UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before the Licensing Board:

G. Paul Bollwerk, III, Chairman
Nicholas G. Trikouros
Dr. James Jackson

	)	
In the Matter of	)	
	)	Docket Nos. 52-025 and 52-026 COL
Southern Nuclear Operating Company, Inc.	)	
	)	ASLBP No. 09-873-01-COL-BD01
Vogtle Electric Generating Plant,	)	
Units 3 and 4	)	August 12, 2010
___________________________________	)	

PROPOSED NEW CONTENTION BY JOINT INTERVENORS REGARDING THE INADEQUACY OF APPLICANT'S CONTAINMENT/COATING INSPECTION PROGRAM

Pursuant to 10 C.F.R. § 2.309(f)(2), Joint Intervenors Blue Ridge Environmental Defense League, Center for a Sustainable Coast, Georgia Women's Action for New Directions for Clean Energy, hereby submit a new contention challenging the adequacy of the combined operating license application ("COLA") submitted by Southern Nuclear Operating Company ("SNC"). Specifically, Intervenors contend that the proposed containment inspection will fail to determine whether corrosion or degraded coatings create an undue risk that holes, cracks or other through-wall penetrations of the containments at the two reactors ("VEGP Units 3 and 4") could foreseeably lead to outside leakage of radioactive material in the event of an accident.

As demonstrated below, this amended contention should be admitted because it is based on information not previously available to Joint Intervenors, the information now available is materially different than information previously available, and this motion is being submitted in a timely fashion.

I. BACKGROUND

On March 28, 2008, SNC submitted a COLA to construct and operate Units 3 and 4 at the VEGP site. In response to this application, Joint Intervenors filed a petition for intervention on November 17, 2008, seeking to admit three contentions. By order dated March 5, 2009, the Atomic Safety and Licensing Board (the "Board") admitted contention SAFETY-1; the Nuclear Regulatory Commission (the "NRC") affirmed admission of SAFETY-1 on July 31, 2009.

On May 19, 2010, the Board granted SNC's motion for summary disposition of SAFETY-1, thus leaving no admitted contentions. LBP-10-08.

In April of this year, a report was submitted to the Advisory Committee on Reactor Safeguards ("ACRS") by Arnold Gunderson, a nuclear engineer in the employ of the AP1000 Oversight Group.[1] In his report, XXX, Mr. Gunderson set forth his concerns regarding an unreviewed safety question regarding the ACRS' pending review of the design of the AP1000 reactor. Specifically, Mr. Gunderson explained that the AP1000, because of its (1) lack of a secondary containment system and (2) unusually high vulnerability to chronic containment corrosion and containment-coating degradation, presents an unusually high risk, in the event of a reactor accident, of leakage to the environment of radioactive materials. Several days later, Mr. Gunderson presented his concerns to the ACRS in person. There Mr. Gunderson explained that the corrosion

[1] . Mr. Gunderson has been retained, separately, by the Joint Intervenors in the instant proceeding.

problems require that the operator of any AP1000 reactor conduct an intensive inspection program to verify frequently that the integrity of the containment and any associated coatings have not been compromised.

In a transcript of that meeting released exactly 30 days ago, Harold B. Ray, Chairman of the ACRS, made a statement to the effect that issues relating to the need for inspections of the containment and containment coatings associated with the "AP1000" reactor design should be addressed not in the pending generic review of the AP1000 design by the ACRS, but within individual COL proceedings. Specifically, Chairman Ray stated:

> CHAIRMAN RAY: Well the coating certainly is an important element of this whole system. And the points that you're making about accessibility for inspection are ones that we have yet to look at. And your input to us is helpful in focusing our attention on that.
>
> I just made the point earlier, Mr. Runkle, that that will be taken up as part of the COL. So if you don't see it being discussed in the context of the DCD, it's because its there and not any other place.
>
> Other things that you've raised about the offsite dose assumption and so on and so forth, those are more likely part of the DCD scope and have been there in that location.
>
> I guess during the course of your presentation I've asked all the questions I have following reading your letter. You can tell that personally I'm more focused on this issue that you mentioned about the coating inspectability and the integrity of the coating, which is obviously important.

Transcript at pp. 58-59.

This announcement by the ACRS Chairman amounts to a determination that questions regarding inspection of the containment and its coatings fall outside the purview of the ACRS's pending proceeding. Accordingly, Intervenors submit the following proposed contention for consideration in this proceeding.

II. PROPOSED CONTENTION SAFETY-2

Joint Intervenors propose to litigate the following contention, suggested to be denominated "SAFETY-2":

> SNC's COLA fails to demonstrate that VEGP Units 3 and 4 can be operated safely because the containment and containment-coating inspection regime proposed in the FSAR, *see* COLA at pp. 6.1-1 – 6.1-4, fails to provide assurance against corrosion-caused penetrations of the containment that would lead, in the event of an accident, to leakage to the environment of radioactive materials in excess of regulatory requirements.

III. COMPLIANCE WITH 10 C.F.R. § 2.309

New contentions must satisfy the requirements of both 10 C.F.R. § 2.309(f)(1), concerning contentions in general, and 10 C.F.R. § 2.309(f)(2), concerning amended or new contentions. The proposed SAFETY-2 satisfies these requirements.

Compliance with 10 C.F.R. § 2.309(f)(1)

SAFETY-2 complies with the provisions of 10 C.F.R. § 2.309(f)(1).

<u>10 C.F.R. §§ 2.309(f)(1)(i) and (iii)</u> –

The proposed contention comprises a challenge to the technical sufficiency of the FSAR (and the COLA), and it is properly within the scope of this proceeding. The attached declaration of Mr. Gunderson, attached as Exhibit 1, in conjunction with his report to the ACRS (Exhibit 3), the associated Powerpoint presentation (Exhibit 4) and the excerpted transcript of the ACRS meeting demonstrate that the design of the AP1000 presents special risks of containment corrosion and coating failure, thus requiring that each plant receive special, intensive inspections that address the special circumstance faced by every plant. Mr. Gunderson has established that SNC's proposed visual inspections via access ports will be insufficient to protect the public health and safety; rather each AP1000 reactor requires visual, perhaps robotic inspections of the interior of the containments, too. Gunderson declaration at par. 41; Report to the ACRS, exh. 3, at 17.

10 C.F.R. § 2.309(f)(1)(ii) – The new contention is based on the FSAR's failure to satisfy the requirement in 10 C.F.R. 52.157 that an applicant demonstrate that, in the event of an accident, "an individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a radiation dose in excess of 25 rem TEDE." Mr. Gunderson's declaration demonstrates that inadequacies in SNC's proposed inspection regime pose a high likelihood of causing a release well in excess of the regulatory threshold.

Similarly, Mr. Gunderson's declaration and supporting materials show that the COLA does not satisfy the requirements of General Design Criterion 53:

Criterion 53--Provisions for containment testing and inspection. The reactor containment shall be designed to permit (1) appropriate periodic inspection of all important areas, such as penetrations, (2) an appropriate surveillance program, and (3) periodic testing at containment design pressure of the leaktightness of penetrations which have resilient seals and expansion bellows.

10 C.F.R. § 2.309(f)(1)(iv) – Joint Intervenors have shown, in Mr. Gunderson's declaration and the supporting materials, that SNC's proposed containment and coating

inspection plan will not assure that the proposed reactors can be operated in a manner that is sufficiently protective of the public health and safety, or that complies with the regulatory provision set forth above. Thus, the contention is material to findings the NRC must make to support licensing.

10 C.F.R. § 2.309(f)(1)(v) – The explanation required by this provision is provided above and in the attached materials, such satisfying the requirements of this provision.

10 C.F.R. § 2.309(f)(1)(vi) – A genuine dispute exists as to whether SNC has provided sufficient evidence of the adequacy of its proposed containment and containment-coating inspection system.

Compliance with 10 C.F.R. § 2.309(f)(2)

Proposed contention SAFETY-2 complies with the provisions of 10 C.F.R. 2.309(f)(2).

10 C.F.R. § 2.309(f)(2)(i) – The proposed new contention is based on information that was released by the ACRS on July 13, 2010. Prior to this date, Petitioners had reasonably assumed that matters related to containment corrosion and containment-coating degradation would be addressed by the ACRS in its generic review of the AP1000. It was not until that date that there was any public record of ACRS Chairman Ray's announcement that questions as to inspections should be raised and resolved in the context of individual COL proceedings. *See generally Duke Energy Corp.* (Oconee Nuclear Station, Units 1, 2, and 3), CLI–99–11, 49 NRC 328, 345 (1999), *quoting Potomac Elec. Power Co.* (Douglas Point Nuclear Generating Station, Units 1 and 2),

ALAB–218, 8 AEC 79, 85 (1974). ‘‘licensing boards should not accept in individual license proceedings contentions which are (or are about to become) the subject of general rulemaking by the Commission.’’

10 C.F.R. § 2.309(f)(2)(ii) – Research reveals no other source of information indicating that flaws in the design of the AP1000 call for unusually intensive inspections of the containment and its coatings. This information was delivered to the ACRS only four months ago. The recently published remarks by the ACRS members demonstrated, for the first time, that NRC personnel see the possible need for enhanced inspection regimes, tailored to the site-specific environmental conditions of every plant site.

10 C.F.R. § 2.309(f)(2)(iii) – The ACRS transcript was published only 30 days ago.

CONCLUSION

For the foregoing reasons, Joint Intervenors respectfully request that the Board admit new contention SAFETY-2 for consideration in this proceeding.

CERTIFICATION

In accordance with 10 C.F.R. §2.323(b), I today spoke with Mr. Stanford Blanton, counsel for SNC. He did not consent to the admission of the proposed new contention. I attempted to reach Mr. Patrick Moulding, counsel for the Staff, by phone, but was unable to reach him.

Respectfully submitted this 12th day of August, 2010.

/signed (electronically) by/

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD PANEL

Before the Licensing Board:

G. Paul Bollwerk, III, Chairman
Nicholas G. Trikouros
Dr. James Jackson

In the Matter of	)	Docket Nos. 52-025 and 52-026-COL
Southern Nuclear Operating Company	)	ASLBP No. 09-873-01-COL-BD01
Vogtle Electric Generating Plant, Units 3 and 4	)	August 12, 2010

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing was served upon the following persons by Electronic Information Exchange and/or electronic mail.

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Dated: August 12, 2010

/signed (electronically) by/
James B. Dougherty

Docket Nos. 52-025-COL and 52-026-COL
BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE
EXHIBIT ONE

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the matter of

Southern Nuclear Operating Company	)	Docket Nos. 52-025-COL and
	)	52-026-COL
Vogtle Electric Generating Plant, Units 3&4	)	ASLBP No. 09-873-01-COL-BD01
Combined License Application	)	August 13, 2010

DECLARATION OF ARNOLD GUNDERSEN SUPPORTING
BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE'S
NEW CONTENTION
REGARDING AP1000 CONTAINMENT INTEGRITY
ON THE VOGTLE NUCLEAR POWER PLANT UNITS 3 AND 4

I, Arnold Gundersen, declare as follows:

1. My name is Arnold Gundersen. I am over the age of 18-years-old.

2. The Blue Ridge Environmental Defense League (BREDL) has retained me as an expert witness in the above captioned matter, and my declaration is intended to support the Contentions of Blue Ridge Environmental Defense League.

3. I earned my Bachelor's Degree in Nuclear Engineering from Rensselaer Polytechnic Institute (RPI) cum laude. I earned my Master's Degree in Nuclear Engineering from RPI via an Atomic Energy Commission Fellowship.

4. I began my career as a reactor operator and instructor in 1971 and progressed to the position of Senior Vice President for a nuclear licensee prior to becoming a nuclear engineering consultant and expert witness. An updated Curriculum Vitae is attached as Exhibit 2.

5. I have qualified as an expert witness before the Nuclear Regulatory Commission (NRC) Atomic Safety and Licensing Board (ASLB) and Advisory Committee on Reactor Safeguards (ACRS), the State of Vermont Public Service Board, the State of Vermont Environmental Court, and the Florida Public Service Commission.

6. I am an author of the first edition of the Department of Energy (DOE) Decommissioning Handbook.

7. As an appointee of Vermont State Legislature for the past two years, I am charged with serving in an oversight role of Entergy Nuclear Vermont Yankee and an advisory role on nuclear reliability issues to the Vermont State Legislature.

8. I have more than 38-years of professional nuclear experience *including and not limited to*: Nuclear Power Operations, Nuclear Safety Assessments, Nuclear Power Management, Nuclear Quality Assurance, Archival Storage and Document Control, NRC Regulations and Enforcement, Licensing, Engineering Management, Contract Administration, Reliability Engineering, In-service Inspection, Thermohydraulics, Criticality Analysis, Radioactive Waste Processes, Decommissioning, Waste Disposal, Cooling Tower Operation, Cooling Tower Plumes, Consumptive Water Use, Source Term Reconstruction, Dose Assessment, Technical Patents, Structural Engineering Assessments, Nuclear Fuel Rack Design and Manufacturing, Nuclear Equipment Design and Manufacturing, Public Relations, Prudency Defense, Employee Awareness Programs, and Whistleblower Protection.

9. My declaration is intended to support Contentions of the Blue Ridge Environmental Defense League and is specific to issues regarding the Combined License Application (COLA), of the Southern Nuclear Operating Company for the Vogtle Electric Generating Plant, Units 3&4.

BACKGROUND

10. On April 21, 2010, the AP1000 Oversight Group, represented by Attorney John Runkle, submitted the *AP1000 Containment Leakage Report Fairewinds Associates*

- *Gundersen, Hausler, 4-21-2010* by Fairewinds Associates, Inc. to the NRC, attached as Exhibit 3.

11. In response to an invitation from the NRC Advisory Committee on Reactor Safeguards (ACRS), Attorney John Runkle and I made an hour and 15 minute presentation to the ACRS on June 25, 2010. The PowerPoint presentation PDF is attached herein as Exhibit 4 and the relevant portion of the ACRS transcript from our presentation to the ACRS is attached as Exhibit 5. The PowerPoint slide show and accompanying audio transcript of the meeting and discussion may be viewed at http://fairewinds.com/content/ap1000-nuclear-design-flaw-addressed-to-nrc-acrs

NEW CONTENTION

12. In the United States, each of the 104 commercial nuclear power plants has a reactor that is fully encased by a containment system.

13. The primary containment system is usually steel or a combination of steel and concrete. Historically the containment system has a secondary system designed to collect any radiation that leaks out and subsequently releases those gases through a stack only after the radioactivity is filtered to specific limits designed to protect public health and safety.

14. In direct contrast to the containment system design of the currently operating nuclear power plants, the Vogtle AP1000 is unique among all other operating pressurized water reactors (PWR's) in that its containment has only a single barrier.

15. Moreover, behind this single barrier there is an air gap that has been specifically designed to pull any air or gases that enter the gap and release them directly into the environment.

16. I named the phenomena of pulling air or gases into the annular gap and wafting them out into the environment as the *chimney effect* in the report I wrote entitled, *AP1000 Containment Leakage Report Fairewinds Associates - Gundersen, Hausler, 4-21-2010* that was presented to the ACRS via a PowerPoint presentation June 25,

2010. My report is Exhibit 3.

17. Nuclear power plant containment systems have a long history of degradation, cracking, and through-wall holes. While there is no single source that identifies all of these containment system problems, I estimate that there have been at least 80-significant cases of containment degradation on United States (U.S.) nuclear reactors during the last several decades. Of these 80 or more incidents, approximately 40 incidents are directly related to failure of the concrete, and approximately 40 incidents of containment system failure are related to failure of the steel.

18. Despite the history of containment integrity failure, Westinghouse has assumed that there is a zero percent probability that its new AP1000 design will fail in an accident scenario and would release any radioactive isotopes.

19. Since the AP1000 has no concrete in its containment system, the remainder of my analysis will address the 40 instances of steel corrosion and steel cracking in U.S. nuclear reactor containment systems.

20. My research indicates that there are four causative factors for steel containment or containment liner failure. These factors are:

    20.1. corrosion of the steel,
    20.2. inadequate inspections,
    20.3. cracking of the steel, and
    20.4. protective coating failures.

21. Additionally, although in some cases the steel liner or containment did not rust through completely, in many other cases there was a complete penetration of either the containment liner or the containment itself.

22. As I discussed in great detail in my attached report, there have been rust-related holes discovered in the liners at Brunswick, DC Cook, Beaver Valley, and other reactors. These holes have been complete penetrations through the steel liners that have had a secondary concrete containment behind them.

23. The NRC Staff's response to these through-wall penetrations of the steel containment is that the secondary containment system would have protected public health and safety by preventing any outside leakage of radioactive material.

24. Additionally, there have also been numerous recorded instances reporting that containment liners have thinned to a level below the regulated minimum-wall thickness and at the same time the protective coatings on the outside of the steel containment system have also failed.

25. In addition to the reported liner failures, there have also been repeated through-wall cracks in thicker containments that happen to be quite similar in design to the AP1000 containment. The through-wall cracks that have heretofore been uncovered have occurred at Hatch 1, Hatch 2, and Fitzpatrick.

26. These through-wall crack failures in the containment are not due to rust but are cracks that have developed over a long period of time due to thermal stress.

27. Therefore, the first item of great concern is that each of the liner or containment failures that have been uncovered to date shares a significant common element. The significant common element is that in every case, the American Society of Mechanical Engineers (ASME) inspection techniques have failed to detect any problem until a crack or hole has in fact become a through-wall failure.

    27.1. As I discussed in my June 25 presentation to the ACRS (Exhibit 4), in each instance the nuclear licensee firmly believed that ASME inspections alone were a reliable method of assessing containment integrity. Moreover, even the NRC had concurred that ASME inspections by themselves were a reliable method of determining containment integrity.

    27.2. Instead, through-wall cracks and holes have developed without warning in containment systems monitored by ASME inspections thus proving that the use of ASME inspections to monitor containment integrity is a wholly inadequate methodology.

28. The second item of major concern regarding containment integrity is the nuclear industry's belief in the viability of protective coatings as a reliable barrier in the protection of public health and safety, when in fact the protective coatings applied to containment systems have a significant history of abject failure.

28.1. In the Fairewinds Associates, Inc PowerPoint presentation to the ACRS (Exhibit 4), I alerted the NRC to the significant failure rate of protective coatings.

28.2. Although protective coating applications have been failing for more than 10-years, the NRC continues to approve these coatings and nuclear power plant licensees continue to claim that these protective coatings are an effective barrier to unmonitored radiation releases.

28.3. Finally, even the NRC Inspector General faults the NRC for not adequately evaluating the veracity of nuclear power plant licensee claims that these protective coatings aid in maintaining containment integrity prior to the NRC approval of nuclear power plant license extensions for an additional 20-years of operation. (Inspector General Report OIG-07-A-15)

29. The Vogtle AP1000 nuclear power plant design is directly and significantly impacted by the nuclear industry's experience of through wall cracks, liner failures, and through-wall rust holes.

30. As I stated earlier in this declaration, existing U.S. operating nuclear power plants have reactors that are backed up by a secondary containment system. In effect such a containment system functions like a double-hulled oil tanker in that if one hull fails, there is a second hull intact to protect the cargo. Similarly, the AP1000 design is comparable to only a single hulled vessel. Thus, in the event of a crack during an AP1000 Loss of Coolant Accident, radioactive gases would leak directly into the environment because they would be wafted out of the containment vessel via the chimney effect I discuss in detail in Exhibits 3 and 4.

31. In lay terminology, *single failure proof* means that a failure caused by a single event will not immediately cascade into failure of the whole system. By design, emergency equipment in a nuclear power plant is expected to be redundant and therefore guarantee that if one emergency system fails to shut down the reactor or cool the fuel, then a second emergency system would take over and complete that critical function. The design of the Vogtle AP1000 containment system is not a single failure proof system. As both Vogtle 3 and 4 are currently designed, if a crack or a hole should develop, radioactive material will leak directly into the environment.

32. To compensate for Vogtle's flaw in containment integrity, the industry and the NRC staff are claiming that protective coatings and the ASME inspection program are mitigating factors that would assure protection of public health and safety in the case of an accident in the single-hulled Vogtle design. However, the data reviewed does not substantiate this industry claim, and instead confirms what the industry knows to be true, that both protective coatings and ASME containment inspection programs have been proven to be wholly inadequate. Due to Vogtle's coating and inspection problems on its proposed Units 3 and 4, critical measures that are discussed in my conclusion must be implement at Vogtle.

CONCLUSION

33. My report to the NRC and presentation to the ACRS concerning industry problems with containment integrity directly addresses containment integrity for the AP1000. With the current AP1000 design, the evidence reviewed shows that there is a significant likelihood of post-accident radioactive isotopic leakage into the environment that will exceed design bases values. Equally important, nuclear engineer and analyst Dr. Gianni Petrangeli has suggested that there is a 46% probability that containment leakage in new reactors could exceed technical specification values during an accident by a factor of 10.

34. Neither the NRC nor the applicant SNC have evaluated the likelihood of a through-wall containment leak at Vogtle that could lead to greater-than-design-basis isotopic leakage in the event of an accident:

34.1. Industry experience indicates through-wall cracking has occurred repeatedly in existing containment systems.

34.2. Industry experience indicates through-wall rust has occurred repeatedly in existing containment systems.

34.3. Industry experience indicates ASME inspection programs have failed to detect cracks and rust holes.

34.4. Industry experience indicates that protective coatings have failed in containment systems.

35. Despite these known failure mechanisms and burgeoning history of containment failure, Southern Nuclear Operating Company assumes the probability for a containment breach at Vogtle to be zero. SNC's assumption regarding Vogtle is not consistent with the historical evidence.

36. Moreover, SNC's proposed Vogtle AP1000 design exacerbates the dispersion of radioactive material during and after an accident.

37. In conclusion, the reactor containment system proposed at Vogtle creates a unique, unanalyzed risk to public health and safety, and there is inadequate assurance that radiation releases during and following an accident will ever meet 10CFR100 accident exposure limits.

38. Clearly, the design changes I discussed during my meeting with the ACRS requiring a filtered ventilation system must be implemented.

39. Fairewinds' Report (Exhibit 3) and PowerPoint presentation to the ACRS (Exhibit 4) clearly establish that existing ASME XI inspection programs for containments and containment liners on operating reactors have a long history of failing to detect incipient cracks or rust until the metal has been completely breached. Yet in Chapter 6 of the Vogtle COL application, the Applicant relies only upon meeting these criteria that have already failed in the past. Given the Vogtle Unit 3 and 4's unique

containment design, the existing inspection regime suggested by the applicant does not provide adequate margins of safety. In addition to the inspections suggested in SNC's COLA, a 100% volumetric inspection of the containment from the inside of the containment once every refueling outage should be required by the ASLB and NRC in order to assure that through-wall propagation of holes or cracks is not occurring.

40. The Fairewinds Associates' Report (Exhibit 3) and Fairewinds' PowerPoint presentation to the ACRS (Exhibit 4) clearly establish that existing ASTM coating application programs and ASTM coating monitoring programs for containment systems and containment liners on operating reactors have a long history of failing to prevent incipient rust until the metal has been completely breached. Page 18 of the Fairewinds' Report (Exhibit 3) clearly indicates that "While coatings can provide some protection when properly applied, there is no assurance that field application can be completely successful...." PowerPoint slide number 8 of Exhibit 4 shows field applied coating failures that the NRC allowed to exist for more than 10-years.

41. Yet in Chapter 6 of the Vogtle COLA, the Applicant relies only upon meeting ASTM D5144-08, ASTM D5163-05a, and ASTM D7167-05. These policies have already failed in the past as indicated in Exhibits 3 and 4. Given that the containment and attached hangers will be welded in the field and coatings will also be applied in the field after welding is completed, the existing coating application and inspection regime suggested by the applicant does not provide adequate margins of safety in Vogtle Units 3 and 4.

42. The applicant bases the adequacy of its coating program on claims that periodic external visual examinations. The annular gap outside the containment provides limited access for personnel and the environmental conditions in the gap are not conducive to long term occupancy. Access ports have been provided for limited visual inspections, however full 360-degree visual inspections of the hangers that are attached to the containment will be nearly impossible to achieve. As discussed in Exhibit 3, these hangers are the most likely location for corrosion to begin, yet are

most difficult to examine. Additionally, coatings will only be applied to a depth of six inches below floor level, and crevices in that area are likely to create rust deposits near the floor similar to those that recently occurred at the Salem PWR.

43. Access problems will definitely limit visual inspections and the frequency of inspections planned by SNC is not adequate to prevent rust propagation. Therefore, for all these reasons, continuous external monitoring of the containment coating by robotic means is required to assure rust will not develop. Additionally, along with the continuous external robotic monitoring, the containment system must also be examined with internal volumetric exams as discussed in #39 of this declaration.

44. Finally, given the probability of gaseous release of radioactive isotopes in the event of an accident, the Vogtle emergency planning zones and the owner-controlled exclusion zones must be expanded.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this day, August 12, 2010 at Burlington, Vermont.

