UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNITED STATES DEPARTMENT OF ENERGY	)	Docket No. 50-537
PROJECT MANAGEMENT CORPORATION	)	
TENNESSEE VALLEY AUTHORITY	)	
	)	
(Clinch River Breeder Reactor Plant)	)	

NRC STAFF TESTIMONY OF THOMAS L. KING ON BOARD QUESTION 4, CONCERNING NATURAL CONVECTIVE CIRCULATION

Q1. Mr. King, please state your name, by whom are you employed, and the nature of your responsibilities regarding the Clinch River Breeder Reactor ("CRBR")?

A1. My name is Thomas L. King. I am employed by the U.S. Nuclear Regulatory Commission as Chief of the Technical Review Branch, Clinch River Breeder Reactor Program Office in the Office of Nuclear Reactor Regulation. I am responsible for direction of the Technical Review Branch's review of the fast sodium-cooled-related aspects of the CRBR safety review.

Q2. Have you prepared a statement of professional qualifications?

A2. Yes. A copy of my statement is attached to this testimony.

Q3. What is the purpose of your testimony?

A3. My testimony addresses the concern raised by the Atomic Safety and Licensing Board ("Board") in Board Question 4, which the Staff has

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been requested to address, as follows:

> The Staff is requested to advise the Board whether it accepts convective circulation as a viable mechanism for fuel protection, and the reason for its answer.

Q4. Is CRBR designed to remove decay heat from the reactor core via natural convective cooling?

A4. Yes. CRBR is designed to remove decay heat from the core via natural convective circulation of sodium, including during the condition of a 2 hour loss of all AC power (station blackout).

Q5. What acceptance criterion must be met in determining whether the decay heat will be adequately removed from the CRBR core via natural convective cooling?

A5. The Staff's acceptance criterion, against which natural convective cooling is evaluated, is maintenance of fuel and cladding temperatures below values which would cause a loss of coolable fuel geometry. For CRBR, the Applicants have implemented this criterion by maintaining the sodium below its boiling temperature (1720°F in the core region). This limit will ensure that the fuel remains in a heat transfer regime which is well characterized, and that the cladding retains sufficient strength to maintain its geometry.

Q6. What features does CRBR utilize to promote natural convective circulation of sodium in the core?

A6. In CRBR, the following features are to be provided to ensure adequate natural convective circulation of sodium. The primary and intermediate sodium heat removal systems are to be designed with a low enough hydraulic resistance and sufficient elevation differences to allow adequate thermal convective forces and flows to develop. The decay heat is to be transferred from the primary and intermediate sodium systems to the steam system by means of the steam generators. Here, the decay heat is to be dumped to the atmosphere via steam venting or steam-to-air heat exchangers called the protected air-cooled condensers (PACCs). The steam system is also to incorporate an auxiliary feedwater system to ensure that adequate feedwater is supplied to the steam generators. Redundant safety grade battery systems supply power sufficient for two hours, for instrumentation, valve control and PACC operation from the control room. Of particular importance in the design is the fact that no operator action will be required to initiate decay heat removal via natural convective circulation. Plant hardware automatically puts the plant in a condition acceptable for this mode of operation upon scram and loss of main feedwater. This is discussed in detail in Section 5.6.3.1 of the CRBR SER, NUREG-0968.

Q7. Will the CRBR design allow the removal of decay heat beyond two hours in a station blackout condition?

A7. Yes. Although removal of decay heat beyond two hours in a station blackout is not required by the Staff, it is feasible with the proposed CRBR design to remove decay heat via natural convective circulation beyond two hours. This can be accomplished by the installation of additional battery capacity to allow control of the

PACCs and feedwater makeup from the control room, or by having plant operators take local manual control of the PACCs and feedwater flow after the batteries become discharged. The need for providing for decay heat removal beyond two hours in a station blackout will be assessed subsequent to resolution of the pending generic safety issue regarding station blackout.

Q8. Has the Staff evaluated the capability of CRBR to remove decay heat from the core through natural convective circulation?

A8. Yes. This evaluation included:

1) A review of the plant design requirements regarding natural convective circulation.
2) A review of the plant systems, configuration and design features which are required to function to allow natural convective circulation.
3) A review of the Applicants' analysis and acceptance criteria which predict fuel and plant behavior under natural convective circulation conditions.
4) A review of the plans for verification of the Applicants' analysis methods.
5) Independent calculations by the Staff as to the ability of CRBR to remove decay heat via natural convective circulation.

This review is documented in Sections 4.4 and 5.6.3 of the CRBR SER.

Q9. What were the results of the Staff's review?

A9. The Staff's review of the Applicants' design requirements, acceptance criteria, and plant systems, configuration and design features which allow natural convective circulation did not identify any major areas of concern. In addition, the Staff reviewed the Applicants' calculations which predicted CRBR in-core sodium temperatures during natural convective cooling, and performed independent calculations of in-core sodium temperatures for this event. Both the Staff's and Applicants' calculations show that in-core sodium temperatures would be well below the sodium boiling temperature. Few, if any, cladding failures (fission gas releases) are expected at these temperatures. These same calculational methods have also been compared against actual experimental data from natural circulation tests performed in FFTF and EBR-II, and have been found to predict the behavior observed in those tests quite well. Thus, there is reasonable assurance that the calculational methods employed in the CRBR natural convective circulation analysis are satisfactory. In addition, the Applicants have committed to demonstrate adequate natural convective circulation in CRBR via a whole plant test during the initial startup testing program.

Q10. Does the Staff accept natural convective circulation as a viable mechanism for fuel protection?

A10. Yes. Based upon the above, the Staff has accepted natural convective circulation in CRBR as a viable mechanism for decay heat removal, whereby the fuel is protected from a condition which could lead to loss of coolable geometry.

Thomas L. King

PROFESSIONAL QUALIFICATIONS

I am presently Chief, Technical Review Branch in the CRBR Program Office, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. In this capacity, I am responsible for the direction of the Branch's Review of those aspects of CRBRP related to a fast, sodium cooled reactor. This includes direction of the Branch's review of CRBRP sodium systems, fuel handling systems, CDA analysis, support systems, reliability program, safety criteria and analysis.

I received a Bachelor of Science degree in Mechanical Engineering from Drexel University. I also received a Master of Science degree in Mechanical Engineering from Stanford University.

I have over fourteen years of professional experience in the nuclear field. while I worked for the Department of Energy (DOE), I held various positions in the Division of Reactor Research and Technology. These included positions as a Reactor and Nuclear Engineer in the Core Design Branch, the Liquid Metal Systems Branch, and the Components Branch where I worked on the FFTF Project, the EBR-2 project and Facilities at the Engineering Technology Center in Santa Susana, California. In 1975 I was assigned to the DOE FFTF Project Office in Richland, Washington where I held positions as a Reactor Engineer in the Operational & Experimental Safety Division and Branch Chief for FFTF Engineering until April 1982 at which time I joined the NRC as a Reactor Engineer.

List of Publications

1) "FFTF Reactor Characterization Program" T. L. King (DOE) & J. Rawlins (HEDL)
ANS invited paper - 1981 Winter Meeting - San Francisco

2) "Reactor and Plant Performance During FFTF Nuclear Startup"
T. L. King & C. E. Moore - DOE
Ans Topical Meeting - September 1981 - Newport, RI
(Technical Basis for Nuclear Fuel Cycle Policy)