UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

IN THE MATTER OF	)	
	)	Docket No. 50-155-OLA
CONSUMERS POWER COMPANY	)	(Spent Fuel Pool
	)	Modification)
Big Rock Point Nuclear	)	
Power Plant	)	

CONSUMERS POWER COMPANY'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW ON CRITICALITY CONTENTION

I. FINDINGS OF FACT

1. O'Neill Contention IIE-3 states:

> The application has not adequately analyzed the possibility of criticality occurring in the fuel pool because of the increased density of storage without a gross distortion of the racks.

2. On February 5, 1982, the Licensing Board denied Licensee's motion for summary disposition of this contention on the ground that Licensee had not analyzed the possibility of criticality occurring in the Big Rock storage pool at credible temperatures over 212°F or under a credible accident that would distort the fuel racks.[1/]

3. On February 19, 1982, the Board determined that a genuine issue of fact existed whether the Big Rock spent fuel pool might reach supercriticality if it were to begin boiling, on the basis of the results presented in Cano, J.M., Caro, R., and Martinez-Val, J.M., "Supercriticality Through Optimum

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1/ Memorandum and Order (Denying Summary Disposition of Criticality Contention), February 5, 1982, at 3-5.

Moderation in Nuclear Fuel Storage," 48 Nuclear Technology at 251-260 (1980).[2/]

4. Dr. Daniel A. Prelewicz is an engineer with thermal hydraulics expertise. His testimony addresses the natural circulation cooling process in the Big Rock spent fuel pool and determines the thermal conditions for use in the criticality anaysis, assuming that all pool cooling systems are lost.[3/]

5. Dr. Rodney Gay is an expert in thermal hydraulic analysis. He co-authored with Dr. Prelewicz a study entitled "Spent Fuel Pool Thermal-Hydraulic Analysis For Big Rock Point Plant", which uses the GFLOW computer code, developed by Dr. Gay, to model the natural convection currents in the Big Rock pool in three dimensions.[4/]

6. Raymond F. Sacramo is a mechanical engineer. His testimony analyzes the nature of the distortion of the racks that could occur as a result of a fuel assembly drop or heating of the pool.[5/]

7. Dr. Yong S. Kim is an expert in criticality analyses. His testimony addresses the questions raised by the

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2/ Memorandum and Order (Concerning Motions for Summary Disposition), February 19, 1982, at 48-49.

3/ "Testimony of Daniel A. Prelewicz Concerning Thermal Hydraulic Conditions for Criticality Analysis," hereinafter "Prelewicz Testimony", following Tr. 1420.

4/ "Spent Fuel Pool Thermal-Hydraulic Analysis for Big Rock Point Plant" is Attachment A to the Prelewicz Testimony.

5/ "Testimony of Raymond F. Sacramo Concerning Possible Distortion of the Spent Fuel Pool Racks (O'Neill Contention IIE-3)," hereinafter "Sacramo Testimony", following Tr. 1421.

Board in its orders of February 5 and February 19: the effect of possible water temperatures higher than 212°F on k-effective, the effect of possible rack distortions on k-effective, and the potential of supercriticality through optimum moderation in nuclear fuel storage.6/

8. Mr. Edward Lantz is a Senior Reactor Engineer in the NRC Staff's Reactor Systems Branch. His testimony addresses the Board's concerns regarding the effects of pool temperature or rack distortion on k-effective and the possibility of supercriticality through optimum moderation.7/

9. On May 13, 1982, the Board requested comments on whether natural convection currents could be substantially altered by either (a) the geometry of the pool, the racks or the fuel elements, or (b) by debris that could fall into the pool under a credible scenario. If so, the Board queried the possible effects on k-effective.8/

10. David P. Blanchard, a Technical Engineer stationed at Big Rock Point, is expert in both thermal hydraulics and criticality analysis and has, in addition, first-hand

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6/ "Testimony of Yong S. Kim Concerning Criticality Analysis (O'Neill Contention IIE-3)", hereinafter "Kim Testimony", following Tr. 1419.

7/ "Testimony of Edward Lantz Concerning O'Neill Contention No. II.E.3.", hereinafter "Lantz Testimony," following Tr. 1905.

