UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
ENTERGY NUCLEAR OPERATIONS, INC.	)	Docket Nos. 50-247-LR/286-LR
	)	
(Indian Point Nuclear Generating	)	
Units 2 and 3)	)	

NRC STAFF'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW PART 9: CONTENTION RK-TC-2 (FLOW ACCELERATED CORROSION)

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March 22, 2013

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I. INTRODUCTION

9.1 In accordance with 10 C.F.R. § 2.1209 and the Atomic Safety and Licensing Board's scheduling Orders,[1] the NRC Staff ("Staff") hereby submits its proposed findings of fact and conclusions of law ("Proposed Findings" or "PFF") for Part 9: Contention RK-TC-2 (Flow Accelerated Corrosion).

9.2 The Staff's Proposed Findings are set forth in ten separate filings, as follows:

Part 1: Overview and Regulatory Standards;
Part 2: Contention NYS-5 (Buried Piping and Tanks);
Part 3: Contention NYS-6/7(Non-EQ Inaccessible Medium and Low Voltage Cables);
Part 4: Contention NYS-8 (Transformers);
Part 5: Contention 12C (Severe Accident Mitigation Alternatives ("SAMA") Analysis Decontamination and Cleanup Costs);
Part 6: Contention NYS-16B (SAMA Analysis Population Estimates);
Part 7: Contention NYS-17B (Real Estate Values);

[1] *See* (1) Scheduling Order (July 1, 2010), at 19; (2) Order (Scheduling Post-Hearing Matters and Ruling on Motions to File Additional Exhibits) (Jan. 15, 2013) at 1; and (3) Order (Granting Parties Joint Motion for Alteration of Filing Schedule (Feb. 28, 2013).

Part 8: Contention NYS-37 (No-Action Alternative);
Part 9: Contention RK-TC-2 (Flow Accelerated Corrosion); and
Part 10: Contention CW-EC-3A (Environmental Justice).[2]

In Part 9 of the Staff's Proposed Findings, set forth below, the Staff addresses the issues raised in Contention RK-TC-2 (Flow Accelerated Corrosion). For the reasons set forth herein, the Staff submits that Contention RK-TC-2 should be resolved in favor of license renewal for Indian Point Nuclear Generating Units 2 and 3.

II. BACKGROUND

9.3 This proceeding concerns the license renewal application ("LRA") for Indian Point Nuclear Generating Units 2 and 3 ("IP2" and "IP3" or "Indian Point"), which was submitted by Entergy Nuclear Operations Inc. ("Entergy" or "Applicant") on April 23, 2007, on behalf of itself, Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC.[3]

9.4 On May 11, 2007, the NRC published a notice of receipt of the Indian Point LRA,[4] and on August 1, 2007, the NRC published a notice of acceptance for docketing and notice of opportunity for hearing on the LRA.[5] On October 18, 2007, an Atomic Safety and Licensing Board ("Board") was established to rule on petitions for leave to intervene and hearing requests,

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[2] The Staff utilized a unique number designator for each separate Part of the Proposed Findings, whereby all paragraphs in Part 1 are consecutively numbered "1.__"; all paragraphs in Part 2 are consecutively numbered "2.__", etc. Accordingly, all paragraph numbers in this Part commence with the number 9.1.

[3] *See* NUREG-1930, Vols. 1-2, "Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3" (Nov. 2009) ("SER") (Ex. NYS000326A), at 1-2.

[4] "Entergy Nuclear Operations, Inc.; Notice of Receipt and Availability of Application for Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3; Facility Operating License Nos. DPR-26 and DPR-64 for an Additional 20-Year Period," 72 Fed. Reg. 26,850 (May 11, 2007).

[5] "Entergy Nuclear Operations, Inc., Indian Point Nuclear Generating Unit Nos. 2 and 3; Notice of Acceptance for Docketing of the Application and Notice of Opportunity for Hearing Regarding Renewal of Facility Operating License Nos. DPR-26 and DPR-64 for an Additional 20-Year Period," 72 Fed. Reg. 42,134 (Aug. 1, 2007).

and to preside over any proceeding that may be held.[6] Petitions for leave to intervene were then timely filed by various petitioners, including Riverkeeper, Inc. ("Riverkeeper").[7]

9.5 On July 31, 2008, the Board granted, inter alia, Riverkeeper's petition to intervene and admitted many of their contentions concerning the LRA or the Environmental Report ("ER") incorporated therein.[8]

9.6 Contention RK-TC-2 is a safety contention that deals with flow accelerated corrosion ("FAC") in the plant piping. The proffered contention was:

> Entergy's program for management of Flow Accelerated Corrosion (FAC) — an aging phenomenon with significant safety implications—fails to comply with 10 C.F.R. § 54.21(a)(3)'s requirement that: ''For each structure and component identified in paragraph (a)(1) of this section, demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation." Entergy also fails to follow the guidance of NUREG-1800, which requires that an aging management program, including a FAC program for life extension, must address each of the following (1) Scope (2) Preventative actions (3) Parameters monitored or inspected (4) Detection of aging effects (5) Trending (6) Acceptance criteria (7) Corrective actions (8) Confirmation processes (9) Administrative processes (10) Operating experience. NUREG-1800, §A.1.2.3.
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> Entergy's program for management of FAC is deficient because it has not demonstrated that components in the Indian Point nuclear power plant that are within the scope of the license renewal rule are vulnerable to FAC will be adequately inspected and maintained during the license renewal term. In particular, Entergy's program for management of FAC is deficient because it relies on the computer code CHECWORKS, without sufficient

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[6] "Establishment of Atomic Safety and Licensing Board," 72 Fed. Reg. 60,394 (Oct. 24, 2007).

[7] *See* Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in the License Renewal Proceeding for the Indian Point Nuclear Power Plant ("Riverkeeper Petition") filed November 30, 2007 at 15-23. The contention is supported by Riverkeeper's expert Dr. Joram Hopenfeld. *See id*. at 16 & Declaration of Dr. Joram Hopenfeld ("Hopenfeld Declaration") in support of Riverkeeper's Contentions TC-1 and TC-2 (November 28, 2007).

[8] *See Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), LBP-08-13, 68 NRC 43 (2008).

> benchmarking of the IP operating parameters. In addition, Entergy's license renewal application fails to specify the method and frequency of component inspections or criteria for component repair or replacement.[9]

9.7 As supported by its expert witness, Dr. Joram Hopenfeld, Riverkeeper contended that CHECWORKS™ can only be reliably used to predict pipe wall thinning if (1) all relevant locations are benchmarked for relevant plant parameters; (2) relevant plant parameters do not change significantly over time; and (3) benchmark data on relevant plant parameters are collected for a sufficiently long period of time. Riverkeeper Petition at 20.

9.8 Entergy opposed admission of this contention, arguing that Riverkeeper TC-2 is inadmissible because it raises issues outside the scope of a license renewal proceeding, lacks sufficient factual or expert support, and fails to establish a genuine dispute with the Applicant, and therefore fails to meet the contention admissibility requirements of 10 C.F.R. § 2.309(f)(1)(iii), (iv), and (vi).[10] According to Entergy, its FAC program is fully consistent with both 10 C.F.R. § 54.21 and the GALL Report, which recommends the use of predictive codes such as CHECWORKS™.[11] Entergy argued that ''[t]he NRC has stated explicitly that '[a]n applicant may reference the GALL Report in a license renewal application to demonstrate that the programs at the applicant's facility correspond to those reviewed and approved in the GALL Report and that no further staff review is required.'"[12] Entergy argued that its AMP met the ten

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[9] Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene in the License Renewal Proceeding for the Indian Point Nuclear Power Plant (Nov. 30, 2007) ("Riverkeeper Petition") at 15-16.

[10] Answer of Entergy Nuclear Operations, Inc. Opposing Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene (Jan. 22, 2008) ("Entergy Riverkeeper Answer") at 44-45.

[11] *Id.* at 46.

[12] *Id.* 46 (citing GALL Report, Vol. 2, at iii).

elements of GALL because the full ten-element program described in the GALL is incorporated by references into the LRA.[13]

9.9 Entergy argued that a challenge to the adequacy of CHECWORKS™ is outside the scope of the license renewal proceeding.[14] Furthermore, CHECWORKS™ had been used since the power uprates, thus at least six years of benchmarking will occur before the period of extended operations.[15]

9.10 The NRC Staff argued that the contention was vague and was not adequately supported.[16]

9.11 The Board, admitted two elements of RK-TC-2 on July 31, 2008, and summarized the contention as 1) Entergy's AMP for components affected by FAC is deficient because it does not provide sufficient details to demonstrate that the intended functions of the applicable components will be maintained during the extended period of operation; and (2) Entergy's program relies on the results from CHECWORKS™ without benchmarking or a track record of performance at Indian Point Energy Center's ("IPEC's") power uprate levels. *Entergy Nuclear Operations, Inc.* (Indian Point, Units 2 and 3), LBP-08-13, 68 NRC 43, 177 (2008). The Board did not view the contention as a challenge to the use of CHECWORKS™ model, but instead, in the Board's view, the contention "questions the sufficiency of the benchmarking needed to provide valid results at IPEC once the plant parameters changed with the 3.26% and 4.85% power uprates during 2004 and 2005." LPB-08-13, 68 NRC 43, 176-177 (2008).

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[13] *Id.* at 47-48 (citing LRA, Appendix B, § B.0.1).

[14] *Id*. at 48-49.

[15] *Id.* at 60.

[16] NRC Staff's Response to Petitions for Leave to Intervene Filed by (1) Connecticut Attorney General Richard Blumenthal, (2) Connecticut Residents Opposed to Relicensing of Indian Point, and Nancy Burton, (3) Hudson River Sloop Clearwater, Inc., (4) the State of New York, (5) Riverkeeper, Inc., (6) the Town of Cortland, and (7) Westchester County at 26 (Jan. 22, 2008) ("NRC Staff Answer") at 119.

9.12 On July 26, 2010, Entergy filed a motion for summary disposition of Contention 4.[17] Entergy stated that the program is implemented via Entergy's fleet-wide procedure EN-DC-315, Rev. 3, "Flow Accelerated Corrosion Program" (March 1, 2010).[18] Under that program, component selection parameters include (1) actual pipe wall thickness measurements from past outages; (2) predictive evaluations performed using the CHECWORKS™ code; (3) industry experience related to FAC; (4) results from other plant inspection programs; and (5) engineering judgment.[19]

9.13 Entergy described how the Staff uses the NUREG-1800, "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants" ("SRP-LR") and NUREG-1801, "Generic Aging Lessons Learned (GALL) Report," ("GALL Report") to review an LRA, and noted in particular that the Commission stated that using the aging management programs ("AMPS") in the GALL Report provides reasonable assurance that the licensee will manage the aging effects during the period of extended operation ("PEO").[20] Entergy described how the IPEC FAC Program satisfies all ten program elements identified in the SRP-LR and GALL Report, and the LRA included the information required by 10 C.F.R. 54.21(d).[21] Entergy argued that its AMP complied with 10 C.F.R. Part 54 because its FAC Program contains, with the requisite specificity, each of the ten factors found in the NRC's Generic Aging Lessons Learned (GALL) Report U.S. Nuclear Regulatory Commission, Generic Aging Lessons Learned

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[17] *See* Applicant's Motion for Summary Disposition of Riverkeeper Technical Contention 2 (Flow-Accelerated Corrosion) (July 26, 2010) ("Applicant MSD"), attaching, *inter alia*, (1) Statement of Material Facts (July 26, 201), and (2) Joint Declaration of Jeffrey Horowitz, Ian Mew, and Alan Cox in Support of Entergy's Motion for Summary Disposition of Riverkeeper Contention TC-2 (Flow-Accelerated Corrosion) (July 26, 2010) (ADAMS Accession No ML102140430).

[18] Applicant MSD at 9.

[19] *Id.* at 10.

[20] *See id.* at 6.

[21] *Id.* at 8.

(GALL) Report, NUREG-1801, Rev. 1, Vol. 2, Tabulation of Results (Sept. 2005).[22] Entergy argued that the NRC Staff's Final Safety Evaluation Report (NUREG-1930, Vol. 2 (Nov. 2009)) confirmed this assertion.[23]

9.14 Entergy also argued that CHECWORKS™ was just one aspect of its FAC program, and that other tools and practices were sufficient to FAC.[24]

9.15 Entergy argued that the CHECWORKS model now included data sets from several post-uprate outages which showed good correlation between the model and the measured wear values.[25] Thus CHECWORKS™ has been sufficiently calibrated at the higher powers.[26]

9.16 Entergy pointed out that after an evidentiary hearing on an identical contention, the *Vermont* Yankee Licensing Board concluded that Entergy's company-wide plan was sufficient.[27]

9.17 The NRC Staff filed an answer with affidavit supporting Entergy's motion.[28] The Staff reviewed Entergy's motion, and did not identify that any genuine issues of material fact exist with respect to TC-2, thus the Staff believed that Entergy was entitled to judgment as a

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[22] *Id.* at 15-16.

[23] *Id.*

[24] *Id.* at 17-19.

[25] *Id.* at 13.

[26] *Id.* at 19.

[27] *Id.* at 16-17 (citing inter alia Entergy Nuclear Vermont Yankee, LLC, & Entergy Nuclear Operations, Inc. (Vermont Yankee Nuclear Power Station), LBP-08-25, 68 NRC 763, 860, 864-93 (2008), rev'd and remanded on other grounds, CLI-10-17, 72 NRC __,__ (slip op.) (July 8, 2010)).

[28] *See* NRC Staff's Answer to Applicant's Motion for Summary Disposition of Riverkeeper Technical Contention 2 (Flow-Accelerated Corrosion) (Aug. 16, 2010) ("NRC Staff Answer") with Affidavit of Kimberly J. Greene and Matthew G. Yoder (Aug. 16, 2012).

matter of law.[29] Thus, the Staff asserted that Entergy's motion should be granted and RK-TC-2 dismissed.[30]

9.18 Riverkeeper filed an answer opposing Entergy's motion.[31] Riverkeeper asserted that genuine material facts remained in dispute concerning (1) Entergy's reliance on CHECWORKS™, and (2) the sufficiency of the FAC Program at Indian Point.[32]

9.19 The Board ruled against summary disposition, noting that, unlike the Board in *Vermont Yankee,* the Indian Point Board had not completed a hearing, and thusly could not weigh the evidence.[33] The Board concluded that

> Declaration of Dr. Joram Hopenfeld demonstrates that there are genuine issues of material fact relating to whether (1) Entergy's AMP for components affected by FAC is deficient because it does not provide sufficient details to demonstrate that the intended functions of the applicable components will be maintained during the extended period of operation; and (2) Entergy's program relies on the results from CHECWORKS without adequate benchmarking or a track record of performance at IPEC's power uprate levels.[34]

9.20 On August 3, 2010, Riverkeeper filed a motion to compel Entergy to disclose "certain documentation related to the implementation of the CHECWORKS™ computer code at

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[29] *Id.* at 8-9.

[30] *Id.* at 9.

[31] Riverkeeper Opposition to Entergy's Motion for Summary Disposition of Riverkeeper Technical Contention 2 (Flow-Accelerated Corrosion) (Aug. 16, 2010) ("Riverkeeper Opposition") attaching, *inter alia*, (1) Counter-Statement of Material Facts (Aug. 16, 2010) and (2) Declaration of Dr. Joram Hopenfeld (Aug. 16, 2010).

[32] *See id.* at 4, 16.

[33] Memorandum and Order (Ruling on Entergy's Motion for Summary Disposition of Riverkeeper TC-2 (Flow-Accelerated Corrosion)) at 8 (Nov. 4, 2010) (unpublished) (ADAMS Accession No. ML103080994).

[34] *Id.*

Indian Point."[35] Riverkeeper sought in disclosure of "disclose any and all documentation related to the implementation of the CHECWORKS™ computer code heretofore undisclosed, in particular, any and all reports for Unit 3 prior to 2001."[36]

9.21 Entergy opposed, arguing, *inter alia*, that through the motion "Riverkeeper is seeking to impermissibly expand the scope of TC-2."[37]

9.22 The Board denied this motion, ruling:

> Riverkeeper Contention TC-2 questions the sufficiency of Entergy's Aging Management Plan (AMP) addressing the effects of FAC which, according to Riverkeeper, relies on the results from CHECWORKS without the benchmarking or track record of performance at Indian Point Energy Center's (IPEC) power uprate levels. However, the data generated during seven post-power uprate outages at Indian Point is already available to assess the ability of CHECWORKS to account for changed plant conditions.[38]

9.23 The Board also expressed its view that "it would be unreasonably burdensome to require Entergy to search for and produce this data which could not, in the Board's view, impact our decision on the merits of this contention."[39]

9.24 On December 22, 2011, Riverkeeper submitted its Riverkeeper Initial Statement of Position Regarding Contention RK-TC-2 (Flow Accelerated Corrosion) (Dec. 22, 2011) (Ex. RIV000002), along with Prefiled Direct Testimony of Dr. Joram Hopenfeld (Ex. RIV000003) and exhibits (Ex. RIV000004 to RIV000033).

