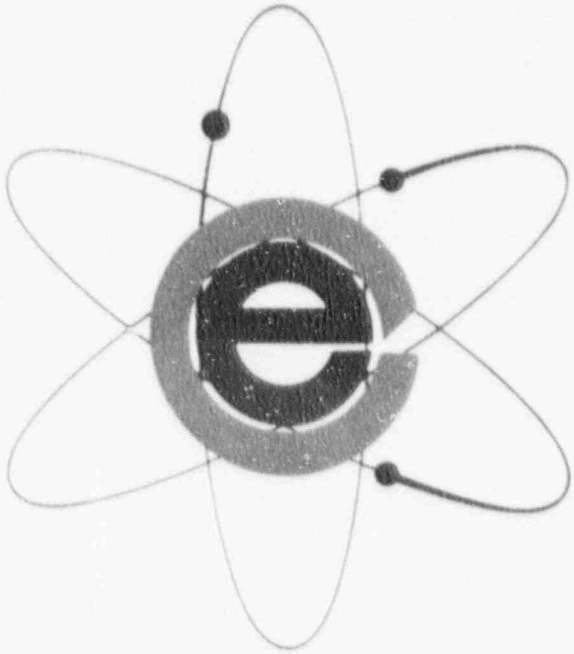
NFSR-0085
REV. 0

Nuclear Fuel Services



COMMONWEALTH EDISON COMPANY TOPICAL

BENCHMARK OF BWR NUCLEAR DESIGN METHODS

BY

JOHN W. KEFFER
WILLIAM H. OSTER
RANDALL R. SCHMIDT
JOAN E. WIEGING

NOVEMBER, 1990

Commonwealth Edison Company

ATTACHMENT

COMMONWEALTH EDISON COMPANY TOPICAL REPORT

BENCHMARK OF BWR NUCLEAR DESIGN METHODS

(NFSR-0085, REVISION 0)

NFSR-0085
Revision 0

Commonwealth Edison Company Topical

Benchmark of BWR Nuclear Design Methods

by

John W. Keffer

William H. Oster

Randall R. Schmidt

Joan E. Wieging

Prepared By: John W. Keffer

William H. Oster

Randall R. Schmidt

Joan Wieging

Reviewed By: ______________________
Nuclear Design Supervisor

Approved By: ______________________ 11/21/90
Nuclear Fuel Services Manager Date

Nuclear Fuel Services
Commonwealth Edison Company
72 W. Adams St., Room 922E
Chicago, Illinois 60603

Statement of Disclaimer

This document was prepared by Commonwealth Edison Company for filing with the United States Nuclear Regulatory Commission for the sole purpose of obtaining approval of Commonwealth Edison Company's BWR Nuclear Design Methods. Commonwealth Edison Company makes no warranty or representation and assumes no obligation, responsibility, or liability with respect to the contents of this report or its accuracy or completeness. Any use of or reliance on this report or the information contained in this report is at the sole risk of the party using or relying on it.

Abstract

This topical report summarizes the nuclear analysis methods employed by the Commonwealth Edison Company (Edison) in support of reload design for its Boiling Water Reactors (BWRs). The nuclear analysis methods are based on the General Electric neutronic design computer codes, TGBLA and PANACEA, which have previously been reviewed and approved by the NRC. The results of an extensive benchmark program are presented to demonstrate Edison's ability to independently perform the nuclear analyses required for the licensing, operation, testing, and surveillance of a BWR reload cycle. The benchmark included a total of 18 unit-cycles, and comparisons were made to measured critical conditions and core power distributions.

Table of Contents

Table of Contents, Continued

Page

Appendices:

List of Tables

List of Figures

List of Figures, Continued

Section 1 - Introduction and Overview

1.1 Introduction

This report summarizes the nuclear analysis methods employed by Commonwealth Edison Company (Edison) in support of reload analysis for its Boiling Water Reactors (BWRs) as well as the benchmark data which resulted from the use of these methods. This report demonstrates Edison's capability to independently perform the steady-state neutronic analysis portions of the reload design process. This encompasses the neutronic analyses required for the the steady-state licensing, operation, testing, and surveillance of a BWR reload cycle.

This benchmarking analysis includes generation of hot and cold critical eigenvalue data and a comparison of the predicted to measured Transverse Incore Probe (TIP) readings. The hot and cold critical eigenvalue data demonstrates that the reactivity of the reactor is predictable and consistent. Accurate prediction of the TIP readings demonstrates the ability to predict the core power distribution.

Results from the following units and cycles are summarized in this report: Quad Cities Station Units 1 and 2, Cycles 7 through 10; Dresden Station Unit 3, Cycles 8 through 11; LaSalle County Station Units 1 and 2, Cycles 1 through 3. This database includes fuel designs from 7x7 to 9x9 fuel pin arrays, various water rod configurations, axially dependent lattice designs throughout the enriched portion of the assembly, and both General Electric (GE) and Advanced Nuclear Fuels (ANF) fuel product lines.

The design codes TGBLA and PANACEA, which were developed by GE, form the methodology basis for this benchmarking effort. Extensive design participation training was provided to five Edison engineers at the GE facilities in San Jose, California. This training included the performance of the full scope of neutronic calculations required for a reload design, use of the appropriate computer programs, and training in the acceptability and limitations of these computer programs for calculating neutronic parameters. Each training assignment lasted approximately one year.

The overall neutronic design process employed by Edison is based on the approach described in GE Document NEDE-24011-P-A, "General Electric Standard Application for Reactor Fuel", Reference 1. Edison's fuel vendors will continue to perform the balance of plant transient and accident analyses. In the future, a separate report will be submitted supporting the use of Edison methods for performing these categories of calculations.

1.2 Overview of NFSR-0085, Revision 0.

A summary of the results and conclusions reached from this benchmark effort is included in Section 2. These results demonstrate Commonwealth Edison's proficiency in the use of the GE neutronic code package.

Section 3 includes a short description of the neutronic methodology used for this benchmark analysis. This methodology has already been approved by the NRC in GESTAR II, Reference 1, and by review of the GE topical on neutronic methods, Reference 2.

Detailed results from the benchmark effort are in Section 4. The key parameters for the benchmark are hot and cold critical eigenvalue data, which demonstrate that the reactivity of the core can be reliably predicted; and comparisons of calculated to measured TIP data, which demonstrate that the core power distribution can be reliably predicted. Comparisons were made to eighteen unit-cycles, demonstrating the adequacy of the methods.

1.3 Scope of Analyses

Edison will perform the neutronic analyses required for the steady-state licensing, operation, testing, and surveillance of a BWR reload cycle. Specifically, the basic neutronic and processing computer codes described in Section 3 will be employed to generate lattice physics data, determine assembly loading patterns, and calculate neutronic parameters for steady-state operation, testing, and surveillance.

Table 1-1 provides examples of the type of neutronic parameters which are required for reactor operation, testing, and surveillance. Edison will evaluate these parameters for each BWR reload cycle for which it performs the neutronic design, regardless of the fuel vendor. An exception to this is the process computer information, which is the cycle specific input data for the onsite core monitoring code. Edison will provide the process computer information only to those plants which are supplied with GE fuel. Edison will not currently be providing process computer information for non GE-supplied reloads in order to maintain compatibility with the critical power correlation and steady-state neutronics models used in the core monitoring software for non GE-supplied reloads. Therefore, Edison is not requesting NRC approval for application of the TGBLA/PANACEA code package for process computer input for non GE-supplied reloads.

The methodology and core conditions employed by Edison to perform the neutronic design and licensing analyses are identical to those employed by

General Electric (Reference 1). Edison's capability to perform the scope of analyses listed in Table 1-1 using the GE methodology is justified by the benchmark results outlined in Section 2 and detailed in Section 4 of this report. Until NRC approval is obtained, Edison will continue to perform the majority of these analyses in parallel with the fuel vendor's analyses of record to ensure proficiency with the code package is maintained.

To summarize, Edison is requesting approval to calculate neutronic parameters required for steady-state operation, testing, and surveillances, examples of which are listed in Table 1-1, for all Edison BWRs, and this request is supported by the results of this report.

1.4 Vendor Interactions

The fuel vendor will continue to be responsible for all balance of plant Anticipated Operational Occurrence analyses, such as pressurization transients, and Loss Of Coolant Accident analyses. The basepoint for the evaluation of each cycle will be transmitted from Edison to the vendor for these analyses.

Table 1-1
Neutronic Parameters Required for Operation, Testing, and Surveillance

The following neutronic parameters are examples of the type of calculations required for reactor operation, testing, and surveillance.

1. Calculation of "R", the additional Shutdown Margin required at the beginning of the cycle to ensure the Minimum Shutdown Margin requirement is met throughout the cycle.

2. Shutdown margin calculations for special conditions, such as out-of-service control rods.

3. Hot excess reactivity.

4. Data required for operation, such as target rod patterns, hot reactivity anomalies and core axial power distribution.

5. Data required for startup, such as control rod worths and criticality predictions.

6. Process Computer Input. This will be provided only to those units using a TGBLA/PANACEA-based core monitoring code and will not be provided by Edison to those units using non GE-supplied fuel as part of the scope of this topical.

Section 2 - Summary and Conclusions

The TGBLA/PANACEA code package shows good agreement with the measured performance parameters of the benchmark data summarized in this report and the results are comparable to those calculated by GE, which were reported in the GE neutronics methods topical, Reference 2. Specifically:

1. The predicted TIP response for the Edison BWRs shows good agreement with measured TIP data.
2. The calculated hot operating core eigenvalue is consistent between reactor types and shows little cycle exposure dependence.
3. The calculated cold critical eigenvalue is consistent and predictable.

Table 2-1 summarizes the benchmark results from the last two cycles for each unit. Based on the results, it is concluded that:

1. Commonwealth Edison has demonstrated proficiency with the TGBLA/PANACEA code package and that Edison can perform in an acceptable manner all neutronic analyses required for the licensing, operation, testing, and surveillance of a BWR reload cycle; and
2. Commonwealth Edison is justified in its application of calculational uncertainties identical to those applied by GE.

Table 2-1
Summary of Benchmark Results

Parameter	Quad Cities	Dresden	LaSalle
Number of Unit-Cycles	4	2	4
Nodal TIP Power, % Standard Deviation	7.95	7.39	7.03
Radial TIP Power, % Standard Deviation	4.22	3.74	3.98
Hot Critical Eigenvalue: Mean	1.0003	1.0041	0.9985
% Standard Deviation	0.14	0.17	0.21
Cold Critical Eigenvalue: Mean	1.0031	1.0062	1.0007
% Standard Deviation	0.21	0.17	0.25

Section 3 - Neutronic Methodology

The methodology used for the benchmark analysis for Edison's BWRs is based on the General Electric (GE) proprietary codes TGBLA, for lattice physics calculations, and PANACEA, for the three-dimensional (3D) core simulation. The GE code package was written for the VAX computer system and was installed on a VAX system at Edison. After installation on the Edison system the code package was validated and verified against a standard set of sample problems to ensure the results were consistent with those generated by GE. For reference purposes, the major codes in the GE code package are listed in Table 3-1.

The NRC has reviewed and approved the methodology of this code package. This approval and a detailed discussion of the methodology can be found in References 1 and 2.

3.1 Lattice Physics Codes

The GE codes TGBLA and GELIB (References 3 and 4, respectively) are used to generate the required lattice physics data for the GE core simulator code PANACEA (Reference 5).

The lattice physics code TGBLA generates the required lattice physics data for the benchmarking effort. TGBLA assumes an infinite lattice, or zero current, bundle configuration and uses a combination of diffusion and transport theory to determine the lattice characteristics. TGBLA calculates the rod-by-rod thermal spectra by the leakage-dependent integral transport method. Leakage iterations between diffusion theory and thermal spectrum calculations are carried out to generate thermal broad group diffusion parameters. Thermal broad-group neutron cross-sections are calculated for homogenized fuel rod cells using a condensed sixteen coarse group thermal cross-section library.

In the epithermal and fast energy range, the level-wise resonance integrals are calculated by an intermediate resonance approximation in which the intermediate resonance parameters are fuel rod temperature dependent. Cross-sections for the fast and epithermal region are calculated using a 68 fine group cross section library.

Two-dimensional, coarse mesh, broad group, diffusion theory calculations are then used to determine the nodal flux and power distributions in the BWR lattice.

GELIB is a data manipulation code which accesses the cross-section and reactivity output from TGBLA and calculates the reactivity fits required for PANACEA. In this manner the results of the TGBLA calculations are reduced to libraries of lattice reactivities, relative rod powers, and few group cross sections as a function of instantaneous void, exposure, exposure-weighted void history, control state, and fuel and moderator temperature for use in the PANACEA calculations.

3.2 Core Simulator Code

PANACEA is a three-dimensional, coarse mesh, one group, coupled nuclear/thermal-hydraulics computer program for analyzing a BWR core. The coarse mesh width is on the same order of magnitude as the fast neutron mean free path. When coupled with the one group assumption, this mesh width is considered adequate as the global neutron flux shape is primarily determined by the diffusion of fast neutrons. A seven-point difference scheme is used to solve the one group diffusion equation. At the boundary the difference equation is modified to include reflector effects.

PANACEA uses k-infinity fits to calculate nodal core reactivity. These fits are quadratic in void history, and table look-up in exposure. LaGrangian interpolation is used to calculate intermediate exposure values. There is a different set of base k-infinities for both the hot and cold conditions. These base k-infinities are corrected for controlled conditions, using a controlled to uncontrolled ratio; for instantaneous void effects; for various neutron poisons; and for Doppler effects. Doppler is represented using an effective fuel temperature, which is based on the nodal power.

Table 3-1
Basic Neutronic Computer Codes

Code Name	Description
TGBLA	Macro- and Microscopic Lattice Cross Section Generator
GELIB	Processing Code to Prepare TGBLA Data for Use by PANACEA
PANACEA	Three Dimensional Spatially Dependent, One Group Core Simulator

Section 4 - Neutronic Methods Validation

The methods validation data for the Edison BWR calculational methods are contained in this section. Comparisons between calculations and measurements are presented for Quad Cities Units 1 and 2, Dresden Unit 3, and LaSalle County Station Units 1 and 2.

4.1 Validation of Lattice Physics Model

Edison used the lattice physics code TGBLA to create the neutronic inputs for the downstream core simulator validation. The methodology in TGBLA has been previously approved by the NRC for use on BWRs. This approval is documented in the GE Licensing Topical, Reference 2. As part of this topical, GE validated the core power distribution predictions based on global gamma scan measurements from Quad Cities Unit 1, Cycles 2, 4, and 5; Hatch Unit 1, Cycles 1 and 3; and Millstone Unit 1, Cycle 7. The isotopic burnup was validated against measurements from Quad Cities 1 Cycle 2.

The ultimate test of the lattice physics model is demonstrated by the validation of the Edison units using historical cycles. This process demonstrates Edison's capability to determine the neutronic parameters for current fuel product lines and core loadings. Details of this validation are contained in Section 4.2.

4.2 Validation of 3D Core Simulator

The PANACEA reactor core simulator code is verified by comparing calculated and measured reactor parameters. Core follow calculations were performed for the Quad Cities, Dresden, and LaSalle reactors and the results were compared to measured data. Pertinent reactor core parameters at rated operating conditions for the units are given in Table 4.2-1. The fresh fuel loaded in the cycles of interest is summarized in Table 4.2-2. Appendix A describes the nomenclature for the bundle names in Table 4.2-2.

It should be noted that the initial core state conditions, namely the nodal exposure and void history data, evaluated for the Quad Cities and Dresden Units were provided by GE and were generated using GE's GENESIS methods. These methods have since been replaced with the TGBLA/PANACEA GEMINI methods. The use of data which were generated using GENESIS methods and supplied by GE as the initial core conditions for this benchmark effort results in anomalous effects due to the use of two discrete methods for the early transitional cycles. These anomalous effects show up as high TIP standard deviations and eigenvalue uncertainties until the transitional effects of the initial core conditions disappear; these effects also are seen in the transitional cycles modelled by GE with their GEMINI methods. This is illustrated by the large decrease in calculated versus measured TIP standard deviations from the early transitional cycles to the more recent cycles.

4.2.1 Hot Critical Eigenvalues

The hot critical eigenvalue results as a function of cycle exposure are shown in Figures 4.2-1 through 4.2-4 for Quad Cities Unit 1; Figures 4.2-5 through 4.2-8 for Quad Cities Unit 2; Figures 4.2-9 through 4.2-12 for Dresden Unit 3; Figures 4.2-13 through 4.2-15 for LaSalle County Unit 1; and Figures 4.2-16 through 4.2-18 for LaSalle County Unit 2.

The hot critical data have not been corrected for reactivity biases associated with the effects of channel bow, crud, incore instrumentation, and fuel assembly spacers.

Hot critical eigenvalues should be consistent and predictable as a function of cycle exposure to enable the engineer to develop adequate projections of the critical eigenvalue for upcoming cycles. The hot critical eigenvalues developed as part of this benchmark effort are shown to be a strong function of plant type and fuel product line being loaded but are consistent within these parameters. A comparison of Figures 4.2-19 through 4.2-21 demonstrate this. The hot critical eigenvalues from the last two cycles of each unit in the database used for this benchmark are shown as a function of exposure on these figures. Quad Cities data is contained on Figure 4.2-19; Dresden on Figure 4.2-20; and LaSalle on 4.2-21. The trends demonstrated in these figures will be used to predict the hot critical eigenvalue for future cycles.

4.2.2 Cold Critical Eigenvalues

The cold critical eigenvalue results are shown in Table 4.2-3 for Quad Cities Station; in Table 4.2-4 for Dresden Station; and in Table 4.2-5 for LaSalle County Station.

All cold critical data are from in-sequence, xenon-free startups. The cold critical data have not been corrected for reactivity biases associated with the effects of channel bow, crud, incore instrumentation, and fuel assembly spacers. Corrections have been made for reactor period and temperature at the time of criticality, as the lattice physics data were generated assuming steady-state conditions and a moderator and fuel temperature of 20 degree C.

As stated in Section 4.2.1 for the hot critical eigenvalues, the cold critical eigenvalues must also be consistent and predictable as a function of exposure, as these are required to calculate core subcriticality. Cold critical eigenvalues have a larger degree of scatter as a function of exposure than hot critical eigenvalues, but also are consistent and predictable as a function of plant type and fuel being loaded in the core. Therefore, core subcriticality can be assured under all conditions.

4.2.3 TIP Results

Measured and calculated Traversing Incore Probe (TIP) data have been compared and are summarized in this section. The TIP standard deviations were calculated over the entire axial length of the core, which is 24 nodes. A detailed discussion of the numerical basis for the TIP standard deviations and asymmetries is included in Appendix B.

The TIP standard deviations and asymmetries for each statepoint are shown in Table 4.2-6 for Quad Cities Station; in Table 4.2-7 for Dresden Station; and in Table 4.2-8 for LaSalle County Station. TIP asymmetry data is included to provide a method for evaluating the adequacy of the TIP standard deviations.

As discussed previously, there are high TIP standard deviations in the early transitional cycles for Quad Cities and Dresden due to the initial core conditions reflecting the transition from the earlier GE GENESIS models to the current GEMINI models. The TIP standard deviations for the last two cycles of each plant are acceptably low, as nodal TIP standard deviations are less than 10% and radial standard deviations are less than 6% for all statepoints. These values demonstrate that the core power distribution is being adequately predicted by the Edison models.

Detailed TIP results are contained in the appendices as follows:

Unit	Cycle	Appendix	Figure
QC1	7	C	C-1
QC1	8	C	C-2
QC1	9	C	C-3
QC1	10	C	C-4
QC2	7	D	D-1
QC2	8	D	D-2
QC2	9	D	D-3
QC2	10	D	D-4
DR3	8	E	E-1
DR3	9	E	E-2
DR3	10	E	E-3
DR3	11	E	E-4
LS1	1	F	F-1
LS1	2	F	F-2
LS1	3	F	F-3
LS2	1	G	G-1
LS2	2	G	G-2
LS2	3	G	G-3

Table 4.2-1
Rated Reactor Core Parameters

Quad Cities Station Units 1 and 2	
Thermal Power, MWt	2511
Core Flow, Mlb/hr	98.0
Inlet Subcooling, Btu/lbm	524
Core Midplane Pressure, psia	1035
Total Assemblies in Core	724
Average Power Density, kw/l	41
Dresden Station Units 2 and 3	
Thermal Power, MWt	2527
Core Flow, Mlb/hr	98.0
Inlet Subcooling, Btu/lbm	524
Core Midplane Pressure, psia	1035
Total Assemblies in Core	724
Average Power Density, kw/l	41
LaSalle County Station Units 1 and 2	
Thermal Power, MWt	3323
Core Flow, Mlb/hr	108.5
Inlet Subcooling, Btu/lbm	528
Core Midplane Pressure, psia	1035
Total Assemblies in Core	764
Average Power Density, kw/l	50

Table 4.2-2
Fuel Loading Summary

Unit	Cycle	Fuel Type Loaded	Number Loaded
QC1	7	GE6-P8DRB265-6G2.0-80M-145	64
		GE6-P8DRB265-6G3.0-80M-145	160
	8	GE7B-P8DRB265-6G3.0-80M-145	116
		GE7B-P8DRB283-7G4.0-80M-145	80
	9	GE7B-P8DRB299-7G4.0-80M-145	144
		GE7B-P8DRB282-7G3.0-80M-145	72
	10	GE8B-P8DQB300-7G4.0-80M-145	120
		GE8B-P8DQB300-9G4.0-80M-145	80
QC2	7	GE7B-P8DRB265-6G3.0-80M-145	204
	8	GE7B 8DRB282-7G3.0-80M-145	72
		GE7 8DRB283-7G4.0-80M-145	104
	9	GE7B-P8DRB299-7G3.0-80M-145	88
		GE7B-P8DRB299-7G4.0-80M-145	64
	10	GE8B-P8DQB300-9G3.0-80M-145	92
		GE8B-P8DQB316-7G4.0-80M-145	72
DR3	8	ANF-P8DEB269-5G3.0-80M-145	224
	9	ANF-P8DEB283-5G3.5-80M-145	184
	10	ANF-P9DNB313-8G4.0-80M-145	160
		ANF-P9DNB313-9G4.0-80M-145	16
	11	ANF-P9DNB313-9GZ-80M-145	72
		ANF-P9DNB313-9GZ1-80M-145	96

Table 4.2-2, Continued
Fuel Loading Summary

Unit	Cycle	Fuel Type Loaded	Number Loaded
LS1	1	8CIB071-NOG-100M-150	92
		8CIB176-4GZ-100M-150	240
		8CIB219-4GZ-100M-150	432
	2	GE7B-P8CRB299-6G3.0-100M-150	232
	3	GE8B-P8CQB301-8GZ-100M-150	112
		GE8B-P8CQB320-9GZ-100M-150	112
LS2	1	8CIB071-NOG-100M-150	92
		8CIB176-4GZ-100M-150	240
		8CIB219-4GZ-100M-150	432
	2	GE7B-P8CRB299-6G3.0-100M-150	224
	3	GE8B-P8CQB300-6G3.0-100M-150	144
		GE8B-P8CQB320-7GZ-100M-150	96

Table 4.2-3
Cold Critical Eigenvalue Results
Quad Cities Station Units 1 and 2

Unit	Cycle	Cycle Exposure, MWd/St	Cold Critical Eigenvalue
QC1	7	0	1.0058
QC1	7	1211	1.0070
QC1	7	3927	1.0049
QC1	8	0	1.0041
QC1	8	4143	1.0015
QC1	8	7115	0.9999
QC1	9	0	1.0037
QC1	9	3400	1.0018
QC1	9	3713	1.0016
QC1	10	0	1.0067
QC1	10	2123	1.0056
QC1	10	8166	1.0035
QC2	7	0	1.0070
QC2	7	1033	1.0075
QC2	7	4713	1.0043
QC2	8	0	1.0050
QC2	8	4064	1.0037
QC2	8	5538	1.0025
QC2	9	0	1.0040
QC2	9	3083	1.0021
QC2	9	3759	1.0016
QC2	10	0	1.0053
QC2	10	316	1.0035
QC2	10	3462	1.0028
QC2	10	6019	0.9986

