November 22, 1982

Peter B. Bloch, Chairman
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Oscar H. Paris
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. Frederick J. Shon
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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In the Matter of
CONSUMERS POWER COMPANY
(Big Rock Point Plant)
Docket No. 50-155
(Spent Fuel Pool Modification)

Dear Administrative Judges:

It has come to my attention that the enclosed memorandum from Harold R. Denton to B. Paul Cotter may not be in the public record in this proceeding. I am by this letter giving copies of this material and the memorandum to which it replies to all parties in this proceeding and having it placed in the public document files for this proceeding.

Sincerely,

Edwin J. Reis
Assistant Chief Hearing Counsel

Enclosures: As Stated

cc: (w/enclosures)
Michael I. Miller, Esq.
John O'Neill, II
Ms. JoAnne Bier
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Atomic Safety and Licensing Board Panel
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Herbert Semmel, Esq.
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MEMORANDUM FOR: B. Paul Cotter, Jr.
Chief Administrative Judge, ASLBP

FROM: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

SUBJECT: POSSIBLE ERROR IN K_{eff} FOR LICENSED FUEL POOLS

Members of the hearing board for Big Rock Point have expressed some concern about whether spent fuel pools might exhibit positive temperature coefficients, as a witness in the hearing, Dr. Yong Kim, testified, and whether such positive temperature coefficients may not be properly accounted for in the criticality analysis. The following discussions comprise the staff response to this concern.

It is true, as the witness testified, that certain spent fuel rack designs exhibit positive temperature coefficients at nominal fuel pool water densities. These racks contain minimum amounts of fixed poison and have relatively large spacings between assemblies. Current high density designs have strongly negative temperature coefficients.

Staff guidelines for analyzing criticality in spent fuel storage racks call for calculations to be performed at the temperature within the fuel pool limits which yields the largest effective multiplication factor. For racks with a positive temperature coefficient this means that analyses be performed at the temperature reached when a single failure occurs in the pool heat removal system, assuming also that the racks contain fuel with the highest anticipated heat output. This temperature is in the 150 to 170 degrees Fahrenheit range. In practice, in order to be conservative, the calculations are usually carried out to the temperature at which the coefficient becomes negative.

The amount by which the effective multiplication factor (K_{eff}) increases when the pool temperature is raised from ambient temperatures to boiling temperatures and above, is small - of the order of tenths of a percent. This is due to the shape of the curve of effective multiplication factor as a function of moderator to fuel ratio for which K_{eff} increases rapidly as the ratio is increased until the peak effective multiplication factor is reached and then decreases slowly. An increase in pool temperature of 25 degrees Fahrenheit (from 212 to 237) would cause a negligible increase in the effective multiplication factor.

Based on the above discussion the staff concludes that positive temperature coefficients are properly considered in the criticality analysis of spent fuel storage pools.

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A second concern expressed by the members of the hearing board was that of possible criticality due to the presence of very low density steam in the pool caused by loss of water. The following discussion addresses that concern.

Consideration of very low density moderation is not part of the design envelope for spent fuel storage pools. Single failure-proof heat removal systems, seismically qualified pools, and interlocks preventing the presence of heavy loads over the pool are all provided to prevent loss of water from the pool. If, nevertheless, it is postulated that long-term loss of cooling occurs and the water boils off or that somehow the water is suddenly lost from the pool with resultant steam flashing from the remaining water, the following comments can be made regarding possible criticality.

If boiling were to occur in the pool, it would first occur within the fuel assemblies with the water between the assemblies remaining at full density. This would cause a decrease in the effective multiplication factor. If boiling were to continue until the fuel begins to be uncovered, there would then be steam both within the assemblies and between them. The density of saturated steam at the boiling point of water (now 212 degrees Fahrenheit since the overpressure has been removed) is approximately $6x10^{-4}$ grams per cubic centimeter. The so-called secondary peak of the effective multiplication factor at very low density occurs for uniform moderator densities in the range of 0.01 to 0.05 grams per cubic centimeter. At the steam density, the effective multiplication factor for the uncovered portion of the pool would be very low. Leakage from the top of the still covered portion of the pool would reduce the effective multiplication factor of that portion still further. Thus we conclude that no criticality problem exists for this scenario.

