United States Nuclear Regulatory Commission Official Hearing Exhibit
In the Matter of: Entergy Nuclear Operations, Inc.
(Indian Point Nuclear Generating Units 2 and 3)
ASLBP #: 07-858-03-LR-BD01
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Submitted: March 31, 2012

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/ 50-286-LR
	)	
(Indian Point Nuclear Generating	)	
Units 2 and 3)	)	

NRC STAFF TESTIMONY OF MATTHEW G. YODER AND ALLEN L. HISER, JR. CONCERNING RIVERKEEPER TECHNICAL CONTENTION RK-TC-2 FLOW ACCELERATED CORROSION

Q.1. Please state your names, occupations, and by whom you are employed.

A.1(a). My name is Matthew G. Yoder. I am employed as a Senior Chemical Engineer in the Steam Generator Tube Integrity and Chemical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission ("NRC"), in Washington, D.C. I received a Bachelor of Science degree in Chemical Engineering from Florida State University. A statement of my professional qualifications is attached hereto.

A.1(b). My name is Dr. Allen Hiser, Jr. I am employed as the Senior Technical Advisor for License Renewal Aging Management in the Division of License Renewal, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission ("NRC"), in Washington, D.C. I received Bachelor of Science and Master of Science degrees in Mechanical Engineering from the University of Maryland at College Park. I also received a Ph.D. in Materials Science and Engineering from Johns Hopkins University, Baltimore, MD. I have been a participant in ASME Working Groups on Flaw Evaluation and Pipe Flaw Evaluation dating back to the early 1980s. For some of this time I was the voting member and NRC representative of the working groups. Currently, I am a member of the Special Working Group on Nuclear Plant Aging Management. A statement of my professional qualifications is attached hereto.

Q.2. Please describe the nature of your current responsibilities.

A.2(a). (Yoder) As the Senior Chemical Engineer in the Steam Generator Tube Integrity and Chemical Engineering Branch of the Division of Engineering, my responsibilities include the technical, safety, and regulatory compliance reviews of a variety of chemistry and chemical engineering topics, including flow accelerated corrosion ("FAC") programs for applicants for license renewal, as well as to how FAC is affected by power uprates. The results of my reviews are documented in safety evaluations which represent the NRC's position.

A.2(b). (Hiser) My 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. I have been employed at the agency for 22 years in the Office of Nuclear Regulatory Research and the Office of Nuclear Reactor Regulation. My responsibilities also include serving as a lead technical expert for aging management evaluation and assisting other NRC staff as they implement their reviews of license renewal applications.

Q.3. Please describe your duties in connection with the NRC Staff's review of the license renewal application (LRA) submitted by Entergy Nuclear Operations, Inc. ("Entergy" or "Applicant") for Indian Point Nuclear Generating Units 2 and 3 ("IP2" and "IP3," or "Indian Point").

A.3(a). (Yoder) During the NRC Staff's review of the *Indian Point Nuclear Generating Unit Nos. 2 and 3 License Renewal Application* (April 23, 2007) ("LRA") (Ex. ENT00015A and ENT00015B), I served as a peer reviewer for the principal reviewer. As such, I 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 safety evaluation report, NUREG-1930, Vol. 1 and Vol. 2, *Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos.*

2 and 3 (November 2009) (ADAMS Accession Nos. ML093170451 and ML093170671) (Ex. NYS00326A-F) (together, "SER"). In addition I supported the Staff's briefing of the ACRS on the license renewal safety evaluation report, including a discussion of the IP FAC Program.

As part of my responsibilities, I 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).

A.3(b). (Hiser) I 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. My 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. I 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. I reviewed and approved the associated requests for additional information and safety evaluation report input produced by my branch. I also supported the Staff's briefing of the ACRS on the license renewal SER.

Q.4. What is the purpose of your testimony?

A.4. The purpose of this testimony is to present the NRC Staff's views with respect to Contention TC-2, filed in this proceeding by Riverkeeper. That contention generally challenges the Program for Management of Flow Accelerated Corrosion (FAC), which was submitted by Entergy Nuclear Operations, Inc., as part of the LRA for Indian Point Nuclear Generating Units 2 and 3 on April 23, 2007 (Ex. ENT00015A and ENT00015B), as supplemented by Letter NL-07-056, *Letter from Indian Point Nuclear Generating Units 2 and 3 - Supplement to License*

Renewal Application, (May 3, 2007) (ADAMS Accession No. ML071280700) (Ex. NRC0000103) and Letter NL-07-078, *Letter from Entergy Nuclear Operations, Inc., to NRC, Indian Point Nuclear Generating Unit 2, Response to NRC Review Status of License Renewal Application,* (June 21, 2007) (ADAMS Accession No. ML071800318) (Ex. NRC0000104). As directed by the Board, we are providing rebuttal testimony on Contention TC-2, filed in this proceeding by Riverkeeper.

Q.5. Please summarize the Staff's review of the IP FAC aging management program (AMP).

A.5. The staff reviewed the Applicant's FAC Program using an in-office review, an on-site aging management audit of the program, and a separate on-site scoping and screening methodology audit.

From the in-office review and the audits, the staff verified that the Applicant's revised program uses in-situ measurements of component wall thickness as the key to the program, with the CHECWORKS™ program one of several bases for establishing which in-scope piping component locations should be scheduled for inspection at the next outage. The staff also verified that the Applicant uses IP2-specific and IP3-specific operating experience, operating experience discussed in NRC generic communications, industry operating experience records or reports, and engineering judgment as additional bases for selecting in-scope piping components for inspection. *See* SER at 3-26 (Ex. NYS00326A-F). The staff also verified that the Applicant's use of the CHECWORKS™ program uses the most recent updated power-uprated operating parameters and inspection results as the basis for establishing the program wear predictions for components that are within the scope of the program. *Id.*

Q.6. What are the issues presented in Contention TC-2?

A.6. The Board admitted RK-TC-2 insofar as it alleged that (1) Entergy's AMP for components affected by FAC is deficient because it does not provide sufficient details (e.g.,

inspection method and frequency, criteria for component repair or replacement) 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 the current power uprate power level. *Entergy Nuclear Operations, Inc.* (Indian Point, Units 2 and 3), LBP-08-13, 68 NRC 43, 177 (2008).

Entergy subsequently filed a motion for summary disposition of this contention on July 26, 2010. *Applicant's Motion for Summary Disposition of Riverkeeper Technical Contention 2 (Flow-Accelerated Corrosion)* (July 26, 2010) (ADAMS Accession No. ML102140430). Kimberly Green and Matthew Yoder provided affidavits for the Staff supporting the motion. 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).

The Board denied the motion, finding that genuine issues of material fact existed regarding the adequacy of the Applicant's plan to manage the effects of FAC during the proposed period of extended operation. Memorandum and Order (Ruling on Entergy's Motion for Summary Disposition of Riverkeeper TC-2 (Flow-Accelerated Corrosion) at 1 (Nov. 4, 2010) (unpublished) (ADAMS Accession No. ML103080994). The Board indicated that it needed to have an opportunity to evaluate and weigh the facts presented to determine if Riverkeeper's claims are true or if Entergy's LRA is sufficient. *Id*. at 8.

Q.7. What is Riverkeeper's current position?