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[35] Riverkeeper, Inc. Motion to Compel Disclosure of Documents Relevant to Riverkeeper Contention TC-2 (Aug. 3, 2010) at 1.

[36] *Id.* at 6.

[37] Entergy's Answer to Riverkeeper, Inc.'s Motion to Compel Disclosure of Documents, (Aug. 13, 2010) at 9.

[38] Order (Ruling on Riverkeeper's Motion to Compel) (Nov. 4, 2010) (unpublished) (ADAMS Accession No. ML103080978) (footnotes omitted).

[39] *Id.* at 5.

9.25 On March 28, 2012, Entergy Nuclear Operations, Inc.'s ("Entergy") submitted its Statement of Position Regarding Contention RK-TC-2 (Flow-Accelerated Corrosion) (Ex. ENT000028), along with the Testimony of Entergy Witnesses Ian D. Mew, Alan B. Cox, Nelson F. Azevedo, Jeffrey S. Horowitz, and Robert M. Aleksick Regarding Contention RK-TC-2 (Flow-Accelerated Corrosion) (Ex. ENT000029) as revised on October 12, 2012 (Ex. ENTR00029) ("Entergy Testimony on RK-TC-2"), and exhibits (Ex. ENT00015A-B, ENT000030 to ENT000089).

9.26 On March 31, 2012, the U.S. Nuclear Regulatory submitted its Commission ("NRC") Staffs Statement of Position Regarding RK-TC-2 (Ex. NRC000120), NRC Staff Testimony of Matthew G. Yoder and Allen L. Hiser, Jr. Concerning Riverkeeper Technical Contention RK-TC-2 Flow Accelerated Corrosion (Ex. NRC000121) as revised October 17, 2012 (Ex. NRCR00121), along with exhibits (Ex. NRC000122 to NRC000131).

9.27 On June 29, 2012, Riverkeeper submitted its Riverkeeper Revised Statement of Position Regarding Contention RK-TC-2 (Flow Accelerated Corrosion) (June 29, 2012) (Ex. RIV000107), along with its Prefiled Rebuttal Testimony of Dr. Joram Hopenfeld Regarding Riverkeeper Contention TC-2 -- Flow Accelerated Corrosion (June 29, 2012) and additional exhibits (Ex. RIV000109 to RIV000113).

9.28 An evidentiary hearing on Contention RK-TC-2 was held in Tarrytown, New York, on October 15 through 17, 2012. Witnesses appeared on behalf of Entergy, the Staff, and Riverkeeper with regard to Contention RK-TC-2 as summarized below.

9.29 These proposed findings of fact and conclusions of law present the Board's findings with respect to the evidence presented at the October 15 through 17 hearing concerning Contention RK-TC-2, and the Board's conclusions of law with respect thereto.

III. FINDINGS OF FACT

A. General Legal and Regulatory Requirements[40]

1. Scope of License Renewal Proceeding

9.30 The scope of the license renewal process is limited.[41] The safety review—and any associated license renewal adjudicatory proceeding—focuses on the detrimental effects of aging posed by long-term reactor operation.[42] Applicants must demonstrate "reasonable assurance" that "the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the current licensing basis ("CLB") for the period of extended operation."[43]

2. License Renewal Regulatory Requirements

9.31 Sections 54.21 and 54.29 of 10 C.F.R. Part 54 set forth the standards governing renewal of a plant's operating license.

9.32 Pursuant to 10 C.F.R. § 54.21(a), Entergy is required to demonstrate that its programs will be effective in managing the effects of aging associated with FAC on susceptible components during the period of extended operation so that the intended functions will be maintained consistent with the CLB.

9.33 Pursuant to 10 C.F.R. § 54.29, a renewed license may not be issued unless actions have been identified and have been or will be taken with respect to the effects of aging associated with FAC such that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the CLB.

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[40] The discussions in this section are set forth in greater detail in the "NRC Staff's Proposed Findings Of Fact And Conclusions Of Law Part 1: Overview And Regulatory Standards" which the Staff is filing separately and incorporating herein.

[41] *Nextera Energy Seabrook, LLC* (Seabrook Station, Unit 1), CLI-12-05, 75 NRC __ (March 8, 2012) (slip op. at 2) (*citing N.J. Envtl. Fed'n v. NRC*, 645 F.3d 220, 224 (3d Cir. 2011)).

[42] *Id.*

[43] *Id.* at 3.

3. Burden of Proof

9.34 Generally, an applicant has the burden of proof in a licensing proceeding. *See* 10 C.F.R. § 2.325. The burden of proof on the question of whether the LRA should be issued is upon the applicant.[44] But the challenger has the *burden of going forward* with evidence to buttress its contention, and if the challenger introduced sufficient evidence to establish a *prima facie* case, then the burden shifts to the applicant to provide sufficient rebuttal to satisfy the Board that it should reject the contention as a basis for denial of the permit or license.[45]

B. Specific Legal Standards and Issues

9.35 Contention RK-TC-2 is an aging management program (AMP) contention. Specifically, it alleges that Entergy's application does not include an adequate AMP for plant piping subject to FAC during the PEO because (1) the LRA does not provide sufficient details of the FAC AMP to demonstrate that the intended functions of the applicable components will be maintained during the extended period of operation and (2) the FAC AMP relies on the results from CHECWORKS™ without benchmarking or a track record of performance at IPEC's power uprate levels. *Entergy Nuclear Operations, Inc.* (Indian Point, Units 2 and 3), LBP-08-13, 68 NRC 43, 177 (2008); *see* also Riverkeeper Initial Statement of Position Regarding Contention RK-TC-2 (Flow Accelerated Corrosion) (Dec. 22, 2011) (Ex. RIV000002) at 2; Riverkeeper Revised Statement of Position Regarding Contention RK-TC-2 (Flow Accelerated Corrosion) (June 29, 2012) (Ex. RIV000107) at 35. As discussed in the Staff's separtely-filed findings Part 1, "Overview and Regulatory Standards," 10 C.F.R. §§ 54.21(a)(3) and 54.29(a) provide the applicable legal standards for the approval of Indian Point's AMP for plant piping due to FAC.

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[44] *See* AmerGen *Energy Co. LLC (*License Renewal for Oyster Creek Generating Station), CLI-09-7, 69 NRC 235, 263.

269 (2009), aff'd *sub nom. N.J. Envtl. Fed'n v. NRC,* 645 F.3d 220 (3d Cir. 2011) (quoting *Consumers Power Co.* (Midland Plant, Units 1 & 2), ALAB-123, 6 AEC 331, 345 (1973).

[45] *Id.*

Pursuant to 10 C.F.R. § 54.21(a)(3) Entergy must establish an AMP that is adequate to provide reasonable assurance that the intended function of the piping subject to FAC will be maintained in accordance with the CLB for the PEO. Entergy must demonstrate that its AMP for piping subject to FAC is adequate, and that it satisfies the "reasonable assurance" standard by a preponderance of the evidence. *Commonwealth Edison Co.*(Zion Station, Units 1 and 2), ALAB-616, 12 NRC 419, 421 (1980)).

C. Evidence Adduced at Hearing

1. Witnesses Presented

9.36 During the evidentiary hearing on Contention RK-TC-2, a total of eight witnesses provided fact and/or opinion testimony on behalf of Entergy, the NRC Staff, and Riverkeeper. All of the witnesses were found to be qualified to present their testimony on the matters they addressed. As previously stated, written direct or rebuttal testimony was submitted for all of the parties' witnesses. All of the witnesses also provided oral testimony in response to questioning by the Board.

9.37 Entergy presented five witnesses in support of its LRA. They were (1) Ian D. Mew, a Senior Engineer in Programs and Components Engineering at IPEC; (2) Alan B. Cox the Technical Manager for License Renewal at Entergy; (3) Nelson F. Azevedo, the Supervisor of Code Programs at Indian Point Energy Center, (4) Dr. Jeffrey S. Horowitz, an independent consultant in the nuclear and mechanical engineering fields, who was the principal creator of the CHECWORKS™ computer code (and its predecessors CHEC and CHECMATE); and (5) Robert M. Aleksick the President and founder of CSI Technologies, Inc., which specializes in FAC services and software development, and has assisted IPEC and other Entergy sites with numerous FAC-related projects for over two decades.

9.38 Mr. Mew holds a Bachelor of Science degree in Mechanical Engineering from the Polytechnic Institute of New York. Entergy Testimony on RK-TC-2 (ex. ENTR00029) at 1. Mr. Mew has more than 30 years of experience in of experience in the nuclear power industry, and

for the past 16 years, has been involved in flow-accelerated corrosion and steam generator program development and inspections, including in-service inspection program development and inspection work throughout the nuclear power industry. *Id.* at 2. Mr. Mew is the FAC engineer for both IP2 and IP3. *Id.* at 2.

9.39 Mr. Cox holds a Bachelor of Science degree in Nuclear Engineering from the University of Oklahoma and a Masters of Business Administration (M.B.A.) from the University of Arkansas at Little Rock. Entergy Testimony on RK-TC-2 (ex. ENTR00029) at 4. Mr. Cox has more than 34 years of experience in the nuclear power industry, having served in various positions related to engineering and operations of nuclear power plants. *Id.* Mr. Cox has participated in the development of eight LRAs and in industry peer reviews of at least eleven additional LRAs. *Id.* As Technical Manager, he was directly involved in preparing the LRA and developing and reviewing Aging Management Program descriptions for IP2 and IP3, including the FAC Program. *Id.* at 5.

9.40 Mr. Azevedo holds a Bachelor of Science degree in Mechanical and Materials Engineering from the University of Connecticut and an M.S. in Mechanical Engineering from the Rensselaer Polytechnic Institute ("RPI") in Troy, New York, and has an M.B.A. from RPI. Entergy Testimony on RK-TC-2 (ex. ENTR00029) at 6. He has 30 years of professional experience in the nuclear power industry. *Id.* He has been responsible for, among other duties, developing the Northeast Utilities' FAC program for the Connecticut Yankee and Millstone Stations and implementing the FAC program for Connecticut Yankee in the early 1990s. *Id.* Presently, as Supervisor of Code Programs at IPEC, he has been responsible for FAC-related issues since January 2001. *Id.* at 7. As such, he has supervised the IPEC FAC Program, as well as refueling outage-related activities, including inspection location selection, field inspections, evaluation of inspection results, and any necessary repairs and/or replacements. *Id.*

9.41 Dr. Horowitz holds hold four degrees in Mechanical Engineering: a Bachelor of Science degree from Newark College of Engineering (now known as New Jersey Institute of Technology), and from the Massachusetts Institute of Technology, a Master of Science degree, a Mechanical Engineer degree and a Doctor of Science degree. Entergy Testimony on RK-TC-2 (ex. ENTR00029) at 8. Dr. Horowitz has over 40 years of professional experience in the field of nuclear energy, including 25 years specializing in FAC and nuclear safety analysis. *Id.* at 8. He was the co-developer of the computer program CHEC (Chexal-Horowitz Erosion Corrosion) and demonstrated and provided it to U.S. utilities in 1987. *Id.* at 9. He was responsible for the overall program design, the development of the predictive algorithm, and the implementation of routines to calculate the pH at temperature. *Id.* He remained the lead technical person in the development of new and revised CHEC-related codes and CHEC's successor computer programs, CHECMATE and CHECWORKS™. *Id.*

9.42 The NRC Staff presented two witnesses in support of its position on Contention RK-TC-2. They were: (1) Dr. Allen L. Hiser, Jr., Senior Technical Advisor for License Renewal Aging Management in the Division of License Renewal, Office of Nuclear Reactor Regulation, U.S. NRC, in Washington, D.C.; and (2) Mr. Matthew G. Yoder, Senior Chemical Engineer in the Steam Generator Tube Integrity and Chemical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation, NRC. Staff Testimony on RK-TC-2 (ex. NRCR00121) at 1.

9.43 Dr. Hiser received Bachelor of Science and Master of Science degrees in Mechanical Engineering from the University of Maryland at College Park, and received a Ph.D. in Materials Science and Engineering from Johns Hopkins University, Baltimore, MD. Staff Testimony on RK-TC-2 (ex. NRCR00121) at 1. He has more than 22 years of experience in the Office of Nuclear Regulatory Research and the Office of Nuclear Reactor Regulation, and his responsibilities include providing technical advice and assistance to the Division of License Renewal on a variety of technical, regulatory and policy issues related to aging management of

nuclear power plant systems, structures, and components. *Id.* at 2. Dr. Hiser was the Chief of the Steam Generator Tube Integrity and Chemical Engineering Branch in the Office of Nuclear Reactor Regulation when the Indian Point LRA was received. *Id.* at 3. His branch was responsible for review of several parts of the Indian Point LRA, including the portions of the LRA that dealt with aging management of FAC. *Id.* He provided leadership to the technical reviewers for the aging management programs related to Steam Generator Tube Integrity, Flow Accelerated Corrosion, Containment Protective Coatings, Steam Generator Blowdown System, Charging and Volume Control System, and Boraflex and Boral in the Spent Fuel Pool. *Id.* He reviewed and approved the associated requests for additional information and safety evaluation report input produced by his branch. *Id.* He also supported the Staff's briefing of the ACRS on the license renewal safety evaluation report. *Id.*

9.44 Mr. Yoder received a Bachelor of Science degree in Chemical Engineering from Florida State University. Staff Testimony on RK-TC-2 (ex. NRCR00121) at 1. As Senior Chemical Engineer in the Steam Generator Tube Integrity and Chemical Engineering Branch of the Division of Engineering, his responsibilities include the technical, safety, and regulatory compliance reviews of a variety of chemistry and chemical engineering topics, including flow accelerated corrosion programs for applicants for license renewal, as well as to how FAC is affected by power uprates. *Id.* at 2. The results of his reviews are documented in safety evaluations which represent the NRC's position. *Id.* During the NRC Staff's review of the LRA (Ex. ENT00015A and ENT00015B), Mr. Yoder served as a peer reviewer for the principal reviewer, and he performed an independent assessment of the application, reviewed and approved all requests for information from the licensee regarding FAC, and reviewed and approved the FAC sections of the Staff's SER (Ex. NYS00326A-F). *Id.* at 2, 3. Mr. Yoder also submitted an affidavit on behalf of the Staff in response to the Applicant's motion for summary disposition of Riverkeeper's Technical Contention RK-TC-2. *See* NRC Staff's Answer to

Applicant's Motion for Summary Disposition of Riverkeeper Technical Contention 2 (Flow-Accelerated Corrosion) (Aug. 16, 2010) (ADAMS Accession No. ML102290354).

9.45 Riverkeeper presented one witnesses in support of RK-TC-2: Dr. Joram Hopenfeld, a mechanical engineer with 45 years of experience, including 18 with the NRC. Hopenfeld Testimony on RK-TC-2 (ex. RIV00003) at 1. Dr. Hopenfeld has a Bachelor of Science and a Master of Science degree in engineering, and a Ph.D. in mechanical engineering, all from the University of California in Los Angeles. *Id.* . Dr. Hopenfeld reviewed the relevant sections of Entergy's LRA, all of the pleadings involving Riverkeeper Contention TC-2, and the relevant portions of NRC Staff's Safety Evaluation Report. *Id.* at 2, 3.

2. Relevant Staff Guidance

a. Standard Review Plan (SRP-LR) and GALL Report

9.46 The Commission has provided detailed regulatory guidance for license renewal applicants regarding the means by which they may demonstrate their compliance with the requirements in 10 C.F.R. Part 54. Principal among the guidance documents are:

(1) NUREG-1800, Rev. 1, "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants," (Sept. 2005) (Ex. NYS000195) ("SRP-LR, Rev. 1"),[46] and

(2) NUREG-1801, Rev. 1, "Generic Aging Lessons Learned (GALL) Report," (Sept. 2005) (Ex. NYS000146A-C) ("GALL Report, Rev. 1").[47]

b. GALL Report Guidance on Ten Program Elements of an AMP

9.47 Both revisions of NUREG-1801, GALL Report, Rev. 1 and Rev. 2, provide the following ten program elements as touchstones for the Staff's evaluation of the adequacy of aging management programs: (1) Scope of Program, (2) Preventive Actions, (3) Parameters Monitored/Inspected, (4), Detection of Aging Effects, (5) Monitoring and Trending, (6)

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[46] NUREG-1800 was updated during the course of the proceeding. *See* NUREG-1800, Rev. 2 (Dec. 2010) (Ex. NYS000161) ("SRP-LR, Rev. 2").

