UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-327/88-60, 50-328/88-60

Licensee: Tennessee Valley Authority
6N 38A Lookout Place
1101 Market Square
Chattanooga, TN 37402-2801

Docket Nos.: 50-327 and 50-328 License Nos.: DPR-77 and DPR-79

Facility Name: Sequoyah Units 1 and 2

Inspection Conducted: December 22 and 23, 1988, and February 22, 1989

Inspectors: A.R. Long 3/1/89
A. R. Long, Project Engineer Date Signed

Approved by: L Q Watson 3/1/89
L. Watson, Chief, Project Section 1 Date Signed
TVA Projects Division

Summary

Scope: This special, unannounced inspection was conducted to review licensee resolution of the differences between measured and predicted critical boron concentrations observed during restart testing of both units, and to review methods being used to predict critical conditions.

Results: One violation was identified during the inspection, with three examples. The licensee failed to promptly initiate the established corrective action process 1) when the licensee identified in approximately May 1988 that the percentage of the boron-10 isotope in the reactor coolant system boron differed from receipt specifications, 2) when the licensee identified in November 1988 that the percentage of boron-10 differed from the value assumed in the nuclear design and safety analysis, and 3) when the licensee identified in December 1988 that a quality control inspector had violated procedures in April 1988 (VIO 327,328/88-60-01 - paragraph 2).

Licensee actions to resolve the critical boron concentration discrepancies were otherwise acceptable.

Two unresolved items* were identified during the inspection. The licensee identified that a quality control inspector had violated procedures by accepting boric acid which did not conform to receipt specifications (URI 327,328/88-60-02 - paragraph 2). The licensee also identified that boric acid appeared to have been released from power stores prior to quality control inspection (URI 327,328/88-60-03--paragraph 2). These items remained unresolved pending additional NRC review.

One licensee-identified violation was identified involving minor deficiencies in completed procedures. Adequate and timely corrective action was taken by the licensee and, per the provisions of the NRC enforcement policy, the violation was not cited (LIV 327,328/88-60-04 - paragraph 2).

Licensee methods for predicting critical conditions were considered acceptable. The licensee continued to demonstrate an ability to perform acceptably in the reactor engineering area. Marked improvement in the control of nuclear engineering computer codes was observed relative to previous NRC inspections.

*Unresolved items are matters about which more information is required to determine whether they are acceptable or may involve violations or deviations.

REPORT DETAILS

1. Licensee Employees Contacted

*D. Adams, Supervisor, Chemical Technical Support
*W. Byrd, Manager, Projects Control and Financial Services
#*M. Cooper, Manager, Compliance Licensing
*R. Fortenberry, Superintendent, Technical Support
G. Gault, Supervisor, Reactor Engineering
*G. Johnson, Reactor Engineer
T. Keys, Supervisor, PWR Core Design
T. Moffett, Systems Analyst, Nuclear Methods Development
*T. Pannell, Nuclear Quality Assurance
J. Patrick, Superintendent, Operations
*M. Riden, Engineering Assurance Engineer
*R. Rogers, Superintendent, Plant Support
*S. Spencer, Nuclear Engineer, Licensing
S. Stevens, Nuclear Chemist

*Attended exit interview on December 23, 1988
#Participated in telephone call on February 22, 1989

NOTE: Acronyms used in this report are listed in the last paragraph.

2. Followup on Previous Inspector Followup Items (92701,61707,72700)

(OPEN) IFI 327,328/88-53-02: Resolution of Issues Identified during Unit 1 Restart Test Program

Inspector Followup Item 327,328/88-53-02 was initiated, in part, to track licensee resolution of the failure to meet the ±50 ppm acceptance criterion on the agreement between measured and predicted HZP critical boron concentration during Unit 1 restart testing in November 1988. The measured HZP BOC critical boron concentration for Unit 1 was less than the predicted value by approximately 61 ppm. For the May 13, 1988, Unit 2 startup, the measured critical boron concentration was less than the prediction by 49 ppm, approaching the acceptance criterion but not exceeding it. Although the critical boron measurements for both units were well within the ±1000 pcm Technical Specification limit on overall core reactivity balance, measured and predicted critical boron concentrations typically agree within 20 to 30 ppm.