8/ Memorandum Clarification Concerning O'Neill Contention IIE-3), May 13, 1982, at 1.

knowledge of plant operations on a daily basis. His testimony addresses the questions raised by the Board in its Memorandum of May 13, 1982.[9/]

11. The saturation, or boiling, temperature of water is a function of pressure and will increase with depth due to the hydrostatic head of water in the pool.[10/]

12. Once the saturation temperature is reached, further energy input to the water results in generation of steam bubbles or voids.[11/]

13. Although the saturation temperature at the bottom of the Big Rock spent fuel pool is 243°F, a natural circulation process prevents this temperature from actually occurring.[12/]

14. Where temperature increases with depth and heat is continuously added, a natural circulation flow is established, whereby heated water rises continuously to the surface near the center of the pool, while cooler water flows downward near the pool walls.[13/]

9/ Tr. 1798-1801; "Testimony of David P. Blanchard in Response to Board Questions Relating to Natural Water Convection Currents," hereinafter "Blanchard Testimony," following Tr. 1431.

10/ Prelewicz Testimony at 3.

11/ Id.

12/ Prelewicz Testimony at 4.

13/ Id.

15. The computer code SFPT2 models the circulation flow as a one-dimensional flow in the pathway, known as a downcomer, between the pool wall and the racks and the up-flow through a row of fuel bundles fed by the downcomer.[14/]

16. The inlet temperature of the water at the bottom of the racks is taken as 212°F and its heat-up as it rises through the fuel bundles is calculated to reach the saturation temperature of 237°F at .276 inches below the top of the most limiting fuel bundle.[15/]

17. The water temperature along the active length of the fuel will vary from approximately 212°F at the bottom to 237°F at the top, an average temperature of 224.5°F.[16/]

18. The length of fuel over which steam bubbles, or voids, will be generated, called the boiling length, is .276 inches.[17/]

19. At the exit of the fuel bundles, the void fraction, or ratio of steam volume to toal fluid volume, is .206. It varies over the boiling length from zero at the start of boiling position to .206 at the exit.[18/]

14/ Prelewicz Testimony at 5.

15/ Prelewicz Testimony at 6.

16/ *Id*.

17/ Prelewicz Testimony at 7.

18/ *Id*.

20. The GFLOW analysis of the Big Rock spent fuel pool performed by Dr. Gay demonstrates that natural circulation patterns in the pool cause the water entering the bottom of the fuel racks to be approximately 212°F, thus verifying Dr. Prelewicz's assumption in this regard.[19/]

21. Although GFLOW is a recently developed code, it can be relied on at least for the limited purpose of calculating the inlet temperature at the bottom of the fuel racks.[20/]

22. When Dr. Kim performed his original criticality analysis, the thermal conditions he was supplied with were a coolant temperature of 212°F and an exit void fraction of 20.6%.[21/]

23. After the Board's Order of February 5, Dr. Prelewicz provided Dr. Kim with the following more realistic conditions: The water temperature varies along the length of the fuel bundles from approximately 212°F at the inlet to 237°F at the exit; the average temperature over the active fuel length is 224.5°F. Bulk voids exist only for the upper .276 inches of the channel; the ratio of steam volume to total fluid volume is .206 at the exit.[22/]

19/ Prelewicz Testimony at 8.

20/ See Gay at Tr. 1630; Prelewicz at Tr. 1656-1663; Lantz at Tr. 1930-1932.

21/ Prelewicz Testimony at 7.

22/ Prelewicz Testimony at 7-8.

24. The Kim Testimony presents new criticality calculations based on the more realistic thermal conditions supplied by Dr. Prelewicz.[23/]

25. The purpose of Dr. Kim's original analysis was to determine the limiting fuel design for the Big Rock spent fuel pool by searching the highest enrichment consistent with the maximum permitted k-effective of 0.95. All existing fuel at Big Rock Point is much less reactive than this limiting design.[24/]

26. When the temperature of 224.5°F, the average temperature along the length of the fuel bundles, is used for the criticality calculation instead of 212°F, an increase of 0.0014 in k-effective results.[25/]

27. Use of the 224.5°F figure is appropriate. The temperature will rise in linear fashion along the fuel bundles,[26/] and reactivity also varies in linear fashion.[27/]

28. In his original analysis, Dr. Kim assumed that the steam void volume fraction of 0.206 was uniformly distributed along the length of the fuel assembly, an excessively conservative assumption in view of the actual void distribution over only the upper 0.276 inches of the fuel length.[28/]

23/ Kim Testimony at 3-4.

24/ Kim Testimony at 6-7.

25/ Kim Testimony at 7.

26/ Prelewicz at Tr. 1553.

27/ Kim at Tr. 1522.