Table 4.2-4
Cold Critical Eigenvalue Results
Dresden Station Unit 3

Unit	Cycle	Cycle Exposure, MWd/St	Cold Critical Eigenvalue
DR3	8	0	1.0056
DR3	8	2815	1.0023
DR3	9	0	1.0068
DR3	9	0	1.0076
DR3	9	841	1.0063
DR3	9	1107	1.0065
DR3	9	3888	1.0040
DR3	9	6072	1.0033
DR3	10	0	1.0078
DR3	10	1179	1.0066
DR3	10	2508	1.0057
DR3	10	4353	1.0032
DR3	11	0	1.0086
DR3	11	4139	1.0055

Table 4.2-5
Cold Critical Eigenvalue Results
LaSalle County Station Units 1 and 2

Unit	Cycle	Cycle Exposure, MWd/St	Cold Critical Eigenvalue
LS1	1	0	1.0041
LS1	1	0	1.0035
LS1	1	0	1.0041
LS1	1	0	1.0050
LS1	1	485	1.0037
LS1	1	574	1.0036
LS1	1	574	1.0038
LS1	1	574	1.0040
LS1	1	897	1.0028
LS1	1	1781	1.0015
LS1	1	1781	1.0021
LS1	1	2125	1.0014
LS1	1	2595	1.0006
LS1	1	2595	1.0005
LS1	1	6002	0.9969
LS1	1	7902	0.9978
LS1	1	8872	0.9966
LS1	1	9321	0.9960
LS1	2	0	1.0033
LS1	2	0	1.0032
LS1	2	2664	1.0002
LS1	2	3477	0.9979
LS1	3	0	1.0020
LS1	3	182	1.0007
LS2	1	0	1.0041
LS2	1	0	1.0040
LS2	1	0	1.0079
LS2	1	843	1.0029
LS2	1	2665	1.0010
LS2	1	4042	1.0000
LS2	1	5715	0.9984
LS2	1	8198	0.9978
LS2	1	8310	0.9984

Table 4.2-5, Continued
Cold Critical Eigenvalue Results
LaSalle County Station Units 1 and 2

Unit	Cycle	Cycle Exposure, MWd/St	Cold Critical Eigenvalue
LS2	2	0	1.0038
LS2	2	5182	0.9963
LS2	3	0	1.0011
LS2	3	3884	0.9986

Table 4.2-6
TIP Results
Quad Cities Station Units 1 and 2

Unit	Cycle	Cycle Exposure, MWd/St	Standard Deviations Radial	Nodal
QC1	7	96	5.4	13.2
QC1	7	3146	6.2	17.1
QC1	7	6362	5.1	14.6
QC1	8	521	6.0	12.7
QC1	8	3931	6.2	12.4
QC1	8	7370	5.8	9.0
QC1	9	599	4.7	8.4
QC1	9	3526	5.0	8.0
QC1	9	7664	4.8	9.1
QC1	10	1026	5.1	8.1
QC1	10	4347	5.1	8.1
QC1	10	6415	4.7	7.7
QC2	7	273	10.0	15.9
QC2	7	3970	9.5	16.0
QC2	7	5496	9.0	17.1
QC2	8	630	4.8	9.6
QC2	8	4195	4.5	7.1
QC2	8	7327	4.5	8.0
QC2	9	129	3.5	6.9
QC2	9	3245	4.3	6.9
QC2	9	5542	3.4	7.3
QC2	10	891	3.0	8.7
QC2	10	3315	3.2	8.0
QC2	10	6974	3.5	7.9

Table 4.2-7
TIP Results
Dresden Station Unit 3

		Cycle Exposure,	Standard Deviations	
Unit	Cycle	MWd/St	Radial	Nodal
DR3	8	1001	5.45	9.69
DR3	8	4048	6.38	10.42
DR3	8	6148	6.37	8.72
DR3	9	314	6.05	10.11
DR3	9	3247	5.91	8.21
DR3	9	4630	6.83	9.79
DR3	10	1287	3.21	7.00
DR3	10	4855	3.34	6.67
DR3	11	166	4.33	7.65
DR3	11	3237	4.15	8.18

Table 4.2-8
TIP Results
LaSalle County Station Units 1 and 2

Unit	Cycle	Cycle Exposure, MWd/St	Standard Deviations Radial	Nodal
LS1	1	1001	2.01	6.58
LS1	1	1605	1.94	7.37
LS1	1	4934	3.34	6.22
LS1	1	6293	3.33	6.96
LS1	1	9395	3.63	6.42
LS1	1	10173	3.39	6.79
LS1	2	1032	4.33	7.75
LS1	2	3375	3.30	6.38
LS1	2	5406	3.16	6.18
LS1	3	1098	3.85	6.44
LS1	3	4167	3.50	6.12
LS1	3	7493	4.12	6.10
LS2	1	704	1.73	9.82
LS2	1	3200	2.69	6.84
LS2	1	9269	2.68	6.51
LS2	2	657	5.11	7.87
LS2	2	3257	3.60	8.94
LS2	2	6732	4.36	6.39
LS2	3	194	3.08	7.59
LS2	3	4090	3.77	6.68
LS2	3	6837	5.36	7.31

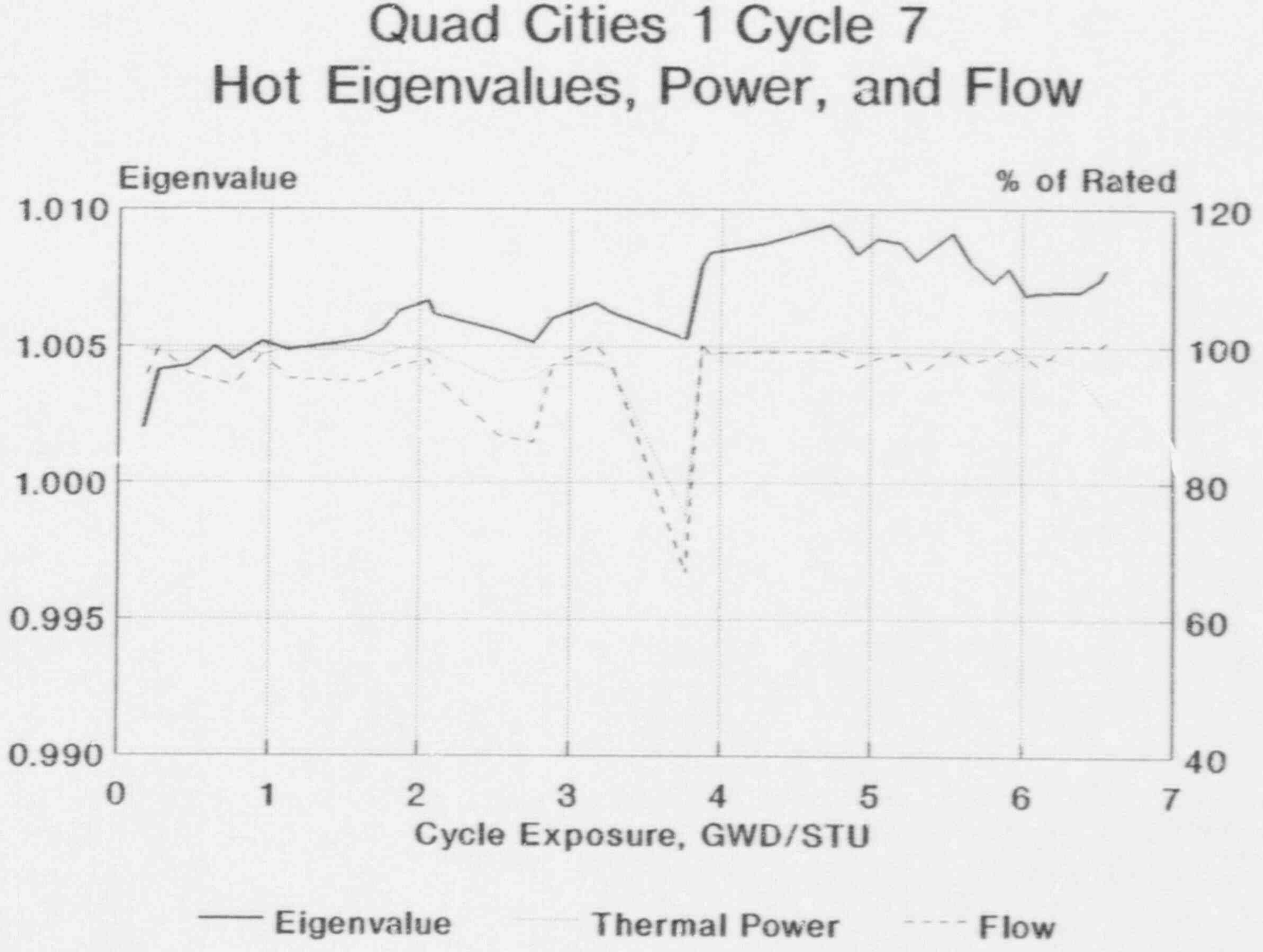

Quad Cities 1 Cycle 7
Hot Eigenvalues, Power, and Flow
Eigenvalue
% of Rated
1.010
1.005
1.000
0.995
0.990
120
100
80
60
40
0
1
2
3
4
5
6
7
Cycle Exposure, GWD/STU
Eigenvalue
Thermal Power
Flow

Figure 4.2-1

Quad Cities 1 Cycle 8
Hot Eigenvalues, Power, and Flow

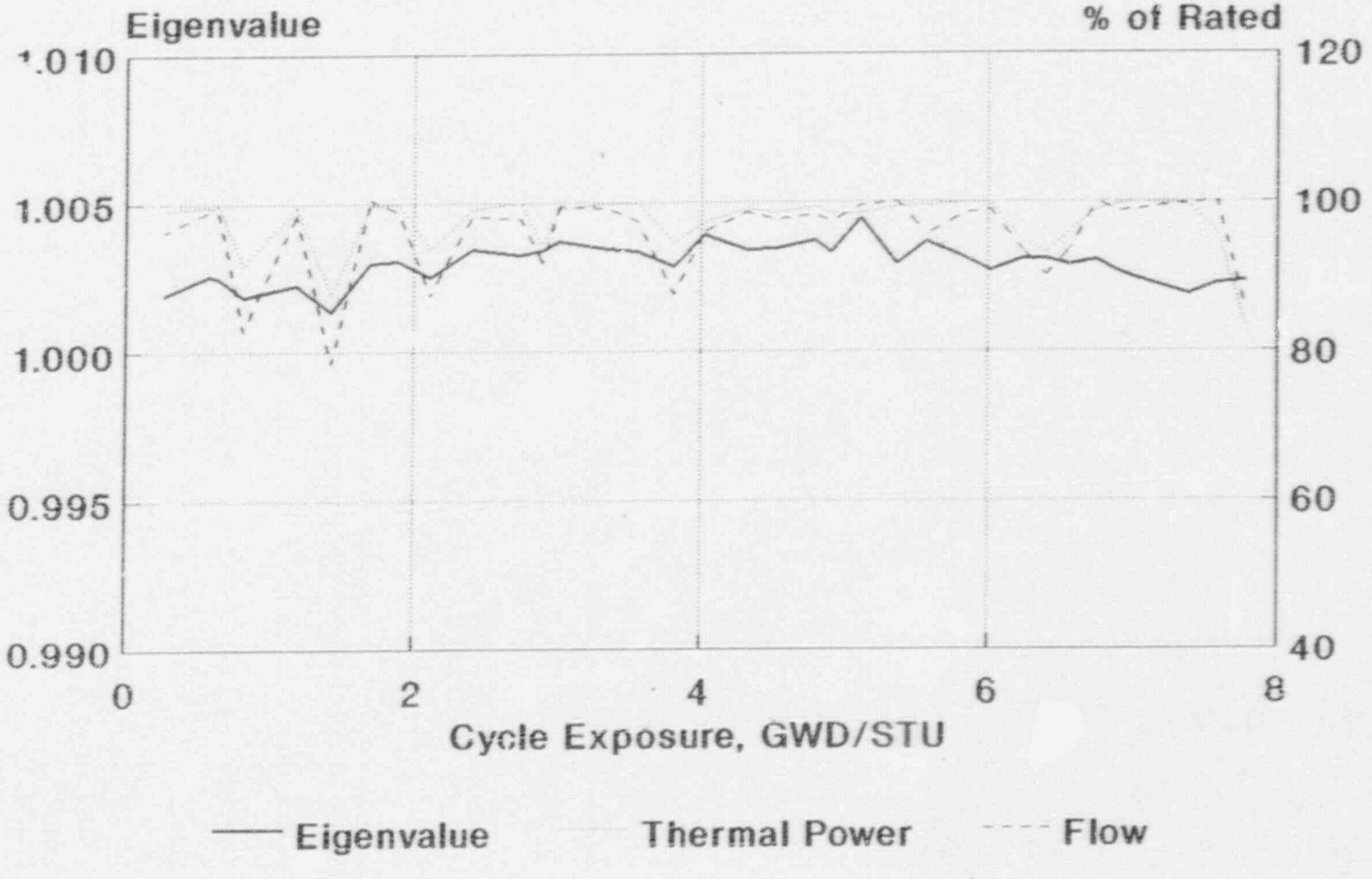


Figure 4.2-2

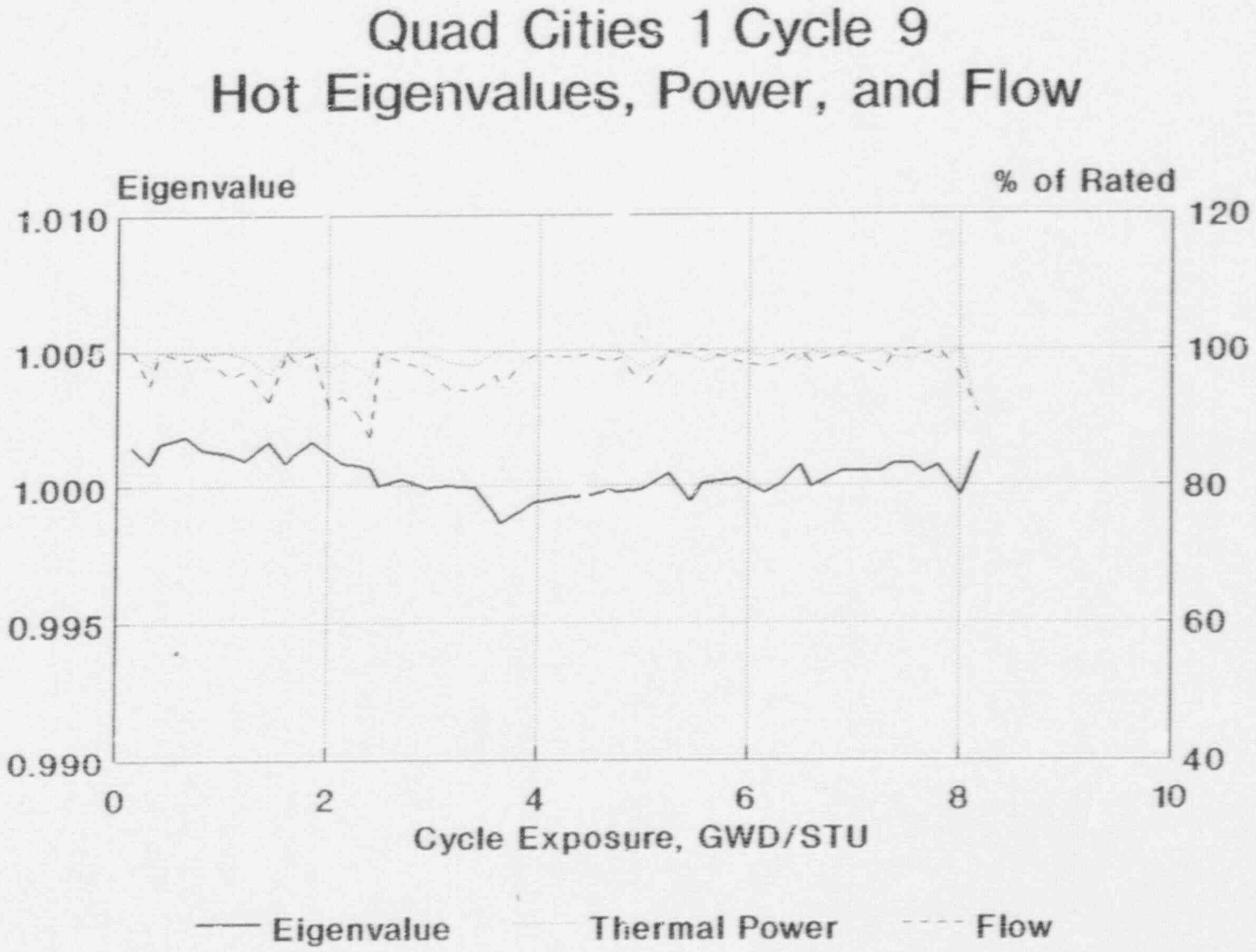
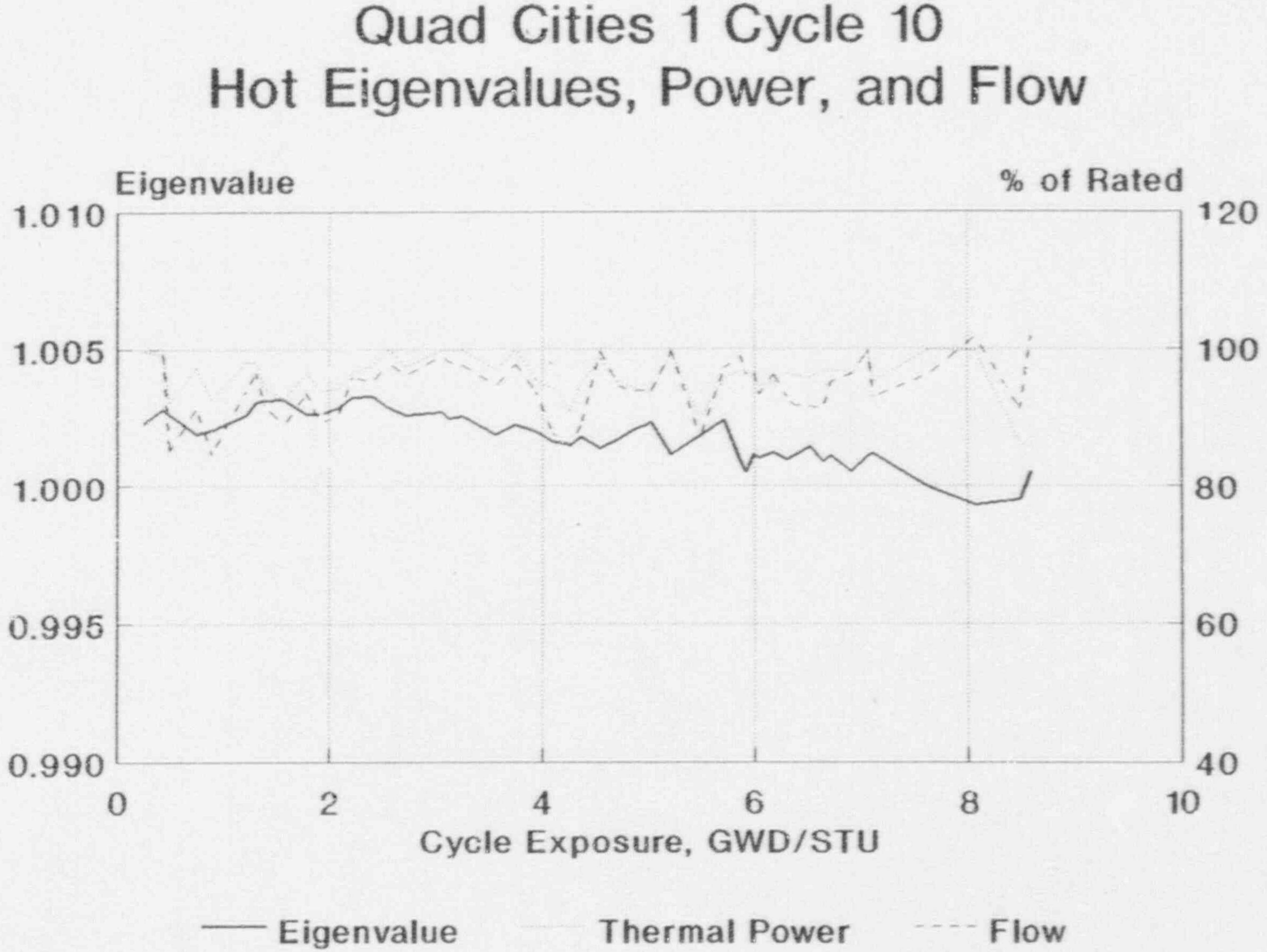

Quad Cities 1 Cycle 9
Hot Eigenvalues, Power, and Flow
Eigenvalue
% of Rated
1.010
1.005
1.000
0.995
0.990
120
100
80
60
40
0
2
4
6
8
10
Cycle Exposure, GWD/STU
Eigenvalue
Thermal Power
Flow