NRC Inspection Report 327,328/88-53 documented the inspector's review of open CAQR CHS880067, which documented initial licensee actions to investigate the cause and impact of the Unit 1 critical boron concentration discrepancy. The safety evaluation concluded that operation of the core with an actual excess reactivity the equivalent of 61 ppm less than the design value had no adverse effect on safety.

During Inspection 327,328/88-53, licensee engineers informed the inspector that a difference between the actual boron-10 isotopic concentration in

the RCS boron and the value assumed in the nuclear design and safety analysis contributed to the differences between the measured and predicted HZP critical boron concentrations for both units.

During this inspection, the inspector reviewed licensee actions in response to the B-10 concentration issue, and reviewed licensee methodologies for predicting critical conditions.

a. Boron-10 Isotopic Concentration

The percentage of B-10 in natural boron varies. The General Electric Chart of the Nuclides, 13th edition, 1984, documents a natural B-10 variation of 19.1 to 20.3 atom percent. The Sequoyah Nuclear Parameters and Operations Package (NUPOP) documented that a B-10 isotopic concentration of 19.8 atom percent was assumed by Westinghouse in the nuclear design and safety analysis. Procedure SQA 159, "Standards and Guides for Quality Assurance Level III Items", Appendix C, specified as a purchasing requirement for boric acid that the undepleted B-10 isotopic concentration be 19.6 ± 0.3 atom percent. However, the report of the independent chemical and isotopic analysis of the boron provided under contract 88NDA-47787A, dated March 1, 1988, showed the actual B-10 concentrations to range from 20.05 to 20.08 atom percent. At the time of the NRC inspection, the licensee had not performed either a measurement or a detailed accounting to determine the actual isotopic composition of the boron in the RCS. Licensee personnel stated to the inspector that the percentage of B-10 in the RCS boron was presumed to be 20.06 atom percent.

The established licensee corrective action process was described in AI-12, "Adverse Conditions and Corrective Actions". This procedure required that a CAQR be initiated promptly upon the identification of a condition adverse to quality. As of the beginning of this inspection, the B-10 concentration had not been addressed in a CAQR. Therefore, no formal evaluation of possible safety impacts or unreviewed safety question determination had been performed, even though the boric acid was being used in both units.

In each of the specific instances described below, licensee personnel identified conditions adverse to quality but failed to promptly initiate the corrective action process required by AI-12.

1) According to Chemical Technical Support personnel, prior to the Unit 2 startup on May 13, 1988, personnel in the Waste Water Processing group informed CTS that the boric acid B-10 concentration was not within the specifications of SQA 159, and questioned whether the boric acid was acceptable for use. The chemistry personnel concluded that the boric acid was acceptable chemically, but did not consider the impact on neutron absorption and core reactivity. The chemists considered changing the receipt specifications in SQA 159 to match the as-received concentration, but this was not pursued.

2) As previously discussed, prior to the conclusion of NRC Inspection 327,328/88-53 on November 12, 1988, licensee engineers informed the inspector that the B-10 concentration in boron being used in Unit 1 differed from the design value, and that this discrepancy indicated a problem with the quality control of material receipt.

3) On December 6, 1988, documentation of improper QC acceptance of boric acid was found by the licensee. Although the composition analysis for the boron received under contract 88NDA-47787A clearly showed the contrary, the (AI 11) material and receiving report had been erroneously signed by a QC inspector on April 7, 1988, certifying that the B-10 concentrations were within the specifications of SQA 159.

The failures to initiate the established corrective action process when it was identified that B-10 concentrations were not within specifications were identified as examples 1 and 2 of Violation 327,328/88-53-01.

The QC acceptance in April 1988 of boric acid which did not conform to receipt specifications appeared to be a failure to adhere to the procedures applicable to the inspection and acceptance of quality controlled materials. This violation of procedures was identified by the licensee, and will be tracked as Unresolved Item 327,328/88-60-02 pending additional NRC review of the issue and the relevant procedural requirements. The failure to promptly implement the corrective action process established by AI 12 when the procedure violation was identified is example 3 of Violation 327,328/88-53-01.

