下一次檢查週期及範圍。

時限老化分析(TLAA 分析)：

本類分析是當初電廠在設計時，對部份重要組件有進行與 40 年運轉時間有關的假設分析，當機組延長至 60 年時，須評估對原來設備的結論是否可以接受。因此業者須整理設計資料，將有關 40 年的假設，評估其適用性。一般常見的時限老化(TLAA)分析為反應爐管嘴疲勞分析、反應爐的壓力溫度運轉曲線限制、管路應力分析、管壁厚度計算、設備環境驗證分析、圍阻體鋼鍵(tendon)預力分析等。以圍阻體 tendon prestress analysis 為例，業者可以(1)用分析的方式證明在延役期間，tendon 的預應力仍符合標準，或(2)證明原來的分析在延役期間仍有效，亦或者(3)證明在延役期間對 tendon 的老化效應有適當的監測機制。包括預應力在預測的預應力之上，在延役期間預應力會高過預測的最低預應力(predicted lower limit) ，及測量出的預應力高過最低要求值(minimum required valve)。

美國在執行 TLAA 分析時，是由電廠的設計基礎文件檔中找出相關 TLAA 的分析。Hatch 電廠的 TLAA 分析計有 10 項，包括：管路應力分析、疲勞分析、管路薄化分析、反應器腐蝕分析、電氣設備環境驗證分析、圍組體穿越器結構分析、反應器壓力槽脆性溫度分析(reference temperature for nil-ductility)、延展性分析(the end-of-life equivalent Charpy Upper-Shelf Energy margin)、壓力槽周向焊道替代檢測方案的有效性、及 MSIV 操作次數變更等分析。其主要評估重點是將原來適用 40 年的分析，在延長為 60 年後， 相關設備的安全功能仍不受影響，詳細評估結果在 Hatch 申請文件的 4.2 至 4.7 節內敘述。

以上為美國核電廠延役申請的評估作業，接下來報告個人赴 Entergy 電力公司旗下的 ANO 核電廠，觀摩該公司執行延役申請的作業方式。

Entergy 的作業實務：

由於 Entergy 電力公司旗下共有 11 部核能機組，該公司與法馮通(Framatone)合作，成立核電廠延役申請服務公司，除了進行該公司的核能電廠延役作業外，並打算服務其他有需求的核電廠。該公司負責本計畫的管理人，為 Garry Young 先生，其專設組織下，Entergy 電力公司的雇員約為 20 人，該組織並擔任 NEI 委託的工作，進行 GALL 報告更新工作，並與 NEI 一起代表工業界，與 NRC 討論。本次很榮幸地獲得 Entergy 公司的同意，讓我觀摩該公司執行核電廠延役申請的作業兩星期。

- 3/22 第一天由 DC 飛至 Arkansas 州府 Little Rock 機場，由 Garry Young 先生接機，送我至 Russellville 旅館休息。
- 第二天先至 ANO 的訓練中心照相，領臨時出入証。由於 911 之後，電廠的保安要求較嚴，因此入口檢查站周圍增設水泥屏障，並增加車道的水泥屏障，使得進入電廠時車行速度降至 5mile/hr 以下。
- Garry 介紹該公司 license renewal 小組成員，合計約 20 人，及簡報美國 license renewal 申請的情形。
- ANO 一號機於 2000 年 2 月送審，於 2001 年 6 月獲得核准，二號機因與一號機之反應器機型設計不同，於 2003 年 10 月將申請文件送至 NRC 審查。

該公司執行延役申請的作業流程介紹如下：

- 因為有一號機的申請經驗，執行整個作業時，先完成相關準備工作，包括完成整體執行計畫的作業準則，共 12 項，內容有整個作業的規劃、環境評估作業準則、scope 執行準則、機械類的老化管理準則、結構類的老化管理準則、儀電類的老化管理準則、TLAA 作業準則、data base 系統作業的使用方式、老化管理計畫的評估、運轉經驗的收集準則、申請文件的編寫準則及申請文件內容的維護等。

- 其中 TLAA 與環境評估的部分，外包給專業的人士/顧問公司評估及編寫，Entergy 內部員工則負責審查顧問公司的結果及其他部分的評估，如整體性電廠評估。而負責此計畫的工作人員以及電廠內運轉、維護等部門，均須接受與延役作業有關的訓練，以增加作業的品質與效率。總經費約一千萬美元，NRC 審查費約五百萬美元(約佔總經費的 50%)，內部作業費用佔 30%，委託顧問費用佔 20%。

- 本專案分成五個 phases，通常 phase1 為先期研究階段；phase 2 為工程實際評估階段，約需 2 年；phase 3 將評估結果彙整成申請文件的主報告，送 NRC 審查，約需 6 個月；phase 4，為 NRC 審查階段，若無公聽會，則是 22 個月，若有公聽會，則須 30 個月；phase 5 為執行階段，將在整個申請流程中所承諾的各項事件，列入電廠的承諾事項管理計畫(commitment control program)內追蹤及執行。因為 ANO 已有一號機的申請經驗，故二號機的 phase1 及 phase 2 僅需 15 個月，節省許多時間。

- ANO 電廠執行老化管理評估時，引用 3 份工業界的使用手冊，以評估系統的老化效應。此 3 份針對機械類、結構類、儀電類的使用手冊分別為 EPRI -1003056、EPRI-1002950、EPRI-1003057。該報告將各類組件所使用的材質，所處的環境下，會有的老化問題個別列出。故電廠系統工程評估時，依電廠設備的材質、環境依序判斷該設備有何老化效應，接著再評估電廠現有的維護作業是否可以及早知道設備的老化，最後會將評估結果寫成系統評估報告，以提供判斷的過程。

- 為了將各領域評估的結果，全部彙整在一起，ANO 並請軟體公司開發一個 data base 系統，使專案工作人員將結果輸入到該 data base 內，協助其他相關人員可以進入該系統查詢或了解評估的結果。

- ANO 在執行機械類的 scope 與 screening 時，將電廠內所有系統一一列出，然後依 10CFR 54 的篩選準則判斷該系統是否納入 10CFR 54 的範圍，並將納入 10CFR54 執行老化管理的組件，在 P&ID 上以顏色標出來，一張圖內有不同系統時，以不同顏色區分，因此一目了然，可以讓審查者很明確的看出哪些組件在 10CFR54 內，其他未標示的組件，即不在 10CFR54 內。此外，因電廠的 P&ID 已轉成 CAD 軟體，故該小組完成標示後，可以將該圖重新印出來，變成專案成果的一部份。(案例如附件三)

- 針對儀電系統的老化評估，因儀電設備的老化與設備所在的環境有很大的關係，執行時不是按各系統個別評估，是以空間

(space)來評估儀電系統，如此可以減少評估的複雜性。

- 每一份系統的評估報告，均有第二人審查，再經專案小組 leader 核准。各項系統的評估報告完成後，再將結果依 NEI 95-10 的格式寫入申請文件的主報告內。
- 由於各項評估報告很多，我在短短的 2 星期內無法一一看完，故 Garry 給我一部分的相關資料，讓我回國後，可以參考。此資料包括一份 ANO-2 申請資料的光碟片，及內部部份評估結果(燒至另一光碟片)。

本次出國，因為有 Garry Young 的幫忙，讓我對電廠執行老化管理的評估程序有一個更深入的了解，可以作為未來本公司執行的參考。

(二) 美國 NRC 2004 年法規年會:

本次法規年會的會議排程如附件四。

- 第一天的項目包括 NRC 主席 Niles J. Diaz 演講 " A time for reflection, a time for action" 、法規趨勢、電力網穩定性、及四項分組專題(包括 reactor oversight process、Licensing issues、New Reactors/Advanced Reactors 及 international issues) 。
- 第二天的議題包括上午 5 組分項專題(有 Security、Communications、Risk Informed Activities、Operating Experience、及 Safety Conscious Work Environment)、TMI 專題及下午的 5 組分項專題(有 Emergency Preparedness、Emergent

Technical Topics、License Renewal、Spent Fuel/Transportation/Disposal、及 Fire Protection）。

- 第三天分 4 組管制區域，報告該組的重要活動及閉幕。

本次法規年會個人覺得較特別的項目為:對 2003 年 8 月 14 日北美大停電事件的檢討、TMI 事故回顧、新建核電廠的法規環境及 TVA 公司報告對 Browns Ferry unit 1 停止運轉約 20 年後，重新啟動的計畫。另外有一組緊急議題(Emergent Technical Topics)個人亦非常有興趣，因與 License Renewal 議題衝突，故未能參加。但因陳副組長詩奎及原能會張欣科長有參加，相信他們會將該議題的內容帶回台灣與本公司討論。

北美大停電事件的檢討：

- 2003 年 8 月 14 日因檢修工作（修剪輸電線下的樹木）不慎，造成電力不穩，引發連鎖反應，造成美國東北部大停電。本次事件造成喪失 62,000 MW 電力，9 部核能機組跳機。值得注意的是各核電廠均依設計自動動作，所有 EDG 均啟動成功，沒有失敗。
- 此事件之後續改善措施為成立多項機構組成專案小組，以預防再度發生類似事件。包括 NRC 負責核能法規、FERC 負責訂定電力網的聯邦規範以供各州遵行、NERC 發展電力網運轉標準及監測是否符合要求(屬工業界標準，雖無法定位階，但可以報告至州政府)、負責輸配線管理的電力公司進行電力網改善、並平衡區域發電量與用電量等工作。

TMI 事故回顧：

- 今年 3 月正逢 TMI 事故 25 週年，故本次會議對此事件作一次回

顧，作為核能從業者的警惕。

- 本次會議除了邀請委員會的委員報告自從 TMI 事件後，核能法規的改善工作成果外，並邀請新書“Three Mile Island: A Nuclear Crisis in Historical Perspective” 作者 Dr. Samuel Walker 演講，從歷史家的觀點看 TMI 事件。
- 該事件發生在 1979 年 3 月 28 日上午，歷經 5 天將 TMI 事故穩定下來。在此期間並無人明確知道此時爐心已熔毀，作者訪問當時的官員，官員說若當時知道爐心已熔毀，可能會下令更廣泛的民眾疏散建議。本事件雖是美國核能電廠運轉以來最嚴重的事件，造成爐心熔毀，但事後證明無任何人員受傷或死亡(包括電廠員工及附近民眾）。
- 事後的檢討工作很多，除了核能電廠的軟硬體改善外，亦包括加強緊急應變計畫的執行(將 NRC 分散式的辦公地點，改成目前的總部)、運轉員訓練(模擬器設施的建立及 shift technical adviser 引入)、系統工程師的設立、人因工程研究、NRC 人員駐廠視察、及 INPO 成立等改善作業。

個人認為 shift technical adviser 及系統工程師的設立，對日後電廠執行設備績效改善，維護法規的執行及核心技術的建立與掌握，有很大的助益。

新建核電廠的法規環境：

- 由於興建核電廠的投資成本很高，目前的障礙包括：核廢料的處置、執照取得的不確定性、很高的投資成本、建廠時間太長及

未來電業自由化的競爭等因素。美國政府為了鼓勵業者新建核電廠，將電廠申請執照的法規環境改善，以降低建廠的不確定性外，目前亦針對業者所面臨的問題，設法改善。包括 Yucca Mountain 核燃料最終處置場預定於 2010 年完工啟用外，DOE(美國能源部)亦定下目標，希望於 2010 年興建核電廠，因此準備將減稅優惠措施給前面幾座申請新建核電廠的電力公司。

- 法規改善部分，包括修改 10CFR 法規，將建廠執照與運轉執照一併核發(稱為 combined license)，並同時進行 early site permit 及 standard design certification。
- 目前有三個 early site permit 申請，包括 North Anna、Grand Gulf、Clinton，而 TVA 電力公司在找新廠址。

Emergent Technical Topics：

- 最近核電廠發生的重要材質劣化事件，有 2000 年 2 月 Indian Point 2 Alloy 600 蒸汽產生器管束破裂、2000 年 10 月 VC Summer 反應爐 nozzle (Alloy 82/182) 焊道裂縫、2002 年 1 月 Quad Cities 1 jet pump holddown beam failure、Oconee 1,2 及 ANO 1 CRDM nozzles(Alloy 600 與 Alloy 82/182 焊道)有裂穿裂縫、2002 年有 Davis-Besse 反應爐蓋硼酸腐蝕裂穿、及 South Texas 爐底儀器管路接頭洩漏。2003 年 Pilgrim nozzle 洩漏、TMI Pressurizer Heater Diaphragm 洩漏、Millstone Pressurizer Heater 洩漏等。
- 為了因應此類材質的老化效應，工業界組成專案小組進行研

究，包括 EPRI、Owners group 等，並進行自我評估工作。業者承諾將引用 NEI-03-08 " Guideline for the Management of Materials Issues" 。