[47] NUREG-1801 was updated during the course of the proceeding. *See* NUREG-1801, Rev. 2, "Generic Aging Lessons Learned (GALL) Report" (Dec. 2010) ("GALL Report, Rev. 2") (Ex. NYS000147A-D).

Acceptance Criteria, (7) Corrective Actions, (8) Confirmation Process, (9) Administrative Controls, and (10) Operating Experience. NUREG-1801 Vol. 1, Rev. 1 (Ex. NYS000146A) at 2-3; NUREG-1801, Rev. 2 (Ex. NYS00147A) at 6.

9.48 Directly addressing the ten program elements with respect to FAC, the GALL Report, Rev. 1, provides AMP XI.M17 Flow-Accelerated Corrosion. GALL Report, Rev. 1 (Ex. NYS000146C) at XI M-61 to XI M63. The AMP for FAC in GALL Report, Rev. 1, relies on implementation of the Electric Power Research Institute (EPRI) guidelines in the Nuclear Safety Analysis Center (NSAC)-202L-R2 for an effective FAC Program. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-61. The program includes performing (a) an analysis to determine critical locations, (b) limited baseline inspections to determine the extent of thinning at these locations, and (c) follow-up inspections to confirm the predictions, or repairing or replacing components as necessary. *Id.*

c. GALL Report Guidance on CHECWORKS™ and NSAC-202L

9.49 Regarding CHECWORKS™, Element 1, "Scope of Program," for the GALL AMP XI.M17 "Flow-Accelerated Corrosion" briefly touches upon the history of FAC, as well as the industry guidelines and accepted computer code. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-61. Specifically, the "Scope of Program" for the GALL Rev. 1 FAC AMP XI.M17 states:

> Scope of Program: The FAC program, described by the EPRI guidelines in NSAC-202L-R2, includes procedures or administrative controls to assure that the structural integrity of all carbon steel lines containing high-energy fluids (two phase as well as single phase) is maintained. Valve bodies retaining pressure in these high-energy systems are also covered by the program. The FAC program was originally outlined in NUREG-1344 and was further described through the Nuclear Regulatory Commission (NRC) Generic Letter (GL) 89-08. A program implemented in accordance with the EPRI guidelines predicts, detects, and monitors FAC in plant piping and other components, such as valve bodies, elbows and expanders. Such a program includes the following recommendations: (a) conducting an analysis to determine critical locations, (b) performing limited baseline inspections to determine the extent of thinning at these locations, and (c) performing follow-up inspections to confirm the predictions, or repairing or replacing components as necessary.

> NSAC-202L-R2 (April 1999) provides general guidelines for the FAC program. To ensure that all the aging effects caused by FAC are properly managed, the program includes the use of a predictive code, such as CHECWORKS, that uses the implementation guidance of NSAC-202L-R2 to satisfy the criteria specified in 10 CFR Part 50, Appendix B, criteria for development of procedures and control of special processes.

Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-61.

9.50 Element 5, "Monitoring and Trending" of the GALL Rev. 1 AMP XI.M17 references CHECWORKS™ as one tool used to predict component degradation in systems conducive to FAC. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-61.

9.51 Element 6, "Acceptance Criteria" of the GALL Rev. 1 AMP XI.M17 references CHECWORKS™ as a method used to calculate the number of refueling or operating cycles remaining before the component reaches the minimum allowable wall thickness. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-61. Furthermore, it notes that if calculations indicate that an area will reach the minimum allowed wall thickness before the next scheduled outage then the component is to be repaired, replaced, or reevaluated. *Id.*

9.52 In GALL Report, Rev. 2, AMP XI.M17 "Flow Accelerated Corrosion," the Staff updated the AMP for FAC by, *inter alia*, allowing an applicant to refer to NSAC-202L-R2 and R3, instead of just R2. *See* GALL Report, Rev. 2, (Ex. NYS000174D) at XI M17-1.

9.53 In GALL Report, Rev. 2, the Staff also updated the discussion of CHECWORKS™ in the fifth element, "Monitoring and Trending" to recognize "that CHECWORKS[™] is not always conservative in predicting component thickness; therefore, when measurements show the predictions to be non-conservative, the model must be re-calibrated using the latest field data." GALL Report, Rev. 2, (Ex. NYS000174D) at XI M17-1 to XI M17-2.

9.54 GALL Report, Rev. 2, states that CHECWORKS™ was developed and benchmarked by comparing

> CHECWORKS predictions against actual measured component thickness measurements obtained from many plants. The inspection schedule developed by the licensee on the basis of the results of such a predictive code provides reasonable assurance that structural integrity will be maintained between inspections. Inspection results are evaluated to determine if additional inspections are needed to ensure that the extent of wall thinning is adequately determined, that intended function will not be lost, and that corrective actions are adequately identified. Previous wear rate predictions due to FAC may change after a power uprate is implemented. Wear rates are updated in CHECWORKS according to power uprate conditions. Subsequent field measurements are used to calibrate or benchmark the predicted wear rates.

GALL Report, Rev. 2, (Ex. NYS000174D) at XI M17-1 to XI M17-2.

9.55 The Staff proposed to revise the GALL report further though publication of Draft License Renewal Interim Staff Guidance LR-ISG-2012-01. *See* Draft License Renewal Interim Staff Guidance LR-ISG-2012-01 (Ex. ENT000573). Proposed revisions include allowing to include wall thinning due to erosion within the AMP for FAC, and revising the definitions of “wall thinning,” “erosion,” and “flow-accelerated corrosion” to eliminate potential misinterpretations of these terms. *Id.* at cover letter page 1.

3. Relevant Industry Guidance NSAC-202L

9.56 As discussed above, the Staff's guidance states that NSAC-202L may be used. NSAC is a technical report called *Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R3).* EPRI, Palo Alto, CA: 2006. 1011838 (Ex. RIV000012). The objective of the report is to "present a set of recommendations for nuclear power plants for implementing an effective program to detect and mitigate FAC." NSAC-202L-R3 (Ex. RIV000012) at 5. NSAC-202L-R3 provides discussions on (1) Elements of an Effective FAC Program, (2) Procedures and Documentation, (3) Recommendations for FAC Tasks, and (4) Development of a Long Term Strategy. *See* generally NSAC-202L-R3 (Ex. RIV000012).

a. NSAC-202L-R3 Incorporates CHECWORKS™ Experience

9.57 The Summary Background section of NSAC-202L-R3 states:

> FAC—sometimes referred to as flow-assisted corrosion or erosion-corrosion—leads to wall thinning (metal loss) of steel piping exposed to flowing water or wet steam. The rate of metal loss depends on a complex interplay of many parameters such as water chemistry, material composition, and hydrodynamics. Carbon steel piping components that carry wet steam are especially susceptible to FAC and represent an industry wide problem. Experience has shown that FAC damage to piping at fossil and nuclear plants can lead to costly outages and repairs and can affect plant reliability and safety. EPRI and the industry as a whole have worked steadily since 1986 to develop and refine monitoring programs in order to prevent FAC-induced failures.
>
> This revision of NSAC-202L contains recommendations updated with the worldwide experience of members of the CHECWORKS™ Users Group (CHUG), plus recent developments in detection, modeling, and mitigation technology. These recommendations are intended to refine and enhance those of the earlier versions, without contradiction, so as to ensure the continuity of existing plant FAC programs. The guidance contained in this document supersedes that contained in EPRI Report NP-3944 and all prior versions of NSAC-202L.

NSAC-202L-R3 (Ex. RIV000012) at 5.

b. Industry Guidance NSAC-202L-R3 Addresses Power Uprates

9.58 With respect to uprates, NSAC-202L-R3 (Ex. RIV00012) states that the new plant heat balance be reviewed and evaluated using the "Predictive Plant Model"[48] (i.e. CHECWORKS™):

> ***4.3.1 FAC Analysis and Power Uprates***
>
> It is recognized that even small power uprates can have a significant affect on FAC rates. This can be caused by changes to equipment and changes to system operating conditions such as flow rates, temperature, dissolved oxygen, and steam quality. When power uprates are being considered, it is recommended that the proposed changes to operating conditions and any possible changes to the plant heat balance diagram be fully

[48] Entergy uses CHECWORKS™ as its Predictive Plant Model. *See* EN-DC-315, Rev. 6, Flow Accelerated Corrosion Program (Ex. ENT000038) at 5 (defining CHECWORKS as "EPRI Computer Modeling Program used to predict rated wall thinning and remaining life of components degraded by FAC.").

> reviewed and evaluated using the Predictive Plant Model. Potential changes to the Susceptible-Not-Modeled lines should also be considered. This should include identification of any piping areas and equipment where FAC rates are predicted to significantly increase such that material upgrades can be considered and changes to the plant inspection plan can be made.
>
> It is recognized that power uprates can be very minor or quite significant. It is recommended that each change to the plant heat balance diagram be evaluated for its effect on FAC in the susceptible systems.

NSAC-202L-R3 at 4-5 (Ex. RIV00012) (emphasis added).

9.59 NSAC-202L-R3 states that the "Susceptibility Analysis" should be periodically reviewed and updated to address, inter alia, changes resulting from power uprates. NSAC-202L-R3 (Ex. RIV000012) at 3-3. Other examples of items which should be reviewed for changes to the Susceptibility Analysis include changes to system operation and system-lineup, replacements of components and lines, and operating experience. *Id.*

c. Industry Guidance NSAC-202L-R3 Addresses Calibration

9.60 Entergy's witnesses described the calibration process as being described in "Recommendations for an Effective Flow-Accelerated Corrosion Program" (NSAC-202L-R3) (May 2006) (Ex. RIV00012). Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 59. As shown therein, a "calibrated line analysis" is based on five criteria:

> *Calibrated Analysis Line* – A Calibrated Analysis Line is an Analysis Line[49] that meets all of the following criteria ...:
>
> 1. All lines of piping which compose the Analysis Line should have very similar chemistry, time of operation, volumetric flow rate, temperature, fluid content (e.g., single- and two-phase lines should not be mixed in an analysis run), and steam quality.
>
> 2. The Analysis Line should have a minimum of five inspected components that have lifetime wear greater than 0.030" (0.8 mm);

[49] An Analysis Line is one or more physical lines of piping that have been analyzed together in the Predictive Plant Model. NSAC-202L-R3 (Ex. RIV000012) at 4-1. The Predictive Plant Model is a mathematical representation of the power plant's FAC-susceptible lines and systems where the operating conditions are known.). NSAC-202L-R3 (Ex. RIV000012) at 4-3 .

> these components should be from main runs of elbows, pipes, nozzles, reducers, expanders, and tees, and from downstream pipe extensions of these components.
>
> 3. The Analysis Line should have a Line Correction Factor[50] between 0.5 and 2.5. A value somewhat outside of this range can be accepted if the reason for the high or low factor is well understood and documented, and a minimum of ten inspected components exist in the Analysis Line.
>
> 4. A plot of predicted wear to measured wear shows a reasonably tight cluster of data along the 45° line.
>
> 5. The Predictive Plant Model includes the inspection data of the most recent outage.
>
> An Analysis Line can also be treated as calibrated if it has been found to exhibit little to no wear and includes a minimum of ten inspected components if no trace alloy measurements were made of the inspected components. If little to no wear was found and measurements of trace alloy content were made of the inspected components, then fewer inspections are needed to treat the Analysis Line as calibrated.

NSAC-202L-R3 (Ex. RIV000012) at 4-1.

9.61 NSAC-202L-R3 gives provides the following descriptions to differentiate between analyses where actual plant measurements have been used:

> *Pass 1 Analysis* – A Pass 1 Analysis is an analysis based solely on the Plant Predictive Model, and is not enhanced by results of the plant wall thickness measurements.
>
> *Pass 2 Analysis* – A Pass 2 Analysis is an analysis where results of the plant wall thickness measurements are used to enhance the Pass 1 Analysis results.

NSAC-202L-R3 (Ex. RIV000012) at 4-2.

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[50] The Line Correction Factor is the median value of the ratios of measured wear for a given component divided by its predicted wear for a given Analysis Line. NSAC-202L-R3 at 4-1 (Ex. RIV000012). A Line Correction Factor of 1.0 is considered ideal as the measured wear equals the predicted wear (median value). NSAC-202L-R3 at 4-1 (Ex. RIV000012)

9.62 NSAC-202L-R3 describes a "CHECWORKS™ run" as a CHECWORKS™ Pass 2 analysis of one or more physical lines that utilize a common LCF. NSAC-202L-R3 at 4-1 (Ex. RIV000012).

9.63 NSAC-202L-R3 does not define "benchmarking," although it uses the term once in passing. *See* NSAC-202L-R3 (Ex. RIV000012) at 5-5 (stating in part "to improve and benchmark the predictions of the Plant Predictive Model for the local hydrazine concentration around the steam circuit, it is recommended to make one-time measurements of the hydrazine concentration [in various locations].").

4. Overview of Entergy's FAC AMP

a. LRA based on NSAC-202L and Follows the GALL Report

9.64 Section 3 of the LRA Indian Point Energy Center License Renewal Application (April 2007) (Ex. ENT00015A-B) provides results of the aging management review (AMR) for structures and components identified as subject to AMR. LRA (Ex. ENT000015A) at 3.0-1. The LRA identifies, inter alia, loss of material as an aging effect requiring management. E.g. LRA (Ex. ENT000015A) at 3.3-32 (listing loss of materials as an aging effect requiring management for nonsafety-related components affecting safety-related systems).

9.65 The appendices to the LRA provide additional description of Entergy's FAC AMP. Appendix A provides the information to be submitted in an Updated Final Safety Analysis Report Supplement as required by 10 C.F.R. § 54.21(d) for the IPEC LRA. LRA (Ex. ENT00015B) at A-1.

9.66 The supplement to the UFSAR, presented in section A.2 of Appendix A, contains a summary description of the program and activities for managing the effects of FAC aging for the renewed operating license. Specifically, Entergy's FAC AMP for the PEO is described in section A.2.1.14. LRA (Ex. ENT00015B) at A-24. As stated therein,

> The Flow-Accelerated Corrosion Program is an existing program that applies to safety-related and nonsafety-related carbon and low alloy steel components in systems containing high-energy

> fluids carrying two-phase or single-phase high-energy fluid > 2% of plant operating time.
>
> The program, based on EPRI guidelines in the Nuclear Safety Analysis Center (NSAC)-202L-R2 for an effective flow-accelerated corrosion program, predicts, detects, and monitors FAC in plant piping and other pressure retaining components. This program includes (a) an evaluation to determine critical locations, (b) initial operational inspections to determine the extent of thinning at these locations, and (c) follow-up inspections to confirm predictions. The program specifies repair or replacement of components as necessary.

LRA (Ex. ENT00015B) at A-24.

9.67 Appendix A states that the information presented in each section will be incorporated into the respective UFSAR following issuance of the renewed operating licenses and upon inclusion of the UFSAR Supplement in each UFSAR, future changes to the descriptions of the programs and activities will be made in accordance with 10 CFR § 50.59. LRA (Ex. ENT00015B) at A-1.

9.68 Appendix B of the LRA discusses lists the AMPs credited in the integrated plant assessment for managing the effects of again. LRA (Ex. ENT00015B) at B-1. Each AMP in Appendix B has ten elements in accordance with the guidance in NUREG-1800 Appendix A.1, "Aging Management Review - Generic," Table A.1-1, "Elements of an Aging Management Program for License Renewal." LRA (Ex. ENT00015B) at B-1.

9.69 For AMPS that are comparable to the programs in the GALL Report, the Appendix B of the LRA compares the ten elements to the ten elements within the GALL Report. LRA (Ex. ENT00015B) at B-1. Otherwise for non-GALL AMPS, the 10 elements are addressed in the LRA. LRA (Ex. ENT00015B) at B-1.

9.70 IPEC Program B.1.15 is Entergy's FAC AMP, and is presented in the LRA as being consistent with GALL AMP XI.M17 and using Entergy’s Existing FAC Program. LRA (Ex. ENT000158) at B-4, B-7, B-13, B-54 to B-55. Entergy's witnesses testified that the Existing FAC Program at IPEC was developed in response to the NRC Staff’s Generic Letter 89-08

"Erosion/Corrosion-Induced Pipe Wall Thinning" (May 2, 1989) (Ex. ENT000042) and related correspondence. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 37.

9.71 Entergy's witnesses stated that "the IPEC FAC Program description in LRA Section B.1.15 incorporates by reference all ten program elements or attributes identified in NUREG-1801, Revision 1, Section XI.M17." Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 35. Further, the LRA (as submitted) met all ten elements ((1) Scope of the Program, (2) Preventive Actions, (3) Parameters Monitored or Inspected, (4) Detection of Aging Effects, (5) Monitoring and Trending, (6) Acceptance Criteria, (7) Corrective Actions, (8) Confirmation Process, (9) Administrative Controls, and (10) Operating Experience) without exception. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 35.