A.7. In the *Riverkeeper Initial Statement of Position Regarding Contention RK-TC-2 - Flow Accelerated Corrosion* (December 22, 2011) (ADAMS Accession No. ML120040315) (Ex. RIV000002), Riverkeeper asserts that Entergy's FAC program is inadequate because the program 1) improperly relies on the CHECWORKS™ computer code, 2) lacks other tools that

are meaningfully independent of the CHECWORKS™ computer code, and 3) fails to address safety concerns caused by inadequate aging management by the FAC program. Further, Riverkeeper asserts that 4) the FAC program's reliance on the CHECWORKS™ computer code doesn't meet NRC regulations and guidance, and 5) the FAC program lacks details of the programmatic elements described in the NRC's guidance.

Q.8. Please summarize your opinion of Riverkeeper's position.

A.8. Based upon our review of the totality of Riverkeeper's arguments and exhibits, we see Riverkeeper's argument as fundamentally a claim that CHECWORKS™ cannot be relied upon for adequate aging management under a renewed license. Since the program proposed to manage FAC under the renewed license is the same program used at present under the current licensing basis at Indian Point, then by extension Riverkeeper's position implies that the current FAC program is inadequate. We will elaborate on our opinions below, but we disagree with all of Riverkeeper's claims.

Entergy's FAC Program utilizes the CHECWORKS™ code as one tool among several independent tools to identify locations to be inspected for wall thickness, where the inspections of wall thickness represent the true core of the FAC Program. There is no need for additional benchmarking of the code at Indian Point because CHECWORKS™ inherently self-benchmarks. The results provided by CHECWORKS™ are reliable and fall within an acceptable range. CHECWORKS™ has a long, proven track record, and has long been accepted by the NRC as one of many tools to address FAC. CHECWORKS™ was developed carefully and purposefully over many years.

The FAC Program described in Entergy's license renewal application meets the regulatory criteria described in 10 C.F.R. Part 54 and is consistent with the guidance in the NUREG-1801, Rev. 2, *Generic Aging Lessons Learned (GALL) Report*, (Dec. 2010) (ADAMS Accession No. ML103490036) (Ex. NYS000147A-D) ("GALL Report Rev. 2"); NUREG-1801,

Rev. 1, *GALL Report*, (September 2005), Vol. 1 (ADAMS Accession No. ML052110005) & Vol. 2 (ADAMS Accesson No. ML052110006) (Ex. NYS00146A-D) (together, "GALL Report Rev. 1"); and NUREG-1800, *Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants* (SRP-LR), Rev. 1, (September, 2005) (ADAMS Accession No. ML052110007) (Ex. NYS000195) ("SRP-LR Rev.1"). 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.

In addition, 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. Thus, they've been a part of the CLB for both plants for more than seven years. 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, but were not re-reviewed as part of the license renewal review.

Q.9. Please describe or list Riverkeeper's exhibits that you will be discussing to support your position.

A.9. Riverkeeper 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) (ADAMS Accession No. ML11356A024) (Ex. RIV000015)), copies of historic NRC generic communications on FAC (e.g., Ex. RIV000007 (NRC Bulletin 87-01, *Thinning Pipe Walls in Nuclear Plants* (July 9, 1987) (ADAMS Accession No. ML11356A020) ("NRC Bulletin 87-01")), and industry's current guidance (e.g., Ex. RIV000012 (*Electric Power Research Institute (EPRI), Recommendations for an Effective Flow-Accelerated*

Corrosion Program, NSAC-202L-R3) (ADAMS Accession No. ML11356A015) ("NSAC-202L-R3")).

Although much of Riverkeeper's arguments regard the 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), we note that, other than Dr. Hopenfeld's testimony and report, none of Riverkeeper's exhibits directly concern the power uprates.

Q.10. What evidence and facts will you present to the Board?

A.10. On the claim that there's not enough detailed information about the Applicant's FAC Program available, we're going to discuss how the exhibits submitted by Riverkeeper contain the information that Riverkeeper claims is missing. We'll give (1) the general background of the NRC's actions and regulatory concerns with how plants address flow accelerated corrosion, (2) generic acceptance of CHECWORKS™ by the NRC, (3) the specific information provided in the Indian Point license renewal application, and (4) why that information is sufficient.

On the assertion that CHECWORKS™ cannot be used due to the small power uprates approved seven years ago, we'll describe (5) how the CLB at Indian Point came to include the use of CHECWORKS™ to monitor FAC at uprated power levels, which was approved for both Unit 2 and Unit 3 as separate licensing actions (a part of the power uprate approvals), and (6) how CHECWORKS™ will calibrate and self-benchmark for the changed parameters associated with the small power increases. To rebut additional assertions by Riverkeeper, we note that (7) CHECWORKS™ is just one of many tools used by Entergy to manage FAC, and (8) the LRA prepared by Entergy does not need to address safety issues that would only occur under a presumption that its AMPs fail.

As appropriate in each section, we will discuss why Riverkeeper's expert Dr. Hopenfeld is incorrect.

BACKGROUND OF THE NRC'S ACTIONS AND REGULATORY CONCERNS WITH FLOW ACCELERATED CORROSION

Q.11. What is flow accelerated corrosion?

A.11. Flow accelerated corrosion, or FAC, is a form of material degradation that 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 interaction of water chemistry, material composition, and hydrodynamics. *See* NSAC-202L-R3 at v (Ex. RIV000012).

Q.12. Please summarize the historical scope of the NRC's guidance related to an acceptable FAC program as it applies to license renewal.

A.12. The background is mentioned in the NRC's guidance documents on license renewal. The GALL Report Rev. 1 AMP XI.M17 "Flow-Accelerated Corrosion" states:

> 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 at XI M-61 (Ex. NYS00146A-D).

Q.13. Outside of license renewal, has the NRC previously required all licensees to provide substantial details on FAC?

A.13. Yes, the NRC has required licensees to address FAC in response to generic communications such as NRC Bulletin 87-01, *Thinning of Pipe Walls in Nuclear Power Plants* (July 9, 1987) (ADAMS Accession No. ML11356A020) (Ex. RIV000007) and Generic Letter (GL) 89-08, *Erosion/Corrosion-Induced Pipe Wall Thinning* (May 2, 1989) (ADAMS Accession No. ML031200731) (Ex. ENT000042) ("GL 89-08"). Thus, although it is addressed in the GALL Report, the history shows that FAC is not a phenomenon unique to license renewal; it is a concern licensee's initial license terms and both the NRC and industry have taken substantial actions to address FAC as part of the current licensing basis for all reactors. For example, recipients of NRC Bulletin 87-01 were required to submit the following detailed information related to FAC:

> [T]he following information concerning their programs for monitoring the wall thickness of pipes in condensate, feedwater, steam, and connected high-energy piping systems, including all safety-related and non-safety-related piping systems fabricated of carbon steel:
>
> 1. Identify the codes or standards to which the piping was designed and fabricated.
>
> 2. Describe the scope and extent of your programs for ensuring that pipe wall thicknesses are not reduced below the minimum allowable thickness. Include in the description the criteria that you have established for:
>
> a. selecting points at which to make thickness measurements
>
> b. determining how frequently to make thickness measurements
>
> c. selecting the methods used to make thickness measurements
>
> d. making replacement/repair decisions
>
> 3. For liquid-phase systems, state specifically whether the following factors have been considered in establishing your criteria for selecting points at which to monitor piping thickness (Item 2a):
>
> a. piping material (e.g., chromium content)

b. piping configuration (e.g., fittings less than 10 pipe diameters apart)
c. pH of water in the system (e.g., pH less than 10)
d. system temperature (e.g., between 190 and 500ºF)
e. fluid bulk velocity (greater than 10 ft/s)
f. oxygen content in the system (e.g., oxygen content less than 50 ppb)

4. Chronologically list and summarize the results of all inspections that have been performed, which were specifically conducted for the purpose of identifying pipe wall thinning, whether or not pipe wall thinning was discovered, and any other inspections where pipe wall thinning was discovered even though that was not the purpose of that inspection.
a. Briefly describe the inspection program and indicate whether it was specifically intended to measure wall thickness or whether wall thickness measurements were an incidental determination.
b. Describe what piping was examined and how (e.g., describe the inspection, instrument(s), test method, reference thickness, locations examined, means for locating measurement point(s) in subsequent inspections).
c. Report thickness measurement results and note those that were identified as unacceptable and why.
d. Describe actions already taken or planned for piping that has been found to have a nonconforming wall thickness. If you have performed a failure analysis, include the results of that analysis. Indicate whether the actions involve repair or replacement, including any change of materials.