TVA 公司報告 Browns Ferry 電廠的重要作業：

- 目前 Browns Ferry 電廠內共有 16 項資本支出與運轉維護計畫進行中，這些活動預算合計三千九百多萬美元，工作人員約 3000 人。
- 重要作業包括再循環泵改成變轉速馬達來驅動、燃料廠家更換、獨立燃料貯存設施的建立、extended power uprate、license renewal、及一號機再啟動運轉。
- 由於二號機與三號機已先執行 5% power uprate，未來將再進行 15% power uprate。而一號機將申請 20% power uprate。
- Browns Ferry 三部機組同時進行 license renewal 申請，已於 2003 年底送 NRC 審查。由於一號機重新起動與本項同時進行，TVA 預期 license renewal 可以在一號機重新起動前核准，因此在核准前會增加一號機重新啟動前的 inspection，並確定一號機的狀況可以反映申請的內容。
- 一號機於 1985 年停機並 defueled 至今，該公司於 2002 年 5 月開始該機組再起動計畫，預計於 2007 年 5 月運轉，總經費為 1 億 8 千萬美金。工作範圍包括 19 項法規條件修改，27 項特別計畫要完成，及約 200 項承諾需執行。凡是二號機與三號機已進行之重要 DCR，一號機亦將在 5 年內執行完畢。包括約 75 萬呎的

電纜線更新，11 萬 1 千呎線管更新，2 萬 5 千呎管路更新及 7 千個管路支架更新。整個法規申請架構於 2003 年 8 月獲 NRC 同意，該計畫有專設的組織管理，目前進度按預定時程進行。

(三) 美國核能工業其他現況:

美國核能工業目前法規發展狀況，主要朝風險告之，法規合理化方向進行。本次出國參加兩次 NRC 所舉行的公開會議討論 PRA 品質的發展方向及功率提升討論，與南加州 Edison 公司的錢善恒博士請教該公司維護法規執行的情形，並參觀 ANO 電廠的其他重要活動，簡述如下：

南加州 Edison 公司維護法規執行情形:

- 該公司執行本法規所動用到的組織架構包括：

  (1)維護法規計畫負責人(MR program coordinator)--負責整個計畫的執行、管理、程序、定期評估、NRC 介面等

  (2)系統工程師--負責各系統功能的維持、監測系統不可用率(unavailability)及故障(failure)的數據、系統可靠度目標的設定等

  (3)PRA 小組--負責設備風險評估工作，及 PRA 模式的維護，共有 9 人

  (4)專家小組--核定系統績效目標、scope 變更及審查故障的原因等工作，主要由系統工程師、維護部門、設計部門、運轉部門，PRA 小組組成

  (5) 運轉部門--負責設備可用性判定的文件紀錄、及設備 out of

service 時的風險評估(由 shift technical advisor 執行），以決定設備維護工作是否可以執行

(6)維護部門--負責 PM 作業的變更，及風險評估

- 錢博士特別強調，一般會有 5%的系統會被歸類到 A(1)類，即需要特別注意的系統，電廠若沒有 A(1)類的系統，代表該電廠執行 maintenance rule 有問題 。

個人心得為：由於近 10 年來美國法規的演變及績效大幅提升，有很大一部份均以 maintenance rule 的執行為基礎，向上發展，建議本公司應盡快引用該法規。而配合該法規的引用，亦須增加人力才能有效執行，以目前的人力配置，各單位均感人力不足，無多餘人力引進新法規。

參加 NRC 公開會議的經驗:

- 首先至 NRC public meeting 的網站上瀏覽是否有相關之議題，知道時間、地點、會議主題、及 NRC 負責人之全名及電話。
- 須於會議前 30 分鐘到達 NRC 的大樓入口處進行安檢，包括用 X 光機檢查隨身行李後（此措施是因應 911 恐怖攻擊之後，美國增加的安全檢查項目），接著到櫃檯登錄參加人員個人的相關資料，輸入此次之目的、NRC 受訪者的全名及電話號碼等資訊，服務人員檢查個人証件後，發給訪客証(visitor)。
- 所有訪客須在一樓大廳等候 NRC 相關人員帶入會議室，每位 NRC 職員一次僅能帶 5 位訪客進入 NRC 大樓內。
- 會議開始，由 NRC 官員主持人作簡單開場白後，接著由全體與

會人員作自我介紹，並簽名代表參加本次會議。

- 會議結束後，所有訪客亦須由 NRC 官員陪同下樓，交還訪客証。

BWR 電廠提升功率後的潛在問題討論:

- 本次會議於 2004 年 2 月 3 日上午 8:30 至 11:00 舉行，因公司目前正在做本項工作的相關評估作業，恰巧從網路上看到本次會議題目，故邀請駐美台北經濟文化代表處科學組副組長陳詩奎博士一起參加本會議。
- 會議開始後，才知道有兩個 BWR 電廠在功率提升至 20%後，發現 Steam dryer 支架有 crack，NRC 官員質疑是否是因功率提高後，因須增加爐心流量，額外引起的震動所造成，且詢問 BWROG 是否爐心內部其他組件亦會有此疑慮。
- 會中由 GE 公司簡報初步評估的結果及未來預定的工作內容。GE 初步用 finite element 分析 dryer 組件的應力後，認為此 steam dryer 的設計屬早期 BWR-3 的設計，後來的 BWR 電廠其 steam dryer 的設計較為流線，應比較不會有此問題。GE 除了於 2003 年 9 月發佈 SIL 644 supp. 1 提供詳細的 dryer 檢查建議外，並將進一步與發生問題的電廠合作，找出肇因。
- 此外，BWROG 同意新增 BWRVIP 專案，對 steam dryer 的檢查、裂紋評估、repair 等項目提出準則，目標在 2004 年 9 月提出。並承諾依未來評估的結果及後續發展，提出相對應的措施。
- 個人認為本公司核一、二廠屬 BWR-4 及 BWR-6，應比較不會出現此問題；此外，會議中與 NRC 官員私下討論有關本公司目前功率

提升的政策時，NRC 官員認為 5%的功率提升，亦應不會有此問題。本項屬於研究範圍外的項目，但因與目前公司內部進行的評估作業有關，故順道參加，並提供給公司參考。

ANO 電廠的其他重要作業:

(1)用過燃料乾式儲存場：

- 由於 ANO 電廠已運轉接近 30 年，其燃料池存放空間已不足，因此該公司於 1996 年底開始引進用過燃料乾式儲存設備。
- 目前於電廠內建立兩個場地放置用過燃料乾式儲存器(cask)，每個 cask 可以放置 24 組 PWR 核燃料，一個場地約可放置 21 個 cask，目前電廠共放置 24 個 cask。該場地的使用執照是另外向 NRC 申請，有獨立的安全分析報告、運轉規範、及偵測試驗規定。
- 電廠人員解釋，存放場地的水泥墊塊比較特別，屬軟性水泥，萬一燃料儲存器倒下，該水泥地需能承受其衝擊，而不會龜裂、破損。
- 此外，該設備靠自然對流將燃料的餘熱帶走，冷空氣由下方進入，熱空氣由上方排出。有輻射強度及溫度指示的設備，提供巡視人員了解設備目前運轉的條件。基本上一天巡察兩次。
- 目前 ANO 引進另一型的乾式儲存器，主要原因為，舊型的設計是內層為 liner，中間為空氣，外層為水泥。但放置於開放空間久了以後，外層水泥表面會有裂紋，容易引起往後的

運轉爭議。新型設計為內層是水泥，中間為空氣冷卻，外層為 liner，如此設計，外層較不會有劣化指示。

- 電廠人員解釋，將乾式儲存器從預定地運至廠房內裝置用過燃料時，除了要有特定的操作設備外，還需調用美國境內最大的起重機將乾式儲存器吊起。每個乾式儲存器約要 1 百萬美金，而其他的配合設施，約需 1 千 3 百萬美金。

(2) 蒸氣產生器更新作業：

- 2 號機於 2000 年執行 SG 更換作業：該機組屬 4 迴路，2 個 SG。執行 SG 更換作業時，需將圍組體切開一個開口，以供 SG 進出。
- SG 更換後需將圍組體補起來並將破壞的 tendon 更新，使圍組體恢復原來的功能。更換下來的舊 SG，放置在電廠的專設廠房內存放。

(3)Power uprate:

- 2 號機於 SG 更換後的一個週期，即申請於 2002 年大修結束後，開始提升功率運轉:
- 為了能將更換 SG 的費用盡快回收，ANO-2 亦規劃進行功率提升作業，經電廠評估的結果，要將各項改善費用回收的經濟效益為至少提升功率至 6.5%，電廠最後提出 7.5%的功率提升申請。因此在更新 SG 時，已考量未來功率提升所需的熱交換面積。

- 個人詢問 power uprate 所花的經費為何時，電廠工作人員很難回答，因為總經費是分散在各項子計畫下，例如 SG 更換、汽機/發電機改善、MSR 改善、condenser 改善、heater drain pump 改善的作業下，故一般員工並不知道總經費為何。從該公司內部網站資訊上得知，該電廠對 1 號機功率提升到 20%的可能性，進行內部評估作業。
- 已向 ANO 要到該廠 power uprate 的申請資料，並轉送給本處安評課江股長參考。

(4)ANO-1 反應爐蓋更新作業:

- ANO-1 因 CRDM 穿越管因硼酸腐蝕，電廠為了考量日後檢查及修復所需花費的金錢及時間，故當 2002 年發現此問題後，ANO 即向法國法馮通訂製 Reactor vessel head。
- 該設備正好於 3/30 運送到電廠，預備明年大修時更換。
- 個人詢問 Garry，未來 2 號機是否也預備更換反應爐頂蓋嗎?Garry 告知，Alloy 600 會因 PWSCC 腐蝕，因此未來 2 號機反應爐頂蓋的更換亦是遲早的事。

四、討論與建議

(一) 有關 10CFR54 美國對延役的核能安全法規要求，本公司原則上可以做到。而美國核電廠延役的環境法規，因本國的地理環境及環保法規與國內不同，法規面可供參考。但個人認為，美國核電廠可以符合美國較嚴謹的環保要求，相信對台灣而言，對環境的影響亦可以接受。至於環境報告要包括哪些項目，建議從美國已評估的 92 項中，請中立單位研究後，納入延役申請報告規定事項內，以供管制單位與本公司遵行的標準。

(二) 美國從維護法規推行後，近 10 年的績效大幅進步，後續的法規發展大部份以此為基礎，建議本公司核一、二、三廠盡早引用。

(三) 進一步評估 GALL 報告內的老化管理計畫，將適用本公司的部份引進至電廠維護作業內，提升維護品質。本作法亦可參考延役申請已核准電廠的作法，修改目前的維護計畫。

(四) 參考美國延役法規，修訂國內的原子能法規（註:本項原能會已將延役辦法草案送各單位提供意見，該草案規定申請文件內容項目與美國一致，但執行細節未明訂。提出時機草案訂為執照到期前 8 年至 5 年，此時間太短，本公司於 93.6.11 赴原能會報告美國核電廠延役申請作業時，初步與原能會溝通，建議參照美國的規定，改為執照到期前 15 年至 5 年，此外，亦建議環境影響評估的名詞改環境檢討報告，此環境檢討報告的主管機關改成原能會，而非環保署）。

(五) 邀請美國專家來指導本公司的延役申請作業。

(六) 美國電力公司的作法，老化管理評估由電力公司自己執行，時限老化分析委託反應器供應廠家或專業的設計顧問公司執行，環境報告另外委託環保專業顧問公司執行，此作法對電力公司最好，可以掌握核心技術。本公司近 10 年人力減少，例行工作量已達飽和，各單位均感人力不足，無人力進行新的專案，及人力老化日益嚴重，建議公司改變用人政策，開始進用新人。

(七) 本次返國後，除了於 93 年 5 月 5 日舉行處內的返國座談外，亦分別於 93 年 5 月 19 日、5 月 20 日、及 5 月 24 日赴核一、二、三廠簡報「美國核電廠延役申請」，各單位反應熱烈。另順便檢視目前本公司各廠規劃的老化管理計劃，分為 3 個 phases，第一階段為 93 年至 96 年，完成三個電廠重要組件的老化管理評估，包括反應爐、反應爐內部組件、反應爐冷卻系統、蒸汽產生器、圍阻體及儀電系統，由核二廠主辦。第二階段為 95 年 7 月至 97 年 6 月，包括二次圍阻體、緊急爐心注水系統、冷凝水等系統，由核一廠主辦；第三階段，從 97 年年至 98 年，包括消防系統、海水系統、通風系統及其它廠房結構等，由核三廠主辦。本規劃目前未涵蓋到時限老化分別項目，未來延役申請時需補上。

(八) 受限於本公司的人力及國內的專業人數限制，若三個電廠同時進行，人力調配不過來，造成時程過久，若比照美國的作法，第一個電廠約需花 3 年時間將申請文件送管制單位，第 2 個電

廠以後，可縮短到 2 年。故建議核一、二、三廠應分開辦理，並成立專案小組，協調公司內各單位，以規劃較完整的延役申請作業。

（九）目前已規劃在 95 年度研發案中增加環境報告檢討項目，委託國內學術單位進行。若本公司核一、二、三廠延役申請要提前進行，可能須要先動用預備金額，提前進行研發案，才來得及配合延役申請時程。

（十）若確定核電廠延役申請，各廠目前的用過燃料中期儲存設施會不足，後端處在規劃用過燃料中期儲存設施時，應考慮電廠延役所需增加的場地。

五、參考資料:

1. 美國法規 10CFR54，Requirements for renewal of operating licenses for NPPs
2. 美國法規 10CFR51，Environmental Protection regulations for domestic licensing and related regulatory functions
3. 法規指引 Regulatory Guild 1.188，Standard Format and Content for Applications to Renew NPPs Operating Licenses
4. 法規指引 Regulatory Guild 4.2 supp. 1，Preparation of Supplemental Environmental Reports for Applications to Renew NPPs Operating Licenses
5. 業界標準 NEI 95-10 rev. 3—Industry Guideline for implementing the requirements of 10CFR 54 the License Renewal rule
6. 標準審查計畫-NUREG-1800—Standard Review Plan for Review of License Renewal Applications for NPPs
7. NUREG-1801--GALL(Generic Aging Lessons Learned) report
8. 標準審查計畫--NUREG-1555, Supp. 1 -Operating License Renewal
9. NUREG-1437--Generic Environmental Impact Statement for License Renewal
10. EPRI 1002950—Aging Effects for Structural Components (Structural Tools), revision 1，August 2003.