_______________**/s/**_____________________

Arnold Gundersen, MSNE
Chief Engineer, Fairewinds Associates, Inc

CURRICULUM VITAE
Arnold Gundersen
Chief Engineer, Fairewinds Associates, Inc
August 2010

Education and Training

ME NE	Master of Engineering Nuclear Engineering Rensselaer Polytechnic Institute, 1972 U.S. Atomic Energy Commission Fellowship Thesis: Cooling Tower Plume Rise
BS NE	Bachelor of Science Nuclear Engineering Rensselaer Polytechnic Institute, Cum Laude, 1971 James J. Kerrigan Scholar
RO	Licensed Reactor Operator, U.S. Atomic Energy Commission License # OP-3014

Qualifications – including and not limited to:

- Chief Engineer, Fairewinds Associates, Inc
- Nuclear Engineering, Safety, and Reliability Expert
- Federal and Congressional hearing testimony and Expert Witness testimony
- Former Senior Vice President Nuclear Licensee
- Former Licensed Reactor Operator
- 39-years of nuclear industry experience and oversight
    - Nuclear engineering management assessment and prudency assessment
    - Nuclear power plant licensing and permitting – assessment and review
    - Nuclear safety assessments, source term reconstructions, dose assessments, criticality analysis, and thermohydraulics
    - Contract administration, assessment and review
    - Systems engineering and structural engineering assessments
    - Cooling tower operation, cooling tower plumes, thermal discharge assessment, and consumptive water use
    - Nuclear fuel rack design and manufacturing, nuclear equipment design and manufacturing, and technical patents
    - Radioactive waste processes, storage issue assessment, waste disposal and decommissioning experience
    - Reliability engineering and aging plant management assessments, in-service inspection
    - Employee awareness programs, whistleblower protection, and public communications
    - Quality Assurance (QA) & records

Publications

Co-author — *Fairewinds Associates 2009-2010 Summary to JFC, July 26, 2010* State of Vermont, Joint Fiscal Office, http://www.leg.state.vt.us/jfo/Vermont%20Yankee.htm

Co-author — *Supplemental Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant July 20, 2010,* to the Vermont State Legislature by the Vermont Yankee Public Oversight Panel.

Co-author — The Second Quarterly Report by Fairewinds Associates, Inc to the Joint Legislative Committee regarding buried pipe and tank issues at Entergy Nuclear Vermont Yankee and Entergy proposed Enexus spinoff. See two reports: *Fairewinds Associates 2nd Quarterly Report to JFC* and *Enexus Review by Fairewinds Associates.*

Author — Fairewinds Associates, Inc *First Quarterly Report to the Joint Legislative Committee*, October 19, 2009.

Co-author — *Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant*, March 17, 2009, to the Vermont State Legislature by the Vermont Yankee Public Oversight Panel.

Co-author — *Vermont Yankee Comprehensive Vertical Audit – VYCVA – Recommended Methodology to Thoroughly Assess Reliability and Safety Issues at Entergy Nuclear Vermont Yankee*, January 30, 2008 Testimony to Finance Committee Vermont Senate.

Co-author — *Decommissioning Vermont Yankee – Stage 2 Analysis of the Vermont Yankee Decommissioning Fund – The Decommissioning Fund Gap*, December 2007, Fairewinds Associates, Inc. Presented to Vermont State Senators and Legislators.

Co-author — *Decommissioning the Vermont Yankee Nuclear Power Plant: An Analysis of Vermont Yankee's Decommissioning Fund and Its Projected Decommissioning Costs*, November 2007, Fairewinds Associates, Inc.

Co-author — *DOE Decommissioning Handbook, First Edition*, 1981-1982, invited author.

Patents

Energy Absorbing Turbine Missile Shield – U.S. Patent # 4,397,608 – 8/9/1983

Committee Memberships

Vermont Yankee Public Oversight Panel, appointed 2008 by President Pro-Tem Vermont Senate
National Nuclear Safety Network – Founding Board Member
Three Rivers Community College – Nuclear Academic Advisory Board
Connecticut Low Level Radioactive Waste Advisory Committee – 10 years, founding member
Radiation Safety Committee, NRC Licensee – founding member
ANSI N-198, Solid Radioactive Waste Processing Systems

Honors

U.S. Atomic Energy Commission Fellowship, 1972
B.S. Degree, Cum Laude, RPI, 1971, 1st in nuclear engineering class
Tau Beta Pi (Engineering Honor Society), RPI, 1969 – 1 of 5 in sophomore class of 700
James J. Kerrigan Scholar 1967–1971
Teacher of the Year – 2000, Marvelwood School
Publicly commended to U.S. Senate by NRC Chairman, Ivan Selin, in May 1993 – "It is true...everything Mr. Gundersen said was absolutely right; he performed quite a service."

Nuclear Consulting and Expert Witness Testimony

<u>U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)</u>

Declaration Of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contentions in the matter of Dominion Virginia Power North Anna Station Unit 3 Combined License Application, Docket No. 52-017, ASLBP#08-863-01-COL, July 23, 2010.

Florida Public Service Commission (FPSC)
Licensing and construction delays due to problems with the newly designed Westinghouse AP1000 reactors in *Direct Testimony In Re: Nuclear Plant Cost Recovery Clause By The Southern Alliance For Clean Energy (SACE)*, FPSC Docket No. 100009-EI, July 8, 2010.

U.S. Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards (NRC-ACRS) AP1000 Sub-Committee
Presentation to ACRS regarding design flaw in AP1000 Containment – June 25, 2010
Power Point Presentation: http://fairewinds.com/content/ap1000-nuclear-design-flaw-addressed-to-nrc-acrs.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
Second Declaration Of Arnold Gundersen Supporting Supplemental Petition Of Intervenors Contention 15: DTE COLA Lacks Statutorily Required Cohesive QA Program – June 8, 2010.

NRC Chairman Gregory Jaczko, ACRS, Secretary of Energy Chu, and the White House Office of Management and Budget
AP1000 Containment Leakage Report Fairewinds Associates - Gundersen, Hausler, 4-21-2010. This report, commissioned by the AP1000 Oversight Group, analyzes a potential flaw in the containment of the AP1000 reactor design.

Vermont State Legislature House Natural Resources – April 5, 2010
Testified to the House Natural Resources Committee regarding discrepancies in Entergy's TLG Services decommissioning analysis. See *Fairewinds Cost Comparison TLG Decommissioning* (http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm).

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – February 22, 2010
The Second Quarterly Report by Fairewinds Associates, Inc to the Joint Legislative Committee regarding buried pipe and tank issues at Entergy Nuclear Vermont Yankee and Entergy proposed Enexus spinoff. See two reports: *Fairewinds Associates 2nd Quarterly Report to JFC* and *Enexus Review by Fairewinds Associates*.
(http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm).

Vermont State Legislature Senate Natural Resources – February 16, 2010
Testified to Senate Natural Resources Committee regarding causes and severity of tritium leak in unreported buried underground pipes, status of Enexus spinoff proposal, and health effects of tritium.

Vermont State Legislature Senate Natural Resources – February 10, 2010
Testified to Senate Natural Resources Committee regarding causes and severity of tritium leak in unreported buried underground pipes. http://www.youtube.com/watch?v=36HJiBrJSxE

Vermont State Legislature Senate Finance – February 10, 2010
Testified to Senate Finance Committee regarding *A Chronicle of Issues Regarding Buried Tanks and Underground Piping at VT Yankee.*
(http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm)

Vermont State Legislature House Natural Resources – January 27, 2010
A Chronicle of Issues Regarding Buried Tanks and Underground Piping at VT Yankee.
(http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm)

Submittal to Susquehanna River Basin Commission, by Eric Epstein – January 5, 2010
Expert Witness Report Of Arnold Gundersen Regarding Consumptive Water Use Of The Susquehanna River By The Proposed PPL Bell Bend Nuclear Power Plant In the Matter of RE: Bell Bend Nuclear Power Plant Application for Groundwater Withdrawal Application for Consumptive Use BNP-2009-073.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
Declaration of Arnold Gundersen Supporting Supplemental Petition of Intervenors Contention 15: Detroit Edison COLA Lacks Statutorily Required Cohesive QA Program, December 8, 2009.

U.S. NRC Region III Allegation Filed by Missouri Coalition for the Environment
Expert Witness Report entitled: *Comments on the Callaway Special Inspection by NRC Regarding the May 25, 2009 Failure of its Auxiliary Feedwater System,* November 9, 2009.

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee
Oral testimony given to the Vermont State Legislature Joint Fiscal Committee October 28, 2009.
See report: *Quarterly Status Report - ENVY Reliability Oversight for JFO*
(http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm).

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee
The First Quarterly Report by Fairewinds Associates, Inc to the Joint Legislative Committee regarding reliability issues at Entergy Nuclear Vermont Yankee, issued October 19, 2009.
See report: *Quarterly Status Report - ENVY Reliability Oversight for JFO*
(http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm).

Florida Public Service Commission (FPSC)
Gave direct oral testimony to the FPSC in hearings in Tallahassee, FL, September 8 and 10, 2009 in support of Southern Alliance for Clean Energy (SACE) contention of anticipated licensing and construction delays in newly designed Westinghouse AP 1000 reactors proposed by Progress Energy Florida and Florida Power and Light (FPL).

Florida Public Service Commission (FPSC)
NRC announced delays confirming my original testimony to FPSC detailed below. My supplemental testimony alerted FPSC to NRC confirmation of my original testimony regarding licensing and construction delays due to problems with the newly designed Westinghouse AP 1000 reactors in *Supplemental Testimony In Re: Nuclear Plant Cost Recovery Clause By The Southern Alliance For Clean Energy*, FPSC Docket No. 090009-EI, August 12, 2009.

Florida Public Service Commission (FPSC)
Licensing and construction delays due to problems with the newly designed Westinghouse AP

1000 reactors in *Direct Testimony In Re: Nuclear Plant Cost Recovery Clause By The Southern Alliance For Clean Energy (SACE)*, FPSC Docket No. 090009-EI, July 15, 2009.

<u>Vermont State Legislature Joint Fiscal Committee Expert Witness Oversight Role for Entergy Nuclear Vermont Yankee (ENVY)</u>
Contracted by the Joint Fiscal Committee of the Vermont State Legislature as an expert witness to oversee the compliance of ENVY to reliability issues uncovered during the 2009 legislative session by the Vermont Yankee Public Oversight Panel of which I was appointed a member along with former NRC Commissioner Peter Bradford for one year from July 2008 to 2009. Entergy Nuclear Vermont Yankee (ENVY) is currently under review by Vermont State Legislature to determine if it should receive a Certificate for Public Good (CPG) to extend its operational license for another 20-years. Vermont is the only state in the country that has legislatively created the CPG authorization for a nuclear power plant. Act 160 was passed to ascertain ENVY's ability to run reliably for an additional 20 years. Appointment from July 2009 to May 2010.

<u>U.S. Nuclear Regulatory Commission</u>
Expert Witness Declaration regarding Combined Operating License Application (COLA) at North Anna Unit 3 *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contentions* (June 26, 2009).

<u>U.S. Nuclear Regulatory Commission</u>
Expert Witness Declaration regarding Through-wall Penetration of Containment Liner and Inspection Techniques of the Containment Liner at Beaver Valley Unit 1 Nuclear Power Plant *Declaration of Arnold Gundersen Supporting Citizen Power's Petition* (May 25, 2009).

<u>U.S. Nuclear Regulatory Commission</u>
Expert Witness Declaration regarding Quality Assurance and Configuration Management at Bellefonte Nuclear Plant *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contentions in their Petition for Intervention and Request for Hearing*, May 6, 2009.

<u>Pennsylvania Statehouse</u>
Expert Witness Analysis presented in formal presentation at the Pennsylvania Statehouse, March 26, 2009 regarding actual releases from Three Mile Island Nuclear Accident. Presentation may be found at: http://www.tmia.com/march26

<u>Vermont Legislative Testimony and Formal Report for 2009 Legislative Session</u>
As a member of the Vermont Yankee Public Oversight Panel, I spent almost eight months examining the Vermont Yankee Nuclear Power Plant and the legislatively ordered Comprehensive Vertical Audit. Panel submitted Act 189 Public Oversight Panel Report March 17, 2009 and oral testimony to a joint hearing of the Senate Finance and House Natural Resources March 19, 2009. (See: http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm)

<u>Finestone v FPL (11/2003 to 12/2008) Federal Court</u>
Plaintiffs' Expert Witness for Federal Court Case with Attorney Nancy LaVista, from the firm Lytal, Reiter, Fountain, Clark, Williams, West Palm Beach, FL. This case involved two

plaintiffs in cancer cluster of 40 families alleging that illegal radiation releases from nearby nuclear power plant caused children's cancers. Production request, discovery review, preparation of deposition questions and attendance at Defendant's experts for deposition, preparation of expert witness testimony, preparation for Daubert Hearings, ongoing technical oversight, source term reconstruction and appeal to Circuit Court.

U.S. Nuclear Regulatory Commission Advisory Committee Reactor Safeguards (NRC-ACRS)
Expert Witness providing oral testimony regarding Millstone Point Unit 3 (MP3) Containment issues in hearings regarding the Application to Uprate Power at MP3 by Dominion Nuclear, Washington, and DC. (July 8-9, 2008).

Appointed by President Pro-Tem of Vermont Senate to Legislatively Authorized Nuclear Reliability Public Oversight Panel
To oversee Comprehensive Vertical Audit of Entergy Nuclear Vermont Yankee (Act 189) and testify to State Legislature during 2009 session regarding operational reliability of ENVY in relation to its 20-year license extension application. (July 2, 2008 to present).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
Expert Witness providing testimony regarding *Pilgrim Watch's Petition for Contention 1 Underground Pipes* (April 10, 2008).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
Expert Witness supporting *Connecticut Coalition Against Millstone In Its Petition For Leave To Intervene, Request For Hearing, And Contentions Against Dominion Nuclear Connecticut Inc.'s Millstone Power Station Unit 3 License Amendment Request For Stretch Power Uprate* (March 15, 2008).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
Expert Witness supporting *Pilgrim Watch's Petition For Contention 1*: *specific to issues regarding the integrity of Pilgrim Nuclear Power Station's underground pipes and the ability of Pilgrim's Aging Management Program to determine their integrity*. (January 26, 2008).

Vermont State House – 2008 Legislative Session
- House Committee on Natural Resources and Energy – Comprehensive Vertical Audit: *Why NRC Recommends a Vertical Audit for Aging Plants Like Entergy Nuclear Vermont Yankee (ENVY)*
- House Committee on Commerce – Decommissioning Testimony

Vermont State Senate – 2008 Legislative Session
- Senate Finance – testimony regarding Entergy Nuclear Vermont Yankee Decommissioning Fund
- Senate Finance – testimony on the necessity for a Comprehensive Vertical Audit (CVA) of Entergy Nuclear Vermont Yankee
- Natural Resources Committee – testimony regarding the placement of high-level nuclear fuel on the banks of the Connecticut River in Vernon, VT

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
MOX Limited Appearance Statement to Judges Michael C. Farrar (Chairman), Lawrence G. McDade, and Nicholas G. Trikouros for the "Petitioners": Nuclear Watch South, the Blue Ridge Environmental Defense League, and Nuclear Information & Resource Service in support of *Contention 2: Accidental Release of Radionuclides, requesting a hearing concerning faulty accident consequence assessments made for the MOX plutonium fuel factory proposed for the Savannah River Site*. (September 14, 2007).

Appeal to the Vermont Supreme Court (March 2006 to 2007)
Expert Witness Testimony in support of *New England Coalition's Appeal to the Vermont Supreme Court Concerning: Degraded Reliability at Entergy Nuclear Vermont Yankee as a Result of the Power Uprate*. New England Coalition represented by Attorney Ron Shems of Burlington, VT.

State of Vermont Environmental Court (Docket 89-4-06-vtec 2007)
Expert witness retained by New England Coalition to review Entergy and Vermont Yankee's analysis of alternative methods to reduce the heat discharged by Vermont Yankee into the Connecticut River. Provided Vermont's Environmental Court with analysis of alternative methods systematically applied throughout the nuclear industry to reduce the heat discharged by nuclear power plants into nearby bodies of water and avoid consumptive water use. This report included a review of the condenser and cooling tower modifications.

U.S. Senator Bernie Sanders and Congressman Peter Welch (2007)
Briefed Senator Sanders, Congressman Welch and their staff members regarding technical and engineering issues, reliability and aging management concerns, regulatory compliance, waste storage, and nuclear power reactor safety issues confronting the U.S. nuclear energy industry.

State of Vermont Legislative Testimony to Senate Finance Committee (2006)
Testimony to the Senate Finance Committee regarding Vermont Yankee decommissioning costs, reliability issues, design life of the plant, and emergency planning issues.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB)
Expert witness retained by New England Coalition to provide Atomic Safety and Licensing Board with an independent analysis of the integrity of the Vermont Yankee Nuclear Power Plant condenser (2006).

U.S. Senators Jeffords and Leahy (2003 to 2005)
Provided the Senators and their staffs with periodic overview regarding technical, reliability, compliance, and safety issues at Entergy Nuclear Vermont Yankee (ENVY).

10CFR 2.206 filed with the Nuclear Regulatory Commission (July 2004)
Filed 10CFR 2.206 petition with NRC requesting confirmation of Vermont Yankee's compliance with General Design Criteria.

State of Vermont Public Service Board (April 2003 to May 2004)

Expert witness retained by New England Coalition to testify to the Public Service Board on the reliability, safety, technical, and financial ramifications of a proposed increase in power (called an uprate) to 120% at Entergy's 31-year-old Vermont Yankee Nuclear Power Plant.

International Nuclear Safety Testimony
Worked for ten days with the President of the Czech Republic (Vaclav Havel) and the Czech Parliament on their energy policy for the 21st century.

Nuclear Regulatory Commission (NRC) Inspector General (IG)
Assisted the NRC Inspector General in investigating illegal gratuities paid to NRC Officials by Nuclear Energy Services (NES) Corporate Officers. In a second investigation, assisted the Inspector General in showing that material false statements (lies) by NES corporate president caused the NRC to overlook important violations by this licensee.

State of Connecticut Legislature
Assisted in the creation of State of Connecticut Whistleblower Protection legal statutes.

Federal Congressional Testimony
Publicly recognized by NRC Chairman, Ivan Selin, in May 1993 in his comments to U.S. Senate, "It is true...everything Mr. Gundersen said was absolutely right; he performed quite a service." Commended by U.S. Senator John Glenn for public testimony to Senator Glenn's NRC Oversight Committee.

PennCentral Litigation
Evaluated NRC license violations and material false statements made by management of this nuclear engineering and materials licensee.

Three Mile Island Litigation
Evaluated unmonitored releases to the environment after accident, including containment breach, letdown system and blowout. Proved releases were 15 times higher than government estimate and subsequent government report.

Western Atlas Litigation
Evaluated neutron exposure to employees and license violations at this nuclear materials licensee.

Commonwealth Edison
In depth review and analysis for Commonwealth Edison to analyze the efficiency and effectiveness of all Commonwealth Edison engineering organizations, which support the operation of all of its nuclear power plants.

Peach Bottom Reactor Litigation
Evaluated extended 28-month outage caused by management breakdown and deteriorating condition of plant.

***Special Remediation Expertise*:**

Director of Engineering, Vice President of Site Engineering, and the Senior Vice President of Engineering at Nuclear Energy Services (NES) Division of Penn Central Corporation (PCC)

- NES was a nuclear licensee that specialized in dismantlement and remediation of nuclear facilities and nuclear sites. Member of the radiation safety committee for this licensee.
- Department of Energy chose NES to write *DOE Decommissioning Handbook* because NES had a unique breadth and depth of nuclear engineers and nuclear physicists on staff.
- Personally wrote the "Small Bore Piping" chapter of the DOE's first edition Decommissioning Handbook, personnel on my staff authored other sections, and I reviewed the entire Decommissioning Handbook.
- Served on the Connecticut Low Level Radioactive Waste Advisory Committee for 10 years from its inception.
- Managed groups performing analyses on dozens of dismantlement sites to thoroughly remove radioactive material from nuclear plants and their surrounding environment.
- Managed groups assisting in decommissioning the Shippingport nuclear power reactor. Shippingport was the first large nuclear power plant ever decommissioned. The decommissioning of Shippingport included remediation of the site after decommissioning.
- Managed groups conducting site characterizations (preliminary radiation surveys prior to commencement of removal of radiation) at the radioactively contaminated West Valley site in upstate New York.
- Personnel reporting to me assessed dismantlement of the Princeton Avenue Plutonium Lab in New Brunswick, NJ. The lab's dismantlement assessment was stopped when we uncovered extremely toxic and carcinogenic underground radioactive contamination.
- Personnel reporting to me worked on decontaminating radioactive thorium at the Cleveland Avenue nuclear licensee in Ohio. The thorium had been used as an alloy in turbine blades. During that project, previously undetected extremely toxic and carcinogenic radioactive contamination was discovered below ground after an aboveground gamma survey had purported that no residual radiation remained on site.

Teaching and Academic Administration Experience

Rensselaer Polytechnic Institute (RPI) – Advanced Nuclear Reactor Physics Lab
Community College of Vermont – Mathematics Professor – 2007 to present
Burlington High School
    Mathematics Teacher – 2001 to June 2008
    Physics Teacher – 2004 to 2006
The Marvelwood School – 1996 to 2000
    Awarded Teacher of the Year – June 2000
    Chairperson: Physics and Math Department
    Mathematics and Physics Teacher, Faculty Council Member
    Director of Marvelwood Residential Summer School
    Director of Residential Life
The Forman School & St. Margaret's School – 1993 to 1995
    Physics and Mathematics Teacher, Tennis Coach, Residential Living Faculty Member

Nuclear Engineering 1970 to Present

Vetted as expert witness in nuclear litigation and administrative hearings in federal, international, and state court and to Nuclear Regulatory Commission, including but not limited to: Three Mile Island, US Federal Court, US NRC, NRC ASLB & ACRS, Vermont State Legislature, Vermont State Public Service Board, Florida Public Service Board, Czech Senate, Connecticut State Legislature, Western Atlas Nuclear Litigation, U.S. Senate Nuclear Safety Hearings, Peach Bottom Nuclear Power Plant Litigation, and Office of the Inspector General NRC.

Nuclear Engineering, Safety, and Reliability Expert Witness 1990 to Present

- Fairewinds Associates, Inc – Chief Engineer, 2005 to Present
- Arnold Gundersen, Nuclear Safety Consultant and Energy Advisor, 1995 to 2005
- GMA – 1990 to 1995, including expert witness testimony regarding the accident at Three Mile Island.

Nuclear Energy Services, Division of PCC (Fortune 500 company) 1979 to 1990

Corporate Officer and Senior Vice President - Technical Services

Responsible for overall performance of the company's Inservice Inspection (ASME XI), Quality Assurance (SNTC 1A), and Staff Augmentation Business Units – up to 300 employees at various nuclear sites.

Senior Vice President of Engineering

Responsible for the overall performance of the company's Site Engineering, Boston Design Engineering and Engineered Products Business Units. Integrated the Danbury based, Boston based and site engineering functions to provide products such as fuel racks, nozzle dams, and transfer mechanisms and services such as materials management and procedure development.

Vice President of Engineering Services

Responsible for the overall performance of the company's field engineering, operations engineering, and engineered products services. Integrated the Danbury-based and field-based engineering functions to provide numerous products and services required by nuclear utilities, including patents for engineered products.

General Manager of Field Engineering

Managed and directed NES' multi-disciplined field engineering staff on location at various nuclear plant sites. Site activities included structural analysis, procedure development, technical specifications and training. Have personally applied for and received one patent.

Director of General Engineering

Managed and directed the Danbury based engineering staff. Staff disciplines included structural, nuclear, mechanical and systems engineering. Responsible for assignment of personnel as well as scheduling, cost performance, and technical assessment by staff on assigned projects. This staff provided major engineering support to the company's nuclear waste management, spent fuel storage racks, and engineering consulting programs.

New York State Electric and Gas Corporation (NYSE&G) — 1976 to 1979

Reliability Engineering Supervisor

Organized and supervised reliability engineers to upgrade performance levels on seven operating coal units and one that was under construction. Applied analytical techniques and good engineering judgments to improve capacity factors by reducing mean time to repair and by increasing mean time between failures.

Lead Power Systems Engineer

Supervised the preparation of proposals, bid evaluation, negotiation and administration of contracts for two 1300 MW NSSS Units including nuclear fuel, and solid-state control rooms. Represented corporation at numerous public forums including TV and radio on sensitive utility issues. Responsible for all nuclear and BOP portions of a PSAR, Environmental Report, and Early Site Review.

Northeast Utilities Service Corporation (NU) — 1972 to 1976

Engineer

Nuclear Engineer assigned to Millstone Unit 2 during start-up phase. Lead the high velocity flush and chemical cleaning of condensate and feedwater systems and obtained discharge permit for chemicals. Developed Quality Assurance Category 1 Material, Equipment and Parts List. Modified fuel pool cooling system at Connecticut Yankee, steam generator blowdown system and diesel generator lube oil system for Millstone. Evaluated Technical Specification Change Requests.

Associate Engineer

Nuclear Engineer assigned to Montague Units 1 & 2. Interface Engineer with NSSS vendor, performed containment leak rate analysis, assisted in preparation of PSAR and performed radiological health analysis of plant. Performed environmental radiation survey of Connecticut Yankee. Performed chloride intrusion transient analysis for Millstone Unit 1 feedwater system. Prepared Millstone Unit 1 off-gas modification licensing document and Environmental Report Amendments 1 & 2.