5. Describe any plans either for revising the present or for developing new or additional programs for monitoring pipe wall thickness.

NRC Bulletin 87-01 at 2 to 3 (Ex. RIV000007).

GL 89-08 requested that each licensee provide assurances that it had implemented a program consisting of systematic measures to ensure that “erosion/corrosion,” which today is called FAC, would not lead to degradation of single phase and two phase high-energy carbon steel systems. The principal concern described in GL 89-08 was whether the affected plants would continue to meet their licensing basis if erosion/corrosion were to degrade the pressure boundary to below the applicable code design value. As described in the GL, at the time of

issuance of GL 89-08, all licensees had developed and put in place an erosion/corrosion monitoring program that meets the intent of NRC Bulletin 87-01, and all plants had completed their initial examinations. *See* GL 89-08 at 2 (Ex. ENT000042).

Q.14. What did GL 89-08 say about corrective actions, repair and replacement?

A.14. GL 89-08 stated that the staff audited 10 operating plants (7 PWRs and 3 BWRs) in late 1988 to assess implementation of erosion/corrosion monitoring programs by licensees and to ensure that adequate guidance was provided for corrective actions and other activities regarding repair and replacement of degraded piping and components. GL 89-08 stated that, in general, all licensees had developed and implemented erosion/corrosion monitoring programs. *See* GL 89-08 at 2 (Ex. ENT000042).

Q.15. At the time of the issuance of GL 89-08, was the Staff satisfied with the licensees' erosion/corrosion monitoring programs?

A.15. No. At the time of issuance of GL 89-08, the staff found that, although all licensees had developed and implemented erosion/corrosion monitoring programs and had completed their initial examinations, none of the licensees had implemented formalized procedures or administrative controls to assure continued long-term implementation of their erosion/ corrosion monitoring programs for piping and components within the licensing basis. This finding led to the staff issuance of GL 89-08. *See* GL 89-08 at 2 (Ex. ENT000042).

Q.16. What did GL 89-08 request from the recipients?

A.16. GL 89-08 requested that each licensee provide assurances that a program, consisting of systematic measures to ensure that erosion/corrosion does not lead to degradation of single phase and two phase high-energy carbon steel systems, has been implemented. The generic letter said that the licensee's response should include information on whether or not the licensee has implemented, or intends to implement, a long term erosion/corrosion monitoring program that provides assurances that procedures or administrative controls are in place to

assure that the Nuclear Utility Management and Resources Council program (Appendix A of NUREG-1344, which was attached to GL 89-08) or another equally effective program is implemented and the structural integrity of all high energy (two phase as well as single phase) carbon steel systems is maintained. *See* GL 89-08 at 2 and 3 (Ex. ENT000042).

Q.17. Did GL 89-08 require detailed information?

A.17. No, GL 89-08 explicitly stated that "detailed information [regarding the erosion/corrosion program] *should not* be submitted to the NRC for review." *See* GL-89-08 at 2 (Ex. ENT000042) (emphasis added).

Q.18. In reviewing Entergy's LRA for Indian Point, did the Staff re-visit the historical responses to NRC Bulletin 87-01 and GL 89-08?

A.18. Yes, the staff reviewed the Indian Point responses to both GL 89-08 and NRC Bulletin 87-01 as part of the staff's review of the Applicant's scope of the FAC AMP. Specifically, as stated in the Staff's SER for license renewal:

> The staff verified that the applicant responded to Bulletin 87-01 for IP2 in a letter dated September 11, 1987 (NRC Microfiche Address 42741, Pages 199-233) and for IP3 in a letter dated September 15, 1987 (NRC Microfiche Address 42739, Pages 131-146). The staff verified that the applicant responded to GL 89-08 for IP2 in a letter dated July 20, 1989 (NRC Microfiche Address 50726, Pages 331-332) and for IP3 in a letter dated July 21, 1989 (NRC Microfiche Address 50737, Pages 100-102). The staff verified that these responses were the docketed documents that initially defined the systems that are within the scope of the applicant's Flow Accelerated Corrosion Programs for IP2 and IP3, and defined how the programs would be implemented. The staff verified that the scope of the applicant's Flow-Accelerated Corrosion Program includes these generic communication responses.

SER at 3-22 (Ex. NYS00326A-F).

Q.19. Riverkeeper submitted NRC Bulletin 87-01 as exhibit RIV000007. Does Riverkeeper address the information provided in response to the NRC Bulletin 87-01, or the follow-up GL 89-08?

A.19. No. Although Riverkeeper provided NRC Bulletin 87-01 as one of many exhibits that show the historical concerns and information requests associated with FAC, Riverkeeper did not discuss the findings associated with the generic requests.

GENERIC ACCEPTANCE OF CHECWORKS™ BY THE NRC

Q.20. What is CHECWORKS™?

A.20. CHECWORKS™ is a computer code used to predict component degradation in the systems conducive to FAC using plant-specific data and information, including characteristics of the materials, along with the plant's hydrodynamic, and operating conditions. CHECWORKS™ models the effects of alloy composition, fluid pH level, control amine, hydrazine concentration, dissolved oxygen, fluid velocity, component geometry, upstream influences, fluid temperature, and steam quality to predict the FAC rate. CHECWORKS™ is an empirical model, meaning that the CHECWORKS™ model for wear rate predictions was developed using measured data from many plants and from controlled laboratory experiments. CHECWORKS™ was "benchmarked" by comparison of the CHECWORKS™ model's predicted susceptible locations with actual wear data obtained from nuclear power plants and additional laboratory data. This comparison showed that the CHECWORKS™ model accurately predicts FAC behavior.

Q.21. Who wrote and maintains CHECWORKS™?

A.21. The Electric Power Research Institute (EPRI) developed and maintains the code. The code is part of a family of "CHEC" computer codes. The authors of the original CHEC code were V.K. Chexal, E.B. Dietrich, J.S. Horowitz, G.A. Randall, V.C. Shevde, and J.A. Thomas. EPRI formed the CHEC/CHECMATE Users Group in 1989, and it is currently named the CHECWORKS™ Users Group. The key purpose of this group is to provide a forum for exchanging information related to FAC issues, provide user support, maintenance and

enhancement of CHECWORKS™, and to support research into the causes, detection, and mitigation of FAC. *See* NSAC-202L-R3 at 1-1 and 1-2 (Ex. RIV000012).

Q.22. Who uses CHECWORKS™?

A.22. CHECWORKS™ is used by fossil and nuclear power plants, and industrial process plants in the United States and in many other countries.

Q.23. How is CHECWORKS™ used at typical nuclear power plants?