28/ Kim Testimony at 7-8

29. The more realistic average void fraction yields an increase in k-effective of 0.00001, which is effectively zero. Because the original analysis had attributed an increase in k-effective of 0.0044 to steam voids, a net decrease of 0.0044 in k-effective results from the new calculation.[29/]

30. The effects of the revised stem void volume fraction and the revised average water temperature yield a net decrease in k-effective of 0.0030, so that the revised k-effective calculated by Dr. Kim is 0.9470, less than the permitted maximum of 0.95.[30/]

31. Dr. Kim's new calculations are correct given their assumptions. These assumptions are appropriately conservative.[31/]

32. Although the record indicates a certain lack of communication between Drs. Prelewicz and Kim during the early stages of their analyses, it in no way impugns their integrity nor casts doubt on the credibility of their testimony.[32/]

29/ Kim Testimony at 8.

30/ Kim Testimony at 8-9.

31/ Blanchard at Tr. 1823-1824.

32/ See Kim at Tr. 1436-1527; Prelewicz at Tr. 1530-1596.

33. Although Mr. Lantz and Dr. Kim followed somewhat different methodologies in determining k-effective for the Big Rock pool, there was no disagreement between them, either as to assumptions or results, for the relatively high water densities that would prevail under the assumed boiling condition.[33/]

34. The scientific literature recognizes the possibility of supercriticality (k-effective greater than 1.0) occurring under conditions where the water in a spent fuel pool is replaced by mist, foam, or some other form of very low density water.[34/]

35. For such low densities to occur at Big Rock Point, the water in the fuel storage pool would have to boil away at least below the level of the fuel racks.[35/]

36. For stainless steel racks of the Big Rock Point type, the supercritical condition never exists even for very low water densities, the maximum k-effective being less than 0.97.[36/]

37. Differences in calculated k-effective among different computer codes and methodologies are much more

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33/ Lantz at Tr. 1926-1927, 1933; Kim at Tr. 1947-1948.

34/ Kim Testimony at 10-11.

35/ Kim Testimony at 11.

36/ Id.

pronounced at very low water densities; at the densities that would prevail at Big Rock Point after the pool cooling system failure, such differences are comparatively small and Dr. Kim's analysis adequately accounts for them.[37/]

38. Dr. Kim's analysis shows k-effective going down between 0% and 10% void, then turning around at 15% to 20% void and thereafter slowly rising to reach maximum in the region of more than 80% void.[38/]

39. Reliable calculations of k-effective at void fractions of 40-50% or more, however, would require more sophisticated techniques, employing more energy groups, than those used in Dr. Kim's analysis.[39/]

40. Boiling-off of the water in the pool down to the level of the racks is not a credible accident scenario. The process would take a very long time; 700 hours would be required for all the water in the pool to boil off.[40/] In addition, Licensee has the capability to make up water lost from the pool during boiling through a remotely activated make-up line and this finding is contingent on our determining that this make-up line is reliable.[41/]

37/ Kim Testimony at 13.

38/ Kim at Tr. 1945; Kim Testimony at 12.

39/ Kim at Tr. 1944; Lantz at Tr. 1942-1943.

40/ Testimony of David P. Blanchard Concerning Christa-Maria Contention 8 and O'Neill Contention IIIE-2 at 8.

41/ *See* Genuine Issue of Fact (1) under Christa-Maria Contention 8 and O'Neill Contention IIIE-2.

41. Supercriticality will not occur at Big Rock Point even at very low water densities.[42/] Although there is doubt whether k-effective would remain below 0.95 at such densities, these conditions are not credible.[43/] Therefore, a more sophisticated calculation of k-effective at these very low water densities is unnecessary.

42. The drop of a fuel assembly into a storage rack could distort the fuel assembly support plate at the bottom of the rack or the lead-in guides at the top of the rack, depending on the way it fell.[44/]

43. The drop of a fuel assembly onto a storage rack would not distort the rack along the length of the stored fuel assemblies; thus, the center-to-center spacing of the storage cans would be maintained.[45/]

44. The drop of a fuel assembly onto a storage rack would produce no change in k-effective.[46/]

45. The maximum water temperature increase calculated by Dr. Prelewicz would produce an increase in the center-to-center spacing of the fuel storage cans of 0.015 inches over the nominal value of 9 inches.[47/]

42/ Finding of Fact 36.

43/ Findings of Fact 35 and 40.

44/ Sacramo Testimony at 3-4.

45/ Sacramo Testimony at 4.

46/ Kim Testimony at 9.