9.72 Entergy's witness described how subsequently, in response to NRC Audit Item, Entergy amended the “scope of program” and “detection of aging effects” program elements to identify use of NSAC-202L-R3 as an “exception” because GALL Rev. 1 references NSAC-202L-R2. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 35. Entergy's witnesses explained that the implementing guidance in NSAC-202L-R3 remained consistent with the guidance of NSAC-202L-R2. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 36; s*ee* also NL-07-153, Letter from Fred R. Dacimo, Entergy, to NRC, “Amendment 1 to License Renewal Application (LRA),” Attach. 1, at 46-48 (Dec. 18, 2007) (Ex. NYS000159).

b. Procedure EN-DC-315 Implements FAC Program

9.73 According to Entergy's witnesses, Entergy's FAC program is implemented under a fleet-wide procedure EN-DC-315, Revision 6, “Flow Accelerated Corrosion Program,” (Ex. ENT000038), which governs the FAC programs at Entergy’s nuclear power plants. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 30. Entergy's witnesses describe how EN-DC-315 implements the recommendations of NUREG-1801, Revision 1 (Ex. NYS00146A-C) and the more detailed EPRI report, NSAC-202L-R3 (Ex. RIV000012). Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 38.

9.74 Procedure EN-DC-315 describes itself thusly:

> [1] The purpose of this procedure is to implement a common approach to establish programmatic control, updating, and documenting Flow-Accelerated Corrosion (FAC) programs for standardization at Entergy's nuclear plants.
>
> [2] The objective of the FAC program is to predict, detect, monitor and minimize degradation in single and two-phase flow piping (safety and non-safety related systems) to prevent failures while enhancing plant safety and reliability.
>
> [3] This procedure provides criteria and methodology for selecting components for inspection, performing inspections, evaluating inspection data and disposition of results, sample expansion requirements, piping repair /replacement criteria, program responsibilities and documentation requirements.
>
> [4] This procedure may be used as a guide for evaluating systems and components that are not included in the FAC program.
>
> [5] The frequency of the activities described in this document shall be on a refuel outage basis, unless otherwise noted. However, in some cases, online or mid-cycle inspection and evaluation may be performed.

EN-DC-315, Rev. 6 at 3 (ex. ENT000038).

9.75 The procedure gives descriptions of Pass 1 and Pass 2 analyses showing how "calibration" relates to actual inspection data and number of runs:

> … PASS 1 Analysis – Runs modeled in CHECWORKS that either have no inspection data, an insufficient number of inspections to provide a proper calibration, or where there is no expectation of ever developing a proper calibration.
>
> … PASS 2 Analysis – The process of utilizing UT inspection data thickness measurements in CHECWORKS to predict wear and wear rates for components.

EN-DC-315, Rev. 6, Flow Accelerated Corrosion Program (Ex. ENT000038) at 8.

c. Entergy uses CHECWORKS™ in its FAC Program

9.76 CHECWORKS™ is described by Entergy's witnesses as a computer program designed to assist in the identification of locations which are vulnerable to FAC. Entergy

Testimony on RK-TC-2 (Ex. ENTR00029) at 57. CHECWORKS™ assists in the predictions of FAC wear rates, and thus helps to plan inspections. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 57 (citing EPRI, CHECWORKS™ Steam/Feedwater Application Version 3.0 User Guide (2008) (Ex. ENT000070) at 5).

9.77 A user of CHECWORKS™ creates a model of the plant's FAC-susceptible piping within CHECWORKS™, and includes plant parameters such as fluid flow rates, fluid chemistry, and fluid temperature. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 57.

9.78 When a CHECWORKS™ run is performed *without* actual measured plant data, the run is called a "PASS-1 Analysis." Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 58.

9.79 The CHECWORKS™ model can be augmented with real-world measured wall thicknesses. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 57. The analyses with measured data are used to produce a "PASS-2 Analysis." Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 58.

9.80 The outputs of CHECWORKS™ are (1) rate of wall thinning for a specific component, and (2) remaining service life for the component. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 57.

9.81 The remaining service life prediction for a component can be used to schedule an inspection of the component, but typically the remaining service life from the CHECWORKS™-independent trending process (which uses measured values) is used to schedule inspections. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 57-58.

d. Line Correction Factor assess CHECWORKS™

9.82 Comparison with the predicted and measured data from a PASS-2 Analysis can be accomplished using a "line correction factor" ("LCF"). Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 58.

9.83 The LCF represents how well measured wear matched predicted wear, and can be used to correct (or calibrate or benchmark) other wear predictions thereby giving a better

wear rate estimate. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 58-59. The LCF is statistically determined to produce the best fit of predicted thicknesses with inspection data. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 58.

9.84 According to Entergy's witnesses, "This calibration, or benchmarking based on measured wall thicknesses, allows for more accurate future predictions of wear rates." Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 59.

5. Key Contested Matters

a. Definition of FAC

9.85 As a threshold matter, the parties disagreed about the proper description of FAC.

i. Position of the Parties on the Definition of FAC

9.86 Entergy's witnesses assert that, consistent with NSAC-202L-R3, Entergy's corporate FAC Program, EN-DC-315, Rev. 6, at 6 (Ex. ENT000038) defines FAC as the "[d]egradation and consequent wall thinning of a component by a dissolution phenomenon, which is affected by variables such as temperature, steam quality, steam/fluid velocity, water chemistry, component material composition and component geometry." ENTR000029 at 29. Entergy witness Mr. Azevedo added that any identified erosion instances would be addressed though the corrective actions program. Tr. at 1828.

9.87 Riverkeeper's witness Dr. Hopenfeld testified that Entergy's definition of FAC arbitrarily excludes wall thinning by cavitation, wet steam, galvanic corrosion, and jet impingement/erosion even though all are affected by flow velocities. Hopenfeld Rebuttal Testimony at 29 (Ex. RIV000108). Dr. Hopenfeld rejects the theory espoused by EPRI that FAC is strictly controlled by metal dissolution. *Id.* Dr. Hopenfeld asserts that Entergy fails to understand the principles of FAC, as well as the underlying assumptions in CHECWORKS™. *Id.* During the hearing, Dr. Hopenfeld testified that the developers of CHECWORKS™ incorrectly asserted that FAC is only controlled by corrosion, whereas it should include erosion. Tr. at 1321. As a consequence the right inputs are not used, and Entergy's calculations are

wrong. *Id.* Dr. Hopenfeld testified that the definition should not have been introduced twenty years ago. Tr. at 1849.

9.88 The Staff's witnesses describe that flow FAC is a form of material degradation that leads to wall thinning (metal loss) of steel piping exposed to flowing water or wet steam. Staff Testimony on RK-TC-2 (ex. NRCR00121) at 9. The rate of metal loss depends on a complex interaction of water chemistry, material composition, and hydrodynamics. *Id.* (citing NSAC-202L-R3 (Ex. RIV000012) at v.).

9.89 The Staff's document Draft License Renewal Interim Staff Guidance LR-ISG-2012-01 proposed to revise, *inter alia*, definitions of “wall thinning,” “erosion,” and “flow-accelerated corrosion” to eliminate potential misinterpretations of these terms. Draft License Renewal Interim Staff Guidance LR-ISG-2012-01 (Ex. ENT0000573) at cover letter page 1. Dr. Hopenfeld testified that he thought the definition in the ISG should have been more scientific. Tr. at 1849-1850. During the hearing, the NRC Staff's witnesses Dr. Hiser and Mr. Yoder addressed the Board's questions regarding these revisions.

9.90 Dr. Hiser explained that, notwithstanding the ISG, FAC does not include erosion forces, and does not include mechanical wall thinning. Tr. at 1702. Furthermore, the Staff was not using an Interim Staff Guidance (ISG) (Ex. ENT000573) to broaden the definition of FAC and include mechanical wall thinning. *Id.* According to Dr. Hiser, "the definition of FAC is still what FAC has been." *Id.* Dr. Hiser described how cavitation, which creates wall thinning from erosion, can be monitored though FAC programs, inasmuch as the programs are measuring wall thickness. *Id.* at 1703, 1704. Dr. Hiser explained that there is not a separate AMP for mechanical wall thinning, but the Staff had recognized that an FAC AMP may be modified to include mechanical wall thinning. *Id.* at 1704-1705. Mr. Yoder explained that while the Staff was proposing that erosion be addressed as part of the FAC AMP, the recommendation was an addition to FAC, not a change to what the staff defined as FAC. Tr. at 1825. Dr. Hiser confirmed that the ISG does not require erosion to be addressed by the FAC AMP. Tr. at 1826.

Dr. Hiser explained that the Staff's consideration of the FAC program is focused on the chemical dissolution aspects of wall thinning, not erosion. Tr. at 1828.

ii. Board Findings on the Definition of FAC

9.91 We find that the current definition "flow accelerated corrosion" is degradation and consequent wall thinning of a component by a dissolution phenomenon, which is affected by variables such as temperature, steam quality, steam/fluid velocity, water chemistry, component material composition, and component geometry. We find that this definition is consistent with the focus of FAC programs, EPRI guidance, the LRA, and the Staff's views.

9.92 However, we also find that measurements taken to track the total effects of all wall thinning mechanisms cannot readily discriminate between the various mechanisms causing pipe wear. Thus, as recognized by the Staff (Tr. at 1704-1705), the effects of erosion can be included as an integral part of the FAC Program.

9.93 Last, with respect to Dr. Hopenfeld assertion that Entergy fails to understand the principles of FAC, as well as the underlying assumptions in CHECWORKS™ (Hopenfeld Rebuttal Testimony at 29 (Ex. RIV000108)), we do not find these assertions to be credible. We note, for example, that Entergy's witnesses include Dr. Horowitz, the co-creator of the CHECWORKS™ model; Dr. Horowitz undoubtedly understands the assumptions he made when creating the model.

b. Details in the LRA AMP for FAC

9.94 The Board admitted RK-TC-2 in part to determine if Entergy's AMP for components affected by FAC is deficient because it does not provide sufficient details to demonstrate that the intended functions of the applicable components will be maintained during the extended period of operation. *See Indian Point,* LBP-08-13, 68 NRC at 177.

9.95 During the course of the evidentiary hearing, the Board addressed how, given a renewal application with a short written description of an aging management program and a declaration that the program is consistent with GALL, a reader of the LRA may understand the

details of the program. *See* e.g. Tr at 1355-1356 (discussing how details are in GALL-referenced documents such as NSAC-202L, as well as Entergy procedures such as EN-DC-315). As will be discussed below, the GALL Report, NSAC-202L referenced therein, in conjunction with implementing procedure EN-DC-315 provide a robust description of the AMP for FAC. *See* Tr. at 1357.

i. Entergy's Assessment of the Ten Elements

9.96 According to Entergy's witnesses, the ten program elements needed for a FAC AMP to satisfy the requirements of 10 C.F.R. Part 54 are: (1) Scope of the Program, (2) Preventive Actions, (3) Parameters Monitored or Inspected, (4) Detection of Aging Effects, (5) Monitoring and Trending, (6) Acceptance Criteria, (7) Corrective Actions, (8) Confirmation Process, (9) Administrative Controls, and (10) Operating Experience. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 35. The Board reviewed how the details available in the LRA and the documents referenced therein (i.e. NSAC-202L), as well as the implementing procedures (e.g. EN-DC-315) which were not included in the LRA. A summary of the information related to the ten program elements follows.

(1) Scope of Program

9.97 Entergy's witnesses also described how Entergy's selections of components for inspection for FAC are done in a manner consistent with NSAC-202L-R3. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 45 (citing EN-DC-315 (Ex. ENT000038) at 15-19).

9.98 Entergy's witness described how the processes described in EN-DC-315 and NSAC-202L-R3 address the process for the initial identification of FAC-susceptible systems though a "system susceptibility evaluation" ("SSE"). Entergy testimony on RK-TC-2 (Ex. ENTR00029) at 42 (citing EN-DC-315 at 17 (Ex. ENT000038) and NSAC-202L-R3 at 4-3 to -5 (Ex. RIV000012)). Entergy describes the “System Susceptibility Evaluation” (“SSE”) as an “Evaluation which addresses and documents all large and small bore piping, categorizing lines by modeled, non-modeled large bore piping and small bore piping susceptible to FAC. All piping

should be considered FAC susceptible unless analyzed as otherwise." EN-DC-315, Rev. 6, Flow Accelerated Corrosion Program (Ex. ENT000038) at 9.

9.99 If the piping or component is modeled within CHECWORKS™, then the criteria for selecting the piping or component for further evaluation are based upon: (1) trending from past measurements; (2) CHECWORKS™ predictions; (3) operating experience; (4) results from other inspection programs; and (5) engineering judgment. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 45-46 (citing NSAC-202L-R3 at 2-3 to -4, 3-2 (Ex. RIV000012)).

9.100 If the piping is NOT modeled within CHECWORKS™, but it is still susceptible to FAC ("susceptible not modeled" or "SNM") then the four non-CHECWORKS™ criteria are used (i.e. (1) trending from past measurements; (2) operating experience; (3) results from other inspection programs; and (4) engineering judgment, along with a special ranking of the non-modeled piping. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 46.

9.101 Entergy's witnesses explained that, as specified in EN-DC-315, every two operating cycles Entergy must update the SSE reports and SNM reports. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 46 (citing EN-DC-315, Revision 6 at 28 (Ex. ENT000038)). Entergy's provided supporting examples of how Entergy updates the SSE reports and the SNM reports to account for physical changes to the plant as well as changes in how the plant is operated. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 46 (listing as examples IP2 SSE Report 0700.104-02 (Ex. ENT000048); IP2 SNM Report 0700.104-03 (Ex. ENT000052); IP3 SSE Report 0700.104-17 (Ex. ENT000049); IP3 SNM Report 0700.104-18 (Ex. ENT000053).

(2) Preventive Actions

9.102 Entergy's witnesses describe how water chemistry improvements have prevented FAC problems by decreasing the rates of FAC at PWRs. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 55-56. Plants had done design changes to remove copper materials and changed to better chemistry control than ammonia. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 56. At IPEC, for example, the plant implemented the industry guidelines to

control water chemistry, and replaced components to improve FAC management. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 56-57, 44-45.

(3) Parameters Monitored/Inspected

9.103 The LRA indicates that Entergy's FAC program is based on NSAC-202L, and includes evaluation to determine critical locations, initial operational inspections to determine the extent of thinning, at these locations, and follow-up inspections. LRA, App. B (Ex. ENT00015B) at B-54. Entergy asserts its FAC Program is consistent with the FAC AMP from the GALL Report. LRA, App. B (Ex. ENT00015B) at B-54.

9.104 As described in GALL Report, Rev. 1, the FAC AMP monitors the effects of FAC on the intended function of piping and components by measuring wall thickness. (Ex. NYS0000146C) at XI M-61.

(4) Detection of Aging Effects

9.105 The LRA indicates that Entergy's program is based on NSAC-202L, and provides an effective means for detecting FAC in plant piping and other pressure-retaining components. LRA, Ap. B (Ex. ENT00015B) at B-54.

9.106 Entergy's witnesses testified that the IPEC FAC program detects material loss due to FAC, and provides for corrective action before the loss of intended functions of the component. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 2. Entergy's witnesses described how these measurements were accomplished using ultra-sonic testing ("UT"). Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 41. Specifically, the witnesses said:

> UT thickness measurements performed in accordance with approved procedures are the primary method used to determine pipe wall thickness. *See* ENDC- 315 at 20 (Ex. ENT000038). Radiography and other nondestructive examination techniques are also occasionally employed. *See id.* at 21. The IPEC FAC Program requires that piping and piping component inspections be conducted by personnel who are qualified and certified in accordance with the requirements of the ASME Code. In addition, the IPEC FAC Program provides detailed instructions for selecting components for inspections, evaluating inspection data against specified acceptance criteria, evaluating any components that fail

> to meet the acceptance criteria, expanding the inspection sample in the case of unexpected thinning, and calibrating the CHECWORKS models. *See* LRA, App. B at B-54 (Ex. ENT00015B); EN-DC-315 at 3, 10-28 (Ex. ENT000038).

Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 41.

9.107 Entergy's witness noted that "for each component inspected with UT, Entergy typically records dozens or hundreds of individual thickness readings, depending on the size and type of the component being inspected." Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 41.(citing EN-DC-315 at 19 (Ex. ENT000038)).

(5) Monitoring and Trending

9.108 Element 5, "Monitoring and Trending" of the GALL Rev. 1 AMP XI.M17 states in part that inspection results are evaluated to determine if additional inspections are needed to assure that the extent of wall thinning is adequately determined and to provide assurance that the intended function are not lost. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-62.