11. EPRI 1003056—Non-Class 1 Mechanical Implementation Guildeline and Mechanical Tools, Revision 3. November 2001

12. EPRI 1003057—License Renewal Electrical Handbook，December 2001.

13 Hatch 電廠延役申請文件

14. ANO-2 電廠延役申請資料

表一:美國核電廠延役申請執行標準

	核能安全	環境規定
法規	10CFR 54	10CFR 51
法規指引	RG 1.188	RG 4.2 supp.1
NEI 準則	NEI 95-10	NEI 98-06(draft)
NRC 審查標準 或研究報告	SRP-NUREG-1800 GALL 報告-NUREG-1801	SRP—NUREG-1555, supp.1 NUREG-1437
工業界報告	EPRI 1002950(土木結構類) EPRI 1003056(機械類) EPRI 1003057(儀電類)	

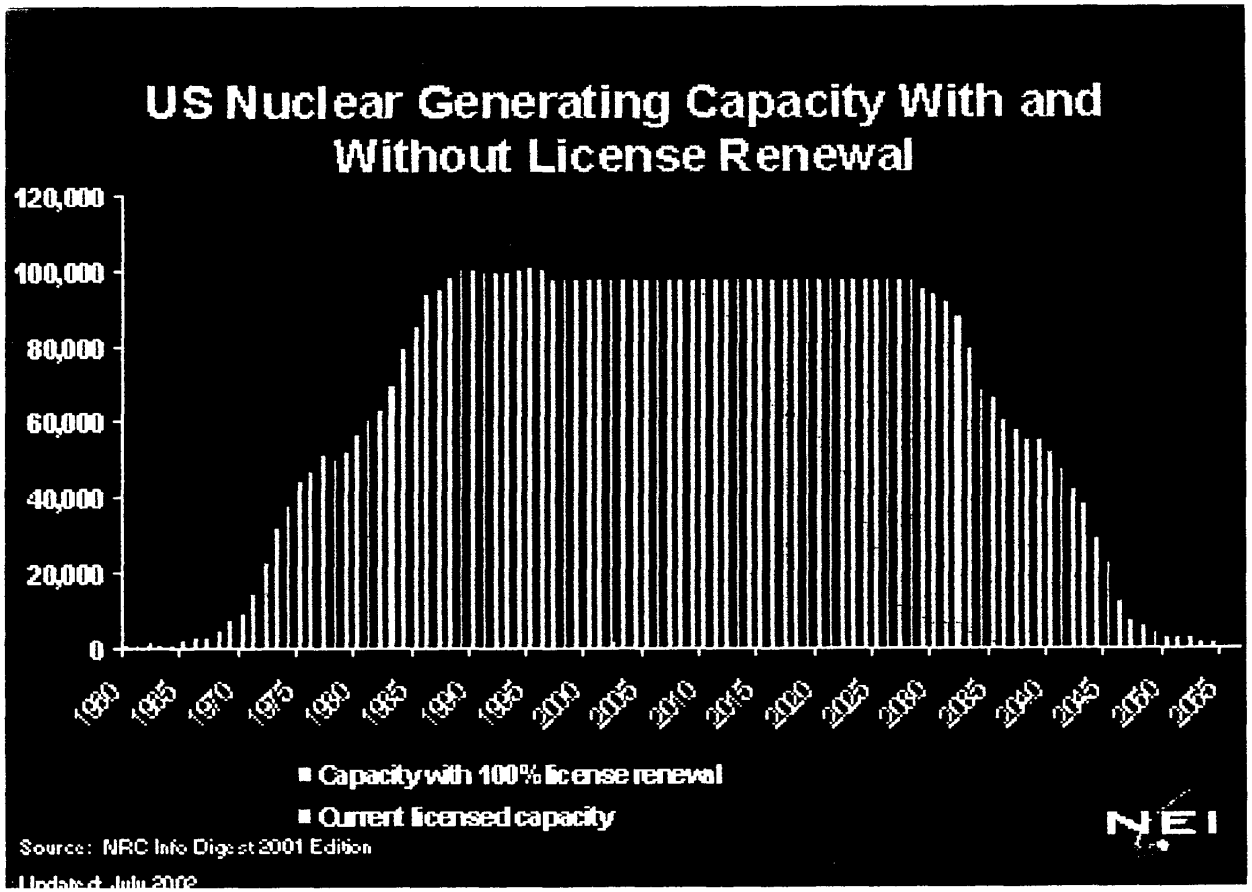


圖 1:美國核能發電量預估情形

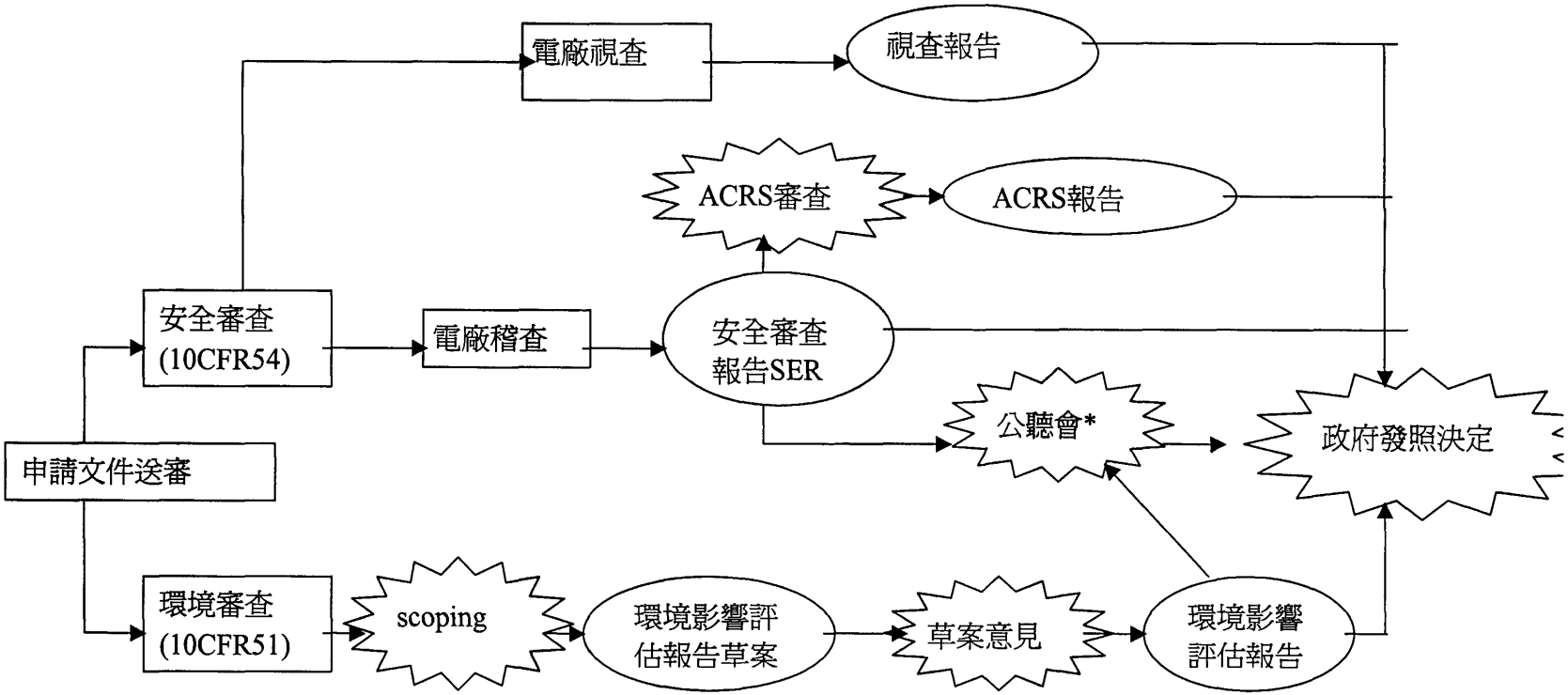


圖2：美國核電廠延役審查程序

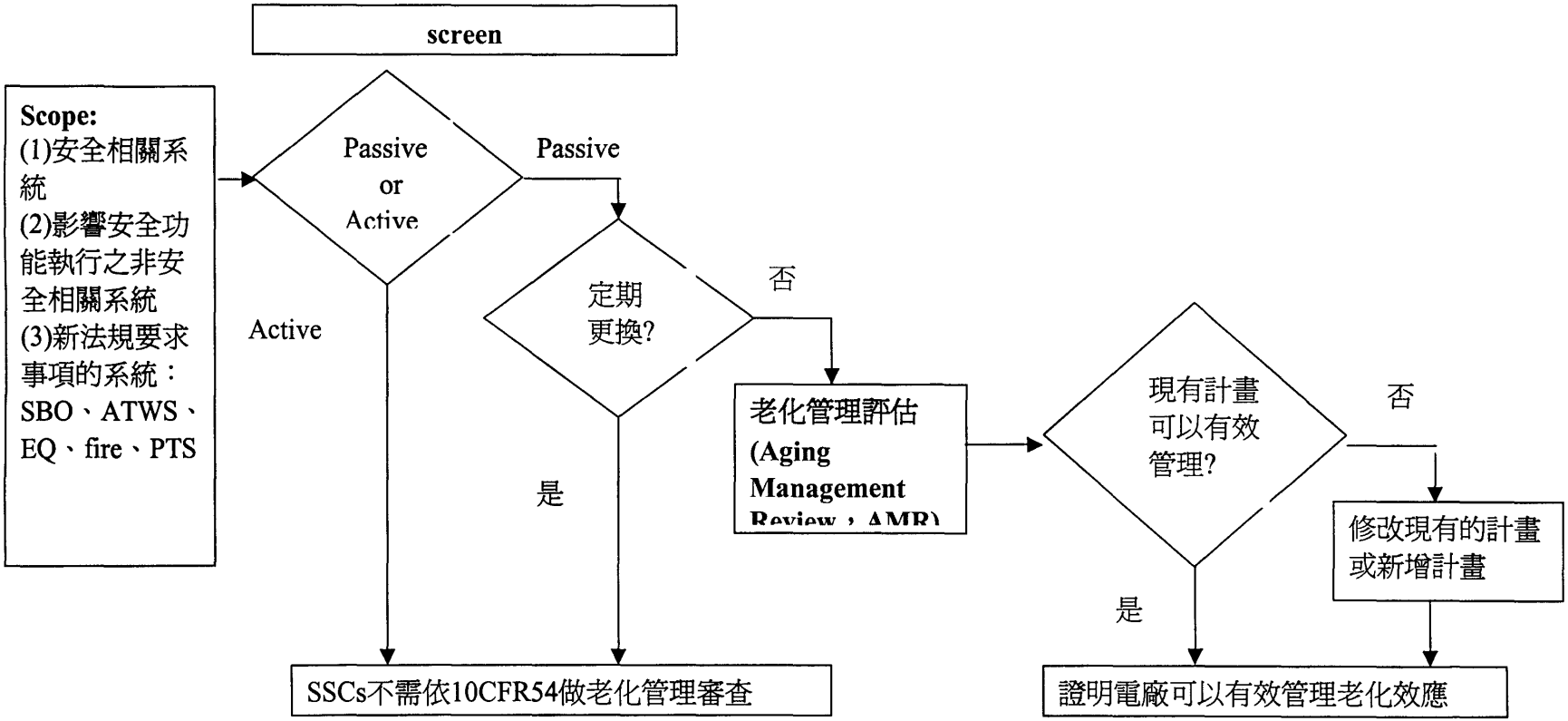


圖3：整體性電廠評估(Integrated Plant Assessment，IPA)

附件一：美國聯邦法規 10CFR51 附錄 B
"Environmental Effect of Renewing the Operating License of a Nuclear Power Plant"

(e) Be circulated with the environmental impact statement or be readily available on request.