Rensselaer Polytechnic Institute (RPI) — 1971 to 1972

Critical Facility Reactor Operator, Instructor

Licensed AEC Reactor Operator instructing students and utility reactor operator trainees in start-up through full power operation of a reactor.

Public Service Electric and Gas (PSE&G) — 1970

Assistant Engineer

Performed shielding design of radwaste and auxiliary buildings for Newbold Island Units 1 & 2, including development of computer codes.

Public Service, Cultural, and Community Activities

2005 to Present – Public presentations and panel discussions on nuclear safety and reliability at University of Vermont, NRC hearings, Town and City Select Boards, Legal Panels, Television, and Radio

2007-2008 – Created Concept of Solar Panels on Burlington High School; worked with Burlington Electric Department and Burlington Board of Education Technology Committee on Grant for installation of solar collectors for Burlington Electric peak summer use

Vermont State Legislature – Public Testimony to Legislative Committees

Certified Foster Parent State of Vermont – 2004 to 2007

Mentoring former students – 2000 to present – college application and employment application questions and encouragement

Tutoring Refugee Students – 2002 to 2006 – Lost Boys of the Sudan and others from educationally disadvantaged immigrant groups

Designed and Taught Special High School Math Course for ESOL Students – 2007 to 2008

Featured Nuclear Safety and Reliability Expert (1990 to present) for Television, Newspaper, Radio, & Internet – Including, and not limited to: CNN (Earth Matters), NECN, WPTZ VT, WTNH, VPTV, WCAX, Cable Channel 17, The Crusaders, Front Page, Mark Johnson Show, Steve West Show, Anthony Polina Show, WKVT, WDEV, WVPR, WZBG CT, Seven Days, AP News Service, Houston Chronicle, Christian Science Monitor, New York Times, Brattleboro Reformer, Rutland Herald, Times-Argus, Burlington Free Press, Litchfield County Times, The News Times, The New Milford Times, Hartford Current, New London Day, evacuationplans.org, Vermont Daily Briefing, Green Mountain Daily, and numerous other national and international blogs

NNSN – National Nuclear Safety Network, Founding Advisory Board Member, meetings with and testimony to the Nuclear Regulatory Commission Inspector General (NRC IG)

Berkshire School Parents Association, Co-Founder

Berkshire School Annual Appeal, Co-Chair

Sunday School Teacher, Christ Church, Roxbury, CT

Washington Montessori School Parents Association Member

Marriage Encounter National Presenting Team with wife Margaret

Provided weekend communication and dialogue workshops weekend retreats/seminars

Connecticut Marriage Encounter Administrative Team – 5 years

Northeast Utilities Representative Conducting Public Lectures on Nuclear Safety Issues

End

Post Accident AP1000 Containment Leakage
An Unreviewed Safety Issue

Fairewinds Associates, Inc, April 21, 2010

A Report by Arnold Gundersen, April 21, 2010
Chief Engineer, Fairewinds Associates, Inc

Affidavit by Rudolf H. Hausler, PhD, Corro-Consulta
Re. Post Accident AP1000 Containment Leakage:
An Un-reviewed Safety Issue

Attachments**:**
Attachment 1 – Curriculum Vitae
Attachment 2 – Table 1 from *Detection of Aging Nuclear Power Plant Structures*
Attachment 3 – Table 35-4 *Summary Of Release Category Definitions*
Attachment 4 – *Declaration Of Arnold Gundersen Supporting Citizen Power's Petition*
Attachment 5 – *Declaration Of Arnold Gundersen Supporting Connecticut Coalition Against Millstone In Its Petition For Leave To Intervene, Request For Hearing, And Contentions*

Post Accident AP1000 Containment Leakage
An Unreviewed Safety Issue

A Report by Arnold Gundersen[1]
April 21, 2010

1. Introduction

The AP1000 design has no secondary containment to provide for fission product control following a design basis accident. The purpose of this report is to describe the basis for concerns regarding an apparently unreviewed safety issue raised by the AP1000 containment system design (Revision 18).

My four concerns are:

- Recent experience with the current generation of nuclear reactors shows that containment corrosion, cracking, and leakage are far more prevalent and serious than anticipated by the U.S. Nuclear Regulatory Commission (NRC) in establishing its regulatory program for the safe operation of nuclear reactors.

- By design, the AP1000 containment has an even higher vulnerability to corrosion than containment systems of current reactor designs because the outside of the AP1000 containment is subject to a high-oxygen and high-moisture environment conducive to corrosion and is prone to collect moisture in numerous inaccessible locations that are not available for inspection.

- By design, the AP1000 containment has an even higher vulnerability to unfiltered, unmonitored leakage than the current generation containment system designs, and it lacks the defense in depth of existing structures. While the AP1000 is called an *advanced passive system*, in fact the containment design and structures immediately outside the containment are designed to create a chimney-like effect and draw out any radiation that leaks through the containment into the

[1] Arnold Gundersen is the Chief Engineer with Fairewinds Associates, Inc., a paralegal and expert witness firm that specializes in nuclear safety, engineering, and reliability issues. Mr. Gundersen holds a bachelor's and master's degree in nuclear engineering and has more than 38 years of experience in nuclear power plant operation, management and design. A copy of his curriculum vitae is attached.

environment. Such a system will also facilitate the more efficient release of unfiltered, unmonitored radiation from any cracks or holes that might develop in the containment.

- Finally, a leakage path exists that is not bounded by any existing analysis and will be more severe than those previously identified by Westinghouse in its AP1000 application and various revisions.

The potential consequences of a radiation release to the environment from a small hole or crack in the AP1000 containment are significant. A containment hole approximately ¾" by ¼", like the one discovered at Beaver Valley in 2009, would create exposure to the public well in excess of the 25 rem limit in 10 CFR 100.11(2) for the entire period of the accident. A hole that is the size of the hole in Beaver Valley's containment is not a low probability event, as several through-wall liner holes have already occurred in existing nuclear containments. Therefore, it is not a concept to be pushed off into the severe accident category. Yet, to my knowledge, neither Westinghouse nor the NRC has adequately analyzed this significant safety issue for the AP1000 design.

2. Background of Containment Design

2.1 General. All nuclear power reactor containment systems are designed to contain the radiation and energy that would be released during a Loss Of Coolant Accident (LOCA). In the absence of a containment system, post accident exposures to the public would be unacceptably high. "A containment building, in its most common usage, is a steel or concrete structure enclosing a nuclear reactor. It is designed to contain the escape of radiation… during any emergency. The containment is the final barrier to radioactive release, the first being the fuel ceramic itself, the second being the metal fuel cladding tubes, the third being the reactor vessel and coolant system."[2]

2.2 Current Reactor Containment Designs. According to H.L. Graves, III, NRC, and D.J. Naus, Oak Ridge National Laboratories, there are two main types of

[2] http://encyclopedia.thefreedictionary.com/containment+structure

containment designs currently in operation: freestanding containments and concrete containments with liners.[3]

> Freestanding Containments are:
> "freestanding, welded steel structures that are enclosed in a reinforced concrete reactor or shield building. The reactor or shield buildings are not part of the pressure boundary and their primary function is to provide protection for the containment from external missiles and natural phenomena (e.g., tornadoes or site-specific environmental events). Thirty-two of the NPPs licensed for commercial operation in the US employ a metal containment."[4]

> Concrete Containments With Liner are:
> "metal lined, reinforced concrete pressure-retaining structures that in some cases may be post-tensioned. The concrete vessel includes the concrete shell and shell components, shell metallic liners, and penetration liners that extend the containment liner through the surrounding shell concrete. The reinforced concrete shell, which generally consists of a cylindrical wall with a hemispherical or ellipsoidal dome and flat base slab, provides the necessary structural support and resistance to pressure-induced forces. Leak-tightness is provided by a steel liner fabricated from relatively thin plate material (e.g., 6-mm thick) that is anchored to the concrete shell by studs, structural steel shapes, or other steel products… Seventy-two of the NPPs licensed for commercial operation in the US employ either a reinforced concrete (37 plants) or post-tensioned concrete (35 plants) containment.[5]"

2.3 AP1000 Containment Design. The proposed AP1000 reactors use concepts common to both types of containment system designs to create a wholly *new hybrid containment* that has had no prior operational history. While the AP1000 is a PWR that uses a dry containment system similar to that which most other existing PWRs use, unlike most currently operating PWRs, the AP1000 design proposes to use a freestanding steel containment and no secondary containment.

2.4 Existing freestanding containment systems are normally surrounded by a reactor building that also acts as a filtered enclosure in the case of a design-basis accident. In the AP1000 design, the freestanding steel containment is surrounded by a

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3 Naus, D.J. and Graves, III, H.L., *Detection of Aging Nuclear Power Plant Structures,* Proceedings of the OECD-NEA Workshop on the Instrumentation and Monitoring of Concrete Structures, NEA/CSNI/ R(2000)15, Organization for Economic Cooperation and Development – Nuclear Energy Agency, ISSY-les-Moulineaux, France, 2001.
4 *Id.,* page 3.
5 *Id.,* pages 3-4.

shield building that is not intended or designed to filter exhaust gases that may leak from the steel containment in the event of an accident.

The AP1000 containment has another unique feature: following an accident it serves a role as a heat exchanger. Unlike any previous containment system ever built, the AP1000 uses a large tank of water above the shield building to pour water directly onto the outside of the steel containment shell. After an accident, the falling water then cools the containment shell, which then cools the radioactive steam inside the containment via two processes known as thermal conduction and convection during which the steel shell evaporates the water that is sprayed from above. As stated in a Westinghouse report:

> "The steel containment vessel provides the heat transfer surface that removes heat from inside the containment and transfers it to the atmosphere. Heat is removed from the containment by the continuous, natural circulation of air. During an accident, air cooling is supplemented by water evaporation. The water drains by gravity from a tank located on top of the containment shield building."[6]

The process of falling water effectively converts the containment into a heat exchanger rather than the passive containment building that is the hallmark of the original PWR containment system design.

2.5 History of NRC Containment Analysis. One of the hallmarks of NRC regulation is that licensees and applicants must apply either *conservative assumptions* or *conservative estimates* in order to meet the NRC's statutory requirement to protect public health and safety. The dictionary defines "*conservative*" *as "Moderate: cautious: a conservative estimate"*. The pattern of recently uncovered weakness in the overall integrity of the current operating containment system design methodology proves that presumptions made for the AP1000 containment system considered in the containment design bases lack the level of prudence and caution as required to protect public health and safety.

3. <u>Discussion</u>

3.1 History of Containment Corrosion and Leakage A recent string of failures in

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[6] W.E. Cummins, et al, *Westinghouse AP1000 Advanced Passive Plant,* Proceedings of ICAPP '03, Cordoba, Spain, May 4-7, 2003, Paper 3235.

the current generation of containment systems strongly indicates that these current containment systems are not as impervious to the post accident environment as was anticipated and calculated by NRC and the nuclear industry in conducting design basis analysis for nuclear reactors. As discussed below in paragraph 3.1.8, this disturbing trend calls for a new analysis of the potential for containment corrosion and leakage. As further discussed in Section 3.2 below, the need for such an analysis is all the more pronounced with respect to the AP1000 design, which appears to invite corrosion through the establishment of a moist oxygenated environment.

For Example:

3.1.1 Beaver Valley. The NRC and the ACRS have received expert witness testimony concerning three pitting indications at Beaver Valley in 2006 and a through-wall hole at Beaver Valley in 2009 as delineated in the April 23, 2009 NRC Event Notification Report 45015. Moreover, the Beaver Valley NRC Event Notification Report clearly shows that visual inspections have proven inadequate to discover leaks before the leaks penetrate the entire metal surface. Below is a picture taken in April 2009 of a through-wall hole in the Beaver Valley containment that was undetected until complete penetration of the liner had occurred.

BEAVER VALLEY UNIT 1 LINER HOLE

3.1.2 European PWRs. Weld anomalies in the containment liner of the latest generation European Pressurized Reactor at Framanville 3 have caused construction delays and setbacks.[7] Weld anomalies may lead to crevices that create through-wall corrosion if they occurred in the unique AP1000 containment design. While there is a significant amount of European data, the data cited in this report is limited to United States nuclear power plants.

3.1.3 Naus and Graves Study. In their treatise, <u>*Detection of Aging Nuclear Power Plant Structures*</u>, Naus and Graves have created a lengthy and comprehensive list of 66 containment system failures beginning as early as 1970 and following through to the end of their published research in 1999. According to their report:

> "As nuclear plant containments age, degradation incidences are starting to occur at an increasing rate, primarily due to environmental-related factors. There have been at least 66 separate occurrences of degradation in operating containments (some plants may have more than one occurrence of degradation). One-fourth of all containments have experienced corrosion, and nearly half of the concrete containments have reported degradation related to either the reinforced concrete or post- tensioning system. Since 1986, there have been over 32 reported occurrences of corrosion of steel containments or liners of reinforced concrete containments. In two cases, thickness measurements of the walls of steel containments revealed areas that were below the minimum design thickness. Two instances have been reported where corrosion has completely penetrated the liner of reinforced concrete containments. There have been four additional cases where extensive corrosion of the liner has reduced the thickness locally by nearly one-half (10)."[8]

Naus and Graves also report that: "Since the early 1970's, at least 34 occurrences of containment degradation related to the reinforced concrete or post-tensioning systems have been reported."[9]

More disturbingly, Naus and Graves chronicled 32 reported incidences of steel containment or liner degradation that are particularly germane to anticipated problems

[7] Oliver, Anthony and Owen, Ed, *New Civil Engineer Magazine* June 18, 2009
[8] *Id.,* page 5.
[9] *Id.,* page 6.

with the proposed AP1000 containment system. While some of the problems detailed by Naus and Graves are corrosion or pitting that did not completely penetrate the containment system, *their report also uncovered complete containment system failures of either the liner or the steel containment shell*. Table 1, labeled Attachment 2, from Detection of Aging Nuclear Power Plant Structures identifies through-wall containment cracks that occurred in 1984 at Hatch 2,in 1985 at Hatch 1, and in 1999, North Anna 2 also experienced a through-wall hole in its containment.

Naus and Graves also identify significant problems with containment inspections in locations where inspections are difficult due to inaccessibility. It is stated on Page 18 of their report that:

> "**Inaccessible Area Considerations**
> Inspection of inaccessible portions of metal pressure boundary components of nuclear power plant containments (e.g., fully embedded or inaccessible containment shell or liner portions, the sand pocket region in Mark I and II drywells, and portions of the shell obscured by obstacles such as platforms or floors) requires special attention. Embedded metal portions of the containment pressure boundary may be subjected to corrosion resulting from groundwater permeation through the concrete; a breakdown of the sealant at the concrete-containment shell interface that permits entry of corrosive fluids from spills, leakage, or condensation; or in areas adjacent to floors where the gap contains a filler material that can retain fluids. Examples of some of the problems that have occurred at nuclear power plants include corrosion of the steel containment shell in the drywell sand cushion region, shell corrosion in ice condenser plants, corrosion of the torus of the steel containment shell, and concrete containment liner corrosion. In addition there have been a number of metal pressure boundary corrosion incidents that have been identified in Europe (e.g., corrosion of the liner in several of the French 900 MW(e) plants and metal containment corrosion in Germany). Corrosion incidences such as these may challenge the containment structural integrity and, if through-wall, can provide a leak path to the outside environment." [10]

Not only do Naus and Graves identify inspection problems with containments in the United States, but also in Europe. The data they collected, however, only reflect containment problems in the United States. While their report was written in 1999, the

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[10] *Id*., Page 18

inspection problems have actually accelerated in severity since that time, with the most recent containment problem reviewed occurring at Beaver Valley in April 2009.

3.1.4 Reports in NRC Information Notice. The 66 incidences of containment system degradation occurring between 1970 and 1999 and reported by Naus and Graves appear to be comprehensive for that specific period of time. While my research to date has not uncovered a comprehensive and all-inclusive list for the current decade from 1999 to present, my review of *USNRC Information Notice 2004-09* identified another eight additional episodes of containment system degradation including a through-wall hole in the containment liner at D.C. Cook in 2001, three through-wall holes through the liner at Brunswick in late 1999, and 60 areas of pitting at D.C. Cook (Ice Containment) in 1998 where the liner was not penetrated but the thickness of the pitting was below the minimum design value[11].

According to the evidence reviewed, at least 77 instances of containment system degradation have occurred at operating US reactors since 1970, including two through-wall cracks in steel containments (Hatch 1 & 2), six through-wall holes in containment liners (Cook, North Anna 2, Beaver Valley 1, and three at Brunswick), and at least 60 instances of liners pitting to below allowable minimum wall thickness (minimum design value).

3.1.5 Citizens Power Report. In its May 2009 filing regarding Beaver Valley's application for a 20-year license extension, Citizen Power recently informed the NRC's Advisory Committee on Reactor Safeguards (ACRS) of the increased likelihood of containment system leakage failures. The expert witness declaration, entitled *Declaration Of Arnold Gundersen Supporting Citizen Power's Petition* and attached herein as Attachment 3 and contained within Citizen Power's filing to the ACRS, identified the *industry-wide* significance of the containment liner hole at Beaver Valley. The declaration detailed potential causes of containment through-wall liner failure and the currently existing weaknesses in inspection techniques on PWR containment systems.

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[11] The minimum standard upon which the licensing design of this specific nuclear power plant was predicated and upon which risk assessment data was factored.

The *Declaration Of Arnold Gundersen Supporting Citizen Power's Petition* also addresses United States patents on containment design that clearly state that concrete containment structures are considered porous to radioactive gases and no credit for retention of radiation in concrete may be allowed.[12]

3.1.6 ACRS 2008 Meeting with Connecticut Coalition Against Millstone. Following my July 9, 2008 testimony to ACRS regarding potential problems with Dominion Nuclear Connecticut Inc.'s Millstone Unit 3's sub-atmospheric *containment system*, the ACRS questioned a *containment specialist staff member of NRC* as to whether the NRC even has the capability to analyze a sub-atmospheric containment. According to the NRC *containment specialist*, the NRC cannot accurately analyze containment systems.

The NRC *containment specialist* and staff member said:

> "It's sort of difficult for us to do an independent analysis. It takes time. We're not really set up to do it. The other thing you have to realize, too, for containment, which isn't as true in the reactor systems area, is that **we don't have the capability**."[13]

To date, the NRC ACRS has met at least twice to discuss Citizen Power's concerns regarding liner failures and the transcripts of those meetings contain key details for containment system failure that should be of concern to the entire nuclear industry.

The most informed discussion of the probability of significant leakage from a PWR containment system may be found in the July 8, 2009 ACRS transcript regarding the Citizen Power petition alerting the NRC to the magnitude and significance of the failure of the containment system. The specific text relating to probability of gross containment leakage is addressed on Page 40 of the July 8, 2009 ACRS transcript:

> "MEMBER RAY: At which point the condition of the concrete can't be taken credit for. So I guess I just think that **the idea that the leakage is**

[12] According to one of Stone and Webster's patents, "A Sub-atmospheric double containment system is a reinforced concrete double wall nuclear containment structure with each wall including an essentially impervious membrane or liner and **porous concrete** filling the annulus between the two walls." US Patent 4081323 Issued on March 28, 1978 to Stone & Webster Engineering Corp. [Emphasis Added]

[13] ACRS Transcript, July 9, 2008, page 88 lines 6-11 [Emphasis added]

> **going to be small from a small hole, from a hole this size, as small as Dan says, in the design-basis conditions isn't logically supportable because the concrete, you can't -- you, yourself said, you can't take credit for the concrete and the reason is because it's condition in the design-basis event can't be predicted, can't be credited. The only thing you can credit is the membrane itself**.
>
> MEMBER SHACK: From a deterministic basis, you're correct. From a probabilistic basis, which is what they use and can take credit based on –
>
> MEMBER RAY: I don't think so.
>
> MEMBER SHACK: Well, that's the way it is.
>
> MEMBER RAY: That's not right."[14]

The July 8, 2009 ACRS discussion between ACRS members Ray and Shack regarding the probability of significant leakage from a PWR containment system occurred after failure of the containment liner at Beaver Valley.

- Ray emphasizes that deterministically the steel containment liner is the only leakage barrier that protects the public.
- Shack implies that the if the liner fails, radiation leaks would be delayed by the concrete containment behind it and therefore a probabilistic risk assessment credit should be given for that reduction in dose release.

My 2008 testimony to ACRS contradicts Shack's assessment and directs one to the original patent delineating the fact that concrete is porous. [See footnote 12]. In the case of the AP1000 design, there is no porous concrete secondary barrier suggested by Shack. Therefore, in regards to the AP1000 design, Ray's position is both deterministically and probabilistically correct.

These ACRS discussions, and further correspondence submitted to the ACRS by Citizen Power indicate that the ACRS has developed an increased awareness of the newly uncovered weaknesses in PWR containment designs. Moreover, a more detailed discussion, including my analysis of the containment issues at Millstone, is detailed within my expert report entitled _Declaration Of Arnold Gundersen Supporting Connecticut Coalition Against Millstone In Its Petition For Leave To Intervene, Request For Hearing, And Contentions,_ herewith filed as Attachment 4.

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[14] Transcript, page 40 [emphasis added].

Furthermore, the ACRS wrote a letter to NRC Executive Director for Operation R. W. Borchart on September 21, 2009 entitled *Request By The ACRS For A Future Briefing By NRR On Current Containment Liner Corrosion Issues And Actions Being Taken By The Staff To Address Them* in which the ACRS said:

> "During the 565th meeting of the Advisory Committee on Reactor Safeguards, September 10-12, 2009, the Committee indicated the need for a future briefing by NRR on the topic of containment liner corrosion. **In recent years liner corrosion issues have been identified on a few of the operating nuclear power reactors. The Committee would like to hear from NRR about current staff efforts to address these issues generically.** Please let us know about a proper date and time for this briefing to take place.[15]

3.1.7 Petrangeli Report. The ACRS is not the only organization expressing concern regarding the overall integrity of PWR containments. In his book Nuclear Safety, Dr. Gianni Petrangeli, a nuclear engineering professor at the University of Pisa in Italy, also reported his concern regarding the likelihood of *containment* breaches *and the probability of severe post-accident leakage from a PWR containment*. In his book, Dr. Petrangeli noted:

> "There is a tendency in the design phase to specify for the containments a figure for the maximum admissible leakage rate which is close to that which is technically obtainable in ideal conditions… In the course of plant operation however, even if at the start the leak rate was the specified one or lower, a certain deterioration in the containment leak rate takes place and then in the case of an accident, the leak rate would probably be higher than that measured in the last leakage test…. In depth studies ... were performed on the deterioration probability of the leak proofing in real containment systems. The picture that emerges is not very reassuring… The probability of overcoming the specification values in the case of an accident is 15 per cent for BWR's and 46 percent for PWRs"[16].

Using US NRC data gathered from 1965 through 1988 and NUREG-1273 on containment leakage from a variety of sources, Dr. Petrangeli presents the probability that a containment system will exceed its technical specification limits during an accident in Table 14-2 reproduced below.

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[15] Meeting Transcript, page 40 [Emphasis Added]

[16] Petrangeli, Gianni, Nuclear Safety, Butterworth-Heinemann, 2006, ISBN 10: 0-7506-6723-0, Page 141.

Table 14-2. Measured containment leaks (USNRC 1988)

Leak measured relative to the specifications	BWRs*	PWRs*
From 1 to 10 times	0.10	0.31
From 10 to 100 times	0.04	0.08
Higher than 100	0.01	0.07

* These columns represent the probability of exceeding the technical specification leakage rates.

In my review of the more comprehensive data from the 1999 Naus and Graves study, as well as significant liner failures between 2000 and 2010 after Naus and Graves collected their data, the leakage rates in Table 14-2 of Dr. Petrangeli's 2006 book may in fact underestimate the post-accident containment system leakage risk.

Dr. Petrangeli further expressed his concerns based on his review of this data as it pertains to the new containment designs including the AP1000 when he said:

> "It is surprising that this issue does not receive much attention in the field of safety studies… This issue has been dealt with here because, for plants now under construction and for future ones, the tendency is to restrict the important consequences of severe accidents to within a very small distance from the plant possibly to avoid the need to evacuate the population. From this perspective, the real leakage of the containment system becomes very important."[17]

Dr. Petrangeli then continues by suggesting as a solution the exact opposite approach to that taken in the AP1000 containment design. Rather than act as a chimney and draw unfiltered gases from the gap between the containment and shield building as the AP1000 does, Petrangeli suggests as a possible solution for severe accident dose mitigation would be "… systems with a double containment with filtering of the effluents from the annulus between the containments…" when a secondary containment can be constructed. I note that the AP1000 shield building is not designed to "contain" any gases, and that Westinghouse has stated, "There is no secondary containment provided for the fission product control following a design basis accident." (AP1000 DCD, Rev. 16, Section 6.5.3.2).

[17] *Id.,* page 142.

3.1.8 Conclusions Regarding Containment Degradation and Leakage. As discussed above, the recent history of nuclear reactor operation shows a disturbing, unanticipated and unanalyzed trend of containment corrosion and leakage. This trend is seen in both standard containments and in containment designs such as the sub-atmospheric design used at Millstone and six other plants, and the ice containment system that has a litany of serious safety related containment failures. And clearly, the newfound containment liner hole at Beaver Valley creates a dilemma for both the industry and regulators in that it shows the increased likelihood of gross leakage by a PWR containment system that would significantly compromise public health and safety.