47/ Sacramo Testimony at 5.

46. This expansion of the fuel racks due to heating of the pool would produce a decrease in k-effective of 0.0018.[48/]

47. For purposes of conservatism Dr. Kim did not take credit for this decrease in his calculation of the value of k-effective.[49/] Had he done so his calculation of k-effective would have decreased from .9470 to .9452.

48. Water circulation in the Big Rock spent fuel pool is slightly altered by the storage of various small hardware items in the pool, but this effect is minimal because of the small volume of this hardware.[50/]

49. There are no features in the design of the fuel pool, the storage racks or the fuel elements that would substantially alter natural water convection currents which were not considered and adequately accounted for in the testimony of Drs. Prelewicz and Gay.[51/]

50. Because Dr. Kim's analysis assumes an infinite array of fuel assemblies, localized increases in the temperature and void fraction of individual assemblies will not significantly alter k-effective.[52/]

51. A large amount of debris would have to enter the pool, producing flow restrictions in large portions of the fuel racks, before a significant increase in reactivity would occur.[53/]

48/ Kim Testimony at 9-10.

49/ Kim Testimony at 10.

50/ Blanchard Testimony at 3-4.

51/ Blanchard Testimony at 4.

52/ Blanchard Testimony at 5.

53/ Id.

52. There are four potential sources of debris that could enter the pool either during normal operation or accident conditions. None of them would result in significant alteration of convective circulation currents in the fuel pool.[54/]

53. Particulate matter referred to as "crud", consisting mainly of iron oxide, is introduced into the pool from the reactor coolant during normal refueling operations. Because the pool water is cycled through filters, however, this crud does not build up and thus does not detrimentally affect natural circulation.[55/]

54. Crud could also be introduced into the pool in the make-up water that might have to be supplied after a loss-of-coolant accident, but the introduction of significant amounts would be limited by the fine mesh strainers through which the water would pass.[56/]

55. If a loss-of-coolant accident occurred, paint and coatings on surfaces within containment would resist the resulting high temperature, moisture and radiation environment. Any flaking of such coatings would be limited to

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54/ Blanchard Testimony at 6.

55/ Blanchard Testimony at 7-8.

56/ Blanchard Testimony at 8-9.

very localized effects that would not introduce debris into the spent fuel pool.[57/]

56. The steam drum blowout panel, mounted over the reactor deck, is filled with aggregate--rocks one to two inches in diameter--to provide biological shielding for the reactor deck.[58/]

57. If the panel should "blow out" from differential pressure following a loss-of-coolant accident, as it is intended to do, it would fall on the reactor deck and a small portion of the aggregate within the easternmost section of the panel could slide into the pool.[59/]

58. If any aggregate fell into the pool, the majority would fall into the southwest corner, which is the cask laydown area and does not contain any spent fuel.[60/]

59. Any effects of the aggregate falling into the pool would be limited to a few fuel assemblies.[61/]

57/ Blanchard Testimony at 9-10; Blanchard at Tr. 1804-1805.

58/ Blanchard Testimony at 10.

59/ Blanchard Testimony at 10-11.

60/ Blanchard at Tr. 1812.

61/ Blanchard Testimony at 11.

II. CONCLUSIONS OF LAW

1. The record demonstrates that the Big Rock Point spent fuel pool as modified in accordance with the pending application will not attain an effective neutron multiplication factor greater than the 0.95 allowed by existing Commission guidance under any credible accident scenario.

2. The possibility of criticality occurring in the fuel pool has been adequately analyzed.

3. The record provides reasonable assurance that the modification of the Big Rock Point spent fuel storage pool pursuant to a grant of the application as submitted would not endanger the health and safety of the public, consistent with 10 C.F.R. § 54.57(a)(3)(i) and General Design Criterion 62 (10 C.F.R. Part 50, Appendix A).

Respectfully submitted,

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DATED: October 1, 1982

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

IN THE MATTER OF CONSUMERS POWER COMPANY Big Rock Point Nuclear Power Plant	Docket No. 50-155-OLA (Spent Fuel Pool Modification)

CERTIFICATE OF SERVICE

I hereby certify that copies of CONSUMERS POWER COMPANY'S PROPOSED INITIAL DECISION ON CRITICALITY CONTENTION and CONSUMERS POWER COMPANY'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW ON CRITICALITY CONTENTION were served on all persons listed below by deposit in the United States mail, first-class postage prepaid, or by Federal Express overnight delivery this 1st day of October, 1982.

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