Figure 4.2-3



Quad Cities 1 Cycle 10
Hot Eigenvalues, Power, and Flow

Figure 4.2-4

Quad Cities 2 Cycle 7
Hot Eigenvalues, Power, and Flow

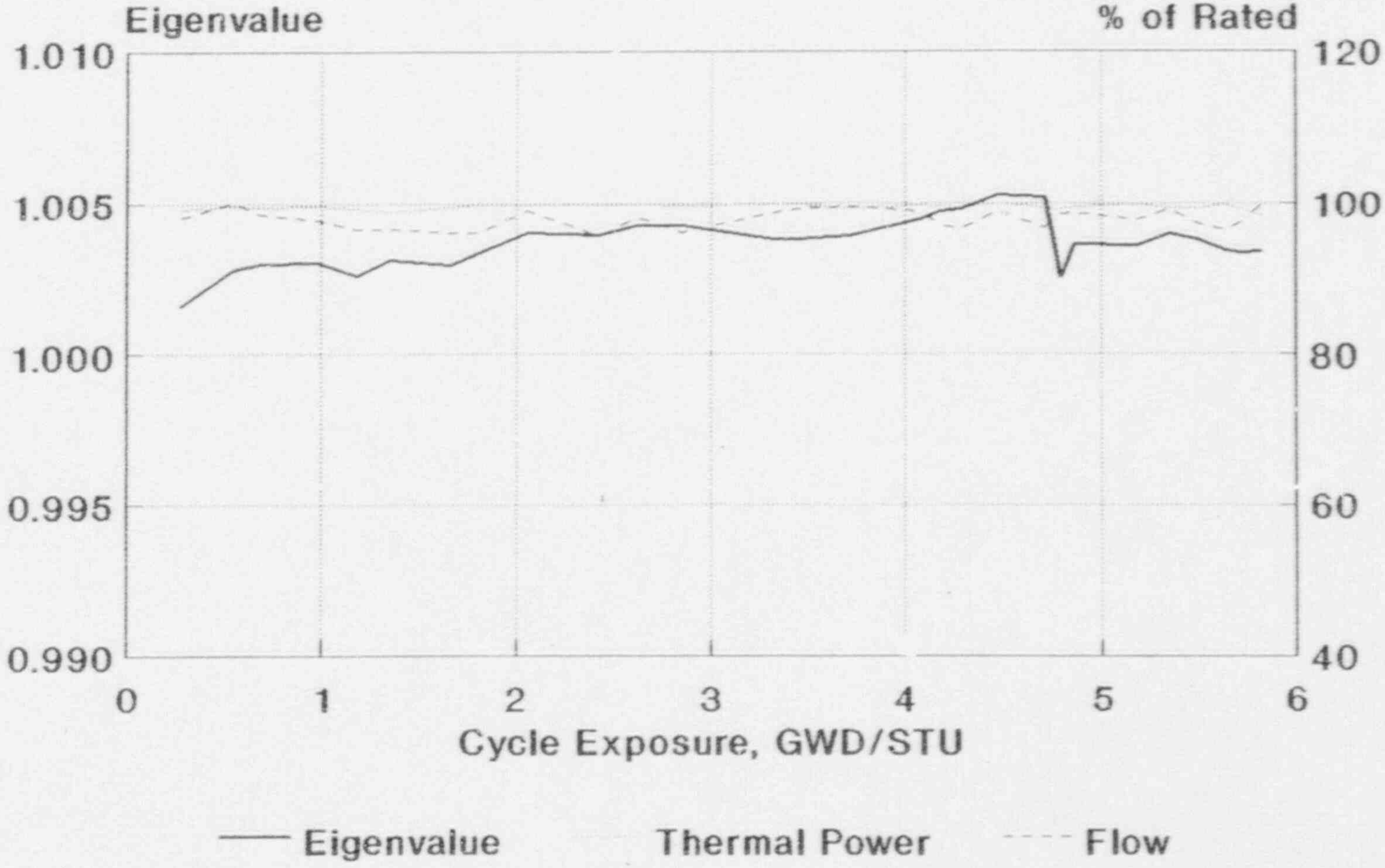
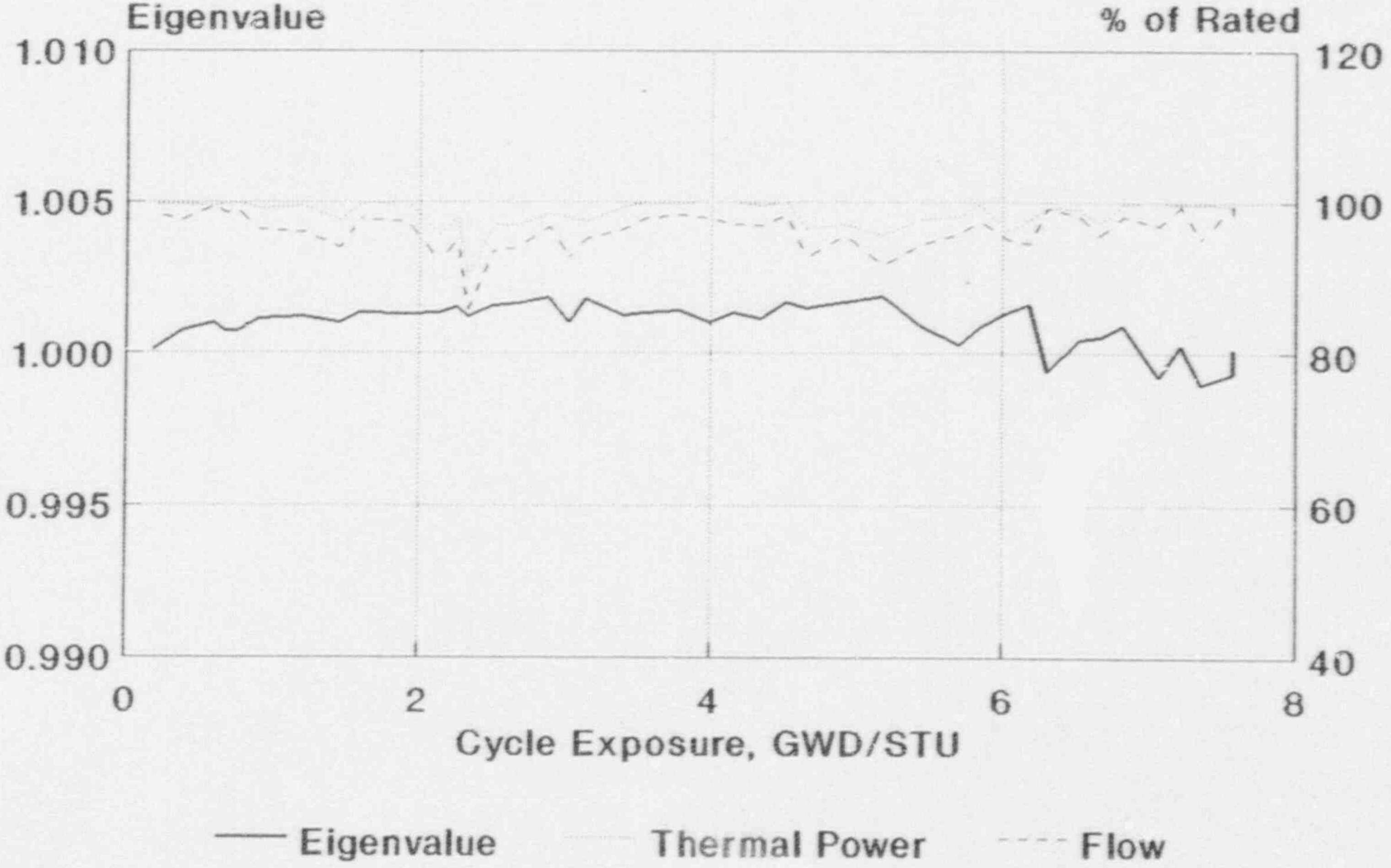


Figure 4.2-5



Quad Cities 2 Cycle 8
Hot Eigenvalues, Power, and Flow

Figure 4.2-6

Figure 4.2-7

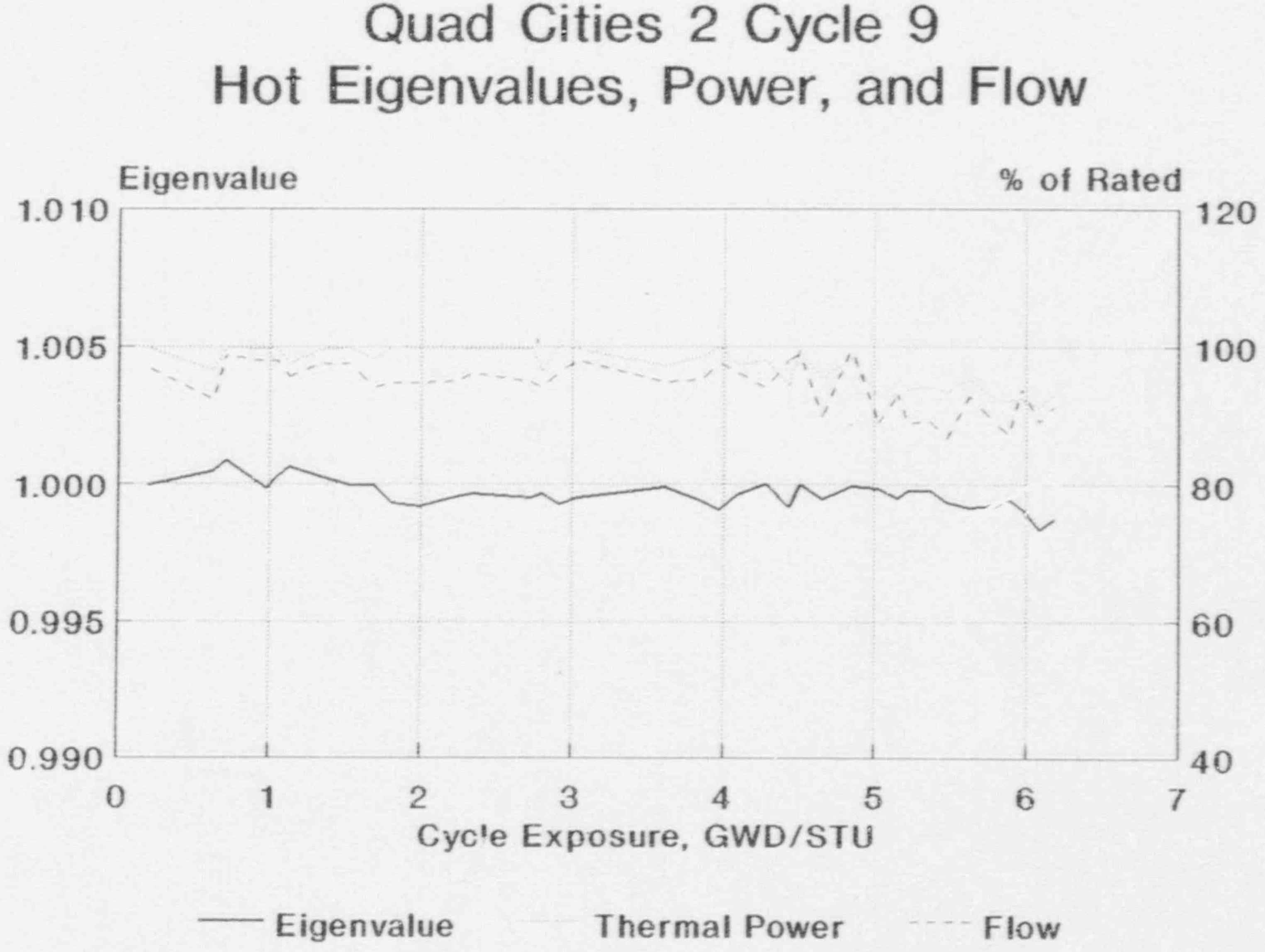
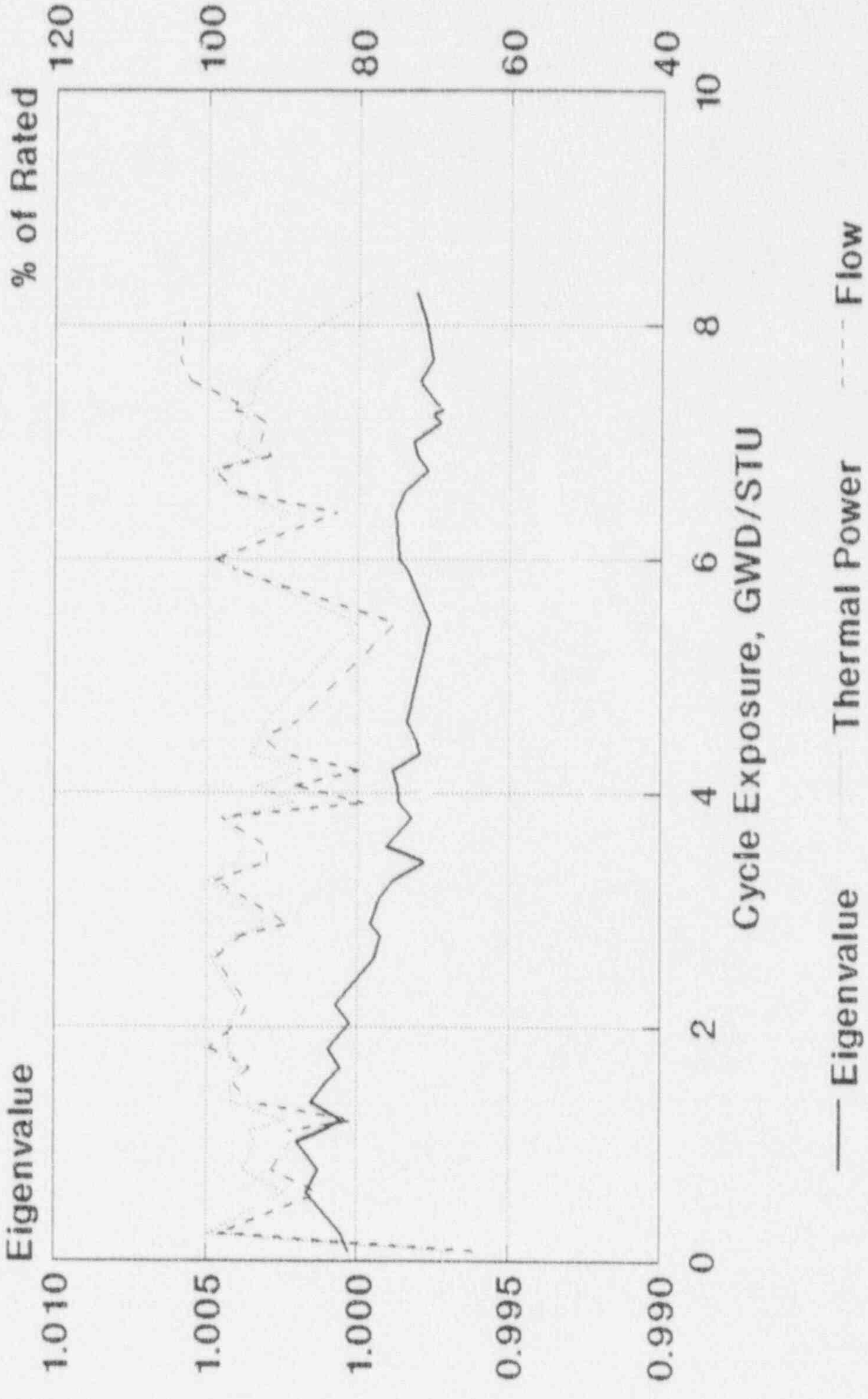

Quad Cities 2 Cycle 9
Hot Eigenvalues, Power, and Flow
Eigenvalue
% of Rated
1.010
1.005
1.000
0.995
0.990
120
100
80
60
40
0
1
2
3
4
5
6
7
Cycle Exposure, GWD/STU
Eigenvalue
Thermal Power
Flow

Figure 4.2-8



Quad Cities 2 Cycle 10
Hot Eigenvalues, Power, and Flow

Dresden 3 Cycle 8
Eigenvalues, Power, and Flow

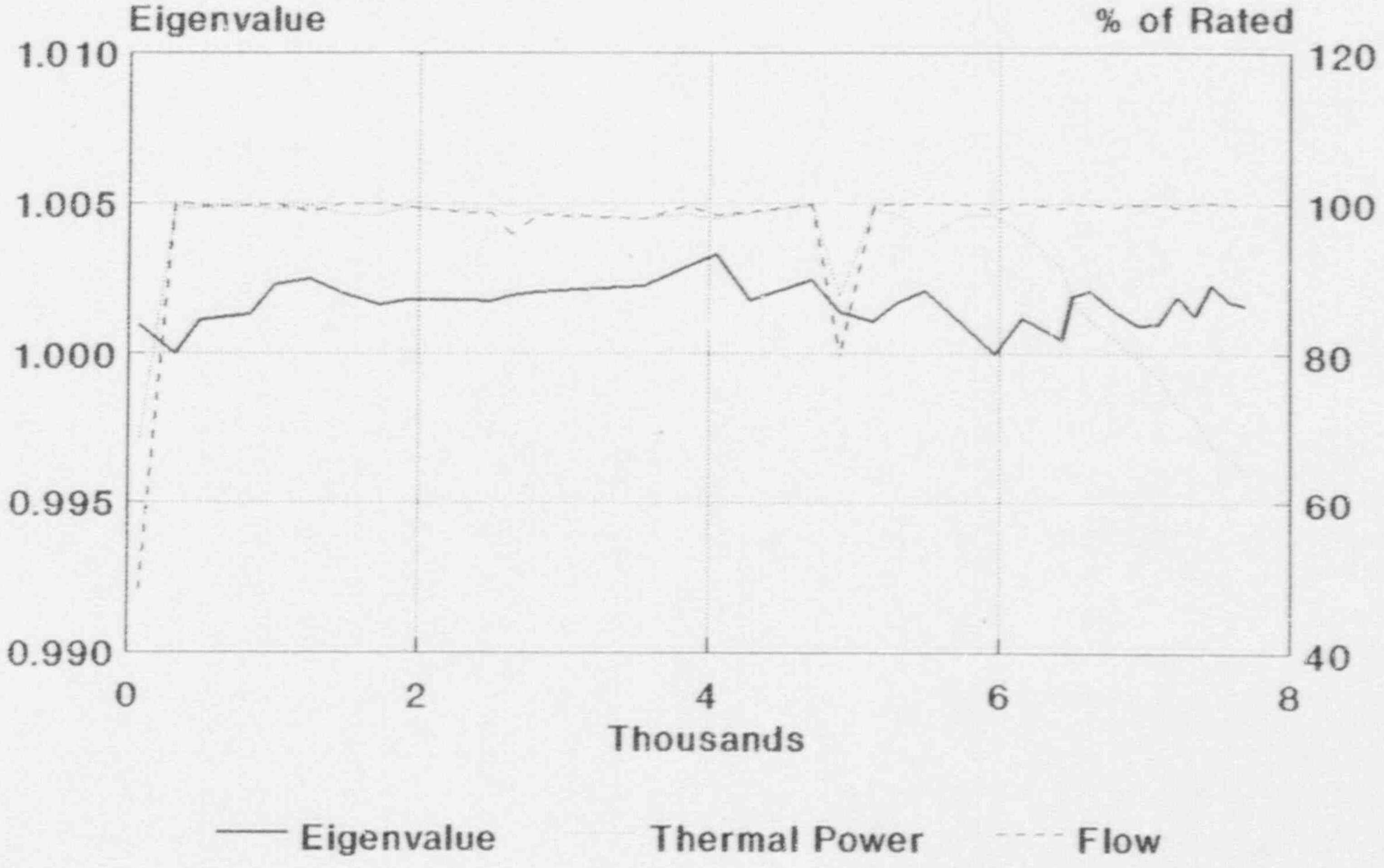
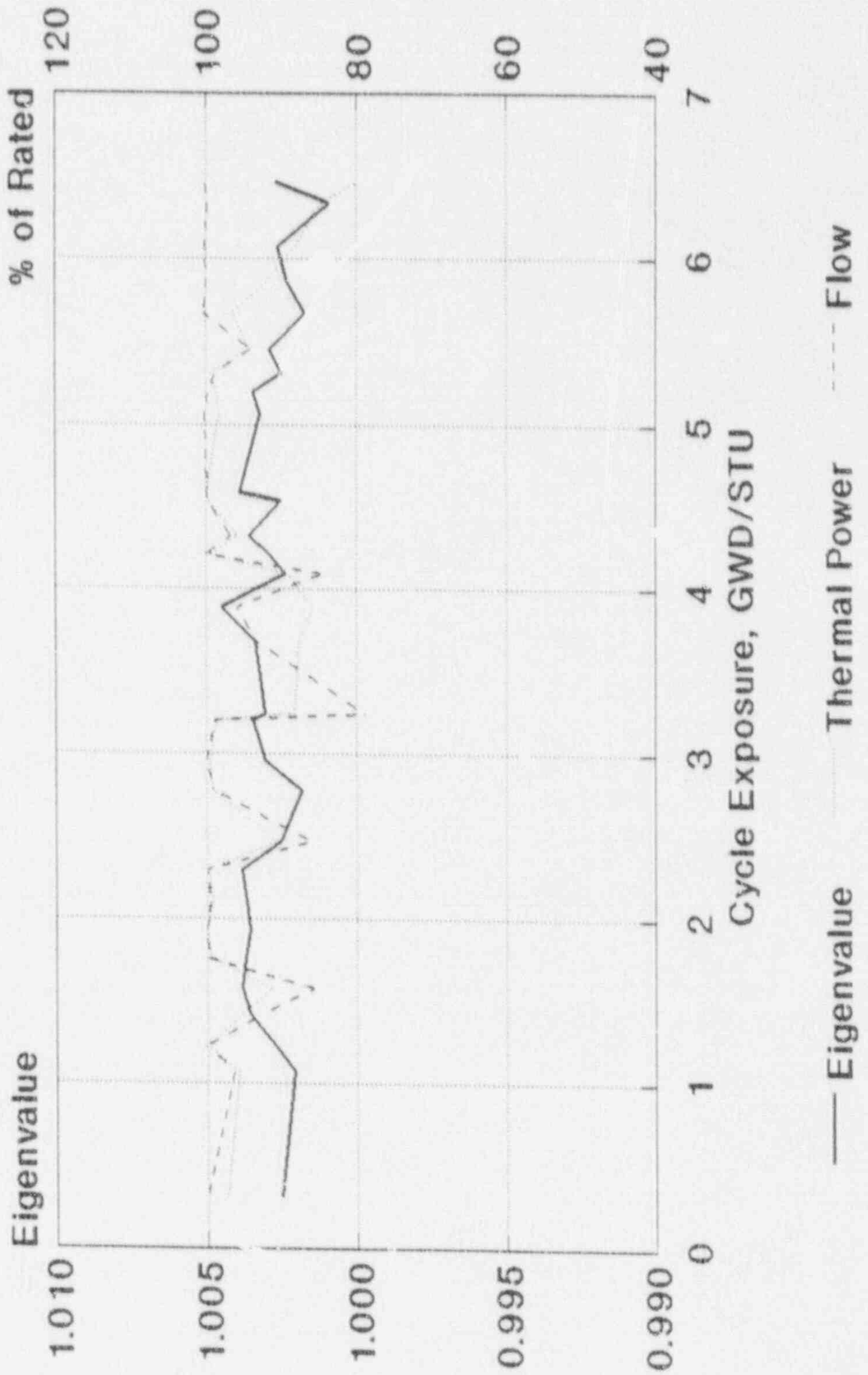
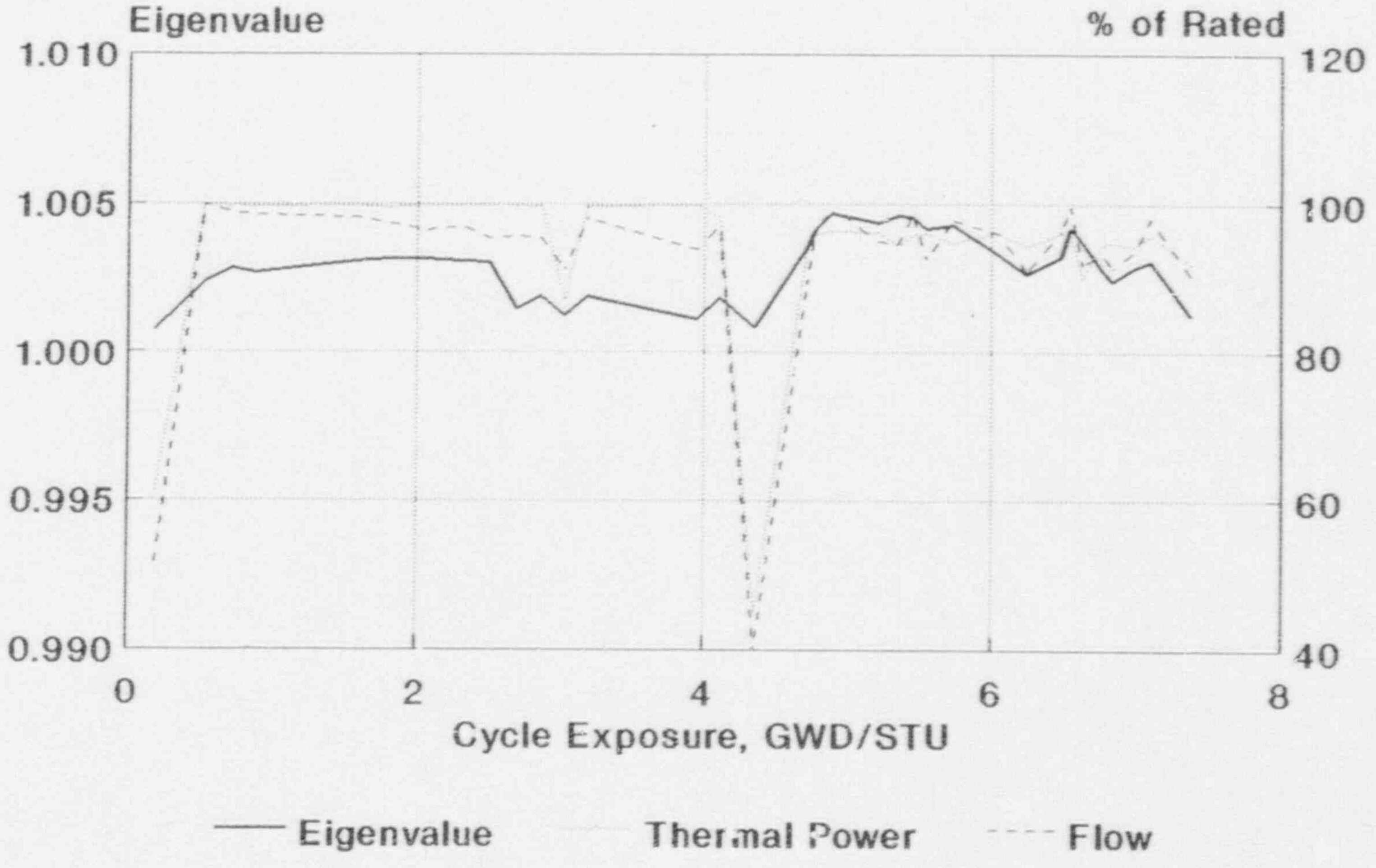


