RAS M-263

UNITED STATES
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Alex S. Karlin, Chairman
Dr. Richard E. Wardwell
Dr. William H. Reed

In the Matter of	)	
	)	
ENTERGY NUCLEAR VERMONT YANKEE, LLC	)	Docket No. 50-271-LR
and ENTERGY NUCLEAR OPERATIONS, INC.	)	ASLBP No. 06-849-03-LR
	)	
(Vermont Yankee Nuclear Power Station)	)	

NEW ENGLAND COALITION, INC'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW

Pursuant to 10 C.F.R. § 2.1209 and the Atomic Safety and Licensing Board's ("Board") August 5, 2008 Memorandum and Order (Regarding Corrections to the Transcript and Proposed Findings of Fact and Conclusions of Law), New England Coalition, Inc. ("NEC") hereby submits its proposed findings of fact and conclusions of law concerning NEC's four contentions before the Board in the above-captioned proceeding. Section I sets forth NEC's proposed statement of the legal standards that govern the Board's determination of NEC's contentions. Section II states proposed findings of fact and conclusions of law with respect to NEC's Contentions 2A and 2B (environmentally-assisted metal fatigue analyses); Section III states proposed finding of fact and conclusions of law with respect to NEC's Contention 3 (steam dryer); and Section IV states proposed findings of fact and conclusions of law with respect to NEC's Contention 4 (flow-accelerated corrosion).

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I. LEGAL STANDARDS.

1. The Nuclear Regulatory Commission ("NRC") may renew a commercial nuclear power plant operating license only if it finds that the license requirements are "in accord with the common defense and security and will provide adequate protection to the health and safety of the public." 42 U.S.C. § 2232(a).

2. The standards governing license renewal are set forth in 10 C.F.R. §§ 54.21 and 54.29. Pursuant to these rules, "[t]he license renewal review is intended to identify any additional actions that will be needed to maintain the functionality of the systems, structures, and components in the period of extended operation." Final Rule, Nuclear Power Plant License Renewal; Revisions, 60 Fed. Reg. 22461, 22646 (May 8, 1995). License renewal proceedings cover: (1) "the plant's systems, structures, and components that are subject to an evaluation of time-limited aging analyses," and (2) "the plant structures and components that will require an aging management review for the period of extended operation." *Duke Energy Corp. (McGuire Nuclear Station, Units 1 & 2; Catawba Nuclear Station, Units 1 & 2)*, CLI-01-20, 54 NRC 211, 212 (2001).

A. Review of plant structures and components subject to an evaluation of Time-Limited Aging Analyses ("TLAA")

3. Time-limited aging analyses ("TLAA") are defined as analyses and calculations a licensee has performed under its current license, which (1) involve time-limited assumptions defined by the current operating term, and (2) were used to make a safety determination concerning the effects of aging on systems, structures or components within the scope of license renewal. 10 C.F.R. § 54.3 (a).[1]

[1] The full definition of TLAAs is as follows:

4. NRC regulation 10 CFR § 54.21(c) requires that a license renewal application ("LRA") must contain "an evaluation of time-limited aging analyses." Section 54.29 in turn provides that the NRC may issue a renewed license only after it finds that any TLAA evaluations provide "reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the [Current Licensing Basis][2] . . . ." 10 C.F.R. § 54.29.

5. "Reasonable assurance" under 10 C.F.R. § 54.29 refers to the required degree of assurance that the "adequate protection to the health and safety of the public"

Those licensee calculations and analyses that:

(1) Involve systems, structures, and components within the scope of license renewal, as delineated in § 54.4(a);
(2) Consider the effects of aging;
(3) Involve time-limited assumptions defined by the current operating term, for example, 40 years;
(4) Were determined to be relevant by the licensee in making a safety determination;
(5) Involve conclusions or provide the basis for conclusions related to the capability of the system, structure and component to perform its intended functions, as delineated in § 54.4(b); and
(6) Are contained or incorporated by reference in the CLB [current licensing basis].

10 CFR § 54.3(a).

[2] Current Licensing Basis ("CLB") is defined in 10 C.F.R. § 54.3 as:

"the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect. The CLB includes the NRC regulations contained in 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications. It also includes the plant-specific design-basis information defined in 10 CFR 50.2 as documented in the most recent final safety analysis report (FSAR) as required by 10 CFR 50.71 and the licensee's commitments remaining in effect that were made in docketed licensing correspondence such as licensee responses to NRC bulletins, generic letters, and enforcement actions, as well as licensee commitments documented in NRC safety evaluations or licensee event reports."

Thus, the CLB incorporates requirements of the license and certain other documents, such as the FSAR and formal commitments made in licensing correspondence.

standard contained in the Atomic Energy Act, 42 U.S.C. § 2232(a), is satisfied. *Commonwealth Edison Co. (Zion Units 1 and 2),* ALAB-616, 12 NRC 419, 421 (1980).

6. Section 54.21(c)(1) defines three options for compliance with the TLAA evaluation requirement. The applicant may include in the LRA either (1) a demonstration that the TLAA analyses are valid for the period of extended operation pursuant to § 54.21(c)(1)(i); (2) a projection of the TLAA analyses to the end of the period of extended operation pursuant to § 54.21(c)(1)(ii); or (3) a plan to manage aging of the systems, structures or components subject to the TLAA, pursuant to § 54.21(c)(1)(iii).[3]

7. Under this three-tiered approach, analysis of the TLAA determines whether an aging management plan is necessary. An applicant may avoid the obligation to develop an aging management plan under § 54.21(c)(1)(iii) if it satisfies § 54.21(c)(1)(i) or 54.21(c)(1)(ii) by demonstrating that the TLAA is either valid or can be projected for the period of extended operation. On the other hand, an applicant must develop an aging management plan if it cannot or chooses not to justify or project the TLAA.

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[3] Section 54.21 reads in relevant part as follows:

> Each application must contain the following information:
>
> (c) An evaluation of time-limited aging analyses.
>
> (1) A list of time-limited aging analyses, as defined in § 54.3, must be provided. The applicant shall demonstrate that –
>
> (i) The analyses remain valid for the period of extended operations;
>
> (ii) The analyses have been projected to the end of the period of extended operation; or
>
> (iii) The effects of aging on the intended function(s) will be adequately managed for the period of extended operations.

10 C.F.R. § 54.21(c)(emphasis added).

8. As the NRC explained in the preamble to Section 54.21(c) published in the Federal Register:

> The applicant for license renewal will be required in the renewal application to –
> (1) Justify that [TLAA] analyses are valid for the period of extended operation;
> (2) Extend the period of evaluation of the analyses such that they are valid for the period of extended operation, for example, 60 years; or
> (3) Justify that the effects of aging will be adequately managed for the period of extended operation if an applicant cannot or chooses not to justify or extend an existing time-limited aging analysis.

Nuclear Regulatory Commission, Nuclear Power Plant License Renewal; Revisions, Final Rule, 60 FR 22461-01, 22480 (May 8, 1995).

9. An aging management program adequate to satisfy the reasonable assurance standard monitors the performance and condition of structures and components subject to aging mechanisms in a manner that allows for timely identification and correction of degraded conditions. *See*, Nuclear Power Plant License Renewal: Revisions, Final Rule, 60 Fed. Reg. 22461, 22469 (1995). An aging management plan under Section 54.21(c)(1)(iii) should therefore consist of a program of component inspection, repair and replacement that specifies scope, method and frequency.

10. Pursuant to the plain language of Section 54.21(c), the analysis to validate or project a TLAA cannot be performed after license renewal is approved as a component of an aging management program developed under Section 54.21(c)(1)(iii). *See, In the Matter of Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3),* ASLBP No. 07-858-03-LR-BD01, Memorandum and Order Ruling on Petitions to Intervene and Requests for Hearing (July 31, 2008) at 112-113 ("[T]he recalculation of the [CUF TLAA for metal fatigue] is not an option for the [aging management plan]. CUFs are threshold values that determine whether such a program is needed for license renewal. . . . Entergy's proposal

to perform [CUFen] calculations in the future, albeit in accordance with specified guidance, is unacceptable because these calculations are not a component of an AMP, but are the fundamental fatigue analyses for time-limited aging that 10 C.F.R. § 54.21(c) requires to be included in the LRA.").

11. An interpretation of Section 54.21(c)(1) to allow performance of a TLAA validation or projection as a component of an aging management plan under Section 54.21(c)(1)(iii) would collapse the distinction between Sections 54.21(c)(1)(i), 54.21(c)(1)(ii) and 54.21(c)(1)(iii). This is therefore an invalid construction of the rule. *See, Kungys v. US*, 485 US 759, 788 (1988) (It is a "cardinal rule of statutory interpretation that no provision should be construed to be entirely redundant."); *Cf, DirectTV Inc. v. Hoa Huynh*, 503 F.3d 837, 853 (9th Cir. 2007)("We must make every effort not to interpret a provision in a manner that renders other provisions of the same statute inconsistent, meaningless or superfluous," and therefore "reject DirecTV's attempt to collapse the distinction between subsections (a) and (e) [of the Federal Communications Act].").

12. NUREG-1801, Rev. 1, Generic Aging Lessons Learned (GALL) Report (2005) ("NUREG-1801") provides guidance for the preparation of TLAAs specifically to evaluate environmentally-assisted metal fatigue. NUREG-1801 advises that a license renewal applicant may address "the effects of the coolant environment on component fatigue life by assessing the impacts of the reactor coolant environment on a sample of critical components for the plant." NUREG-1801, Vol. 2 at X M-1 (NRC Staff Exhibit 7). Examples of critical components are identified in NUREG/CR-6260, Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components

(1995). The sample of critical components "can be evaluated by applying environmental life correction factors to the existing ASME Code fatigue analyses." NUREG-1801, Vol. 2 at X M-1. If these components are found not to comply with the ASME Code acceptance criteria, CUF less than one with the environmental correction factor applied, "corrective actions" must be taken that "include a review of additional affected reactor coolant pressure boundary locations." Id. at X M-2.

B. Aging Management Review

13. License renewal applicants must "demonstrate how their [aging management] programs will be effective in managing the effects of aging during the period of extended operation." *Florida Power & Light Co. (Turkey Point Nuclear Generating Plant, Units 3 & 4)*, CLI-01-17, 54 NRC 3, 8 (2001).

