December 14, 2002

Petitioner's Responses to Comments by Westinghouse and NEI

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On page 2 of the attachment to its comments dated October 22, 2002, Westinghouse states, "More recently, Westinghouse conducted tests with pure oxygen instead of steam." With difficulty, the Petitioner located a reference that apparently describes this work, WCAP-12610, Appendix E, August, 1990. Only a limited portion of the report is available to the public and it is classified by Westinghouse as a proprietary report. The high temperature oxidation tests were performed by Nuclear Electric, plc in the United Kingdom. Twenty four ZIRLO alloy and six Zr-4 samples were tested at temperatures ranging from 1832F to 2372F. The cylindrical tubing specimens were approximately 0.6 inches long and were from production grade 17x17 tubing.

Appendix E candidly discloses: "Since, particularly at high temperatures, the self heating of the specimen results in its being at a higher temperature than its surroundings, any temperature measured will be equal to or lower than that of the test specimen." In other words, in order for the investigators at Nuclear Electric to prevent runaway from the heat of reaction at high temperatures (self heating) it was necessary to maintain the surroundings at a substantially lower temperature than the specimen. In this manner, the heat loss by radiation to the relatively cold surroundings compensated for the heat produced by chemical reaction with the pure oxygen. This then leads to the question: What if Nuclear Electric had conducted the investigation with a 17x17 arrangement of ZIRLO or Zr-2 tubes captured within a Zircaloy-4 structural grid with ZIRLO thimbles as depicted in FIGURE 2-1 of WCAP-12610? The answer is that the assembly would have rapidly been destroyed in runaway if a sufficient flow of oxygen had been maintained.

The oxidation tests of the ZIRLO alloy and Zr-4 samples were conducted within a very "quiet" oxygen atmosphere. The apparatus was extremely delicate. The investigators reported, "Pure oxygen gas was used as the oxidant rather than steam. It is believed that, if steam were used, condensation on the suspension wire could invalidate the weight gain measurements." From this it may be inferred that the apparatus was certainly insufficiently robust to accommodate the turbulent thermal hydraulic conditions of LOCA. The oxygen supply system and flow rates are not disclosed in Appendix E, but it must have been a very tender application of oxygen to not upset the suspension wire and the weight gain apparatus.

Next the Petitioner responds to comments from Westinghouse and NEI that cover another matter. In its October 22, 2002, set of remarks Westinghouse asserts, "The conditions of FLECHT Run 9573 were extremely severe and from a LOCA standpoint should be considered beyond the design basis for ECCS. Despite the severity of the conditions and the observed extensive zirconium water reaction, the oxidation was within the expected range and runaway oxidation occurred beyond 2300F." The comments from NEI dated October 25, 2002, also refer to FLECHT Run 9573 and runaway as follows, "The test, FLECHT Run 9573, has not been ignored. The test was performed under very severe, beyond design basis conditions. Post test evaluations showed that oxidation was within

the expected range and "runaway" oxidation did not occur until the temperature was well beyond 2300F."

Westinghouse asserts that the temperature of the cladding at start of reflood was excessive in Run 9573. Westinghouse says nothing about the impact of the severe fouling on fuel elements that has been observed at several nuclear power reactors. Of course, severe fouling means that the fuel cladding will likely reach substantially higher temperatures during LOCA than was the case in Run 9573. Run 9573 was designed with no allowance for the severe fouling that characterizes today's nuclear power plant operations within technical specifications.

Westinghouse submitted the report WCAP-12610 to the NRC with a two page cover letter (NS-NRC-90-3519) on June 13, 1990. The opening sentence is, "Westinghouse has developed an advanced fuel assembly design which provides increased corrosion resistance (allowing for increased flexibility in coolant chemistry operations), enhanced fuel reliability, and the capability to support discharge burnups up to a lead rod average burnup of 75,000 MWD/MTU." The so-called increased flexibility in coolant chemistry operations is likely among the sources of the mindset that severe fouling of nuclear fuel elements is an acceptable operating condition that is well within technical specifications. As the Petitioner has already stated: Run 9573 was designed with no allowance for the severe fouling that characterizes today's nuclear power plant operations within technical specifications.

So:

What actions should the Commission pursue that would provide a rational basis for the regulation of emergency core cooling systems?

One required action is the performance of more experiments with zircaloy cladding on the scale necessary to overcome (or confirm) the impression left from run 9573. The experiments must include the severe fouling that has characterized the operations of several LWRs.

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