A.23. CHECWORKS™ is used to identify the most susceptible components for inspection and to calculate wear rates to predict when the components will reach the minimum allowable wall thickness. After initial measurements of the component baseline wall thickness, follow-up inspections throughout the life of the plant are used to confirm and update the predictions. Plants using CHECWORKS™ input plant specific operating parameters to enable component susceptibility rankings for the plant. Data from physical inspections of components are entered into CHECWORKS™ to determine the actual wear rate and to calibrate the predictive models in the code. The future predicted wear rates and thickness values are based on the calibrated models that have been adjusted to reflect the actual wear from the inspection data. In other words, wear rates and wear rate predictions are based on calibration of CHECWORKS™ using actual physical inspection data from components.

Q.24. How is CHECWORKS™ “calibrated” for a plant?

A.24. 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.

Q.25. What are the benefits of self-benchmarking CHECWORKS™?

A.25. Self-benchmarking of CHECWORKS™ improves the accuracy of wear predictions from the plant-specific model to account for the actual wear that is occurring in the plant. The self-benchmarking improves the estimates of FAC and helps to indicate the locations for future inspections.

Q.26. Riverkeeper submitted as Ex. RIV000012 a technical report called *Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R3)*. EPRI. What is this technical report?

A.26. This report is Revision 3 of NSAC-202L, a report prepared by the Electric Power Research Institute (EPRI) to address management of flow-accelerated corrosion (FAC). As stated in the abstract:

> This document presents a set of recommendations for an effective flow-accelerated corrosion program. These recommendations are the product of successful implementation of FAC inspection programs and experience of the operating nuclear power plants. The essential ingredients for an effective FAC program are presented in this document. The steps that utilities should take to minimize the chances of experiencing a FAC-induced consequential leak or rupture are also presented.

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

Q.27. Why was NSAC-202L developed by EPRI?

A.27. The introduction to NSAC-202L-R3 briefly describes a tragic event at Surry Power Station where four people were killed as a result of a piping failure caused by flow accelerated corrosion. *See* NSAC-202L-R3 at 1-1 (Ex. RIV000012). The introduction states that Appendix D of NSAC-202L-R3 provides a history of industry and NRC activities to address FAC, including a description of the development of the CHEC family of computer codes (CHECWORKS™ Steam/Feedwater Application or more commonly "CHECWORKS™"). *Id.* at 1-2. The code was developed as a predictive tool to assist utilities in planning inspections and

evaluating the inspection data to prevent piping failures caused by FAC. *Id.* at 1-1. NSAC-202L-R3 notes that the continuing occurrence of FAC failures shows that plant programs to mitigate FAC should be maintained and improved as necessary as industry knowledge evolves and more operating and plant data become available. *Id.* It describes the role of the CHECWORKS™ Users Group (CHUG), an industry-sponsored group formed to deal with FAC-induced wall thinning, and other associated activities in identifying a set of recommendations (i.e., NSAC-202L) to help utility personnel develop and effectively implement a comprehensive FAC program. *Id.*

Q.28. What does NSAC-202L-R3 describe as important elements and tasks of an effective FAC program?

A.28. NSAC-202L-R3 describes the important organizational and programmatic elements necessary to implement a successful FAC program. *See* NSAC-202L-R3 at 2-1 (Ex. RIV000012). The report describes eight separate tasks for creating an effective FAC program: 1) identifying susceptible systems, 2) performing FAC analysis (using a predictive methodology such as CHECWORKS™); 3) selecting and scheduling components for inspection; 4) performing inspections; 5) evaluating inspection data; 6) evaluating worn components; 7) repairing and replacing components; and 8) determination of the safety factor. *Id.* at 4-1 to 4-28. NSAC-202L-R3 is written to be of use to all utilities, irrespective of the predictive analytical methodology being used (e.g., CHECWORKS™ or other computer code). Revisions to NSAC-202L have been based on successful utility experiences as well as improvements to FAC technology and understanding of the phenomena. *Id.* at 1-1

Q.29. Is NSAC-202L widely adopted in the U.S.?

A.29. Yes. As noted in Riverkeeper's Exhibit RIV000011, NRC Information Notice 2006-08 (ADAMS Accession No. ML11356A021) ("IN 2006-08"), *Secondary Piping Rupture at the Mihama Power Station in Japan* (March 16, 2006), most U.S. licensees manage FAC by

implementing the Electric Power Research Institute (EPRI) guidelines described in NSAC-202L. *See* IN 2006-08 at 3 (Ex. RIV000011).

Q.30. What revisions of NSAC-202L are acceptable to the Staff?

A.30. Both Revisions 2 and 3 are acceptable to establish an effective flow-accelerated corrosion program. The program described in each revision includes performing (a) an analysis to determine critical locations, (b) limited baseline inspections to determine the extent of thinning at these locations, (c) implementation of a computer code to predict future wall thinning, and (d) follow-up inspections to assess the wall thickness and confirm the predictions, with component repair or replacement as necessary.

The NRC's GALL Report, Rev. 1, Aging Management Program ("AMP") XI.M17, "Flow-Accelerated Corrosion," provides guidance on the elements of an acceptable program to manage the effects of FAC during the period of extended operation. GALL Report AMP XI.M17 relies on implementation of EPRI guidelines in the NSAC-202L. Revision 1 of the GALL Report allows use of the latest revision of NSAC-202L available at the time of issuance of Revision 1 of the GALL Report, specifically NSAC-202L-R2; Revision 2 of the GALL Report issued in December of 2010, allows use of NSAC-202L-R3.

Q.31. What is the NRC's overall view on using CHECWORKS™?

A.31. The NRC has long accepted use of CHECWORKS™ and its predecessor CHEC as important tools to manage FAC. The acceptably of CHECWORKS™ has long existed in the NRC's guidance documents.

Q.32. Riverkeeper argues that CHECWORKS™ lacks a track record of performance at Indian Point. What is your opinion?

A.32. Riverkeeper's argument is without merit because its own witness's report, *Report of Joram Hopenfeld in Support of RK-TC-2*, (December 21, 2011) (ADAMS Accession No. ML11356A010) (Ex. RIV000005) ("Hopenfeld Report"), states that CHECWORKS™ has been

implemented at Indian Point since at least 2000 for Unit 2 and 2001 for Unit 3, including under the power uprate conditions of Unit 2 since 2004 and Unit 3 since 2005. *See* Hopenfeld Report at 5 (Ex. RIV000005). As cited in Dr. Hopenfeld's report, Indian Point has identified, through successful implementation of CHECWORKS™ in its FAC Program, the need for repairs or replacement due to wall-thinning below minimum wall requirements in some cases. *See* Hopenfeld Report at 17 (Ex. RIV000005). Dr. Hopenfeld's report defines these cases as "failures" as if pipe structural failure is imminent. What he does not state is that the minimum wall thickness requirements incorporate use of additional margin in the form of structural factors on the applied loads, such that a wall thickness below the allowable minimum wall thickness does not constitute a structural failure, but rather identifies a situation that requires a corrective action.

INFORMATION SPECIFIC TO INDIAN POINT

Q.33. How was the FAC Program described by Indian Point in the LRA?

A.33. The IP LRA states that the Flow-Accelerated Corrosion Program is an existing program that applies to safety-related and non safety-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. *See* LRA at B-54 (Ex. ENT00015A and ENT00015B). The LRA states that the program, which is based on EPRI guidelines in NSAC-202L-R2 for an effective flow-accelerated corrosion program, predicts, detects, and monitors FAC in plant piping and other pressure-retaining components. *Id.* 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, or repair or replace components as necessary. *Id.* The LRA further states that this program is consistent with the program described in NUREG-1801, Section XI.M17, "Flow-

Accelerated Corrosion," without exception or enhancement. *Id.* The LRA concludes that the existing FAC Program at IP is acceptable without modification to provide assurance that the effects of aging will be managed such that applicable components will continue to perform their intended functions consistent with the current licensing basis through the period of extended operation. *Id.* at B-55.