14. NRC rule 10 C.F.R. § 54.21(a)(3) requires an applicant to "demonstrate that the effects of aging will be adequately managed so that [structures and components subject to aging management review] will be maintained consistent with the CLB for the period of extended operation." NRC rule 10 C.F.R. § 54.29(a) requires an applicant to identify and take (or plan to take) actions to manage the effects of aging "such that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the CLB . . . ."

15. An applicant's "demonstration" pursuant to § 54.21(a)(3) must include enough detail regarding how the applicant proposes to manage the effects of aging as to allow the NRC Staff and any intervenors before the ASLB to understand and rigorously evaluate the content and likely effectiveness of that program, in order to determine whether the § 54.29(a) "reasonable assurance" standard is satisfied.

16. If an applicant provides insufficient detail regarding its aging management plans, the NRC will not have enough information to find reasonable assurance of public safety and would be arbitrary and capricious in approving the license renewal. Alternatively, the NRC must postpone its substantive review of aging management plans that must be the basis for its finding of reasonable assurance until after a license is issued. This postponement would illegally curtail intervenors' rights to a hearing before the ASLB on all issues material to the licensing decision. *See, Union of Concerned Scientists v. United States Nuclear Regulatory Commission*, 735 F.2d 1437 (C.A.D.C. 1984) (Section 189(a)) of the Atomic Energy Act (AEA) requires the NRC to grant a hearing at the request of an interested person on any material issue relevant to the licensing decision; the NRC may not exclude a material public-safety related issue from consideration by the Atomic Safety and Licensing Board.). It would also violate NRC precedent holding that "the mechanism of post-hearing resolution must not be employed to obviate the basic findings prerequisite to an operating license." *In the Matter of Consolidated Edison Company of New York, Inc. (Indian Point Station, Unit No. 2)*, CLI-74-23, 7 A.E.C. 947, 950-52 (1974).

C. <u>The status of NRC Staff and industry guidance in license renewal review.</u>

17. An applicant's demonstration that an aging management program or TLAA validation or projection methodology conforms to NRC Staff or industry guidance is not dispositive of whether that program or analysis satisfies the "reasonable assurance" standard under 10 C.F.R. § 54.29(a).

18. "Agency interpretations and policies are not 'carved in stone' but must rather be subject to re-evaluation of their wisdom on a continuing basis." *Kansas Gas and Electric Co. (Wolf Creek Generating Station, Unit 1),* 49 NRC 441, 460 (1999),

citing, Chevron USA, Inc. v. Natural Resources Defense Council, Inc., 467 U.S. 837, 863-64 (1984)).

19. NUREG-1801, the GALL report, does not contain legally binding regulatory requirements. Its Summary and Introduction includes the following explanation of its legal status:

> Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG series publications.
>
> * * *
>
> The GALL report is a technical basis document to the SRP-LR, which provides the Staff with Guidance in reviewing a license renewal application . . . . The Staff should also review information that is not addressed in the GALL report or is otherwise different from that in the GALL report.

NUREG-1801, Vol. 1, Summary, Introduction, Application of the GALL Report.

20. The GALL report and other NRC guidance documents are treated as evidence of legitimate means for complying with regulatory requirements, but the NRC Staff must prove the validity of its guidance if it is contested by an intervenor. *In the Matter of Carolina Power & Light Company and North Carolina Eastern Municipal Power Agency (Shearon Harris Nuclear Power Plant)*, ASLBP No. 82-472-03-OL, 23 NRC 294 (1986); *See also, In the Matter of Connecticut Yankee Atomic Power Company (Haddam Neck Point)*, ASLBP No. 01-787-02-OLA, 54 NRC 177, 184 (2001) ("NUREGs and similar documents are akin to 'regulatory guides.' That is, they provide guidance for the Staff's review, but set neither minimum nor maximum regulatory requirements."); *In the Matter of Private Fuel Storage, LLC,* ASLBP No. 97-732-02-ISPSI, 57 NRC 69, 92 (2003)("[A]n intervenor, though not allowed to challenge duly

promulgated Commission regulations in the hearing process. . . is free to take issue with . . . NRC Staff guidance and thinking . . . .").

D. Operating License Conditions Subsequent: the Proper Scope of Post-Licensing Resolution by the NRC Staff

21. Only "minor matters" may be left to the NRC Staff for post-hearing resolution. *In the Matter of Long Island Lighting Company (Shoreham Nuclear Power Station, Unit 1)*, ALAB-788, 20 NRC 1102, 1159 (1984). The Staff's post-hearing role should be "ministerial," and should not involve "overly complex" or "discretionary" judgments on legal or factual issues. *In the Matter of Private Fuel Storage, L.L.C. (Independent Spent Fuel Storage Installation)*, CLI-00-13, 52 N.R.C. 23, 34 (2000); *See also, In the Matter of Southern California Edison Company, et. al. (San Onofre Nuclear Generating Station, Units 2 and 3)*, LBP-82-39, 15 N.R.C. 1163, 1216, 1217 (1982) (NRC Staff could properly determine whether public information should be printed in Spanish and confirm the delivery of emergency equipment, but further hearings were required concerning the adequacy of medical services to be made available to the public).

22. A license condition or commitment must not affect "an improper delegation of decisional responsibility over adversary issues from the Board to the staff." *In the Matter of Long Island Lighting Company (Shoreham Nuclear Power Station, Unit 1)*, 20 NRC at 1160. Fundamentally:

> [T]he mechanism of post-hearing resolution must not be employed to obviate the basic findings prerequisite to an operating license – including a reasonable assurance that the facility can be operated without endangering the health and safety of the public. In short, the 'post-hearing' approach should be employed sparingly and only in clear cases. **In doubtful cases, the matter should be resolved in an adversary framework prior to issuance of a license, reopening the record if necessary.**

In the Matter of Consolidated Edison Company of New York, Inc. (Indian Point Station, Unit No. 2), CLI-74-23, 7 A.E.C. 947, 950-52 (1974)(emphasis added).

E. Burden of Proof in License Renewal Proceeding

23. In an operating license proceeding, the licensee bears the ultimate burden of proof. 10 C.F.R. § 2.325; *Metropolitan Edison Co. (Three Mile Island Nuclear Station, Unit 1)*, ALAB-697, 16 NRC 1265, 1271 (1982). It is Entergy's[4] burden to demonstrate by a preponderance of the evidence that it has satisfied the "reasonable assurance" standard with respect to the issues raised by each of NEC's contentions. *Commonwealth Edison Co. (Zion Units 1 and 2), ALAB-616, 12 NRC 419, 421 (1980)*(Applicants have to "provide 'reasonable assurance' that public health, safety, and environmental concerns were protected, and to demonstrate that assurance by 'a preponderance of the evidence.'").

II. NEC CONTENTIONS 2A AND 2B (Environmentally-Assisted Metal Fatigue Analyses)

A. Proposed Findings of Fact

1. Background Concerning Entergy's CUFen Analyses and Statement of the Issue

24. NEC's Contentions 2A and 2B contest the validity of analyses Entergy has performed to evaluate the impact of environmentally-assisted metal fatigue on vulnerable plant components and to demonstrate that plant components will meet the ASME Code acceptance criterion for metal fatigue throughout the period of extended operation.

[4] "Entergy" refers to the license renewal Applicant, Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc.

25. "Fatigue" is as an age-related degradation mechanism caused by cyclic stressing of a component by either mechanical or thermal stresses that eventually cause the component to crack. Exhibit NEC-JH_03 at 22.

26. The fatigue life of a component is represented by a cumulative usage factor ("CUF"), which represents the fraction of the allowable fatigue cycles that the component has experienced. Exhibit NEC-JH_03 at 1, 22. "Cumulative Usage Factor" is defined as the summation of usage fatigue factors. "Usage Fatigue Factor" is defined as the number of cycles n at any given stress amplitude divided by the corresponding number of cycles to end of life, N. Exhibit NEC-JH_03 at 22; Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A7.

27. The ASME Code acceptance criterion for metal fatigue requires that the CUF for a Class 1 component not exceed 1.0. ASME Code Section III; Exhibit NEC-JH_03 at 1; Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A8.

28. An NRC Staff witness testified that, when ASME Code fatigue curves are used, a CUF of 1.0 indicates a 1-5% chance of formation of a three millimeter crack. Testimony of Mr. Fair, Tr. 900-902. There is, however, wide disagreement among researchers regarding the degree of conservatism of the ASME Code curves. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A12; Exhibit NEC-JH_26 at 71.

29. The reactor coolant environment is more aggressive than air; it accelerates the rate of degradation by fatigue and reduces the fatigue life of components. Joint

Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A9. To account for this, the CUF for a component exposed to reactor coolant is multiplied by a correction factor, "Fen", to obtain an environmentally adjusted CUF or "CUFen." Id. at A9, A12; Exhibit NEC-JH_03 at 1. Fen is the ratio of fatigue life in air at room temperature to fatigue life in water at the local temperature. Exhibit NEC-JH_03 at 1.

30. CUFen must not exceed unity. Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A12.

31. Entergy's License Renewal Application (LRA) § 4.0 describes Entergy's evaluations of Time Limited Aging Analyses ("TLAA") pursuant to 10 C.F.R. § 54.21(c). Section 4.3 addresses Entergy's "[metal] fatigue evaluations that meet the definition of TLAA for Class 1 and non-Class 1 mechanical components at VYNPS." LRA at 4.3-1. Table 4.3-3 reports Entergy's calculations of the CUFen values that would obtain at the conclusion of the period of extended operation for nine components. These components correspond to the limiting locations identified in NUREG/CR-6260. Safety Evaluation Report Related to the License Renewal of Vermont Yankee Nuclear Power Station (February 2008)("FSER"), Exhibit NRC Staff_01 at 4-32.

32. CUFen values reported in LRA Table 4.3-3 for the following components are greater than one: feedwater nozzle, RR inlet nozzle, RR outlet nozzle, RR piping tee, core spray nozzles, core spray safe end, and feedwater piping.

