Joseph E. Pollock
EXECUTIVE DIRECTOR
FUKUSHIMA RESPONSE COORDINATION AND STRATEGY

October 5, 2012

Mr. David L. Skeen
Director, Japan Lessons Learned Project Directorate
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Containment Filtration Strategies for Mitigating Radiological Releases in Severe Accidents for BWR Mark I and Mark II Plants to Reduce the Risk of Land Contamination

Project Number: 689

Dear Mr. Skeen:

Thank you for your letter of September 21, 2012, responding to Nuclear Energy Institute (NEI)[1] letters of May 15 and June 14, 2012, requesting additional information regarding the industry's position on containment filtration strategies for mitigating radiological releases. This letter offers updated information and describes plans for moving this issue forward.

Industry Position

Boiling water reactors (BWR) with Mark I and Mark II containments licensed to operate in the United States should have the capability to use various filtration strategies to mitigate radiological releases from containment. The approach to developing these strategies or enhancing existing strategies should be founded on scientific and factual analysis and should be performance-based to achieve the desired outcome. A comprehensive approach is required to ensure that radionuclide aerosols are filtered and retained in containment during severe events.

[1] NEI is the organization responsible for establishing unified nuclear industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all utilities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

1776 I Street, NW | Suite 400 | Washington, DC | 20006-3708 | P: 202.739.8114 | F: 202.533.0127 | jep@nei.org | www.nei.org

Containment Filtering Strategies for BWR Mark I and Mark II Plants

Containment filtering strategies have been developed through an initiative to provide the best, safest and most comprehensive methods to mitigate releases from BWR Mark I and Mark II containments should there be damage to the core. Many of the elements of the filtering strategies are existing severe accident management capabilities or refinements to severe accident management guidance or capabilities. The findings of this scientific initiative were released on September 25, 2012, by the Electric Power Research Institute (EPRI) in a comprehensive technical report[2] that engineers and scientists have completed over the past year. The findings demonstrate that substantial decontamination factors for radioactive releases can be achieved by a comprehensive strategy that includes installed equipment, operator actions and capabilities that are largely consistent with the diverse and flexible coping strategy (FLEX). The EPRI report evaluates filtering strategies that maintain and in many cases enhance the containment function during scenarios that involve long-term loss of station power with installed equipment not available. These strategies included water injection, spray of the containment, venting, controlled venting, filtered venting and various combinations of these actions.

These important conclusions are drawn from the EPRI report:

- First and foremost, all effective filtering strategies – with or without external filters – must rely on operator action and active systems to provide water to cool the fuel debris that is outside the reactor vessel.
- Maintaining containment integrity is critical to preventing radioactive releases that by-pass the containment vent. This can only be achieved by active debris cooling and controlled containment venting.
- Water injection into containment by spray and immersion (flood) both cool the fuel debris and filter aerosols, thereby mitigating potential releases.
- Controlling the reliable hardened vent by cycling (periodic opening and closing of the containment vent) maximizes aerosol capture and prevents hydrogen buildup.
- A combination of these actions would result in 99.9 percent removal of radionuclides that have the potential to contaminate the environment. (They provide for a containment system decontamination factor (DF) of greater than 1000, which is a common international requirement.)
- Low specific-DF filters used in combination with the other strategies may further reduce radionuclide releases. However, the aerosols remaining after using the other required strategies would be composed of much smaller particles. The efficiency of the removal of

[2] EPRI (Electric Power Research Institute, 2012), *Investigation of Strategies for Mitigating Radiological Releases in Severe Accidents – BWR Mark I and Mark II Studies* (EPRI Product No. 1026539) Palo Alto, CA: EPRI (available on EPRI.com)

these very small particles has not been demonstrated with current filter designs and additional research would be needed.

No strategy has been identified where an external filter alone would successfully mitigate releases. Every strategy involving success with an external filter also required actions to cool the fuel debris, which are the same actions that successfully filter fission products with the water used to cool the containment and fuel debris.

Importantly, the external filters in use (or planned) in other countries are tanks partially filled with water where the aerosols in gases vented from containment are removed by being injected into the water. During a severe event involving fuel damage water must – in all cases – be injected into containment to cool core debris. The EPRI analysis shows that the water in containment filters the aerosols from the containment vent gas and has the advantage of retaining the radionuclides in containment.

Decontamination Factor as Performance Basis

The EPRI report examines how containment system DF varies with land contamination and, therefore, provides a performance basis for judging filtering strategies. As described in Appendix A of the EPRI report, once the containment system DF reaches 1,000, the benefit of larger DFs diminishes significantly. A DF of 1,000 is a common international requirement for removal of aerosols from containment vent gas and is also the point where DF measurements become very difficult to discern, especially for pre-filtered effluents such as from BWR wetwell vents. Taking these factors together indicates that containment system DF is a good performance basis for filtering strategies.

Impact on Individual Plant Designs

To implement the EPRI study findings at individual plants, companies will have to conduct an evaluation based on the EPRI analysis to determine the appropriate filtering strategy for that plant. This will require development of a performance-basis prior to the analysis, which is discussed below.