Although a CAQR on the B-10 concentration had not been initiated prior to the NRC inspection, the issue was being informally pursued. The inspector noted that AI 12 required a CAQR to be promptly initiated when a condition adverse to quality is identified, but the procedure did not specify a time limit for CAQR initiation. The procedure did specify time limits for each step in the investigation, review, and approval process once a CAQR has been initiated. The inspector discussed with licensee management whether the lack of a time limit for initiating CAQRs represented a potential weakness in the corrective action program, in that CAQR initiation could be delayed in order to gain extra time for investigating a problem prior to bringing the AI 12 time limits into effect. The position of the licensee was that the three examples of Violation 327,328/88-60-01 were isolated cases of failing to implement AI 12 as intended, and did not indicate a weakness in the CAQR procedure or program. Licensee management agreed to address the basis for this position in additional detail in the response to the violation.

Licensee personnel stated that the boric acid of contract 88NDA-47787A was possibly released from power stores prior to QC inspection, indicating a possible violation of material control procedures. This issue was identified as Unresolved Item 327,328/88-60-03 pending confirmation and review.

b. Adequacy of Methods for Calculating Critical Conditions

Effects of the difference between the presumed actual B-10 concentration and the value assumed in the nuclear design analysis would account for approximately 25 ppm of the observed critical boron concentration discrepancy on Unit 1, bringing the measured value well within the acceptance criterion. The presumed B-10 concentration difference would account for about 10 ppm of the observed discrepancy during the Unit 2 restart. Subsequent to the Unit 2 startup, Westinghouse had provided a refined HZP BOC critical boron calculation, using a 3-dimensional model to account for the reactivity effects of axial burnup history, which agreed with the measurement to within 5 ppm. Therefore, with the probable effects of the B-10 concentration taken into account, no significant core modeling errors were apparent in the HZP predictions for either unit.

Similarly, no significant modeling errors were apparent in the HFP critical boron concentration data for Unit 2 operation (attached). The inspector discussed with the licensee how the measured and predicted curves were derived, and what factors were included. The agreement between the measured and predicted data was acceptable, and the observed effects of the extended shutdown on the agreement between measured and predicted boron concentrations were consistent with industry experience.

Technical Specification 4.1.1.2 required a comparison of the overall core reactivity balance to predicted values at least once per 31 EFPD to demonstrate agreement within ±1 percent delta k/k. The inspector reviewed the core reactivity balance calculations for the current cycle of Unit 2, performed per SI 120, "Overall Reactivity Balance." The surveillances were adequately performed at the required intervals, with acceptable results, and no problems were identified with the methodology. The inspector confirmed that the licensee was including a correction for the reactivity effects of the extended shutdown in the SI 120 calculations.

The inspector reviewed the Unit 2 ECP calculations performed subsequent to the Unit 2 restart on May 13, 1988. All were calculated relative to the May 13, critical conditions. The reactivity differences between the measured and predicted critical conditions were approximated by the inspector in units of ppm of boron, using data from the NUPOP, and the results are tabulated below. Insufficient data was available to compile a similar comparison for Unit 1.

UNIT 2 STARTUP DATE	MEASURED		PREDICTED		REACTIVITY DIFFERENCE	
	CBC	BANK D	CBC	BANK D	PCM	PPM
5/20/88	773	101	773	159	229	27
5/24/88	733	95	733	139	55	6

UNIT 2 STARTUP DATE	MEASURED CBC	MEASURED BANK D	PREDICTED CBC	PREDICTED BANK D	REACTIVITY DIFFERENCE PCM	REACTIVITY DIFFERENCE PPM
6/7/88	696	119	697	167	165	19
6/8/88	827	145	827	118	99	11
6/19/88	928	179	928	175	31	4

The calculations which were reviewed encompassed a range of xenon conditions, and the inspector considered the data sufficiently representative to demonstrate the acceptability of the ECP methodology with respect to supporting the upcoming Unit 1 startup.

To account for reasonable modeling uncertainties, TS 4.1.1.2 requires that predicted core reactivity values shall be normalized to correspond to the actual core conditions prior to exceeding a fuel burnup of 60 EFPD after each fuel loading. Similarly, by basing ECB/ECP calculations on previous actual critical conditions, the effects of modeling uncertainties and the B-10 difference are implicitly accounted for in the calculations.