In my professional opinion, this disturbing trend calls for a new analysis of the potential for containment corrosion and leakage in the existing fleet of operating reactors. As further discussed in Section 3.2 below, the need for such an analysis is all the more pronounced with respect to the AP1000 design, which appears to invite corrosion through the establishment of a moist environment.

3.2 The Unique AP1000 Design Introduces An Unanalyzed Vulnerability

3.2.1 General. In the event the AP1000 containment leaks radioactive material into the annular gap between it and the shield building, the AP1000 is specifically designed to immediately act as a chimney and draw those vapors directly into the environment without filtration. The design of the AP1000 containment also has a greater potential to leak than existing containments with an increased likelihood that the leakage will exceed dose exposure limits at the Low Population Zone.

3.2.2 AP1000 Integrity and Corrosive Attacks. Well before the discovery of pitting (2006) or the through wall leak (2009) at Beaver Valley, the NRC expressed concerns about the integrity of the AP1000 containment to resist a corrosive attack. In 2003 the NRC wrote:

> "The staff's review of the containment shell design identified a concern that the 4.44 cm (1.75 in.) thickness of the cylindrical shell just meets the minimum thickness requirement of 4.4336 cm (1.7455 in.) of the 1998 ASME Code, Section III, Subsection NE, Paragraph NE-3324.3(a), based on a 406.8 kPa (59 psi) design pressure, a 148.9 °C (300 °F) design temperature, allowable stress, S = 182 MPa (26.4 ksi), and a containment vessel radius, R = 1981.2 cm (780 in.). **The staff noted that there is no**

> **margin in the nominal design thickness for corrosion allowance.** Of particular concern is the embedment transition region of the cylinder, which has been prone to corrosion in operating plants. Paragraph NE-3121 specifically requires that the need for a corrosion allowance be evaluated. Consequently, the staff requested the applicant to provide justification for (1) making no provision, in defining the nominal design thickness, for general corrosion of the containment shell over its 60-year design life, and (2) not specifying a corrosion allowance in the embedment transition region. In its response to RAI 220.002 (Revision 1), the applicant submitted the following information to address the corrosion allowance for the AP1000 containment shell:
>
> > The ASME Code of record has been updated to the 2001 Edition including 2002 Addenda. (The applicant has revised the DCD to incorporate this change.) Per the revised Code of record, S = 184.09 MPa (26.7 ksi) and tmin = 4.38 cm (1.726 in.), which provides a nominal margin for corrosion of 0.06 cm (0.024 in.).
> >
> > The design has been changed to add a corrosion allowance for the embedment transition region, as was provided for the AP600. The nominal thickness of the bottom cylinder section is increased to 4.76225 cm (1.875 in.) and the vertical weld joints in the first course will be post-weld, heat-treated per ASME Code requirements. Design of Structures, Components, Equipment, and Systems
> >
> > Corrosion protection has been identified as a safety-related function for the containment vessel coating in DCD Tier 2, Section 6.1.2.1.1, "General (Protection Coatings)." The COL applicant will provide a program to monitor the coatings, as described in DCD Tier 2, Section 6.1.3.2, "Coating Program."
> >
> > On the basis that enough corrosion allowance and proper corrosion protection were provided, the staff found the applicant's response acceptable, pending (1) incorporation of the design change in the cylinder embedment transition region in a future revision, and (2) designation of the "inhibit corrosion" function as "safety" for coatings on the outside surface of the containment vessel in a future revision of DCD Tier 2, Table 6.1-2. This was Confirmatory Item 3.8.2.1-1 in the DSER." [18]

The use of the term *corrosion allowance* refers to situations during which the containment experiences general corrosion over a large area. This general corrosion is a structural problem because it is a broad attack upon the entire structure rather than a pinhole, and therefore the NRC staff concern regarding a general corrosion issue with the

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[18] Page 3-106 AP1000 SER

AP1000 does not address the potential for the through-wall pitting problem reviewed and analyzed in this report. The unique features of the AP1000 exacerbate the likelihood of through-wall pitting corrosion that would increase post accident leakage.

The NRC requirements for increasing the thickness of the AP1000 containment by only one-eighth of an inch and by adding field applied protective coatings do not provide adequate assurance to mitigate potential pitting. The proposed NRC remedies are inadequate in light of industry experience and the unique features of the AP1000 containment design. One needs only to review the 3/8"-thick hole at Beaver Valley which occurred on a field coated surface and other through-wall failures discussed above to conclude that the 1/8 inch corrosion allowance in the AP1000 design is simply not adequate to address pitting.

3.2.3 Vulnerability To Hole Propagation. As discussed in 3.1.3 above, Naus and Graves have already identified the difficulty of thoroughly inspecting inaccessible locations in any containment system. The data reviewed show that such inspections will be more problematic in the AP1000 where abundant air, moisture and corrosive chemicals may allow holes to continue to grow over extended periods of time thereby forming unlimited pockets of corrosion in crevasses at inaccessible locations. This action would likely be especially true in the vicinity of non heat-treated or poorly heat-treated welds of high strength steels. In comparison, the corrosion at Beaver Valley and other existing PWRs has not progressed quite as rapidly as what is projected to occur in the AP1000 because there was no constant replenishment of oxygen and moisture on the outside of the containment liner shell. However, in the event that a corrosion site begins on the outside of the AP1000 containment, unlimited amounts of oxygen, moisture and corrosive chemicals are available for the corrosion to propagate and eventually result in broad weakening of the shell by deep grooves.

The annular gap outside the AP1000 containment is continually subjected to air, is subject to moisture buildup from humidity and condensation in the air, and subject to corrosive chemicals creating the ideal incubator for crack propagation and the creation of holes. The AP1000 containment design effectively continuously "breathes" in air, moisture and contaminants into the annular gap between the shield building and the containment. "Breathing" in this case is what engineers would call natural convection. For example, at Turkey Point and other saltwater sites, that air would also contain salt and other minerals that give ocean air its familiar *ocean smell* and corrosivity of the salt water. On cooling tower sites, the AP1000 would "breath" in cooling tower drift (fine water droplets in the vapor cloud), containing chlorides and biocides and accumulated minerals in the cooling water. The net effect is that these chemicals are corrosive agents traveling immediately next to the outside of the steel containment.

Furthermore, the 800,000-gallon water tank[19] situated above the containment may leak over extended periods of time thereby providing additional moisture to aid in the propagation of holes.

In addition to the possibility of holes or pitting in the wall of the AP1000 containment due to the factors previously discussed, there is also an additional failure mode due to corrosion that must be addressed. Since concrete cannot bond to steel, a gap or pocket will be formed at the interface between the containment wall and the concrete containment floor. History has proven that over time moisture and contamination will enter this gap and cause corrosion to begin. Once again, as Naus and Graves suggest, it is at just such an inaccessible location that pitting can grow to cause either complete failure of the containment system or deterioration of the containment wall thickness to below the Code Allowable.

A second method of containment integrity failure would also be possible at the junction between the concrete floor and steel wall. In this inaccessible location, it is most likely that corrosion would first form as numerous pits ultimately coalescing into a grove that would present a mechanism of loss of structural integrity called *buckling*. If devolved pitting were to occur at the junction between the concrete floor and steel wall, then the low margin of safety for the overall thickness of the AP1000 containment actually becomes a serious structural issue and not just a hole that causes increased leakage.

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[19] The original Gundersen Fairewinds Associates, Inc Report issued March 26, 2010 contained a decimal point error that erroneously stated that the water tank was an 8,000,000-gallon (8-million-gallon) water tank, rather than the correct amount of 800,000 gallons with a weight of 3,300 tons. This typographical error has been corrected in the body of the report and this change has no effect upon the analysis or conclusions contained herein.

The net effect of all these parameters upon the AP1000 design is that through-wall holes or flaws below minimum allowable wall thickness are at least as vulnerable to develop in the new AP 1000 design as compared to the existing PWR containments in which the industry has already witnessed failures.

3.2.4 Inspection Of The AP1000 Containment. Current visual inspections of the containment from easily accessible areas within existing containments have a history of failing to identify any corrosion until the containment barrier itself has been penetrated. Visual inspection on the inside of all containments therefore relies upon a hole fully penetrating the containment in order to be detected.

My experience as a Senior Vice President of an ASME Section XI non-destructive testing division and my review of the AP1000 containment design has led me to conclude that the AP1000 design presents similar obstacles to visual and ultrasonic inspection techniques, and also introduces more locations that are inaccessible to inspection and prone to corrosive attack. Moisture buildup and corrosive agent attack in small crevasses between the containment and the shield building will most likely increase the likelihood of hole-propagation at exactly the locations that are most difficult or impossible to inspect.

3.2.5 Field Welding and Coatings on the AP1000. The AP1000 containment is not a single piece of steel but rather many sheets welded together in the field. These numerous field-welded connections to the containment provide ideal locations both for pitting and crevice corrosion to develop and horizontal surfaces for moisture to collect. In addition, an Idaho National Laboratories Report entitled *Study Of Cost Effective Large Advanced Pressurized Water Reactors That Employ Passive Safety Features* states that, "The containment vessel supports most of the containment air baffle. …Flow distribution weirs are welded to the dome as part of the water distribution system…"[20]

In addition to field-welds, coatings will also be applied to the containment in the field. According to the Idaho National Labs report, "The containment vessel is coated with an

[20] Pages 2-11 and 2-12 of an Idaho National Laboratories Report entitled Study Of Cost Effective Large Advanced Pressurized Water Reactors That Employ Passive Safety Features (DOE/SF/22170) dated November 12, 2003

inorganic zinc coating".[21] While coatings can provide some protection when properly applied, there is no assurance that field application can be completely successful and will last for the 40 to 60 years of projected operating life. In fact, field quality assurance problems during the construction of existing containments have been determined to be the root cause of many of the containment degradation issues identified earlier in this report. Moreover, there are oil and gas facilities where components have completely corroded even though they were protected by galvanic coatings. A galvanic coating protects only as long as the zinc is present as a metal. For protection, the zinc corrodes and thereby prevents the underlying iron from corroding. However, when the zinc is gone the iron corrodes.

Given that moisture and corrosive chemicals will be drawn into the gap between the shield building and the containment and that various welded connections will provide locations for pit and crevasse corrosion to initiate, it is possible that intergranular corrosion in weldments could propagate at a rate of 0.15inches per year of faster, and in locations that are under stress, cracks could form. In my opinion a small crack could create a hole that would remain undetected and completely penetrate the AP1000 containment in a through-wall leak within approximately ten years or less.

3.2.6 AP1000 Chimney Effect. The AP1000's containment design is uniquely designed to act like a chimney and draw air and moisture out of the annular gap between the containment and the shield building. In the event a containment hole develops, the pressure inside the containment will push any radioactivity into the annular gap and then that radioactivity will immediately be drawn out into the air above the reactor by this chimney effect.

3.2.7 Increased Radiation Exposure From A Leak Into Annular Gap. Based upon my experience in Integrated Leak Rate Testing, the industry expectation is that a ¼ inch hole in the containment will produce leakage in excess of 100 Standard Cubic Feet per Hour (SCFH) resulting in an off-site exposure of approximately 25-rem at the Low Population Zone (LPZ). The hole at Beaver Valley was significantly larger than the aforementioned industry standard and would have resulted in approximately ten times

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[21] *Id.,* page 2-12.

that exposure, as leakage increases with the square of the hole diameter. However, as noted earlier in the conversation between ACRS members Ray and Shack, the existing steel liner at Beaver Valley was also backed up by a concrete containment. No such redundancy is incorporated in the AP1000 design. A hole the size of Beaver Valley's would clearly exceed the NRC's Low Population Zone (LPZ) dose limits. Admittedly the AP1000 containment is thicker than Beaver Valley's, but hole propagation is not self-limiting in the AP1000 design as previously described.

3.2.8 Implications To The AP1000 Design. The ACRS concern regarding containment integrity following the discovery of the Beaver Valley hole, Dr. Petrangeli's concern with respect to new containment design leakage rates, and the detailed history of at least 77-containment system failures nationwide, demand a wholly new analysis to determine exactly how the newly proposed AP1000 design accommodates leakage through the wall of its unique hybrid containment system.

Containment system leakage from through-wall holes in steel has already occurred at North Anna, Beaver Valley, Hatch 1, Hatch 2, Cook and Brunswick. However, in each of these circumstances ACRS member Shack articulated the fact that there was another potential barrier by which to collect and filter the airborne radiation that leaked from the containment system. Previous freestanding steel containments with holes were enclosed within a reactor building into which the leakage entered and was controlled. The liner failures appeared to be backed up by a concrete containment building.

In the event of an accident at a proposed AP1000 reactor, leakage through the freestanding steel containment will pass directly into the gap between the steel and the shield building. Therefore, the proposed AP1000 containment design is inherently less safe than current reactors presently licensed and operating.

The following four pages contain accident sequence illustrations.

- Figure 1 – AP1000 in normal operation.
- Figure 2 – AP1000 design basis accident begins.
- Figure 3 – AP1000 containment hole opens as containment fills with radioactive gases.
- Figure 4 – AP1000 chimney effect draws radioactivity directly into the environment.

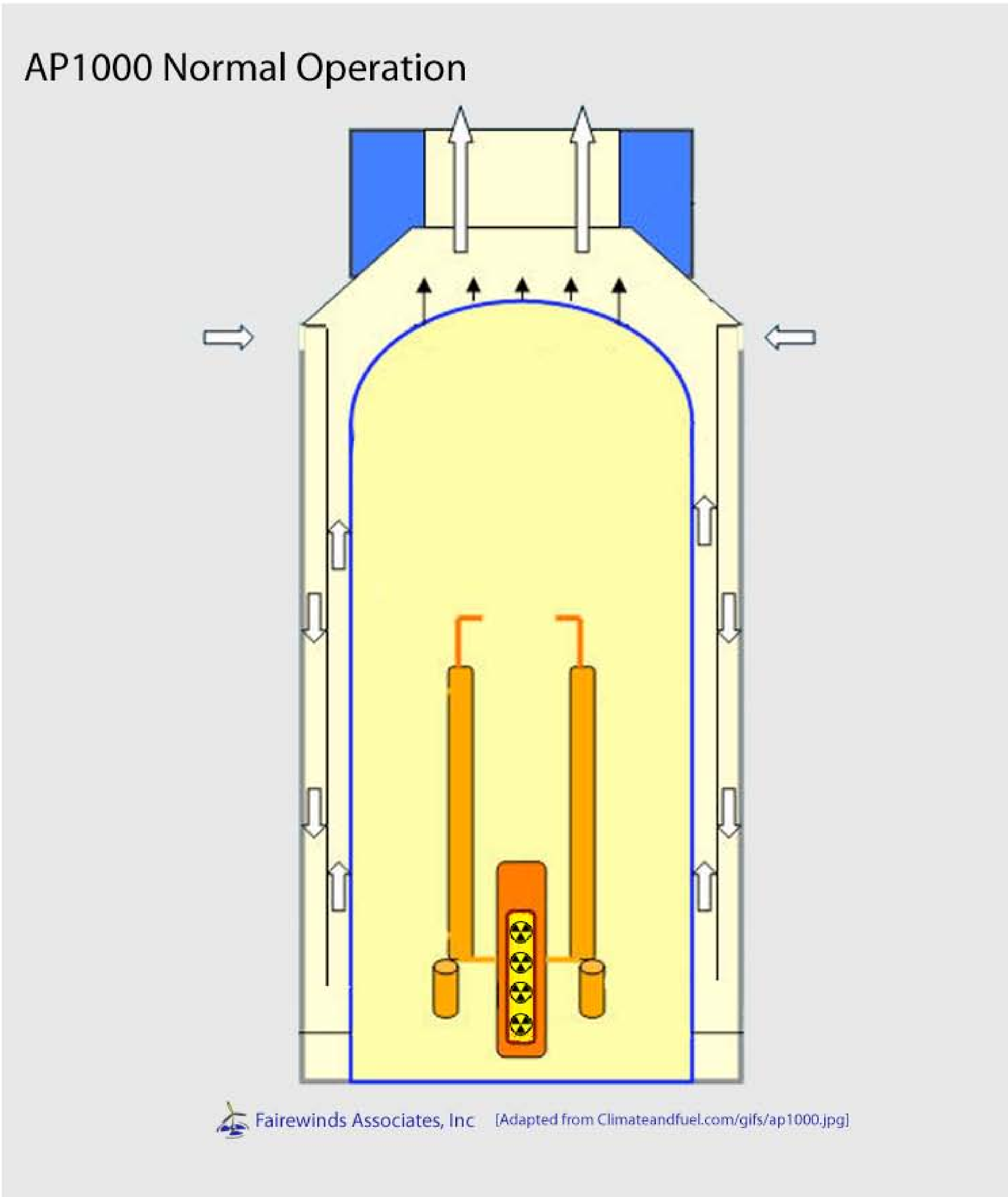
AP1000 Normal Operation
Fairewinds Associates, Inc
[Adapted from Climateandfuel.com/gifs/ap1000.jpg]

Figure 1

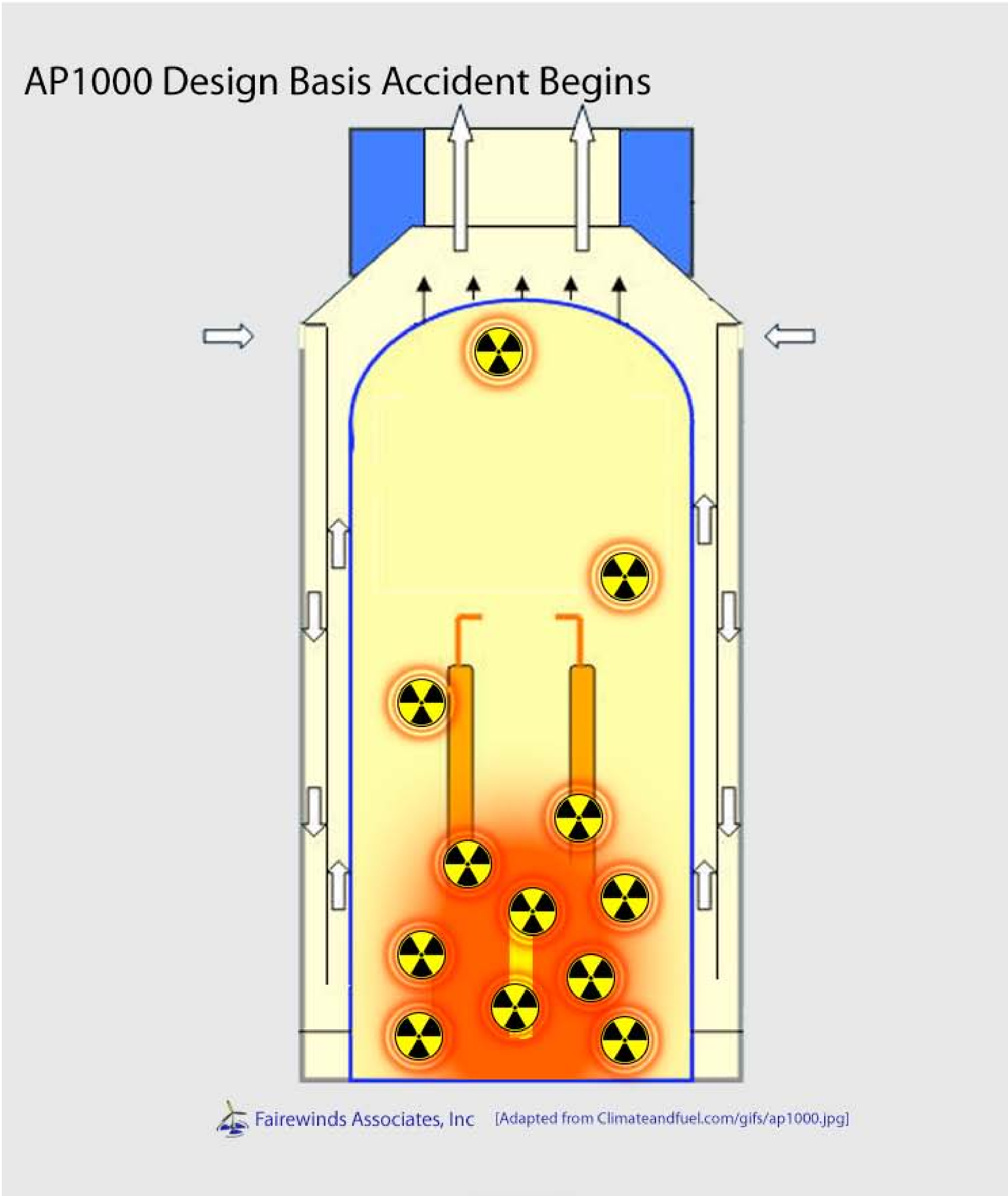
AP1000 Design Basis Accident Begins
Fairewinds Associates, Inc
[Adapted from Climateandfuel.com/gifs/ap1000.jpg]

Figure 2

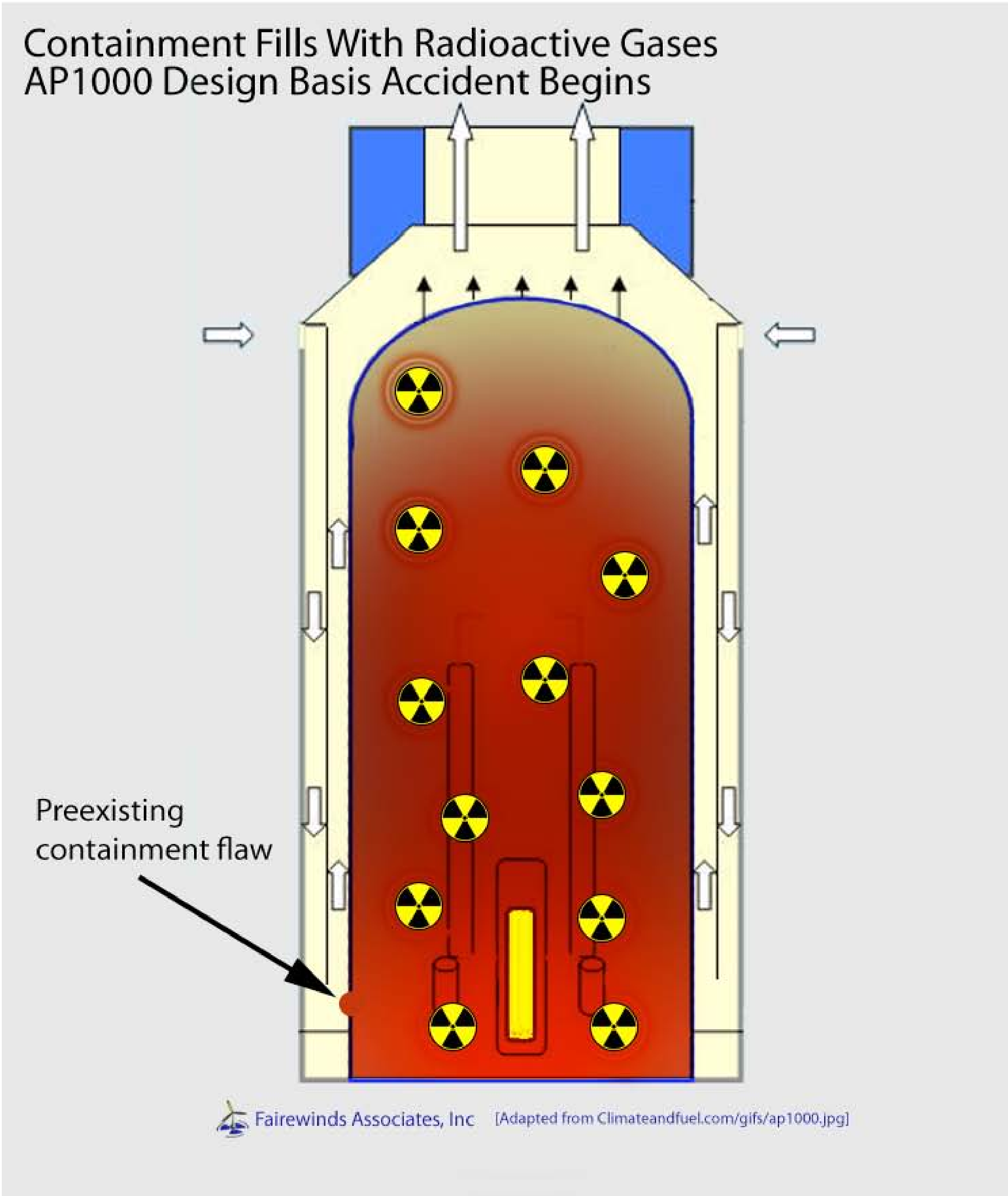
Containment Fills With Radioactive Gases
AP1000 Design Basis Accident Begins
Preexisting
containment flaw
Fairewinds Associates, Inc
[Adapted from Climateandfuel.com/gifs/ap1000.jpg]

Figure 3

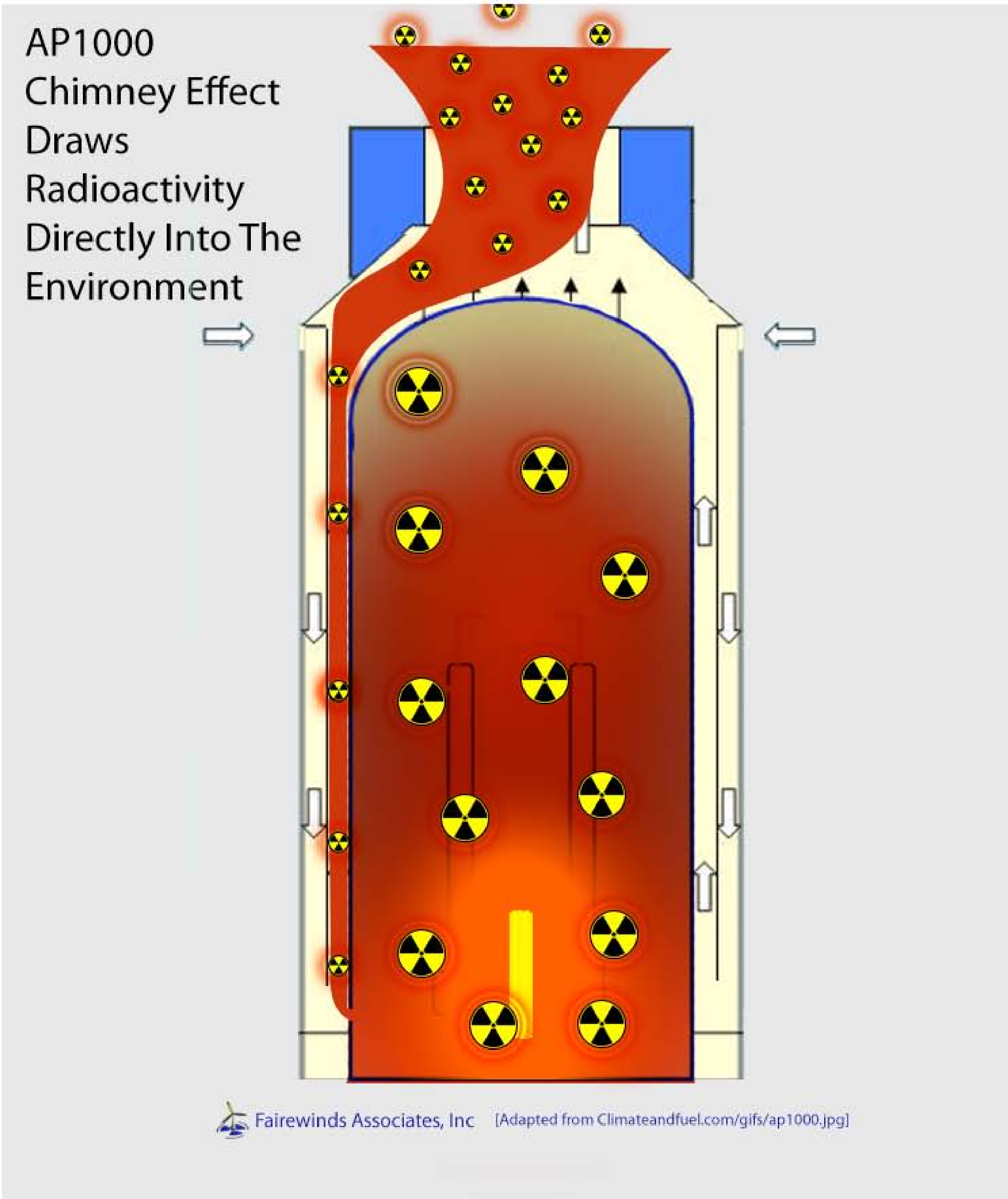
AP1000
Chimney Effect
Draws
Radioactivity
Directly Into The
Environment
Fairewinds Associates, Inc
[Adapted from Climateandfuel.com/gifs/ap1000.jpg]

Figure 4

Concernedly, the hybrid AP1000 containment system appears to lack any of the redundancy or defense in depth[22] in containment system design that was present in earlier designs reviewed in this report and upon which *design bases events* are predicated.