Once the course for each plant is determined, plant modifications may be needed to:

- ensure reliable containment spray and/or fuel immersion during a severe accident
- provide reliable wetwell and drywell severe accident vents that can be used to control the venting rate, either automatically or manually (or in combination)
- enhance FLEX capability to support filtering strategy deployment
- enhance Severe Accident Management Guidelines (SAMGs)

- protect Mark II wetwell – drywell interface to prevent vent bypass
- add filters as on a plant specific basis, if needed.

We are encouraging innovation by the nuclear industry vendor community to provide designs and products that will assist companies in meeting this challenge.

Timeline

Applying the findings of the EPRI study to individual plants will take significant effort and time. At a minimum, each plant (or class of plants) will have to perform a specific evaluation based on the EPRI methodology to determine the appropriate strategy to implement. This would require, prior to initiation of the study, alignment with NRC on the filtering strategy performance-basis, development of a regulatory vehicle, implementation guidance, design basis assumptions, severe hazard considerations, accident scenario requirements, etc. Experience suggests that this will involve numerous meetings among NRC staff, industry and other stakeholders over at least 24 months.

Following development of the performance-basis, etc., a significant amount of time is required to perform the required analysis, engineering, design, development, procurement, plant walk-downs, installation, testing, training, and so on. These timeline considerations apply regardless of whether or not the filtering strategy selected by an individual plant includes an external filter.

Questions Raised by NRC about Filtering Strategies

The EPRI study is a major step forward in understanding the scientific direction that containment vent filtration should take to mitigate radiological releases from BWR Mark I and Mark II containments during severe events. However, the engineering needed to apply the study findings to the individual plants has not been done. The questions posed in the September 21 letter require additional effort to provide the desired information to assure the industry, NRC and the public that the filtering strategies can be reliably implemented when needed. This includes an evaluation of the NRC analyses supporting the forthcoming commission paper on filtered containment venting systems. We intend to provide additional information and review in the coming months as information is developed. With this said, there are three items we wish to address here:

1. Operator reliability during severe accident conditions: As part of filtering strategies development, plant personnel will receive the appropriate training. This applies to all operator actions that need to be carried out during a severe event and not just those related to implementing filtering strategies. Furthermore, since any filtering strategy, including any that involve an external filter, require water injection to containment to cool the core debris, these operator actions are not exclusive to filtering strategies without external filters. On a related matter, NRC is currently engaged in a rulemaking concerning SAMGs and emergency

procedures. This will afford NRC regulatory oversight of the SAMG implementation for filtering strategies, as well.

2. Containment vent control: We understand the need to provide appropriate reliability to this operation whether it will be a self-actuating relief valve, an instrumented valve capable of operating during station blackout conditions, a manual valve or a combination. The actual duty cycle for this valve will be determined by plant specific analysis. While not downplaying the importance of the reliability of this operation and potential service conditions, the valve would not have to actuate repeatedly throughout the life of the plant.
3. Hydrogen control: This is a situation that the EPRI report suggests is aided by cycling the containment vent. However, hydrogen control has not been fully addressed. Hydrogen control is a post-Fukushima Tier 3 issue involving long-term review.

Need for Integration with Other NRC Beyond Design Basis Activities

As the industry is implementing the Tier 1 post-Fukushima requirements, safety enhancements are not being delayed. Therefore, there is time to gauge the impact of the Tier 1 actions and learn the lessons from their implementation. There are four matters the NRC is considering concurrently that are directly related to each other through potential off-site effects of severe events: Near-Term Task Force Recommendation 1 about beyond design-basis regulation, Risk-Management Task Force Report, economic consequences of land contamination, and filtered containment venting systems. Each of these four major efforts has the potential to alter in a significant manner all or important parts of the way NRC regulates nuclear power plants. The NRC should consider these matters as one and develop a consistent direction. This would avoid Commission decisions on each matter made in isolation from the others. This would allow for synergistic decision making that would benefit each matter by avoiding overlap and the potential for conflicting decisions.

The industry has recently conducted international benchmarking studies in addition to participating in international forums where filters have been a focus area. It is important to note that while filters have been installed in some non-US operating facilities, they were not designed in consideration of extreme external events. Evaluations are starting of changes to strategy and designs needed in consideration of extreme external events. It has been made clear by our international counterparts, that this transition in design consideration will not be a simple task and will require significant analysis by industry scientists and engineers to ensure no unintended consequences are created.

The best approach to reduce the potential for land contamination is fundamentally by the numerous actions already promulgated under Tier 1 to prevent core damage. Having stated this, it is important to also state that the industry is fully committed to continuing our scientific research and technical analysis to provide the most effective means to further improve our mitigation capabilities.

We look forward to continuing to engage with NRC and other stakeholders to further the development of a performance-based approach to mitigating releases from containment during severe events.

If you have any questions, please do not hesitate to contact me or Steven P. Kraft (202-739-8116; spk@nei.org).

Sincerely,

Joseph E. Pollock

c: Mr. Michael R. Johnson, EDO, NRC
Mr. Robert M. Taylor, NRR/JLD, NRC
Mr. John D. Monninger, NRR/JLD, NRC