During the inspection of the Unit 2 ECP calculations, a licensee reactor engineer identified a number of minor deficiencies in the completed procedures. These included discrepancies between values for the same parameter recorded in different sections of the procedures, examples of data not being recorded, and a suspect xenon value in the May 20, 1988, ECP calculation. None of the identified deficiencies appeared to invalidate the outcome of the procedure being performed. The reactor engineer promptly initiated corrective actions, including reporting to his management that the discrepancies possibly indicated inadequate reviews of the completed procedures. At the time of the inspection, procedure revisions were already in place to reduce such errors by requiring additional data to be recorded, and by providing more guidance. Due to the minimal actual safety significance of the identified deficiencies, and the corrective action already taken by the licensee, per the provisions of the NRC enforcement policy this violation was not cited and will be tracked as LIV 327,328/88-60-04. No response to this item is required and the item is considered closed.

The inspector discussed with licensee personnel the administrative controls for computer programs being used to perform ECPs and other reactivity calculations. NQAM Part I Section 2.2.1, addressing QA software, was implemented in part by Nuclear Fuels Procedure 8, "Digital Computer Methods Control", and Methods Branch Instruction MBI 02, "Development or Modification and Release of Class A and Class B Computer Programs". The inspector noted marked improvement in the licensee's control of nuclear engineering computer codes relative to previous inspections in this area.

The positive working relationship between licensee and vendor nuclear engineering personnel noted by the NRC during the Unit 1 startup was also observed during this inspection. Biweekly phone conversations on core performance issues were being conducted, and included site, corporate, and Westinghouse personnel.

The inspector concluded that the methods being used to predict critical boron concentrations were acceptable. The restart critical boron discrepancies on both units appeared to have resulted from a combination of normal model uncertainties, increased model uncertainties due to extended shutdown effects, and differences between the actual B-10 isotopic concentration and the value assumed in the nuclear design analysis.

IFI 327,328/88-53-02 remains open pending the resolution of other portions of the IFI which were not addressed in this report.

3. Exit Interview (30703)

The inspection scope and findings were summarized on December 23, 1988, and on February 22, 1989, with those persons indicated in paragraph 1. The inspector described the areas inspected, and discussed in detail the inspection findings listed below. The licensee acknowledged the inspection findings. Proprietary material was reviewed during the inspection, but was not retained by the inspector.

Inspection Findings:

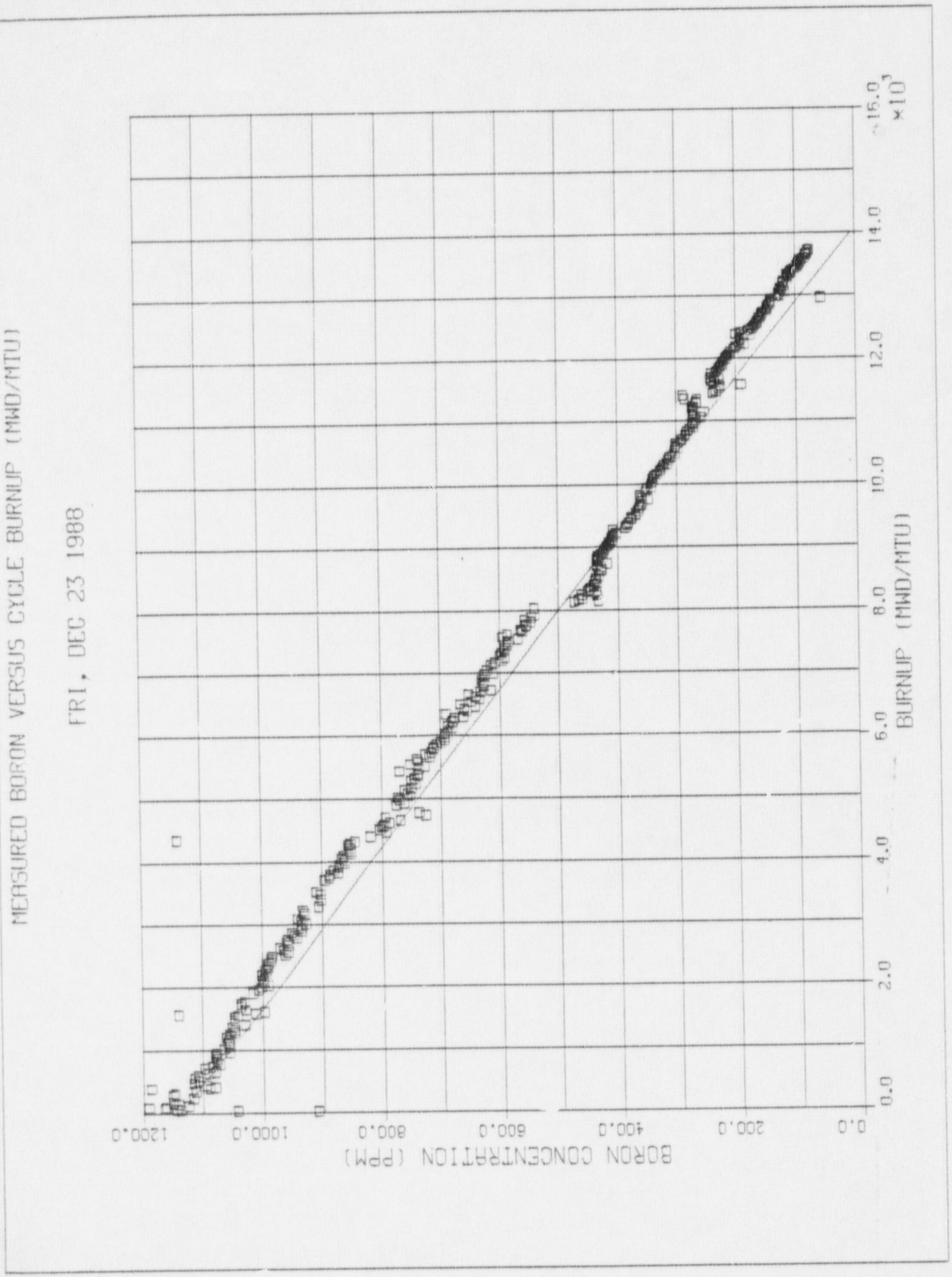
(Open)VIO 327,328/88-60-01:	Failure to Promptly Identify and Initiate Adequate Corrective Action for Conditions Adverse to Quality - Three Examples (Paragraph 2)
(Open)URI 327,328/88-60-02:	QC Acceptance of Boric Acid which did not Conform to Receipt Specifications (Paragraph 2)
(Open)URI 327,328/88-60-03:	Release of Boric Acid from Power Stores Prior to QC Inspection (Paragraph 2)
(Closed)LIV 327,328/88-60-04:	Licensee-Identified Discrepancies in Completed ECP Procedures (Paragraph 2)
(Open)IFI 327,328/88-53-02:	Followup on Issues Identified during Unit 1 Restart Initial Criticality (Paragraph 2)

4. List of Acronyms

AI - Administrative Instruction
B - Boron
BOC - Beginning of Cycle

CAQR - Conditions Adverse to Quality Report
CBC - Critical Boron Concentration
CFR - Code of Federal Regulations
CTS - Chemical Technical Support
ECB - Estimated Critical Boron (Concentration)
ECP - Estimated Critical (Control Rod) Position
EFPD - Effective Full Power Days
HFP - Hot Full Power
HZP - Hot Zero Power
IFI - (NRC) Inspector Followup Item
NOV - Notice of Violation
NQAM - Nuclear Quality Assurance Manual
NRC - Nuclear Regulatory Commission
NUPOP- Nuclear Parameters Operations Package
OSP - Office of Special Projects
PCM - Percent millirho
PPM - Parts per million
QA - Quality Assurance
QC - Quality Control
RCS - Reactor Coolant System
SI - Surveillance Instruction
TS - Technical Specifications
TVA - Tennessee Valley Authority
URI - (NRC) Unresolved Item
VIO - (NRC) Violation

ATTACHMENT


MEASURED BORON VERSUS CYCLE BURNUP (MWD/MTU)
FRI. DEC 23 1988
BORON CONCENTRATION (PPM)
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
BURNUP (MWD/MTU)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
15.0
×10³