Discussion of Footnotes

1. *Tiering.*

40 CFR 1502.20 states:

"Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review (§1508.28). Whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment is then prepared on an action included within the entire program or policy (such as a site specific action) the subsequent statement or environmental assessment need only summarize the issues discussed in the broader statement and incorporate discussions from the broader statement by reference and shall concentrate on the issues specific to the subsequent action. The subsequent document shall state where the earlier document is available. Tiering may also be appropriate for different stages of actions. (Sec. 1508.28)."

40 CFR 1508.28 states:

"'Tiering' refers to the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. Tiering is appropriate when the sequence of statements or analyses is:

"(a) From a program, plan, or policy environmental impact statement to a program, plan, or policy statement or analysis of lesser scope or to a site-specific statement or analysis.

"(b) From an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe."

Incorporation by reference. 40 CFR 1502.21 states:

"Agencies shall incorporate material into an environmental impact statement by reference when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described. No material may be incorporated by reference unless it is reasonably available for inspection by potentially interested persons within the time allowed for comment. Material based on proprietary data which is itself not available for review and comment shall not be incorporated by reference."

2. *Adoption.*

40 CFR 1506.3 states:

"(a) An agency may adopt a Federal draft or final environmental impact statement or portion thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations.

"(b) If the actions covered by the original environmental impact statement and the proposed action are substantially the same, the agency adopting another agency's statement is not required to recirculate it except as a final statement. Otherwise the adopting agency shall treat the statement as a draft and recirculate it (except as provided in paragraph (c) of this section).

"(c) A cooperating agency may adopt without recirculating the environmental impact statement of a lead agency when, after an independent review of the statement, the cooperating agency concludes that its comments and suggestions have been satisfied.

"(d) When an agency adopts a statement which is not final within the agency that prepared it, or when the action it assesses is the subject of a referral under part 1504, or when the statement's adequacy is the subject of a judicial action which is not final, the agency shall so specify."

[49 FR 9381, Mar. 12, 1984, as amended at 61 FR 28490, June 5, 1996; 61 FR 66546, Dec. 18, 1996]

APPENDIX B TO SUBPART A—ENVIRONMENTAL EFFECT OF RENEWING THE OPERATING LICENSE OF A NUCLEAR POWER PLANT

The Commission has assessed the environmental impacts associated with granting a renewed operating license for a nuclear power plant to a licensee who holds either an operating license or construction permit as of June 30, 1995. Table B–1 summarizes the Commission's findings on the scope and magnitude of environmental impacts of renewing the operating license for a nuclear power plant as required by section 102(2) of the National Environmental Policy Act of 1969, as amended. Table B–1, subject to an evaluation of those issues identified in Category 2 as requiring further analysis and possible significant new information, represents the analysis of the environmental impacts associated with renewal of any operating license and is to be used in accordance with §51.95(c). On a 10-year cycle, the Commission intends to review the material in this appendix and update it if necessary. A scoping notice must

be published in the FEDERAL REGISTER indicating the results of the NRC's review and inviting public comments and proposals for other areas that should be updated.

TABLE B–1—SUMMARY OF FINDINGS ON NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS [1]

Issue	Category [2]	Findings [1]
Surface Water Quality, Hydrology, and Use (for all plants)		
Impacts of refurbishment on surface water quality.	1	SMALL. Impacts are expected to be negligible during refurbishment because best management practices are expected to be employed to control soil erosion and spills.
Impacts of refurbishment on surface water use.	1	SMALL. Water use during refurbishment will not increase appreciably or will be reduced during plant outage.
Altered current patterns at intake and discharge structures.	1	SMALL. Altered current patterns have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Altered salinity gradients	1	SMALL. Salinity gradients have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Altered thermal stratification of lakes	1	SMALL. Generally, lake stratification has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Temperature effects on sediment transport capacity.	1	SMALL. These effects have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Scouring caused by discharged cooling water.	1	SMALL. Scouring has not been found to be a problem at most operating nuclear power plants and has caused only localized effects at a few plants. It is not expected to be a problem during the license renewal term.
Eutrophication	1	SMALL. Eutrophication has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Discharge of chlorine or other biocides.	1	SMALL. Effects are not a concern among regulatory and resource agencies, and are not expected to be a problem during the license renewal term.
Discharge of sanitary wastes and minor chemical spills.	1	SMALL. Effects are readily controlled through NPDES permit and periodic modifications, if needed, and are not expected to be a problem during the license renewal term.
Discharge of other metals in waste water.	1	SMALL. These discharges have not been found to be a problem at operating nuclear power plants with cooling-tower-based heat dissipation systems and have been satisfactorily mitigated at other plants. They are not expected to be a problem during the license renewal term.
Water use conflicts (plants with once-through cooling systems).	1	SMALL. These conflicts have not been found to be a problem at operating nuclear power plants with once-through heat dissipation systems.
Water use conflicts (plants with cooling ponds or cooling towers using make-up water from a small river with low flow).	2	SMALL OR MODERATE. The issue has been a concern at nuclear power plants with cooling ponds and at plants with cooling towers. Impacts on instream and riparian communities near these plants could be of moderate significance in some situations. See § 51.53(c)(3)(ii)(A).
Aquatic Ecology (for all plants)		
Refurbishment	1	SMALL. During plant shutdown and refurbishment there will be negligible effects on aquatic biota because of a reduction of entrainment and impingement of organisms or a reduced release of chemicals.
Accumulation of contaminants in sediments or biota.	1	SMALL. Accumulation of contaminants has been a concern at a few nuclear power plants but has been satisfactorily mitigated by replacing copper alloy condenser tubes with those of another metal. It is not expected to be a problem during the license renewal term.
Entrainment of phytoplankton and zooplankton.	1	SMALL. Entrainment of phytoplankton and zooplankton has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Cold shock	1	SMALL. Cold shock has been satisfactorily mitigated at operating nuclear plants with once-through cooling systems, has not endangered fish populations or been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds, and is not expected to be a problem during the license renewal term.
Thermal plume barrier to migrating fish.	1	SMALL. Thermal plumes have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Distribution of aquatic organisms	1	SMALL. Thermal discharge may have localized effects but is not expected to effect the larger geographical distribution of aquatic organisms.

TABLE B-1—SUMMARY OF FINDINGS ON NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS [1]—Continued

Issue	Category [2]	Findings [3]
Premature emergence of aquatic insects.	1	SMALL. Premature emergence has been found to be a localized effect at some operating nuclear power plants but has not been a problem and is not expected to be a problem during the license renewal term.
Gas supersaturation (gas bubble disease).	1	SMALL. Gas supersaturation was a concern at a small number of operating nuclear power plants with once-through cooling systems but has been satisfactorily mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Low dissolved oxygen in the discharge.	1	SMALL. Low dissolved oxygen has been a concern at one nuclear power plant with a once-through cooling system but has been effectively mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses.	1	SMALL. These types of losses have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Stimulation of nuisance organisms (e.g., shipworms).	1	SMALL. Stimulation of nuisance organisms has been satisfactorily mitigated at the single nuclear power plant with a once-through cooling system where previously it was a problem. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)		
Entrainment of fish and shellfish in early life stages.	2	SMALL, MODERATE, OR LARGE. The impacts of entrainment are small at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems. Further, ongoing efforts in the vicinity of these plants to restore fish populations may increase the numbers of fish susceptible to intake effects during the license renewal period, such that entrainment studies conducted in support of the original license may no longer be valid. See §51.53(c)(3)(ii)(B).
Impingement of fish and shellfish	2	SMALL, MODERATE, OR LARGE. The impacts of impingement are small at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems. See §51.53(c)(3)(ii)(B).
Heat shock	2	SMALL, MODERATE, OR LARGE. Because of continuing concerns about heat shock and the possible need to modify thermal discharges in response to changing environmental conditions, the impacts may be of moderate or large significance at some plants. See §51.53(c)(3)(ii)(B).
Aquatic Ecology (for plants with cooling-tower-based heat dissipation systems)		
Entrainment of fish and shellfish in early life stages.	1	SMALL. Entrainment of fish has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Impingement of fish and shellfish	1	SMALL. The impingement has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Heat shock	1	SMALL. Heat shock has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Ground-water Use and Quality		
Impacts of refurbishment on ground-water use and quality.	1	SMALL. Extensive dewatering during the original construction on some sites will not be repeated during refurbishment on any sites. Any plant wastes produced during refurbishment will be handled in the same manner as in current operating practices and are not expected to be a problem during the license renewal term.
Ground-water use conflicts (potable and service water; plants that use <100 gpm).	1	SMALL. Plants using less than 100 gpm are not expected to cause any ground-water use conflicts.
Ground-water use conflicts (potable and service water, and dewatering; plants that use >100 gpm).	2	SMALL, MODERATE, OR LARGE. Plants that use more than 100 gpm may cause ground-water use conflicts with nearby ground-water users. See §51.53(c)(3)(ii)(C).

TABLE B–1—SUMMARY OF FINDINGS ON NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS [1]—Continued

Issue	Category [2]	Findings [3]
Ground-water use conflicts (plants using cooling towers withdrawing make-up water from a small river).	2	SMALL, MODERATE, OR LARGE. Water use conflicts may result from surface water withdrawals from small water bodies during low flow conditions which may affect aquifer recharge, especially if other ground-water or upstream surface water users come on line before the time of license renewal. See § 51.53(c)(3)(ii)(A).
Ground-water use conflicts (Ranney wells).	2	SMALL, MODERATE, OR LARGE. Ranney wells can result in potential ground-water depression beyond the site boundary. Impacts of large ground-water withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal. See § 51.53(c)(3)(ii)(C).
Ground-water quality degradation (Ranney wells).	1	SMALL. Ground-water quality at river sites may be degraded by induced infiltration of poor-quality river water into an aquifer that supplies large quantities of reactor cooling water. However, the lower quality infiltrating water would not preclude the current uses of ground water and is not expected to be a problem during the license renewal term.
Ground-water quality degradation (saltwater intrusion).	1	SMALL. Nuclear power plants do not contribute significantly to saltwater intrusion.
Ground-water quality degradation (cooling ponds in salt marshes).	1	SMALL. Sites with closed-cycle cooling ponds may degrade ground-water quality. Because water in salt marshes is brackish, this is not a concern for plants located in salt marshes.
Ground-water quality degradation (cooling ponds at inland sites).	2	SMALL, MODERATE, OR LARGE. Sites with closed-cycle cooling ponds may degrade ground-water quality. For plants located inland, the quality of the ground water in the vicinity of the ponds must be shown to be adequate to allow continuation of current uses. See § 51.53(c)(3)(ii)(D).
Terrestrial Resources		
Refurbishment impacts	2	SMALL, MODERATE, OR LARGE. Refurbishment impacts are insignificant if no loss of important plant and animal habitat occurs. However, it cannot be known whether important plant and animal communities may be affected until the specific proposal is presented with the license renewal application. See § 51.53(c)(3)(ii)(E).
Cooling tower impacts on crops and ornamental vegetation.	1	SMALL. Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Cooling tower impacts on native plants.	1	SMALL. Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Bird collisions with cooling towers	1	SMALL. These collisions have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Cooling pond impacts on terrestrial resources.	1	SMALL. Impacts of cooling ponds on terrestrial ecological resources are considered to be of small significance at all sites.
Power line right-of-way management (cutting and herbicide application).	1	SMALL. The impacts of right-of-way maintenance on wildlife are expected to be of small significance at all sites.
Bird collision with power lines	1	SMALL. Impacts are expected to be of small significance at all sites.
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock).	1	SMALL. No significant impacts of electromagnetic fields on terrestrial flora and fauna have been identified. Such effects are not expected to be a problem during the license renewal term.
Floodplains and wetland on power line right of way.	1	SMALL. Periodic vegetation control is necessary in forested wetlands underneath power lines and can be achieved with minimal damage to the wetland. No significant impact is expected at any nuclear power plant during the license renewal term.
Threatened or Endangered Species (for all plants)		
Threatened or endangered species	2	SMALL, MODERATE, OR LARGE. Generally, plant refurbishment and continued operation are not expected to adversely affect threatened or endangered species. However, consultation with appropriate agencies would be needed at the time of license renewal to determine whether threatened or endangered species are present and whether they would be adversely affected. See § 51.53(c)(3)(ii)(E).