9.109 Entergy's witnesses described how trending at IPEC is done to calculate projected component thicknesses at the next refueling outage. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 54-55.

9.110 Entergy's witnesses described three major steps used to trend:

> 9.111 First, determine the "minimum acceptable wall thickness" which is the highest thickness needed (1) to carry the design loads; (2) to meet the piping replacement criterion of 0.3 nominal thickness for Class 1 piping; or (3) to meet the piping replacement criterion of 0.2 nominal thickness for Class 2, Class 3, and non-safety related piping. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 54-55.

9.112 Second, determine the wear rate by dividing the *measured* wear with the time between measurements. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 55.

9.113 Third, calculate a predicted wear and "Remaining Service Life" which includes a safety-factor of 1.1. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 55.

9.114 Entergy's witnesses indicated these steps are done in accordance with EN-DC-315 (Ex. ENT000038) and NSAC-202L-R3 (Ex. RIV000012). *See* Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 54-55.

9.115 Last, Entergy's witnesses stated that CHECWORKS is not part of trending:

> Thus, trending is an aspect of the FAC Program that is entirely independent of CHECWORKS. Moreover, trending is accomplished in the same manner irrespective of the reason for the original inspection (*i.e.*, regardless of whether the component was selected based on CHECWORKS, operating experience, engineering judgment, or other reason).

Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 55.

9.116 According to Entergy's witnesses, none of the trending calculations described in Entergy's FAC procedure EN-DC-315 involve the use of CHECWORKS™, but are instead done by a FAC engineer or by a structural design engineer using software or procedures other than CHECWORKS™. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 54.

(6) <u>Acceptance Criteria</u>

9.117 The LRA indicates that the FAC Program follows EPRI's guidelines in NSAC-202L. LRA, Ap. B (Ex. ENT00015B) at B-54.

9.118 Entergy's witnesses explained that determining the acceptance criteria is based on evaluating wall thicknesses to determine the remaining service life. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 53. Then, as long as there is at least one operating cycle in the remaining service life, the component can still be used. Entergy Testimony on RK-TC-2 (Ex.

ENTR00029) at 53. The details on the acceptance criteria calculations are provided in various procedures including are provided through various procedures including: EN-CS-S-008-MULTI, Revision 0, “Pipe Wall Thinning Structural Evaluation” (Jan. 1, 2010) (Ex. ENT000065) and EN-DC-126, Revision 4, “Engineering Calculation Process” (Jan. 31, 2011) (Ex. ENT000066). Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 53.

9.119 With respect to a criterion for expanding the inspections based on measured results, Entergy's witnesses explain that should calculations or findings show a component to be less than the required thickness, then Entergy will perform additional inspections on similar components. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 53-54. The decision-making process for additional samples when one is below an acceptance criterion is detailed in NSAC-202L-R3 and EN-DC-315. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 54 (citing NSAC-202L-R3 (Ex. RIV000012) at 4-10, EN-DC-315 (Ex. ENT000038) at 25-26).

(7) Corrective Actions

9.120 The GALL Report, Rev. 1, Element 7, "Corrective Actions" notes that the Staff finds the requirements of 10 C.F.R. Part 50, App. B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" acceptable for corrective actions. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-62.

9.121 Entergy's witnesses explained how the FAC Program at IPEC appropriately considers, on a case-by-case basis, what corrective actions to do when inspections show unacceptable results. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 80. Potential corrective actions include increasing inspections and replacing lines. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 80. Actual measured data are used to determine the appropriate corrective action. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 80.

(8) Confirmation Process

9.122 The confirmation process element for license renewal AMPs consists of follow-up actions to verify that the corrective actions implemented are effective in preventing a recurrence.

NUREG-1801, Rev. 2, (Ex. NYS00147D) at A-1 ("Quality Assurance for Aging Management Programs").

9.123 Entergy's LRA states that the confirmation process is part of the corrective action program and includes reviews to assure that proposed actions are adequate, tracking and reporting of open corrective actions, and review of corrective action effectiveness. LRA Appendix B Section B.0.3 (Ex. ENT00015B) at page B-2.

9.124 The IPEC confirmation process is consistent with NUREG-1801. LRA Appendix B Section B.0.3 (Ex. ENT00015B) at page B-2.

(9) Administrative Controls

9.125 The GALL Report, Rev. 1, Element 9, "Administrative Controls" notes that the Staff finds the requirements of 10 C.F.R. Part 50, App. B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" acceptable for administrative controls. Gall Report, Rev. 1 (Ex. NYS000164C) at XI M-62.

9.126 Entergy's LRA states that administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. LRA Appendix B Section B.0.3 (Ex. ENT00015B) at page B-3.

9.127 The Entergy Quality Assurance Program applies to safety-related structures and components, and administrative (document) controls for both safety-related and nonsafety-related structures and components are accomplished per the existing document control program. LRA Appendix B Section B.0.3 at page B-3 (Ex. ENT00015B).

9.128 Entergy's witnesses describe how its FAC program conforms to EPRI guidelines in NSAC-202L-R3 and includes appropriate procedures (e.g. EN-DC-315 (Ex. ENT000038)) and administrative controls to provide reasonable assurance of the structural integrity of the carbon steel lines with high-energy fluids. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 26.

(10) Operating Experience

9.129 Entergy's LRA notes that in general site procedures require reviews of site and relevant industry operating experience as the site continues operation through the license renewal period. LRA Appendix B Section B.0.3 at page B-3 (Ex. ENT00015B).

9.130 Specific to FAC, the LRA described that operating experience was addressed by, for example, a review of best practices for the FAC program at all Entergy sites. LRA, App. B (Ex. ENT00015B) at B-54 to B-55 (Ex. ENT00015B).

9.131 Entergy's witnesses described the substantial operating experience which, through the years, has been incorporated into the FAC Program. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 37-38. They noted that the FAC Program is an established IPEC program, based on a common fleet-wide Entergy program, which Entergy has updated and revised as appropriate. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 37.

9.132 Citing Entergy's corporate operating experience procedure, Entergy's witnesses testified that sources of operating experience for FAC program include the NRC, other utilities, and experiences at Entergy's other sites. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 47 (citing Entergy, EN-OE-100, Rev. 12, Operating Experience Program (Apr. 15, 2011) (Ex. ENT000055)).

ii. Staff Assessment of the Ten Elements of the AMP for FAC

9.133 As described in the SER, the Staff evaluated the claims in the LRA, as amended, by conducting an audit or a technical review to verify the claims on how the LRA was consistent with GALL. SER (Ex. NYS000326B) at 3-5, 3-21. For the FAC AMP, the Staff's Audit Report for Plant Aging Management Programs and Reviews (Ex. ENT00041) documents the Staff's review and verification of Elements (1) to (6) of the FAC program. (Ex. ENT000041) at 13-23. The audit included review by the Staff of supporting program documentation, and interviews of the applicant’s license renewal team and technical staff. (Ex. ENT000041) at 13. Based on its

audit, the staff determined that the AMP for FAC was consistent with the GALL Report AMP elements (1) to (6). (Ex. ENT000041) at 23.

9.134 The Staff's SER section 3.0.4 , "QA Program Attributes Integral to Aging Management Programs" describes the global review the Staff performed for elements (7) “corrective actions,” (8) “confirmation process,” and (9) “administrative controls.” SER (Ex. NYS000326C) at 3-220 to 3.222. The Staff noted that Entergy uses its Entergy Quality Assurance Program (EQAP) for the elements of corrective action, confirmation process, and administrative controls. SER (Ex. NYS000326C) at 3.220. Based on review of the procedure and comparison with Staff guidance, the Staff concluded that elements (7) to (9) were met. SER (Ex. NYS000326C) at 3-221 to 3-222.

9.135 In addition, the Staff reviewed Element 7, "Corrective Actions" with respect to whether repair/replacement activities for in-scope components involved replacement with components using FAG-resistant materials. SER (Ex. NYS000326B) at 3-21. The staff also verified that the AMP for FAC included applicable acceptance criteria for evaluating in-scope components and applicable corrective actions (repair, replacement, or re-evaluation) for components that are projected to exhibit an unacceptable amount of FAC-induced wall thinning. SER (Ex. NYS000326B) at 3-21.

9.136 Last, the Staff reviewed Element 10, "Operating Experience" and found that FAC properly considered operating experiences. SER (Ex. NYS000326B) at 3-22 to 3-23. Specifically, the Staff found, "scope of the program is consistent with NRC-identified, industry-identified, IP2-specific, and IP3-specific operating experience." SER (Ex. NYS000326B) at 3-23.

9.137 The Staff determined that the current FAC Program for IP2 and IP3 is acceptable, writing:

> On the basis of its audit and review of the applicant’s Flow-Accelerated Corrosion Program, the staff finds that all program

> elements are consistent with the GALL Report. The staff concludes that the applicant has demonstrated that the effects of aging will be adequately managed so that the intended functions will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the UFSAR supplement for this program and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).

NRC Staff Testimony on RK-TC-2 at 33 (quoting SER at 3-31 (Ex. NYS00326B)).

iii. Riverkeeper's View on the Ten Elements

9.138 Dr. Hopenfeld believes that it is not sufficient for Entergy to just state that it adopted the elements outlined in the GALL Report, and Entergy must instead describe how those elements will be implemented to ensure that the critical wall thickness of all susceptible components will be maintained between inspections. Hopenfeld Rebuttal (Ex. RIV000108) at 42 & 53-54.

9.139 Dr. Hopenfeld testified that Entergy was required to provide sufficient details about its FAC programs to meet the GALL Report and the SRP-LR, but had failed to do so. Riverkeeper Testimony (Ex. RIV000003) at 16. Dr. Hopenfeld asserted that such detail was needed because, according to Dr. Hopenfeld, CHECWORKS has not been successful historically, and would not be successful in the future. *See id.* Thus, Dr. Hopenfeld originally asserted that more information was needed about inspection scope, frequency, component replacement and repair criteria, etc.. *Id.* & *id.* at 20.

iv. Entergy Asserts the Level of Detail is Sufficient

9.140 Entergy's witness testified that the IPEC FAC Program incorporates by reference all ten elements, as described in NUREG-1801, Revision 1, Section XI.M17, with the exception that Entergy used a later version of NSAC-202L which included more operating experience. *Id.* at 35-36. Thus, the IPEC FAC Program meets the intent of NUREG-1801, Revision 2, Section XI.17, without exception. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 108.

9.141 Entergy's witness Mr. Cox described how there was not a lot of detail in the LRA because the LRA referred to the GALL Report. Tr. at 1342. The details of FAC AMP are then incorporated by reference. *Id.* at 1343.

9.142 According to Mr. Cox, being "consistent with GALL" is synonymous with having the program discussed in the GALL Report. Tr. at 1345. Thus, according to Entergy's witness, the secondary documents referenced in the GALL Report itself (e.g. NSAC-202L) (Ex. RIV000012) provide "a fairly detailed description of an effective FAC management program." *Id.* at 1346.

9.143 Entergy's witnesses state that the details of their FAC Program are given in Entergy fleet procedure EN-DC-315, *Flow Accelerated Corrosion Program* (Ex. ENT000038), which implements the recommendations of NUREG-1801 and the more detailed EPRI guidelines contained in NSAC-202L-R3. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 38 & 108.

9.144 Entergy's witnesses describe how NSAC-202L-R3 addresses the elements of an effective FAC program, appropriate procedures, implementation procedures, FAC program tasks, and how to develop a long-term strategy for reducing plant FAC susceptibility. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 26.

9.145 Entergy's witness Mr. Azevedo explained that the actual plant procedures for implementing the FAC program are in the Entergy fleet-wide procedure governing FAC programs, which is EN-DC-315 (Ex. ENT000038). Tr. at 1351, 1352.

9.146 Entergy's witness Mr. Cox explained that implementing procedures such as EN-DC-315 are not typically what is included in an LRA. Id. at 1357. However, according to Mr. Cox, examination of EN-DC-315 will show it to be consistent with the GALL Report. *Id.* Mr. Azevdeo stated that EN-DC-315 itself is not entirely stand-alone, in that execution of EN-DC-315 requires additional procedures, such as a procedure on how to perform ultrasonic inspections, and a procedure on how to calculate the critical thickness of a wall. Tr. at 1358.

9.147 The Board inquired about why more information was not needed to show that the FAC AMP meets GALL. Tr. at 1361. In particular the Board observed that no IPEC site specific procedure had been submitted. Tr. at 1364. Mr. Azevedo explained that EN-DC-315 is, in fact, applicable to IPEC. Tr. at 1377, 1378. Mr. Aleksick likewise explained that EN-DC-315 applies to IPEC. *Id.* at 1378.

9.148 Mr. Cox explained his view that the program description is separate from the implementing procedures, and maintained that the details presented in the referenced documents (e.g. NSAC-202L) combined with the Entergy fleet-wide procedure EN-DC-315 composed a sufficiently-detailed FAC AMP. Tr. at 1365-1372. Mr. Cox showed how the information in NSAC-202L provides information such as frequency and timing of inspections, and that the information in EN-DC-315 is not significantly different. *Id.* at 1401. Thus, details of the FAC AMP are found though the LRA Appendix B and, by incorporation, NSAC-202L. *Id.* at 1402.

9.149 The Board asked Entergy's witnesses about the three areas where Riverkeeper alleged the AMP was insufficiently-detailed -- the inspection frequency, inspection method, and the repair/replacement criteria. Tr. at 1477.

9.150 Regarding inspection frequency, Mr. Cox explained that under the FAC program and following NSAC-202L, at every inspection cycle or refueling outage Entergy determines the remaining service life of components and establishes the next inspection date. Tr. at 1478. Notably Entergy does not establish an inspection frequency, but instead produces an inspection date. *Id.* 1479. Mr. Mew testified that the service life determination is done independently from CHECWORKS™, and is based on measured values rather than CHECWORKS™ calculations. *Id.* at 1479-1480.

9.151 Entergy's witnesses described the methods and noted that the ASME Code must be followed where appropriate. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 41. As to inspection method, EN-DC-315, section 5.5 "NDE Test Methods and Documentation" states

"Components can be inspected for FAC wear using ultrasonic testing (UT), radiography testing (RT), visual observation or other approved methods." EN-DC-315, Rev. 6 (Ex. ENT000038) at 20.

9.152 As to repair/replacement criteria, Entergy's witnesses describe how the criteria are provided in NSAC-202L and EN-DC-315. Tr. at 1477. The criteria are based on calculated critical thicknesses and steps to assure that components are repaired or replaced within the limits. Tr. at 1482-1483. Entergy's witnesses testified that the repair/replacement service life calculations are done in accordance with specific procedures and guidelines. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 53 (citing, inter alia, EN-CS-S-008-MULTI, Revision 0, “Pipe Wall Thinning Structural Evaluation” (Jan. 1, 2010) (Ex. ENT000065)).

9.153 Entergy's procedure EN-DC-315, section 5.13 "Repair/Replacement of Degraded Components" (Ex. ENT000038) requires, inter alia, that Entergy follow its ASME Section XI Repair and Replacement Program for Class 1, 2, and 3 piping and components.

v. <u>The Staff Asserts the Level of Detail is Sufficient</u>

9.154 The Board noted that the LRA is very similar to the GALL Report, essentially repeating back the GALL Report, and inquired about putting in more site-specific detail into the LRA. Tr. at 1722- 1724. The Staff's witness Dr. Hiser explained that in the Staff's view more information in the LRA was not needed because the Staff would perform an AMP audit to verify if a program was consistent with the GALL Report. *Id.* at 1724. Indeed, the Staff had audited Entergy’s existing FAC Program and found Entergy’s approach to be consistent with the approved regulatory guidance. Staff testimony on RK-TC-2 (Ex. NRC000121) at 27-29.

9.155 According to the Staff's witnesses Dr. Hiser and Mr. Yoder, the details available on the FAC Program, as described in Riverkeeper’s exhibits, are sufficient to demonstrate that the effects of FAC will be managed during the period of extended operation. Staff testimony on RK-TC-2 (Ex. NRCR000121) at 7.

9.156 With respect to the LRA, the Staff found the details available on the FAC Program, as described in Riverkeeper's exhibits, are sufficient to demonstrate that the effects of FAC will be managed during the period of extended operation. Staff Testimony on RK-TC-2 (Ex. NRC000121) at 7.

9.157 In its SER, the NRC Staff specifically reviewed Entergy's claims regarding its existing FAC Program and found that all the program elements conform to the criteria in the NUREG 1801, AMP XI.M17, and that the program is effective in managing FAC at the plant. SER (Ex. NYS00326B) at 3-21 to 3-31. Based on this review, the Staff concluded that Entergy had demonstrated that the effects of aging for FAC will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the PEO. SER (Ex. NYS00326B) at 3-31.