Figure 4.2-9

Figure 4.2-10



Dresden 3 Cycle 9
Eigenvalues, Power, and Flow



Dresden 3 Cycle 10
Hot Eigenvalues, Power, and Flow

Figure 4.2-11

Dresden 3 Cycle 11
Eigenvalues, Power, and Flow

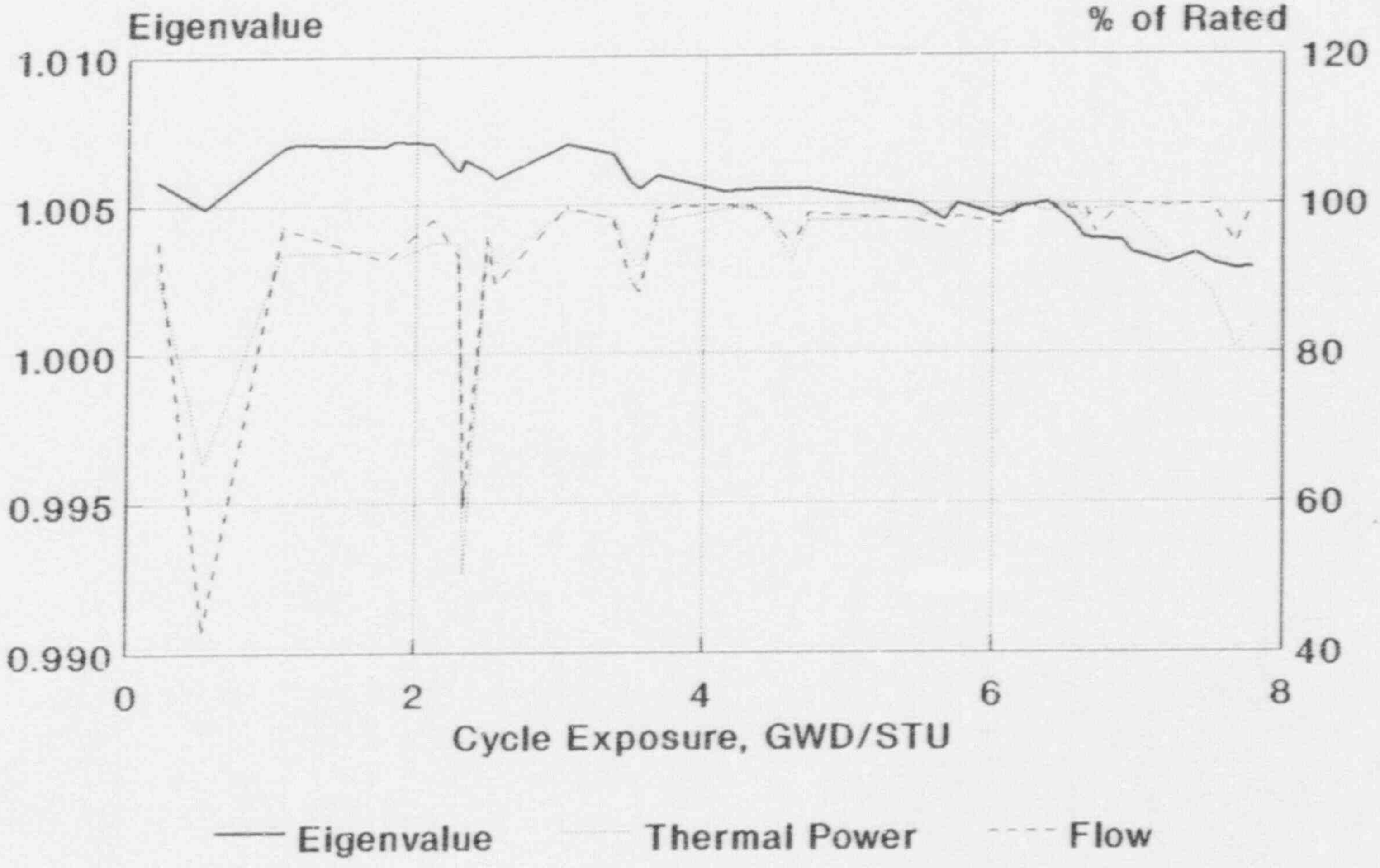


Figure 4.2-12

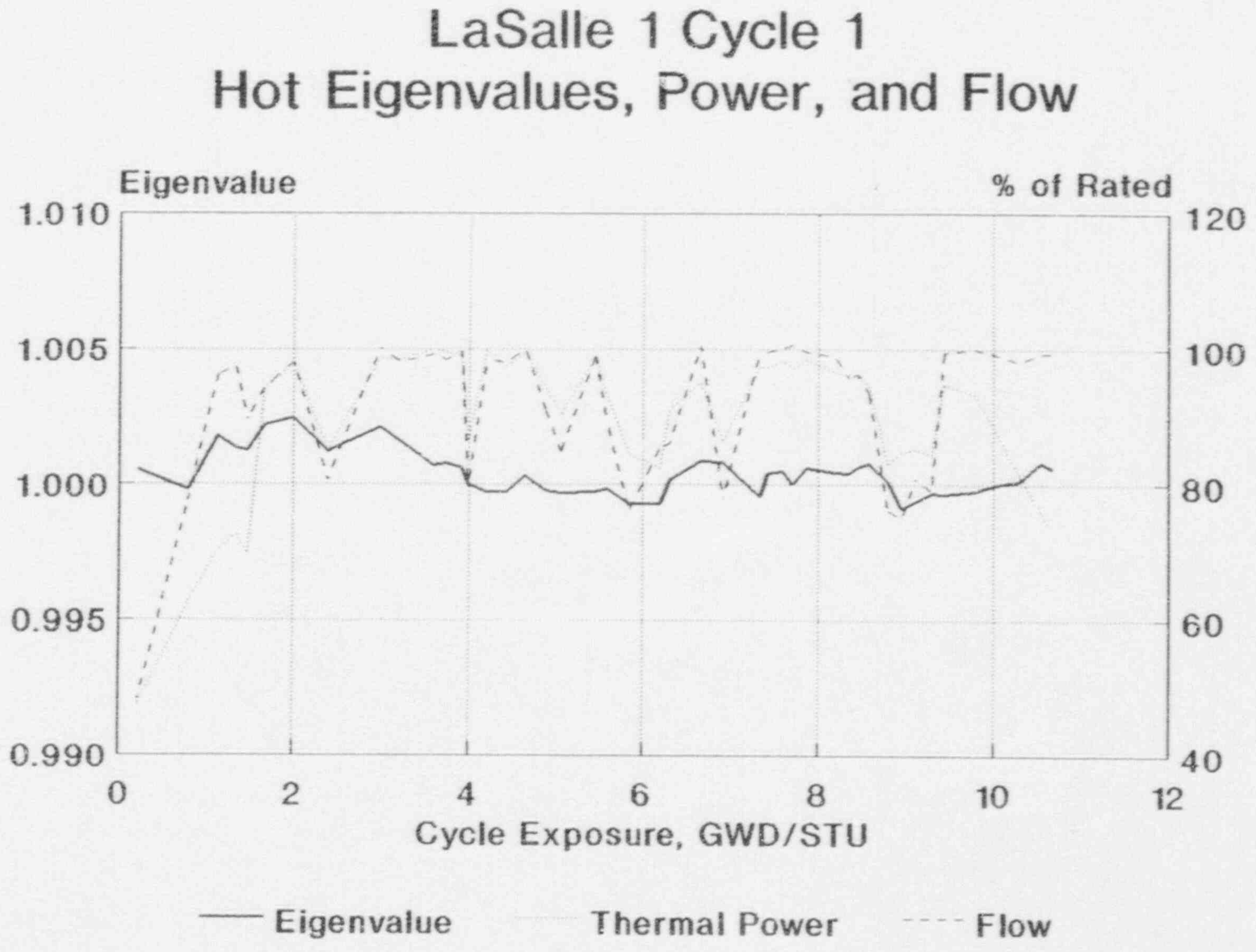

LaSalle 1 Cycle 1
Hot Eigenvalues, Power, and Flow

Figure 4.2-13

LaSalle 1 Cycle 2
Hot Eigenvalues, Power, and Flow

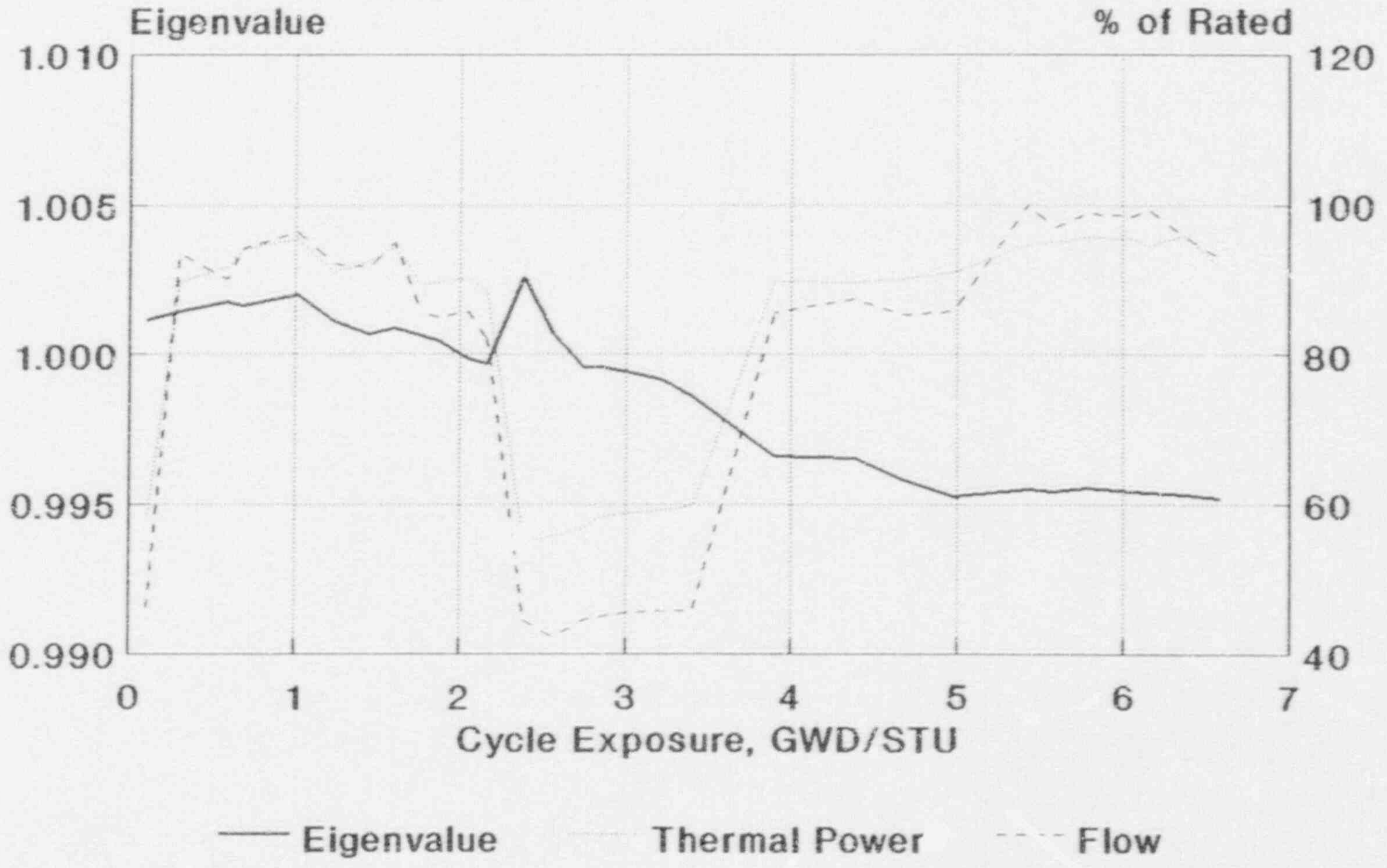
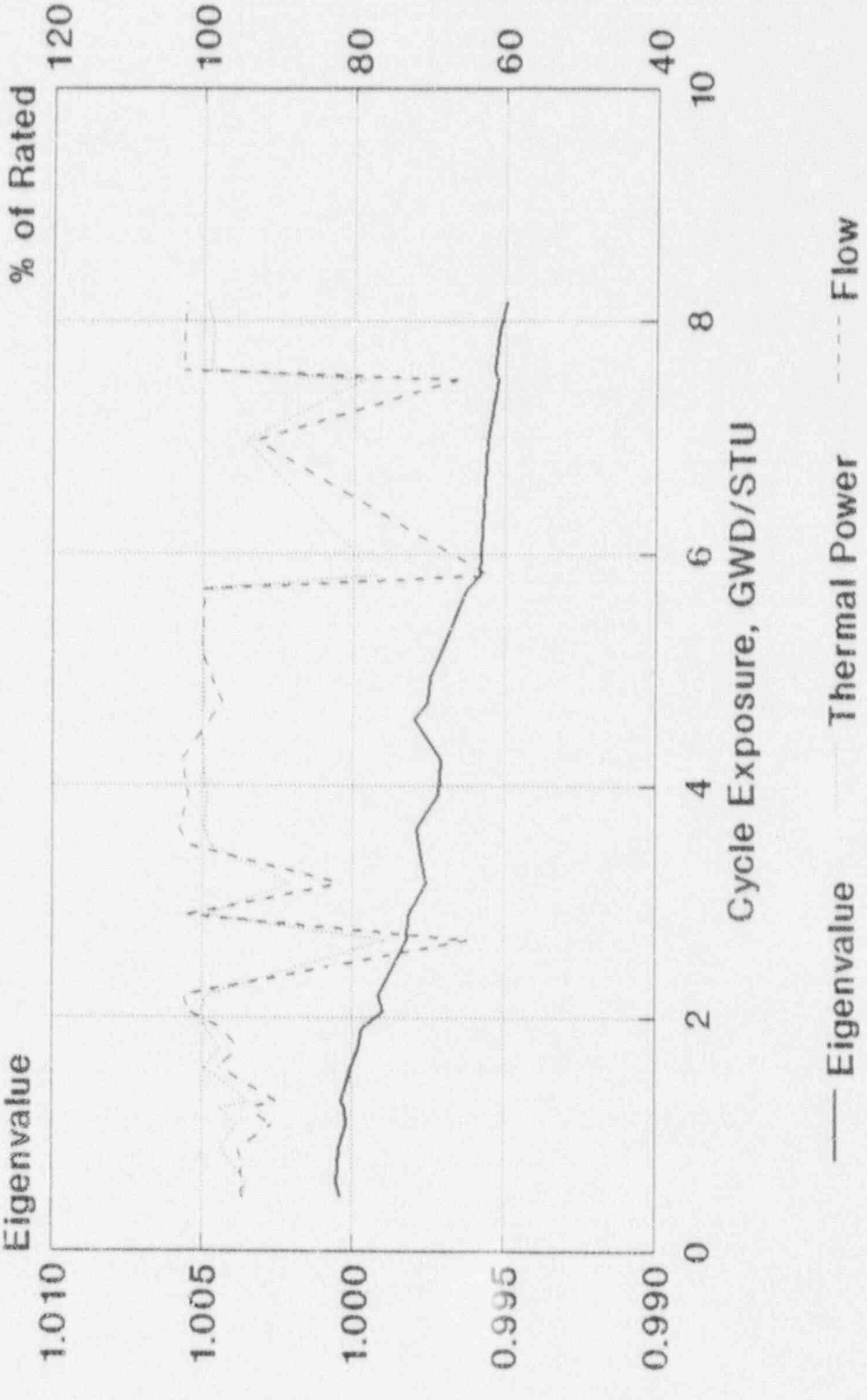


Figure 4.2-14

Figure 4.2-15



LaSalle 1 Cycle 3
Hot Eigenvalues, Power, and Flow

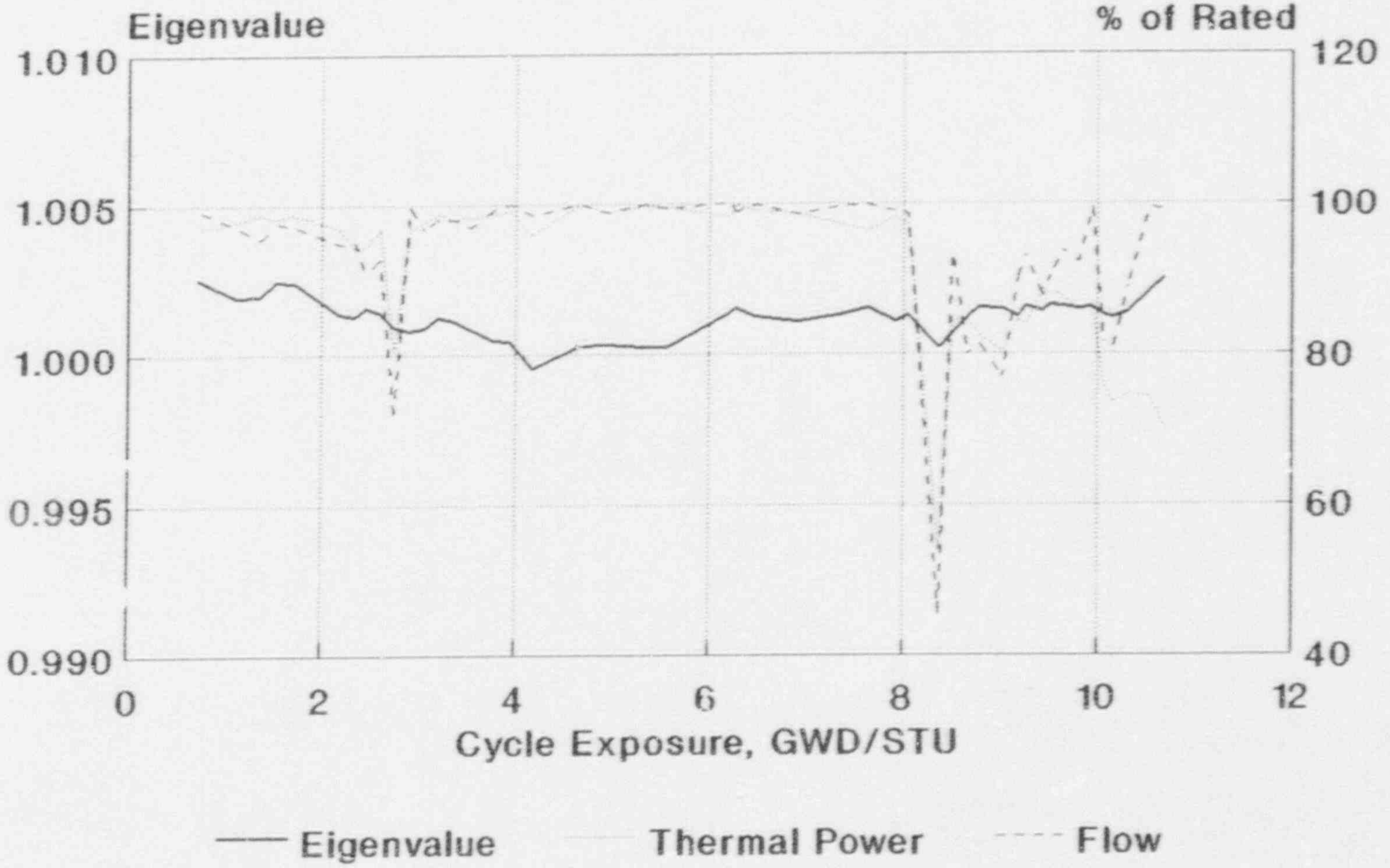

LaSalle 2 Cycle 1
Hot Eigenvalues, Power, and Flow

Figure 4.2-16

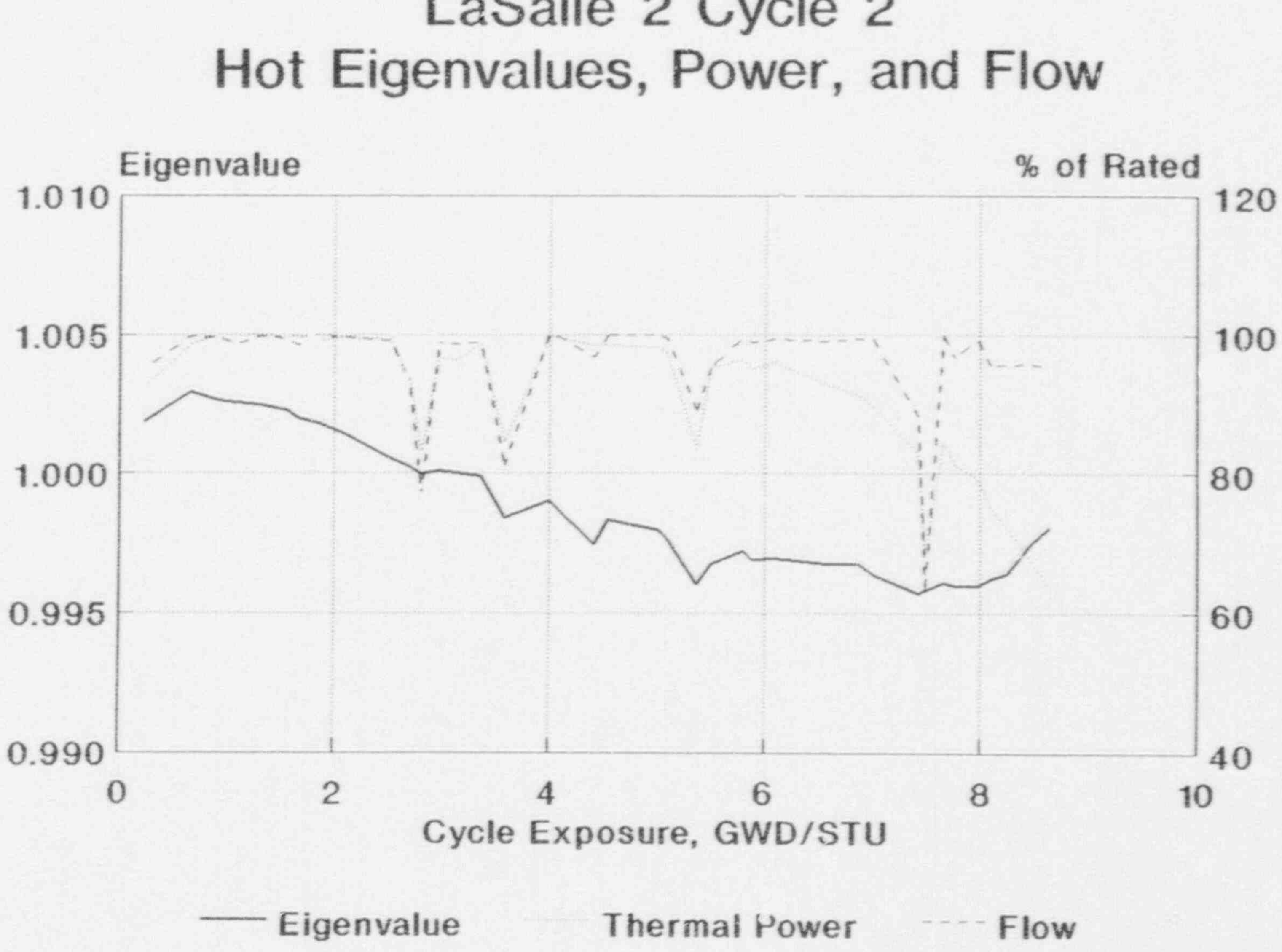

LaSalle 2 Cycle 2
Hot Eigenvalues, Power, and Flow
Eigenvalue
% of Rated
1.010
1.005
1.000
0.995
0.990
120
100
80
60
40
0
2
4
6
8
10
Cycle Exposure, GWD/STU
Eigenvalue
Thermal Power
Flow