Q.35. Please describe Entergy's document EN-DC-315, Revision 3, which was submitted by Riverkeeper as Exhibit RIV000015 ("EN-DC-315").

A.35. EN-DC-315 is the overall controlling procedure for the FAC Program that Entergy implements on a fleet-wide basis, including at Indian Point, for managing the effects of FAC. EN-DC-315, Revision 3, is the latest revision of the procedure.

Early in the license renewal process, Entergy briefly discussed, in Attachment I to letter NL-07-124, *Letter From Entergy Nuclear Operations, Inc., to NRC, Indian Point Nuclear Generating Units 2* and 3, Supplement to License Renewal Application, (Oct. 11, 2007) (ADAMS Accession No. ML072910276) (Ex. NRC0000105) ("NL-07-124"), the development of EN-DC-315 in Audit Item 45:

> To support the Entergy standardization effort, a fleet-wide FAC procedure was developed to standardize the FAC program at all the Entergy Nuclear sites. A common corporate procedure provides a consistent approach to managing FAC. This enables more efficient use of shared resources, and facilitates the effective use of knowledge/expertise and operating experience across the fleet.

NL-07-124 at 9 and 10 (Ex. NRC0000105).

Q.36. What are the elements of the Entergy fleet-wide FAC Program described in EN-DC-315?

A.36. EN-DC-315 provides 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. It includes inspections of single-phase and two-phase piping components for both safety and non-safety related systems. This procedure is applicable to both BWR and PWR plants.

Q.37. What industry guidelines, if any, do Entergy's procedures follow?

A.37. EN-DC-315 follows the latest version of EPRI guidelines in the NSAC-202L.

Q.38. How does Riverkeeper discuss EN-DC-315?

A.38. The only reference to this exhibit by Riverkeeper is to support its claim that EN-DC-315 is focused heavily on the use of CHECWORKS™ to predict timing and locations of wall thinning. *See* Hopenfeld Report at 25 (Ex. RIV000005).

Q.39. Besides the overall procedure EN-DC-315, are there additional more detailed procedures used for the FAC Program?

A.39. There are several more-detailed procedures listed in EN-DC-315. Among these are 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"). *See* EN-DC-315 at 28 (Ex. RIV000015). The Staff's *Audit Report for Plant Aging Management Programs and Reviews, Indian Point Nuclear Generating Unit Nos. 2 and 3*, (January 13, 2009) (ADAMS Accession No. ML083540662) (Ex. ENT00041) ("AMP Audit Report") documented reviews of EN-CS-S-008 and CEP-NDE-0505. *See* AMP Audit Report at 13 (Ex. ENT00041).

Q.40. What is your overall conclusion on the level of detail for the FAC Program?

A.40. As Riverkeeper's exhibits demonstrate, Entergy provides detailed information on its FAC Program, particularly in the Entergy fleet procedure, EN-DC-315. Furthermore, the information available to the staff during its review and audit activities, including additional information provided by the Applicant in response to staff requests, provided the staff with an

abundance of details on the FAC Program, as described for public information in the audit report and the safety evaluation report.

Q.41. Riverkeeper argues in its Statement of Position and the testimony of Dr. Joram Hopenfeld that the findings of the Board in the *Vermont Yankee* license renewal proceeding regarding the Entergy fleet-wide FAC Program, power uprates, CHECWORKS™, and the level of detail in the LRA cannot be applied at Indian Point. What is your opinion on their arguments?

A.41. A comparison of the *Vermont Yankee* license renewal proceeding contentions to the FAC contention in this proceeding indicate that there are many similarities and overlapping aspects to each case, such that the findings of the Board in the *Vermont Yankee* license renewal proceeding on the FAC contention are applicable to Indian Point.

The first similarity is that the same Entergy fleet procedure that the Board in the *Vermont Yankee* license renewal proceeding found acceptable for the FAC Program at Vermont Yankee, EN-DC-315, is the procedure used at Indian Point. This fleet procedure is the key document used by Entergy to define the elements of its FAC Program, 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 improve future wall thickness predictions.

The second similarity is that each facility had undergone recent power uprates. As in the *Vermont Yankee* license renewal proceeding, one aspect of the contention relates to use of CHECWORKS™ code under power uprate conditions and the inadequacy of the benchmarking of the CHECWORKS™ code at each facility. Since the Board in the *Vermont Yankee* license renewal proceeding found that future benchmarking of CHECWORKS™ at power uprate conditions was acceptable, the current availability of inspection data for the power uprate conditions at Indian Point would appear to be even more favorable to demonstrate the

continued effectiveness of the FAC Program under the power uprate conditions during the period of extended operation.

The third similarity relates to the level of detail provided in the LRA for each facility. The Board in the *Vermont Yankee* license renewal proceeding found that the information in the Vermont Yankee LRA in combination with Entergy's corporate FAC Program and the existing Vermont Yankee FAC Program supplied sufficient specificity to meet the demonstration requirement of 10 C.F.R. § 54.21(a)(3). In fact, the same corporate procedure applies to both Vermont Yankee and Indian Point, the NRC staff performed on-site audits of the FAC Program at the two facilities, and the staff in both cases found that the FAC Program was consistent with GALL Report AMP XI.M17, which relies on the guidelines of NSAC-202L.

SUFFICIENCY OF THE INFORMATION ON THE IP FAC AMP

Q.42. The Staff's SER identifies a number of requests for additional information (RAIs) on the FAC Program. Was there information missing from the LRA that was then added through an RAI response?

A.42. Both IP2 and IP3 had previously implemented power uprates that were approved by the staff. Although the previously approved power uprates are not part of the LRA review, the staff requested information to provide a complete understanding of how the existing FAC Program has addressed the power uprate conditions in IP's current licensing basis (CLB), as one step to ensuring that the program will be effective for use in the period of extended operation. By letter from K. Green (NRC) to M. Balduzzi (Entergy Nuclear Operations, Inc), *Requests for Additional Information for the Review of the Indian Point Nuclear Generating Unit Nos. 2 and 3, License Renewal Application* (December 7, 2007) (ADAMS Accession No. ML073250226) (Ex. NRC0000106) ("Green Letter"), the Staff asked a three-part RAI. The topics for the RAI involved the power uprates and requested information on (1) changes made

to the Flow Accelerated Corrosion Program in order to account for changes that would need to be made to the process variables in CHECWORKS™ as a result of implementing the uprates; 2) the systems most susceptible to FAC, and 3) information to assess the accuracy of CHECWORKS™. *See* Green Letter at 2 (Ex. NRC0000106). In Attachment I to letter NL-08-004, *Letter from Entergy Nuclear Operations, Inc., to NRC, Indian Point Nuclear Generating Units 2 and 3, Response to Request for Additional Information Regarding License Renewal Application - (Steam Generator Tube Integrity and Chemistry),* (Jan 4, 2008) (ADAMS Accession No. ML080160123) (Ex. ENT000082) ("NL-08-004"), the Applicant provided responses to each of these requests, which were found acceptable by the Staff. *See* SER at 3-25 to 3-26 (Ex. NYS00326A-F).