9.158 The Staff's witnesses testified that substantial details of the FAC programs had already been provided by the licensees outside of the license renewal process. Staff testimony on RK-TC-2 (Ex. NRCR000121) at 10. Nonetheless, the historical information was reviewed by the Staff. *Id.* at 13.

9.159 It is sufficient for an applicant to state that its AMP is comparable to NUREG-1801 in order to demonstrate that the effects of aging will be managed for the PEO, because, as described in the SRP-LR, the Staff conducts an audit and review at the Applicant's facility to evaluate AMPs that the Applicant claims to be consistent with the GALL Report. *See* SRP-LR Rev. 1 at 3.0-3 (Ex. NYS000195); Staff testimony on RK-TC-2 (Ex. NRC000121) at 27.

9.160 Rebutting Riverkeeper's assertion that detailed information was missing, the Staff specifically notes that Riverkeeper itself submitted a variety of exhibits containing a significant amount of detailed information concerning FAC, the NRC's historic actions, how industry addressed FAC, and how Entergy in particular addresses FAC. Among the exhibits Riverkeeper provided are Entergy's controlling procedure for its FAC program (EN-DC-315, Rev. 3, Flow Accelerated Corrosion Program (March 1, 2010) (Ex. RIV000015)), copies of historic NRC

generic communications on FAC (e.g., (NRC Bulletin 87- 01, Thinning Pipe Walls in Nuclear Plants (July 9, 1987) (Ex. RIV000007)), and industry's current guidance (e.g., Electric Power Research Institute (EPRI), Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L-R3 (Ex. RIV000012). Staff testimony on RK-TC-2 (Ex. NRCR000121) at 7-8.

9.161 Regarding EN-DC-315 in particular, the Staff describes this procedure as providing detailed criteria and methodology for selecting components for inspection, performing inspections, evaluating inspection data, disposition of results, sample expansion requirements, piping repair/replacement criteria, program responsibilities, and documentation requirements. Staff testimony on RK-TC-2 (Ex. NRCR000121) at 20-21.

9.162 According to the Staff, Inspection Frequency is addressed in Section 5.10 ("Re-Inspection Requirement"); Component Replacement and Repair Criteria are in several sections including Sections 5.9 ("Disposition of Inspection Results"), 5.11 ("Components Failing to Meet Initial Screening Criteria") and 5.13 ("Repair/Replacement of Degraded Components") of EN-DC-315. Staff testimony on RK-TC-2 (Ex. NRCR000121) at 25-26.

9.163 The Staff highlights that EN-DC-315 itself refers to additional detailed procedures including: ENN-EP-S-005 ("Flow Accelerated Corrosion Component Scanning and Gridding Standard"), EN-CS-S-008 ("Pipe Wall Thinning Structural Evaluation"), CEP-NDE-0505 ("Ultrasonic Thickness Examination"), and EN-LI-102 ("Corrective Action Process"). Staff testimony on RK-TC-2 (Ex. NRCR000121) at 21 (discussing EN-DC-315 at 28 (Ex. RIV000015)).

9.164 The Staff witnesses testified that the Staff's Audit Report for Plant Aging Management Programs and Reviews, Indian Point Nuclear Generating Unit Nos. 2 and 3, (January 13, 2009) (Ex. ENT00041) ("AMP Audit Report") documented reviews of EN-CS-S-008 and CEP-NDE-0505. Staff testimony on RK-TC-2 (Ex. NRCR000121) at 20-21 (citing AMP Audit Report at 13 (Ex. ENT00041)).

9.165 The Staff's witnesses point out that neither Dr. Hopenfeld nor Riverkeeper acknowledge that each of the topics that Dr. Hopenfeld identifies as needing more information or detail are, in fact, addressed in the Entergy corporate FAC Program EN-DC-315, which Riverkeeper itself supplied as Exhibit RIV000015. Staff testimony on RK-TC-2 (Ex. NRCR000121) at 25.

9.166 The Staff witness Dr. Hiser explained that the GALL FAC AMP, i.e. Program XI.M17, has sufficient information and the needed level of detail. Tr. at 1385, 1386. Dr. Hiser went on to explain that during the Staff's Audits performed at IPEC, the Staff has the opportunity to review site procedures, and had, in fact reviewed EN-DC-315. *Id.* at 1386, 1387.

9.167 Dr. Hiser viewed adding additional details to the LRA as "inadvisable" because the Staff wanted the FAC AMP to be a "living program" that can respond to new information. Tr. at 1389.

9.168 Dr. Hiser noted that changes to the program would be subject to review as part of the NRC's routine oversight process. *Id.* at 1390.

vi Riverkeeper Acknowledges Some Details are Available

9.169 During the hearing, the Board noted that RK-TC-2, as admitted, asserted that the AMP did not identify the inspection frequency, inspection method, and the repair/replacement criteria. Tr. at 1477. In light of the extensive level of details containd in the evidentiary record, the Board asked Riverkeeper's witness Dr. Hopenfeld about the level of detail, in particular with the information on the GALL elements of inspection frequency, inspection methods, and repair and replacement criteria. *See.* Tr. at 1492.

9.170 Dr. Hopenfeld admitted that Entergy's program included or defined processes for inspection frequency, inspection methods, and repair or replacement criteria. Tr. at 1494, 1495 (stating at tr. at 1495 "I agree there's a general framework. The verbiage is generally correct.").

vii. Board Findings on Level of Detail

9.171 The Board finds the level of details with respect to the challenged areas of inspection frequency, inspection methods, and repair and replacement criteria to be sufficiently-incorporated into the LRA by reference.

9.172 Through incorporation by reference, the elements of the FAC Program are readily apparent and available for audit by the Staff.

9.173 The Board finds that EPRI's NSAC-202L, along with Entergy's corporate FAC program and procedures supply sufficient specificity – including detailed instructions on how inspections should be conducted, how the inspection data should be evaluated, acceptance criteria for inspection components, criteria for the disposition of components failing to meet acceptance criteria, sample expansion criteria, and instructions for incorporating inspection data into the CHECWORKS™ model – to met the demonstration requirement of 10 C.F.R. § 54.21(a)(3).

9.174 The Board notes that the FAC corporate procedure EN-DC-315 has been revised at least six times since inception, and the Board agrees with the Staff that including a living multi-site procedure with a specific licensing request can be inadvisable, in that it hinders the ability of new information to be incorporated into the procedure.

9.175 The Commission consistently finds that a license renewal applicant who commits to implement an AMP that is consistent with the corresponding AMP in the GALL Report has demonstrated reasonable assurance under 10 C.F.R. § 54.29(a) that the aging effects will be adequately managed during the period of extended operation. Nextera Energy Seabrook, LLC (Seabrook Station, Unit 2), CLI-12-05, __ NRC __, __, (March 8, 2012) (slip op. at 18) (citing *Vermont Yankee*, CLI-10-17, 72 NRC at 36; *Oyster Creek*, CLI-08-23, 68 NRC at 467-68). The Board's finding is consistent with this controlling Commission precedent.

c. CHECWORKS™, Uprates, Calibration, and Benchmarking

9.176 The Board admitted contention RK-TC-2 in part to determine if Entergy's program relies on the results from CHECWORKS™ without benchmarking or a track record of performance at IPEC's power uprate levels. *Indian Point*, LBP-08-13, 68 NRC at 177. The Board did not view the contention as a challenge to the use of CHECWORKS™ model, but instead, in the Board's view, the contention "questions the sufficiency of the benchmarking needed to provide valid results at IPEC once the plant parameters changed with the 3.26% and 4.85% power uprates during 2004 and 2005." *Id.* at 176-177.

i. Entergy Asserts CHECWORKS™ Performs at Power Uprated CLB

9.177 Entergy's witnesses testified that Entergy had updated the IP2 and IP3 CHECWORKS™ models to include power uprate operating parameter changes (*e.g.*, flow rates and operating temperatures). Entergy testimony on RK-TC-2 (Ex. ENTR00029) at 62. Entergy provided the exact date when this was done: March 23, 2005. *Id*. (citing Indian Point Unit 2, CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 (Mar. 23, 2005) (Ex. ENT000072); Indian Point Unit 3, CHECWORKS Power Uprate Analysis, Calc. No. 040711-01 (Mar. 23, 2005) (Ex. ENT000073); NRC Audit Report (Ex. ENT000041) at 15).

9.178 Regarding model inputs, Indian Point Unit 2 CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 states:

> This calculation documents the revision of the Indian Point Unit 2 CHECWORKS model to predict Flow-Accelerated Corrosion (FAC) wear rate changes due to Stretch Power Uprate (SPU). The Indian Point Unit 2 SPU will change feedwater and steam flow rates, temperatures, and enthalpies, which in turn change local chemistry values. All of these factors affect wear rates due to FAC. As a result of the uprate, some lines will experience accelerated rates of FAC, while others will have reduced rates. The impact on each line depends on the complex interaction of changes in flow rate, pressure, temperature, enthalpy, steam quality, and chemistry on the FAC degradation mechanism.
>
> Indian Point 2 had previously developed a CHECWORKS model of FAC-susceptible piping. However, the previous model did not address the changes that will result from Appendix K Uprate and

> Stretch Power Uprate. This calculation details the process required to revise the CHECWORKS model so that it correctly reflects all plant power levels (the original power level, Appendix K Uprate, and Stretch Power Uprate). Also documented are the changes in FAC wear rates due to the SPU.
>
> Note that historical (Pre-uprate and Appendix K Uprate) operating conditions remain within the model, associated to the applicable operating cycles. The SPU operating conditions are associated to the calendar time that those conditions are scheduled to occur, starting in Cycle 17 [7.3.1] [sic]. In this way, the model's predictions of total current and future wear will be as accurate as possible because the predictions will be based on both historical and expected future operating conditions.

Indian Point Unit 2, CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 (Mar. 23, 2005) (Ex. ENT000072) at 2.

9.179 Entergy revised the Indian Point Unit 3 CHECWORKS™ model to predict Flow-Accelerated Corrosion (FAC) wear rate changes due to Stretch Power in the same manner as Unit 2. E.g. Compare Indian Point Unit 3, CHECWORKS Power Uprate Analysis, Calc. No. 040711-01 (Mar. 23, 2005) (Ex. ENT000073) at 2 with Indian Point Unit 2, CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 (Mar. 23, 2005) (Ex. ENT000072) at 2 (both provide similar discussion on the modeling updates).

9.180 Thus, by the time the period of extended operation (PEO) arrives, Entergy's witnesses predict that four post-uprate Unit 2 refueling outages and five post-uprate Unit 3 refueling outages will have occurred, all with CHECWORKS™ being used as part of the CLB. Entergy Testimony on RK-TC-2 (ENTR00029) at 63.

9.181 Entergy disagrees that any special extended benchmarking must be used following an uprate because a fundamental purpose of CHECWORKS™ is to allow a user to predict the impacts from changes in plant parameters, such as operating conditions including water chemistry. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 85. Entergy notes that wear rate algorithm in CHECWORKS™ uses well-know principles from fluid mechanics. *Id.*

9.182 Mr. Aleksick testified that the CHECWORKS™ model was revised to account for the power uprate conditions. Tr. at 1747. The revisions accounted for new temperatures, flow rates, and chemistry conditions. *Id.*

9.183 The CHECWORKS™ FAC Model discusses the "Heat Balance Diagram" and the "Plant Power Level Data," and indicates that the 104.48% power information was used. Calculation No. 050714b-01, Revision 0 Calculation, at 7 of 31 (July 5, 2005) (page 8 of 278 in ENT000074). With respect to specific CHECWORKS inputs, the change from 100% to 104.48% power resulted in the following changes to CHECWORKS input fields:

> Steam Rate increased from 13.205620 Mlb/hr to 13.903750 Mlb/hr
>
> Pressure increased from 754.0 pisa to 765.0 psia
>
> Temperature increased from 511.4 F to 513.1 F.

9.184 Calculation No. 050714b-01, Revision 0, Appendix C, page C-2 of 8 (page 45 of 278 in ENT000074).

9.185 Entergy's exhibits show how Entergy quantified the effect of the power uprate on FAC. For example, Section 5.7. "Quantify Effect of Stretch Power Uprate" of one of Entergy's calculations stated:

> An analysis was performed to calculate the change in CHECWORKS predicted wear rates due to the SPU conditions. Wear Rate Analysis was performed for two periods representing the original power level and the SPU power level. The water treatment for these two periods was modeled as identical, so wear rate changes are due to SPU conditions only. In both cases, Wear Rate Analysis was performed using Pass 2 methods, where predictions are calibrated to inspection history.
>
> The analysis obtained both actual results and percentage differences for representative components and lines so that detailed comparisons could be made. The analysis was limited to non-Chromium containing components only, so average values would not be skewed by these components. In addition the changes due to SPU for some of the dominant parameters affecting FAC wear rates (temperature, steam quality, and flow rate) were determined.

Indian Point Unit 2, CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 (Mar. 23, 2005) (Ex. ENT000072) at 16.

9.186 The Unit 2 calculation also included an analysis on a sample of some of the components in the model most susceptible to FAC, with a Pass 2 Wear Rate Analysis performed at the pre-uprate, original power level and the SPU power level. Indian Point Unit 2, CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 (Mar. 23, 2005) (Ex. ENT000072) at 17 (stating the results of the analysis are in Appendix B of the calculation).

9.187 Additionally, the Unit 2 calculation included an analysis comparing steam cycle level changes in wear rate predictions due to the SPU. CHECWORKS Power Uprate Analysis, Calc. No. 040711-02 (Mar. 23, 2005) (Ex. ENT000072) at 17 (stating the results of the analysis are in Appendix C of the calculation).

9.188 Regarding the post-outage predictions, Entergy saw very small predicted changes in wear rates associated with the uprates, with changes in wear rates on the order of one to four mils out of typical ten to thirty mils per year wear rates. Tr. at 1748.

9.189 Entergy's witnesses testified that comparison of the measured wear and CHECWORKS™ model-predicted wear indicates a level of correlation following the uprates consistent with the level of correlation at IPEC before power uprates. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 87. Mr. Aleskick estimated that, based on about 100 inspections per refueling outage, there are around 400 post-power uprate inspections. Tr. at 1746.

9.190 Entergy's witness testified that a review of CHECWORKS™ predictions on twenty-two plants that had power increases of up to 20% shows that the CHECWORKS™ predictions reasonably matched the inspection findings. *Id.* at 86-87 (citing EPRI, Plant

Engineering: Impact of Electric Power Uprates on Flow-Accelerated Corrosion (July 2011) (Ex. ENT000081)).[51]

9.191 Dr. Horowitz testified that CHECWORKS™ is used at more than 150 nuclear power plants. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 89. Mr. Azevedo testified that his experience with approximately twenty uprate models showed him that CHECWORKS continues to be effective post-uprate. *Id.*

9.192 In response to Dr. Hopenfeld's attempts to distinguish Vermont Yankee (VY) from IPEC by asserting that that the IPEC FAC program relies integrally on CHECWORKS™, Entergy's witnesses explain that between one-quarter and one-third of inspection locations are based on CHECWORKS™. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 94. This is consistent with VY. *Id.* Entergy's witnesses described how the same processes and procedures (e.g. EN-DC-315) are used at all Entergy plants as part of the FAC program. *Id.* at 90. Entergy's witnesses further describe how Dr. Hopenfeld had unsuccessfully raised the same challenges to the same procedures at Entergy's Vermont Yankee plant. *Id.* at 90-91. In response to Dr. Hopenfeld's attempts to distinguish IPEC from VY based on design differences including power and flow rates, Entergy's witnesses explain why such matters are considered at the design of the plants. *Id.* at 91.

9.193 Entergy's witness Dr. Horowitz explained that the calibration process is defined and described in NSAC-202L. Tr. at 1743. Entergy's witnesses testified:

> Consistent with NSAC-202L-R3 and with EN-DC-315, CHECWORKS predictions are compared with measurements at each individual plant. Whether this process is called “refinement” or “calibration” or “benchmarking” is a matter of semantics.

Entergy testimony on RK-TC-2 (Ex. ENTR00029) at 85-86.

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[51] Dr. Hopenfeld dismisses this study for not including Indian Point. RIVR0008 at 32. The Board disagrees with Dr. Hopenfeld, and finds that Entergy appropriately considered the performance of CHECWORKS at other sites though ENT000081.

9.194 As Mr. Aleksick described Entergy's calibration is consistent with NSAC-202L, and considers five criteria. Tr. at 1751-1752.

