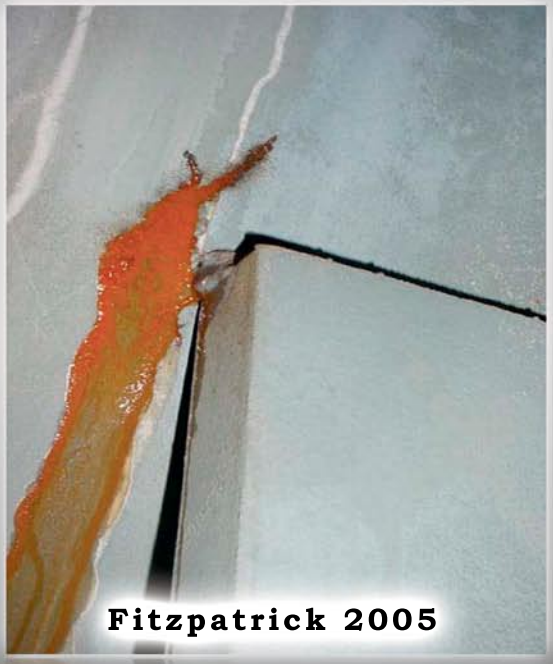
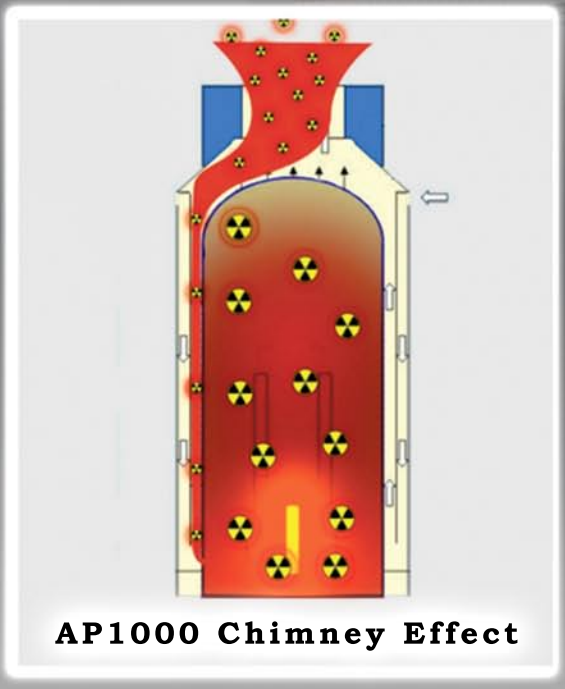
NUCLEAR CONTAINMENT FAILURES:

Ramifications for the AP1000 Containment Design



Fitzpatrick 2005

Beaver Valley 2009



AP1000 Chimney Effect

Fairewinds Associates, Inc
December 21, 2010

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Introduction and Background

During the fall of 2009, Fairewinds Associates, Inc was retained by the AP1000 Oversight Group to independently evaluate the proposed design of the Westinghouse AP1000 nuclear power plant. Following six-months of research and peer review, Fairewinds Associates prepared and submitted an expert report entitled *Post Accident AP1000 Containment Leakage, An Unreviewed Safety Issue* to the AP1000 Oversight Group. In response to Fairewinds Associates' expert report, the AP 1000 Oversight Group sent the report to the NRC and the ACRS April 28, 2010.

As a result of Fairewinds Associates' expert report regarding the unreviewed safety issues of significant potential containment leakage in the event of a design basis accident in an AP1000 nuclear power plant, the ACRS invited Fairewinds Associates' chief engineer Arnie Gundersen and AP1000 Oversight Group Attorney John Runkle to make a formal presentation to the ACRS June 25, 2010. The concerns raised by Fairewinds Associates, Inc regarding the unreviewed safety issues contained in the design of the Westinghouse AP1000 are delineated in its expert report and additional supplemental information is contained in the Power Point presentation Mr. Gundersen and Attorney Runkle made June 25, 2010 to the NRC ACRS.