The hole in the Beaver Valley containment confirms Dr. Petrangeli's analysis about the increased likelihood of severe containment leakage. In his analysis, Dr. Petrangeli shows that there is at least a 10-percent likelihood and potentially a 31-percent likelihood of leakage from the AP1000 containment system being 10-times higher than that specified in the AP1000 Design Basis and Technical Specifications. This significant variation in potential leakage corresponds roughly to the size of the hole in the Beaver Valley Containment. See Table 14-2 on Page 12 for comparative chart.

Incongruously, the purpose of *the gap between the steel and the shield building* in the design has ***NOT*** been created to collect and treat radiation as Dr. Petrangeli suggests would be appropriate, but rather to allow air and moisture to cool the containment itself and then to act as a chimney allowing those gases to be siphoned directly out into the environment.

Consequently, the design of the proposed AP1000 containment and its shield building might actually cause the occurrence of a larger leakage rate and a higher probability of a through-wall leakage than the currently existing containment system failures discussed above due to the active role of the AP1000 shield building in acting as a chimney which draws radioactively contaminated air into the environment.

Specifically, the outside of the containment is designed to be wetted and for that reason it has millions of gallons of water suspended above it in order to provide moisture following an accident. More specifically, containment holes and leaks in existing

[22] **Defense in depth** is an approach to nuclear power plant safety that builds-in layers of defense against release of radioactive materials so that no one layer by itself, no matter how good, is completely relied upon. To compensate for potential human and mechanical failures, *defense in depth* is based upon several layers of protection with successive barriers to prevent the release of radioactivity to the environment. This approach includes protection of the barriers to avert damage to the plant and to the barriers themselves. It includes further measures to protect the public, workers, and the environment from harm in case these barriers are not fully effective. *Defense in depth* is a hallmark of nuclear regulation and risk assessment to meet the statutory requirements inherent in the NRC responsibility to protect public health and safety.

containment systems were previously self-limiting because they ran out of moisture and oxygen. Moisture, oxygen and corrosive chemicals would be plentiful in the annular gap surrounding the containment and would promote the propagation of holes in normal AP1000 operational scenarios.

Existing data shows that containment system failures occur with moisture and oxygen. Therefore, it is clear that for the AP1000 design, leakage from the water tank, water from testing the tank, and/or atmospheric moisture due to the condensation on the water tank will create a constant environment of moisture and oxygen that may in fact provoke a through-wall containment failure in locations that are difficult and/or impossible to inspect.

Consequently, by looking at the historical record of containment system failures detailed in NRC records and in this report, and given the lack of a bond between the concrete floor and steel containment wall, and the inspection difficulty within crevasses in the annular gap between the AP1000 containment and the shield building, it is very likely that corrosion will develop that will limit the containment's effectiveness in the event of an accident.

4. Severe Accident Scenario or Design Basis Event?

4.2.1 General. Published reports indicate that the NRC already considers a breach of existing containments to be a plausible accident scenario. Emergency planning exercises at Oyster Creek and Callaway have already been based upon containment failure. My concern is that the potential for a breach of the AP1000 containment as discussed in this report is not a remote probability event, and may in fact occur prior to a design basis accident, and may remain undetected until the accident occurs.

4.2.2 AP1000 PRA. According to Chapter 35 of the Westinghouse AP1000 Probabilistic Risk Assessment on file with the NRC, Westinghouse has not assessed the possibility of radioactive gasses moving through the annular gap between the steel containment and the shield building and then directly out into the environment.

In Chapter 35 of the Westinghouse AP1000 probabilistic risk assessment, which is entitled *CONTAINMENT EVENT TREE ANALYSIS*, ***none*** of the seven AP1000 accident scenarios assumed containment leaks into the an annular gap of the shield building that would then move radiation out into the environment without filtration.

Moreover, in Table 35-4 entitled *SUMMARY OF RELEASE CATEGORY DEFINITIONS* on page 35-24 of the report (reproduced as Attachment 5), only seven possible "*Release Categories*" have been defined and identified by Westinghouse as possible candidates for releasing gases into the environment following an accident. None of these release categories identified by Westinghouse include steel containment failure directly into the annular gap created by the shield building.

4.2.3 Severe Accident Mitigation Design Alternatives (SAMDA). As part of the AP1000's *Severe Accident Mitigation Design Alternatives (SAMDA)* analysis, Westinghouse claims to have considered and rejected the need for "Secondary Containment Filtered Ventilation". In its Revision 9 of the AP1000 Design Control Document, Page 1B-6 Westinghouse said:

> **"Secondary Containment Filtered Ventilation**
> This SAMDA consists of providing the middle and lower annulus… of the secondary concrete containment with a passive annulus filter system for filtration of elevated releases. The passive filter system is operated by drawing a partial vacuum on the middle annulus through charcoal and HEPA filters. The partial vacuum is drawn by an eductor with motive flow from compressed gas tanks. The secondary containment would then reduce particulate fission product release from any failed containment penetrations (containment isolation failure). In order to evaluate the benefit from such a system, this design change is assumed to eliminate the CI release category."

I have no understanding of why, in the above quotation, Westinghouse uses the term "*secondary concrete containment*" to refer to the AP1000 Shield Building. The Shield Building is proposed to be of modular construction and will not serve the purpose of containing radiation. It is not designed to contain anything, but rather is designed to disperse air and moisture used to cool the containment. *Westinghouse's use of the term "secondary concrete containment" is a misnomer.*

The starting point (base case) for all the AP1000 containment scenarios is the "Intact Containment". The intact containment is explained as "Release Category IC" on Page 1B-10:

> "**Release Category IC – Intact Containment**
> If the containment integrity is maintained throughout the accident, then the release of radiation from the containment is due to nominal leakage and is expected to be within the design basis of the containment. This is the "no failure" containment failure mode and is termed intact containment. The main location for fission-product leakage from the containment is penetration leakage into the auxiliary building where significant deposition of aerosol fission products may occur."

In addition to this base case scenario, the SAMDA analysis then postulates several extremely low probability events on Pages 1B-10 and 1B-11:

> "**Release Category CFE – Early Containment Failure**
> Early containment failure is defined as failure that occurs in the time frame between the onset of core damage and the end of core relocation. During the core melt and relocation process, several dynamic phenomena can be postulated to result in rapid pressurization of the containment to the point of failure. The combustion of hydrogen generated in-vessel, steam explosions, and reactor vessel failure from high pressure are major phenomena postulated to have the potential to fail the containment. If the containment fails during or soon after the time when the fuel is overheating and starting to melt, the potential for attenuation of the fission-product release diminishes because of short fission-product residence time in the containment. The fission products released to the containment prior to the containment failure are discharged at high pressure to the environment as the containment blows down. Subsequent release of fission products can then pass directly to the environment. Containment failures postulated within the time of core relocation are binned into release category CFE."

> "**Release Category CFI – Intermediate Containment Failure**
> Intermediate containment failure is defined as failure that occurs in the time frame between the end of core relocation and 24 hours after core damage. After the end of the in-vessel fission- product release, the airborne aerosol fission products in the containment have several hours for deposition to attenuate the source term. The global combustion of hydrogen generated in-vessel from a random ignition prior to 24 hours can be postulated to fail the containment. The fission products in the containment atmosphere are discharged at high pressure to the environment as the containment blows down. Containment failures postulated within 24 hours of the onset of core damage are binned into release category CFI."

“**Release Category CFL – Late Containment Failure**
Late containment failure is defined as containment failure postulated to occur later than 24 hours after the onset of core damage. Since the probabilistic risk assessment assumes the dynamic phenomena, such as hydrogen combustion, to occur before 24 hours, this failure mode occurs only from the loss of containment heat removal via failure of the passive containment cooling system. The fission products that are airborne at the time of containment failure will be discharged at high pressure to the environment, as the containment blows down. Subsequent release of fission products can then pass directly to the environment. Accident sequences with failure of containment heat removal are binned in release category CFL.”

“**Release Category CI – Containment Isolation Failure**
A containment isolation failure occurs because of the postulated failure of the system or valves that close the penetrations between the containment and the environment. Containment isolation failure occurs before the onset of core damage. For such a failure, fission-product releases from the reactor coolant system can leak directly from the containment to the environment with diminished potential for attenuation. Most isolation failures occur at a penetration that connects the containment with the auxiliary building. The auxiliary building may provide additional attenuation of aerosol fission-product releases. However, this decontamination is not credited in the containment isolation failure cases. Accident sequences in which the containment does not isolate prior to core damage are binned into release category CI.”

“**Release Category BP – Containment Bypass**
Accident sequences in which fission products are released directly from the reactor coolant system to the environment via the secondary system or other interfacing system bypass the containment. The containment failure occurs before the onset of core damage and is a result of the initiating event or adverse conditions occurring at core uncovery. The fission-product release to the environment begins approximately at the onset of fuel damage, and there is no attenuation of the magnitude of the source term from natural deposition processes beyond that which occurs in the reactor coolant system, in the secondary system, or in the interfacing system. Accident sequences that bypass the containment are binned into release category BP.”

4.2.4 Analysis of SAMDA Assumptions. A brief examination of the SAMDA assumptions Westinghouse applied to the AP1000 containment beyond its design basis (*Intact Containment*) scenario shows many non-conservative assumptions.

- For Release Category CLF (Late Containment Failure), Westinghouse assumes that the postulated containment failure occurs only 24-hours after the accident has begun and that the failure is due to the inability of the containment to remove decay heat. Westinghouse has simply made an arbitrary choice of the 24-hour number and the causative action.

- For Release Category CI (Containment Isolation), Westinghouse first assumes that the containment fails to properly isolate. Secondly, Westinghouse assumes that the isolation failure occurs at a containment penetration from which any additional leakage then enters the auxiliary building. Leakage into another building then provides additional filtration and delay. Westinghouse **does *not* assume** that the failure might occur at a location in the containment that directly exhausts into the annular ring between the containment and the shield building. Any leakage into this annular gap would then leak directly into the environment, which has not been factored into either the Westinghouse assessment or the NRC review of the Westinghouse data.

- For Release Category BP (Containment Bypass) Westinghouse has assumed that the containment is bypassed through an open piping system. Once again, Westinghouse fails to consider or factor in to its analysis that the containment failure might occur at a location in the containment that directly exhausts into the annular ring between the containment and the shield building. Any leakage into this annular gap would then leak directly into the environment. As delineated before, the Westinghouse assessment has not considered all the pertinent data.

Westinghouse has ignored the long history of previous containment and containment liner failures that indicate there is an unacceptably high risk that the AP1000 containment might be in a failed condition at the onset of an accident. Inspection results of existing PWR containments have shown numerous occasions when containment liners have completely failed or experienced holes below minimum allowable wall thickness. Therefore, there is a significant probability that leakage from the AP1000 containment would begin immediately and most likely **will *not* occur** at the site of containment penetration. This potential AP1000 leakage is not related to an extraordinary SAMDA event, but may be anticipated to exist at the beginning of the accident due to uninspected corrosion of the containment as discussed in this report. The leakage problem in the AP1000 design is exacerbated because it is the only containment design that has an annular gap specifically created to act as a chimney and draw air directly into the environment.

4.2.5 SAMDA Summation. In every case Westinghouse chose to analyze, it ignored the likelihood that radioactive leakage would move directly into the annular gap between the containment and the shield building.

Moreover, in the design *features* of the Westinghouse AP1000 reactor, this leakage would *be deliberately* wafted out into the environment. Furthermore, there are several significant and extraordinary assumptions within the Westinghouse analysis that has the net effect of minimizing the AP1000's unique design weakness.

These non-conservative SAMDA assumptions include:

- The likelihood of containment failure is minimized.
- The timing of the failure is delayed, hence reducing radionuclide concentrations.
- The location of the failure is chosen to avoid the annular gap.
- The likelihood of significant leakage is minimized.
- And, the dose consequences are therefore also minimized.

With these five erroneous assumptions, Westinghouse has failed in its efforts to *prove* that there is no need to modify the AP1000 Containment and Shield building in order to eliminate the possibility of releases directly into the environment and to protect public health and safety. In fact, containment failure through only a small hole similar to that at Beaver Valley should not be a SAMDA event, but is likely to exist when the design basis event occurs.

5. Conclusion

Given the newly discovered Beaver Valley containment system failure and a litany of other containment failures identified throughout this report, the facts show that it is unreasonable to assume that the AP1000 containment design for the proposed AP1000 reactors will not leak radiation directly into the annular gap created by the shield building.

In conclusion, the potential for containment leakage directly through holes in the steel shell creates an unanalyzed safety risk to the public from the proposed AP1000 containment design. Releases from this potential leakage path are not bounded by any existing analysis and will be more severe than those previously identified by Westinghouse in its AP1000 applications and various revisions.

Four contributing factors will increase the consequences of an accident in which the containment leaks radiation directly into the annular gap.

- First, more radiation is likely to be released than previously analyzed.
- Second, radiation will be released sooner than in other scenarios because the hole or leakage path exists prior to the accident.
- Third, radioactive gases entering this gap are not filtered or delayed.
- Fourth, moisture and oxygen, routinely occurring between the containment and the shield building in the AP1000 design, exacerbates the likelihood of larger than design basis containment leaks.

Filtration of the air leaving the annular gap between the containment and the shield building was previously rejected by Westinghouse's SAMDA analysis. However, in my opinion, this issue should be reconsidered because it is a design basis event and not a low probability SAMDA occurrence. Finally, because the NRC and Westinghouse have not analyzed the containment system for the design of the proposed AP1000 reactors in light of these flaws, the public is presented with an *unreviewed safety issue* that creates a potential accident with much more severe consequences than previously analyzed.

Attachments:

Attachment 1 – Curriculum Vitae

Attachment 2 – Table 1 from *Detection of Aging Nuclear Power Plant Structures*

Attachment 3 – Table 35-4 *Summary Of Release Category Definitions*

Attachment 4 – *Declaration Of Arnold Gundersen Supporting Citizen Power's Petition*

Attachment 5* – *Declaration Of Arnold Gundersen Supporting Connecticut Coalition Against Millstone In Its Petition For Leave To Intervene, Request For Hearing, And Contentions* – *This attachment is a separate document due to email and PDF size constraints. All reports are posted on www.fairewinds.com/reports.

Note: See footnote 19 for typographical change notation also pasted below.

> The original Gundersen Fairewinds Associates, Inc Report issued March 26, 2010 contained a decimal point error that erroneously stated that the water tank was an 8,000,000-gallon (8-million-gallon) water tank, rather than the correct amount of 800,000 gallons with a weight of 3,300 tons. This typographical error has been corrected in the body of the report and this change has no effect upon the analysis or conclusions contained herein.

CORRO-CONSULTA
Rudolf H. Hausler, PhD

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Kaufman, TX 75142
e-mail: rudyhau@msn.com

Tel. 972 962 8287
Mobile 972 824 5871
Fax. 972 962 3947

Affidavit

Re.

Post Accident AP1000 Containment Leakage: An Un-reviewed Safety Issue

By
Arnold Gundersen, March 26, 2010

I, Rudolf H. Hausler, Corrosion Engineer, NACE Corrosion Specialist, recipient of the NACE Technical Achievement Award, and NACE Fellowship, dipl. Chemical Engineer and PhD in Technical Sciences, hereby assert that I have read subject report in detail.

I agree with the assessment that the construction of the containment building of the AP1000 leaves the reactor containment (carbon steel shell) subject to various modes of corrosion attack. Even though both the inside and the outside of the containment may be coated for corrosion protection (it is not clear that they are because heavy protective paint coat layers will reduce the necessary heat transfer rate) there are always pinholes in any paint layer where corrosion processes may be initiated. Inaccessible areas will be most vulnerable to defects and hence corrosion.

In recent years coatings for applications in nuclear energy plants have been given much attention. However, with all the testing in salt spray cabinets supplemented by irradiation, there are no manufacturers who will give assurances beyond the life expectancies based on intuitive extrapolations.

It turns out that the paint manufactures develop paints and perform test procedures according to industry standards but leave the final selection of a paint schedule to the operating engineer at the respective generating plants. Clearly in this case the blind are leading the seeing.

Because of the impossibility of ruling out defects in the protective coating, the uncertainty of the fitness for purpose of coatings beyond the customarily guaranteed 10 years, the further uncertainty of the performance of the natural convection cooling scheme of the AP-1000, it would appear extremely risky to deny and rule out need for secondary containment.

I therefore agree with Arnold Gundersen's assessment in its entirety.

Signed

Rudolf H. Hausler

March 29, 2010

Docket Nos. 52-025-COL and 52-026-COL
BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE
EXHIBIT 4

Post Accident AP1000 Containment Leakage

Arnold Gundersen, Chief Engineer
Fairewinds Associates, Inc
June 25, 2010
Presentation to ACRS

Post Accident AP1000 Containment Leakage

AP1000 Oversight Group
John Runkle
Fairewinds Associates, Inc
Arnie Gundersen

Peer reviewed by Dr. Rudolf Hausler

On March 9, 1982, former NRC Commissioner Peter A. Bradford said,

"If a Secretary of Agriculture endorsed better meat inspection, you wouldn't have a debate of near religious fervor about whether that a person was pro- or anti-meat, whether he had sold out to the vegetarians. You'd debate whether the stricter regulations made sense. It's somehow unique to nuclear power that, when one refuses to have nuclear power on the industry's terms, one gets chucked into a bin labeled 'anti-nuclear'."

Arnie Gundersen

- MP1 MSIV
- Montague LRT briefed NRC
- MP3 Containment structural analysis
- VY NPSH
- Millstone 3 ACRS letter
- Beaver Valley ACRS letter
- AP1000 ACRS Letter
- Sr. V.P. of ASME XI inspection business


D
Millstone 3

Industry Experience through 2008

Detection of Aging Nuclear Power Plant Structures

Naus& Graves 1970-1999

“…at least 66 separate occurrences of degradation in operating containments…”

“…over 32 reported occurrences of corrosion of steel containments or liners…”

“Two instances … where corrosion has completely penetrated the liner.”

“… four additional cases where extensive corrosion of the liner reduced the thickness … by nearly one-half.”

Industry Experience through 2008

USNRC Information Notice 2004-09

- Eight additional episodes of containment system degradation.
- Through-wall hole in the liner of D.C. Cook, 2001
- Three through-wall holes in the liner of Brunswick, 1999
- Sixty pits (below minimum design value) D.C. Cook, 1998
- Hatch 1 & 2 – Two through-wall cracks in steel containment.

Industry Experience through 2008

Nuclear Safety **© 2007**

Dr. Gianni Petrangeli, University of Pisa

"The picture that emerges is not very reassuring…the probability of overcoming the specification values…is…46% for PWR's"

"…for plants now under construction and for future ones, the tendency is to restrict the important consequences of severe accidents…"

Petrangeli recommends "…systems with a double containment with filtering of effluents from the annulus between the containments."

Industry Experience through 2008

OIG -07-A-15

Page 21-23

"OIG's analysis of this corrective action program indicates that the coatings aging management program had not been implemented consistent with the statements in the Oconee license renewal application."

"…the staff did not offer any indication of having conducted an independent look at coatings operating experience."

This condition existed for 10-years.

Example of Coatings Degradation at Oconee

Photo from: OIG-07-A-15


INCHES 1
2
MADE IN 3
U.S.A.
Beaver Valley 1

Industry Experience 2009 - 2010

Beaver Valley Liner Failure, April 2009

Leading up to this failure Beaver Valley told the NRC the following:

LRA 3.5-47 "Loss of material due to corrosion is not significant for inaccessible areas…"

LRA B2.8 & B2.9 "Identification of deficiencies and subsequent corrective actions, along with engineering evaluation of inspection results, provide reasonable assurance that the program will be effective for managing loss of material."

LRA B2.9 "Conclusion: Continued implementation of the ASME Section XI… provides reasonable assurance that…structures…will continue to perform their intended functions."

Industry Experience 2009 - 2010

Beaver Valley Liner Failure, April 2009

Leading up to this failure the NRC said the following about Beaver Valley:

SER, January 2009

"The applicant's assurance of the use of…ASME Section XI…ensures that the applicant's IWE program will be consistent with GALL…the staff finds the applicant's exceptions acceptable." pg. 3-102 to 107

"The applicant further stated that these additional examination requirements…provide reasonable assurance that potential corrosion on the concrete side of the containment liner plate will be identified and addressed." pg.3-102 to 107

"The staff finds the applicants inspections…in accordance with ASME Section XI…to manage the loss of material due to general pitting and crevice corrosion are adequate because the aging effect has been effectively monitored. " pg.3-589

Industry Experience 2009 - 2010

MP3 Secondary Containment Inoperable for 16 Days

Power Reactor	Event Number: 45969
Facility: MILLSTONE Region: 1 State: CT Unit: [ ] [ ] [3] RX Type: [1] GE-3,[2] CE,[3] W-4-LP NRC Notified By: NORMAN KUZEL HQ OPS Officer: VINCE KLCO	Notification Date: 06/01/2010 Notification Time: 16:57 [ET] Event Date: 06/01/2010 Event Time: 15:50 [EDT] Last Update Date: 06/01/2010
Emergency Class: NON EMERGENCY 10 CFR Section: 50.72(b)(3)(v)(C) - POT UNCNTRL RAD REL	Person (Organization): GLENN DENTEL (R1DO)

POTENTIAL LOSS OF RADIATION RELEASE CONTROLS

"On May 27, 2010, during a control board walkdown, it was discovered that two sets of auxiliary building tunnel exhaust dampers were open at the same time. This configuration created a path way from the secondary containment to the outside. The condition was immediately corrected. Additional investigation determined that this condition existed since May 11, 2010, when Millstone 3 was in Mode 5.