9.195 Mr. Aleksick stated that typically the inspections performed during outages produce around one hundred sets of data for components, and the data sets include wall thickness measurements which are then used in the CHECWORKS™ programs to assist in adjusting or calibrating the "Line Correction Factor" thereby refining the predictions. Tr. at 1744, 1245.

9.196 Mr. Aleksick testified that about two thirds of the lines are calibrated. Tr. at 1755. With respect to lines or components which are not yet "calibrated," determinations to reinspect are based purely on thickness measurements. Tr. at 1753.

ii. The Staff Asserts CHECWORKS™ is Acceptable for Power Uprates

9.197 The Staff testified how, when considering Entergy's 2004 and 2005 requests for power uprates at Indian Point Units 2 and 3, Entergy's applications and the Staff's reviews had considered and approved the FAC Program for the "uprated" powers. Staff Testimony on RK-TC-2 (NRCR00121) at 29-30. As an example of how the FAC program at higher power levels was already part of the CLB, the Staff noted that analyses contained in WCAP-16212-NP, *Indian Point Nuclear Generating Unit No. 3 Stretch Power Uprate NSSS and BOP Licensing Report* (June 2004) (Ex. NRC000129) ("WCAP-16212-NP"), Section 10.3 "Flow-Accelerated Corrosion Program, "described how the power uprate would result in changes in fluid flow velocities and temperatures in several plant systems, the Main Feedwater and Condensate System, Heater Drains System, Main Steam System (MSS), Extraction Steam System (ESS), and Steam Generator Blowdown System (SGBS). Staff testimony on RK-TC-2 (Ex. NRCR00121) at 29.

9.198 Nonetheless, during the license renewal review, the Staff requested that had Entergy verify that inputs to the IP2 and IP3 FAC Programs were updated to include the stretch power uprate (SPU) operating parameter changes (e.g., flow rates and operating temperatures),

and that the programs to incorporated the results of previous wall thickness measurements into the CHECWORKS modeling to allow for updated FAC-induced wear rate predictions. Staff testimony on RK-TC-2 (Ex. NRCR00121) at 34.

9.199 The Staff's witnesses Dr. Hiser and Mr. Yoder testified that the higher power levels of IP2 and IP3 have been part of the current licensing basis (CLB) since October 27, 2004, for Unit 2 and since March 24, 2005, for Unit 3, upon issuance of the license amendment for each unit. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 7.

9.200 According to the Staff, the changes in maximum licensed thermal power IP2 and IP3 were relatively small, resulting in very small changes to the operating parameters that influence FAC. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 34 (citing SER (Ex. NYS00326B) at 3-25 to 3-29).

9.201 The Staff witnesses testified that the FAC Program and the implementation of CHECWORKS™ at Indian Point were important parts of the NRC approval of the power uprate and associated change to the licensing basis for both IP2 and IP3. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 34. Notably, for example, the Unit 3 power uprate license amendment request was in part supported by analyses contained in WCAP-16212-NP, Indian Point Nuclear Generating Unit No. 3 Stretch Power Uprate NSSS and BOP Licensing Report (June 2004) (Ex. NRC0000129) ("WCAP-16212-NP"). Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 29. Section 10.3, "Flow-Accelerated Corrosion Program," of WCAP-16212-NP described how the power uprate would result in changes in fluid flow velocities and temperatures in several plant systems, the Main Feedwater and Condensate System, Heater Drains System, Main Steam System (MSS), Extraction Steam System (ESS), and Steam Generator Blowdown System (SGBS). *Id.* This section of the report stated that evaluations of the impact of the power uprate on FAC for the piping in these systems was performed, and that the CHECWORKS™ models will be updated to incorporate flow and thermal performance data at the power uprate conditions. *Id.*

9.202 The witnesses explained that during the LRA review, the Staff re-reviewed and re-read the technical information concerning FAC. Tr. at 1713, 1714. However, the Staff did not, as part of the LRA review, review "in gory detail" the FAC Program itself because the program is a long-standing program that has been subject to previous reviews including responses to a generic letter, and consideration during the power uprate reviews. Tr. at 1715-1716. Nonetheless, the Staff performed a full detailed audit of the FAC AMP, as described in the pre-filed written testimony and the Staff's SER. Tr. at 1717-1718. The Staff directly considered power uprates, and was satisfied with that prolonged benchmarking claimed by Riverkeeper was not necessary. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 34, 35.

9.203 With respect to Riverkeeper's claims regarding benchmarking, the Staff testified that the CLB of IP2 and IP3, which allows use of CHECWORKS™ at the current licensed power levels, is the root of Riverkeeper's concerns. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 30. In the Staff's view, the underlying claim of inadequate benchmarking would still exist even if Entergy never requested to renew its licenses, and is not part of license renewal. *Id.* In the Staff's view, Riverkeeper provides no discussion of the power uprate LARs, and also fails to identify any unique aging effect associated with Riverkeeper's concerns. *Id.* at 31.

9.204 In essence, according to the Staff, Riverkeeper should have raised its concern with the uprates and CHECWORKS™ at the time the uprates were being considered (i.e. 2004 and 2005), because by trying to raise the issues in the LRA, Riverkeeper is challenging the CLB. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 31-32. Riverkeeper's provided no evidentiary support (other than Dr. Hopenfeld's report and testimony) to support Riverkeeper's claim that CHECWORKS™ cannot be used because it hasn't been properly calibrated to reflect power uprates granted in 2004 (for Unit 2) and 2005 (for Unit 3). Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 8. The Staff states that Riverkeeper never discusses the power uprate license amendment requests beyond acknowledging that they happened and that, as a

consequence and in their view, CHECWORKS™ must be benchmarked for 10-15 years before it can be used. Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 31.

9.205 As for CHECWORKS™ performance post-uprate, Dr. Hiser and Mr. Yoder believe that CHECWORKS™ is performing as-expected, and described its performance as "reasonably good." Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 35.

9.206 The Staff's testimony also uses "benchmarking" as synonymous with "calibration." Specifically, the Staff testified:

> CHECWORKS™ is “calibrated” for the plant by adding plant-specific data from actual physical inspection data from components, developed over the course of several inspections. This calibration process is sometimes called “self-benchmarking.” The calibration evaluates a line correction factor for a given line, which is used to adjust wear rate predictions in a given line to account for plant operating conditions that may vary with time. The line correction factor is determined by comparing the predicted wear to the measured wear at locations in the line which have been inspected.

Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 15.

9.207 The Staff testified that Entergy is following NSAC-202L-R3 (Ex. RIV000012). Staff Testimony on RK-TC-2 (Ex. NRCR00121) at 21.

iii. Riverkeeper Challenges CHECWORKS™ as Unusable

9.208 Dr. Hopenfeld's report described how CHECWORKS™ was developed to assist utilities in planning inspections and evaluation the inspection data to prevent piping failures caused by FAC. *Report of Dr. Joram Hopenfeld in Support of Contention Riverkeeper TC-2 Flow Accelerated Corrosion* (Dec. 21, 2011) (Ex. RIVR00005) (“Hopenfeld Report”) at 2-3. He notes that CHECWORKS™ has been in use since the early 1990s, and at IP Units 2 and 3 since at least 2000 - 2001. *Id.* at 5.

9.209 Dr. Hopenfeld's report states that it is important to update CHECWORKS™ with any power uprate data. *Id.* at 4. He acknowledges that Entergy has been using

CHECWORKS™ both before and after the uprates of 2004 and 2005 for IP2 and IP3 respectively. *Id.*

9.210 But Dr. Hopenfeld, in his report, alleges that there is currently no track record of performance of the CHECWORKS™ code at Indian Point, as the model has not been able to detect FAC before component wall thickness fall below minimum design requirements, and Entergy's use of CHECWORKS™ violates the ASME code and poses safety concerns. *Id.* at 18. Dr. Hopenfeld asserts that the facts plainly show that CHECWORKS™ has a demonstrable history of failing to prevent FAC at nuclear power plants. *Id.* at 16.

9.211 Riverkeeper's witness Dr. Hopenfeld originally testified that, based on his review of 6,500 data points from ten outages, both before and after power uprates, CHECWORKS™ was not properly calibrated. Riverkeeper Testimony on RK-TC-2 (Ex. RIV00003) at 5-7. Dr. Hopenfeld states that the only way to demonstrate that CHECWORKS is "recalibrated" after the power uprates is to compare CHECWORKS™ predictions with actual measured component thicknesses. Hopenfeld Rebuttal (Ex. RIV000108) at 31. He believes that CHECWORKS is not "recalibrated" because, both before and after the minor power uprates, "approximately 50% of the data points are non-conservative." *Id.* at 31.

9.212 Dr. Hopenfeld's testimony (Ex. RIV00003) and supporting report (Ex. RIVR00005) did not describe or discuss any specifics changes in flow rates, pressures, water chemistry, temperature, etc., associated with the uprates. Similarly, Dr. Hopenfeld was silent on any associated changes in how FAC needed to be managed differently due to an uprate.

9.213 Riverkeeper's witness Dr. Hopenfeld refers synonymously to "benchmarking" and "recalibration" Hopenfeld Rebuttal at 31 (Ex. RIV0000108) ("the CHECWORKS code is not adequately benchmarked, despite years of continuous recalibration"); *see* also Hopenfeld Report (Ex. RIVR00005) at 25 ("documents imply that CHECWORKS should be properly benchmarked or calibrated"). Dr. Hopenfeld states that he does not know the difference between calibrating and benchmarking. Tr. at 1728.

9.214 Dr. Hopenfeld does not directly address calibration in the terms used by NSAC-202L-R3 (Ex. RIV000012) (i.e. in terms of Calibrated Analysis Line).

9.215 Regarding the first criterion needed for a *Calibrated Analysis Line*, i.e. that the physical parameters of the lines being modeled be similar, Riverkeeper presented no evidence this was not being done. As for the second criterion, that a *Calibrated Analysis Line* has at least at least five inspected components meeting threshold lifetime wear, Riverkeeper similarly cites no contrary examples.

9.216 The third criterion is that a Calibrated Analysis Line should have a LCF of between 0.5 and 2.5, with the caveat that a value somewhat outside of this range can be accepted if the reason for is well understood, documented, and a minimum of ten inspected components exist in the Analysis Line. On this factor, Dr. Hopenfeld acknowledges that Entergy is using the LCF range criterion, although he questions the basis for 0.5 to 2.5.[52] Report of Hopenfeld (Ex. RIVR00005) at 8.

9.217 The fourth criterion is that, for a Calibrated Analysis Line, a plot of predicted wear to measured wear shows a reasonably tight cluster of data along the 45° line. Dr. Hopenfeld recognizes that Energy is performing this step. Report of Hopenfeld (Ex. RIVR00005) at 6. However, when Dr. Hopenfeld reviews the plots, his view is that the data are widely-scattered. Report of Hopenfeld (Ex. RIVR00005) at 6. But Dr. Hopenfeld fails to link his view on data scatter with any actual decision made by Entergy to call a line "Calibrated." Dr. Hopenfeld instead attempts to argue that CHECWORKS™ is flawed because it made "non-conservative predictions about 40-60% of the time." Report of Hopenfeld (Ex. RIVR00005) at 6.

9.218 The fifth and last criterion for a Calibrated Analysis Line is that the Predictive Plant Model includes the inspection data of the most recent outage. Riverkeeper has identified no overlooked data; to the contrary, Riverkeeper's exhibits show how inspection data were used

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[52] Dr. Horowitz testified that that the LCF criterion has existed since 1989 and has not been challenged. Tr. at 1754. Riverkeeper has not explained why the LCF values are incorrect.

in the IPEC CHECWORKS™ FAC program and showed that Entergy updated the calculations with new outage information. For example, Indian Point Unit 2 CHECWORKS FAC Model Calculation No. 050714b-01 stated:

> This report uses plant design and operation information to document the CHECWORKS model for IP2. It documents the CHECWORKS Pass 1 analysis to generate a wear rate prediction for every piping component modeled in CHECWORKS. Component inspection data through the Refuel Outage 16 was imported to the model where available. A Pass 2 analysis was performed on all lines to provide wear predictions calibrated to the inspection data, as well as remaining lives based upon measured wear rates for inspected components. The results of these analyses can be used to select components for inspection in order to mitigate pipe deterioration due to FAC.

Calculation No. 050714b-01, Revision 0, at 2 (page 53 of 181 in RIV00016A).

9.219 Riverkeeper's exhibits also showed that Entergy revised the calculation using data from the next refueling outage (i.e. from Refuel Outage 17). Calculation No. 050714b-01, Revision 1, at 2 (page 86 of 181 in RIV00016A). Entergy similarly used inspection data from Refuel Outage 18. Indian Point Unit 2 CHECWORKS SFA Model, Calculation No. 0705.101-01, Appendix A, Revision 1, at 2 (page 160 of 181 in RIV00016A).

9.220 Riverkeeper does not address the alternative factor though which a line may be considered "calibrated" (e.g. ten inspected components with little to no wear).

9.221 The Board directly asked Dr. Hopenfeld if benchmarking was still an issue. Tr. at 1727. Dr. Hopenfeld responded by stating that benchmarking isn't an issue because it is impossible to benchmark CHECWORKS™. *Id.* at 1727-1733.

9.222 The Board inquired if Dr. Hopenfeld was challenging the use of CHECWORKS™ at all plants, and Dr. Hopenfeld stated that he believes the same problems with CHECWORKS™ exist at all plants, although he did not have access to data from all plants. Tr. at 1730-1733. Dr. Hopenfeld testified that he does not know how to benchmark CHECWORKS™. Tr. at 1729 & 1737-1738.

9.223 According to Dr. Hopenfeld, another 10 or 20 years of data collection would not be sufficient to benchmark CHECWORKS because CHECWORKS™ is fundamentally-flawed. Tr. at 1738.

9.224 The Board asked Dr. Hopenfeld if he observed any accelerated wear rates beyond those already reported by Entergy after the power uprates. Tr. at 1755. Dr. Hopenfeld testified that he could not tell any difference. Tr. at 1755. He stated that the uprate was not "huge" and that the change in velocity was not huge. *Id.* He maintained that CHECWORKS™ has not been calibrated after twenty years of service and cannot be calibrated. *Id.*

9.225 Dr. Hopenfeld is aware that the Board found his position not sustainable in *Vermont Yankee*, but asserted that key differences in changes in flow velocity, plant geometry, etc., combined with historical data differentiated IPEC from *Vermont Yankee. Id.* at 8-9; Report of Hopenfeld (Ex. RIVR00005) at 19-20. Dr. Hopenfeld did not elaborate on the key differences by providing any specific values with supporting explanations.

iv. Board Findings on CHECWORKS™ and Power Uprates

9.226 The Board finds, by undisputed evidence, that as of March 23, 2005, Entergy updated the inputs to CHECWORKS™ for both Unit 2 and Unit 3 with the uprate data which were also the CLB.

9.227 Contention RK-TC-2 in part asserts that Entergy's program relies on the results from CHECWORKS™ without benchmarking or a track record of performance at IPEC's power uprate levels. *Indian Point*, LBP-08-13, 68 NRC 43, 177 (2008). In admitting Contention RK-TC-2, the Board explicitly stated that it did not view the contention as challenging the use of CHECWORKS™ model; the Board views RK-TC-2 as questioning "the sufficiency of the benchmarking needed to provide valid results at IPEC once the plant parameters changed with the 3.26% and 4.85% power uprates during 2004 and 2005." LPB-08-13, 68 NRC 43, 176-177 (2008). Thus, the Board did not intend that the RK-TC-2 could become a wholesale challenge to the existing current licensing basis, which includes CHECWORKS. Entergy's current usage

of CHECWORKS is not litigable before this board, notwithstanding Dr. Hopenfeld's numerous claims that CHECWORKS is not and will never be benchmarked at IPEC, and is non-conservative half the time. *See* Rebuttal Hopenfeld (Ex. RIV000108) at 30-34. Thus, the Board finds that all Riverkeeper's claims alleging that CHECWORKS™ failed to work historically are beyond the scope of the RK-TC-2 as admitted.

9.228 It is undisputed that the FAC Program is an existing program and part of the CLB (which includes the power uprates of 2004 and 2005). Insofar Riverkeeper's contention RK-TC-2 attacks the standards for the *current operations* at Indian Point, which include a CLB FAC Program and CLB usage of CHECWORKS™ at the uprated power levels, all evidence proffered to show that CHECWORKS™ can or cannot be used at the uprated powers is outside the scope of this proceeding. *See* Crow Butte Resources, Inc. (North Trend Expansion Area), CLI-09-12, 69 NRC 535, 553 (2009).