Fairewinds Associates, Inc wrote *Nuclear Containment Failures: Ramifications for the AP1000 Containment Design*, December 21, 2010, in order to:

1. Reference and combine the conclusions, produced in its previous *AP 1000 Containment Leakage* Report, the June 2010 Power Point, and Mr. Gundersen's oral testimony to NRC ACRS.
2. Add new evidence in the form of additional failure data and new failure modes that Fairewinds Associates has recently reviewed.
3. Address the erroneous information provided to the ACRS by the NRC Staff at the October 2010 ACRS meeting.
4. Address the application of protective coatings in light of new evidence.
5. Address misconceptions relating to <u>all known</u> failure modes of existing containments and their applicability to the AP1000 design.

The Chimney Effect

The *Post Accident AP1000 Containment Leakage, An Unreviewed Safety Issue* Report identified a problem in the AP1000 containment design that Fairewinds Associates, Inc named the *Chimney Effect.* To summarize briefly, in the event of only a small failure in the containment system of the AP1000, the radioactive gasses inside the AP1000 would leak directly into the environment, because the gasses would be sucked out the hole in the top of the AP1000 Shield Building via the *chimney effect*. The *AP 1000 Containment Leakage* Report shows at least 40 occasions when significant corrosion and other failures had developed on containments of all types, and yet this is only a partial picture of all the containment failure data now available.

Failure Modes Causing Containment Malfunction

At least five different failure modes have caused containment failures in existing thick-walled containment vessels or their liners. These failure modes were identified and discussed in the aforementioned *AP1000 Containment Leakage* Report and are identified by the following means:

1. Pitting of the liner from the outside to the inside at the area where the liner is in direct contact with the concrete. (Example: DC Cook)
2. Failure of the liner from the outside to the inside due to construction debris erroneously left in the finished containment that then came in contact with both the concrete and the containment liner. (Example: Beaver Valley 1)
3. Failure of thick walled containments due to expansion and contraction. (Example: Hatch 1 and 2)
4. Inadequacies associated with ASME visual inspections. (Numerous)
5. Inadequate coating application. (Oconee)

Based upon these five types of very diverse failure modes, the initial report concluded that the Westinghouse analysis of SAMDA failure probabilities and consequences must be reevaluated. Moreover, if a complete and proper SAMDA analysis had been conducted, it would show that Filtered Vents would be required on the Westinghouse AP1000 design in order to reduce accident exposures in the scenario postulated in the Fairewinds Associates *Post Accident AP1000 Containment Leakage Report*. Finally, it appears that both the NRC staff and the ACRS are focusing their attention on items 1 and 2 and ignoring items 3, 4, and 5 that are also directly applicable to the AP1000 design. The NRC staff and the ACRS have not initiated an analysis of Filtered Vents as a mitigation measure.

Fairewinds Associates June 25, 2010 AP1000 Power Point presentation to ACRS from June 2010 incorporated and expanded upon the earlier Fairewinds Associates' Report. In addition, it also provided new information that clearly showed that both the NRC and its licensees have ignored:

1. Significant coating degradation information and findings. (Oconee)
2. Clearly evident inadequacies in ASME visual inspections for containment Aging Management Programs. (Beaver Valley)
3. Significant inadequacies in ASME inspections of the joint where the containment wall meets the floor. (Salem)

Containment Corrosion

Only a few days prior to the release of Fairewinds Associates' June 25, 2010 Power Point presentation to the ACRS, the NRC staff released Information Notice 2010-12 identifying additional unreported containment failures. Fairewinds Associates was not aware of these additional and newly reported containment failures at the time of its initial report. Moreover, an industry-wide or NRC sponsored database is not available to track such containment failures, like the containment corrosion issue recently reported at Salem. The containment condition that occurred at Salem began inside the containment liner and progressed outward eventually exceeding ASME Code minimum wall thickness. The Salem containment failure is particularly relevant to Fairewinds Associates' AP1000 contention because:

1. Salem's corrosion is from the inside progressing outward.
2. A boric acid leak that occurred during a period of 30-years caused the corrosion.
3. The corrosion remained undetected by all forms of ASME visual inspections *even though* it occurred on the inside of Salem's containment, which was allegedly visually accessible.
4. The Salem containment corrosion was found to be located in the joint between the wall and the floor.
5. More troubling is that this is the specific location Fairewinds Associates pinpointed in its April 2010 report as being problematic to the Westinghouse design of the AP1000.