TABLE B-1—SUMMARY OF FINDINGS ON NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS [1]—Continued

Issue	Category [2]	Findings [3]
Air Quality		
Air quality during refurbishment (nonattainment and maintenance areas).	2	SMALL, MODERATE, OR LARGE. Air quality impacts from plant refurbishment associated with license renewal are expected to be small. However, vehicle exhaust emissions could be cause for concern at locations in or near nonattainment or maintenance areas. The significance of the potential impact cannot be determined without considering the compliance status of each site and the numbers of workers expected to be employed during the outage. See §51.53(c)(3)(ii)(F).
Air quality effects of transmission lines.	1	SMALL. Production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases.
Land Use		
Onsite land use	1	SMALL. Projected onsite land use changes required during refurbishment and the renewal period would be a small fraction of any nuclear power plant site and would involve land that is controlled by the applicant.
Power line right of way	1	SMALL. Ongoing use of power line right of ways would continue with no change in restrictions. The effects of these restrictions are of small significance.
Human Health		
Radiation exposures to the public during refurbishment.	1	SMALL. During refurbishment, the gaseous effluents would result in doses that are similar to those from current operation. Applicable regulatory dose limits to the public are not expected to be exceeded.
Occupational radiation exposures during refurbishment.	1	SMALL. Occupational doses from refurbishment are expected to be within the range of annual average collective doses experienced for pressurized-water reactors and boiling-water reactors. Occupational mortality risk from all causes including radiation is in the mid-range for industrial settings.
Microbiological organisms (occupational health).	1	SMALL. Occupational health impacts are expected to be controlled by continued application of accepted industrial hygiene practices to minimize worker exposures.
Microbiological organisms (public health)(plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river).	2	SMALL, MODERATE, OR LARGE. These organisms are not expected to be a problem at most operating plants except possibly at plants using cooling ponds, lakes, or canals that discharge to small rivers. Without site-specific data, it is not possible to predict the effects generically. See §51.53(c)(3)(ii)(G).
Noise	1	SMALL. Noise has not been found to be a problem at operating plants and is not expected to be a problem at any plant during the license renewal term.
Electromagnetic fields, acute effects (electric shock).	2	SMALL, MODERATE, OR LARGE. Electrical shock resulting from direct access to energized conductors or from induced charges in metallic structures have not been found to be a problem at most operating plants and generally are not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric shock potential at the site. See §51.53(c)(3)(ii)(H).
Electromagnetic fields, chronic effects [5].	[4] NA	UNCERTAIN. Biological and physical studies of 60-Hz electromagnetic fields have not found consistent evidence linking harmful effects with field exposures. However, research is continuing in this area and a consensus scientific view has not been reached.[5]
Radiation exposures to public (license renewal term).	1	SMALL. Radiation doses to the public will continue at current levels associated with normal operations.
Occupational radiation exposures (license renewal term).	1	SMALL. Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be well below regulatory limits.

TABLE B–1—SUMMARY OF FINDINGS ON NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS [1]—Continued

Issue	Category [2]	Findings [3]
Socioeconomics		
Housing impacts	2	SMALL, MODERATE, OR LARGE. Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or in areas with growth control measures that limit housing development. See § 51.53(c)(3)(ii)(I).
Public services: public safety, social services, and tourism and recreation.	1	SMALL. Impacts to public safety, social services, and tourism and recreation are expected to be of small significance at all sites.
Public services: public utilities	2	SMALL OR MODERATE. An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability. See § 51.53(c)(3)(ii)(I).
Public services, education (refurbishment).	2	SMALL, MODERATE, OR LARGE. Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors. See § 51.53(c)(3)(ii)(I).
Public services, education (license renewal term).	1	SMALL. Only impacts of small significance are expected.
Offsite land use (refurbishment)	2	SMALL OR MODERATE. Impacts may be of moderate significance at plants in low population areas. See § 51.53(c)(3)(ii)(I).
Offsite land use (license renewal term).	2	SMALL, MODERATE, OR LARGE. Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal. See § 51.53(c)(3)(ii)(I).
Public services, Transportation	2	SMALL, MODERATE, OR LARGE. Transportation impacts (level of service) of highway traffic generated during plant refurbishment and during the term of the renewed license are generally expected to be of small significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites. See § 51.53(c)(3)(ii)(J).
Historic and archaeological resources.	2	SMALL, MODERATE, OR LARGE. Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archaeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection. See § 51.53(c)(3)(ii)(K).
Aesthetic impacts (refurbishment)	1	SMALL. No significant impacts are expected during refurbishment.
Aesthetic impacts (license renewal term).	1	SMALL. No significant impacts are expected during the license renewal term.
Aesthetic impacts of transmission lines (license renewal term).	1	SMALL. No significant impacts are expected during the license renewal term.
Postulated Accidents		
Design basis accidents	1	SMALL. The NRC staff has concluded that the environmental impacts of design basis accidents are of small significance for all plants.
Severe accidents	2	SMALL. The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives. See § 51.53(c)(3)(ii)(L).
Uranium Fuel Cycle and Waste Management		
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high level waste).	1	SMALL. Off-site impacts of the uranium fuel cycle have been considered by the Commission in Table S–3 of this part. Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small.

TABLE B-1—SUMMARY OF FINDINGS ON NEPA ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS [1]—Continued

Issue	Category [2]	Findings [1]
Mixed waste storage and disposal	1	SMALL. The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.
On-site spent fuel	1	SMALL. The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage is not available.
Nonradiological waste	1	SMALL. No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants.
Transportation	1	SMALL. The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4—Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in §51.52.
Decommissioning		
Radiation doses	1	SMALL. Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem caused by buildup of long-lived radionuclides during the license renewal term.
Waste management	1	SMALL. Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected.
Air quality	1	SMALL. Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term.
Water quality	1	SMALL. The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts.
Ecological resources	1	SMALL. Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.
Socioeconomic impacts	1	SMALL. Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth.
Environmental Justice		
Environmental justice [6]	[4] NA	NONE. The need for and the content of an analysis of environmental justice will be addressed in plant-specific reviews.[6]

[1] Data supporting this table are contained in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (May 1996) and NUREG-1437, Vol. 1, Addendum 1, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Main Report Section 6.3—'Transportation,' Table 9.1 'Summary of findings on NEPA issues for license renewal of nuclear power plants,' Final Report" (August 1999).

[2] The numerical entries in this column are based on the following category definitions:

Category 1: For the issue, the analysis reported in the Generic Environmental Impact Statement has shown:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic;

(2) A single significance level (i.e., small, moderate, or large) has been assigned to the impacts (except for collective off site radiological impacts from the fuel cycle and from high level waste and spent fuel disposal); and

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

The generic analysis of the issue may be adopted in each plant-specific review.

Category 2: For the issue, the analysis reported in the Generic Environmental Impact Statement has shown that one or more of the criteria of Category 1 cannot be met, and therefore additional plant-specific review is required.

[3] The impact findings in this column are based on the definitions of three significance levels. Unless the significance level is identified as beneficial, the impact is adverse, or in the case of "small," may be negligible. The definitions of significance follow:

SMALL—For the issue, environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small as the term is used in this table.

MODERATE—For the issue, environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

LARGE—For the issue, environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For issues where probability is a key consideration (i.e., accident consequences), probability was a factor in determining significance.

[4] NA (not applicable). The categorization and impact finding definitions do not apply to these issues.

[5] If, in the future, the Commission finds that, contrary to current indications, a consensus has been reached by appropriate Federal health agencies that there are adverse health effects from electromagnetic fields, the Commission will require applicants to submit plant-specific reviews of these health effects as part of their license renewal applications. Until such time, applicants for license renewal are not required to submit information on this issue.

[6] Environmental Justice was not addressed in NUREG–1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," because guidance for implementing Executive Order 12898 issued on February 11, 1994, was not available prior to completion of NUREG–1437. This issue will be addressed in individual license renewal reviews.

[61 FR 66546, Dec. 18, 1996, as amended at 62 FR 59276, Nov. 3, 1997; 64 FR 48507, Sept. 3, 1999]

PART 52—EARLY SITE PERMITS; STANDARD DESIGN CERTIFICATIONS; AND COMBINED LICENSES FOR NUCLEAR POWER PLANTS

GENERAL PROVISIONS

附件二：美國 EPRI 老化效應整理評估報告之案例內容

Table 4-1 Aging Effects Summary - Stainless Steel, Nickel-Based Alloys, and Titanium

Material	Aging Mechanism	Mechanism Applicability Criteria	Aging Effect	Relevant Sections and Assumptions
Wrought Austenitic Stainless Steel *and* CASS *and* Nickel-Based Alloys	Crevice Corrosion	1. O_2 > 100 ppb	Loss of material	Sections 2.1.1, 2.1.2, 3.1.4 Assumptions 4.1.1, 4.1.2, 4.1.3
	Pitting Corrosion	1. O_2 > 100 ppb *and* 2. Chlorides > 150 ppb *or* fluorides > 150 ppb (PWR only) *or* sulfates > 150 ppb *and* 3. Low flow (< 3 fps)	Loss of material	Sections 2.1.1, 2.1.2, 3.1.5 Assumptions 4.1.1, 4.1.3, 4.1.4
	SCC/IGA	1. BWR power production loop	Cracking	Sections 2.1.1, 2.1.2, 2.2.1, 3.2.2 Assumptions 4.1.1, 4.1.5, 4.1.6
		1a. O_2 > 100 ppb *or* 1b. Chlorides > 150 ppb *or* fluorides > 150 ppb (PWR only) *or* sulfates > 150 ppb *and* 2. Temperature > 140°F (stainless steel) Temperature > 500°F (nickel-based alloy)	Cracking	Sections 2.1.1, 2.1.2, 3.2.2 Assumptions 4.1.1, 4.1.5, 4.1.6, 4.1.7

Material	Aging Mechanism	Mechanism Applicability Criteria	Aging Effect	Relevant Sections and Assumptions
Wrought Austenitic Stainless Steel *and* CASS *and* Nickel-Base Alloys *and* Titanium	MIC	1. Potential for MIC contamination *and* 2. pH < 10 *and* temperature < 210°F	Loss of material	Sections 2.1.1, 2.1.2, 3.1.7 Assumptions 4.1.1, 4.1.11
Titanium	Crevice Corrosion	1. Temperature > 160°F *and* 2. O_2 > 100 ppb *and* 3. Chlorides > 150 ppb *or* fluorides > 150 ppb (PWR only) *or* sulfates > 150 ppb	Loss of material	Sections 2.1.6, 3.1.4 Assumptions 4.1.1, 4.1.2
CASS	Thermal Embrittlement	1. Temperature > 482°F	Reduction in fracture toughness	Sections 2.1.1, 2.1.2, 3.3.1 Assumptions 4.1.1, 4.1.8

Table 4-2 Aging Effects Summary - Carbon Steel, Cast Iron, Aluminum, and Aluminum Alloys

Material	Aging Mechanism	Mechanism Applicability Criteria	Aging Effect	Relevant Sections and Assumptions
Carbon Steel *and* Low Alloy Steel *and* Cast Iron *and* Aluminum and Aluminum Alloys	General Corrosion	1. Material is carbon steel, low alloy steel, or cast iron	Loss of material	Sections 2.1.3, 2.1.4, 3.1.1 Assumption 4.1.1
	Crevice Corrosion	1. O_2 > 100 ppb	Loss of material	Sections 2.1.3, 2.1.4, 3.1.4 Assumptions 4.1.1, 4.1.2, 4.1.3
	Pitting Corrosion	1. O_2 > 100 ppb *and* 2. Chlorides > 150 ppb *or* fluorides > 150 ppb (PWR only) *or* sulfates > 150 ppb *and* 3. Low flow (< 3 fps)	Loss of material	Sections 2.1.3, 2.1.4, 3.1.5 Assumptions 4.1.1, 4.1.3, 4.1.4
	Galvanic Corrosion	1. Contact with metal higher in the galvanic series	Loss of material	Sections 2.1.3, 2.1.4, 2.1.7, 3.1.3
	Flow Accelerated Corrosion	1. Part of main steam, feedwater, condensate, or other system identified in Section 3.1.6 *and* 2. Not dry or superheated steam *and* 3. pH<9.5 *and* 4. Material chromium content < 1.0%	Loss of material	Sections 2.1.3, 2.1.4, 3.1.6
	Erosion	1. Material is subject to high velocity, constricted flow, or fluid direction change *and* 2. Fluid contains particulates (single phase) or water droplets (two phase flow)	Loss of material	Sections 2.1.3, 2.1.4, 3.1.6 Assumption 4.1.9