33. To address this problem, Entergy initially proposed the following in the LRA:

> Prior to entering the period of extended operation, for each location that may exceed a CUF of 1.0 when considering environmental effects, VYNPS will implement one or more of the following:
>
> (1) further refinement of the fatigue analyses to lower the predicted CUFs to less than 1.0;
>
> (2) management of fatigue at the affected locations by an inspection program that has been reviewed and approved by the NRC (e.g., periodic non-destructive examination of the affected locations at inspection intervals to be determined by a method acceptable to the NRC);
>
> (3) repair or replacement of the affected locations.
>
> Should VYNPS select the option to manage environmentally-assisted fatigue during the period of extended operation, details of the aging management program such as scope, qualification, method, and frequency will be provided to the NRC prior to the period of extended operation.
>
> The effects of environmentally-assisted thermal fatigue for the limiting locations identified in NUREG-6260 have been evaluated. Cracking by environmentally-assisted fatigue of these locations is addressed using one of the above three approaches in accordance with 10 CFR 54.21(c)(1).

LRA at 4.3-7.

34. Entergy later submitted License Renewal Commitment 27, which reads in part:

> At least 2 years prior to entering the period of extended operation, for the locations identified in NUREG/CR-6260 for BWRs of the VY vintage, VY will refine our current fatigue analyses to include the effects of reactor water environment and verify that the cumulative usage factors (CUFs) are less than 1.

NRC Staff Exhibit 01 at A-8.

35. On August 20, 2007, the NRC Staff rejected Commitment 27 on the following grounds:

> It is the NRC position that in order to meet the requirements of 10 CFR § 54.21(c)(1), an applicant for license renewal must demonstrate in the LRA that the evaluation of the time-limited aging analyses (TLAA) has been

completed. The NRC does not accept a commitment to complete the evaluation of TLAA prior to entering the period of extended operation.

NRC Summary of Telephone Conference Call Held on August 20, 2007, Between the U.S. Nuclear Regulatory Commission and Entergy Nuclear Operations, Inc., Concerning the Vermont Yankee Nuclear Power Station License Renewal Application (October 25, 2007), Exhibit NEC-JH_62 at Enclosure 2.

36. Entergy therefore agreed to amend its LRA to demonstrate that it had completed the refinement of its environmentally-assisted fatigue analysis to verify that CUFens for the NUREG/CR-6260 limiting locations are less than one. Id.

37. Entergy then undertook CUFen reanalyses that proceeded in two major steps. Entergy first performed a CUFen reanalysis addressing all components listed in its LRA Table 4.3-3, corresponding to the NUREG/CR-6260 limiting locations ("the initial CUFen Reanalysis"). Entergy's methodology for this analysis included the use of a simplified Green's function method to calculate stress loads during plant transient operations on three of the components analyzed: the core spray, recirculation and feedwater nozzles. Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A37-A39; Testimony of Mr. Stevens, Tr. 925 at lines 9-13.

38. The NRC Staff rejected Entergy's initial CUFen Reanalysis results for the core spray, recirculation and feedwater nozzles because Entergy and the NRC Staff "were unable to resolve the issues raised [with respect to Entergy's use of Green's functions to calculate stress loads]." FSER, NRC Staff Exhibit 01 at 4-40. The NRC Staff ultimately concluded that Entergy's initial CUFen Reanalysis could not be the analysis of record for the three nozzles due to insufficient conservatism resulting from the simplified Green's function

method. Id. at 4-43 ("[T]he results of the Green's function application using the specific software could underestimate CUF, and therefore cannot be the analysis of record.").

39. The NRC Staff therefore requested that Entergy perform, and Entergy did perform, an additional so-called "confirmatory" CUFen analysis of the feedwater nozzle only, using the ASME Code Section III, Subsection NB-3200 methodology to calculate the stress intensities "without referencing Green's function." FSER, NRC Staff Exhibit 01 at 4-41; *See also,* Exhibit NEC-JH_22 (Summary of Meeting Held on January 8, 2008, Between the U.S. Nuclear Regulatory Commission Staff and Entergy Nuclear Operations, Inc. Representatives to Discuss the Response to a Request for Additional Information Pertaining to the Vermont Yankee Nuclear Power Station License Renewal Application).

40. Entergy's Initial CUFen Reanalysis required 12-14 "man weeks" per component to complete. Testimony of Mr. Stevens, Tr. 916 at lines 9-11, 17. The "confirmatory" analysis took nine "man weeks" per component. Testimony of Mr. Stevens, Tr. 919 at line 7. The execution of either the initial or confirmatory analysis is not a mechanical task, but rather requires the analyst to exercise judgment. Testimony of Mr. Stevens, Tr. 919 at lines 2, 10; Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A25.

41. Entergy's "confirmatory" analysis differed from its initial CUFen Reanalysis in two respects. First, the simplified Green's Function approach was not used. Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A39. Second, in one version of Entergy's "confirmatory" calculation, maximum Fen values were computed for each

stress load pair used in calculating CUF, whereas a single more conservative Fen value based on the maximum transient temperature for all load pairs was used in the initial CUFen Reanalysis. Id. At the request of the NRC Staff following a February 14, 2008 audit of the confirmatory calculations, Entergy also performed the confirmatory calculation using the same single maximum Fen value used in the initial CUFen Reanalysis. Id.; FSER, NRC Staff Exhibit 1 at 4-42.

42. Entergy has thus reported four different CUFen values for the feedwater nozzle: a) 2.86 (License Renewal Application Table 4.3-3); b) 0.64 (Initial CUFen Reanalysis using Simplified Green's Function Method); c) 0.35 ("confirmatory" analysis using Fen values computed for each stress load pair); and d) 0.89 ("confirmatory" analysis using same maximum Fen value used in Initial CUFen Reanalysis). LRA Table 4.3-3; Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A40.

43. The "confirmatory" analysis of the feedwater nozzle is not bounding for the recirculation and core spray nozzles. Testimony of Mr. Fair, Tr. at 923, lines 19-25, and 924, lines 1-4, 946, lines 15-25, 951, lines 5-10, 1137 at lines 12-19.

44. The NRC Staff accepted Entergy's "confirmatory" analysis as the "analysis of record" for the feedwater nozzle. FSER, NRC Staff Exhibit 1 at 4-43. Because it does not consider the "confirmatory" analysis bounding for other components, however, the Staff "concludes that similar analysis should be performed for the CS and RR outlet nozzles and that these analyses will be documented as the 'analysis of record' for these two nozzles." FSER, NRC Staff Exhibit 1 at 4-43. To this effect, "a license condition for performing the ASME Code analyses for the CS and RR outlet nozzles will

remain in effect until the applicant has completed and submitted those final analyses for NRC review and approval no later than two years prior to entering the [period of extended operations]." FSER, NRC Staff Exhibit 1 at 4-43, 1-12.

45. The NRC Staff also ultimately accepted a slightly revised version of the same License Renewal Commitment 27 it rejected in August, 2007 on grounds that "in order to meet the requirements of 10 CFR § 54.21(c)(1), an applicant for license renewal must demonstrate in the LRA that the evaluation of the time-limited aging analyses (TLAA) has been completed." Exhibit NEC-JH-62 at Enclosure 2. The Staff reversed its prior position to find that Entergy's commitment to complete the environmentally-assisted metal fatigue TLAA at least two years prior to entering the period of extended operation "will address environmentally assisted metal fatigue for the seven components which have not been addressed." FSER, NRC Staff Exhibit 1 at 4-43, A-8 –A-9.

46. NEC's Contention 2A contests the validity of Entergy's Initial CUFen Reanalysis. NEC contends that "the analytical methods employed in Entergy's [environmentally corrected CUF, or] CUFen Reanalysis were flawed by numerous uncertainties, unjustified assumptions, and insufficient conservatism, and produced unrealistically optimistic results. Entergy has not, by this flawed reanalysis, demonstrated that the reactor components assessed will not fail due to metal fatigue during the period of extended operation." Board Memorandum and Order (Ruling on NEC Motions to File and Admit New Contention), November 7, 2007 at 3. NEC's Contention 2B contests the validity of Entergy's "confirmatory" reanalysis of the feedwater nozzle on these same grounds. Board Order (Granting Motion to Amend NEC Contention 2A), April 24, 2008 at 2.

2. Entergy Used a Flawed Methodology in Both its Initial and Confirmatory CUFen Reanalyses.

47. Entergy used a flawed methodology in both its Initial CUFen Reanalysis and its "confirmatory" reanalysis of the feedwater nozzle. Flaws in Entergy's methodology resulted in understatement of CUFen values and overestimation of the fatigue life of the components analyzed. Neither analysis is adequate to demonstrate that the components assessed, corresponding to the NUREG/CR-6260 limiting locations, will meet ASME criteria for safe operation, CUF less than one, throughout the period of extended operation.

a. Flaws in Method Used to Compute 60-Year CUF Values

ii. Simplified Green's Function Method Used in Initial CUFen Reanalysis for Feedwater, Core Spray and Recirculation Nozzles Understated CUF by 40%

48. A comparison of the CUFen value Entergy calculated for the feedwater nozzle using the simplified Green's Function method in its Initial CUFen Reanalysis, 0.64, with its "confirmatory" result calculated using the same single Fen value for all load pairs used in the Initial CUFen Reanalysis, 0.89, demonstrates that the simplified Green's Function method understated CUF by about 40%. Exhibit NEC-JH_03 at 6-7, 17-18.

49. Entergy has neither explained nor investigated the physical reasons for discrepancies between results obtained by the Green's Function methodology and the more exact methodology, classic NB-3200 analysis. Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contentions 2A/2B – Environmentally Assisted Fatigue at A58; Testimony of Mr. Stevens, Tr. 936 at lines 23-25; Tr. 937 at lines 1-13.

Results obtained by the Green's Function methodology therefore incorporate unquantified uncertainties. Hopenfeld Rebuttal at A20. Id.

50. In addition to rejecting Entergy's Initial CUFen Reanalysis results obtained using the simplified Green's Function method, the NRC Staff is revisiting the sufficiency of environmentally-assisted fatigue analyses based on the simplified Green's function method submitted in support of license renewal for plants other than VYNPS. On April 18, 2008, the NRC Staff issued a Regulatory Issue Summary ("RIS"), requesting that "license renewal applicants that have used this simplified Green's function methodology perform confirmatory analyses to demonstrate that the simplified Green's function analyses provide acceptable results." Exhibit NEC-JH-23 at 2. This RIS also states: "For plants with renewed licenses, the staff is considering additional regulatory actions if the simplified Green's function methodology was used." Id. On April 3, 2008, the NRC Staff issued a Notification of Information in Docket No. 50-219-LR (License Renewal for Oyster Creek Nuclear Generating Station), stating that it will require "confirmatory" fatigue analyses due to Oyster Creek's reliance on the simplified Green's function method. Exhibit NEC-JH_24.

iii. Unjustified Assumption that Heat Transfer Coefficients are Constant.