Containment Cracks

On June 28, 2010, three days after the ACRS meeting, Fairewinds Associates, Inc informed the ACRS of *yet another containment failure*, this time at the Fitzpatrick nuclear power plant in 2005. The photo below of the 4 ½" crack was taken in 2005 from the outside of the containment torus at the Fitzpatrick nuclear power plant in Oswego, NY.

As a result of questions during the ACRS discussion period relating to BWR thick containment designs like the through wall cracks at Hatch 1 and 2, Fairewinds researched additional failures and found that the Fitzpatrick nuclear power plant developed a large though-wall leak that was not due to corrosion. Once again, here is a unique violation of the BWR containment system that is directly applicable to the Westinghouse design of the AP1000.

The Fitzpatrick crack is due to differential expansion in a thick containment that is of similar thickness to the proposed AP1000 design and like the cracks previously uncovered at Hatch 1 and Hatch 2. Thus to date, three thick containments have experienced complete through-wall

failures that remained undetectable by ASME visual techniques until each through-wall crack actually appeared.

Protective Coating Failures

Fairewinds Associates clearly showed in its June 25, 2010 presentation to the ACRS that the application of protective coatings throughout the nuclear industry has been proven to be prone to repeated failures (Oconee). The proposed AP1000 containment design relies upon, and indeed requires, the successful application of protective coatings to prevent rust and through-wall holes from developing. Since Fairewinds Associates' presentation to the ACRS, a broader coating concern has arisen involving the integrity of the very contractors who attempt to apply those coatings. Examples of whistleblower suppression in the coatings application industry show us that the application of coatings in the AP1000 cannot be expected to be failsafe.

More disturbingly, in September 2010, the NRC issued a significant decision against the Shaw Group because its management staff harassed and intimidated a foreman who had expressed concerns about protective coating applications.[1] At the time the AP1000 Oversight Group identified the coating issue to the ACRS, this intimidation by the Shaw group had not been publicized or decided. While we commend the NRC for its decision against the Shaw Group, the issue does not stop there for it serves to highlight the significance of our report to the ACRS.

Inadequate and untimely NRC review

Once again the NRC staff has downplayed significant safety issues in its review regarding the AP1000 design. The October 2010 presentation to the ACRS ignored critical containment safety issues in the AP1000 design that were delineated by Fairewinds Associates, Inc in its April 2010 report and its June 2010 ACRS presentation. Instead of conducting a thorough analysis of the data presented, the NRC staff cherry-picked the design failures and only focused on one type of containment failure mode in its October 2010 presentation to ACRS. Additionally, the NRC staff simply chose to focus on and then dismiss as an anomaly the leakage from outside inward due to construction debris associated corrosion like the 2009 through-wall containment hole uncovered at Beaver Valley.

[1] http://www.kmblegal.com/2010/09/21/u-s-nuclear-regulatory-commission-orders-shaw-group-to-protect-whistleblowers/

NRC staff chose to ignore five other key areas of containment failure in its presentation to ACRS in October 2010. The key failure modes ignored by NRC staff are:

1. Pitting on the outside not associated with debris (DC Cook, Beaver Valley 2006),
2. Rust associated with corrosive attack (boric acid) from the inside out as at Salem and now Turkey Point, and
3. Through-wall cracks in thick containments due to thermal stresses like Fitzpatrick and Hatch 1 & 2.
4. Poor coating application and threats against those who try to apply coatings properly
5. The common theme is that ASME XI inspections missed all of them until through wall cracking or corrosion holes occurred.

NRC never mentioned the additional corrosion and cracking failure modes in their October 2010 presentation to the ACRS. Additionally, it appears that the NRC Staff simply pre-judged these AP1000 design concerns as insignificant in its rush to fast track the design in its accelerated certification process. It appears that the NRC staff once again ignored significant safety related issues.

More New Unreviewed Containment Failures

Yet another through-wall hole in the liner of a containment system was experienced in October 2010 in the sump liner at Turkey Point 3. Like the corrosion at the Salem nuclear plant this hole emerged from the inside of the containment to the outside, and once again, it was generated in an area that was readily accessible to ASME visual inspections. Why was it missed by the ASME inspections? Once more we have another failure mode directly related to Fairewinds Associates' concerns regarding the inadequacy of the AP1000 design.