Material	Aging Mechanism	Mechanism Applicability Criteria	Aging Effect	Relevant Sections and Assumptions
	MIC	1. Potential for MIC contamination *and* 2. pH < 10 *and* temperature < 210°F	Loss of material	Sections 2.1.3, 2.1.4, 3.1.7 Assumptions 4.1.1, 4.1.11
	Selective Leaching	1. Material is gray cast iron	Loss of material	Sections 2.1.3, 2.1.4, 3.1.2 Assumption 4.1.1
	SCC	1. Potential for MIC contamination *and* 2. pH < 10 *and* temperature < 210°F *and* 3. Nitrite corrosion inhibitor in use *and* 4. Material is carbon or low alloy steel	Cracking	Sections 2.1.3, 3.1.7, 3.2.2 Assumptions 4.1.1, 4.1.6, 4.1.11
Aluminum Alloys	SCC	1. O_2 > 100 ppb *and* 2. Chlorides > 150 ppb *or* fluorides > 150 ppb (PWR only) *or* sulfates > 150 ppb	Cracking	Sections 2.1.8, 3.2.2 Assumptions 4.1.1, 4.1.6

Table 4-3 Aging Effects Summary - Copper and Copper Alloys

Material	Aging Mechanism	Mechanism Applicability Criteria	Aging Effect	Relevant Sections and Assumptions
Copper *and* Copper Alloys	Crevice Corrosion	1. Material is not Brass/Bronze < 15% Zn *or* Aluminum Bronze < 8% Al *and* 2. O_2 > 100 ppb	Loss of material	Sections 2.1.5, 3.1.4 Assumptions 4.1.1, 4.1.2, 4.1.3
	Pitting Corrosion	1. Material is not Brass/Bronze < 15% Zn *or* Aluminum Bronze < 8% Al *and* 2. O_2 > 100 ppb *and* 3. Chlorides > 150 ppb *or* fluorides > 150 ppb (PWR only) *or* sulfates > 150 ppb *and* 4. Stagnant or low flow (< 3 fps)	Loss of material	Sections 2.1.5, 3.1.5 Assumptions 4.1.1, 4.1.3, 4.1.4
	Galvanic Corrosion	1. Contact with metal higher in the galvanic series	Loss of material	Sections 2.1.5, 2.1.7, 3.1.3
	Erosion	1. Subject to high velocity, constricted flow, or fluid direction change *and* 2. Fluid contains particulates (single phase) or water droplets (two phase flow)	Loss of material	Sections 2.1.5, 3.1.6 Assumption 4.1.9
	SCC/IGA	1. Fluid contains ammonia or ammonium compound *and* 2. Material is Brass/Bronze > 15% Zn *or* material is Aluminum Bronze > 8% Al *or* material is Silicon Bronze *and* 3. O_2 > 100 ppb	Cracking	Sections 2.1.5, 3.2.2 Assumptions 4.1.1, 4.1.6

Material	Aging Mechanism	Mechanism Applicability Criteria	Aging Effect	Relevant Sections and Assumptions
	MIC	1. Potential for MIC contamination *and* 2. pH < 10 *and* temperature < 210°F	Loss of material	Sections 2.1.5, 3.1.7 Assumptions 4.1.1, 4.1.11
	Flow Accelerated Corrosion	1. Subject to high velocity, constricted flow, or fluid direction change *and* 2. Part of main steam, feedwater, condensate, or other system identified in Section 3.1.6 *and* 3. Not dry or superheated steam *and* 4. pH<9.5	Loss of material	Sections 2.1.5, 3.1.6
	Selective Leaching	1. Material is not an "inhibited" copper alloy *and* 2. Material is Brass/Bronze with > 15% Zn *or* material is Aluminum Bronze with > 8% Al	Loss of material	Sections 2.1.5, 3.1.2 Assumption 4.1.1

Table 5-1
Applicable Aging Effects for Concrete Structures and Structural Members

Applicable Aging Effects	Environment			
	Below Grade	Raw Water	Protected from Weather	Exposed to Weather
Loss of Material				
Freeze-Thaw	N	Y	N	Y
Abrasion or Cavitation	N	Y	N	N
Elevated Temperature	N	N	Y	N
Aggressive Chemicals	Y	Y	N	Y
Corrosion of Embedded Steel and Steel Reinforcement	Y	Y	N	Y
Cracking				
Freeze-Thaw	N	Y	N	Y
Reaction with Aggregates	Y	Y	Y	Y
Shrinkage	N	N	N	N
Settlement	Y	N	N	N
Elevated Temperature	N	N	Y	N
Irradiation	N	N	Y	N
Fatigue	N	N	Y	N
Cracking of masonry block walls'	N	N	Y	Y
Change in Material Properties				
Leaching of $Ca(OH)_2$	Y	Y	N	Y
Aggressive Chemicals	Y	Y	N	Y
Elevated Temperature	N	N	Y	N
Irradiation	N	N	Y	N
Creep	N	N	N	N

Key: Y means aging mechanism is applicable for concrete structures located in this environment and potentially requires aging management if the mechanism applicability criteria identified in Table 5-2 are met.

N means aging mechanism is not applicable for concrete structures located in this environment.

' – Masonry block walls include concrete block walls or brick walls

The specific references for the temperature and radiation values reported in the table below can be found in Appendix B, Basis for the 60-Year Service Limiting Temperature. The values identified in Table 9-1 were picked to be conservative and may differ from plant-specific data that is based on other referenced tests. The data in Table 9-1 is provided as a convenience and does not prevent the use of plant-specific values.

NOTE:
Crediting plant-specific EQ test reports for non-EQ cable and connection materials may expose the plant to unnecessary problems. The world of EQ is sometimes very volatile. With non-EQ cables tied to an EQ analysis, failure or questions raised regarding the EQ analysis could also implicate the review of non-EQ cables that now depend on that analysis.

Table 9-1
All Commonly Used Age-Degradable Materials, Applications and 60-Year Service-Limiting Environments

Material Name, Common Abbreviation	Cables		Connections		60-Year Service-Limiting Environment	
	I&C	Power	I&C	Power	Temperature	Radiation Dose
	✓ = material application					
Bus Bar Insulation Tube, BBIT (heat shrink)		✓		✓	171°F (77.4°C)	1×10^7 rads
Butyl Rubber, BR		✓			125°F (51.8°C)	5×10^6 rads
Chloroprene, Neoprene	✓		✓		107°F (41.7°C)	2×10^6 rads
Chlorosulfonated Polyethylene, CSPE (Hypalon)	✓	✓			167°F (75.0°C)	2×10^6 rads
Cross-linked Polyethylene, XLPE, XLP	✓	✓			188°F (86.6°C)	1×10^6 rads
Epoxy, XR5126 (Westinghouse)			✓		150°F (65.7°C)	1×10^7 rads
Ethylene Propylene Diene Monomer, EPDM	✓	✓	✓		189°F (87.2°C)	5×10^7 rads
Ethylene Propylene Rubber, EPR, EP	✓	✓	✓	✓	167°F (75.0°C)	5×10^7 rads
Halar, ECTFE	✓				306°F (152.0°C)	1×10^8 rads
High Temperature Kerite, HTK (N98)	✓	✓			185°F (85.2°C)	1×10^8 rads
Kerite FR, FR (HC-711)	✓	✓			129°F (54.1°C)	5×10^7 rads
Kerite FR, FR (HI-70)	✓	✓			141°F (60.8°C)	5×10^7 rads
Kerite FR2, FR2			✓		193°F (89.2°C)	5×10^7 rads

Table 9-1
All Commonly Used Age-Degradable Materials, Applications and 60-Year Service-Limiting Environments (Continued)

Material Name, Common Abbreviation	Cables		Connections		60-Year Service-Limiting Environment	
	I&C	Power	I&C	Power	Temperature	Radiation Dose
	✓ = material application					
Kerite FR3, FR3			✓		167°F (74.8°C)	5 x 10^7 rads
Melamine			✓	✓	205°F (96.2°C)	5 x 10^7 rads
Phenolic			✓	✓	231°F (110.6°C)	~4 x 10^7 rads
Polyalkene	✓				190°F (87.5°C)	1 x 10^7 rads
Polyamide, Nylon			✓		119°F (48.5°C)	2 x 10^6 rads
Polyethylene, PE	✓				112°F (44.4°C)	2 x 10^7 rads
Polyimide, Kapton	✓	✓	✓		266°F (130.2°C)	2 x 10^8 rads
Polypropylene, PP	✓				70°F (21.2°C)	5 x 10^6 rads
Polyvinyl Chloride, PVC	✓	✓	✓	✓	112°F (44.2°C)	2 x 10^7 rads
Polyvinyldine Fluoride, PVF (Kynar)			✓		227°F (108.1°C)	1 x 10^7 rads
Silicone Rubber, SR, SiR	✓	✓	✓	✓	273°F (133.9°C)	3 x 10^6 rads
Teflon, FEP	✓		✓		647°F (341.7°C)	5 x 10^4 rads
Tefzel, EFTE	✓	✓			228°F (108.6°C)	3 x 10^7 rads
Western Cable Sleeve Fire Resistant-Nuclear, WCSF-N			✓		192°F (88.7°C)	1 x 10^6 rads

NOTE:
Some insulation abbreviations include the letters FR. When FR is used in combination with a material abbreviation it means fire or flame retardant or resistant. For example, FREP would be fire retardant ethylene propylene rubber. In these cases the properties of both materials (in this example, the properties of EP and FREP) are essentially the same and the 60-year service-limiting environments identified for EP would apply for FREP.

NOTE:
Non-age-degradable materials are also used for cable insulation such as fiberglass, magnesium oxide and other mineral insulation materials. Being non-age-degradable they have no aging effects requiring management, are not included in Table 9-1 and need not be included in a plant AMR.

practices. Installations that do not meet the plant installation standards are a current license term issue and are not within the scope of the license renewal review.

- Low-voltage cable compression fitting vibration and tensile stress are identified in DOE Cable AMG Table 4-18. Compression fittings subject to vibration and tensile stress occur at active electrical component connections (passive electrical components do not vibrate), which are inspected and maintained along with active components. Active component connections meet the definition of an active component as discussed in the statement of considerations that accompanied the license renewal rule and are not included in the review. See Appendix B, Basis Information for Technical Guidance, for further information.
- An additional low-voltage cable heat aging effect of "increased vulnerability to failure in harsh environment" appears in DOE Cable AMG Table 4-18. This aging effect is only applicable to cables included in the EQ program, which are not subject to an AMR.
- Cable jacketing is identified for low-voltage cable as a subcomponent along with insulation. Heat and radiation are identified as applicable stressors. Cable jackets are used to protect the cable insulation during installation and cable jackets of non-EQ cables and their materials have no significant effect on the normal aging process of the primary insulation. The primary insulating material is the only material reviewed in the AMR and aging of the jackets is not included in the review.
- Low-voltage connector contact surface corrosion and oxidation caused by moisture is identified. Section 3.7.2.1.3 of the DOE Cable AMG states that only 3% of all low-voltage connector failures were identified as being caused by moisture intrusion. Based on the total number of reported connector failures in the DOE Cable AMG, moisture intrusion accounted for 10 failures in all of the operating plants in the United States. Plant installation practices provide appropriate protection for connectors from moisture (such as in enclosures). This aging effect is not applicable.

The columns from the DOE Cable AMG table are kept for consistency and with the above adaptations the result is the standard aging effects presented in Table 10-1 that are evaluated for insulated cables and connections.

Table 10-1
Aging Effects for Insulated Cables and Connections

Subcomponent	Applicable Stressors	Degradation	Aging Effects
Insulation material	Heat, oxygen	Embrittlement, cracking, melting, discoloration	Reduced IR, electrical failure
	Radiation, oxygen	Embrittlement, cracking, discoloration, swelling	
Medium-voltage (2kV to 15kV) cable insulation material	Moisture and voltage stress	Formation of water trees, localized damage	Electrical failure (breakdown of insulation)

Aging Effects for Electrical Portions of Electrical and I&C Penetration Assemblies

The aging effects for electrical portions of electrical and I&C penetration assemblies are the same as the aging effects identified for insulated cables and connections in the previous section.

Aging Effects for Phase Bus

It has been found that the various types of phase bus (e.g., isolated-phase bus, nonsegregated-phase bus, segregated-phase bus) are constructed of similar materials. With similar materials, the aging effects to be reviewed are similar. Aging effects for phase bus that have been previously reviewed are listed in the following table.

Table 10-2
Aging Effects for Phase Bus

Material	Stressor or Mechanism	Aging Effect
Aluminum (bus, solid and flexible connectors and ground straps)	Connection surface oxidation	Change in material properties leading to increased resistance and heating
Silicone caulk	Temperature and Radiation	Change in material properties leading to loss of maintained spacing between the bus and bushing
Steel (bolts, washers, nuts and clamp screws)	Moisture	Change in material properties (corrosion) leading to loss of function for the part
Rigid bus parts	Vibration	Cracking

Aging Effects for Switchyard Bus

Aluminum (in non-conductor applications; i.e., insulator fastening hardware) has no applicable aging effects under its service conditions. Aluminum in conductor applications may be susceptible to change in material properties. This potential aging effect is listed in the following table. In addition, vibration was introduced as a potential stressor by the NRC staff in their RAIs [15, Attachment 3]. These aging effects are described and listed below.