Figure 4.2-17

LaSalle 2 Cycle 3
Hot Eigenvalues, Power, and Flow

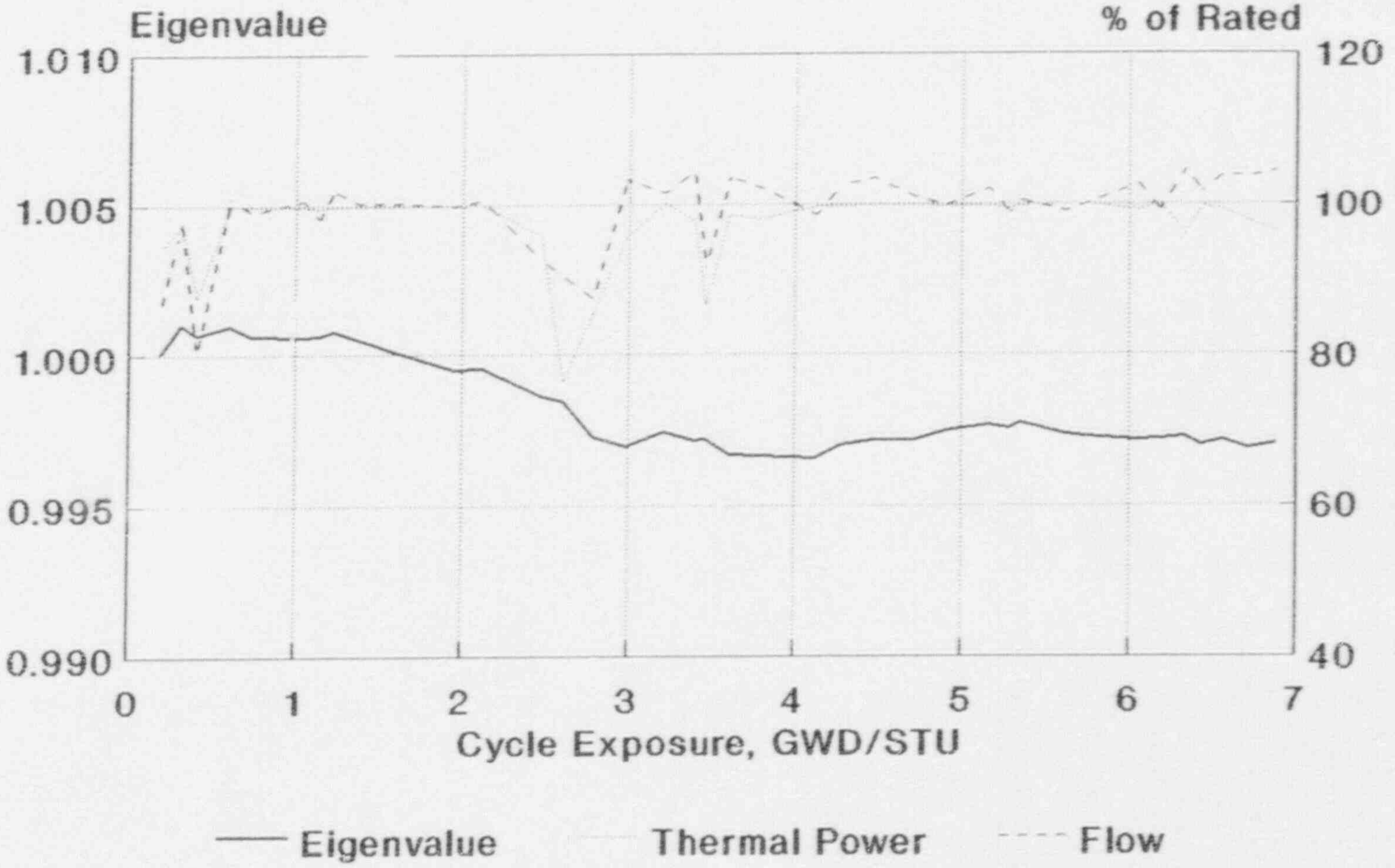


Figure 4.2-18

Quad Cities Station
Summary of Hot Critical Eigenvalues

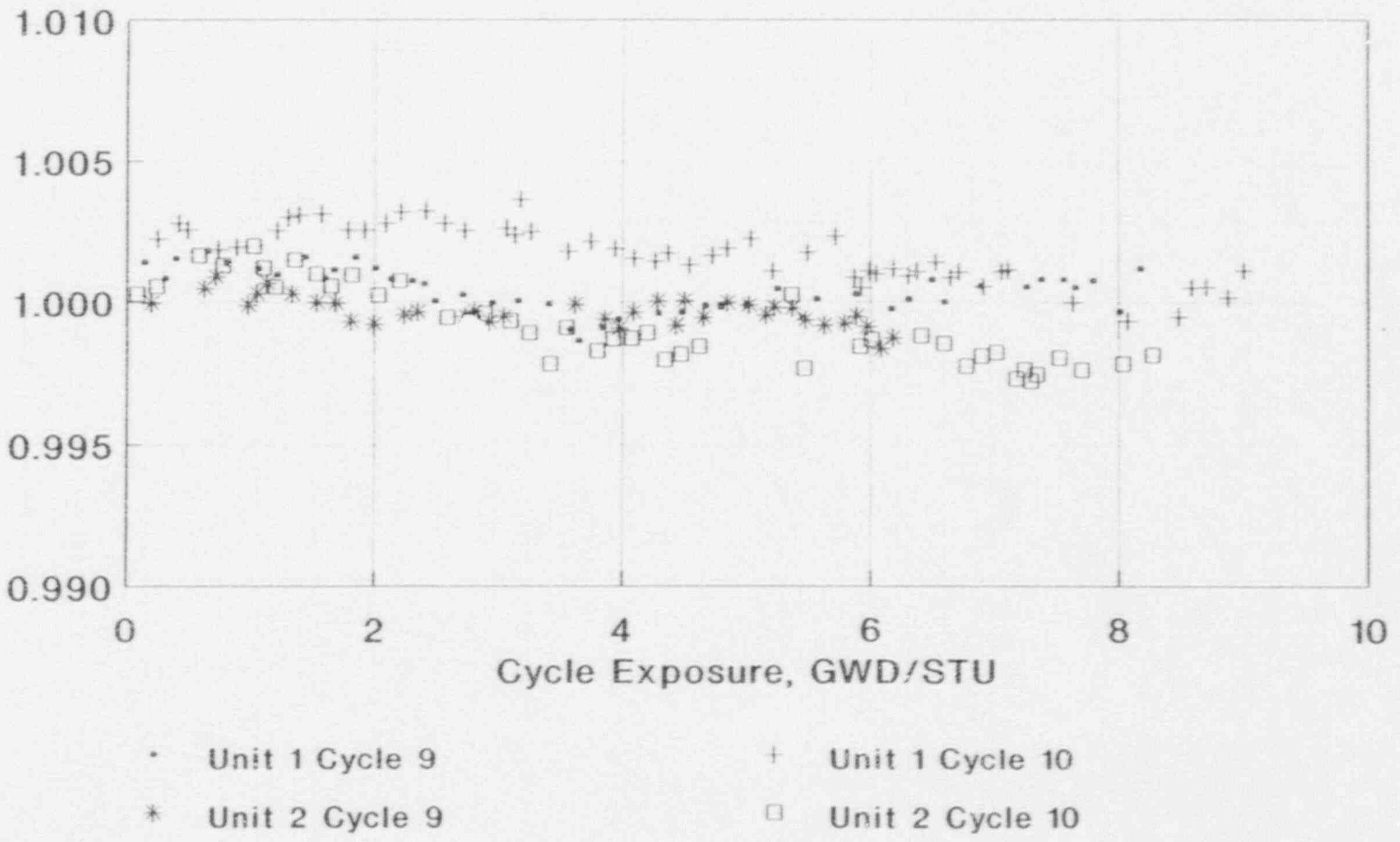


Figure 4.2-19

Dresden Station
Summary of Hot Critical Eigenvalues

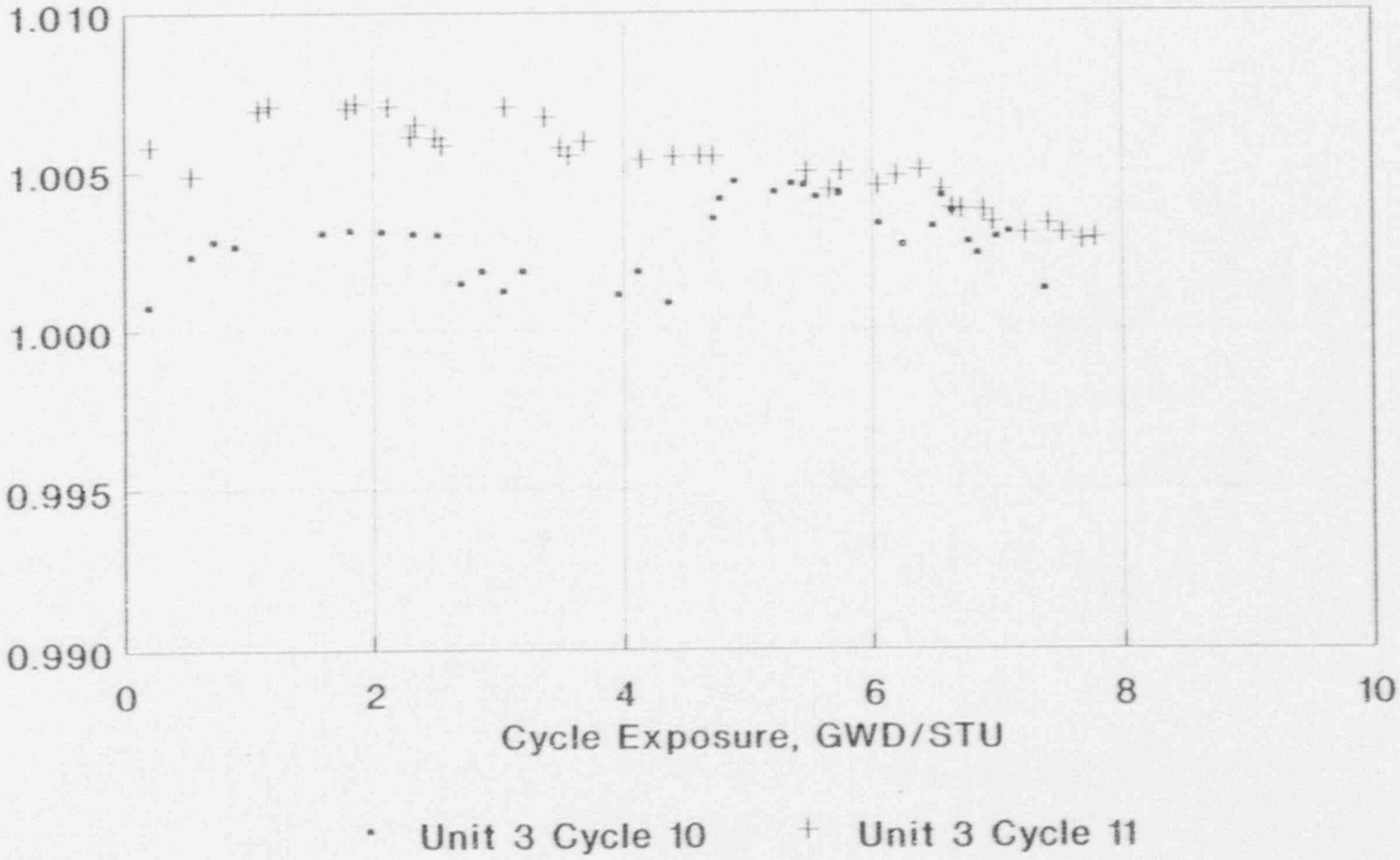


Figure 4.2-20

LaSalle County Station
Summary of Hot Critical Eigenvalues

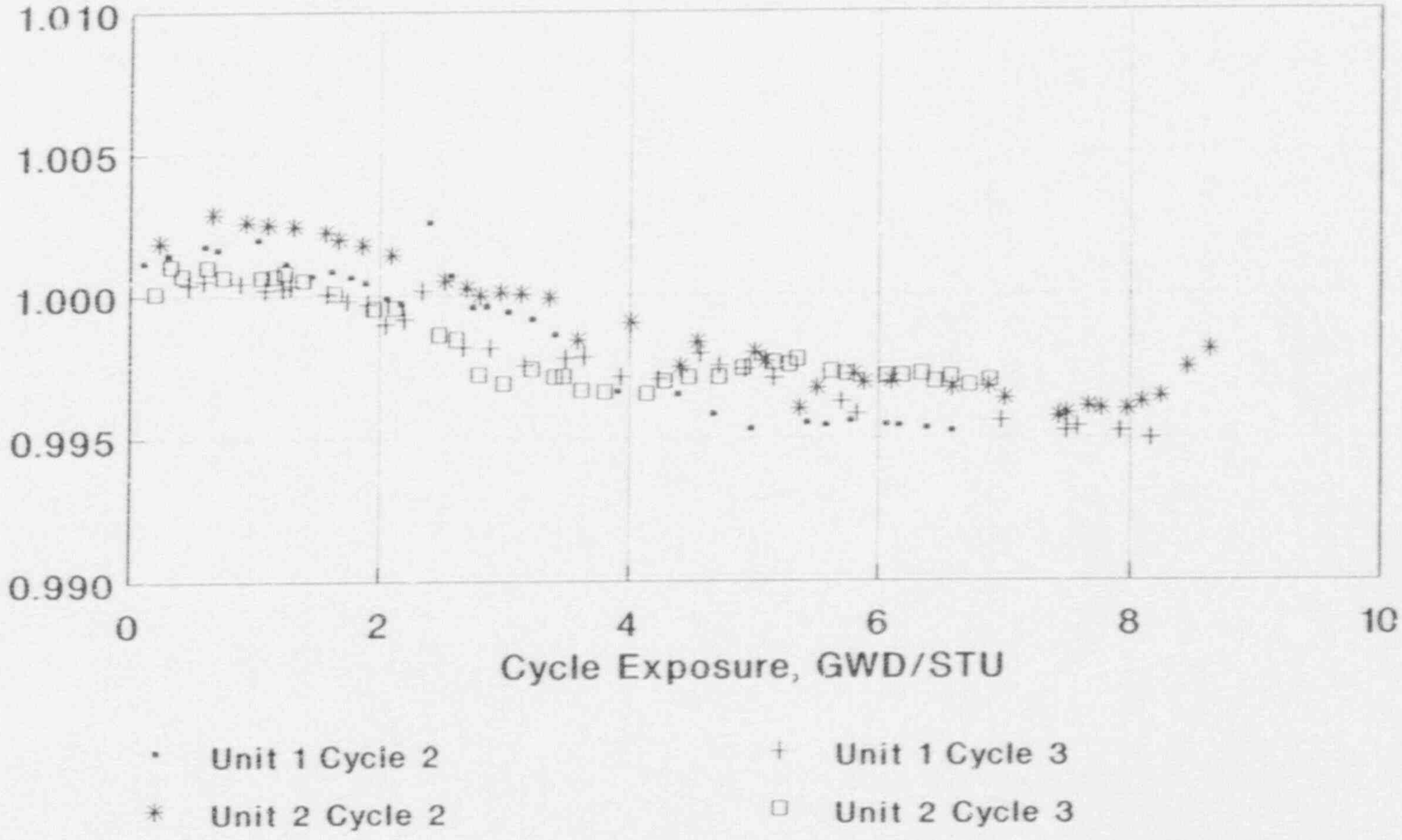


Figure 4.2-21

Section 5 - References

1. GE Proprietary Document NEDE-24011-P-A, "General Electric Standard Application for Reactor Fuel", as supplemented.

2. GE Proprietary Document NEDE-30130-P-A, "Steady-State Nuclear Methods", April 1985.

3. R. T. Chiang and M. Yamamoto, GE Proprietary Document NEDE-30002P, "TGBLA Lattice Physics Methods", December 1982.

4. GE Document NEDE-25337, Revision 2, "An Introduction to the GELIB System", October 1982.

5. C. L. Martin and F. Rahnema, GE Proprietary Document NEDE-20884P, "PANACEA - BWR Core Simulator", March 1988.

Appendix A
Bundle Nomenclature

The bundle nomenclature used in this report is best described by an example.

Bundle Name = GE8B-P8DQB300-7G4.0-80M-145

Where:

GE8B - Fuel Product Line Identifier
Options:
ANF = All ANF Fuel Product Lines
GExB = GE Fuel Product Line x, with or without Barrier (B)

P - Pre-pressurized fuel.
Options:
P - Pressurized Greater than 1 atm.
No Entry - Unpressurized (1 atm)

8 - Lattice Array Size
Options:
7 = 7x7 Lattice Array
8 = 8x8 Lattice Array
9 = 9x9 Lattice Array

D - Lattice Type
Options:
D = D-lattice (Non Uniform Water Gaps)
C = C-lattice (Uniform Water Gaps)

Q - Lattice Product Line
Options:
I = GE Initial Core Fuel
R = GE Reload Fuel (Prior to GE8)
Q = GE8 Reload Fuel
E = ANF 8x8 1 Water Rod Reload Fuel
N = ANF 9x9 2 Water Rod Reload Fuel

B - Indicates this is a Bundle Name, Not a Lattice Name

300 - Average enrichment of bundle, w/o U235 * 100

7G4.0 - Gadolinia Loading
7 - Maximum Number of Gadolinia pins in any layer
4.0 - Gadolinia Concentration. This is set to "Z" if the bundle has axially varying gadolinia.

80M - Channel Thickness
80M - 80 mil thickness (Quad Cities and Dresden)
100M - 100 mil thickness (LaSalle)

145 - Fuel Length, inches
144 or 145 - Quad Cities and Dresden
150 - LaSalle

Appendix B
Statistical Basis for TIP Results

Several standard deviations are presented in the text. The bases for these calculations are discussed in this appendix.

Nodal Standard Deviation

The nodal standard deviations are based on the nodal percent differences for each TIP reading in the core. The nodal percent differences are calculated as follows:

Nodal Percent Difference = (C - M) / Mbar * 100

where:

C - Calculated TIP Reading
M - Measured TIP Reading
Mbar - Average of all TIP Readings

Since the measured data are normalized such that the core average value is one, Mbar will always be equal to one and the above equation simplifies to the difference between the calculated and measured values.

The nodal standard deviations were calculated using the nodal percent differences calculated in this way for the entire axial length of the core, or 24 nodes. This is more conservative than using 20 node data, as the low power nodes in the core top and bottom are more difficult to predict, but are given equal weighting in the calculation.

Radial Standard Deviation

The radial standard deviations are based on the radial percent differences for each TIP string in the core. The radial percent differences are the differences between the summations of the calculated TIP readings and the measured TIP readings for each TIP string. Again, since the measured data are normalized such that the core average value is one, the normalization factor Mbar will always be equal to one.

The radial standard deviations were calculated using the radial percent differences calculated in this way for the entire axial length of the core, or 24 nodes.

Appendix C
TIP Traces for Quad Cities Station Unit 1

A comparison of calculated versus measured core axial TIP traces for Quad Cities Station Unit 1 is included in this appendix. Figures included are:

Figure C-1 - Quad Cities Station Unit 1 Cycle 7 Results

Figure C-2 - Quad Cities Station Unit 1 Cycle 8 Results

Figure C-3 - Quad Cities Station Unit 1 Cycle 9 Results

Figure C-4 - Quad Cities Station Unit 1 Cycle 10 Results

Figure C-1
Quad Cities Station Unit 1 Cycle 7 Results

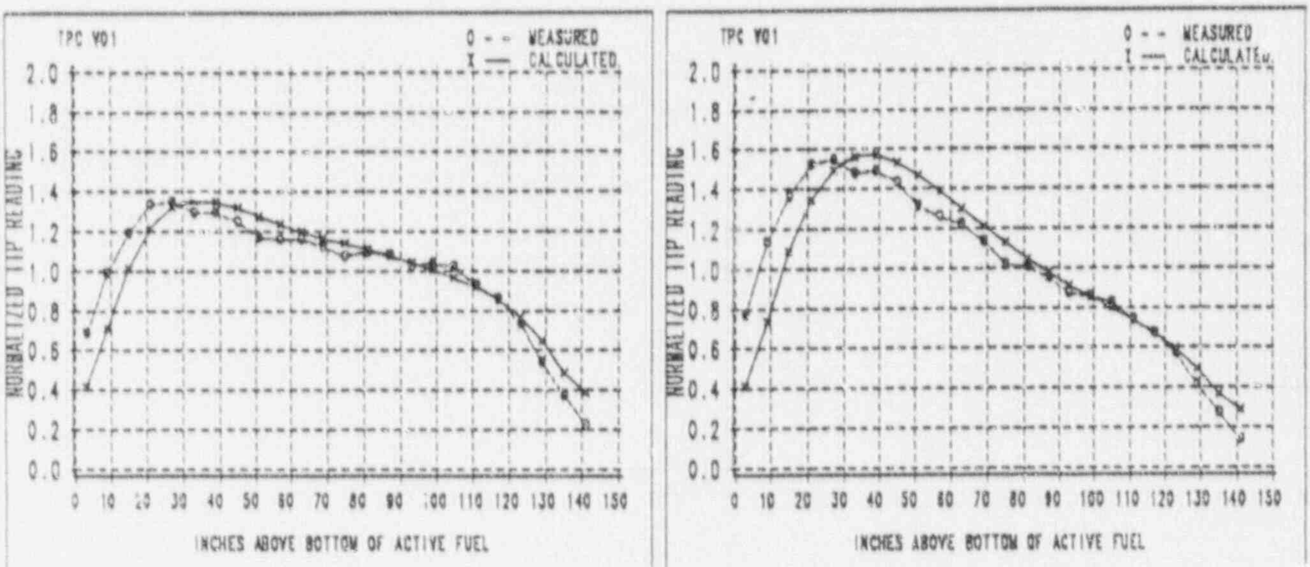


FIGURE Q1 C7 CA1 01-03-83 106.3 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSJKS JOB06269 07/11/90

FIGURE Q1 C7 CA1 07-14-83 3468.2 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSJKS JOB06269 07/11/90

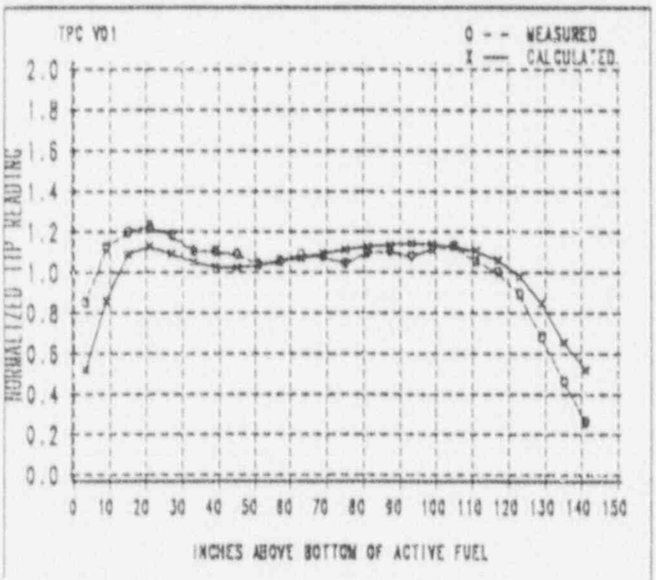


FIGURE Q1 C7 CA1 02-15-84 7012.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSJKS JOB06269 07/11/90