51. In both its Initial and "confirmatory" CUFen reanalyses, Entergy used a two-dimensional axisymetric model in calculating thermal stresses during transients. This two-dimensional model cannot account for circumferential variations in temperature. Testimony of Mr. Stevens, Tr. 1114 at lines 7-12, Tr. 1116 at lines 7-11. Entergy's analyses therefore assume that heat transfer coefficients are constant across the

entire surface of the components analyzed. Testimony of Dr. Hopenfeld, Tr. 1100-1101, 1108-1109; Testimony of Mr. Stevens, Tr. 1111 at lines 101-13.

52. The use of a two-dimensional model in the analyses is a shortcut that saves time and money. Effects of circumferential temperature variations could be evaluated through use of a three-dimensional model that includes the circumferential portion of the structure. Testimony of Mr. Stevens, Tr. 1114 at lines 13-16. It takes more time to build a three-dimensional model than it does to build a two-dimensional model. Testimony of Mr. Stevens, Tr. 1114 at lines 19-21.

53. Heat transfer coefficients are constant only when flow is fully developed; fully developed flow does not allow for temperature variations. Exhibit NEC-JH_03 at 12; Testimony of Mr. Stevens, Tr. 1118 at lines 16-21.

54. Flow may not be fully developed in the feedwater, core spray and recirculation nozzles because they are relatively short and contain geometric discontinuities. Exhibit NEC-JH_03 at 12-13. To justify the use of the axisymetric model and the assumption of constant heat transfer coefficients, Entergy must show that the flow upstream of each nozzle is fully developed at the entrance to the nozzle. Exhibit NEC-JH_03 at 13.

55. To determine whether flow is fully developed through the feedwater, core spray and recirculation nozzles, it would be necessary to know how the connecting pipes are oriented with respect to each nozzle; how many diameters the pipe is straight upstream of each nozzle, and whether there are any discontinuities, such as welds, upstream of each nozzle. Exhibit NEC-JH_03 at 8. The record before the Board does not contain this information.

56. Entergy's witness Mr. Stevens testified that there are 48 inches of horizontal pipe upstream of the feedwater nozzle, and this length is sufficient for fully developed turbulent flow to occur through the nozzle region. Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contentions 2A/2B – Environmentally Assisted Fatigue at A54. NEC's witness Dr. Hopenfeld disagreed that 48 inches would be enough to establish fully developed flow for forced convection. Since the inside diameter of the feedwater nozzle is 9.7 inches, about 30 to 60 diameters are required to establish fully developed flow through the nozzle. Pre-filed Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A16. Even when flow straighteners are inserted to form a uniform flow at the entrance to flow meters, a minimum 12.5 diameters of straight section upstream of the flow straightener is required, with the length depending on whether the fitting upstream from the flow straightener is an elbow or a valve. Testimony of Dr. Hopenfeld, Tr. 1127 at lines 1-12.

57. Entergy did not submit testimony or any exhibit stating the straight section lengths upstream of the recirculation and core spray nozzles. If that length is also on the order of 48 inches, the flow in these nozzles will not be fully developed because the diameter of these nozzles is larger than the diameter of the feedwater nozzle. Id.

58. Based on the record evidence before the Board, Entergy's assumption that flow through the feedwater, core spray and recirculation nozzles is fully developed and heat transfer coefficients are therefore constant is unjustified.

59. Thermal stresses are very sensitive to the heat transfer coefficient. Testimony of Dr. Hopenfeld, Tr. 1102-1103; Testimony of Mr. Stevens, Tr. 1106 at lines 5, 14-16. Where flow is not fully developed, heat transfer coefficients can vary at

different points around a nozzle. Testimony of Dr. Hopenfeld, Tr. 1109-1110. Differences in the flow and temperature field azimuthally around a nozzle create large shear stresses. Testimony of Mr. Stevens, Tr. 1117 at line 20. If Entergy had recognized possible circumferential variations in the heat transfer coefficient in its CUFen analyses through use of a three-dimensional model, it might have obtained significantly higher stresses and CUF values. Testimony of Dr. Hopenfeld, Tr. 1110 at line 3.

60. Entergy's use of a constant heat transfer coefficient does not describe the variation of heat transfer coefficient, and the stresses, along a pipe in transients where the flow is transitioned from forced convection flow to free convection flow. Exhibit NEC-JH_03 at 14.

61. To calculate temperature distribution in the nozzles during transients when condensation takes place, one must use local heat transfer coefficients, not average values. Entergy improperly used average values. Exhibit NEC-JH_03 at 15.

iii. *Transient Cycle Count.*

62. The number of transient cycles used in calculating 60-year CUF values in both Entergy's Initial and "confirmatory" CUFen analyses may not be sufficiently conservative.

63. The record before the Board is unclear regarding exactly how Entergy determined transient cycle counts. The prefiled Testimony of Entergy witness Mr. Stevens states the following:

> The transients used in the EAF analysis are a combination of the original VY design transients and additional, more detailed design conditions from a later BWR 4 design specification. (The later BWR plants have more detailed thermal transient definitions based on the operating experience from earlier BWRs). Then VY projections for 60 years were made based on all available sources, including the numbers of cycles for 40 years in

> the VY reactor pressure vessel Design Specification, the number of cycles actually analyzed in the VY Design Stress Report, and the numbers of cycles experienced by VY after approximately 35 years of operations (July 2007).

Joint Declaration of James C. Fitzpatrick and Gary L Stevens on NEC Contentions 2A/2B – Environmentally Assisted Fatigue at A55. In oral testimony to the Board, Mr. Stevens testified that design basis counts projected to 60 years by linear extrapolation were used. Testimony of Mr. Stevens, Tr. 856 at lines 2-3; Tr. 871 at lines 2-12.

64. Entergy's CUFen analyst testified that he believed the transient count used in the CUFen analyses is conservative because the design basis count exceeds the number of transients VYNPS has actually experienced, and he does not believe VYNPS will experience a higher rate of transients as it ages beyond its design life (a "bathtub effect"). Testimony of Mr. Stevens, Tr. 856, Tr. 1143 at lines 2-25.

65. Entergy's CUFen analyst assumed VYNPS would not experience a "bathtub effect" even though he had no information about whether the rate of transients at VYNPS has increased following the power uprate implemented in 2006. Testimony of Mr. Stevens, Tr. 1143 at lines 25. The NRC Staff has not reviewed this issue either. Testimony of Mr. Fair, Tr. 1143 at line 22.

66. In fact, VYNPS has experienced three significant unplanned transients since August, 2007 – two due to failures of the plant cooling towers (in August, 2007 and July, 2008), and one due to a turbine stop valve incident (August, 2007). Testimony of Mr. Fitzpatrick, Tr. 1170-1171. Based on this experience, Entergy should assume VYNPS is likely to experience an increased number of transients during the period of extended operations over what it has experienced during the current license term.

67. NEC's witness Dr. Hopenfeld testified that he was unable to determine whether the transient cycle numbers used in the CUFen analyses are conservative. Prefiled Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3, and 4 at A21. NRC Staff witness Dr. Chang similarly testified that he was "unable to determine the level of conservatism regarding the number of transient cycles at this time." Affidavit of Kenneth Chang Concerning NEC Contentions 2A & 2B (Metal Fatigue) (May 12, 2008) at A10.

b. Flaws in Method Used to Compute Fen Multipliers

i. Failure to Consider Most Recent Data Published in NUREG/CR-6909

68. In calculating environmental life correction (Fen) factors in both its Initial and "confirmatory" analyses, Entergy should have considered the most recent data on this subject published in NUREG/CR-6909, Exhibit NEC-JH_26, in February, 2007.

69. Entergy calculated Fen factors using the Fen methodology published in 1998 in NUREG/CR-6583 for carbon and low-alloy steels (NRC Staff Exhibit 11) and in NUREG/CR-5704 for austenitic steels (NRC Staff Exhibit 12). Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contentions 2A/2B – Environmentally Assisted Fatigue at A28.

70. NUREG-1801, Vol. 2 at X M-1 references the NUREG/CR-6583 and NUREG/CR-5704 formulae. The NRC Staff currently requires use of the NUREG/CR-6909 methods and information only for fatigue analyses in new reactors. Regulatory Guide 1.207 (NRC Staff Exhibit 13).

71. NUREG/CR-6909, however, is based on a larger database than NUREG/CR-6583 and NUREG/CR-5704. The NRC Staff testified that it includes more and better data, at least with respect to stainless steel, Testimony of Mr. Fair, Tr. 791 at lines 23-25, 792 at lines 1-23. The Staff also testified that, from a technical standpoint, there is no reason not to apply NUREG/CR-6909 to license renewal. Testimony of Mr. Fair, Tr. 845 at lines 1-5.

ii. Failure to Account for Uncertainties in the Impact of Multiple Relevant Factors

72. Fen methodology is a developing technology. EPRI has cautioned that "the current state of the technology with respect to Fen methodology is incomplete or lacking in detail or specificity." Exhibit NEC-JH_64 at 4-25.

73. NUREG/CR-6909 updates formulae for computing Fen, but it also explains the limitations of these formulae in a way that NUREG/CR-6583 and NUREG/CR-5704 did not. NUREG/CR-6909 describes multiple factors known to affect fatigue life that are not accounted for in either the ANL 1998 Equations contained in NUREG/CR-6583 and NUREG/CR-5704 or the updated equations contained in NUREG/CR-6909. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A5.

74. Surface finish is one significant factor known to affect fatigue life that is not fully accounted for in any of the Fen formulae. Fatigue life is sensitive to surface finish. A rough surface significantly reduces fatigue life. Exhibit NEC-JH_03 at 11. In air, fatigue life is reduced by a factor of 3 when the surface finish of a smooth surface increases in roughness to 4 microns, which is typical of a maximum roughness of

surfaces from different metal-working processes in the automotive industry. NUREG/CR-6909, Exhibit NEC-JH_26 at 14.