"Technical Specification 3.6.6.2 'Secondary Containment' is applicable in Modes 1, 2, 3, and 4. The condition discovered on May 27, 2010, rendered Secondary Containment inoperable. Further evaluation since the discovery date concludes that the secondary containment structure was in a condition which could prevent the fulfillment of the safety function for controlling the release of radioactive material. [On June 1, at 1550 EDT the licensee determined that the event was potentially reportable].

Industry Experience 2009 - 2010

ACRS Transcript July 9th, 2009 p.88, lines 6-11

Emphasis added

"MEMBER RAY: At which point the condition of the concrete can't be taken credit for. So I guess I just think that ***the idea that the leakage is going to be small from a small hole, from a hole this size, as small as Dan says, in the design-basis conditions isn't logically supportable because the concrete, you can't -- you, yourself said, you can't take credit for the concrete and the reason is because it's condition in the design-basis event can't be predicted, can't be credited. The only thing you can credit is the membrane itself.***

MEMBER SHACK: From a deterministic basis, you're correct. From a probabilistic basis, which is what they use and can take credit based on –

MEMBER RAY: I don't think so.

MEMBER SHACK: Well, that's the way it is.

MEMBER RAY: That's not right."

Probability of primary/secondary containment breach

For the period between 6/09 to 7/10 there has been a primary containment breach at Beaver Valley and a secondary containment breach at Millstone 3. Fairewinds calculates the approximate probability of a complete containment breach as follows:

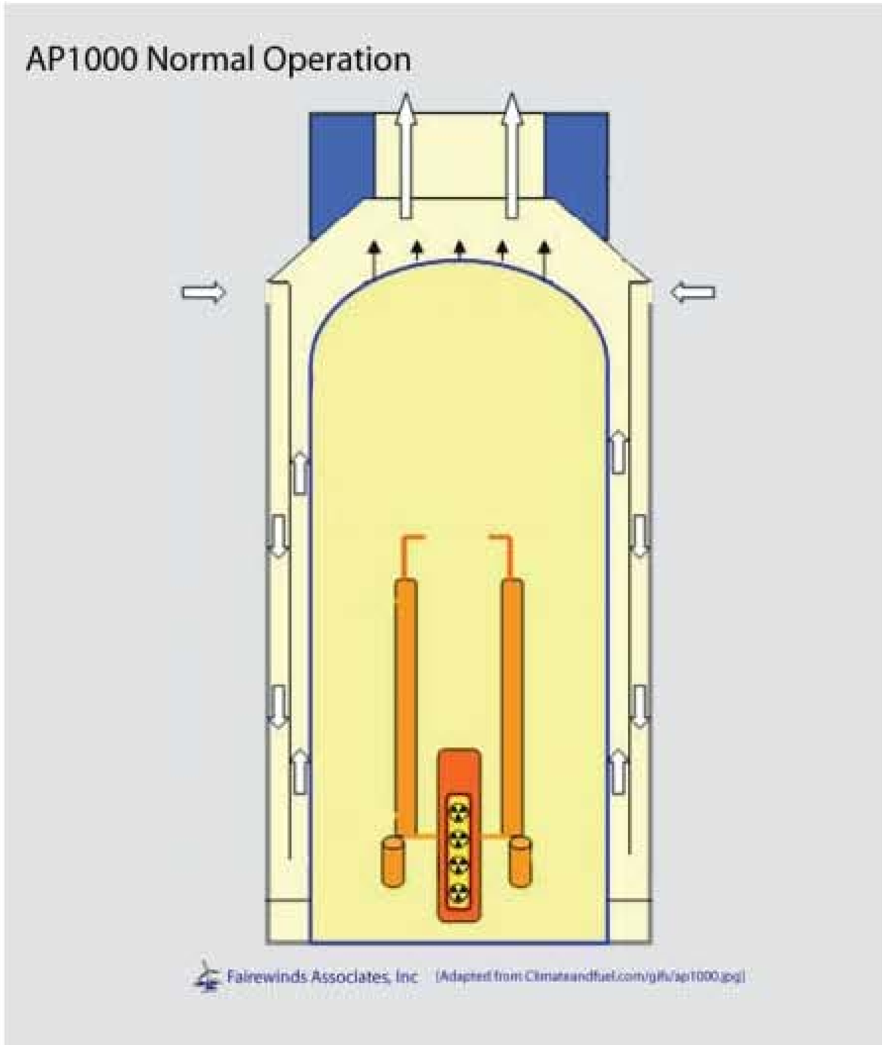
The BV primary containment hole existed for at least a year. The probability of primary containment failing would be 1% per year based on 100 reactors.

The MP3 breach lasted for two weeks. Therefore the probability of a secondary containment breach .035% of the time (2 weeks/56 weeks * 100 reactors).

The overall probability of the failure of both primary and secondary containment would therefore be .00035% or 1 in 285,000.

This is a significantly large probability that shows that the SAMBDA approach used by the AP1000 is not conservative.

AP1000 Containment



AP1000 Containment

During the AP1000 review, the staff expressed concerns about corrosive attack on the AP1000 containment. In response to concerns from the NRC in 2003, Westinghouse made the containment 1/8th inch thicker and added a nuclear-grade protective coating. The AP1000 has access ports to allow for visual examination of some portions of the outside of the containment.

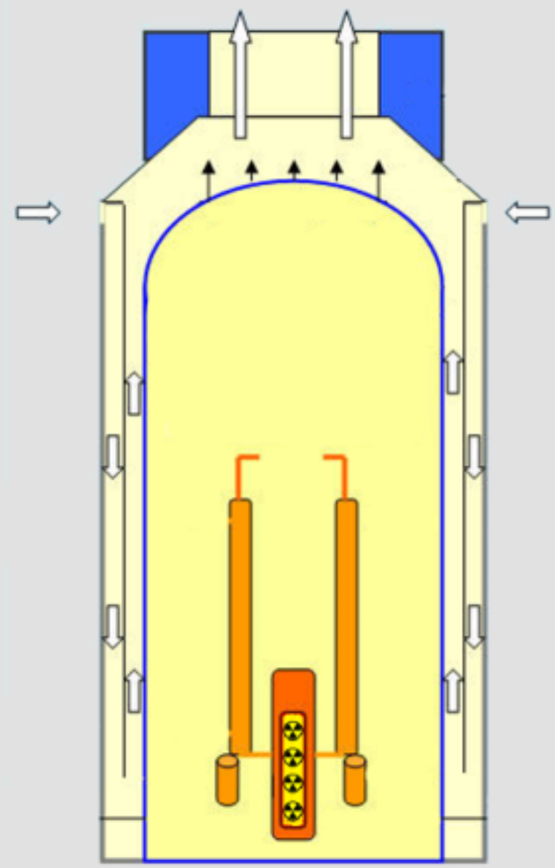
In the 2003 AP1000 SER the NRC stated:

"The staff noted there was no margin in the nominal design thickness for corrosion allowance."

"The COL applicant will provide a program to monitor the coatings."

"On the basis that enough corrosion allowance and proper corrosion protection were provided, the staff found the applicant's response acceptable..."

AP1000 Normal Operation



Fairewinds Associates, Inc (Adapted from Climateandfuel.com/gifs/ap1000.jpg)

AP1000 Containment

Fairewinds and Hausler have the following concerns with the NRC's analysis:

ASME XI inspection programs have historically missed flaws in the containment.

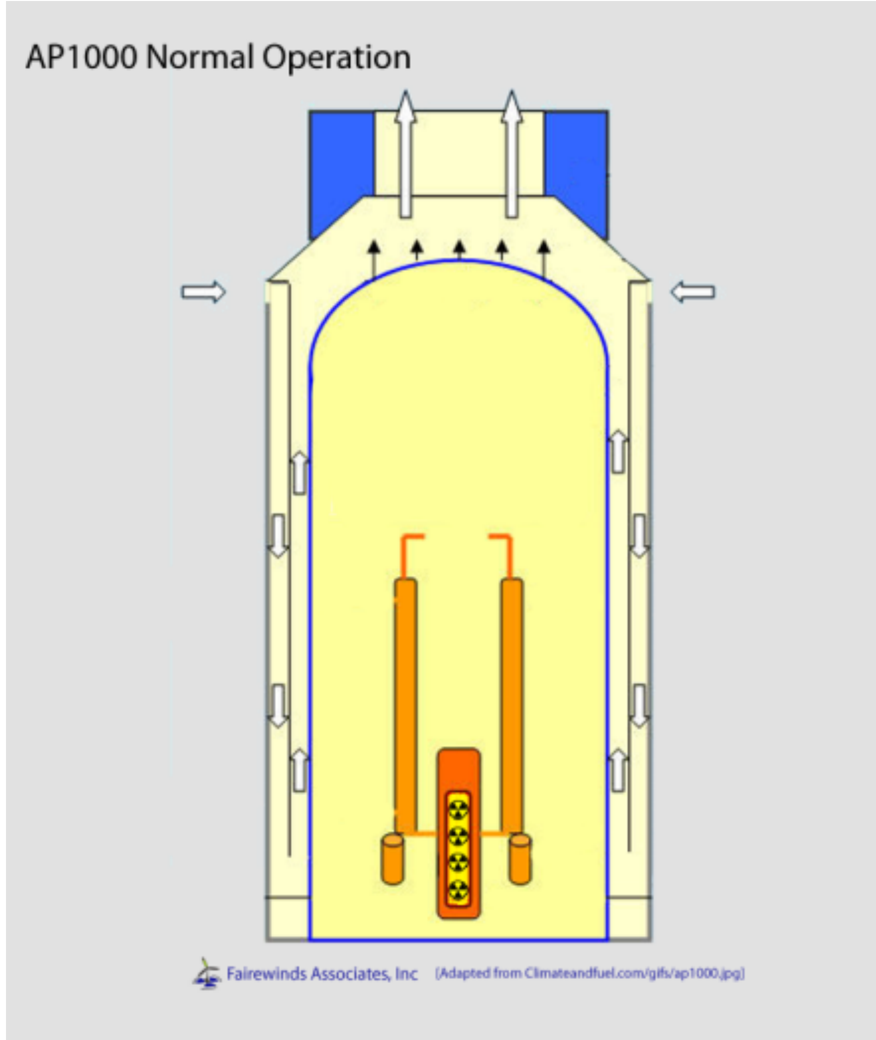
Application of protective coatings has historically allowed for coating degradation.

Wall-brackets on the outside of the AP1000 containment create crevices that allow for moisture build-up and creates a corrosive environment.

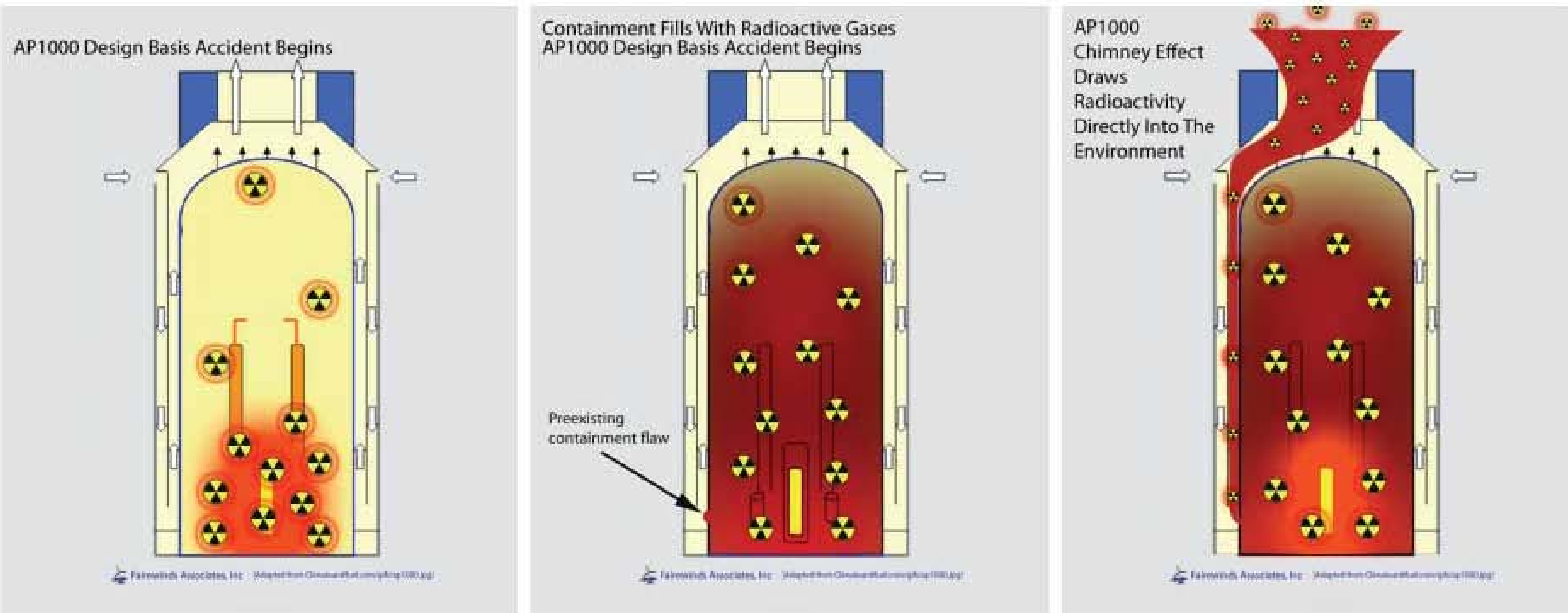
The junction between the wall and the floor creates a crevice that allows for moisture build-up and creates a corrosive environment.

The shield building breathes in moist outside air containing contaminants that can be deposited in crevices and cause corrosion.

Hausler estimates corrosion rates as fast as 0.15 inches per year.



Proposed Accident Sequence



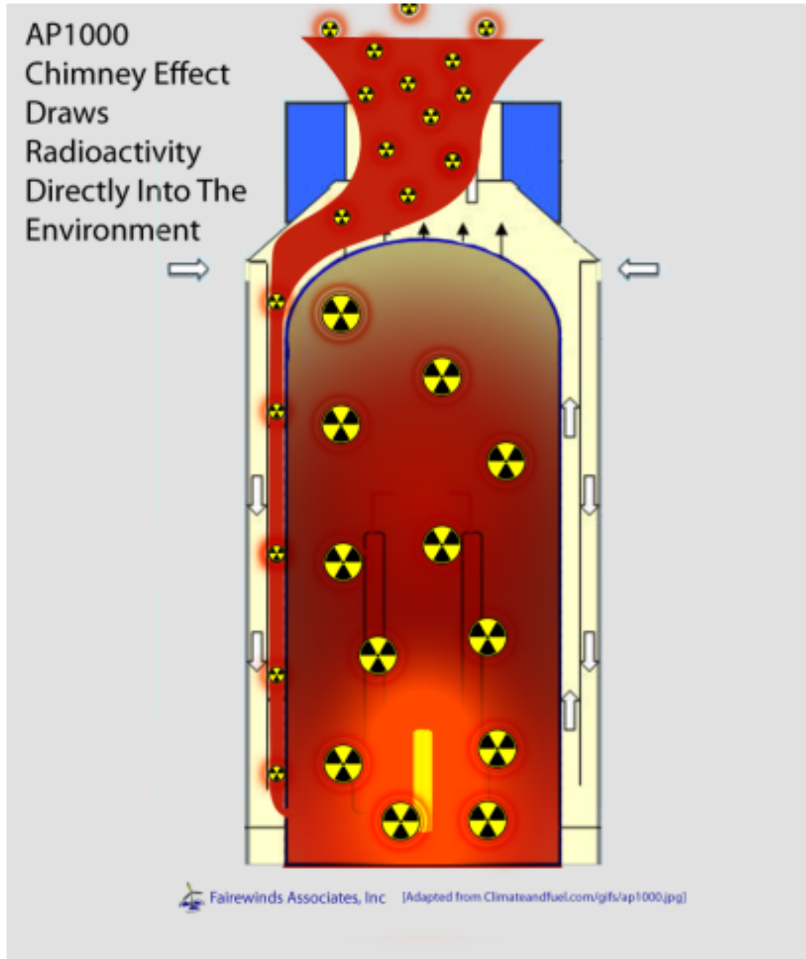
SAMDA or Design-Basis Event?

Westinghouse considers an Intact Containment "…to be within the design basis of the containment… "

"This is the 'no-failure' containment failure mode and it's termed intact containment. The main location for fission/product leakage from the containment is penetration leakage into the auxiliary building…"

For its SAMDA analysis, Westinghouse assumes a late containment failure (CLF), a failure of the containment to isolate (CI), and bypass through an open piping system (BP).

For the CLF, CI, and BP scenarios, Westinghouse assumes that containment leakage is into other filtered areas of the plant and is not released directly into the environment.

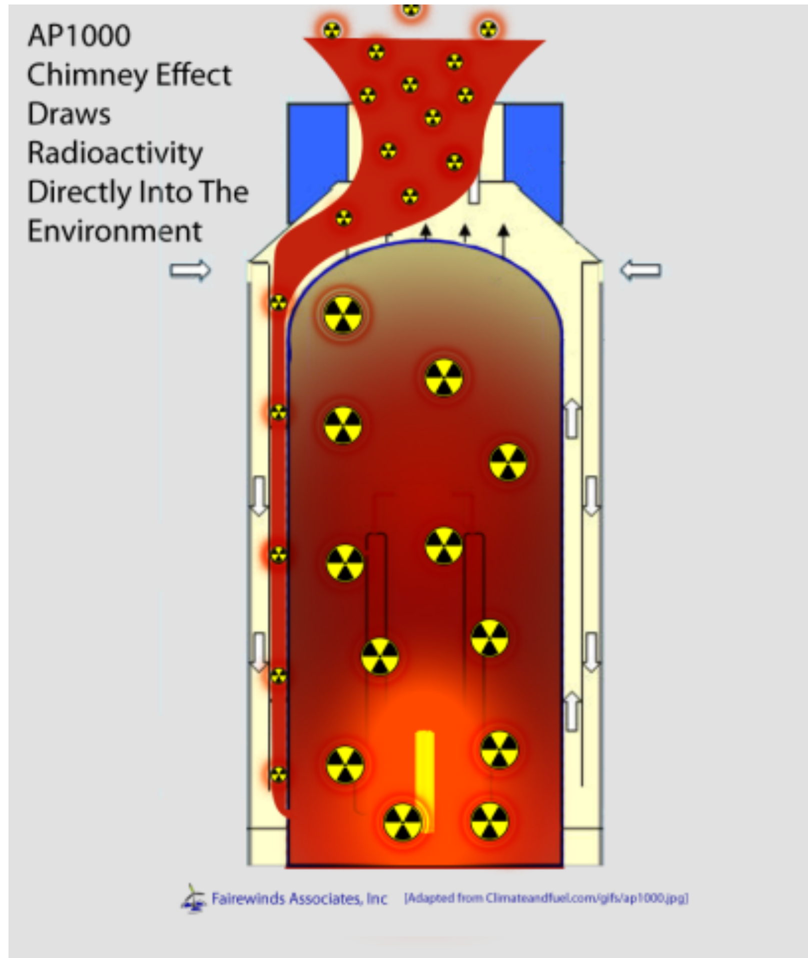


SAMDA or Design-Basis Event?

Both Westinghouse and the NRC assume that ASME XI inspections and protective coatings applied to the outside of the AP1000 containment will reduce the risk of a pinhole leak to **ZERO**.

Fairewinds analysis of 40-years of problems associated with the integrity of containment shows there is a relatively high probability of a pinhole leak in the AP1000 containment.

Should this pinhole leak exist, post accident pressures of 50-psi inside the containment will push radioactive gases into the annular gap causing off-site doses to exceed 10 CFR 100 allowable exposure levels.

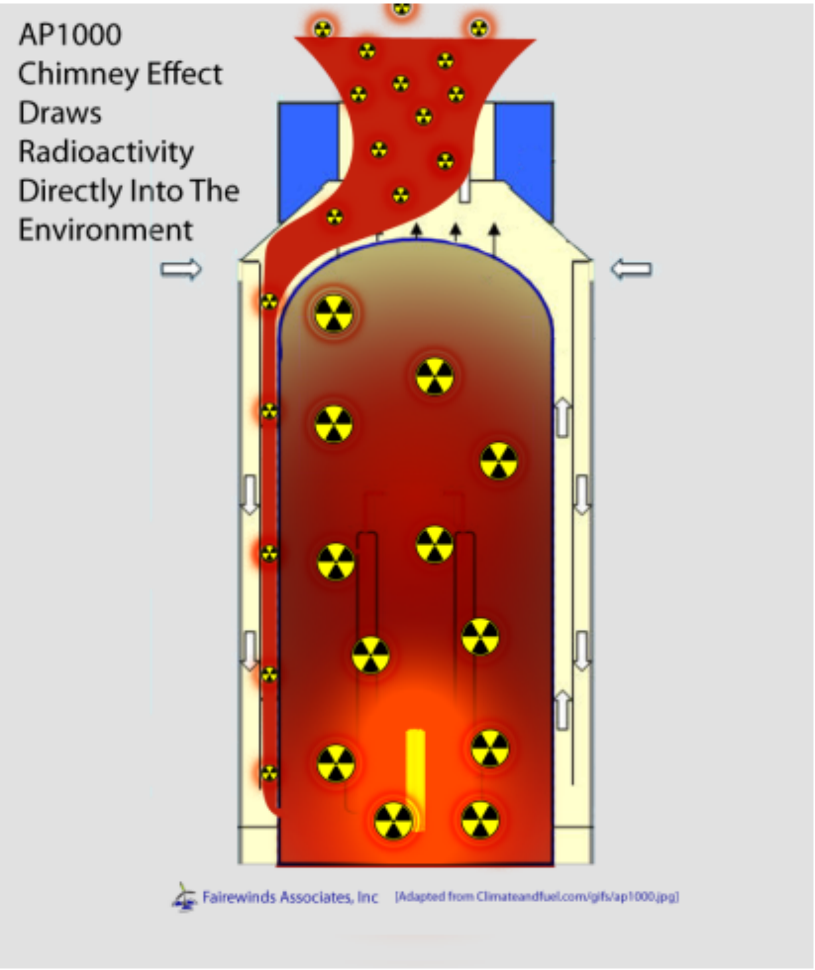


Filtered Ventilation

Westinghouse has already analyzed and then discarded the option of filtered ventilation.

"Secondary Containment Filtered Ventilation… The passive filter system is operated by drawing a partial vacuum on the middle annulus through charcoal and HEPA filters…the secondary containment would then reduce fission product release from any containment penetration."

Even this proposed option does not completely eliminate Fairewinds' concerns as leakage into the annular gap through a pinhole leak in the containment wall might not be captured.

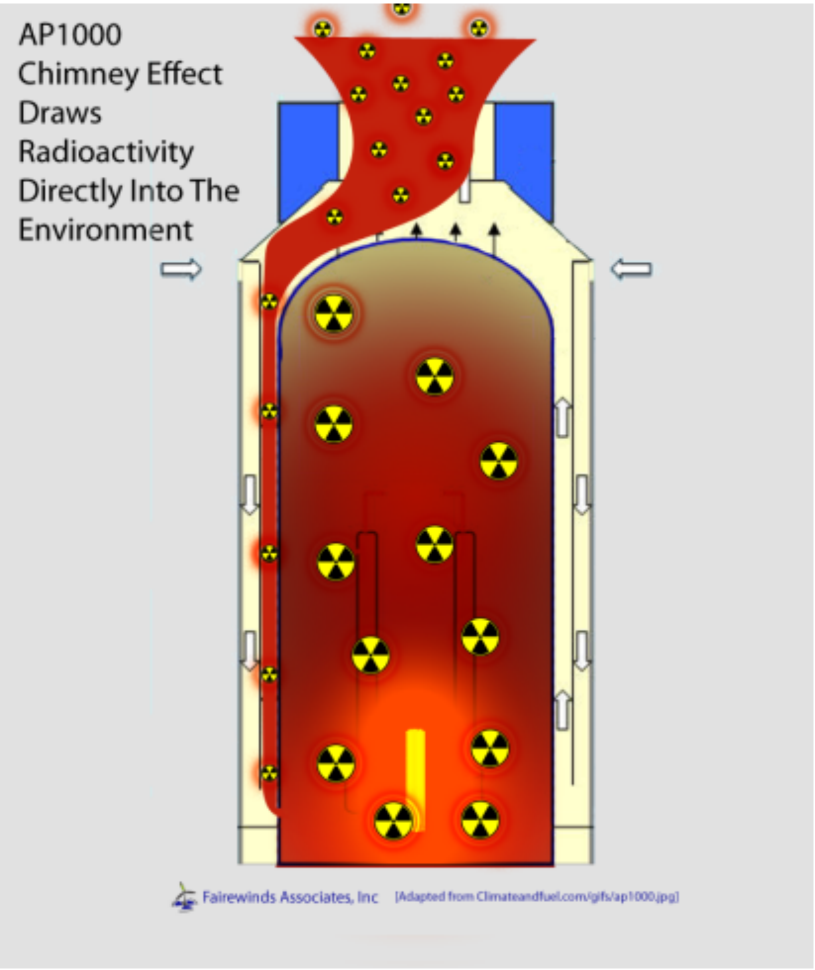


Conclusion

Given the history of containment failures, it is reasonable to assume that a pinhole in the AP1000 containment would be undetected and present at the initiation of a LOCA.