Figure C-2
Quad Cities Station Unit 1 Cycle 8 Results

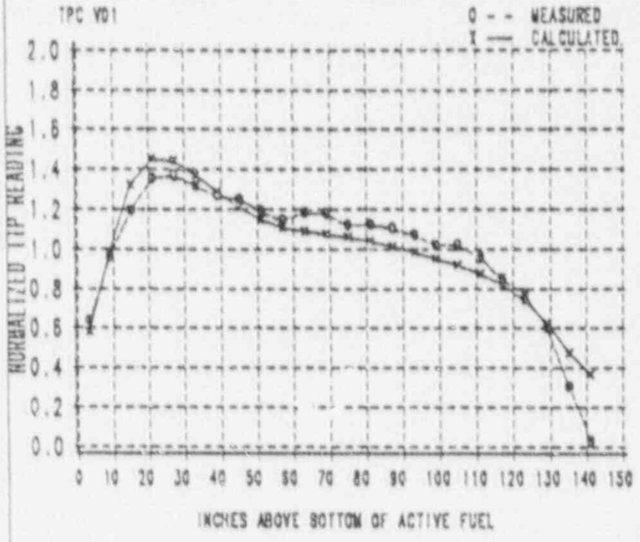


FIGURE Q1 C8 CA1 09-25-84 574.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSJKS JOB08269 07/11/90

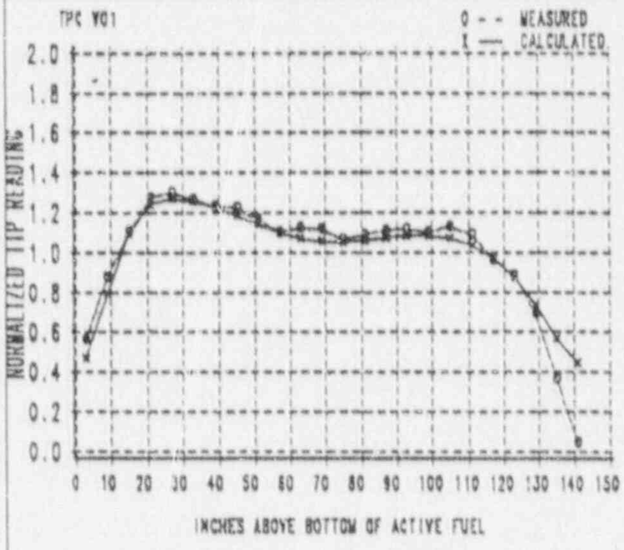


FIGURE Q1 C8 CA1 04-24-85 4332.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSJKS JOB08269 07/11/90

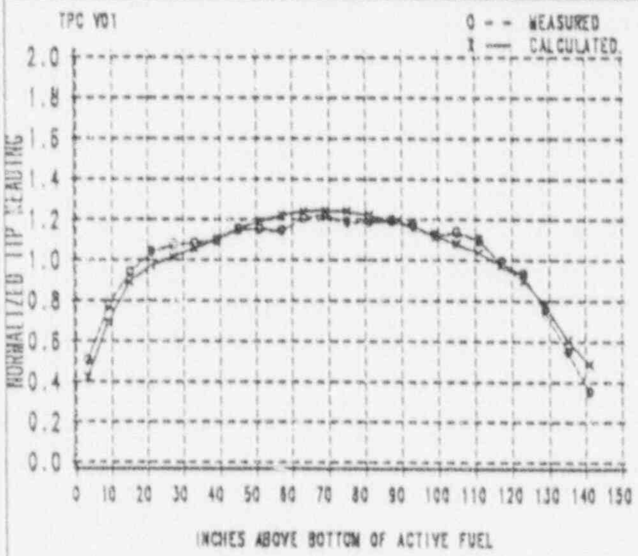


FIGURE Q1 C8 CA1 12-10-85 8123.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSJKS JOB08269 07/11/90

Figure C-3
Quad Cities Station Unit 1 Cycle 9 Results

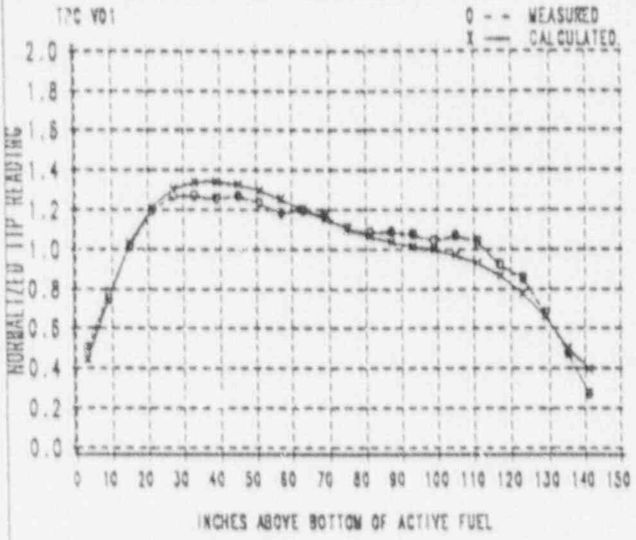


FIGURE Q1 C9 CA1   05-12-86   659.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG.   =   1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSJKS   J0806269   07/11/90

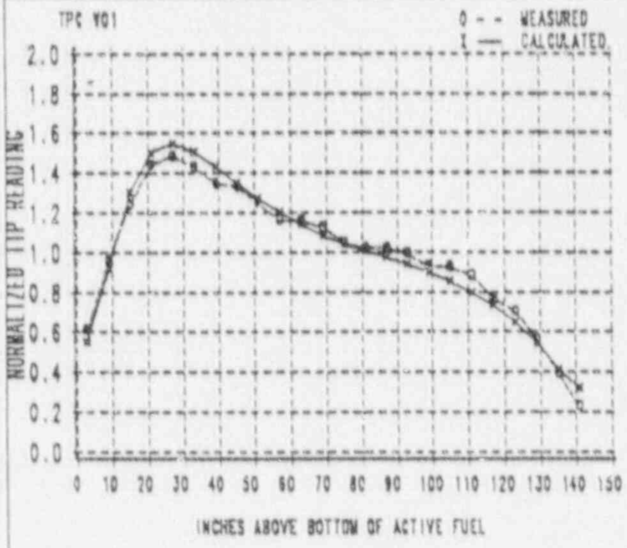


FIGURE Q1 C9 CA1   11-24-86   3886.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG.   =   1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSJKS   J0806269   07/11/90

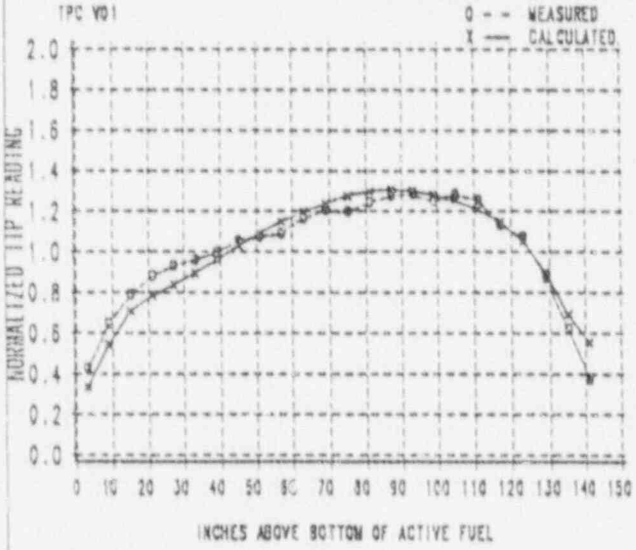


FIGURE Q1 C9 CA1   08-07-87   8448.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG.   =   1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSJKS   J0806269   07/11/90

Figure C-4
Quad Cities Station Unit 1 Cycle 10 Results

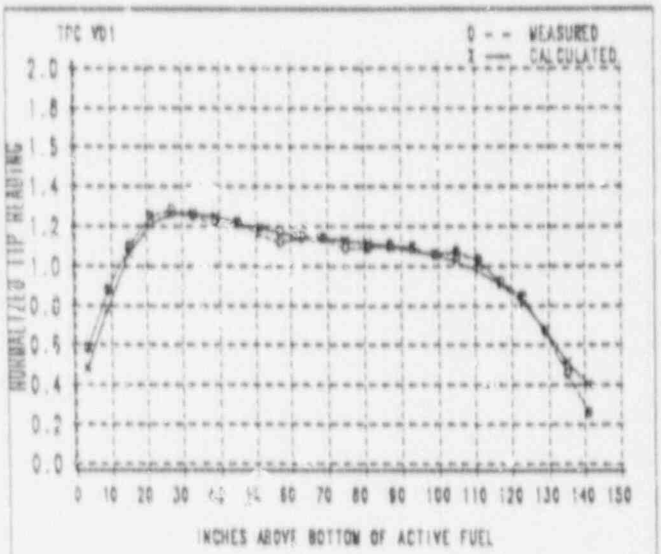


FIGURE Q1 C10 CA1   02-29-88   1131.1 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSJKS   JOB08269 07/11/90

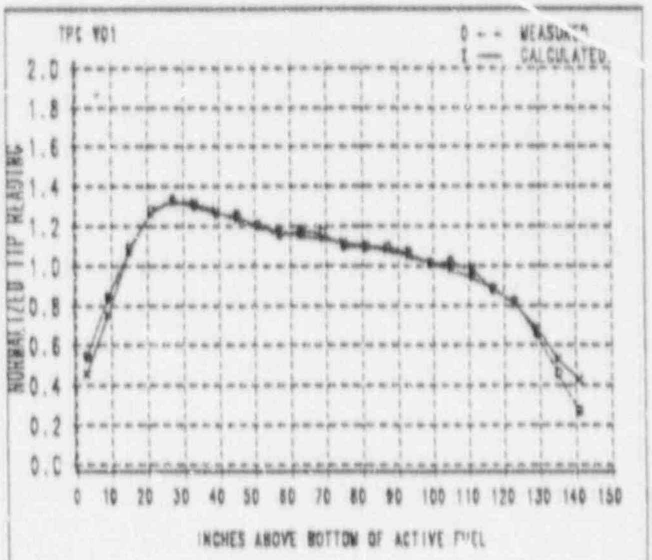


FIGURE Q1 C10 CA1   10-20-88   4792.2 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSJKS   JOB08269 07/11/90

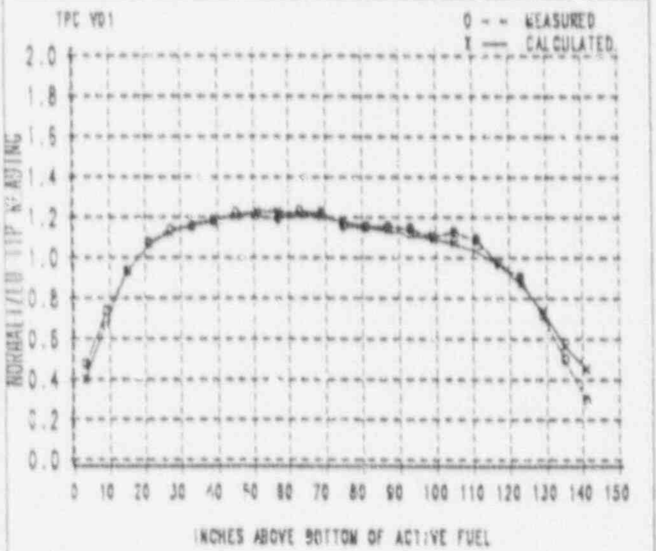


FIGURE Q1 C10 CA1   02-27-89   7071.3 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSJKS   JOB08269 07/11/90

Appendix D
TIP Traces for Quad Cities Station Unit 2

A comparison of calculated versus measured core axial TIP traces for Quad Cities Station Unit 2 is included in this appendix. Figures included are:

Figure D-1
Quad Cities Station Unit 2 Cycle 7 Results

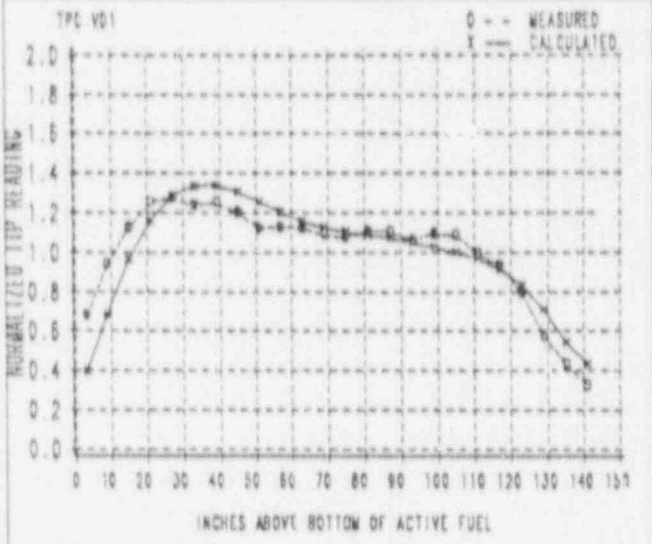


FIGURE Q2 C7 CA1 03-13-84 301.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

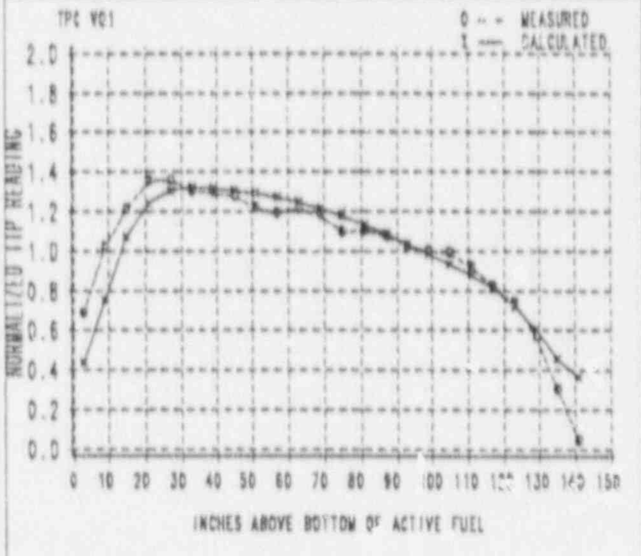


FIGURE Q2 C7 CA1 11-08-84 4376.1 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXD JOB09372 09/24/90

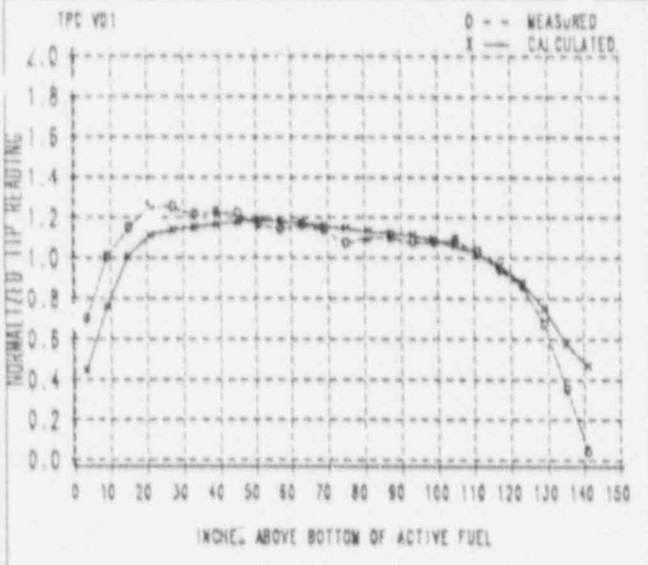


FIGURE Q2 C7 CA1 02-25-85 6057.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

Figure D-2
Quad Cities Station Unit 2 Cycle 8 Results

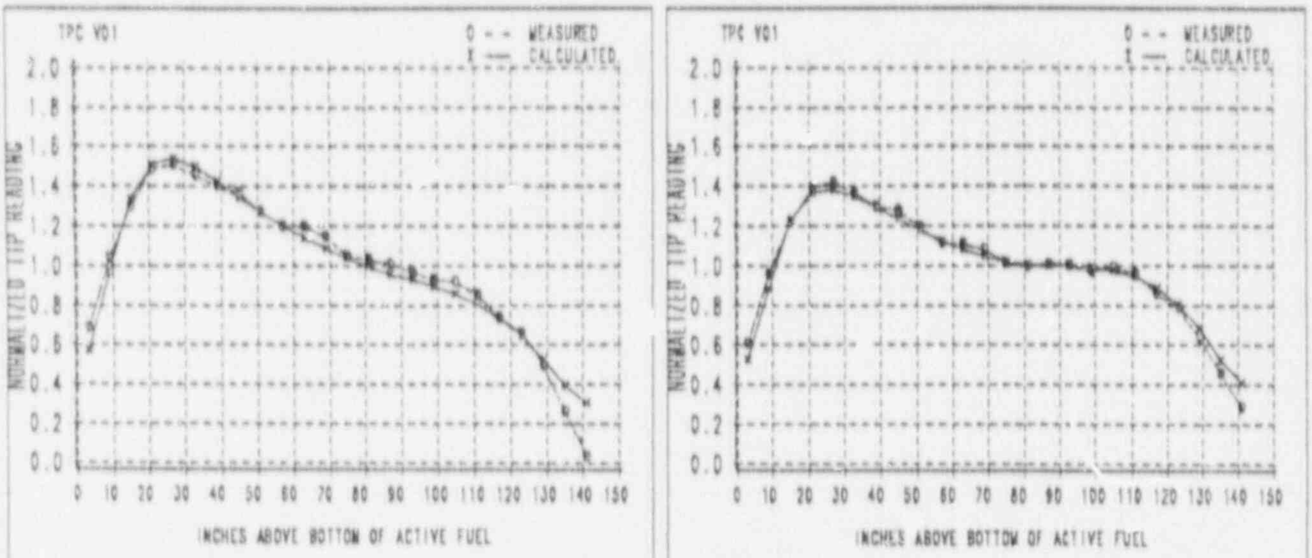


FIGURE Q2 C8 CA1 07-17-85 694.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

FIGURE Q2 C8 CA1 03-11-86 4623.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

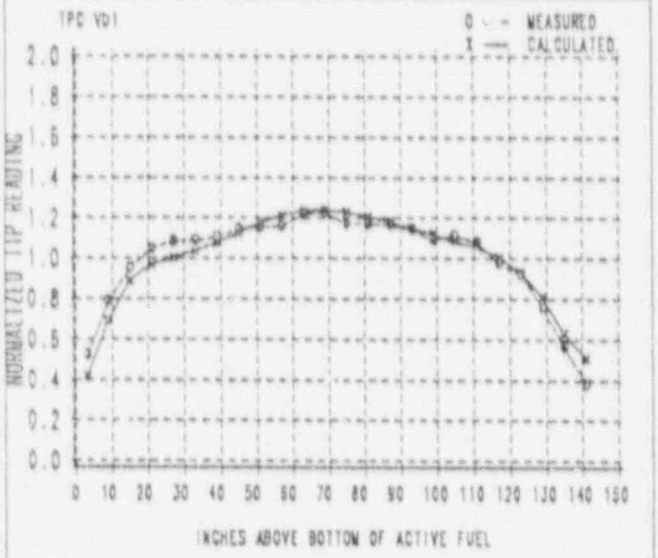


FIGURE Q2 C8 CA1 09-18-86 8077.1 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

Figure D-3
Quad Cities Station Unit 2 Cycle 9 Results

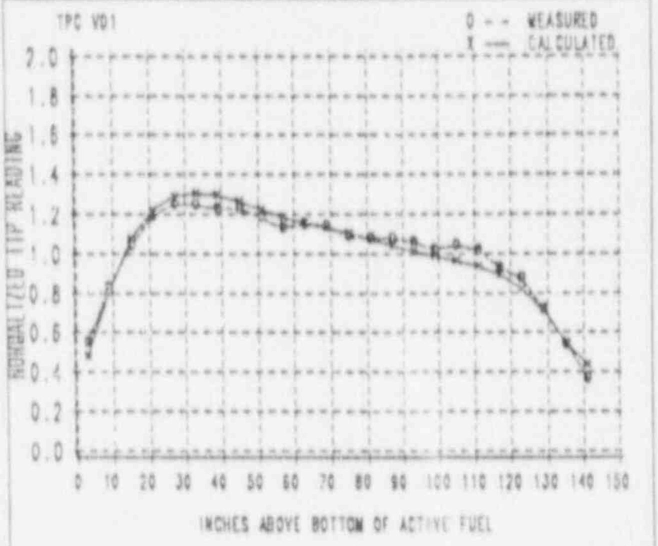


FIGURE Q2 C9 CA1   02-04-87   141.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSRXS   JOB05458 07/18/90

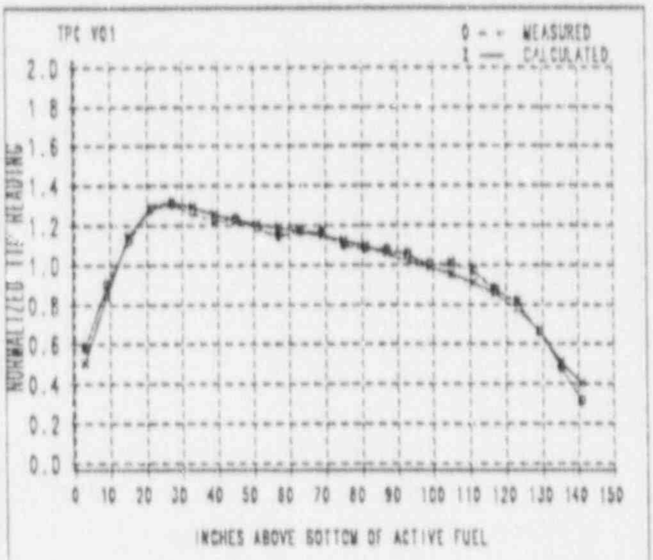


FIGURE Q2 C9 CA1   09-16-87   3576.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSRXS   JOB05458 07/18/90

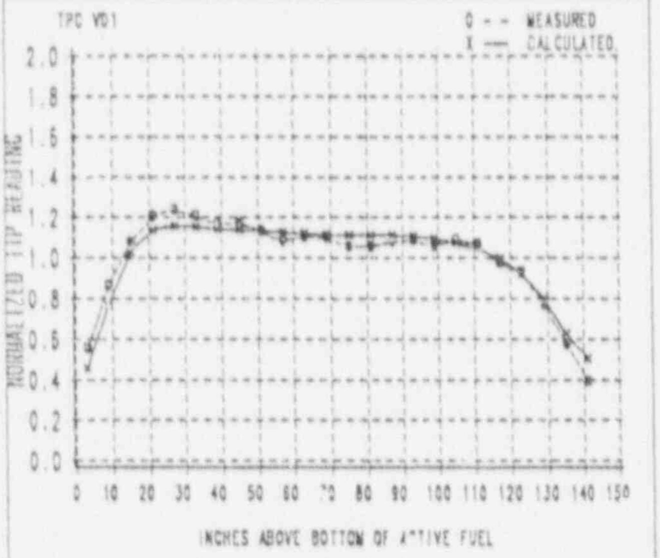


FIGURE Q2 C9 CA1   02-25-88   6108.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSRXS   JOB05458 07/18/90