75. Entergy's CUFen analyses assumed that the ASME fatigue curves were adjusted to account for effects of surface finish, and therefore did not account for surface finish in the Fen calculation. Testimony of Mr. Stevens, Tr. 1088 at lines 17-20. This approach was in error.

76. Entergy and NEC witnesses agree that the ASME Code curves were adjusted for surface finish by a factor of four to account for different fabrication processes – ie, for the difference between mirror polished test specimens and machined components. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A13; Testimony of Mr. Stevens, Tr. 1088 at lines 3-9. Machined surfaces, however, are not prototypical of surfaces with roughness formed by corrosion after long exposure to the reactor environment. Surfaces exposed to the LWR environment are subject to corrosion, erosion and pitting, exhibiting a combination of smooth surfaces, ridges and holes of various sizes. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A13; Testimony of Dr. Hopenfeld, Tr. 1073 at lines 3-12. Surface holes and grooves may provide sites for accelerated corrosion attack, which can accelerate crack growth under cyclic loads. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A13. The ASME Code design fatigue curves therefore do not account for the relevant surface roughness. Id.

77. Also, the ASME Code design fatigue curves are adjusted to account for the effects of surface finish in air. Neither the ASME code fatigue curves nor the ANL

equations account for the effects of actual roughness in reactor water, which may not be the same as in air. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A5, Table 1.

78. Existing surface cracking is another significant factor known to affect fatigue life that is not accounted for in any of the Fen formulae. NEC and Entergy witnesses agree that existing fatigue cracks at the feedwater nozzles can provide sites for accelerated corrosion and thereby accelerate fatigue failure under cycling loads. Exhibit NEC-JH_03 at A5, Table 1; Testimony of Mr. Stevens, Tr. 1053 at 15-16.

79. In the late 1970s, the feedwater nozzles of many BWR plants developed cracks due to high cycle fatigue because of differences in the thermal properties of the cladding and base metal. Exhibit NEC-JH_03 at 15. The cladding was removed from most BWR plants, but not from VYNPS. Id.

80. Entergy inspects the feedwater nozzles for cracking with ultrasonic testing, but this type of testing is difficult to do reliably when the carbon steel base metal is clad with stainless steel. Testimony of Dr. Hopenfeld, Tr. 1056 at lines 5-13. Entergy has acknowledged to the NRC that the feedwater nozzle cladding may contain cracks and that such cracks could grow into the base metal. FSER, NRC Staff Exhibit 1 at 4-26 – 4-27.

81. Based on the industry history of feedwater nozzle cracking, Entergy should have adjusted Fen values in its CUFen analyses to account for the impact possible cracks in the feedwater nozzle cladding and base metal would have on the fatigue life of the nozzles. Exhibit NEC-JH_03 at 15-16; Testimony of Dr. Hopenfeld, Tr. 1039 at lines 10-18.

82. Trace impurities in water is a third factor known to affect fatigue life that is not accounted for in any of the Fen formulae. Prefiled Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A5, Table 1. Entergy witnesses testified that Entergy's CUFen analyses did not account for this factor because Entergy assumes trace impurities are not present at VYNPS. Testimony of Mr. Stevens, Tr. 1094 at lines 13-19; Tr. 1172 at line 14. The record before the Board, however, contains no evidence that trace impurities are not present at VYNPS. A conservative analysis therefore would have assumed that they are present, and increased Fen factors accordingly.

83. NUREG/CR-6909 includes bounding values for Fen. These values are 12 for austenitic stainless steel and 17 for carbon and low-alloy steel. Exhibit NEC-JH_26, NUREG/CR-6909 at *iii* (Abstract). Because neither the ANL 1998 nor the ANL 2007 equations account for all environmental factors known to affect fatigue life, these bounding values should be used in CUFen analyses for license renewal.

84. When the bounding values stated in NUREG/CR-6909 are used to correct the CUF values Entergy submitted in the LRA, the final CUFen of all but one of the NUREG/CR-6260 sample locations exceeds 1.0. Exhibit NEC-JH-03 at 20, Table 1.

ii. *Use of Incorrect Dissolved Oxygen Values*

85. In both its Initial and "confirmatory" CUFen reanalyses of carbon and low-alloy steel components, Entergy improperly used values for dissolved oxygen ("DO") that were biased toward steady state operating conditions, when it should have used substantially higher DO values that occur during transients.

86. Fatigue cracking is very sensitive to dissolved oxygen. Testimony of Mr. Stevens, Tr. at 952, lines 4-6. Higher concentrations of dissolved oxygen worsen fatigue cracking of carbon and low alloy steel. Testimony of Mr. Stevens, Tr. at 954, lines 11-13.

87. Dissolved Oxygen values are higher during transients than during steady state operations. Gases have a negative solubility coefficient. As temperatures go down, oxygen concentrations go up. Testimony of Dr. Hopenfeld, Tr. 975 at lines 5-11; Exhibit NEC-JH_53 at Figure 1.

88. Entergy used a DO value of 50-100 ppb in its CUFen analyses of carbon and low-alloy steel components. Testimony of Dr. Hopenfeld, Tr. 981 at lines 10-12; Exhibit E-212 at 14. These values are biased toward steady state operating conditions: they represent an average of 13 years daily measurement data, plus one standard deviation. Testimony of Mr. Fitzpatrick, Tr. 972 at lines 19-23, 973 at lines 1-8, Tr. 988 at line 18.

89. NUREG/CR-6583 prescribes that, in CUFen analyses for carbon and low-alloy steels, "[t]he values of temperature and [dissolved oxygen] may be conservatively taken as the maximum values for the transient."

90. NUREG/CR-6909 goes a step further and recommends a specific value: 0.4 ppm (400 ppb):

> The [dissolved oxygen] value is obtained from each transient constituting the stress cycle. For carbon and low-alloy steels, the dissolved oxygen content, DO, associated with a stress cycle is the highest oxygen level in the transient . . . . A value of 0.4 ppm for carbon and low-alloy steels . . . can be used for the DO content to perform a conservative estimate.

NUREG/CR-6909, Exhibit NEC-JH_26 at A.5.

91. NEC witness Dr. Hopenfeld recalculated CUFen for the carbon and low-alloy steel components Entergy analyzed, using Entergy's formulae, but substituting a dissolved oxygen value of 400 ppb for the 50-100 ppb values Entergy used, and obtained CUFen values exceeding 1.0 for multiple components. Testimony of Dr. Hopenfeld, Tr. 985 at lines 12-16.

c. Lack of Error Analysis: Unjustified Assumptions that Methodology is "Conservative"

92. Entergy has not performed an error analysis to show the admissible range for each variable in its CUFen analyses. Entergy's witness Mr. Stevens testified that Entergy's CUFen analyses incorporated several "conservatisms," but he was unable to quantify the degree of conservatism. Joint Declaration of James C. Fitzpatrick and Gary L. Stevens on NEC Contention 2A/2B – Environmentally Assisted Fatigue (May 12, 2008) at A30; Testimony of Mr. Stevens, Tr. 854 at lines 4-16, Tr. at 905-906, 910.

93. Because the level of uncertainty in Entergy's analysis is high, properly identified assumptions and a competent assessment of their relative effects on CUFen is essential. In other words, to assume conservatism without quantification is not very conservative. Without an error band, Entergy's results have little significance and impart little confidence that fatigue failure will not occur. Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A25.

B. Proposed Conclusions of Law

94. CUF analyses are a TLAA. *See,* Entergy's LRA § 4.3 (CUF analyses are "metal fatigue evaluations that meet the definition of TLAA"); Exhibit NEC-JH_62, NRC Summary of Telephone Conference Call Held on August 20, 2007, Between the

U.S. Nuclear Regulatory Commission and Entergy Nuclear Operations, Inc., Concerning the Vermont Yankee Nuclear Power Station License Renewal Application at Enclosure 2 ("Fatigue analyses based on a set of design transients and on the life of the plant are treated as TLAAs."); *In the Matter of Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3),* ASLBP No. 07-858-03-LR-BD01, Memorandum and Order Ruling on Petitions to Intervene and Requests for Hearing (July 31, 2008) at 112-113.

95. Entergy's CUFen analyses that NEC's Contentions 2A and 2B address are analyses to project Entergy's CUF TLAA to the end of the period of extended operations pursuant to 10 C.F.R. § 54.21(c)(1)(ii). As such, these analyses would substitute for the management of aging due to environmentally-assisted metal fatigue through an aging management program involving inspection, repair and replacement of components. 10 C.F.R. § 54.21(c)(1).

96. Entergy must demonstrate by a preponderance of the evidence that its CUFen analyses provide "reasonable assurance" that plant components vulnerable to environmentally-assisted metal fatigue will meet the acceptance criteria (CUFen less than one) throughout the period of extended operations. 10 C.F.R. §§ 54.21(c), 54.29, 2.325.

97. For the reasons stated in paragraphs 47-93, neither Entergy's Initial nor its "confirmatory" CUFen analysis satisfies this standard. Acceptance of the results of these analyses as the basis to forego an aging management plan involving inspection, repair and replacement will jeopardize public health and safety.

98. In addition, because Entergy's "confirmatory" CUFen analysis for the feedwater nozzle does not bound the analysis for other components, Entergy's CUFen analyses are incomplete.

99. Both Entergy's License Renewal Commitment 27 and the proposed License Condition that would require Entergy to submit "confirmatory" CUFen analyses for the core spray and recirculation nozzles two years prior to entering the period of extended operation are both inconsistent with NRC regulations. Pursuant to 10 C.F.R. § 54.21(c)(1)(ii), Entergy must include the complete results of its CUFen analyses in its License Renewal Application.

100. License Renewal Commitment 27 and the proposed License Condition are also inconsistent with NRC precedent that confines the NRC Staff's post-licensing role to the ministerial determination of minor matters that do not involve complex or discretionary judgments on factual or legal issues. The NRC Staff's review of Entergy's "confirmatory" CUFen analyses for the core spray and recirculation nozzles, which will involve the application of a highly complex methodology that requires the analyst to exercise substantial subjective judgment, cannot be considered minor or ministerial.