In addition to the request for additional information related to the impact of the power uprate on FAC, the Staff identified during the on-site aging management program (AMP) audit that, although the program description provided for AMP B.1.15, "Flow-Accelerated Corrosion," in the LRA states that the program is based on the guidelines of EPRI NSAC-202L Revision 2, Indian Point Procedure EN-DC-315, Rev. 0, references the "latest" revision of this document, which at that time was Revision 3. As described in response to Audit Item 156 in Attachment 1 to NL-07-124, the Applicant stated that Indian Point was implementing NSAC-202L-R3, and described the differences between NSAC-202L-R2 and NSAC-202L-R3, concluding that the differences had minimal impact on the program. *See* NL-07-124 at 36 (Ex. NRC0000105).

Furthermore, as discussed in the SER, the Staff found the scope of the FAC Program to be acceptable because it incorporated the Applicant's responses to the generic communications. SER at 3-22. The scope includes plant systems identified by the Staff and by the Applicant as being highly or potentially susceptible to FAC, and the scope was consistent with operating experience. *See* SER at 3-23 (Ex. NYS00326A-F).

Q.43. Does Dr. Hopenfeld or Riverkeeper acknowledge or address the topics and information covered in EN-DC-315, Rev. 3 (Ex. RIV000015)?

A.43. No, 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, which Riverkeeper itself supplied as Exhibit RIV000015.

Regarding Inspection Scope, for example, Section 5.3 of EN-DC-315, Rev. 3, "Preparation of Outage Inspection Plan," describes how the FAC Engineer prepares an "FAC Outage Inspection [S]cope." It describes how inspection selections shall be made in accordance with the requirements of EN-DC-315, Rev. 3, and shall be identified based on CHECWORKS™ results, industry/station/utility experience, required re-inspections, the non-modeled program piping, and engineering judgment. *See* EN-DC-315 at 17 (Ex. RIV000015). It lists the following 10 criteria for selection of components for inspection:

> (1) Components selected from measured OR apparent wear found in previous inspection results.
> (2) Components ranked high for susceptibility from current CHECWORKS™ evaluation.
> (3) Components identified by industry events/experience via the Nuclear Network OR through the EPRI CHUG.
> (4) Components selected to calibrate the CHECWORKS™ models.
> (5) Components subjected to off normal flow conditions. Primarily isolated lines to the condenser in which leakage is indicated from the turbine performance monitoring system.
> (6) Engineering judgment / Other
> (7) Piping identified from Work Orders (malfunctioning equipment, downstream of leaking valves, etc.).
> (8) Susceptible piping locations (groups of components) contained in the Small Bore Piping database, which have NOT received an initial inspection.
> (9) Piping identified from Condition Reports/ Corrective action, Work Orders (malfunctioning equip, downstream of leaking valves, etc.).
> (10) Vessel Shells - Feed-water heaters, moisture separator re-heaters, drain tanks etc.

Id. at 17-18.

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"). As a last example, Section 5.3 Step [9] describes how to obtain the minimum acceptable wall thickness (t_{accpt}). *Id.* at 24, 23, 24, 26, 18, respectively.

Q.44. Did the staff perform a detailed review of the FAC overall corporate procedure and the associated detailed procedures?

A.44. For existing programs, such as the FAC Program at Indian Point, the scope of the license renewal review is limited to assessing the adequacy of the existing program (which is described in EN-DC-315) to manage the effects of aging during the period of extended operation, consistent with the requirements of 10 CFR 54.29(a)(1), such that there is reasonable assurance that plant operation under the renewed license will continue to be conducted in accordance with the CLB, in accordance with 10 CFR 54.29(a). Since the FAC Program is a part of the CLB at Indian Point, it is not necessary for the staff to re-visit the details of the FAC Program other than those related uniquely to continuation of the program into the period of extended operation.

Q.45. With respect to the IP FAC Program, do you agree with Riverkeeper's assertion that Entergy's AMP for components affected by FAC is deficient because it does not provide sufficient details (e.g., inspection method and frequency, criteria for component repair or replacement) to demonstrate that the intended functions of the applicable components will be maintained during the extended period of operation?

A.45. No.

Q.46. What is the basis for disagreeing with Riverkeeper's assertion, and where is this documented?

A.46. Based on its review of the FAC Program of the Indian Point facility, the Staff finding in SER Section 3.0.3.1.5 concluded that the program provides reasonable assurance

that components degraded by FAC will be identified, and repaired or replaced as necessary, in a timely manner such that the component will continue to meet its safety function(s), consistent with the current licensing basis, for the period of extended operation. *See* SER at 3-21 to 3-31 (Ex. NYS00326A-F). This Staff's finding was based, in part, on its audit and review of the Applicant's FAC Program (including Entergy procedure EN-DC-315), which concluded that all program elements are consistent with the GALL Report. *See* AMP Audit Report at 13 to 23 (Ex. ENT00041). The elements reviewed by the Staff during the audit include those that address inspection method and frequency and criteria for component repair or replacement.

Q.47. Since the information provided in the Indian Point LRA does not explicitly discuss inspection method and frequency, and criteria for component repair or replacement, why is it acceptable for the Staff to make its conclusion without having that information in the LRA?

A.47. For Indian Point, Entergy procedure EN-DC-315 (Riverkeeper Exhibit RIV000015), which was reviewed by the staff during the audit, provides details on implementation of the FAC Program, such as the inspection method and frequency, and criteria for component repair or replacement.

The Staff reviews and evaluates the LRA for compliance with the requirements of 10 CFR Part 54, using the SRP-LR as guidance. 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). The FAC Program is an existing program that the Applicant identified as being consistent with GALL Report AMP XI.M17, "Flow-Accelerated Corrosion."

Q.48. Please describe the audit(s) as they related to the FAC AMP.

A.48. The staff assessed the ten program elements of the Indian Point FAC Program (scope, preventive actions, parameters to be monitored or inspected, detecting of aging effects, monitoring and trending, acceptance criteria, corrective actions, confirmation process,

administrative controls, and operating experience) for consistency with those elements of GALL Report AMP XI.M17 to verify their technical adequacy, during an on-site aging management audit and a separate on-site scoping and screening methodology audit.

For the on-site aging management audit of Indian Point, the staff developed an audit plan, *Audit and Review Plan for Plant Aging Management Reviews and Programs – Indian Point Generating Units Nos. 2 and 3* (ADAMS Accession No. ML072290180) (Ex. NRC0000101) ("Audit Plan"), in which the FAC Program is one of the AMPs listed for audit. *See* Audit Plan at C-3 (Ex. NRC0000101). For the scope of work defined in this audit plan, the project team sought to verify that the Applicant's aging management activities and programs will adequately manage the effects of aging on structures and components, so that their intended functions will be maintained consistent with the IP2 and IP3 current CLB for the period of extended operation. This aging management audit explicitly addressed the following FAC Program elements: Scope of program, Preventive actions, Parameters monitored/inspected, Detection of aging effects, Monitoring and trending, Acceptance criteria.

A related, but separate and distinct, on-site scoping and screening methodology audit addressed FAC Program elements "corrective actions," "confirmation process," and "administrative controls."

The results from both of these audits are summarized in two audit reports: *Audit Report for Plant Aging Management Programs and Reviews, Indian Point Nuclear Generating Unit Nos. 2 and 3*, (January 13, 2009) (ADAMS Accession No. ML083540662) (Ex. ENT000041), and the Staff's scoping and screening audit report, *Scoping and Screening Methodology Audit Trip Report For Indian Point, Units 2 and 3*, (January 13, 2009) (ADAMS Accession No. ML083540648) (Ex. NRC0000102). The combination of the reviews described in these audit reports and the staff's review of the "operating experience" element supports the finding in the

SER that the ten elements of the Indian Point FAC Program are consistent with the ten elements of GALL Report AMP XI.M17. *See* SER at 3-21 to 3-31(Ex. NYS00326A-F).