Similar conclusions with respect to steam densities in the pool may be drawn for the second scenario - that of flashing steam from a sudden loss of water from the pool. It should be noted that the existence of realizable overpressures in the auxiliary building would not change these conclusions since the steam density can only be increased by a factor of two or three from this cause.

In summary, the staff concludes that positive temperature coefficients are properly treated in the analysis and review of spent fuel pool criticality, that the effect of very low density moderation does not need to be considered, and that no further investigation or analysis is required as a result of Dr. Kim's testimony.

I hope that this discussion satisfactorily addresses your concerns in this matter. If additional information is required, do not hesitate to inquire.

~~Original signed by~~ Original Signed by H. R. Denton

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL
WASHINGTON, D.C. 20555

June 28, 1982

MEMORANDUM FOR: William J. Dircks
Executive Director for Operations

FROM: B. Paul Cotter, Jr. BPC
Chief Administrative Judge

SUBJECT: POSSIBLE ERROR IN K_{eff} FOR LICENSED FUEL POOLS

Enclosed for your consideration is information on the possibility of subject error that arose in the Big Rock Point hearing. You may wish to explore the matter further.

Enclosures:
1. Memo fm Bloch and Shon to BPCotter, Jr. dtd 6/25/82
2. Transcript excerpt

cc: F. Shon
P. Bloch

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL
WASHINGTON, D.C. 20555

June 25, 1982

MEMORANDUM FOR: B. Paul Cotter, Jr.
Chief Administrative Judge

FROM: Peter B. Bloch
and
Frederick J. Shon

SUBJECT: POSSIBLE ERROR IN K_{eff} FOR LICENSED FUEL POOLS

In the course of the Big Rock Point hearing, Dr. Yong S. Kim stated that he has examined other spent fuel pools, beside Big Rock, in which K_{eff} had a positive temperature coefficient. (The relevant transcript section and Dr. Kim's resume are enclosed.)

If Dr. Kim is correct concerning positive temperature coefficients, then these other pools may exceed the 0.95 maximum k_{eff} standard imposed by the staff and apparently applicable under pool boiling conditions. It is traditional to analyze k_{eff} based on a maximum boiling temperature of water of 212°F, but fuel pools have a substantial head of water and may boil at temperatures as high as 237°F. In addition, under conditions in which water is lost from the pool, boiling may result in a very low density environment of steam and may cause unexpectedly high values for k_{eff}.

This matter should be brought to the Staff's attention, so that it may decide whether Dr. Kim's testimony raises a possible matter for further investigation or analysis.

Enclosures:
1. Transcript dtd 6/9/82
2. Resume, Yong S. Kim

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the Matter of: :
CONSUMERS POWER COMPANY : Docket Number 50-155-OLA
(Big Rock Point) :
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Aurora Room
Boyne Mountain Community Cent
Boyne Falls, Michigan

Wednesday, June 9, 1982

The hearing in the above-entitled matter, reconvened, pursuant to adjournment, at 9:00 a.m.

BEFORE:

PETER B. BLOCH, Chairman
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

DR. OSCAR H. PARIS
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

FREDERICK J. SHON
Administrative Judge
Atomic Safety and Licensing Board
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

between the assemblies is smaller.

JUDGE SHON: It's simply due to the fact that this design has much larger spaces, is that it, that the usual spent fuel pool?

WITNESS KIM: That is correct.

JUDGE SHON: Thank you. That's all I wanted to find out.

WITNESS KIM: May I add to your comment?

JUDGE SHON: Yes, please do.

WITNESS KIM: This is not the only spent fuel rack I analyzed. I looked at other types of spent fuel racks where whether the k goes up or goes down with the temperature, it depends on the individual type racks.

It's a combination of three or four different parameters. Some go up; some go down. When I say most, most means the ones I looked at, most of the fuel racks exhibited decreasing k with the temperature.

JUDGE SHON: Most of them exhibit --

WITNESS KIM: Right, but I have seen in my past that k goes up with the temperature for some other racks, which I actually looked at it myself.

JUDGE SHON: You have seen racks that --

WITNESS KIM: Yes, I have.

JUDGE SHON: -- were that over-moderated tha k goes up with temperature?

WITNESS KIM: Yes.

JUDGE BLOCH: Dr. Kim, I'm of a mixed mind here, because this really is not the reason that we sequestered witnesses. On the other hand, it's an important question.