AP1000 SAMDA analysis does not assume a containment breach concurrent with the initiating LOCA.

The AP1000 SAMDA analysis rejected the possibility of filtering some leakage.



Docket Nos. 52-025-COL and 52-026-COL
BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE
EXHIBIT 5

Meeting of

The Advisory Committee on Reactor Safeguards (ACRS)

June 25, 2010

Extracted Relevant Portion of Meeting Transcript

The entire portion of the presentation to the ACRS by Arnold Gundersen, Chief Engineer, Fairewinds Associates, Inc and John Runkle, Attorney representing the AP1000 Oversight Group has been extracted from the transcript of the whole meeting.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

SUBCOMMITTEE ON THE WESTINGHOUSE AP1000 DCD AND

VOGTLE UNITS 3 AND 4 COL

+ + + + +

FRIDAY

JUNE 25, 2010

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Harold B. Ray, Chairman, presiding.

SUBCOMMITTEE MEMBERS:

HAROLD B. RAY, Chairman

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, Member

SAID ABDEL-KHALIK, Member

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

With that, we'll turn to our public presentation scheduled here this morning on the agenda. And Messrs. Runkle and Gundersen are here with us to make this presentation.

And the floor is yours, gentlemen.

MR. RUNKLE: Thank you, Chairman.

My name is John Runkle. I'm the counsel for the AP1000 Oversight Group.

And for those of you on the phone bridge, the PowerPoint presentation is available on the fairewinds.com website. That's F-A-I-R-E-W-I-N-D-S.com. So if you want to download that, you can follow along when Mr. Gundersen makes his presentation.

The Oversight Group is an association of local groups, primarily in the Southeast where the utilities have applied for license in the Westinghouse AP1000 reactors, along with several regional and national organizations, some local governments and other corporations.

Our position is that if the AP1000 design is not safe, the NRC should not be issuing an operating license until all issues with that design are safely resolved.

Let me remind you of Commissioner

Bradford's statement back in 1982. "If a Secretary of Agriculture endorsed better meat inspection, you want to have a debate of near religious fervor about whether that person was pro or anti-meat, whether he had sold out to the vegetarians. You'd debate whether the stricter regulations made sense. It's somehow unique to nuclear power that when one refuses to have nuclear power on the industry's terms, one gets chucked into a bin labeled 'anti-nuclear.'"

Now the Oversight Group firmly believes in the protection of public health and safety, and that's why we're here today. This should be the overarching mandate for all of us.

Last year there were several instances of corrosion in containment structure in operating nuclear reactors. Mr. Gundersen, who I have worked with before on other nuclear plant safety issues brought these incidents to us. We then commissioned Fairewinds to do an analysis for us on what similar corrosion would mean if one of the AP1000 reactors were operating.

We appreciate the opportunity to present to you the results of the Fairewinds study. We sent the study to the NRC and the ACRS on April 21, 2010 requesting a special investigation on what we see as a fundamental design flaw.

Just a week ago, the NRC issued Information Notice 2010-12 on the Containment Liner and Corrosion. I've supplied copies of that also to you. And it looked at significant corrosion problems at Beaver Valley, Brunswick and Salem Nuclear Power Plants corroborating, in large part, the findings of the Fairewinds study.

And again for those people on the bridge the PowerPoint presentation is available on the fairewoods.com website.

And I'm sure, gentlemen, you all don't want to hear more from an attorney, so I'm going to turn it over to Mr. Arnie Gundersen, Chief Engineer at Fairewinds.

MR. GUNDERSEN: Thank you very much for having me, and having us.

My background, just briefly. Commissioner Bradford and I served together on the Vermont Yankee Oversight Panel. And last year we signed a consensus report that suggested Vermont Yankee should be allowed to continue to operate for 20 more years with some suggestions. And Commissioner Bradford and I are working together again on another report that will be due out next month on a similar vein.

So, he's a smart guy.

In my career I've worked on -- I guess I got involved on this way back with Millstone 1 in '72, main steam isolation valve leakage which was a significant problem. And that then rolled into a unit called Montague if there's anybody in here that remembers that one. That's one that Sam Lovejoy toppled the met. tower back in the '70s also. But the integrated leak rate problems we had on Montague were significant and I briefed the staff on integrated leak rate issues. And actually was fundamental in working with the staff on mapping out leakage into both vented and filtered areas versus areas that were unfiltered. In the '80s I had 70 structural engineers working on containment analysis at Millstone 3.

And now my concern revolves around net positive suction head on boiling water reactors, which of course if the containment were to fail, would cause the problems to cavitate, and that's how basically I've been following containment issues since '03 when net positive suction head became a problem in uprates.

I was commissioned by some folks down in

Connecticut to write a letter to the ACRS, in I think '06 or '07 about the Millstone 3 containment, which was a sub-atmospheric four loop Westinghouse. It was incredibly small and the position I took was that the power of the value ratios on that reactor compared to all the other four loop Westinghouse's merited more evaluation.

I was hired by Citizens Power to work on Beaver Valley after the crack was detected, the hole was detected in the containment liner, and wrote to the ACRS on that.

And now, of course, there's the AP1000 that we're here for today.

I think the other piece of my background that's important is I was a Senior VP of an inspection division. I had about 300 inspectors, ASME 11 inspectors, working for me at the peak. As you know, it's a peak and valley business. We'd dropped down to 40, and then hit 300, 40 and 300 as the outage cycles occurred. So I know the capabilities and the limitations of visual inspections and inspectors in general.

This picture, it's a great one, it's from Millstone 3 when my team of 70 engineers completed the containment structural issues we were involved in. And it's taken from up on the bridge, up on the crane looking down. You can actually see the individual fuel rods. It's a great photograph.

But now on to the presentation. There is no single industry database on containment issues. And I'll call it containment system. Because we've the liner, the metallics thing, but you've also got the concrete. And there's been problems in both.

One of the areas I was able to find a lot of information was a report by Naus and Graves. They seem to be the go-to source on containment degradation. And between 1970 and 1999, according to Naus and Graves, there were 66 occurrences of degradation in operating containments and 32 of them were due to corrosion in the steel, either the containment or the liner. The 34 were concrete issues. So about half were metallic and half were concrete issues according to Naus and Graves.

CHAIRMAN RAY: Excuse me.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: By the way, it's the nature of ACRS, as you probably know, to interrupt speakers and ask questions as you go along.

None of these 66 involved isolation valve leakage or anything of that kind?

MR. GUNDERSEN: No.

CHAIRMAN RAY: It sounded like you were putting them in these two buckets.

MR. GUNDERSEN: You're absolutely right. It didn't involve integrated leak rate testing or failure of an isolation valve to meet a leak rate criteria. No, that was not in the database.

There were two instances before 2000 where the liners were completely penetrated and there were four more instances before 2000 where liner thicknesses were reduced by half or more. So about six out of the 66, or 10 percent involved liner issues that were more than half through-wall, and two cases were completely through-wall.

This presentation is footnoted when the material is not in the report that I've provided to the ACRS two months ago. So there's a couple of new items, like the Information Notice that came out this week that are footnoted. But if it's not footnoted, it's because it's been provided. The footnotes are in the original report.

CHAIRMAN RAY: Understood.

MR. GUNDERSEN: Okay. So Naus and Graves have a pretty analysis up until around 1999. I don't know if it's complete. I did find some overlap, but

I also found some holes. But it's pretty close. There were 66 problems in the initial three decades of nuclear power.

CHAIRMAN RAY: And as I recall, that's just U.S. or not?

MR. GUNDERSEN: Yes. That was just the U.S., correct.

The next source I found that was a significant collection of information was Information Notice 04-09, 2004-09. And of course this one, 2010-12 is sort of the next one in the line, as far as I could tell.

But according 2004-09 there were eight additional episodes of containment degradation in the period from 2000 to 2004. And there was a through-wall hole at DC Cook in '01, there were three through-wall holes in the liner in Brunswick in '99. And there were 60 pits at DC Cook that were below minimum design but didn't go through-wall in '98. Those are the ones of significance.

In addition, Hatch had two through-wall cracks not in a liner, but in a containment. Apparently there was a nitrogen line that was cold, and I say inerted portions of that containment. Repeatedly there was thermal stresses that caused a through-wall crack in Hatch 2 and then a through-wall crack in Hatch 1 as well.

Other industry experience, and I guess taken individually each one of these is not evidence in and of itself, but there's a significant volume when you look at all of it.

Dr. Gianni Petrangeli at the University of Pisa wrote a book called *Nuclear Safety* and he has a section in the book on containment. He's got a chapter on containment. These are his quotes from his book.

"The picture that emerge is not very reassuring." He estimates that the probability of overcoming speculation values is 46 percent for PWRs. And as I read it, and it's written in English but he is Italian so some of the words are not exactly the same. I think what he means by "specification values" is the probability of exceeding tech specs, the tech spec leakage rate for a PWR in a real accident situation is 46 percent.

MEMBER BROWN: How does that correlate with the results of the testing that's done periodically, do you know?

MR. GUNDERSEN: Well, that's a great question. Having done a couple of them, the integrated leak rates test done periodically are done awfully gingerly. And, you know for instances, the MSIDs are lapped and all of the individual penetrations have had their individual leakage confirmed --

MEMBER BROWN: So it's not an as-found test then?

MR. GUNDERSEN: Right. Right. It's not as-found and it's also, you know in an accident you get a very rapid pressure rise, and physically you can't pressurize the containment that way. So it's a slow pressure rise so it's not the shock.

And I think what Petrangeli was talking about, is that combination, is we can't when we do an integrated leak rate test simulate the rapid pressure stresses on it and it's not as-found conditions on the valve. So it's twofold

MEMBER BROWN: Let me --

MR. GUNDERSEN: Yes?

MEMBER BROWN: My background is Naval nuclear program. So I'm looking a little bit at this as education for me.

What I get out of your statement about how they run the test is they prep the containment prior to performing it?

MR. GUNDERSEN: Yes.

MEMBER BROWN: I'm phrasing it slightly differently, but you go through and you look at all the potential leak paths and you kind of clean them up and seal them and do whatever you need to do, so you kind of prep the system.

MR. GUNDERSEN: Yes, that's correct.

MEMBER BROWN: Okay. I just wanted to understand that point, make it clear at least in my mind.

MR. GUNDERSEN: Right. And it sort of makes sense because in a lot of the examples is like the containment access door will be removed and, you know various things will come in and out during the outages. And then access door will be put back in place. And you wouldn't want to test the containment before you removed the access door and then screw it up. So it does make sense to do it. It's almost the last thing in an outage is the integrated test.

MEMBER BROWN: Yes.

MR. GUNDERSEN: But, yes, you're right.

MEMBER BROWN: That's a clarification. Thank you.

MR. GUNDERSEN: And then Petrangeli recommends for new systems going forward a double containment and filtering of the effluents for the annulus between the containments.

This slide is not in the presentation I provided you guys two months. This is from the Inspector General's report on the licensee renewal application process. And the photo is also from that report, page 21 to 23 in that report.

This happens to be the liner out of Oconee and the condition existed for ten years, according other OIG report.

Two things. First is in the license renewal the NRC, the licensee told them that they had an effective liner monitoring program, but yet this condition existed while the licensee was making statements --

MEMBER BROWN: How do they document that? Is there a series of pictures that show this over the ten year period that show peeling and spalling of coatings, or is that just --

MR. GUNDERSEN: I don't know.

MEMBER BROWN: There's no data to back that up other than the statement of --

MR. GUNDERSEN: It's the OIG report.

MEMBER BROWN: Okay. Thank you.

MR. GUNDERSEN: I got that from the OIG

report.

MR. RUNKLE: Yes. In the OIG report they documented how the ten years and what the actual system was at the time. So there's a lot more details in the report.

MEMBER BROWN: Okay. So they do have details to back up the statement.

DR. FORD: Oh, yes. Yes. It's not an oh, it's been there for ten years, but they've documented inspections and those kinds of things.

MR. GUNDERSEN: And this OIG report was not aimed at liners or containments. It was aimed at the LRA process. And in this case they happened to look at statements made by Duke at Oconee relating to the liner. One, the statements were inaccurate, and; (2) the second bullet is just as important, the staff didn't conduct any indication -- provided no indication of having conducted an independent look at the coating operating experience. So they accepted what Oconee told them and then moved on. And again, that's not in my report, but is available.

The next one, and it begins to get us into the NRC Information Notice, is that this is a photograph of the hole in Beaver Valley. It's about an inch by 3/8th of an inch, the hole itself. But I think what's also interesting if I can get them out, is that is the rust patch around the whole, which tells me that the paint actually blistered and held the water in behind it. So for the rust to develop outside the hole on the visible side before the paint was peeled, I think the paint was actually acting as a barrier allowing the moisture to work its way into the surrounding seal.

So the actual hole itself was an inch by 3/8ths. The portion of the liner that was degraded was ten square inches.

I went back and I went to the LRAs, and this is what Beaver Valley told the NRC in their LRAs. Again, I'm referencing here because they were not in my 35 page report to you a couple of months ago.

In the LRA, Beaver Valley said "Loss of material due to corrosion is not significant for inaccessible areas." So a year before this hole, Beaver Valley's position was that the hole couldn't happen.

They go on to say "Identification of deficiencies and subsequent corrective actions," and I think the next line is "along with engineering evaluation of inspection results, provide reasonable assurances that the program be effective for managing loss of material." Clearly that didn't happen because about a year later the hole occurred. And again, in the LRA the "conclusion was that if they implemented ASME XI...provides reasonable assurance that..structures...will continue to perform their intended function."

So the position of the applicant at the time of this hole was that it basically couldn't happen because the visual inspection program was more than adequate.

Then I went back and I looked at the SER.

CHAIRMAN RAY: Excuse me a second.

MR. GUNDERSEN: Yes, sir.

CHAIRMAN RAY: Maybe I missed something. Can you back that up a second?

MR. GUNDERSEN: I'm trying.

CHAIRMAN RAY: Never mind. Don't.

MR. GUNDERSEN: Okay.

CHAIRMAN RAY: Okay. You referred to Section XI and then you referred to visual inspection. Section XI is more than just visual inspection, right?

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: You didn't mean to make

that a coincident --

MR. GUNDERSEN: That's correct.

CHAIRMAN RAY: Okay.

MR. GUNDERSEN: Although it's interesting, and in my Beaver Valley letter I talk about it pretty extensively.

CHAIRMAN RAY: Okay.

MR. GUNDERSEN: The liners are not volumetrically examined very often. Beaver Valley committed to a volumetric inspection of 70 square feet -- a 71 square foot panels. In part because it's awfully hard to find a pit using UT. You know, UT can -- if you know you've got a wall, you can check the weld seam and you can be very accurate. But the odds of finding a p;it with UT are not good. And so the liner inspection seemed to be more visual, although it appears, and perhaps from the NRC, it's suggesting we do something more in the future.

CHAIRMAN RAY: Well, that's right. I don't want to interrupt your presentation too much, although maybe I have already. But I'd like to explore with you a little bit more this Section XI versus visual inspection as the means by which integrity is affirmed, you know.

MR. GUNDERSEN: Yes. The example, there

is -- UT takes time, and I think part of the issue is you preferred the visual because you can keep your outages short.

There are ultrasonic techniques which are pretty terrific at detecting racks. An example is with MIC microbiologically induced corrosion, which are little tiny pits that work their way through the backside of a carbon seal pipes. There are ultrasonic techniques out there that will find it, but they're slow and --

CHAIRMAN RAY: Well, these are means that are available. But Section XI, in and of itself, requires what exactly?

MR. GUNDERSEN: Containment is predominantly -- on containments after they're built, predominately visual.

CHAIRMAN RAY: Okay.

MR. GUNDERSEN: Okay. Now I went to the SER, and in January of '09, so four months before the hole developed, this is what the NRC had to say about Beaver Valley's program. The applicant's assurance that the use of the Section XI ensures that you'll be consistent with GALL and the staff finds that the applicant's exceptions are acceptable.

CHAIRMAN RAY: That's why I'm asking is

there is so much explicit reference to Section XI and I just wanted to your take on what it does and does not do.

MR. GUNDERSEN: Well, since you were saying, before I came I should also mentioned that this was peer reviewed by Dr. Rudy Hausler. And Rudy and I spoke before I came here. And he believes there are much better volumetric techniques available, including remote techniques that -- you know, rollers that could be attached to walls that could do this job when it's off-outage. They are not being used. And, yes, it is predominately visual for containment liners.

Am I answering your question?

CHAIRMAN RAY: Yes, you are.

When you say "predominately," it infers that under certain circumstances you would use other inspection techniques.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: And I'm just trying to get you to elaborate on that a little bit.

MR. GUNDERSEN: It's mainly at the welds is where the volumetric inspections are: (1) best suited and applied. Because those large sheets, I'm not aware of volumetric exams being required once a containment is up and running.

CHAIRMAN RAY: So it would be just the integrated leak rate test that would find it?

MR. GUNDERSEN: And the visual.

CHAIRMAN RAY: Right.

MR. GUNDERSEN: And it's interesting, too, because Beaver Valley passed this integrated leak rate test. They removed their steam generators in '06 and when you cut the containment and patch it back up, you have to do an integrated leak rate test. And Beaver Valley passed its integrated leak rate test in '06, and yet in 2009 they have a through-wall hole. So, again, they gingerly test is probably why it passed.

But in any event, again the staff said that the applicant further stated these additional examination requirements provide reasonable assurance that potential corrosion on the concrete side of the liner plate will be identified and addressed. Well, this was corrosion on the concrete side that works it way through and it was not identified, nor was it addressed.

And finally, the staff finds that the applicant's inspections in accordance with the ASME code will manage the loss of material due to general pitting and crevice corrosion. Again, this is three months before the leak occurred.

MR. RUNKLE: And the Information Notice 2010-12 also has some more details on the Beaver Valley and the other problems, and cites back to other documents, licensee incident reports and those kind of things.

CHAIRMAN RAY: Yes. We have had the opportunity to review Beaver Valley as well.

MR. GUNDERSEN: Oh, okay.

Okay. Before I move on to some of the general border issues that effect the AP1000, there are a couple more in a historical perspective what's happened before today. Operating reactors that I did want to talk about.

Last year the failure of the metal in Beaver Valley, but we also had the Crystal River delamination. I don't believe that's really an operating problem. I believe there was when they cut the rebar, it has allowed the delamination to grow.

But another interesting one was Bellefonte. Bellefonte blew several of the tension cables. And Bellefonte has not run yet. It's been 40 years old but hasn't run. And the containment has been tensioned for 40 years. And workers were inside

Bellefonte and they heard what they thought were shotgun blasts. And it turns out that several of the cables disconnected from their anchor on the ground side, apparently.

So one thing, I'm glad to hear the NRC is doing, is trying to get all the stuff into one database. But it appears from the Information Notice that they're just looking at liner issues, when in fact there's also concrete issues.

And I think, you know the key here up until today, it's been a containment system. You've got the liner and you've got the concrete and they work together. And the difference with the AP1000 is that there's one thing. It's thick, a little less than two inches. But it is one thing whereas before we've always had two.

CHAIRMAN RAY: Well, I think you do point out in your report that there's a lot of freestanding steel containments in operation today.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: So in that sense, at least, it's not a new event or new circumstances. There are other things that make it unique.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: But just the mere fact

that it's a freestanding steel pressure vessel is not the thing that makes it different?

MR. GUNDERSEN: That's correct.

CHAIRMAN RAY: All right.

MR. GUNDERSEN: Okay. I'm touching on the Information Notice just briefly.

In addition to Beaver Valley, the Information Notice talks about Brunswick. And there where the access door came into the containment there was a false fitting allowing for expansion and contraction. Apparently the felt got wet and over time blistering occurred on the side. It was detected with visual inspection after it had gone on -- Brunswick's an old plant. It had gone for 30 plus years.

And then the other one, which is I think the most important on here, is Salem. And this is the most recent, October of '09. And Salem noticed heavy corrosion where the liner meets the floor.

And when Dr. Hausler reviewed my report, the portions of my report about where the liner meets the floor are Dr. Hausler's concern.

They had an exception from the ASME code because it was inaccessible, it was not looked at and yet there was the severe degradation where the liner meets the floor at Salem.

They have a program in place now to continually monitor it until they figure out a different program. But, in fact, that rust occurred at that point and it was due to water leaking from the service water system. Is a significant problem.

And I guess when you look at a lot of these problems in total, there's no -- that the staff would like to believe that it's due to an organic compound behind the liner. And that's true for several of them. But when you look at all of the failures, there is no single thing.

You know, DC Cook was a unique containment and there were problems with the ice condenser containment, not just at Cook, but at others that led to severe pitting.

There's been several problems with sub-atmospheric containments. I don't know whether they're because they are sub-atmospheric or because of material behind them. But Beaver Valley and North Anna both had through-wall holes because of construction rubble left behind.

But there is to my way of thinking there is no common thread here. And I hope that the staff broadens its perspective to look at the potential that there are many ways that a containment can fail. And if we're just focusing on construction rubble behind the liner, I think we're missing the point.

MEMBER BANERJEE: So that 32 reported occurrences of corrosion that you were looking, how many do you think occurred due to some organic material coming in contact and how many didn't? You said that obviously some had not?

MR. GUNDERSEN: Yes, that's a real good question.

Beaver Valley had the through-wall hole because of organic material behind the liner. But in '06 when they cut the hole and removed the liner, there was pitting behind it that was not associated with organic materials, and in four places. Three were significant enough that to be rewelded and built back up.

So I think where it has gone through-wall at North Anna and Beaver Valley and perhaps the Brunswick issue here, have been because of material that's stayed wet for an extended period of time. But the pitting, which is more endemic, I don't believe is related to an organic thing behind it.

Yes, certainly they're all due to moisture and they're all do to oxygen. And as I stated in my letter to you, that the root as I see it are if you have moisture and you have enough oxygen, you'll get a through-wall leak. And a lot of the pitting that's been discovered has been what they call self-limiting because there's not enough moisture or there's not enough oxygen to allow that rust hole to continue. And one of the differences in the AP1000 design is that on the outside there's lots of moisture available and lots of oxygen. So that is the difference.

One last bit of experience here. This happened about --

MEMBER BANERJEE: Does this mean that you contact ships with steel hulls?

MR. GUNDERSEN: You know, you're one slide ahead of me. When the Exxon Valdez hit a rock, the solution was not to make the hull thicker, it was to go to double hull. And when gas stations around the country began to rust their tanks through, the solution was not to get a thicker tank, but it was to go to double hull tanks.

And I think we're there as an industry. And the discussion with Member Ray that referenced one slide from now actually discusses that.

We have a double hull design right now.

We have a liner and a containment and a secondary containment in many situations. But to me this seems to be going back to a single hull design when in fact experience teaches us, and as well as the gas station down the street, that the solution is to go not to a thicker single container but to a double hull design. And the same with the Exxon Valdez.

So, did I answer your question?

MEMBER BANERJEE: Yes, partly. But, I mean there are many containments in the chemical industry which are storing all sorts of things with a single wall.

MR. GUNDERSEN: Yes.

MEMBER BANERJEE: So, should we do away with all steel vessels that contain anything? Like should we make them all double hulled?

MR. GUNDERSEN: Like the reactor?

MEMBER BANERJEE: Well, I'm talking about, let's say we store butane. Do you think we should make double hulled containers for butane?

MR. GUNDERSEN: Well, most of those containers now are double hulled. All the chemical, all the gasoline --

MEMBER BANERJEE: Are they?

MR. GUNDERSEN: -- containers, everything has got the --

MEMBER BANERJEE: Is that on the record that you say that all these large containers for storage on the petrochemical industry are double hulled?

MR. RUNKLE: In my experience in North Carolina all the underground storage tanks are double hulled because you can't inspect them. Some of the ones on the surface, the very large ones, anything under pressure is double hulled these days.

Yes, you can store butane in a tank, but if you're going to have it there for a long time under a lot of pressure, you'd better have it double hulled or be able to inspect frequently or a replaceable type thing.

MEMBER BANERJEE: Well, inspection is one thing. But are they all double hulled?

MR. RUNKLE: I can't say that they're all double hulled. But certainly anything under high pressure or anything under ground it certainly is.

MR. GUNDERSEN: And I think the difference is the consequences here are we're dealing with a low probability high consequence thing. And I would argue that the probability is not zero and needs to be factored into a SAMDA, whereas I think the present AP1000 document assumes that that probability is zero. And my position is that experience indicates it's not zero.

This is an event report that's only a couple of weeks old. And if I use the mouse, I can show you down here Millstone 3 had lost its secondary containment for 16 days to a set of valves that were inadvertently left open. And so they basically had no secondary containment for two days.

The bottom paragraph says "rendered the secondary containment inoperable." So it's not about a sealed vessel, but it is about this concept of containment system. Now if you've got the primary containment and its working, well it's okay if the secondary system is inoperable. Or if you've got the secondary system inoperable but the primary system is working, that's okay too. But when both are inoperable, of course, you've got essentially no containment or if you don't have one of those two, which is the way the Westinghouse design is going, you're also in a similar situation.

And Member Ray you're quoted here. This is a quote from last year's ACRS where basically it's a discussion between you and Member Shack on whether the Beaver Valley hole constituted a containment breach or not. And as I understand it, you're suggesting that deterministically it did. And then Member Shack talks about, well, yes, but probabilistically it didn't.