Rush To Certify AP1000 Design Without Adequate Review

In its rush to certify the AP1000 design and continue the COLA fast-track demanded by the nuclear industry, the NRC staff and NRC committees continue to ignore legitimate safety concerns and significant design flaws that fly in the face of nuclear power probabilistic risk assessment upon which the construction of nuclear power plants was predicated. The AP1000 Chimney Effect identified by Fairewinds is not the only significant technical issue that the NRC

appears to be downplaying in order to issue final design approval before the end of 2011. In a closed session ACRS meeting on December 3, 2010, NRC engineer John Ma, discussed his concern that the AP1000 shield building lacks flexibility and could crack in the event of an earthquake or aircraft impact. A cracked shield building would cause the AP1000 passive "chimney effect" airflow to fail, creating an accident scenario even worse than that postulated by Fairewinds Associates, Inc. Furthermore, NRC engineer Ma stressed his concern that the AP1000 shield building design does not even meet American Concrete Institute (ACI) standards and the design also failed required shear test certifications. In a continuation of its rush for approval of the AP1000 design, some of the NRC staff agreed with Westinghouse that the existing approach was adequate, while still acknowledging that the shield building design did not meet ACI criteria.

The NRC's complete failure to address Fairewinds Associates' legitimate technical safety-related issues and concerns and the new admission by NRC's own engineers that the AP1000 has failed tests and does not meet ACI criteria are indicative of NRC capitulation to industry-wide pressure for NRC to certify the AP1000 prior to the end of 2011. The passive cooling approach of the proposed Westinghouse AP1000 design poses unique problems requiring significant NRC technical review and safety hearings, even at the expense of delaying the certification.

Conclusion

In conclusion, while corrosion from the outside inward is certainly an AP1000 issue, the inside outward corrosion problems uncovered at Salem and Turkey Point and the thermal cracking at Hatch and Fitzpatrick are equally damning concerns illustrated to the ACRS by the AP1000 Oversight Group June 25, 2010. Fairewinds Associates, Inc remains convinced that the application of a protective coating and reliance on the ASME visual inspection will not and cannot address the Chimney Effect matter of contention we discussed with the ACRS in June 2010.

The AP1000 has a design post accident containment leak rate of one tenth of one percent per day for the first day of an accident and five hundredths of one percent thereafter[2]. In the Fairewinds

[2] *Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design (NUREG-1793), SER, Chapter 15, Transient And Accident Analysis, Table 15.3-7: Assumptions Used to Evaluate the Radiological Consequences of the Loss-of-Coolant Accident,* Page 15-98.

Associates' April report, the evidence reviewed shows three major matters in question that differentiate Fairewinds Associates' review from the non-conservative assumptions assembled to facilitate certification of the AP1000 design. These differences are:

1. First, Fairewinds' report shows that the leakage through a rust hole is much larger than one-tenth of one-percent per day.
2. Second, Fairewinds' report shows that the leakage through the rust hole would not decrease as the accident progresses.
3. Third, Fairewinds' report shows that the leakage progresses directly into an unfiltered area. And, because the annular area is unfiltered, radioactive iodine is not eliminated and therefore thyroid doses are a factor of 100 times higher than they would be if filtration were to occur.

The net effect of all these non-conservative assumptions in the AP1000 design by Westinghouse its NRC review is that post accident radiation doses to the public could be several orders of magnitude higher (one hundred to one thousand times higher) than those assumed by Westinghouse in its AP1000 design. Such calculational flaws quite seriously impact emergency planning over a much broader area than that presently assumed in the Westinghouse SAMDA analysis and NRC staff review.

Fairewinds Associates' Recommendation

In order to rectify the problems that Fairewinds has identified, Westinghouse and the NRC Staff must revise the AP1000 SAMDA analysis that presently ignores the large number of existing containment failures. Industry failure data does not substantiate the erroneous assumption that there is not a possibility that leakage from the AP1000 could exceed one-tenth of one-percent. The SAMDA analysis must include a realistic containment failure rate in conjunction with its associated increase in radiation exposure to the public.

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December 21, 2010