If you have an objection, Mr. Gallo, we could discontinue this line of questioning and resume it later.

MR. SEMMEL: Actually, I'm finished with this line of questioning.

JUDGE SHON: Yes, but we're not.

MR. SEMMEL: Oh, I see.

MR. GALLO: I'll waive any objection to this line.

JUDGE BLOCH: We appreciate that.

Dr. Kim, how close to 0.95 criticality of k-effective were these other pools that you found that were also over-moderated?

WITNESS KIM: Those other pools I looked at, the calculations are based on the existing fuel they have at the site.

They were in the range of .91 to .93. That's for the existing fuel.

But Big Rock Point is not for the existing fuel. I'm shooting for .95.

JUDGE BLOCH: I see. If they had been

analyzed for the same kinds of conservative assumptions that you used, do you have any idea whether they would have approached or exceeded .95?

WITNESS KIM: No, they would not have exceeded.

JUDGE BLOCH: Even if analyzed for the conservative assumptions that you are talking about, not the actual amount of fuel in those other pools, but the fresh fuel assumptions and full rack assumptions that you've used?

WITNESS KIM: Yes. We use almost the same exact assumptions for different types of racks, and it would not exceed .95.

I'm talking about not Big Rock Point rack, but the racks I looked at in the past.

JUDGE BLOCH: Yes. We had asked about other racks, that's right, as to how close those racks came to .95.

I thought you had said that analyzing those other racks for the amount of fuel actually in them, that the k-effective was either .91 or .93, but that you hadn't seen analyses for theoretical maximum amounts of fuel for those other pools. Is that what you said?

WITNESS KIM: When you say maximum amount, it's maximum enrichment?

JUDGE BLOCH: Both.

WITNESS KIM: I did not analyze for maximum enrichment for those racks I'm discussing -- I'm mentioni

JUDGE BLOCH: For the other pools?

WITNESS KIM: Right.

JUDGE BLOCH: Thank you.

Mr. Gallo, we have a special constraint because we scheduled a witness for 1:00 o'clock last night -- 1:00 o'clock this afternoon.

So if you could conclude in the next four or five minutes and then we could take a recess, that would be helpful; not conclude with the witness necessarily, but reach a breaking point.

MR. SEMMEL: Actually, I think this would be an appropriate breaking point. I mean, I'm about to change the subject again.

JUDGE BLOCH: The hearing is in recess unti 1:00 o'clock. At that time we have another witness for the first 15 minutes, and then you would be recalled.

We wish to remind you about the sequestratic order, which means there should be no discussion on these subjects during the lunch hour.

(Whereupon, at 12:00 noon, the hearing was recessed, to reconvene at 1:00 p.m., the same day.)

- - -

YONG S. KIM

EDUCATION

Catholic University of America, Ph.D., 1970
Massachusetts Institute of Technology, M.S., Nuclear Engineering, 1961
University of Wisconsin, B.S., Chemical Engineering, 1958

REGISTRATION

Department of Defense Certified Fallout Shelter Analyst
Registered Professional Engineer, State of Maryland, 1977
Registered Professional Engineer, State of California, 1977

EXPERIENCE

NUS CORPORATION, 1963–Present
Internuclear Company, 1961–1962
M.I.T. Department of Nuclear Engineering, 1958–1960

NUS — Coordinates and participates in the nuclear criticality analysis activities for the design and licensing of poisoned and unpoisoned spent-fuel storage racks. Performed nuclear analysis of advanced once-through BWR design incorporating solid moderator as part of ACDA/DOE uranium resource utilization program. Participated in nuclear criticality analysis and technical review of cavern growth related to human intrusion of nuclear waste repository in a domed salt formation. As Acting Manager of Nuclear Analysis, was responsible for technical work performed by nuclear analysis staff, including core design evaluation and analysis, core follow of operating reactors, computer code development, and training relative to nuclear, thermal-hydraulic, and mechanical behavior of fuel in nuclear reactors. In charge of reactor physics computer program development and applications. Adapted numerous nuclear and engineering computer programs to different types of digital computers ranging from the large scientific/engineering computers to minicomputers, and performed improvement and modification of existing large computer codes. Managed and participated in the training of nuclear utility engineers in the area of in-core nuclear and thermal-hydraulic analyses and the use and installation of related computer codes. Involved with bid evaluation of various commercial power reactors with regard to nuclear design. Performed a complete nuclear analysis of the shuffled core of a U.S. nuclear merchant ship, NS *Savannah*. Performed nuclear design analysis, shielding calculations, and safety analysis of military power reactors, including PM-1, PM-2A, PM-3A, SM-1, SM-1A, and MH-1A.