Figure D-4
Quad Cities Station Unit 2 Cycle 10 Results

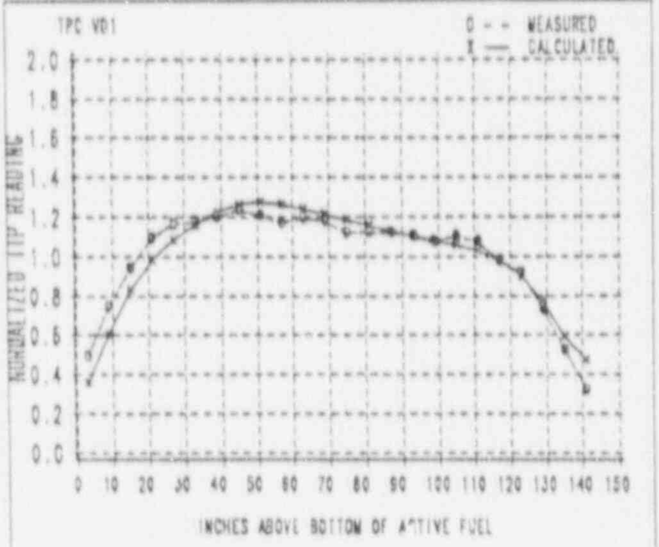


FIGURE Q2 C10 CA1 09-21-88 981.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

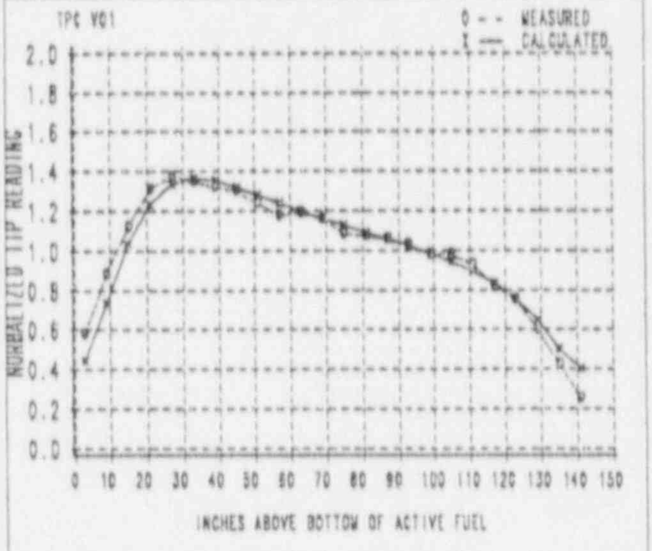


FIGURE Q2 C10 CA1 02-20-89 3654.3 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

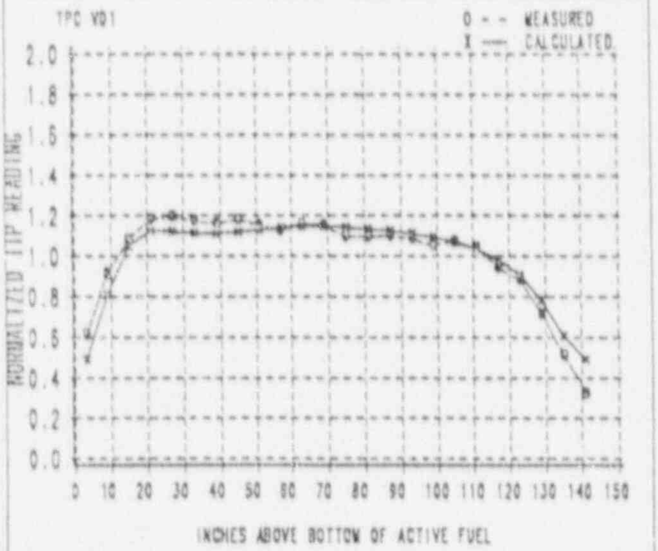


FIGURE Q2 C10 CA1 11-01-89 7687.4 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRXS JOB05458 07/18/90

Appendix E
TIP Traces for Dresden Station Unit 3

A comparison of calculated versus measured core axial TIP traces for Dresden Station Unit 3 is included in this appendix. Figures included are:

Figure E-1 - Dresden Station Unit 3 Cycle 8 Results

Figure E-2 - Dresden Station Unit 3 Cycle 9 Results

Figure E-3 - Dresden Station Unit 3 Cycle 10 Results

Figure E-4 - Dresden Station Unit 3 Cycle 11 Results

Figure E-1
Dresden Station Unit 3 Cycle 8 Results

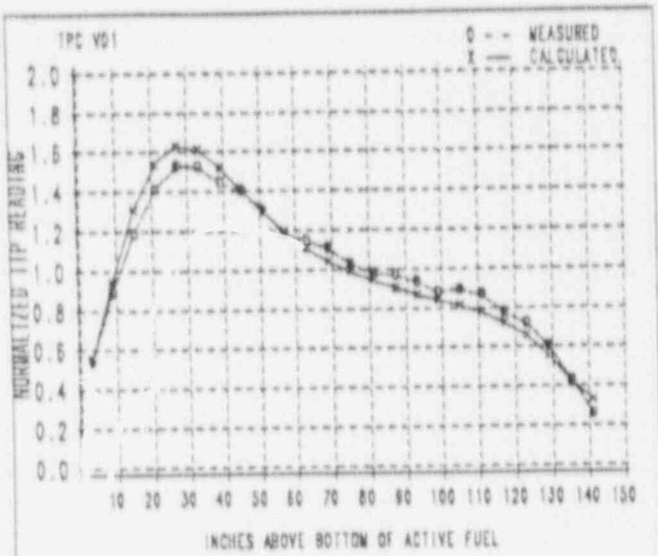


FIGURE D3 C8 CA1 07-09-82 1103.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

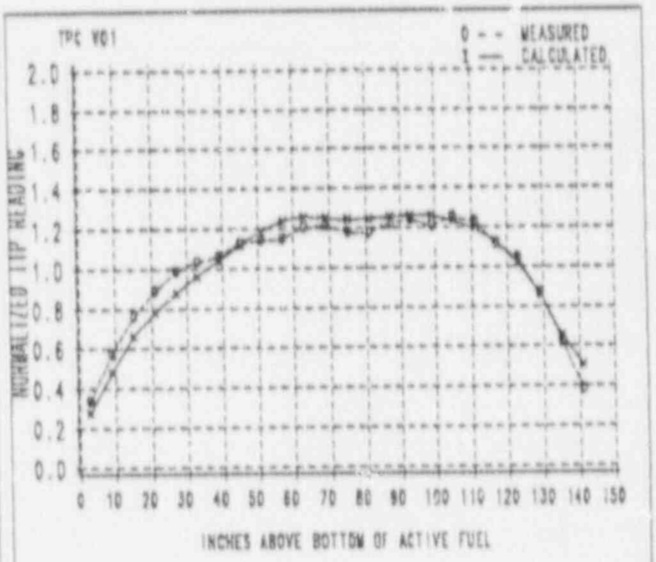


FIGURE D3 C8 CA1 01-21-83 4462.6 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

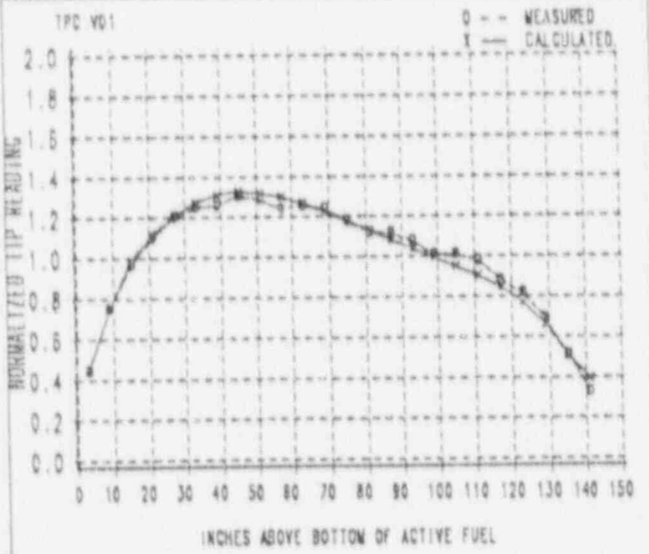


FIGURE D3 C8 CA1 05-01-83 6777.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

Figure E-2
Dresden Station Unit 3 Cycle 9 Results

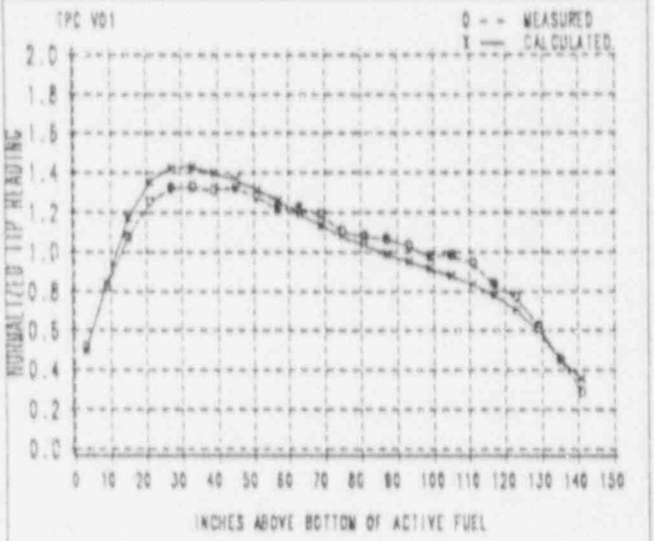


FIGURE D3 C9 CA1 08-16-84 345.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

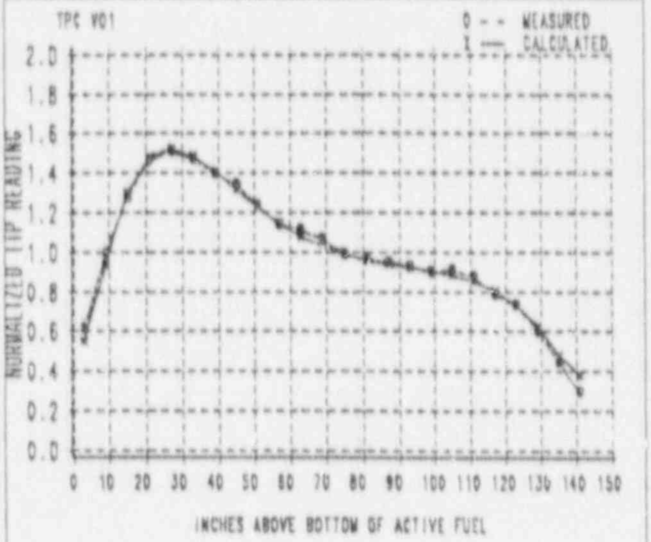


FIGURE D3 C9 CA1 03-15-85 3578.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

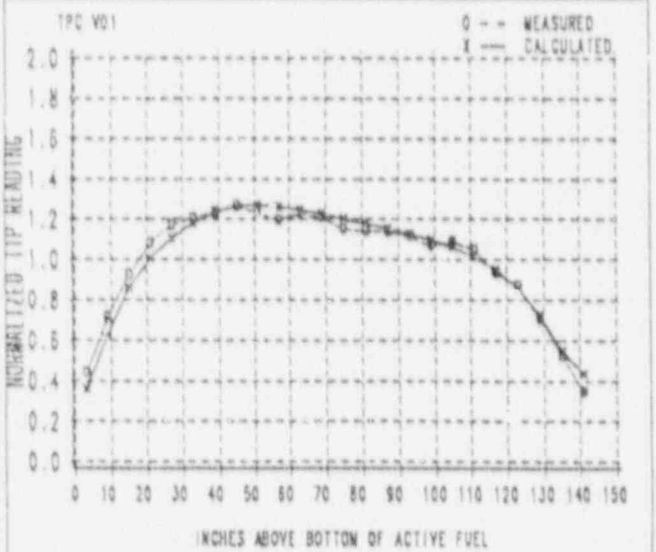


FIGURE D3 C9 CA1 06-18-85 5103.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

Figure E-3
Dresden Station Unit 3 Cycle 10 Results

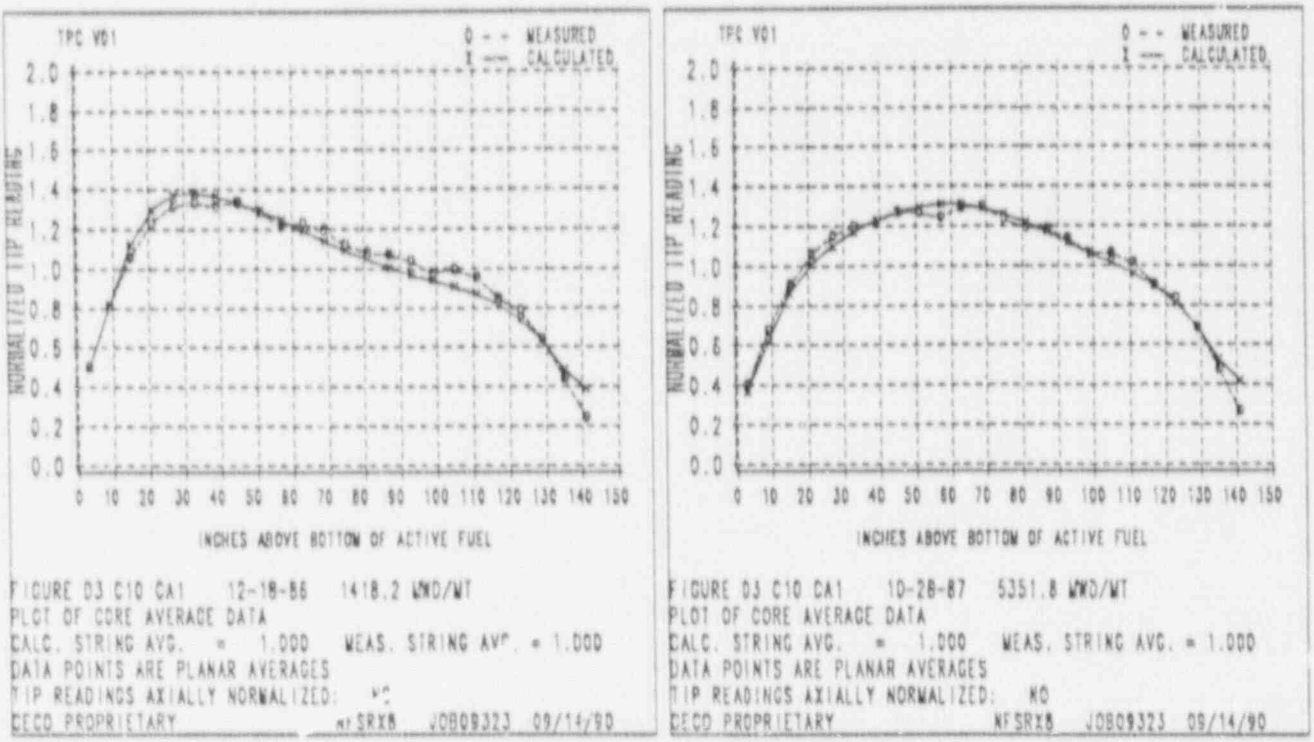


FIGURE D3 C10 CA1   12-18-86   1418.2 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG.   =   1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSRX8   JOB09323 09/14/90

FIGURE D3 C10 CA1   10-28-87   5351.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG.   =   1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSRX8   JOB09323 09/14/90

Figure E-4
Dresden Station Unit 3 Cycle 11 Results

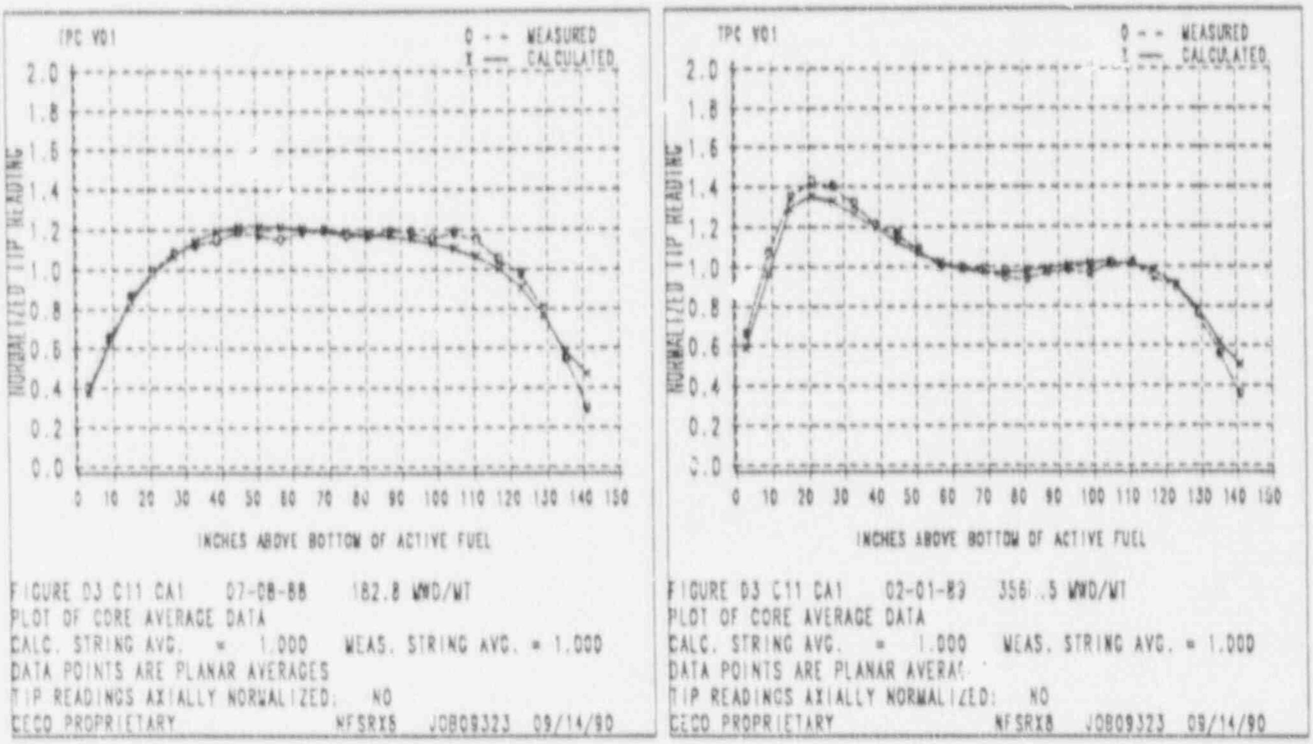


FIGURE D3 C11 CA1 07-08-88 182.8 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

FIGURE D3 C11 CA1 02-01-89 3561.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSRX8 JOB09323 09/14/90

Appendix F
TIP Traces for LaSalle County Station Unit 1

A comparison of calculated versus measured core axial TIP traces for LaSalle County Station Unit 1 is included in this appendix. Figures included are:

Figure F-1
LaSalle County Station Unit 1 Cycle 1 Results

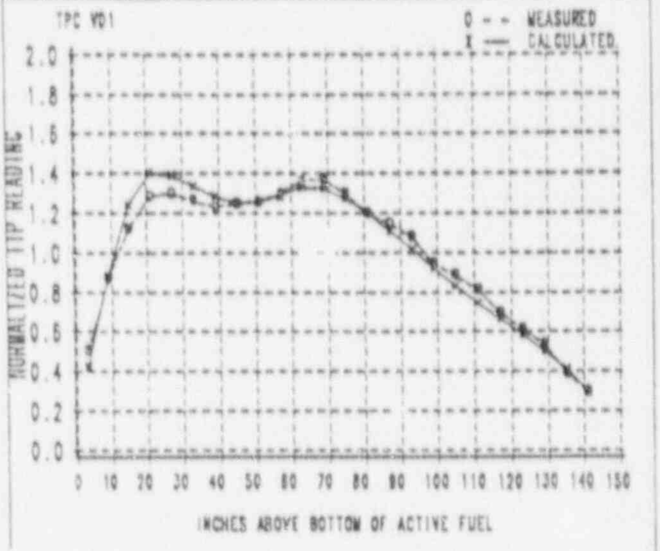


FIGURE L1 C1 CA1 05-14-83 1103.4 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWDX JOB05477 11/08/90

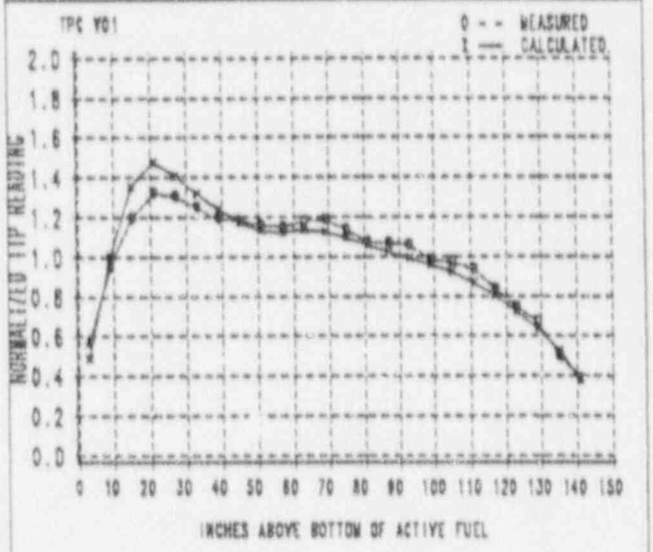


FIGURE L1 C1 CA1 08-08-83 1769.2 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWDX JOB05477 11/08/90

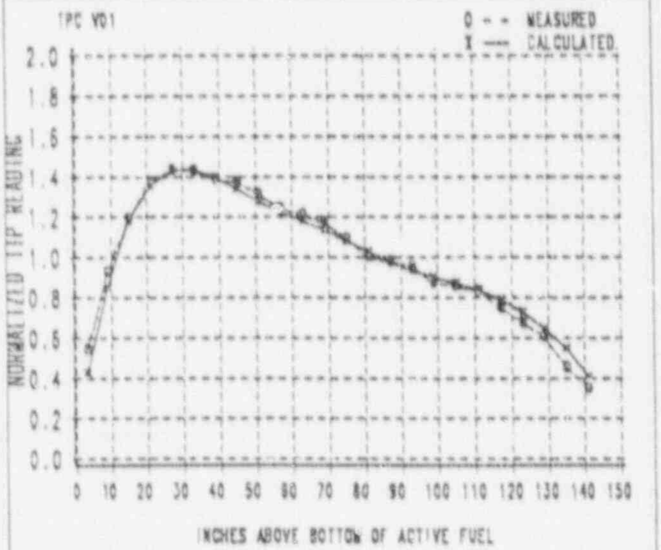


FIGURE L1 C1 CA1 07-27-84 5438.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWDX JOB05477 11/08/90

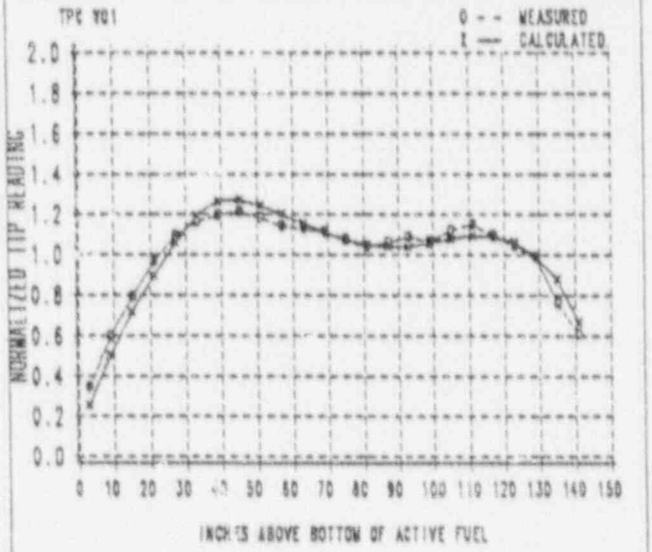


FIGURE L1 C1 CA1 12-14-84 6937.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWDX JOB05477 11/08/90

