RESPONSE TO CITIZEN POWER ISSUES

Citizen Power Issue 1

The visual inspections are unlikely to detect significant amounts of corrosion originating from the outside of the containment liner until the corrosion goes through-wall. In addition, the scheduling of the IWE visual inspection (three times over a 10-year period) does not guarantee that the hole will be small when discovered. Specifically, once the corrosion goes through-wall, the corrosion location may then have access to additional moisture and oxygen, which could speed up the progress of the corrosion. Furthermore, the shape of the initial corrosion pocket may be important. If a broad area of the liner is corroded, then a greater amount of corrosion can possibly occur before going through wall, resulting in a larger extent of thinning liner surrounding the through-wall location.

Response

FirstEnergy Nuclear Operating Company (FENOC) provided commitments in letters dated June 1, 2009, July 28, 2009, September 2, 2009, September 8, 2009, and September 14, 2009, for extensive visual and volumetric examination of the Beaver Valley Power Station (BVPS) Units 1 and 2. These inspections include 100 percent visual examination of the accessible areas of the containment liner plate by an American Society of Mechanical Engineers (ASME) code qualified inspector during the next refueling outage for each unit, October 2009 for Unit 2 and October 2010 for Unit 1. These inspections are a part of corrective actions for liner degradation found in April 2009. These examinations will be followed by an enhanced ASME IWE visual examination scheduled 18 months later for BVPS, Units 1 and 2 (i.e., in April 2012 and April 2011, respectively).

In addition, FENOC has committed to perform volumetric examination of a minimum of eight non-random areas and 75 randomly-selected one-foot square locations of the containment liner plate of BVPS, Units 1 and 2. The non-random areas will be selected based on site-specific operating experience from areas that are likely to be subjected to localized pitting corrosion. The specific areas to be considered for selection include:

- areas that have been repainted more than once
- areas with irregular contour
- an area below the 2006 steam generator replacement construction opening (Unit 1 only)
- an area at grade level where concrete containment is exposed to the environment
- an area adjacent to where the through-wall degradation of the liner was discovered in April 2009 (Unit 1 only)

The BVPS, Unit 1, volumetric examination of non-random areas will commence on-line, within the current fuel cycle and will be completed prior to the end of the 1R20 refueling outage, not to exceed December 31, 2010. The volumetric examination of 75 randomly selected locations in BVPS, Unit 1, will be accomplished during the next three refueling outages starting with the October 2010 outage with completion no later than prior to the start of the period of extended operation in January 2016 (should the license be granted). For BVPS, Unit 2, the volumetric examination of random and non-random areas will be completed before the start of the period of extended operation. FENOC has also committed to evaluate applicable statistical methodologies to gain additional insight to be used as internal operating experience to augment the containment liner inspection program and to characterize the general state of the liner.

The U.S. Nuclear Regulatory Commission (NRC or the staff) has reviewed the containment liner plate operating experience in other United States nuclear power plants that were identified during different studies as well as related license event reports. According to the Oak Ridge National Laboratory detailed study (Reference 1) related to inspection and degradation of containments, visual examination of the liner plate is effective for gross defect detection and identification of areas to be included for more detailed examination. Furthermore, the industry experience with liner corrosion to date has revealed highly localized corrosion, versus degradation of broad areas of the liner. The staff has determined that the planned 100 percent visual examination of the accessible area of the BVPS, Units 1 and 2, containment liner plates, supplemented by volumetric examination of BVPS, Unit 1, non-random and random areas, will provide reasonable assurance that a broad area of the liner corrosion can be detected before going through-wall, which may result in a larger area of thinned liner surrounding the through-wall corrosion location. However, if such areas are identified, they will be evaluated to see if the sample size merits expansion.

Citizen Power Issue 2

The Integrated Leak Rate Test (ILRT) also suffers from not being designed to detect corrosion until it goes through-wall. In addition, the containment concrete inhibits airflow, making the ILRT highly inaccurate for measuring the leak-tightness of the steel liner without compensating for the concrete. Any analysis of whether the liner satisfies the Title 10 of the *Code of Federal Regulations* (10 CFR) Part 100 requirements may similarly be inaccurate if it is based solely on an ILRT. It was, in our opinion, unclear whether extrapolating the North Anna Power Station (North Anna) localized pressure tests to determine the estimated leakage at BVPS, Unit 1, was appropriate. It should also be noted that the 2006 ILRT did not detect the hole discovered on April 23, 2009.