III. NEC CONTENTION 3 (Steam Dryer)

A. Proposed Findings of Fact

1. Background

101. In a boiling water reactor, the steam dryer is a stainless steel component that removes moisture from steam before it leaves the reactor. The dryer is installed in the reactor vessel above the steam separator assembly. Joint Declaration of John R. Hoffman and Larry D. Lukens on NEC Contention 3 – Steam Dryer at A11.

102. NEC, Entergy and the NRC Staff agree that, although the steam dryer does not perform any safety functions, its structural integrity must be maintained through all plant operating conditions to avoid the generation of loose parts that might travel through the plant and damage other safety-related equipment. Joint Stipulation (July 8, 2008) ¶¶ 9, 10; Exhibit NEC-JH_54 at 1; Joint Declaration of John R. Hoffman and Larry D. Lukens on NEC Contention 3 – Steam Dryer at A11-A14. Maintaining the structural integrity of the steam dryer is the objective of Entergy's steam dryer aging management plan.

103. The generation of loose parts from the steam dryer can result from fatigue failure of the steam dryer caused by flow-induced vibration. Flow induced vibration is mechanical vibration resulting from interactions between the elastic forces in the dryer and the dynamic forces of the flowing steam. Exhibit NEC-JH_54 at 1. An increase in flow velocity, such as occurred when VYNPS increased its operating power by 20% in 2006, results in increased potential for destructive flow-induced vibration. Exhibit NEC-JH_54 at 4-5.

104. Fatigue failure can result from either "high-cycle" or "low-cycle" fatigue. High-cycle fatigue results from lower stresses over a large number of cycles. Low-cycle fatigue results from high stress over a small number of cycles. Testimony of Mr. Hoffman, Tr. 1263 at lines 3-7.

105. Fatigue failure of the steam dryer resulting in the generation of loose parts occurred at the Quad Cities nuclear power plant following a power uprate. Exhibit NEC-JH_55, GE-SIL-644 at Appendices A and B. This industry experience demonstrates that even small pressure fluctuations on the dryer can generate alternating stresses that exceed the endurance limit at some dryer locations. Exhibit NEC-JH_54 at 2, *citing*, GE-SIL-644.

106. To identify all the specific mechanisms by which loose pieces of the steam dryer might damage safety-related equipment, or exclude any specific mechanism, it would be necessary to conduct a comprehensive analysis of the possible accident scenarios. Testimony of Dr. Hopenfeld, Tr. 1252 at lines 23-25, 1253 at lines 1-15, 1255 at lines 24-25, 1256 at lines 1-10. The record before the Board does not include such a study.

2. Entergy's Proposed Steam Dryer Aging Management Plan

107. The complete description of Entergy's steam dryer aging management plan included in the License Renewal Application is as follows:

> Cracking due to flow-induced vibration in the stainless steel steam dryers is managed by the BWR Vessel Internals Program. The BWR Vessel Internals Program currently incorporates the guidance of GE-SIL-644, Revision 1. VYNPS will evaluate BWRVIP-139 once it is approved by the staff and either includes its recommendations in the VYNPS BWR Vessel Internals Program or inform the staff of VYNPS's exceptions to that document.

License Renewal Application, § 3.1.2.2.11 "Cracking due to Flow-Induced Vibration."

108. BWRVIP-139 is a guidance document for steam dryer management prepared by an industry association, the BWR Owners Group. Testimony of Mr. Scarborough, Tr. 1201 at lines 3-20. A proposed revised version of this guidance document, "BWRVIP-139A," is now undergoing review and possible amendment by the NRC Staff. FSER, NRC Staff Exhibit 1 at 3-174; Testimony of Mr. Scarborough, Tr. 1215 at line 4; Testimony of Mr. Hsu, Tr. 1234 at lines 8-16.

109. Neither BWRVIP-139 nor draft BWRVIP-139A is included in the record before the Board. NRC Staff and Entergy witnesses testified that the two documents differ regarding recommendations for visual inspection of the steam dryer in BWR plants operating under EPU conditions. BWRVIP-139 recommends a visual inspection, but does not

recommend a program of regular reinspection. BWRVIP-139A may ultimately recommend reinspection criteria of some kind. Testimony of Mr. Lukens, Tr. 1124 at lines 1-3; Testimony of Mr. Scarborough, Tr. 1224 at lines 18-25, 1225 at 1-5.

110. As stated in the LRA, once BWRVIP-139A is approved by the NRC Staff, VYNPS will decide whether to incorporate any new recommendations into the VYNPS steam dryer aging management plan. VYNPS may take exception to conditions or limitations that exceed the requirements of BWRVIP-139. Testimony of Mr. Lukens, Tr. 1219 at lines 10-13.

111. The NRC Staff has accepted Entergy's License Renewal Commitment 37 to "[c]ontinue inspections in accordance with the steam dryer monitoring plan, Revision 3 in the event that the BWRVIP-139 is not approved prior to the period of extended operation." FSER, NRC Staff Exhibit 1 at A-12.

112. The steam dryer aging management program the NRC Staff reviewed and approved in the FSER is the program described in this Steam Dryer Monitoring Plan, Revision 3 ("SDMP"), not the program described in BWRVIP-139. Testimony of Mr. Rowley, Tr. 1231 at lines 21-23. Likewise, Entergy's prefiled written testimony to the Board regarding its steam dryer aging management plan describes the SDMP, not the BWRVIP-139. Testimony of Mr.Lukens, Tr.1238 at lines 18, 19.

113. The Steam Dryer Monitoring Plan (SDMP), Exhibit E3-05-VY, was developed in conjunction with Entergy's VYNPS application to the NRC for extended power uprate (EPU), which was approved in 2006. The SDMP sets guidelines for monitoring and inspection of the steam dryer during and for a finite period of time after ascension to uprate power.

114. The SDMP requires monitoring of certain plant parameters that may indicate that the steam dryer is damaged. Exhibit E3-05-VY at 3. It also requires visual inspection of the steam dryer in accordance with procedures recommended in General Electric Service Information Letter 644 (GE-SIL-644) during refueling outages scheduled in Fall 2005, Spring 2007, Fall 2008 and Spring 2010. Id. at 7.

115. GE-SIL-644 is a document published by General Electric ("GE") that contains GE's recommendations for maintenance of GE steam dryers, including guidelines for baseline and repeat visual inspection of steam dryers in BWR plants like VYNPS that are operating at an uprated power level. Exhibit E3-06 at 7, Appendix C.

116. Entergy is required to implement the SDMP pursuant to Vermont Yankee Nuclear Power Station, Amendment to Facility Operating License, Amendment No. 229. Under the terms of this license condition, Entergy's obligation to implement the SDMP will expire once (1) Entergy conducts a visual inspection of the steam dryer during three scheduled refueling outages (beginning in the Spring of 2007); (2) Entergy implements "operating limits, required actions and surveillances" specified in [the SDMP] during one full operating cycle at EPU; and (3) visual inspection of the steam dryer does not reveal any new unacceptable flaw or flaw growth due to fatigue. *Id.* at § 2.M.4-8. If visual inspection does reveal new unacceptable flaws or flaw growth, [SDMP] requirements "shall extend another full operating cycle until the visual inspection standard of no new flaws/flaw growth based on visual inspection is satisfied." *Id.* at § 2.M.4. The NRC Staff acknowledges that Entergy's obligation to implement the SDMP will expire pursuant to the terms of License Amendment No. 229. Testimony of Mr. Scarborough, Tr. 1196 at lines 14-19, 1197 at lines 1-11.

117. The requirement to visually inspect the steam dryer in accordance with GE-SIL-644 is part of the VYNPS current licensing basis only via the SDMP and Operating License Amendment No. 229. Testimony of Mr. Scarborough, Tr. 1410 at line 3; Testimony of Mr. Hsu, Tr. 1410 at line 8-9; Testimony of Mr. Lukens, Tr. 1410 at lines 16-18.

118. The steam dryer aging management program Entergy proposes to implement during the period of extended operation does not involve any means of estimating and predicting stress loads on the steam dryer, establishing flow induced vibration load fatigue margins, or demonstrating that stresses on the dryer will fall below ASME fatigue limits.

119. Entergy did perform this type of stress load analysis in conjunction with the VYNPS EPU application. The record before the Board in this proceeding does not include any specific information about how this analysis was performed or its results. Neither of Entergy's Contention 3 witnesses were involved in the pre-EPU analysis or could testify to it. Testimony of Mr. Hoffman, Tr. 1271 at line 1; Testimony of Mr. Lukens, Tr. 1271 at lines 4-5. Entergy has represented in this proceeding that its steam dryer aging management program does not depend upon or use the pre-EPU analysis. Declaration of John R. Hoffman in Support of Entergy's Motion for Summary Disposition of NEC Contention 3, Exhibit NEC-JH_61 at ¶¶ 23-24

120. Entergy provided additional detail concerning the plant parameter monitoring component of its aging management program under the SDMP in testimony to the Board. According to the testimony of Entergy witness Mr. Hoffman: "VY Off-Normal Procedure ON-3178, [Exhibit E3-07] alerts the operators that any of the following events could be indicative of significant dryer damage: (a) sudden drop in main steam line flow > 5%; (b) > 3 inch difference in reactor vessel water level instruments; and (c) sudden drop in steam dome

pressure > 2 psig. In addition, periodic measurements of moisture carryover are evaluated in accordance with the requirements of GE-SIL-644 to determine whether significant cracking has occurred." Joint Declaration of John R. Hoffman and Larry D. Lukens on NEC Contention 3 – Steam Dryer.

121. Entergy's witnesses testified that they assume the parameter monitoring component of the proposed steam dryer aging management program will effectively detect any damage to the steam dryer in time to permit plant operators to shut down the plant before dryer degradation results in the generation of loose parts. Testimony of Mr. Hoffman, Tr. 1270 at line 5. This assumption is not supported by the record evidence, as stated in the following paragraphs 122-126.

122. Entergy and NEC witnesses agree that only fairly large cracks that are open enough to allow flow through will affect the plant parameters Entergy proposes to monitor. Exhibit NEC-JH_54 at 5. Testimony of Mr. Hoffman, Tr. 1296 at lines 4-10; Testimony of Mr. Hoffman, Tr. 1310 at lines 21-25.