NRC APPROVAL OF USE OF CHECWORKS™ FOR INDIAN POINT POWER UPRATE OPERATING CONDITIONS

Q.49. What is the relevance of the previously approved power uprate licensing actions to the license renewal applications?

A.49. The relevance of the historical small changes to the maximum licensed powers in power in 2004 and 2005 is that the uprated power limits are part of the CLB for each unit. However, the license renewal requests are not an opportunity to re-review of the adequacy of the existing CLB; the Staff had already considered the adequacy of FAC Program at the higher licensed power levels, and the program had already been incorporated into the CLB. For Unit 3, for example, the 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) (ADAMS Accession Nos. ML041620616 & ML041630103) (Ex. NRC0000107) ("WCAP-16212-NP"). 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*. at 10-7 to 10-9. 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*. at 10-8. Therefore, the CLB of IP2 and IP3 have included the higher power operating levels for the past seven years the CLB, and the license renewal review did not need to focus on the adequacy of

the FAC Program for the power uprate operating conditions.

Nonetheless, as part of the LRA review, the staff familiarized itself with the CLB, including the authorized maximum power levels. The staff requested additional information pertaining to the uprates to verify that the process variables were changed to account for the power uprated conditions and to verify that the IP CHECWORKS™ models were already updated with the flow rates, temperatures, and chemistry resulting from the 2004 and 2005 licensing actions.

Q.50. What is your opinion of the nature of Riverkeeper's concern with CHECWORKS™ and with the power uprates at IP2 and IP3?

A.50. The concerns expressed by Riverkeeper are concerns that apply to the current usage of CHECWORKS™ at IP2 and IP3, not just the usage during any renewed license term. In other words, the CLB of IP2 and IP3, which allows use of CHECWORKS™ at the current licensed power levels, is the root of Riverkeeper's concerns. The underlying claim of inadequate benchmarking would still exist even if Entergy never requested to renew its licenses. It is not an issue unique to aging management, which is the purpose of the license renewal application and review in accordance with 10 CFR Part 54.

The fact that Riverkeeper is concerned with the CLB is very clear from Dr. Hopenfeld's statements. For example, he states that the CHECWORKS™ model has never been properly benchmarked and currently does not account for changes in plant operating parameters that occurred associated with the power uprate for each unit. *See* Hopenfeld Report at 5 (Ex. RIV000005).

Q.51. Regarding how the power the CLB was changed in 2004 and 2005 to allow the higher power limits, without any restrictions or conditions on using CHECWORKS™ at the new powers, does Riverkeeper identify any errors, omissions or deficiencies in the license amendment requests which resulted in the NRC authorizing operation at the slightly higher

power limits?

A.51. No. 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. Although Dr. Hopenfeld concludes that CHECWORKS™ was not accurate due to the uprates and it cannot be used for license renewal, neither he nor Riverkeeper explicitly identify issues with the use of CHECWORKS™ as a part of the CLB for the current operating period. Instead, Riverkeeper's expert says that, based upon past performance, CHECWORKS™ is not a "viable or effective tool." *See* Hopenfeld Report at 13 (Ex. RIV000005). He also describes CHECWORKS™ as "useless." *Id*. He even gives a table in which he presents the "Inaccuracy of CHECWORKS™ wear predictions" during the past decade. *Id*. at 9-12

Relative to aging effects and management of aging, neither Dr. Hopenfeld nor Riverkeeper identify any aging effects due to or from FAC that are unique to license renewal that would render use of CHECWORKS™ acceptable as a part of the CLB but not for license renewal.

Q.52. Do you agree with Riverkeeper's claim that CHECWORKS™ fails to provide useful or accurate results, and cannot be calibrated as a consequence of the power uprates?

A.52. The Staff already found, through the separate licensing actions to approve the power uprates, that CHECWORKS™ was acceptable as part of the CLB at the new uprated power levels. Therefore, I disagree with Dr. Hopenfeld's contrary assertions.

Q.53. Would Dr. Hopenfeld's concerns with the existing FAC program be alleviated by denying the renewal requests?

A.53. Dr. Hopenfeld's concerns with the use of CHECWORKS™ at Indian Point should have existed at least since the approval of the power uprate license amendments on October 27, 2004, and March 24, 2005. The power uprates remain in effect even if no license

renewal was requested.

Q.54. Does Entergy's LRA propose to change its use of CHECWORKS™ during the period of extended operation?

A.54. No. The plant has not proposed to use CHECWORKS™ any differently in the period of extended operation than during the current operating period. It will continue to use the same corporate procedure and subtier procedures in the same manner as it does now.

Q.55. Why is the use of the existing CLB program acceptable?

A.55. Regarding review of existing programs for license renewal, Staff paper, SECY 99-148, *Credit for Existing Programs for License renewal* (June 3, 1999) (ADAMS Accession No. ML992770130) (Ex. NRC0000108) ("SECY") described options and provided a recommendation to credit existing programs, such as the FAC program, and focus staff review on areas where the existing programs need to be augmented, thereby improving the efficiency of the license renewal process. In the Staff Requirements Memorandum (SRM), *Staff Requirements – SECY-99-148- Credit for Existing Programs for License renewal* (August 27, 1999) (ADAMS Accession No. ML003751930) (Ex. NRC0000109) ("SRM"), the Commission approved the Staff's recommendation and directed the Staff to focus the review guidance in the SRP-LR on areas where existing programs should be augmented for license renewal. As approved in the SRM, the SRP-LR would reference a "Generic Aging Lessons Learned" (GALL) report, which evaluates existing programs generically, to document (1) the conditions under which existing programs are considered adequate to manage identified aging effects without change, and (2) the areas where existing programs should be augmented. *See* SECY at 6 (Ex. NRC0000108).

GALL AMP XI.M17, "Flow-Accelerated Corrosion," provides guidance on the elements of an acceptable program to manage the effects of FAC. This AMP relies on implementation of

the EPRI guidelines in the NSAC-202L-R2 or R3 for an effective FAC program, without any areas identified for augmentation.

Q.56. Has the Staff reached a conclusion concerning the adequacy of continuing to use the CLB FAC Program for license renewal of IP2 and IP3?

A.56. Yes. The Staff has determined that the current FAC Program for IP2 and IP3 is acceptable. As set forth in the Staff's SER, the FAC Program fulfills the applicable regulatory criteria.

In this regard, the Staff made the following specific findings in the SER:

> 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 10CFR 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).

SER at 3-31 (Ex. NYS00326A-F).

The bases for these findings are set forth in Section 3.0.3.1.5 of the Staff's SER for license renewal of IP2 and IP3. *See* SER at 3-21 to 3-31 (Ex. NYS00326A-F).

CALIBRATION AND SELF-BENCHMARKING OF CHECWORKS™ FOR THE CHANGED PARAMETERS ASSOCIATED WITH THE SMALL POWER INCREASE

Q.57. Contention TC-2 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. Does the Staff's license renewal SER address this issue?

A.57. Yes. As documented in the SER, the Staff reviewed CHECWORKS™ modeling with respect to how power uprate conditions are incorporated, to ensure that the CLB FAC

Program will be sufficient for the period of extended operation. It should be noted that the changes in maximum licensed thermal power IP2 and IP3 were relatively small, resulting in power increases of 3.26% and 4.85% rated thermal power. Changes of this magnitude generally result in very small changes to the operating parameters that influence FAC. *See* SER at 3-25 to 3-29 (Ex. NYS00326A-F).