And actually, while I agree with you that deterministically it's a problem, the real point is that you could have that discussion on the Beaver Valley issue. And the reason you could have it is because there was redundancy built in: If the liner failed, you had concrete behind it. And that issue of redundancy is off the table in the AP1000 design, as I see it.

So, it doesn't matter who wins this argument, but that the argument can occur because of the redundancy in the containment I think is the important point that I was trying to bring up.

Now I did a real quick, and I'm sure this not a quality assured calculation, but I did a real quick calculation. Over the last 13 months what's the probability of both the primary and the secondary containment breaching? You got a primary breach at Beaver Valley and secondary breach at Millstone 3.

At Beaver Valley the hole existed for the entire year, if not two or three. And so therefore, the probability per year of breach in a liner is one percent based on a 100 reactors.

And then Millstone, the breach existed for two weeks. So the probability of secondary containment with breach is two weeks divided by 56, and then also divided by a 100 reactors.

If you combine those two together, you get a small number, but not an infinitesimal number. You got the probability of a primary and secondary containment not being effected simultaneously, as one in a -- and that's not zero. And I think the point I'm trying to make is that in the AP1000 design they're assuming that the probability of the containment system, which is just one barrier in their case, is zero whereas experience last year says that it's a non-zero number.

Okay. We're over the hump and coming off the presentation here.

This is how the AP1000 works, and I don't think I have to brief anybody on that. The passive feature has an 8 million gallon water tank on the roof and the water pours onto the containment. And in the event of an accident, evaporated off and pull a lot of heat out the roof.

Interesting, I worked on La Crosse which was an ancient reactor built by Allis-Chalmers which also had an enormous tank of water, but it was inside the containment for positive suction had issues. And the structural problems with having an enormous mass of water on the roof are impressive, but not part of my presentation today.

Okay. During the AP1000 review the staff did express concerns. Back in 2003 the staff did express concerns about corrosion of the liner and Westinghouse did agree to make the liner one-eighth of an inch thicker and they added nuclear grade protective coating. I might add that the Oconee protective coating was also nuclear grade. And then also there are inspection ports that allow for visual inspections of some portions of the outsides of the containment.

Before the containment was made one-eighth of an inch thicker the staff noted that there was no margin in the nominal design thickness for corrosion allowance. An eighth of an inch is .125.

Dr. Hausler estimates that in ideal conditions a hole could propagate at .15 inches in a year. So the corrosion allowance if that were pitting were to occur would be eaten up in less than 12 months.

The staff went on to say that is pushed

back to the COL applicant to provide a program to monitor the coatings. And yet if we look at one of the COL applicants, Duke on McGuire, had a program in place to monitor the coatings and the program failed for ten years. So we're not longer relying on a thing, a containment system, a liner and some concrete. We're relying on a thing, a thick containment and visual inspections which have a record of missing thing, and coatings which have a record also inadequacies.

CHAIRMAN RAY: Let's stop here for a minute.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: Because I am personally more focused on this issue of coatings and their role in this whole business.

Are you asserting that because -- and I'm not familiar with McGuire so I'll just accept what you're saying is evidence that coatings in the past have not been inspected thoroughly enough for the sake of the discussion.

Is it not possible to have an adequate inspection program for a coating system, do you think, I mean if one realized now with the benefit of experience that that's very important to do, is it possible?

MR. GUNDERSEN: You know, I had as many as 300 inspectors working for me at one time. And during that one time, 295 were really great. But there would be five that would show up with a hangover, or whatever. And so you're relying on people to be perfect. And I have that sooner or later in any foolproof system, eventually you're going to see the proofs. And I think that's my concern here is that the existing designs have a backup so that if one were to fail, we've got some redundancy. In this case we have a thick containment, there's no doubt about that, but that's all we have that we can be sure of.

Maybe the next slide will address that.

CHAIRMAN RAY: Well, I'm really imposing a question, maybe it isn't a fair question, but nevertheless recognizing that coatings play a very important role here. It's not merely the inside of a liner on a composite structure like you're referring to, but it's the heat transfer surface on the outside of the containment --

MR. GUNDERSEN: Right.

CHAIRMAN RAY: -- which is exposed to the atmosphere that we're talking about. The question is do you think it's possible to have an inspection program for a coating system in that application that would provide adequate assurance against -- localized, because I think what we're talking about is localized corrosion.

MR. GUNDERSEN: Right

CHAIRMAN RAY: Or not and if not, why not?

MR. GUNDERSEN: Right.

CHAIRMAN RAY: You've indicated that the fallibility of the inspectors is one reason. Is there any other reason why?

MR. GUNDERSEN: Yes. I think that I don't believe it will be foolproof. You know, zero percent probability. And maybe the issue is what is an allowable level, and I probably can't put a number on that. But there's no areas of concern on this design.

And the first on the bulk containment where if you're just looking at this thing as a sheet, I don't believe you're going to get rapid pitting through the sheet. But there are appurtenances that's hung off the outside sheet that form crevices.

One, it's very difficult to get paint to adhere to crevice. You know, nuclear grade or not, it's difficult to get the paint to adhere to the crevice. And of course, the experience is that the coating will actually hide the corrosion until it comes through, which is what happened at Beaver Valley.

So in situations where the crevice exists and the paint is over it, you can actually miss it even if you did a visual until significantly late in the process because the coating is actually providing a gap.

CHAIRMAN RAY: Okay. I think you're answering the question I'm getting to.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: You're just skeptical that an inspection program not matter how diligent could assure the integrity of the coating system over the life of the plant.

MR. GUNDERSEN: Right. Now Dr. Hausler's concern was that the -- I was looking up, he was looking down. Westinghouse committed when the staff expressed their concerns to take the protective coating down six inches below the concrete and then so there's be: If this were the wall and here were the concrete, there would be about six inches of coating down below there. And Dr. Hausler's experience is that -- and it's true on steam generators too, where you never get a perfect connection and you form a crevice which allows moisture to get in and work its way through. And that is absolutely uninspectable because it's below the concrete.

Now Salem it's problem is down there, but apparently they only looked above the concrete. It would be fascinating if before the Salem issue is completely resolved if they actually go down and looked below the concrete as well, which is where you can get a corrosion pathway working its way through.

CHAIRMAN RAY: Okay. I mean, there are explanations where concrete is in contact with steel, as you know.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: That that provides a protective --

MR. GUNDERSEN: Right, the pH issues and things like this.

CHAIRMAN RAY: -- environment for the steel.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: All right. Go on.

MR. GUNDERSEN: Okay. So the staff, the last bullet on this, allowed -- given there's a thicker containment and given that the COL applicants have a proper corrosion protection, the staff allowed the AP1000 to be licensed. Not to be licensed, to move forward in the licensing process.

CHAIRMAN RAY: Certified. It's certified.

MR. GUNDERSEN: Yes. Yes. But you're still at it.

And I think maybe I touched on all these things that I'll be talking about on this slide. But Dr. Hausler and Fairewinds have these concerns:

The first is that ASME XI inspection programs have historically missed flaws. And it's interesting because the Beaver Valley flaws were in places where they were easy to see, but the Salem flaws were in essentially what you would consider an inaccessible location, which is exempted by the ASME XI code.

So the first thing is there are weaknesses in the ASME XI code that cause flaws to be missed. And there's a lot of history on it.

The second is that application of protective coatings has allowed for coating degradation and the staff and the residents have allowed it to continue in Oconee's case for ten years.

The third one is my concern is that wall-brackets will create crevices where moisture can build up. And Dr. Hausler's concern is that the junction with the wall and the floor creates a crevice where moisture can build up.

And the last point is, and probably the new point on the slide, that the AP1000 design breathes on the outside, essentially. And that it doesn't take in dry air, it takes in whatever the air is. So at Turkey Point you're going to take in air that has some salt in it. If you're a cooling tower site and the drift is heading toward the containment, you're going to take in air that's got biocides, algicides and moisture in with the oxygen, all of which lies inside that containment and provides a large source of water whereas before we've had small sources of water; a large source of water and a large source of oxygen, which are the two things you need to make a crevice grow.

So, in addition the AP1000 has got a large tank of water on the roof and it's hard for me to believe that the sprinklers won't leak some or there won't be condensation, or there won't be rain that get in and on that containment shell. And in conjunction with the airborne contaminates that are brought in and lie in crevices, that you couldn't get an attack at a crevice.

And as I said, Hausler says these cracks, he felt a hole could develop at a rate of about .15 inches in a year in the proper conditions.

We'll finish at 9:30.

My suggestion for an accident sequence, this is the Westinghouse approach is that the containment works and the heat is removed through the containment. If there is a preexisting hole, which is down in the lower left -- this is unanalyzed condition by the way. Which then allows gases, especially of the iodine, but also a hole the size of the Beaver Valley hole is enough to exceed tech specs based on the rules of thumb I used when I was doing MSID testing.

So that air would not just go into the gap between what used to be a primary and secondary containment, but now it goes into a gap where it's deliberately designed to --

CHAIRMAN RAY: I got to stop you again.

For a composite structure, you're

referring to the concrete portion as the secondary containment? I don't mean to repeat the debate I had with Bill Shack. But is that what you're calling the secondary containment?

MR. GUNDERSEN: In a lot of cases, it's a tertiary containment. If we called the concrete structure the secondary, then in most cases there's another building behind that which is held at a negative pressure and exhausts it through.

CHAIRMAN RAY: Well, perhaps you wouldn't want to say "most cases." In some cases.

MR. GUNDERSEN: Yes. Right.

In Westinghouse's SAMDA analysis they consider an intact containment to be the design basis. The containment doesn't have any flaw.

These are Westinghouse quotes, and they're in my report.

The no-failure containment model is termed intact. Whatever leakage leaks out of the Westinghouse analysis goes into the auxiliary building, which is a filtered space.

And then in the SAMDA analysis Westinghouse does look at three alternatives: A late containment failure, they call it the CLF, a failure for the containment to isolate and bypass through an open system. All of those, though, are into filtered locations. The situation I'm proposing is not addressed in the SAMDA analysis by Westinghouse.

Westinghouse does propose, and then eliminate an alternative that -- I'm sorry. I'm slide ahead of myself.

So they basically say the probability of a pinhole leak is zero. And my experience is that, and especially I think re-enforced by the Information Notice, which was also written to Part 52 licensees as well as Part 50 licensees. I thought that was important. That they're assuming it's a zero probability. And in light of 40 years of liner failures and the Hatch problems, you know I guess there will always be something we didn't anticipate. If you make sure that every glove is accounted for, you won't have the glove issues. If you remove the felt from the door, you won't have the felt issues. But then you wind up like at Hatch where we had a cold pipe going into a warm containment and causing some thermal stresses that caused the crack. I'm not convinced that there won't be an issue that has not been analyzed. And it seems to happen when we change containment designs, like when we went to an ice containment or the sub-atmospheric containments.

Should this exist? There's 50 pounds of pressure behind it and a lot of volume. So the leak would occur for a long period of time for a lot of motive force to push it out into that annular gap.

Westinghouse did look at filtering the ventilation, and it was eliminated from consideration in their SAMDA because the probability, as they viewed it, was too low. And you multiple probability time consequences it didn't hit the threshold.

They did look at filtered ventilation, but as I read it it was not filtering ventilation into this annular gap. It was filtering ventilation into other places within the plant and any duct work would be applied.

So even though what Westinghouse considered and then rejected filtering the ventilation, I don't think that goes far enough and that this event really is not addressed at all in the SAMDA analysis.

CHAIRMAN RAY: You're talking about now filtering this natural circulation flow which is inherent in the passive design for the heat removal. That's what you're talking about filtering.

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: Do you think that would--

MR. GUNDERSEN: No, Westinghouse doesn't propose that.

CHAIRMAN RAY: I understand that, but that's what you're talking about?

MR. GUNDERSEN: Yes.

CHAIRMAN RAY: All right. Do you think that would effect the passive nature of the heat removal to put a filter in the flow path --

MR. GUNDERSEN: I don't know what the pressure path would be across the filters. And if the pressure drop was small enough and if the pressure drop was large, I would. And I'm sorry, I don't know what that is.

CHAIRMAN RAY: Okay.

MR. GUNDERSEN: And the conclusions are there's been a history of containment failures throughout the industry and now we're going basically from a double hull design to a really thick single hull design. The Westinghouse SAMDA analysis never assumes that there's a leak into that annular gap. and I think it should.

So we're getting back to carnivores and omnivores and vegetarians here. And did you want to have any time here.

MEMBER BLEY: Could I ask you before we

get to your summary --

MR. GUNDERSEN: Yes. Sure.

MEMBER BLEY: I'm familiar with most of the events that you've described. I'm not familiar with the Salem one, and I intend to find out about that one. Were any of the ones, and I don't recall that anyone you talked about were, but have you found any events where the thick freestanding steel vessels, not liners against concrete, have had anything approaching a through-wall?

MR. GUNDERSEN: Hatch 1 and 2 had --

MEMBER BLEY: I'm sorry.

MR. GUNDERSEN: Hatch 1 and 2 in the analyses report from the '90s had through-wall cracks. And that's a BWR.

MEMBER BLEY: Okay.

MR. GUNDERSEN: So there's two cases of a through-wall crack in a BWR.

MEMBER BLEY: Okay. And that's a containment with in the wet well area, as I understand?

MR. GUNDERSEN: Yes. Yes. I think the closest to substantial containment, the example is Hatch 1 and 2.

MEMBER BLEY: Okay.

MR. GUNDERSEN: And that was not corrosion, that was a thermal expansion. Had a nitrogen line that was cold and containment that was warm.

MR. RUNKLE: What I find troublesome about this whole thing is that the AP1000 design sort of takes a big step backwards from 40 year old technology. We had double hulled containment, now it's a single hulled containment and we're really replacing it with zinc liners and visual inspections. And it seems to be a major step backwards.

Now we understand that the NRC sent a letter to Westinghouse giving an aggressive schedule for their rulemaking on the AP1000 certification. The schedule has a big "if" in it. And that is the schedule does not begin until Westinghouse files its review scope and closure strategy for several outstanding technical and safety issues. And we think the containment issue today should be included in that list of issues that have not been safely resolved.

CHAIRMAN RAY: Mr. Runkle, you're speaking of the schedule for the amendment which we're considering, is that right?

MR. RUNKLE: Yes.

CHAIRMAN RAY: Okay.

MR. RUNKLE: And we're on this Revision 18 of the AP1000 design control document that we don't see an end in sight. There are still unresolved issues that some material we're plowing through, and I hate to add this to your workload, but we think that the containment issues that Mr. Gundersen brought to you should be included on that list and being considered very seriously in looking at amendments and looking at final approval of the design.

So when we brought to the NRC and ACRS, we asked for a special investigation, which of course now this is our information, we brought it to you as soon as we could. We could have waited until there was a rulemaking petitions and we could have brought later on in the process. But we think that it's important enough to bring to you and try to resolve now safely.

And while this investigation is going on there should be no operating license issued using this fundamentally flawed design. And even though this design may be certified, it certainly is not final, it certainly has not been completely reviewed and approved.

So we appreciate the opportunity. And Mr. Gundersen and we will available if there's follow-up questions or if you have additional information that we may have that you need, or the NRC staff or consultants need. It's an important issue and really it raises to the level that we think that it needs to be resolved before this AP1000 design continued in its process of being approved.

CHAIRMAN RAY: Okay. Well let me try and pick up on a couple of things that you said here so we don't lose the thread.

MR. RUNKLE: Sure.

CHAIRMAN RAY: As Mr. Gundersen pointed out, the coating system is a part of this picture we're talking about. And as he indicated, it is part of the combined operating license application; the coating system, its application, its monitoring, that sort of thing.

And so it's likely that we'll be reviewing that perspectively because its not been certified, that's an ongoing current activity and not necessarily all of it, at least that part of it, as part of the DCD, the certified reactor design. So I just want to alert you to the fact that there are these two pieces. And the concern that you're talking about here may be addressed partly in one piece and partly in another piece. So just bear that in mind, if you would.

On the issue of step back, I would just note that it is the way it is because it has the inherent passive advantage of not relying upon a lot of equipment that's in current plants, for example, to remove decay heat following an accident but instead relies on the passive nature of this heat transfer mechanism which at least in this design, depends on the conditions that we've talked about existing: There is a single containment surface exposure to the atmosphere.

MR. RUNKLE: But the passive nature of the reactor actually brings in more moisture and more air.

CHAIRMAN RAY: Understood.

MR. RUNKLE: And even with the best liners --

MEMBER BANERJEE: You have to speak in the microphone.

CHAIRMAN RAY: He will, I think.

MR. RUNKLE: When we're looking at the inspection of the liner doing what the liner's supposed to do, looking at -- you know, there can be no inspection, no visual inspection on this side. From inside you can look and you can inspect and see if the liner is --

CHAIRMAN RAY: Excuse me. Why are you saying you can't inspect on the outside.

MR. RUNKLE: Because there's another wall in here. This is almost inaccessible.

CHAIRMAN RAY: Well, I think that's an important point. And Mr. Gundersen pointed out himself, the baffle, I'll call it, in there has ports that allow you to gain access to at least a portion of the containment outside surface. And a gap nominally without considering what stuff is in there, is 42 feet. So one would, at least initially, think that there is access to that surface. But I wanted to give you an opportunity to explain why there wasn't in your opinion.

MR. GUNDERSEN: Well, I think the example that's closest is at Salem. I mean you actually walk up to the joint in Salem, but yet it was considered inaccessible for the --

CHAIRMAN RAY: Yes. Now let me again, I don't want to do anything other than be clear here. I'm not trying to debate the issue one way or another.

But if you're talking about below the floor level, that is as you say inaccessible unless you do removal of the concrete.

MR. GUNDERSEN: I was saying at Salem it was above the floor level.

CHAIRMAN RAY: Okay.

MR. GUNDERSEN: You could walk up to it. But you still couldn't see it very well.

CHAIRMAN RAY: Because?

MR. GUNDERSEN: And there is an ASME exclusion because it was considered inaccessible.

CHAIRMAN RAY: Why? Just a little bit more, please. Why was it inaccessible?

MR. GUNDERSEN: You know, as Member Bley said, I just discovered the Salem flaw.

CHAIRMAN RAY: All right. Okay. We'll have to look at that a little more closely. But normally that exclusion applies below the floor level, that's why I thought that was what you were talking about.

MR. GUNDERSEN: Right. This applied above the floor. So there are going to be places that are inaccessible above the floor.

CHAIRMAN RAY: Okay.

MR. GUNDERSEN: On the inside. And where

the hangers meet the -- this baffle plate is hung off the containment by an angle. And where that angle meets, I don't believe it's possible to inspect there. And I also believe that the coating can actually create a void under which you can get corrosion get occur in its absence.

CHAIRMAN RAY: Well the coating certainly is an important element of this whole system. And the points that you're making about accessibility for inspection are ones that we have yet to look at. And your input to us is helpful in focusing our attention on that.

I just made the point earlier, Mr. Runkle, that that will be taken up as part of the COL. So if you don't see it being discussed in the context of the DCD, it's because its there and not any other place.

Other things that you've raised about the offsite dose assumption and so on and so forth, those are more likely part of the DCD scope and have been there in that location.

I guess during the course of your presentation I've asked all the questions I have following reading your letter. You can tell that personally I'm more focused on this issue that you mentioned about the coating inspectability and the integrity of the coating, which is obviously important.

Other members? Dennis?

MEMBER BLEY: No.

CHAIRMAN RAY: Okay. Sanjoy?

MEMBER BANERJEE: I just wanted to understand your main concern is that areas which are inaccessible for inspection and weren't the areas you feel might be close to the concrete steel liner interfaced?

MR. GUNDERSEN: I am not concerned about bulk corrosion of the liner.

MEMBER BANERJEE: The pitting corrosion?

MR. GUNDERSEN: But it's pitting corrosion --

MEMBER BANERJEE: Right.

MR. GUNDERSEN: -- in inaccessible locations. I look up at the hangers and Dr. Hausler looks down at the junction with the floor and the concrete. But it's even when there's been the ability to visually inspect, like at Beaver Valley using ASME approved processes, the flaws were missed.

Now it's a one-sided inspection at Beaver Valley, but yet it's an ASME approved process.

It would be possible to do volumetric exams in the area of these hangers, but that's not part of the code.

CHAIRMAN RAY: Based on your experience, it cannot be done through this coding that we're talking about here, the volumetric examinations?

MR. GUNDERSEN: I think so, yes.

CHAIRMAN RAY: I'm sorry, Sanjoy. Go ahead.

MEMBER BANERJEE: Okay. I think I got the answer.

CHAIRMAN RAY: Okay. Charlie?

MEMBER BROWN: I just would like to try to clarify something. There's a 1.75 inch thick containment.

MR. GUNDERSEN: I think it's 1.87.

MEMBER BROWN: Yes. That's the extra --

MR. GUNDERSEN: That's the extra.

MEMBER BROWN: The extra one-eighth, okay. And there are many, many, many years, like 50 years experience with submarine hulls which are high strength steel in a salt water environment where we have coatings as well to deal with. And yet you talk about a rapid through-hole corrosion occurring within that time frame. Now I guess I'm just relating back to some experience with some other very critical situations which are under very high pressure type circumstances where the inspection programs also had difficulty of accessibility to certain parts of those hulls. And yet they've been successful over the years. I don't know whether I'm talking apples and oranges. You know, I'm not a --

MR. GUNDERSEN: I think you got two of the three -- I've never been a submarine, although I talk to so many submariners I think I qualify for about four years at sea at this time. But --

MEMBER BLEY: No.

MEMBER BROWN: I'll tell you, once you've gone down about 30 times rapidly, to whatever and then come back up, you want to have some confidence it's not going to break.

MR. GUNDERSEN: I think you got two of the three elements that I discuss here. But it's the absence of the third that I don't think makes the analogy just right.

You have moisture and salt is clearly a corrosive element. But you don't have oxygen. Now if you'll look at the boats that have been selling, they get down further into water where there's no oxygen, they last a long time whether it's these wooden ships that are uncovered that are 400 or 500 years old, or that Confederate sub they got pulled out of the water or out of Charleston. It's only when that then gets into contact with the oxygen that the rust really kicks in. So I'm not sure that the hull analogy is perfect, although two of the three elements are always --

MEMBER BROWN: Well, submarines aren't always way, way down. You know, they don't operate at 5,000 feet.

MR. GUNDERSEN: Right. But if you look at the hull on a ship, you know it's the rust occurs on the waterline.

MEMBER BROWN: And they are in port for a significant amount of time also. So that they are exposed about probably a third of the hull at the top of the hull.

I'm just trying to relate the two together. I understand the thought process, but I'm trying to --

MR. GUNDERSEN: I guess you need three things. You need water, you need something to accelerate the water, although that's not --

MEMBER BROWN: And you need oxygen.

MR. GUNDERSEN: And you need oxygen.

Right.

And at Beaver Valley there wasn't a lot of oxygen behind that crack, there wasn't a lot of moisture whereas in this case you've got a situation where both the oxygen and the moisture replenished.

MEMBER BROWN: Okay. Thank you.

That's all I had. Thank you.

CHAIRMAN RAY: Tom?

CONSULTANT KRESS: As part of your view that periodic leak testing will not be sufficient to find such a leak, or you think it would be --

MR. GUNDERSEN: I have done a couple of leak rate testing, and you certainly have to have leak rate tests but they're so gingerly done that I guess I understand why you have them every ten years and you should have been, but I don't think they're going to pick up these types of failures because they're not a dynamic process.

CONSULTANT KRESS: Right.

MR. GUNDERSEN: But I guess in closing, I think clearly there's AP1000 issues I'm here to discuss today. But there's also broad industry issues on containment leak rates, as it effects NPSH for example that I hope you will also keep in mind.

CHAIRMAN RAY: Tom, were you done?

CONSULTANT KRESS: Yes.

CHAIRMAN RAY: Okay. Thank you, gentlemen.

MR. GUNDERSEN: Thank you.

MR. RUNKLE: Thank you.

CHAIRMAN RAY: Okay. We'll take a -- I'm going to ask given that it's Friday and we aren't exactly what more we're going to need to do today, yet but let me take a two minute break. I'd like everybody to come back by five minutes to the hour and we'll resume.

I will recess.

(Whereupon, at 9:45 a.m. off the record until 10:00 a.m.)

CHAIRMAN RAY: I got permission to use my judgment, which I will now proceed to do. Back on the record.

I've asked indulgence of everybody yet again to allow us to have this discussion of ACRS interactions ahead of the discussion ACRS action items because we are anticipating an early end to today's session and I wanted to not shortchange what time we can give Westinghouse by wanting to get to this other item. So if we can get this behind us, we'll then be able to give Westinghouse what time we

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE SECRETARY

In the Matter of	)	
	)	Docket Nos. 52-025 and 52-026-COL
Southern Nuclear Operating Company, Inc.	)	
	)	
Combined License for Vogtle Electric Generating Plant Units 3 and 4	)	

NOTICE OF APPEARANCE FOR JAMES B. DOUGHERTY, ESQ.

Notice is hereby given that the undersigned attorney herewith enters an appearance in the above-captioned matter. In accordance with 10 C.F.R. § 2.314(b), the following information is provided:

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Dated: August 12, 2010

Respectfully submitted,

_____/signed (electronically) by/_____________

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