Response

The North Anna, Unit 2, and BVPS, Unit 1, containments are identical in diameter, concrete wall and liner plate thickness. The diameter of the hole found in the North Anna, Unit 2, liner plate in 1999 was 0.25 inch, while the equivalent diameter for the hole in BVPS, Unit 1, liner plate was 0.69 inch. FENOC extrapolated the leakage rate from the North Anna, Unit 2, local leak rate test performed at the 0.25 inch hole. BVPS, Unit 2, liner plate hole area is 7.6 times greater than that of North Anna, Unit 2. Therefore, North Anna, Unit 2, leakage rate was increased by a factor of 7.6 to get equivalent leakage for BVPS, Unit 1. The staff has determined that this extrapolation is conservative because the 54 inch-thick concrete containment wall, which is connected to the liner plate, contributes significantly to leak-tightness of the containment in the event the liner plate is perforated.

The leakage rate requirements in 10 CFR 100 and 10 CFR 50.67 are for the whole containment system and not specific to the liner plate. The leakage rate of 0.10 percent of containment volume for the BVPS, Units 1 and 2, containment is for the complete containment system that includes leakage through the liner plate, penetrations, isolation valves, and concrete. Therefore, the staff has determined that FENOC's analysis for compliance with 10 CFR 100 and 10CFR 50.67 requirements is appropriate and acceptable.

Citizen Power Issue 3

The methodology of the random sample supplemental volumetric examination (based on c Chapter 4 of Electric Power Research Institute [EPRI] TR-107514) is not applicable to BVPS, Unit 1. The purpose of that report was to develop age related degradation inspection requirements for five piping systems at the Calvert Cliffs Nuclear Power Plant. FENOC inappropriately lifted the sampling mechanism of that report without applying the surrounding framework. Specifically, the program methodology requires that plausible age related degradation mechanisms (ARDM) be determined and sorted according to whether they were “probable (expected to occur), possible (not expected to occur) or impossible (cannot occur).” Probable ARDMs with significant impacts on the safety function require a formal response resolution. Only when the mechanism is not expected to occur, would the Chapter 4 sampling mechanism apply. This mirrors the language in Chapter 4 stating that “one key feature of this [sampling] approach is the assumption that none of the inspected items will contain significant levels of a degradation mechanism (X=0),” and "...the underlying assumption used throughout this report is that the degradation mechanism in question does not exist for the system/component being investigated...” In short, in order to use this statistical method, the null hypothesis is assumed to be that there is no degradation of the containment liner. When degradation of the containment liner has already been discovered, as in the current case, we believe that an alternative statistical model must be used that is based on a null hypothesis that there is already degradation.

In the case of BVPS, Unit 1, two separate events of significant degradation have occurred, with two different mechanisms explaining them (in one case a piece of wood and the other case water and oxygen accumulation during the construction of the concrete shell). According to evidence presented by the NRC staff during the Transcript of the 564th Advisory Committee of Reactor Safeguards (ACRS) meeting on July 8, 2009 (Agencywide Documents Access and Management System Accession Number ML092290693), two other sub-atmospheric plants have experienced significant liner corrosion originating from the outside. Both North Anna, Unit 2, and Surry Power Station (Surry),Unit 2, have had a two by four piece of wood found between the liner and the concrete causing corrosion. Since half of the three-loop sub-atmospheric plants have experienced significant liner degradation due to foreign materials located in the concrete, it is reasonable to state that this is a probable ARDM for these types of plants. This is especially true given that only two out of 97 plants that have not utilized a three-loop sub-atmospheric design have experienced similar problems. Therefore, the use of the Chapter 4 sampling program is inappropriate for this ARDM.

In addition, if FENOC wishes to rely on the guidance of EPRI TR-107514, other plausible ARDMs should be identified and categorized as probable, possible or impossible. If any of these ARDMs are possible, a sampling framework should be set up for each individual ARDM identifying areas that are more likely to have corrosion. Samples would then be taken to meet the 95/95 standard for each of the possible ARDMs.

Response

The staff has reviewed the operating experience records of United States nuclear power plants and found that the following plants have previously experienced through-wall corrosion of the containment liner plate:

- North Anna Unit 2, PWR sub-atmospheric containment
- DC Cook Unit 2, Ice Condenser, atmospheric containment
- Brunswick Unit 2, BWR, atmospheric containment

Foreign objects (wood or a glove) were found to be trapped behind the liner in all the three plants (North Anna, Unit 2, Brunswick Steam Electric Plant, Unit 2, and Donald C, Cook Nuclear Plant, Unit 2) that had through-wall corrosion. Therefore, the industry has concluded that construction imperfections and foreign objects trapped behind the liner is the root cause. As indicated in the listing for the three plants (and including BVPS, Units 1 and 2), the type of containment (sub-atmospheric or atmospheric) is not a common characteristic of the plants which have identified through-wall corrosion of the liner plate. FENOC reached the same conclusion for BVPS, Unit 1, liner perforation since the as-found condition is similar to that identified at these three plants (e.g., localized corrosion tied to foreign material at the concrete to liner interface). The staff also believes that foreign objects are the root cause of the localized, through-wall corrosion at BVPS, Unit 1, however; additional visual and volumetric examinations planned by FENOC may provide further insight regarding the potential corrosion mechanism in the containment liner plate.