Table 10-3
Aging Effects for Switchyard Bus

Material	Stressor or Mechanism	Aging Effect
Aluminum (bus)[xvii]	Connection surface oxidation	Change in material properties leading to increased resistance and heating
Switchyard bus	Vibration	Cracking

[xvii] Connection surface oxidation is not an applicable aging effect for copper.

Aging Effects for Transmission Conductors

The only aging effect for transmission conductors that could be found in an industry review is loss of conductor strength. Vibration was introduced as a potential stressor by the NRC staff in a RAI during the Oconee license renewal application review [15, Attachment 3]. These aging effects are described and listed below.

Table 10-4
Aging Effects for Transmission Conductors

Material	Stressor or Mechanism	Aging Effect
Aluminum conductor reinforced with galvanized steel	Corrosion	Loss of conductor strength
Hardware fastening to insulator	Wind loading vibration or sway	Loss of material (wear) Fatigue

Aging Effects for High-Voltage Insulators

The aging effects for high-voltage insulators identified through an industry review are identified below.

Table 10-5
Aging Effects for High-Voltage Insulators

Material	Stressor or Mechanism	Aging Effect
Porcelain	Airborne contaminants	Surface contamination Cracking
Metal	Mechanical wear	Loss of material
Cement	None	None

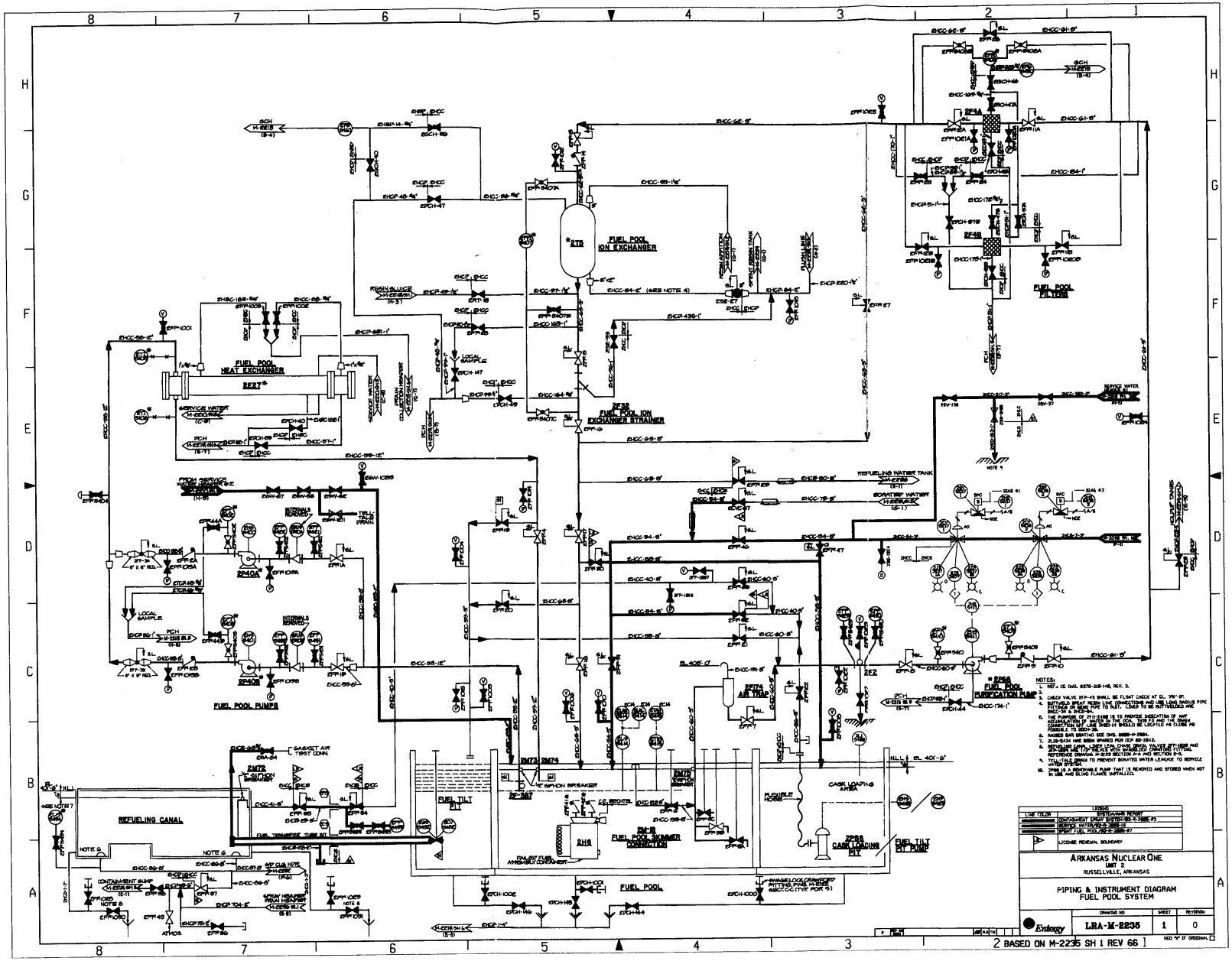
Aging Effects for Uninsulated Ground Conductors

Aging effects identified for uninsulated ground conductors are identified below.

Table 10-6
Aging Effects for Uninsulated Ground Conductors

Material	Stressor or Mechanism	Aging Effect
Copper	Corrosion	Change in material properties

附件三：美國 ANO 電廠進行系統內要納入老化評估設備的案例


FUEL POOL ION EXCHANGER
FUEL POOL HEAT EXCHANGER
FUEL POOL ION EXCHANGER STRAINER
FUEL POOL FILTERS
FUEL POOL PUMPS
FUEL POOL PURIFICATION PUMP
REFUELING CANAL
FUEL POOL
CASK LOADING AREA
CASK LOADING PIT
FUEL TILT PIT
FUEL TILT PIT PUMP
ARKANSAS NUCLEAR ONE
UNIT 2
RUSSELLVILLE, ARKANSAS
PIPING & INSTRUMENT DIAGRAM
FUEL POOL SYSTEM
LRA-M-2235
Entergy
2 BASED ON M-2235 SH 1 REV 66

附件四：美國 NRC 2004 年法規年會議程表

RIC 2004

PROGRAM AND SCHEDULE

www.nrc.gov/public-involve/conference-symposia/ric/

"Promoting Openness Through Effective Communication"

Updated: March 9, 2004 (10:33AM)

Session No.	Session Information	Contact Information
Wednesday, March 10, 2004		
W1	**Welcome** — **Location: Presidential Ballroom** **10:00 - 10:45 am** • **James E. Dyer, Conference Chairman and Director (D)/Office of Nuclear Reactor Regulation (NRR)/NRC** • **William D. Travers, Executive Director for Operations (EDO)/NRC**	
W2	**Plenary Session: Presentation / Q&A Session** — **Location: Presidential Ballroom** **10:45 - 11:45 am** ***NRC Chairman Nils J. Diaz***	
W3	**Plenary Session: Regulatory Trends** — **Location: Presidential Ballroom** **11:45 am - 12:15 pm** **James E. Dyer, D/NRR/NRC**	
LUNCH 12:15 - 1:45 pm		
W4	**Plenary Session: Grid Stability / Next Steps** **1:45 - 3:00 pm** — **Location: Presidential Ballroom** **Panel Chair:** Samuel J. Collins, Deputy Executive Director for Reactor Programs/ Office of the Executive Director for Operations (OEDO)/NRC **Panelists:** • Cornelius F. Holden, Jr., Project Directorate (PD) I/Division of Licensing Project Management (DLPM)/NRR/NRC • Jeffrey Lyash, Senior Vice President (VP)/Energy Delivery/Progress Energy • William J. Museler, President and Chief Executive Officer/New York Independent System Operator • David R. Nevius, Senior VP/North American Electric Reliability Council	**Session Coordinator:** John P. Boska JPB1@nrc.gov 301-415-2901
BREAK 3:00 - 3:30 pm		
BREAKOUT SESSIONS (Set of four concurrent sessions) 3:30 - 5:15 pm		

Session No.	Session Information	Contact Information
Wednesday, March 10, 2004		
W5	**Reactor Oversight Process** **3:30 - 5:15 pm** **Location: Presidential Ballroom** **Panel Chair:** Cynthia A. Carpenter Deputy Director (DD)/ Division of Inspection Program Management (DIPM)/NRR/NRC **Panelists:** • Bruce S. Mallett, Regional Administrator (RA)/Region IV (RIV)/NRC • Stuart A. Richards, Chief (C)/Inspection Program Branch/DIPM/NRR/NRC • David Garchow, VPEngineering and Technical Support for PSEG Nuclear, LLC • Michael Parker, PE, Bureau Chief of the Bureau of Nuclear Facility Safety/Illinois Emergency Management Agency • Anthony R. Pietrangelo, Senior Director/Risk Regulation/Nuclear Energy Institute (NEI) ***Theme: "ROP: What's Working and What's Not"***	**Session Coordinator:** Daniel J. Merzke DXM2@nrc.gov 301-415-3777
W6	**Licensing Issues** **3:30 - 5:15 pm** **Location: Federal A/B Rooms** **Panel Chair:** Ledyard "Tad" B. Marsh D/DLPM/NRR/NRC **Panelists:** • Michael R. Johnson, DD/Division of Systems and Safety Analysis (DSSA)/ NRR/NRC • William H. Ruland, PD III/DLPM/NRR/NRC • James Fisicaro, Manager/Nuclear Assessments and Issues/Duke Energy Corporation • Keith R. Jury, D/Licensing Licensing and Regulatory Affairs/Exelon Corporation • Michael Schoppman, Senior Project Manager (PM)/Operations Support/NEI ***Theme: "Addressing Licensing Challenges"***	**Session Coordinator:** Margie Kotzalas MXK5@nrc.gov 301-415-2737
W7	**New Reactors / Advanced Reactors** **3:30 - 5:15 pm** **Location: South American A/B Rooms** **Panel Chair:** James E. Lyons Program Director (PD), New Research and Test Reactors/ Division of Regulatory Improvement Programs (DRIP)/NRR/NRC **Panelists:** • Mary Ann Ashley, Team Leader, Construction Inspection Program, Inspection Program Branch, DIPM/NRR/NRC • Joseph M. Sebrosky, Senior PM/New Reactors Section/DRIP/ NRR/NRC • Russell J. Bell, Senior PM/NEI • Eugene S. Grecheck, VP Nuclear Support Services/Dominion Energy, Inc. • Thomas P. Miller, Acting Associate Director for Nuclear Power Systems/ Office of Nuclear Energy, Science, and Technology/U.S. Department of Energy (DOE) ***Theme: "Preparing for Review of Combined License Applications"*** **Subtopics:** • NRC activities to prepare for receipt and review of COL applications. • DOE initiatives in support of COL application submittals. • Industry activities and plans focused on COL issue resolution. • Progress on and issues with preparing for COL reviews from potential applicant's perspective.	**Session Coordinator:** Michael L. Scott MLS3@nrc.gov 301-415-1421

Session No.	Session Information	Contact Information
Wednesday, March 10, 2004		
W8	**International Issues** **3:30 - 5:15 pm** **Location: Pan American Room** **Panel Chair:** R. William Borchardt DD/NRR/NRC **Panel Co-Chair:** Janice Dunn-Lee D/Office of International Programs/NRC **Panelists:** • K. S. Choi, Special Advisor to the President of Korea Institute of Nuclear Safety (KINS) on Public Communication and Policy/Korea • André-Claude Lacoste, Director General/General Directorate for Nuclear Safety and Radiation Protection (DGSNR)/France • Christer Viktorsson, MSc/D/Office for Reactor Safety and DD General/Swedish Nuclear Power Inspectorate/Sweden • Michael Weightman, HM Deputy Chief/Inspector of Nuclear Installations/ Health & Safety Directorate/UKNII/United Kingdom ***Theme: "Approaches and Challenges in Communication"***	**Session Coordinator:** Michael C. Cullingford MCC@nrc.gov 301-415-1276
WEDNESDAY RECESS 5:15 pm		

RIC 2004

PROGRAM AND SCHEDULE

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"Promoting Openness Through Effective Communication"

Updated: March 9, 2004 (10:33AM)