Previously developed computer programs for calculation of radiation doses due to radioactive release from nuclear power plants of nuclear rocket launch sites under normal or accident conditions. Analyzed physics design of the Japan Material Testing Reactor, and calculated shielding requirements for proposed radiation exposure facility at the AFRRI Reactor. Evaluated and compared nuclear fuel costs of proposed power reactors to assist electric utilities in the selection of reactor types. Instructed in NUS Fuel Management Workshop courses.

Developed and programmed NULOC-2, Control Data 6600 code for multicompartment loss-of-coolant accident analysis; NUTRIX and NUSIM, Control Data-6600 codes for three-dimensional physics analysis of operating reactors; NADAT-1 Honeywell DDP-516 assembly language code for transfer of radiation data; WINDIF, wind diffusion program for evaluation of reactor sites and air pollution for IBM-7090 and Control Data-3600; MOREDO, Control Data-3600 code to compute external whole body gamma dose in any population due to reentering nuclear rockets (for Space Nuclear Propulsion Office); NEEP, program for IBM-7090 and Control Data-3600 to compute effective energy of radioactive isotopes deposited in internal body organs (for SNPO); NURSE, nuclear rocket safety evaluation program for Control Data-3600 (for SNPO); FUELCOST-I, fuel cycle cost program for comparative study of fuel costs of different power reactors for IBM-7090 and Control Data-3600; EXGAM, code to predict integrated gamma dose for an airborne release of radioactivity for Control Data-3600.

Internuclear — Performed detailed nuclear calculations, including lifetime evaluation for a fully enriched boiling water reactor. Performed nuclear calculations for the University of Missouri Research Reactor. Analyzed and programmed one-dimensional transport problem with mono-directional sources and an isotropic scattering for radiative transfer applications for IBM-7090 (ISOLATE). Performed heat transfer analysis of small nuclear reactors for activation analysis applications.

M.I.T. — As laboratory instructor, supervised graduate students performing experiments on reactor physics, radiation detection, and shielding. Made experimental measurement of degradation rate of lucite physical properties in a reactor core; correlated degradation rate with radiation dose as part of the organic loop experiment at the M.I.T. Reactor. Designed in-pile radiation monitor instruments for this experiment.

MEMBERSHIPS

American Nuclear Society
Society of Sigma Xi

PUBLICATIONS

"High-Density Spent Fuel Storage Racks Design Analysis Report, Kewaunee Nuclear Plant, Criticality Analysis," NUS-1931, Part D, August 1977.

"Core Analysis Procedures Manual," CD-NA-76782, December 1976.

"NUMICE-2, A Spectrum Dependent Non-Spatial Cell Depletion Code," NUS-894, Revision 1, March 1976.

"NUSIM-3, A Digital Computer Program for Three Dimensional Nodal Reactor Simulation," March 1975.

"NUCELL — Cell Spectrum and Depletion Code Based on MUFT and THERMOS," May 1975.

"CYREP-III, In-Core Fuel Management Code," May 1975.

"NULOC-2, NUS Multi-Compartment Pressure-Temperature-Temperature History Program in Response to a Loss-of-Coolant Accident," NUS-1160, March 1974.

"NUCONTEMPT, NUS Version of CONTEMPT-PS for Prediction of Pressure-Temperature Response to a Loss-of-Coolant Accident," NUS-1164, March 1974.

"NUTRIX, A Digital Computer Program for Three Dimensional Analysis of Time-Dependent Operating Reactor," NUS-657, March 1970, and Revision 1, March 1972.

"FLYASH-II, A CDC-6600 Computer Code to Calculate Time-Dependent Isotopic Inventory and Radioactive Disintegration Rates in a Nuclear Reactor," NUS-878, February 1972.

"NUFLOW-1, A Three Dimensional Nodal Core Analysis Computer Program with Internally Calculated Core Flow Distribution," NUS-857, January 1972.