Surry, Units 1 and 2, have not experienced through-wall liner plate corrosion. In 2001, pieces of wood were found in external surface of the containment dome concrete at Surry, Unit 2. One one and a half inch by one and a half inch piece of wood extended through the containment concrete to the dome liner; the wood piece was removed. The liner was cleaned in this area and the measured thickness was still at design thickness. The concrete was then repaired.

FENOC determined the random sample size based on the assumption that there is no other corrosion at the liner- concrete interface. The degraded areas that were discovered previously have been replaced. If any of the 75 samples are found to be measurably degraded (consistent with FENOC's commitment), the size of the sample will increase in accordance with EPRI TR-107514. The use of this new random sampling plan is consistent with the current practice in the nuclear industry, and is considered to provide a high confidence level from a statistical standpoint. For instance, for the Inservice Inspection (ISI) of snubbers (i.e., hydraulic seismic dampers for piping) and buried piping, during each new random sample, the size of population selected is the same and not dependent on any previous degradation noted.

Any degradation discovered that does not meet the volumetric examination acceptance criteria will result in examination of additional randomly selected samples, as necessary to meet the confidence criterion described in EPRI TR-107514. In addition, FENOC will evaluate applicable statistical methodologies to characterize the general state of the containment liner plate.

The staff has determined that the selection of the initial random sample of a minimum of 75 locations, and the inclusion of additional random samples, in case one or more of the initial sample fails the examination acceptance criteria, conforms to the guidance provided in Section 4 of EPRI TR-107514 and NUREG 1475, "Applying Statistics." In any case, FENOC will perform sufficient random sampling to ensure 95 percent confidence that 95 percent of the accessible portions of the containment liner are not experiencing localized pitting corrosion of concern with greater than 10 percent loss of material. For all of the planned supplemental volumetric examinations, adverse findings will be addressed by FENOC's corrective action program as described above.

Citizen Power Issue 4

Citizen Power does not believe the proposed sampling regime is appropriate. However, if the EPRI TR-107514 sampling method is used as proposed by FENOC, it will not provide a 95 percent confidence that 95 percent of the liner is not degraded. One reason is that not all of the liner is accessible. If the corrosion mechanism results in the distribution of corrosion not occurring randomly across the liner, then a sample of only the accessible areas of the liner may result in an understatement or overstatement of an attribute. The key factor in predicting whether the corrosion would be random across the liner is an understanding of the differing potential mechanisms of corrosion. If any locations are more likely to have corrosion based on any possible ARDM, then these areas (at least the accessible ones) should be sampled independently using a method designed to meet the 95/95 standard. This is exactly what is proposed in EPRI TR-107514.

In addition, the timing of the samples, according to Amendment No. 39 to the BVPS, Units 1 and 2, license renewal application (LRA), can take place over a period of years. It is clear that the 95/95 standard will not be reached until the last sample is investigated because the required sample size will not be met until then. For BVPS, Unit 1, this can be as late as January 26, 2016, and for BVPS, Unit 2, it can be as late as May 27, 2027. This also parallels another problem with the proposed sampling. If the sampling is not accomplished within as short of a time frame as possible, the results may be skewed. For example, a sample that has just less than 10 percent corrosion depth when being sampled in the first year may have greater than 10 percent corrosion depth at the time of the last sample, years later. This phenomenon should be adjusted for by conservatively estimating (in this case the fastest probable corrosion rate) future increases in corrosion depth for these locations from the time they are sampled to the time that the sampling is completed.

Response

The inaccessible areas of the BVPS, Units 1 and 2, liner plate are those areas where the liner plate is embedded in concrete or made inaccessible during construction or otherwise obstructed by adjacent structures or components; examination of these areas is not practical. However, FENOC is committed to evaluating statistical methodologies to gain insights to augment the containment liner inspection program based on visual, non-random, and randomly selected volumetric examinations of the accessible area. The inaccessible areas of the BVPS, Units 1 and 2, liner are quite small, constituting less than five percent of the containment liner surface.

The staff determined that FENOC’s planned volumetric examination at a minimum of eight non-random locations, described previously for Issue 1, will supplement the results of examinations at the 75 randomly selected (one-foot square) locations and will provide an early indication of loss of containment liner plate integrity and leak tightness by December 2010. Adverse findings from the examinations will be addressed in the corrective action program and will involve additional examinations, assessments, and repairs, as necessary. Completing volumetric examinations for BVPS, Unit 2, before the period of extended operation is acceptable since liner plate degradation has only been identified in BVPS, Unit 1. BVPS, Unit 2 was constructed several years later than BVPS, Unit 1.