Session No.	Session Information	Contact Information
Thursday, March 11, 2004		
BREAKOUT SESSIONS (Set of five concurrent sessions) 8:00 - 9:30 am		
T1	**Safeguards / Security** **8:00 - 9:30 am** **Location: Presidential Ballroom** **Panel Chair:** William F. Kane Deputy Executive Director for Homeland Protection and Preparedness/OEDO/NRC **Panel Co-Chair:** Roy P. Zimmerman D/Office of Nuclear Security and Incident Response (NSIR)/NRC **Panelists:** • Glenn M. Tracy, D/Division of Nuclear Security/NSIR/NRC • Danielle Brian, Executive Director/Project on Government Oversight • David A. Christian, CNO/Dominion • Thomas Lockwood, Homeland Security Advisor/Office of Governor/State of Maryland • Paul Nicholas, Acting Senior Director for Critical Infrastructure Protection/ Homeland Security Council ***Theme: "Perspective on Security Initiatives - Past, Present, & Future"***	**Session Coordinator:** Travis L. Tate TLT@nrc.gov 301-415-8474
T2	**Communications** **8:00 - 9:30 am** **Location: Congressional/Senate Rooms** **Panel Chair:** James E. Dyer D/NRR/NRC **Panelists:** • R. Jan Strasma, Public Affairs Officer/Region III (RIII)/NRC • David Lochbaum, Nuclear Safety Engineer/Union of Concerned Scientists • J. Scott Peterson, VP Communications/NEI • Cecil Settles, Section Head/Nuclear Facility Inspection Section/Illinois Emergency Management Agency ***Theme: "Communicating the Proper Safety Perspective"***	**Session Coordinator:** Eric J. Benner EJB1@nrc.gov 301-415-1171

Session No.	Session Information	Contact Information
Thursday, March 11, 2004		
T3	**Risk Informed Activities** **8:00 - 9:30 am** **Location: Federal A/B Rooms** **Panel Chair:** Michael R. Johnson DD/DSSA/NRR/NRC **Panelists:** • Patrick W. Baranowsky, C/Operating Experience and Risk Assessment Branch/Division of Risk Analysis and Applications (DRAA)/Office of Nuclear Reactor Research (RES)/NRC • Michael D. Tschiltz, C/Probabilistic Safety Branch/DSSA/NRR/NRC • Michael Knapik, Chief Editor/McGraw-Hill's *Inside NRC* • Biff Bradley, Senior PM/NEI • Douglas True, VP/Safety and Reliability/ERIN Engineering ***Theme: "A Phased Approach to Improving PRA Quality"*** **Subtopics:** • Risk Communication	**Session Coordinator:** Stewart L. Magruder, Jr. SLM1@nrc.gov 301-415-3139
T4	**Operating Experience** **8:00 - 9:30 am** **Location: South American A/B Rooms** **Panel Chair:** Bruce A. Boger D/DIPM/NRR/NRC **Panelists:** • Charles Ader, D/DRAA/RES/NRC • Terry Reis, C/Reactor Operating Experience/DIPM/NRR/NRC • Javier Reig, Head/Nuclear Safety Division/OECD Nuclear Energy Agency • Jerry Roberts, D/Nuclear Safety Assurance/Entergy ***Theme: "Communicating Operating Experience"***	**Session Coordinator:** I. Jerry Dozier JXD@nrc.gov 301-415-1014
T5	**Safety Conscious Work Environment** **8:00 - 9:30 am** **Location: Pan American Room** **Panel Chair:** David B. Matthews D/DRIP/NRR/NRC **Panel Co-Chair:** Frank J. Congel D/Office of Enforcement (OE)/NRC **Panelists:** • Nicholas D. Hilton, Senior Enforcement Specialist/OE/NRC • Lisamarie L. Jarriel, Agency Allegations Advisor/OE/NRC • Chuck Dugger, VP/Nuclear Operations/NEI • Christer Viktorsson, MSc/D/Office for Reactor Safety and DD General/Swedish Nuclear Power Inspectorate/Sweden	**Session Coordinator:** Sally A. Adams SAA2@nrc.gov 301-415-0209
BREAK 9:30 - 10:00 am		
T6	**Plenary Session: TMI** **Location: Presidential Ballroom** **10:00 - 11:00 am** **Panel Chair:** William D. Travers EDO/NRC **Panelists:** • Nils J. Diaz, NRC Chairman • Harold Denton, Nuclear Safety Consultant • Oliver D. Kingsley, Jr., President and Chief Operating Officer/Exelon Corporation • The Honorable Richard Thornburgh, Former Attorney General	**Session Coordinator:** John R. Jolicoeur JRJ1@nrc.gov 301-415-1724
T7	**Plenary Session: Presentation / Q&A Session** **Location: Presidential Ballroom** **11:00 am - 12:00 pm** ***NRC Commissioner Edward McGaffigan, Jr.***	

Session No.	Session Information	Contact Information
	Thursday, March 11, 2004	
	BREAK 12:00 - 12:15 pm	
T8	**NEI Luncheon** **Location: Congressional/Senate Rooms** **12:15 - 1:15 pm** **Guest Speaker:** ***Mark Shields*** ***CNN Columnist and Commentator***	
	BREAK 1:15 - 1:45 pm	
T9	**Plenary Session: Presentation / Q&A Session** **Location: Presidential Ballroom** **1:45 - 2:45 pm** ***NRC Commissioner Jeffrey S. Merrifield***	
	BREAK 2:45 - 3:15 pm	
	BREAKOUT SESSIONS (Set of five concurrent sessions) 3:15 - 4:45 pm	
T10	**Communications & Emergency Preparedness** **3:15 - 4:45 pm** **Location: Presidential Ballroom** **Panel Chair:** John W. Craig Associate Director for Inspection and Programs (ADIP)/ NRR/NRC **Panelists:** • Susan M. Frant, DD/Division of Incident Response/NSIR/NRC • Michael S. Beeman, Chief of External Affairs/Federal Emergency Management Agency/Region II • Mark S. Lemke, Emergency Planning (EP) Manager/Diablo Canyon Power Plant • William F. Renz, D/Nuclear Protection Services & EP/Dominion Generation • Michael C. Sinclair, Radiological EP Coordinator/Illinois Emergency Management Agency • Walter E. Wright, D/Linn County Emergency Management/Linn Country Iowa ***Theme: "Communication and Emergency Preparedness"***	**Facilitator:** Francis X. "Chip" Cameron FXC@nrc.gov 301-415-1642 **Session Coordinator:** Robert E. Moody REM2@nrc.gov 301-415-1737
T11	**Emergent Technical Topics** **3:15 - 4:45 pm** **Location: Congressional/Senate Rooms** **Panel Chair:** Brian W. Sheron Associate Director for Project Licensing and Technical Analysis (ADPT)/ NRR/NRC **Panelists:** • Wayne D. Lanning, D/DRS/RI/NRC • Christopher Crane, President & Chief Nuclear Officer (CNO)/Exelon Nuclear • Thomas J. Jordan, VP/Engineering and Technical Services/ South Texas Project (STP) Nuclear Operating Company • Alexander Marion, Senior Director/Engineering/NEI **Subtopics:** • Materials Degradation Issues • Emergency Core Cooling Sump Issues	**Session Coordinators:** Tanya M. Mensah TME@nrc.gov 301-415-3610 Stacey L. Rosenberg SLR1@nrc.gov 301-415-1733

Session No.	Session Information	Contact Information
Thursday, March 11, 2004		
T12	**License Renewal** **3:15 - 4:45 pm** **Location: Federal A/B Rooms** **Panel Chair:** Frank P. Gillespie DD/DRIP/NRR/NRC **Panel Co-Chair:** C. Randy Hutchinson, Senior VP Business Development/NEI License Renewal Working Group Chairman/Entergy Nuclear **Panelists:** • P. T. Kuo, PD/License Renewal and Environmental Impacts (RLEP)/DRIP/NRR/NRC • K. Steven West, Section Chief/RLEP Section B/DRIP/NRR/NRC • Frederick W. Polaski, License Renewal Manager/Exelon Nuclear • Garry G. Young, Manager/License Renewal Services/Entergy Nuclear	**Session Coordinator:** Stephen T. Hoffman STH@nrc.gov 301-415-3245
T13	**Spent Fuel / Transportation / Disposal** **3:15 - 4:45 pm** **Location: South American A Room** **NRR Sponsor:** Christopher I. Grimes DD/Division of Engineering/ NRR/NRC **Panel Chair:** C. William Reamer DD/Division of Waste Management Office of Nuclear Material Safety and Safeguards (NMSS)/NRC **Panelists:** • Martin J. Virgilio, D/NMSS/NRC • Margaret S.Y. Chu, D/Office of Civilian Radioactive Waste Management/DOE • Louis B. Long, VP Technical Support/Southern Nuclear Operating Company & Chair/NEI Spent Nuclear Fuel Working Group • Martin G. Malsch, Esq., Partner/Egan, Fitzpatrick, Malsch & Cynkar, PLLC ***Theme: "Programmatic Aspects of Spent Fuel Transportation and Disposal"*** **Subtopics:** • Yucca Mountain, importance of the project to the industry, importance of industry experience to the project • Status of NRC's Regulatory Program for a potential geologic repository	**Session Coordinator:** Latif S. Hamdan LSH@nrc.gov 301-415-6639

Session No.	Session Information	Contact Information
Thursday, March 11, 2004		
T14	**Fire Protection** **3:15 - 4:45 pm** **Location: South American B Room** **Panel Chair:** Suzanne C. Black D/DSSA/NRR/NRC **Panelists:** • Dwight D. Chamberlain, D/DRS/RIV/NRC • J. S. Hyslop, Senior Risk and Reliability Engineer/Probabilistic Risk Analysis Branch/DRAA/RES/NRC • Alexander R. Klein, Sr. Fire Protection Engineer/Plant Systems Branch/ DSSA/NRR/NRC • Joseph P. Grimes, D/Engineering/Exelon Nuclear • Dennis W. Henneke, Sr. PRA Engineer/Duke Power Company and Chairman, American Nuclear Society/Fire PRA Standard Writing Group ***Theme: "Cooperative Effort Amongst All Stakeholders"*** **Subtopics:** • Fire Protection Communication • Research Interactions • Regional Fire Protection Interface • ANS Fire PRA Standard	**Session Coordinator:** Alexander R. Klein ARK1@nrc.gov 301-415-3477
THURSDAY RECESS 4:45 pm		

RIC 2004

PROGRAM AND SCHEDULE

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"Promoting Openness Through Effective Communication"

Updated: March 9, 2004 (10:33AM)

Session No.	Session Information	Contact Information
Friday, March 12, 2004		
BREAKOUT SESSIONS (Set of four concurrent sessions) 8:00 - 10:00 am		
F1	**Region III Breakout** **8:00 - 10:00 am** **Location: Presidential Ballroom** **Panel Chair:** James L. Caldwell RA/RIII/NRC **Panelists:** • Brian W. Sheron, ADPT/NRR/NRC • John Paul Cowan, Executive VP & CNO/Nuclear Management Company	**Session Coordinator:** Michael E. Parker MEP@nrc.gov 630-829-9679
F2	**Region IV Breakout** **8:00 - 10:00 am** **Location: Congressional/Senate Rooms** **Panel Chair:** Bruce S. Mallett RA/RIV/NRC **Panelists:** • R. William Borchardt, DD/NRR/NRC • James J. Sheppard, President and Chief Executive Officer/STP Nuclear Operating Company	**Session Coordinator:** William B. Jones WBJ@nrc.gov 817-860-8147
F3	**Region I Breakout** **8:00 - 10:00 am** **Location: Federal A/B Rooms** **Panel Chair:** Hubert J. Miller RA/RI/NRC **Panelists:** • James E. Dyer, D/NRR/NRC • Bill Levis, VP/Mid Atlantic Operations/Exelon Nuclear	**Session Coordinator:** Christopher G. Cahill CGC@nrc.gov 610-337-5108 **Co-Session Coordinator:** David M. Kern DMK@nrc.gov 717-948-1165
F4	**Region II Breakout** **8:00 - 10:00 am** **Location: South American A/B Rooms** **Panel Chair:** Luis A. Reyes RA/Region II (RII)/NRC **Panelists:** • John W. Craig, ADIP/NRR/NRC • Ashok Bhatnagar, Site VP/Browns Ferry Nuclear Power Plant	**Session Coordinator:** Joel T. Munday JTM@nrc.gov 404-562-4560
BREAK 10:00 - 10:30 am		

Session No.	Session Information	Contact Information
Friday, March 12, 2004		
F5	**Plenary Session: Inter-Regional** **10:30 - 11:15 am** **Location: Presidential Ballroom** **Panel Chair:** James E. Dyer D/NRR/NRC **Panelists:** • Hubert J. Miller, RA/RI/NRC • Luis A. Reyes, RA/RII/NRC • James L. Caldwell, RA/RIII/NRC • Bruce S. Mallett, RA/RIV/NRC	**Session Coordinator:** Eric J. Benner EJB1@nrc.gov 301-415-1171
F6	**Plenary Session: Session Feedback and Conference Closing** **Location: Presidential Ballroom** **11:15 - 11:45 am**	
CONFERENCE RECESS		