123. Entergy's witnesses could not testify to the resolution of the proposed parameter monitoring program; Entergy does not know the minimum size crack its monitoring program can detect. Testimony of Mr. Hoffman, Tr. 1334 at line 21. Entergy's witness Mr. Hoffman was unable to offer even a rough estimate of program resolution, and could not say whether the program would detect a six foot long crack opened up one foot. Testimony of Mr. Hoffman, Tr. 1334 at line 25.

124. GE-SIL-644 states the limitations of parameter monitoring as follows: "monitoring steam moisture content and other reactor parameters does not consistently

predict imminent dryer failure nor will it preclude the generation of loose parts." Exhibit E3-06 at 6.

125. Even assuming that a crack in the steam dryer did cause abnormal parameter readings detected by Entergy's monitoring program, plant operators would not immediately shut down the plant. Plant staff would undertake an evaluation to determine whether abnormal parameter readings result from steam dryer damage or some other factor, and would make a judgment call about whether to shut down the plant. Testimony of Mr. Hoffman, Tr. 1308-1309, Tr. 1342-1343.

126. Fatigue cracks may be slow to initiate, but once initiated they propagate very fast when exposed to alternating stresses of sufficient magnitude and frequency. Exhibits NEC-JH_54 at 4; NEC-JH_63 at 24.

127. It is possible if not likely that fatigue failure of the steam dryer would lead to the generation of loose parts before damage to the dryer is detected by the proposed parameter monitoring program, or before plant operators complete the evaluation of abnormal parameter readings that would precede a decision to shut down the plant.

128. Entergy's witnesses testified that their confidence in the sufficiency of the proposed aging management program is substantially based on their assumption that the VYNPS steam dryer is not subject to high-cycle fatigue and therefore either would never suffer fatigue-induced degradation under normal operating conditions, or might develop only very slow-growing cracks. Testimony of Mr. Hoffman, Tr. 1297 at lines 20-24, Tr. 1310 at lines 21-25, Tr. 1321 at lines 9-13. The record evidence does not support Entergy's assumption that the steam dryer is not subject to high-cycle fatigue.

129. In direct contradiction to testimony he submitted in support of summary disposition of NEC's Contention 3, Exhibit NEC-JH_61 at ¶¶ 23-24, Entergy's witness Mr. Hoffman testified at the Board hearing on NEC's Contention 3 that Entergy substantially relies on the results of its pre-EPU stress load analysis of the steam dryer for confirmation that the dryer is not subject to high-cycle fatigue. Testimony of Mr. Hoffman, Tr. 1270 at lines 16-23, 1280, lines 19-25, 1282 at lines 7-12 and 19-22, 1283 at lines 3-14. The record evidence before the Board contains no detailed information regarding the methods or results of this analysis. The Board is therefore unable to evaluate this analysis as a basis for Entergy's aging management program.

130. Mr. Hoffman further testified that Entergy assumes the VYNPS steam dryer is not experiencing high cycle fatigue because Entergy has not detected fatigue damage during the two years since EPU. Testimony of Mr. Hoffman, Tr. 1294 at lines 16-25, 1295 at lines 1-5, Tr. 1298 at lines 8-12. In other words, Entergy assumes that the dryer will never break because it hasn't broken so far. Mr. Hoffman testified: "we could have built a component and never analyzed it and simply operate it, and operate it beyond a certain level without a failure you would conclude without any knowledge of what the stresses were that it was not subject to high cycle fatigue." Testimony of Mr. Hoffman, Tr. 1311 at lines 18-24.

131. This is not a valid assumption. It is not possible to know that the VYNPS steam dryer is not subject to high-cycle fatigue without performing the measurements and analysis necessary to actually make that determination. Testimony of Dr. Hopenfeld, Tr. 1314, Tr. 1349 at lines 10-25, Tr. 1350 at lines 1-12. Fatigue cracking is a time-dependent phenomenon; the fact that cracks have not developed to date is not at all an indication that

they will not develop in the future. Prefiled Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 3 at A29, A33.

132. Entergy witnesses testified that it would be impractical to place instruments on the steam dryer in order to measure dryer loads. Testimony of Mr. Lukens, Tr. 1378. However, General Electric has measured loads by placing instrumentation on prototype steam dryers for new reactor designs. Testimony of Dr. Hopenfeld, Tr. 1387 at lines 7-16.

133. Finally, Entergy has not demonstrated how the steam dryer would respond to sudden large changes in forces on the dryer caused by a design basis accident. The NRC Staff did not review this issue. Testimony of Mr. Hsu, Tr. 1318 at lines 20-22. Entergy's only evidence of the dryer's ability to withstand a design basis accident stems from the pre-EPU analysis. Testimony of Mr. Scarborough, Tr. 1397 at lines 21-23; Testimony of Mr. Hsu, Tr. 1398 at line 5. The pre-EPU analysis is not part of the record before the Board in this proceeding.

B. Proposed Conclusions of Law

134. Entergy must demonstrate by a preponderance of the evidence that its steam dryer aging management program is adequate to provide reasonable assurance that fatigue-induced deterioration of the steam dryer will not lead to the generation of loose parts during normal operations, transients or accident events throughout the proposed period of extended operation. 10 C.F.R. §§ 54.21, 54.29, 2.325.

135. Entergy fails to satisfy this standard. First, Entergy's proposed aging management program is unacceptably ambiguous, and subject to multiple contingencies. The BWRVIP-139 program referenced in Entergy's License Renewal Application (LRA) is not described in any detail in the LRA, and is not in evidence before the Board in this

proceeding. Its contents are therefore unknown to the Board. This document will soon be superseded by BWRVIP-139A, the contents of which are also unknown to the Board. Entergy may choose in its discretion not to implement some of the unspecified recommendations of BWRVIP-139A. The aging management program the NRC Staff reviewed in the FSER and Entergy described in its testimony to the Board is the Steam Dryer Monitoring Program, Rev. 3 ("SDMP"). Entergy is obligated to implement the SDMP only pursuant to Amendment No. 229 to its current VYNPS operating license. This obligation will expire, possibly before the expiration of Entergy's current operating license.

136. Entergy is obligated to conduct repeat visual inspection of the steam dryer only pursuant to the SDMP. Entergy therefore has not committed to a program of visual inspection throughout the period of extended operation.

137. Entergy's proposed aging management plan reduces to a program, which is not described in the License Renewal Application, consisting solely of the monitoring of plant parameters that could indicate failure of the steam dryer, uninformed by knowledge of stress loads on the dryer. As stated in paragraphs 107-133, this proposed program is insufficient to satisfy the "reasonable assurance" standard.

IV. NEC CONTENTION 4 (Flow-Accelerated Corrosion)

A. Proposed Findings of Fact

1. Background Concerning Entergy's Proposed FAC Management Program and NEC's Contention 4

138. NEC Contention 4 is that Entergy's plan for managing flow-accelerated corrosion (FAC) in plant piping fails to meet the requirements of 10 C.F.R. § 54.21(a)(3),

ie, fails to demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB during the period of extended operations.

139. Entergy's LRA states that its FAC management program during the period of extended operation will be "comparable" to the program described in NUREG-1801, Vol. 2, Rev. 1, Section XI.M17. LRA at B-47. NUREG 1801 XI.Ml7 states that the FAC program:

> Relies on implementation of the Electric Power Research Institute (EPRI) guidelines in the Nuclear Safety Analysis Center (NSAC)-202L-R2 for an effective flow-accelerated corrosion (FAC) program. 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.

140. In testimony filed in this proceeding, Entergy has represented that its FAC management program during the period of extended operation will be identical to the FAC program now in effect at VYNPS under the current operating license. Joint Declaration of Jeffrey S. Horowitz and James C. Fitzpatrick on NEC Contention 4 – Flow-Accelerated Corrosion (May 12, 2008) at A19. Entergy makes no commitment in its License Renewal Application to extend its existing program, nor does it describe any specific detail of its existing program in the LRA. Testimony of Mr. Fitzpatrick, Tr. 1502 at lines 5-6.

141. Entergy also represented in testimony to the Board that it will use a predictive code called CHECWORKS to define the scope of FAC inspection. Id. at A20, A21. CHECWORKS is currently used at VYNPS as a tool to identify piping locations susceptible to FAC, predict FAC wear rates, plan inspections, and evaluate inspection data. Joint Declaration of Jeffrey S. Horowitz and James C. Fitzpatrick on NEC

Contention 4 – Flow-Accelerated Corrosion at A26. Approximately one-third of FAC inspection locations at VYNPS are selected based on CHECWORKS predictions. Testimony of Mr. Fitzpatrick, Tr. 1674 at lines 6-7.

142. CHECWORKS is meant to provide "a bounding analysis for FAC." NUREG-1801, Vol. 2, Rev. 1, Section XI.M17 ¶ 5.

143. CHECWORKS is an empirical model that is calibrated with plant-specific data. Direct Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A22; Joint Declaration of Jeffrey S. Horowitz and James C. Fitzpatrick on NEC Contention 4 – Flow-Accelerated Corrosion at A28. Plant inspection data are input to the model in the form of a matrix of thickness readings covering a component. Joint Declaration of Jeffrey S. Horowitz and James C. Fitzpatrick on NEC Contention 4 – Flow-Accelerated Corrosion at A28.

2. Entergy Must Recalibrate the CHECWORKS Model Following Implementation of EPU

144. If plant parameters that affect FAC change, CHECWORKS must be recalibrated based on sufficient inspection data to reestablish reliable FAC trends under the new operating conditions. Direct Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A22; Exhibit NEC-JH_36 at 6-8.

145. The twenty percent increase in the VYNPS operating power implemented in 2006 changed parameters that affect FAC, including flow velocity. Direct Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A22.

146. It is necessary to recalibrate the CHECWORKS model following an increase in flow velocity because the rate and location of FAC varies significantly with the flow rate, and it is difficult to predict specifically how it will change. NEC-JH_36 at

2-4, 20; Exhibit NEC-RH_03 at 1-7. It is difficult to predict a) where localized corrosion will occur; b) how fast it will take place, and c) where it will move as the flow rate changes. Exhibit NEC-RH_03 at 1-7.

147. This is because FAC is in part a local phenomenon due to variations of local turbulence caused by geometric discontinuities such as curved pipe, nozzles, tees, or orifices. FAC rates vary depending on the intensity of local turbulence, and the relationship between flow velocity and FAC rate is not always linear. The linear relationship between FAC rates and fluid velocity transitions to an exponential one as the local turbulence becomes such that erosional features are manifest. Whether such transition actually occurs when flow velocity increases must be determined experimentally. Rebuttal Testimony of Rudolf Hausler at A5; Rebuttal Testimony of Dr. Joram Hopenfeld at A42, A52, A53, A54.