Citizen Power Issue 5

The eight non-random sample locations should be selected based upon possible corrosion mechanisms, as described in EPRI TR-107514. Some mechanisms, such as foreign matter, will most likely not exhibit any spatial bias. However, some possible mechanisms may result in corrosion in some locations more often then others. These potential mechanisms should be identified and more-likely corrosion locations based on these mechanisms should be the sample from which the non-random locations are chosen.

Response

The non-random locations will be based upon possible corrosion mechanisms based on operating experience as stated in response to Issues 1 and 4.

Citizen Power Issue 6

In Citizen Power's opinion, at this point in time, FENOC cannot know the actual condition of the liner because the visual IWE inspections and the ILRT are ill-suited to detect corrosion originating from outside the liner. Therefore, it is impossible to know whether the design limits for the containment liner are being exceeded without a proper investigation of the liner for corrosion. Given that there is a possibility that the containment liner currently would not perform its intended function in the event of an accident, Citizen Power believes that the only way to provide assurance that corrosion of the liner is not a safety issue is to immediately conduct an adequate ultrasonic testing examination of the containment liner.

Response

Visual examinations on BVPS, Unit 1, liner plate were conducted in April 2009 as a part of a scheduled IWE examination; the highly localized, through-wall corrosion of the liner plate was detected during this examination. The liner plate portion with the degradation was removed and replaced. The visual examination of BVPS, Unit 1, liner plate provided reasonable assurance that other areas of the liner plate are free of through wall corrosion at the time of inspection. FENOC is committed to complete BVPS, Unit 1, non-random sample examination online prior to the end of the next scheduled outage in December 2010. The non-random sample locations will be selected in areas most likely to have through-wall corrosion based on plant operating experience as described in response to Issue 4 above. The volumetric examination at non-random locations examination will provide early insight regarding potential corrosion mechanisms in the containment liner plate.

Through-wall corrosion is a slow process as evidenced by industry operating experience. Therefore, the staff has determined that the current schedule of completing the volumetric examination for the BVPS, Unit 1, non-random samples on-line by December 2010 (18 months after the last visual examination) and volumetric examination of randomly selected samples in the next three scheduled outages will provide reasonable assurance that containment liner plate has been adequately scrutinized to ensure that it will perform its intended safety function in the event of an accident.

Citizen Power Issue 7

Finally, in the July 24, 2009, conference call, FENOC suggested the following wording for their clarification letter to their request for additional information response letter L-09-139, "These random inspections will commence in the 2010 refueling outage at unit #1 and the 2011 refueling outage at unit #2. The additional informed sampling of Unit 1 will commence on-line, within the bounds of the current fuel cycle. All inspections will be completed by December 31, 2012." However, in the Amendment No. 39 to the BVPS, Units 1 and 2, LRA, the updated LRA sections indicate that random examinations of BVPS, Unit 1, are to be completed by January 2016, the random examinations of BVPS, Unit 2, are to be completed by May 2027, and the implementation schedule for non-random examination of BVPS, Unit 2, is May 27, 2027. Citizen Power believes that inspection schedules that stretch out this long imperil public safety because there is no guarantee that corrosion of the liner will be detected before breach of the containment occurs.

Response

Subsequent to July 24, 2009, conference call, the staff held several conference calls and received several letters from FENOC which clarified the schedule for volumetric examinations for BVPS, Units 1 and 2, containment liner plate. The final schedule proposed by FENOC and accepted by the staff is as follows:

BVPS, Unit 1

- 100 percent visual examination of the liner plate during the next refueling outage in October 2010.

- Volumetric examination of a minimum of eight non-random sample locations will commence on-line, prior to the beginning of the refueling outage in 2010. The examinations will be completed by December 31, 2010.

- Volumetric examination of the initial sample lot of a minimum of 75 random sample locations will be completed in the next three refueling outages beginning with BVPS, Unit 1, refueling outage in 2010. The random sample plan will be completed by January 29, 2016.

- Visual examination during the scheduled IWE examination in April 2012.

- FENOC will evaluate if any appropriate/applicable statistical method exists to gain additional insight into potential liner plate degradation. Data gathered will be evaluated and used to determine the general state of the liner.

BVPS, Unit 2

- 100 percent visual examination of the liner plate during the next refueling outage in October 2009.
- Visual examination during the scheduled IWE examination in April 2011.
- Volumetric examination of a minimum of eight non-random sample locations will be completed by May 27, 2027.
- Volumetric examination of the initial sample lot of a minimum of 75 random sample locations will be completed by May 27, 2027.

The applicant will provide a summary of the volumetric examination results as docketed information to the NRC after each BVPS, Unit 1 and 2, outage.

As discussed in response to Issue 6, the staff has determined that the visual and volumetric examination schedule noted above for BVPS, Units 1 and 2, containment liner plates provides reasonable assurance that the containment system will perform its intended safety function in the event of an accident.