Figure F-1, Continued
LaSalle County Station Unit 1 Cycle 1 Results

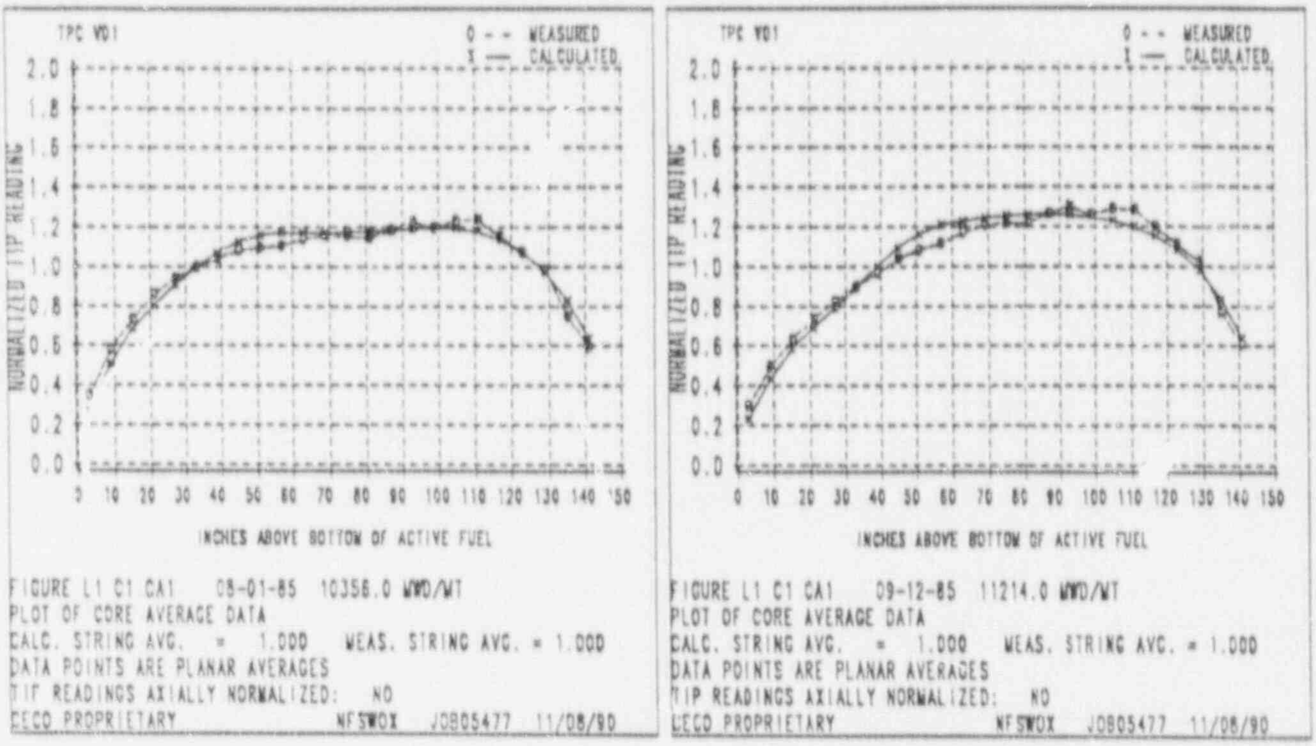


FIGURE L1 C1 CA1   08-01-85 10356.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSWOX J0805477 11/08/90

FIGURE L1 C1 CA1   09-12-85 11214.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000   MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY   NFSWOX J0805477 11/08/90

Figure F-2
LaSalle County Station Unit 1 Cycle 2 Results

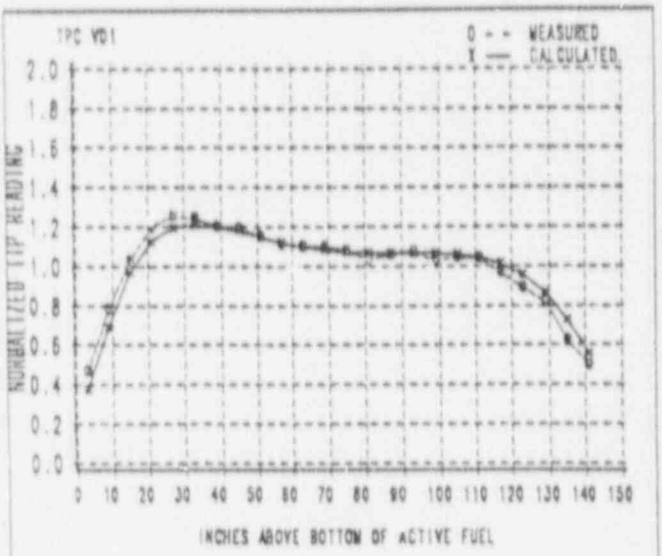


FIGURE L1 C2 CA1 11-18-86 1138.3 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB05477 11/08/90

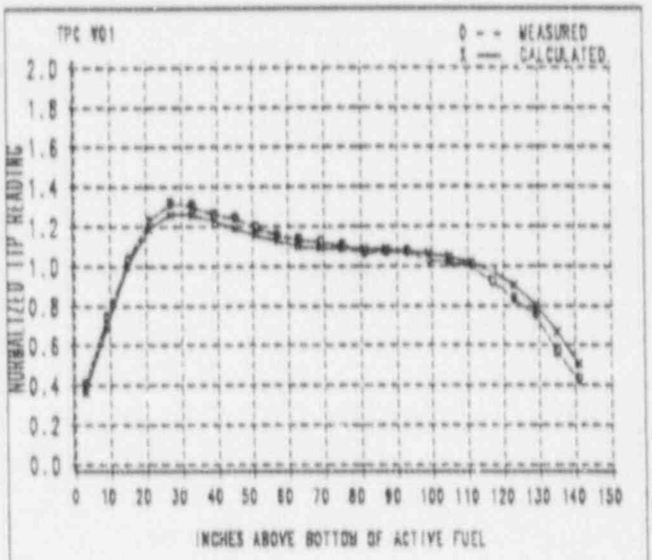


FIGURE L1 C2 CA1 05-20-87 3719.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB05477 11/08/90

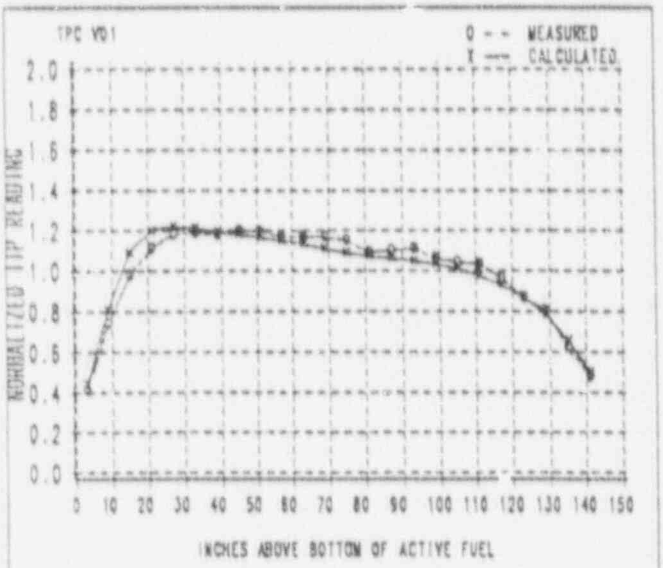


FIGURE L1 C2 CA1 01-06-88 5958.6 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB05477 11/08/90

Figure F-3
LaSalle County Station Unit 1 Cycle 3 Results

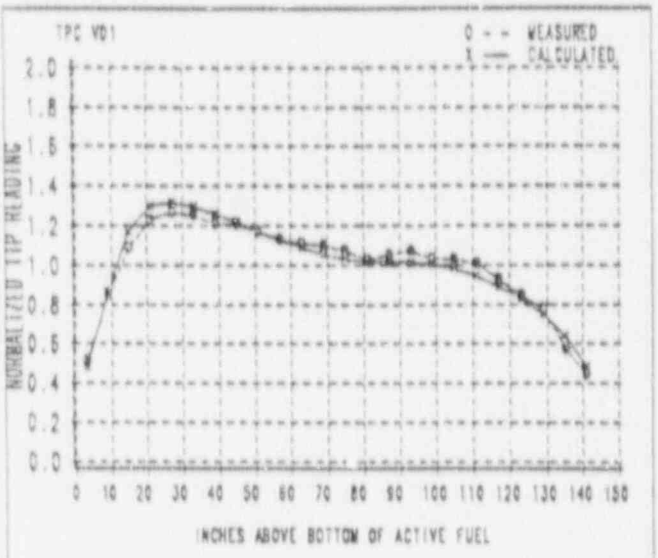


FIGURE L1 C3 CA1 09-14-88 1209.6 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB05477 11/08/90

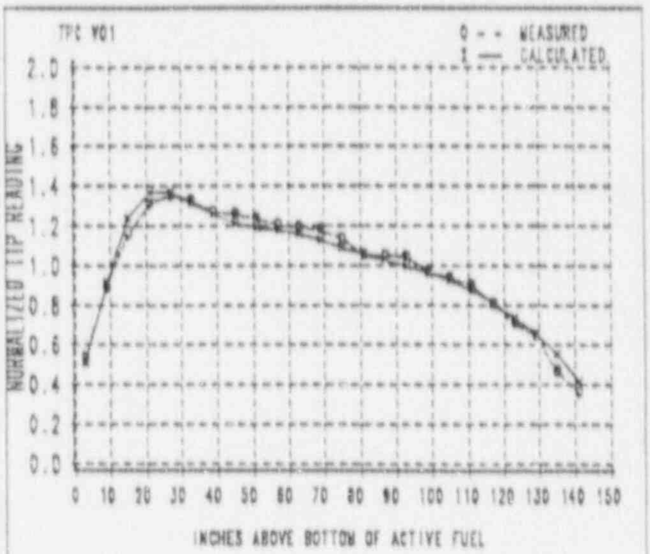


FIGURE L1 C3 CA1 02-18-89 4592.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB05477 11/08/90

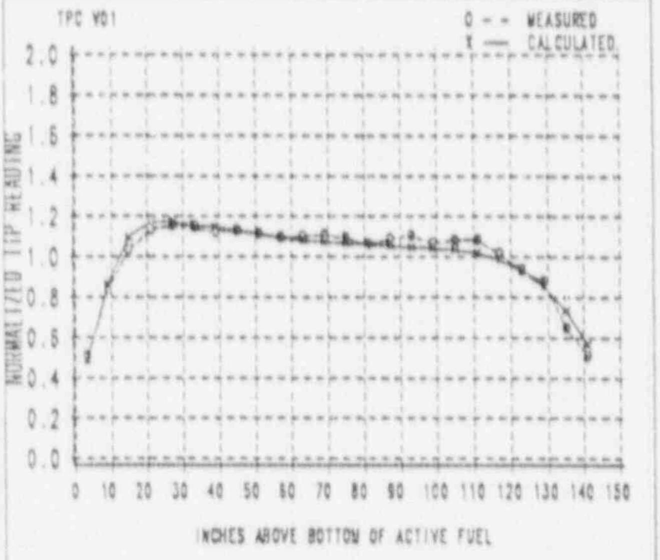


FIGURE L1 C3 CA1 08-07-89 8259.2 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB05477 11/08/90

Appendix G
TIP Traces for LaSalle County Station Unit 2

A comparison of calculated versus measured core axial TIP traces for LaSalle County Station Unit 2 is included in this appendix. Figures included are:

Figure G-1 - LaSalle County Station Unit 2 Cycle 1 Results

Figure G-2 - LaSalle County Station Unit 2 Cycle 2 Results

Figure G-3 - LaSalle County Station Unit 2 Cycle 3 Results

Figure G-1
LaSalle County Station Unit 2 Cycle 1 Results

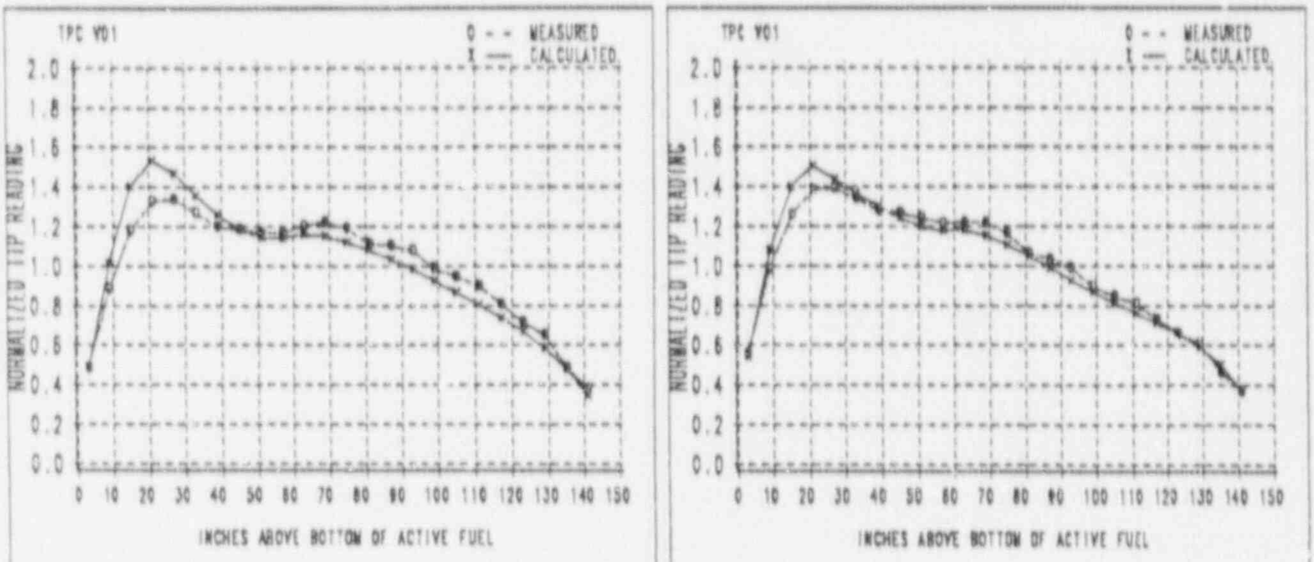


FIGURE L2 C1 CA1 07-26-84 775.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

FIGURE L2 C1 CA1 01-17-85 3527.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

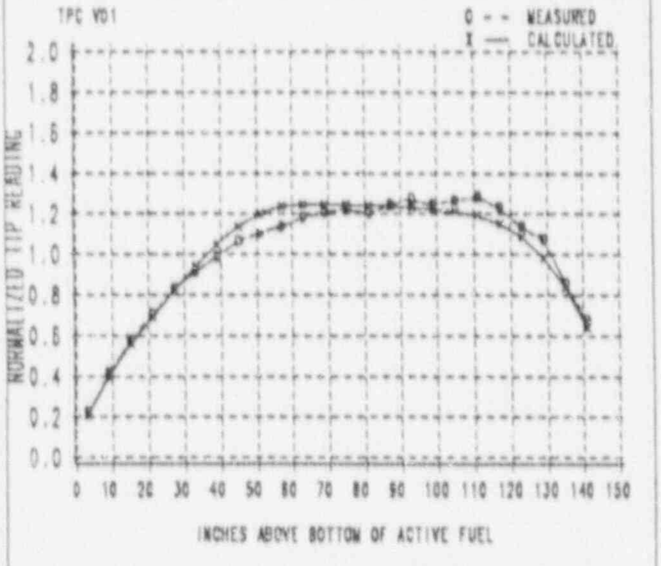


FIGURE L2 C1 CA1 10-07-86 10216.9 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

Figure G-2
LaSalle County Station Unit 2 Cycle 2 Results

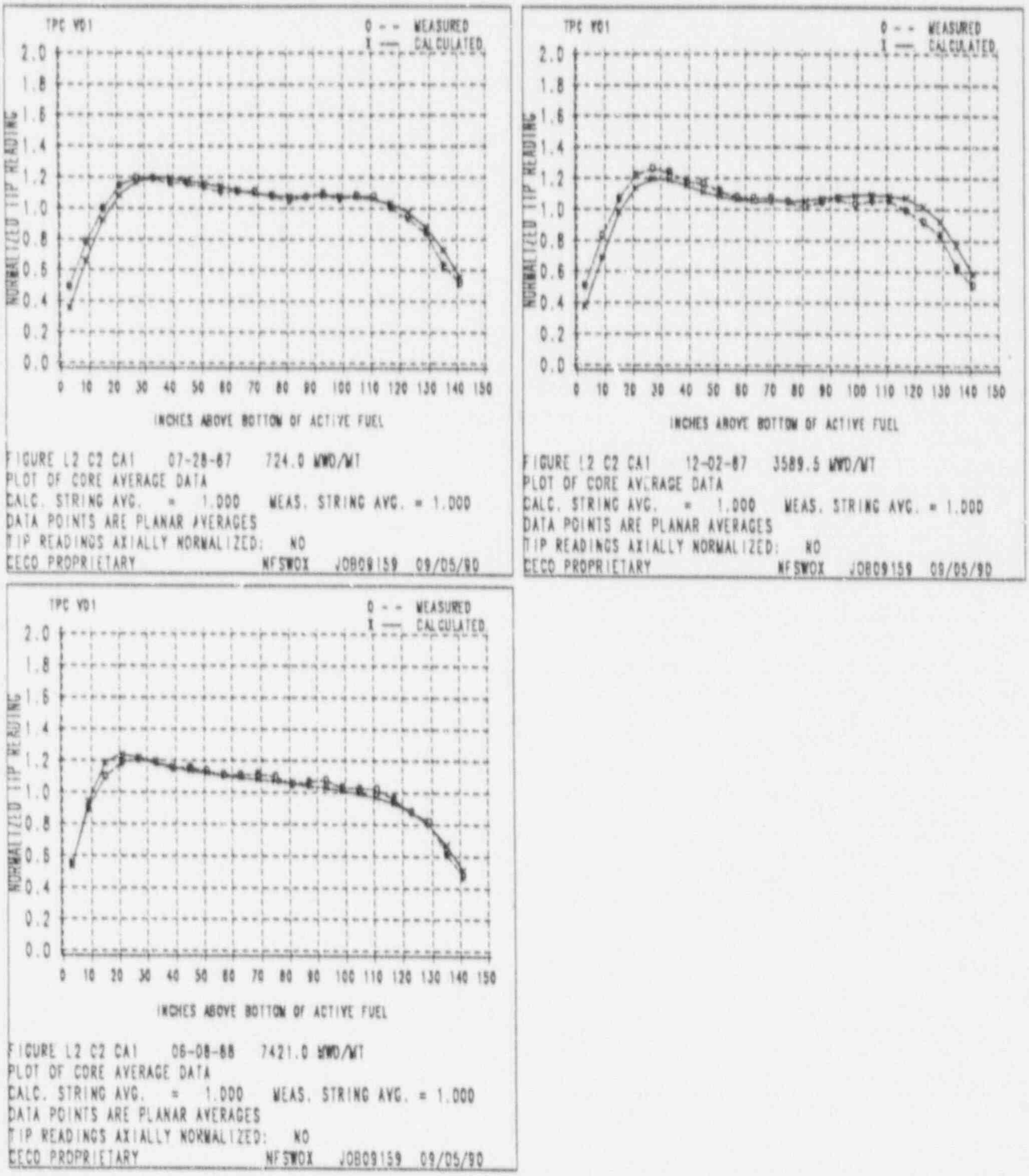


FIGURE L2 C2 CA1 07-28-87 724.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

FIGURE L2 C2 CA1 12-02-87 3589.5 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

FIGURE L2 C2 CA1 06-08-88 7421.0 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

Figure G-3
LaSalle County Station Unit 2 Cycle 3 Results

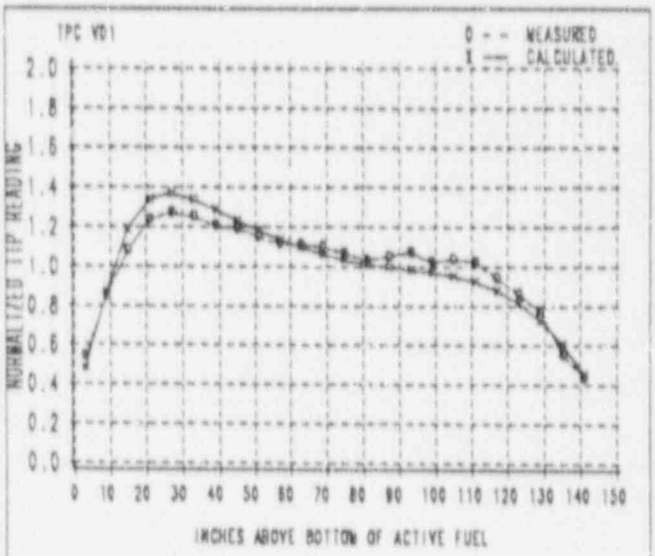


FIGURE L2 C3 CA1 02-24-89 214.2 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90

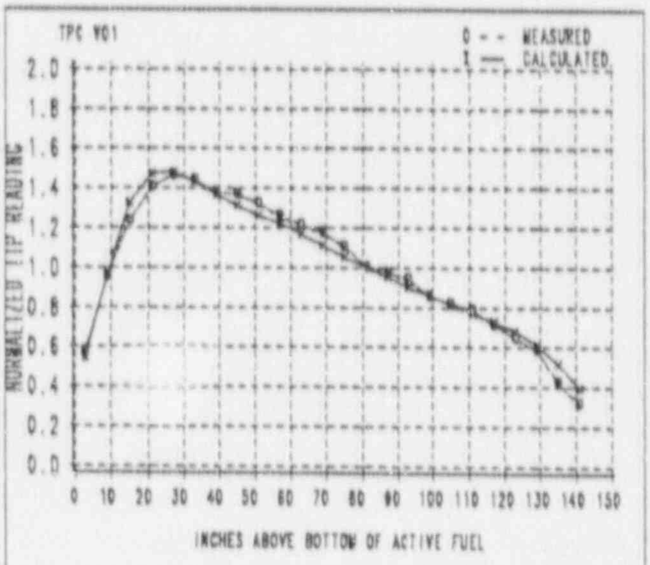


FIGURE L2 C3 CA1 10-26-89 4509.1 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/

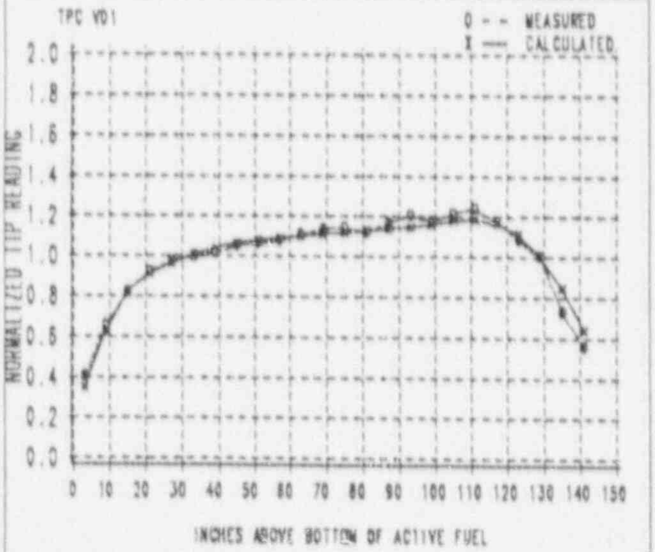


FIGURE L2 C3 CA1 03-09-90 7535.7 MWD/MT
PLOT OF CORE AVERAGE DATA
CALC. STRING AVG. = 1.000 MEAS. STRING AVG. = 1.000
DATA POINTS ARE PLANAR AVERAGES
TIP READINGS AXIALLY NORMALIZED: NO
CECO PROPRIETARY NFSWOX JOB09159 09/05/90