148. The need to calibrate the CHECWORKS model with inspection data regularly, not just following changes in plant parameters that affect FAC, results from the fact that FAC does not necessarily vary linearly with time. Rebuttal Testimony of Dr. Joram Hopenfeld at A53. The rate of FAC is not constant with time because FAC causes the material surface to change. As the surface changes, the turbulence and mass transfer also change, and the rate and location of corrosion may change. Testimony of Dr. Hausler, Tr. 1688 at lines 5-11.

149. Entergy's witness Dr. Horowitz testified that he believes that the velocity dependence of FAC is linear, not exponential, because that assumption is built into the CHECWORKS model, and confirmed by the fact that the model works well. Testimony of Dr. Horowitz, Tr. 1622 at lines 1-9. In fact, the model does not work well; the

correlation between CHECWORKS predictions and actual data is poor. Testimony of Dr. Hopenfeld, Tr. 1618 at lines 2-12; Exhibit E4-30 at 57.

150. The linear velocity model that CHECWORKS incorporates is based on data on copper dissolution in hydrochloric acid, which is drastically different from the corrosion of carbon steel in water. Rebuttal Testimony of Dr. Joram Hopenfeld at A41.

151. There has never been an independent study or analysis of the capabilities of CHECWORKS. Testimony of Dr. Horowitz, Tr. 1592 at line 23. EPRI members have been unwilling to pay for a "nuclear level QA" of the program. Horowitz, Tr. 1595 at lines 18-25.

152. Entergy's witness on NEC's Contention 4 contended that it is not necessary to recalibrate CHECWORKS with plant inspection data following an increase in flow velocity in part because they defined FAC to exclude corrosion with erosional features, such as occurs where the relationship between corrosion and fluid velocity transitions from linear to exponential. According to Entergy's witness Dr. Horowitz, CHECWORKS is designed to predict only FAC defined as metal dissolution. Testimony of Dr. Horowitz, Tr. 1469 at lines 23-25.

153. Witnesses for NEC defined FAC to include corrosion with erosional features caused by local turbulence. Rebuttal Testimony of Dr. Rudolf Hausler at A6; Exhibit NEC-RH_05; Rebuttal Testimony of Dr. Joram Hopenfeld Regarding NEC Contentions 2A, 2B, 3 and 4 at A45, A42, A52, A54. The NRC Staff concurred in this definition, which was the basis for the NRC Staff review of Entergy's FAC program. According to the testimony of NRC Staff witnesses Mr. Hsu and Mr. Rowley: "Flow-accelerated corrosion is also known as erosion-corrosion. It is corrosive attack

accelerated by high velocity flow, either washing away otherwise protective films or mechanically disturbing the metal itself." Affidavit of Kaihwa Hsu and Jonathan G. Rowley Concerning NEC Contention 4 (Flow-Accelerated Corrosion) (May 13, 2008) at A4.

154. The NRC Staff testified that if Entergy's aging management program for FAC does not address mechanical corrosion, Entergy has other programs to manage this problem. The NRC Staff could not, however, identify these alleged programs. Testimony of Mr. Hsu and Mr. Rowley, Tr. 1483-1485. This issue is not addressed in the FSER. Testimony of Mr. Hsu, Tr. 1487 at lines 18-19.

155. For the reasons stated in paragraphs 144-154, the increase in flow velocity resulting from VYNPS's 2006 power uprate will likely result in new locations of corrosion that CHECWORKS as calibrated to pre-uprate conditions will be unable to predict. Entergy therefore should not consider CHECWORKS "a bounding analysis for FAC" until the model is recalibrated to the current operating conditions.

156. Reliance on CHECWORKS before full recalibration could result in an improper scope of FAC inspection, and the failure to inspect and identify hazardous FAC of plant equipment.

3. Time Needed to Recalibrate CHECWORKS

157. Entergy conducts FAC inspections during refueling outages every 1.5 years.

158. Entergy does not take a measurement at every inspection point within the scope of its FAC management program each time an inspection is conducted. In three inspections since the power uprate in 2006, Entergy will have taken one measurement for

each inspection point and two measurements for some inspection points. Testimony of Mr. Fitzpatrick, Tr. 1677 at lines 10, 17-18.

159. Entergy does not attempt to quantify the variability of any single measurement. The baseline inspection is a single measurement process. Testimony of Mr. Fitzpatrick, Tr. 1560 at lines 5-7.

160. A minimum of three data points for each inspection location are necessary to establish a trend. Assuming that measurements are taken at one-third of all inspection locations during each inspection period, and an inspection period is 1.5 years, it would take nine inspections, or 13.5 years, to obtain three data points for each location. Testimony of Dr. Hausler, Tr. 1676 at lines 3-25; 1677 at lines 1-6; Exhibit NEC-JH_36 at 15-16; Exhibit NEC-RH_03 at Appendix A.

4. Entergy Fails to Commit Sufficient Resources to its FAC Management Program in Violation of NSAC-202L Guidance

161. For optimal performance, CHECWORKS should be updated with plant inspection data within 60-90 days after each inspection cycle/ refueling outage. Testimony of Mr. Fitzpatrick, Tr. 1585 at lines 1-2; Testimony of Dr. Horowitz, Tr. 1714 at lines 8-9, 20-21. No requirement of the current licensing basis addresses the frequency with which Entergy must update the model. Testimony of Mr. Rowley, Tr. 1588 at lines 16.

162. VYNPS has gone as long as three years between CHECWORKS updates. Testimony of Mr. Fitzpatrick, Tr. 1585 at lines 15-16; Exhibit NEC-UW-09. Model update lapses were due to resource constraints. Testimony of Mr. Fitzpatrick, Tr. 1585 at lines 5-6, Tr. 1715 at lines 10-15.

163. NSAC-202L-R3, Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R3) states: "Corporate commitment is essential to an effective FAC program. It is recommended that this commitment include the following: Providing adequate financial resources to ensure that all tasks are properly completed." Exhibit E4-07 at 2-1. The failure to keep the CHECWORKS model consistently updated at VYNPS due to resource constraints indicates a failure to satisfy this requirement.

B. Proposed Conclusions of Law

164. Entergy is required to demonstrate by a preponderance of the evidence that its aging management program for flow-accelerated corrosion is adequate to provide reasonable assurance that, consistent with the VYNPS CLB, the minimum wall thickness of plant equipment vulnerable to flow-accelerated corrosion (FAC) will not be reduced by FAC to below ASME code limits during the proposed period of extended operations. 10 C.F.R. §§ 54.21, 54.29, 2.325.

165. For the reasons stated in paragraphs 138-163, Entergy fails to satisfy this standard.

V. CONCLUSION

Extended operation of VYNPS as Entergy has proposed in its LRA will jeopardize public health and safety. The LRA should be denied. If the Board does not deny the LRA, it should at a minimum require the following with respect to the issues addressed by NEC's Contentions 2A, 2B, 3 and 4.

A. Formulation of a Fatigue Management Program

1. Prior to the approval of the LRA, Entergy should develop a fatigue management plan founded on the premise that the CUFens for all the NUREG/CR-6260 sample components, with the exception of the RR Inlet Nozzle, will exceed 1.0 at some

time during the extended period of operation. Following are the elements of the program:

2. Expand the fatigue analysis as outlined in EPRI MPR-47, Exhibit NEC-JH_64 at 3-5.

3. For the selected high usage components, calculate Fen values either by using bounding Fen values as specified in NUREG/CR-6909 or using Fen equations as specified in NUREG/CR-6909.

4. If NUREG/CR-6909 Fen equations are selected, use oxygen concentrations of 400 ppb for carbon and low-alloy steel during transients as specified in NUREG/CR-6909. For stainless steel components, use steady state oxygen concentration.

5. In calculating temperature distributions for components where the flow is not well characterized, allow for local heat transfer variations using appropriate geometric factors that can be found in the literature.

6. In determining the number of transients for the 60 year period, use the actual number of transients up to the time of the power uprate, 34 years, and multiply by (60/34)(1.2). The factor of 1.2 accounts for the expectation that the power uprate together with the increase in the plant's age would result in a larger number of transients.

7. For all components with CUFen exceeding one, formulate a detailed inspection and maintenance program, specifying inspection frequency, probability of detecting fatigue cracks in the affected areas, and criteria for repair or replace components.

8. The fatigue management program should be reviewed by an independent third party.

B. Requirements for Steam Dryer Monitoring

Before VY is granted License Extension, Entergy should be required to complete the following:

1. A thorough evaluation of the feasibility of instrumenting the dryer to obtain information about loads on critical parts of the dryer during steady state and transient operations.

2. If instrumenting the dryer is feasible, install instrumentation prior to the extended period of operation.

3. If instrumenting the dryer is not feasible, instrument the steam lines and improve on present analytical tools to predict loads on the dryer, including additional scaling tests at GE.

C. Inspection Requirements for FAC at VY

Entergy should institute a FAC program at VY in accordance with the procedure described in Exhibit NEC-JH-36 at 15. Briefly, this should be executed as follows:

1. Identify all safety related components in the entire VY plant that are subject to FAC as defined in NEC-JH-36 at 1.

2. The list of components should be reviewed by an independent third party.

3. In order to facilitate inspection, the components listed in 1 should be classified into four groups of workable size. Each group should be inspected in accordance with the schedule outlined in the Table at Exhibit NEC-JH_36 at 15. An inspection grid for each component should not exceed 1"x1".

August 25, 2008 New England Coalition, Inc.

by: _____

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
Entergy Nuclear Vermont Yankee, LLC	)	Docket No. 50-271-LR
and Entergy Nuclear Operations, Inc.	)	ASLBP No. 06-849-03-LR
	)	
(Vermont Yankee Nuclear Power Station)	)	

CERTIFICATE OF SERVICE

I, Christina Nielsen, hereby certify that copies of NEW ENGLAND COALITION, INC.'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW in the above-captioned proceeding were served on the persons listed below, by U.S. Mail, first class, postage prepaid; and, where indicated by an e-mail address below, by electronic mail, on the 25th of August, 2008.

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