9.229 The Commission's regulations at 10 C.F.R. § 54.30 require that if the license renewal reviews reveal that there is not reasonable assurance during the current license term that licensed activities will be conducted in accordance with the CLB, then the licensee shall take measures under its current license to correct the issue. 10 C.F.R. § 54.30(a). Furthermore, the licensee's compliance with the obligation to address CLB deficiencies under its current license is not within the scope of the license renewal review. 10 C.F.R. § 54.30(a). Accordingly the Board finds that evidence proffered to show that CHECWORKS™ is or is not being used correctly at the uprated powers is outside the scope of this proceeding.

9.230 However, even if the Board was to consider Dr. Hopenfeld's claims against CHECWORKS™ usage, we find, based on the overwhelming evidence provided Entergy's witnesses, which included Dr. Horowitz, coauthor of CHECWORKS™, that no special post-uprate benchmarking is required to account for the power uprates of 2004 and 2005. We find that the CHECWORKS™ model is designed to handle new operating parameters that change with the uprated power level, and it is undisputed that Entergy used the used the uprated power

in its inputs into the CHECWORKS™ models. We find that CHECWORKS™ produced very small predicted changes across the 8000 modeled components post-uprate. We conclude that CHECWORKS™ is designed to predict the impact of changes in plant operating conditions and water chemistry.

9.231 Thus, the Board finds by overwhelming evidence that Entergy is following the calibration process described in NSAC-202L-R3 (Ex. RIV00012). The Board also finds that the processes and criteria by which a line becomes a "Calibrated" line is explicitly provided by NSAC-202L-R3 at 4-1 (Ex. RIV00012).

9.232 The Board finds that, by definition, an "Analysis Line" is "calibrated" or "benchmarked" under the following two circumstances:

> First, an "Analysis Line" is calibrated when it meets the criteria for 1) similarity of physical parameters, 2) at least five inspected components meeting threshold lifetime wear, 3) acceptable LCF with, if needed, at least 10 inspected components, 4) "reasonable" match predicted-to-measured wear, and 5) the Predictive Plant Model (i.e. CHECWORKS) includes the inspection data of the most recent outage.
>
> Second, an "Analysis Line" is "calibrated" even if, subsequent to at least 10 component inspections, little to no wear is detected; fewer than 10 component inspections are acceptable if certain trace alloy content measurements are completed.

9.233 The Board finds that, as used by NSAC-202L and EN-DC-315, there is no special definition of "calibrated" or "benchmarked" applicable to CHECWORKS™ in isolation. While CHECWORKS™ must include the inspection data from the most recent outage when CHECWORKS™ is used to "calibrate" an FAC Analysis Line, the mere act of including the data is just one factor into the determination of whether or not an Analysis Line may be called "calibrated."

9.234 The Board finds that the New/Calibrated/Non-Calibrated status of a line is used to guide selection of the line for additional FAC Analysis.

9.235 The Board finds that FAC analyses may be performed on a line regardless of the New/Calibrated/Non-Calibrated status of the line.

9.236 We find that CHECWORKS™ does not require inspection data from multiple outages to make these predictions. The undisputed evidence in EPRI's Plant Engineering: Impact of Electric Power Uprates on Flow-Accelerated Corrosion (July 2011) (Ex. ENT000081) confirms that CHECWORKS™ properly accounts for changes in FAC rates based upon changes in input parameters which themselves represent changes in plant power. While Riverkeeper's witness would have us disregard this comparative study, we find no evidence disputing the information in the study, nor information showing that the study cannot be applied to IPEC. As such, there is no need to benchmark CHECWORKS™ in any special manner in response to the 2004 and 2005 uprates.

9.237 We find that the CHECWORKS™ model was revised at the time of the power uprates in 2005 to account for the new operating conditions, temperatures, flow rates, and operating chemistry. We also find that CHECWORKS™ responded to the power uprate changes with changes in predicted wear rates. Thus, we find that, with respect to CHECWORKS™, Entergy adequately addressed the fact that the plants were authorized to run at slightly higher maximum power levels several years ago.

9.238 Dr. Hopenfeld has provided unsupported speculation that CHECWORKS™ must be calibrated further based on an illogical argument that CHECWORKS™ is defective for overpreditcing wall thicknesses half the time. Dr. Hopenfeld's argument seems to be that, because half the time the predictive model under predicts, and half the time it over predicts, the model is flawed. The Board finds to the contrary -- a model which is "non-conservative" 40-60% of the time is simultaneously conservative 40-60% of the time, and thusly is, on the average, a good predictive model. The Board finds Dr. Hopenfeld's claims that more calibration is needed particularly unpersuasive in light of Dr. Hopenfeld's admission (tr. at 1755) that he could not tell any differences in the wear rates when he contrasted pre-uprate data with post-uprate data.

9.239 Dr. Hopenfeld is vague and non-specific regarding how many outages (i.e. how many inspections) must occur for sufficient data to be gathered to complete calibration. We find this lack of specificity to be unpersuasive, especially when weighed against the testimony and evidence presented by Entergy concerning how the changes in plant parameters are immediate entered in to the CHECWORKS™ model. We also note that, assuming *arguendo* that some post-upate time was required to "calibrate" CHECWORKS™, a substantial number of years and inspection cycles have passed since the small uprates were authorized, and the associated inspection data sets have been entered into CHECWORKS™.

d. Overreliance on CHECWORKS™

9.240 Dr. Hopenfeld asserts that these other tools do not operate independently from CHECWORKS™ to manage FAC. Riverkeeper Testimony on RK-TC-2 (Ex. RIV000003) at 16. To the contrary, Dr. Hopenfeld asserted the tools "largely depend upon CHECWORKS." *Id.* at 13. The Board explored this further.

i. Entergy Views Reilance on CHECWORKS™ as Small and Acceptable

9.241 Entergy's witnesses testified that significantly, CHECWORKS™ is NOT used the for trending of actual measurements of pipe wall thicknesses from past outages. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 69.

9.242 Entergy's witnesses testified that IPEC (like other plants) follow the guidance in NSAC-202L to select inspection locations based on (1) the trending of actual measurements of pipe wall thicknesses from past outages; (2) predictive evaluations performed using the CHECWORKS™ computer code; (3) industry experience related to FAC; (4) results from other plant inspection programs; (5) engineering judgment; and (6) the susceptible-not-modeled (SNM) rankings. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 69 (citing EN-DC-315 at 17-18 (Ex. ENT000038)).

9.243 Section 4.4 of "Recommendations for an Effective Flow-Accelerated Corrosion Program" (NSAC-202L-R3) (May 2006) (Ex. RIV00012), at 4-5 to 4-6, lists seven factors to

consider when an licensee selects components for inspection under the FAC Program. These factors are:

> 1. Results of lines analyzed using the Predictive Plant Model.
>
> 2. Results of evaluations of lines that cannot be accurately analyzed in the Predictive Plant Model due to uncertain operating conditions. ...
>
> 3. Extrapolations of prior inspection results, commonly called “trending”.
>
> 4. Plant experience.
>
> 5. Operating experience.
>
> 6. FAC-susceptible equipment.
>
> 7. Engineering judgment.

Id. at 4-6.

9.244 Regarding the first factor for selecting locations for FAC analysis, inspection locations based on the Predictive Plant Model are considered for 1) new lines, 2) calibrated lines, and 3) non-calibrated lines. *Id.* at 4-6 to 4-7.

9.245 EPRI recommends that a proportionally-greater number of evaluations using the Predictive Plant Model be made for the "New Line" category. *Id.* at 4-6.

9.246 EPRI recommends that selections of inspection locations for "Calibrated Lines" concentrate on the lines with the highest "Pass 2" predicted wear and the shortest remaining service life. *Id.* at 4-7.

9.247 EPRI recommends that a proportionally-greater number of inspections for "Non-Calibrated Lines" as compared to "Calibrated Lines." *Id.*

9.248 Entergy's witnesses cited a number of examples of methods independent from CHECWORKS: Industry Operating Experience, including information from other inspection programs, can be independent from CHECWORKS™. Entergy Testimony on RK-TC-2 (Ex. ENTR00029) at 70. Engineering Judgment is independent from CHECWORKS™. *Id.* at 71.

9.249 The SNM rakings, in as much as they are concern lines not modeled in CHECWORKS™ are independent from CHECWORKS™. *Id.*

9.250 Overall, only about 22% of the susceptible lines at IP2 and 20% of the susceptible lines at IP3 are modeled in CHECWORKS™. *Id.* at 49. This is consistent with other PWRs. *Id.*

9.251 Entergy's witnesses addressed Dr. Hopenfeld's claims that Entergy lacked FAC Program tools which were independent of CHECWORKS. Entergy's witnesses explain that in fact over 75% of the FAC susceptible lines at IPEC are not modeled within CHECWORKS™. Entergy testimony on RK-TC-2 at 69. With respect to the FAC program, those lines are obviously "truly independent" of CHECWORKS™. *Id.*

9.252 Entergy's witness testified that at IPEC, between one-quarter and one-third of inspection locations are based on CHECWORKS™, as is clearly shown in documents Entergy has disclosed to Riverkeeper. Entergy testimony on RK-TC-2 (Ex. ENTR00029) at 94 (citing Scope of Flow-Accelerated Corrosion Inspection Points for 3R14 Outage (Apr. 2, 2007) (Ex. ENT000061)).

9.253 According to Mr. Aleksick, each outage Entergy inspects around 100 lines or components, and of those 100, half are previously-inspected, and half are newly-selected for inspection. Tr. at 1507. Half of the newly-selected were based on CHECWORKS™. Tr. at 1507. Thus, 25 of the 100 inspections are based on CHECWORKS™. Tr. at 1507. Mr. Aleksick described how, since 1992, the aggregate numbers of modeled components is 8000, and the number of components inspected is 3700. Tr. at 1508.

9.254 Thus, Entergy's witnesses conclude that CHECWORKS™ is only one of several independent tools and processes used at IPEC to assist Entergy in selecting component locations for inspection in order to avoid the potential adverse effects of FAC. It is used in conjunction with other sources of information, such as the trending of pipe wall thickness measurements from past inspections, industry operating experience related to FAC, data from

other plant inspection programs, condition reports, and engineering judgment. ENTR00029 at 108.

ii. The Staff Views Reliance on CHECWORKS™ as Acceptable

9.255 Regarding the clam that Entergy relies too much on the code, the Staff's witnesses explain that Entergy does not "over rely" on CHECWORKS™. Staff testimony on RK-TC-2 (Ex. NRCR00121) at 36-37.

9.256 The Staff points out that Section 5.3 of EN-DC-315, Rev. 3, “Preparation of Outage Inspection Plan,” describes how the FAC Engineer selects components for inspection and provides a list of 10 separate criteria of which only one is based on results from the CHECWORKS™ computer code. Staff testimony on RK-TC-2 (Ex. NRCR00121) at 36-37. The Staff's witnesses point to the Staff's SER at 3-26 (Ex. NYS00326A-F) in which the Staff documented its verification that the Applicant's revised program used the CHECWORKS™ program as one of several bases, along with IP2-specific and IP3-specific operating experience, operating experience discussed in NRC generic communications, industry operating experience records or reports, and engineering judgment for establishing which in-scope piping component locations should be scheduled for inspection at the next outage. *Id.* at 37.

iii. Riverkeeper's Revised View on the Level of Reliance

9.257 Dr. Hopenfeld testified that measurements of actual wall thicknesses are only useful with a predictive code, and, inasmuch as he believes CHECWORKS is not a predictive code, actual wall measurements must be disregarded. Riverkeeper Testimony on RK-TC-2 (Ex. RIV000003) at 13.

9.258 In response to claims by Entergy that it is trending data independently of CHECWORKS™, Dr. Hopenfeld assets this practice fails to meet the GALL Report, which contemplates CHECWORKS™, or a similar code, being used along with data. Hopenfeld Rebuttal (Ex. RIV000108) at 12.

9.259 Along that same vein, Dr. Hopenfeld asserts that actual pipe wall thickness, plant, and industry experience provide an insufficient basis for engineering judgment to be used as the FAC program. Riverkeeper Testimony on RK-TC-2 (Ex. RIV000003) at 14. Additionally, Dr. Hopenfeld claims that Entergy lacks the sufficient knowledge, skills, and data sets to use engineering judgment. *Id.* at 15.

9.260 Dr. Hopenfeld testified that Entergy's program is inconsistent with EPRI guidance because it *under-utilizes* a predictive code, such as CHECWORKS™. Rebuttal Hopenfeld (Ex. RIV0000108) at 11. Dr. Hopenfeld determined that, based on Entergy's testimony, the total CHECWORKS™ contribution to the FAC program is about 25%, with less than half of that amount being attributed to actual wear predictions and inspection schedules. Hopenfeld Rebuttal (Ex. RIV000108) at 10. Dr. Hopenfeld views this percentage as significant, and asserts that the FAC Program is therefore flawed. Rebuttal Hopenfeld (Ex. RIV0000108) at 11.

9.261 The Board noted that Dr. Hopenfeld testified repeatedly that CHECWORKS™ was non-conservative half the time. Tr. at 1597. Thus, The Board questioned Dr. Hopenfeld regarding how Dr. Hopenfeld's testimony on non-conservatism related to the claim of over-reliance on CHECWORKS™. Tr. at 1597. Dr. Hopenfeld acknowledged that only 6.25% of the FAC AMP will be attributed to non-conservative estimates from CHECWORKS™. Tr. at 1597. According to Dr. Hopenfeld, "it's really a small part of the whole program." Tr. at 1597.

9.262 Under questioning by The Board, Dr. Hopenfeld agreed that CHECWORKS™ is, in fact, not emphasized as the "main tool" for the FAC program. Tr. at 1597. In other words, "It's not the primary tool for inspection." Tr. at 1609.

iv. Board Findings on Overreliance

9.263 The Board finds that in the majority of the time, the FAC Program is operating independently from CHECWORKS™, and relies on other methods, including, for example, the trending of actual measurements of pipe wall thicknesses from past outages.

9.264 Entergy uses CHECWORKS™ for a small portion of the program -- approximately one quarter of the new inspection locations are based on CHECWORKS™.

9.265 Approximately one fifth of the susceptible lines are modeled in CHECWORKS™.

9.266 The Board also finds that, even if CHECWORKS™ was giving non-conservative information, that this information would impact less than 7% of the FAC Program.

9.267 The Board finds that Riverkeeper's claim that Entergy is over reliant on CHECWORKS™ is without merit.

IV. CONCLUSIONS OF LAW

9.268 The Board has considered all of the evidence presented by the parties on Contention RK-TC-2. Based upon a review of the entire record in this proceeding and the proposed findings of fact and conclusions of law submitted by the parties, and based upon the findings of fact set forth above, which are supported by reliable, probative and substantial evidence in the record, the Board has decided all matters in controversy concerning this contention and reaches the following conclusion.

9.269 The basic issues before this Board are whether Entergy has demonstrated: (1) that the effects of aging from FAC on the intended functions of the piping and components susceptible to FAC will be adequately managed for the PEO associated with the proposed license renewal as required by 10 C.F.R. § 54.21(a)(3) and (2) that there is reasonable assurance that the activities authorized by the renewed license will be in accordance with the requirements of the AEA and Part 54, as required by 10 C.F.R. § 54.29.

9.270 Based on the description of the program in the LRA and the testimony presented at the hearing, the Board finds that: (1) the AMP is sufficiently-detailed because Entergy will use its Existing FAC Program based on EPRI's NSAC-202L and implemented thought EN-DC-315, which will carry into the PEO as Entergy's FAC AMP. That program follows NUREG-1801, which, in turn, references the specific requirements of the power industry recommendations presented in EPRI's NSAC-202L, all of which discuss, at length, the details of how FAC is

managed; (2) the computer model CHECWORKS™ is only used as one of several means to select the critical locations for inspections and has a non-dominate or marginal role in implementing the FAC AMP; and (3) Entergy is not required to, before using CHECWORKS™ as part of an AMP, perform additional "benchmarking" as a consequence of the power uprates authorized in 2004 and 2005.

9.271 All issues, motions, arguments, or proposed findings presented by the parties, but not addressed herein have been found to be without merit or unnecessary for the Board's decision on contention RK-TC-2.

Respectfully submitted,

/Signed (electronically) by/

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Dated at Rockville, Maryland
this 22nd day of March 2013

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
ENTERGY NUCLEAR OPERATIONS, INC.	)	Docket Nos. 50-247/286-LR
	)	
(Indian Point Nuclear Generating	)	
Units 2 and 3)	)	

CERTIFICATE OF SERVICE

Pursuant to 10 C.F.R § 2.305 (as revised), I hereby certify that copies of the foregoing "NRC STAFF'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW PART 9: CONTENTION RK-TC-2 (FLOW ACCELERATED CORROSION" dated March 22, 2013, have been served upon the Electronic Information Exchange (the NRC's E-Filing System), in the above- captioned proceeding, this 22nd day of March, 2013.

/Signed (electronically) by/

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