Q.58. Why isn't prolonged benchmarking of 10-15 years at the 2004 and 2005 power levels needed before CHECWORKS™ can be used?

A.58. More than four years ago, during the license renewal review, the Staff considered this issue and requested additional information from Entergy on this topic. In response, Entergy verified 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. Regarding benchmarking of the IP2 and IP3 CHECWORKS™ program, Entergy stated:

> The input to the CHECWORKS™ modeling program includes plant operating parameters such as flow rates, operating temperatures and piping configuration, as well as measured wall thicknesses from FAC program components. This input, in conjunction with the CHECWORKS™ predictive algorithm, is used to predict the rate of wall thinning and remaining service life on a component-by component basis. The value of the model lies in its ability to predict wear rates based on changing parameters, such as flow rate, without having to have actual measured wall thickness values. The predictive algorithms built into CHECWORKS™ are based on available laboratory data and FAC data from many plants. CHECWORKS™ was designed, and has been shown, to handle large changes in chemistry, flow rate and or other operating conditions. In its use throughout the industry, the CHECWORKS™ model has been benchmarked against measurements of wall thinning for components operating over a wide range of flow rates. *Consequently, the validity of the model does not depend on benchmarking against plant-specific measured wear rates of components operating under SPU conditions.* In addition, by the time IPEC enters the period of extended operation (in the year 2013), inspection data under SPU conditions will have been obtained. These additional data sets, when added to the CHECWORKS™ database, will result in more refined wear rate

> predictions. Since the previously most susceptible locations have been replaced, wear rates are low. Due to the low wear rates, the small changes in operating parameters due to SPU, and the relatively short time since SPU, changes to wear rates since SPU will be very small. The accuracy of the model is not expected to change significantly due to the SPU.

NL-08-004 at 3 (emphasis added) (ENT000082).

The staff determined that the Applicant provided an acceptable basis for using CHECWORKS™ as one of several means for identifying components for inspection and for scheduling components for inspection at the next unit refueling outage, because the current predictions from the computer model are based on the power uprated conditions and the most recent inspection results for systems and components that are within the scope of and have been modeled by CHECWORKS™. *See* SER at 3-26 (Ex. NYS00326A-F).

Q.59. Dr. Hopenfeld claims that his review of Entergy's data indicates that CHECWORKS™ has yielded non-conservative predictions of actual wear measurements contrasted with predicted wear about 40-60% of the time. Is the Staff concerned that such a performance by CHECWORKS™ would indicate adversely on the usefulness of predictions by CHECWORKS™?

A.59. No, such a performance by CHECWORKS™ is to be expected. To take the converse of Dr. Hopenfeld's statement, CHECWORKS™ yields conservative predictions about 60-40% of the time, which also is expected. For models such as CHECWORKS™, there is an expectation that the model will yield conservative and non-conservative predictions about 50% of the time. Dr. Hopenfeld has determined that the predictions are conservative and non-conservative 50% ± 10% of the time, which is a reasonably good performance. It is not realistic to expect physical inspection data of component thickness to fit the predicted values exactly 100 percent of the time, which is why CHECWORKS™ predictions are only one of many factors used to select components for inspection.

Q.60. Do you agree with Dr. Hopenfeld's concerns about Entergy's “line correction factors?”

A.60. No, Dr. Hopenfeld's concerns about Entergy's “line correction factors” are not well founded. Variations of line correction factors from the optimum value of 1 may be due to a number of factors, principal of which is likely to be the relative uncertainty of the thickness measurements compared to the amount of wall thinning. In particular, in some cases the wall thinning may be small such that it is of the same order of magnitude as the uncertainty in the measurements.

Concerns with line correction factors would be a concern only if the CHECWORKS™ code was the lone basis for aging management in the FAC Program. However, the key component of the FAC Program is the implementation of inspections to actually monitor the wall thickness, with the CHECWORKS™ code only one factor used to identify locations to be inspected.

OVERRELIANCE OF THE ENTERGY FAC PROGRAM ON CHECWORKS™

Q.70. Do you agree with Dr. Hopenfeld’s assertion that Entergy primarily relies upon the use of CHECWORKS™, and has no other tools that are meaningfully independent of CHECWORKS™ that would sufficiently address FAC at Indian Point?

A.70. No, the IPEC FAC Program uses CHECWORKS™ as one of multiple criteria in determining which in-scope piping component locations will be inspected at the next outage. 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. *See* EN-DC-315 at 17 and 18. Regarding criteria for inspection selections, the Entergy procedure further states:

> Inspection selections shall be made in accordance with the requirements of this procedure AND shall be identified based on CHECWORKS results, industry/station/utility experience, required re-inspections, the non-modeled program piping AND engineering judgment.

EN-DC-315 at 17 (Ex. RIV000015).

The staff verified that the Applicant's revised program used the CHECWORKS™ program as one of several bases for establishing which in-scope piping component locations should be scheduled for inspection at the next outage. *See* SER at 3-26 (Ex. NYS00326A-F). The staff also verified that the Applicant uses IP2-specific and IP3-specific operating experience, operating experience discussed in NRC generic communications, industry operating experience records or reports, and engineering judgment as additional bases for selecting in-scope piping components for inspection. *Id*. at 3-26. The staff also verified that the Applicant's use of the CHECWORKS™ program uses the most recent updated power-uprated operating parameters and inspection results as the basis for establishing the program wear predictions for components that are within the scope of the program. *Id*. at 3-26.

CONSIDERATION OF SAFETY ISSUES IF THE FAC PROGRAM FAILS

Q.71. Riverkeeper claims that Entergy fails to address safety issues posed due to inadequate aging management of FAC during the period of extended operation. How should Entergy have addressed the issues identified in this claim?

A.71. There is no additional information that Entergy should have provided relative to this claim, because these issues are outside the scope of the license renewal review as provided for in 10 CFR Part 54.

The purpose of aging management for license renewal is to demonstrate that the effects of aging will be adequately managed, including the definition of acceptance criteria and guidance on repair and replacement, so that the intended functions will be maintained

consistent with the CLB for the period of extended operation, such that the concerns cited by Riverkeeper will not occur. It would be illogical for the Applicant to address failure of aging management in its LRA. In addition, the NRC's ongoing reactor oversight verifies that the licensee implements its aging management activities consistent with its CLB.

Q.72. Does this complete your testimony?

A.72. Yes.

March 30, 2012

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/ 50-286-LR
	)	
(Indian Point Nuclear Generating	)	
Units 2 and 3)	)	

AFFIDAVIT OF MATTHEW YODER

I, Matthew Yoder, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 C.F.R. § 2.304(d)

Matthew Yoder
Senior Chemical Engineer
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
301-415-4017
Matthew.Yoder@nrc.gov

Dated at Rockville, Maryland
This 30th day of March, 2012

March 30, 2012

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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AFFIDAVIT OF ALLEN L. HISER, JR. CONCERNING RIVERKEEPER TECHNICAL

CONTENTION RK-TC-2 FLOW ACCELERATED CORROSION

I, Allen L. Hiser, Jr., do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 C.F.R. § 2.304(d)

Allen Hiser, Jr.
Mechanical Engineer
Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
(301) 415-5650
Allen.Hiser@nrc.gov

Dated at Rockville, Maryland
This 30th day of March, 2012