Docket File

50-289

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 20, 1995

LICENSEE: GPU Nuclear Corporation

FACILITY: Three Mile Island Nuclear Station, Unit 1 (TMI-1)

SUBJECT: SUMMARY OF OCTOBER 12, 1995, MEETING WITH GPU NUCLEAR CORPORATION REGARDING FUEL CLADDING DISTINCTIVE CRUD PATTERNS AT THREE MILE ISLAND NUCLEAR STATION, UNIT 1 (TMI-1)

On Monday, October 12, 1995, a public meeting was held between the U.S. Nuclear Regulatory Commission (NRC) and GPU Nuclear Corporation (GPUN) at the NRC Headquarters Office in Rockville, Maryland. The purpose of the meeting was to discuss the cause and safety implications of a distinctive crud pattern (DCP) observed on several fuel rods during the 11R refueling outage. Attachment 1 is the list of participants at the meeting. Attachment 2 is a copy of the handouts used during the meeting.

BACKGROUND

During examination of fuel pins during the 11R refueling outage, GPUN and Babcock & Wilcox Fuel Company (BWFC) observed a corrosion pattern in 40 of the 177 fuel assemblies that is significantly different than the "normal" corrosion pattern. Ten fuel rods were found to be defective (through-wall pinhole leaks) through a combination of ultrasonic and eddy current testing. Nine of the defective rods were in the most recently loaded batch ("first-burn" rods), which was installed in October 1993. Although the number of failed rods is not unusual, the unusual crud deposition pattern on the 9 first-burn failed rods, described as a marbled (or variegated) pattern, was unanticipated. This pattern was also observed on 173 other first-burn rods adjacent to the defective rods and in symmetrically equivalent rods in other quadrants of the core. The core quadrant where the most prevalent damage (7 defective rods) and unusual crud pattern occurred had an initial flux tilt of slightly more than + 2%. The area of the rods exhibiting the failures and abnormal patterns is consistently in the range of 100 to 130 inches above the bottom of the core. Furthermore, the abnormal corrosion patterns and failures were only found on the outside surface of peripheral fuel rods.

On the basis of the initial failures detected by UT, GPUN initiated additional visual and ECT examinations of 173 fuel rods. No failed rods or rods that indicate any amount of clad thinning (by ECT) were reinstalled in the core. GPUN made a decision that it is acceptable to reinstall rods with the DCP as long as no clad thinning can be measured. Fuel assemblies with nonreusable rods were reconstituted using either stainless steel rods or "donor" rods containing fuel. The examination of 173 rods and reconstitution of 20 fuel assemblies were completed on October 2. A total of 87 rods were replaced with stainless steel rods, as allowed by License Amendment No. 183 (implementing the provisions of Generic Letter 90-02).

GPUN assembled a panel of experts (including B&W, EPRI, Duke Power, and GE) on 9/28/95 to review all available information, agree on a most probable root cause of the DCP, make corrective/preventive action recommendations, and arrive at a consensus opinion on reuse of rods that exhibit DCP but have no clad thinning.

DISCUSSION

An introductory discussion by GPUN reviewed the charter, root cause assessment, and recommendations of the special Degraded Fuel Advisory Panel assembled to review the DCP anomaly (see Attachment 2). The panel concluded that the root cause was that low pH due to high boron and low lithium concentrations caused unusual crud deposits in high temperature regions of the core where localized boiling in adjacent hot channels occurred. The panel's recommendations included operating in the future with reactor coolant system (RCS) pH level no less than 6.9 and other RCS parameters consistent with the new EPRI primary water chemistry guidelines.

GPUN reviewed the core history for operating cycle 10 and compared various core parameters to previous cycles. Cycle 10 had fuel enrichment as high as 4.75 w/o U-235 and had maximum local power peaking factors of 1.51. The staff expressed concern that the combination of high peaking factors and enrichment may have caused abnormally high local linear heat generation rates that contributed to localized boiling and accelerated corrosion. GPUN stated that other B&W cores have had higher linear heat rates without the DCP and that the major contributing factor was the decision to operate at pH levels between 6.6 and 6.8 during the first five months or so of the operating cycle. Reduced pH enhances generation and deposition of corrosion products and the deposition will occur preferentially in areas of higher temperatures and lower flow.

BWFC reviewed the results of their investigation of the DCP. They concluded that there was no correlation to manufacturing or materials. The only new fuel design feature (other than higher than previous enrichment) in the fuel installed in 1993 was four rods containing gadolinia (burnable poison) near the corners of 28 fuel assemblies. All core analyses were performed in accordance with the NRC-approved topical report (BAW-10179P-A). The expected power in fresh assemblies was expected to be slightly higher than in other cycles. BWFC also stated that the quadrant flux/power tilt was not excessive but that the upper level detectors in the outer ring showed unusual behavior with burnup. The conclusion was that the DCP-affected areas of the core correlate to high temperature and low flow velocities but these conditions would not in themselves lead to fuel degradation.

The special advisory panel, GPUN, and BWFC concluded that it is acceptable to reinstall rods with the DCP for Cycle 11 as long as no clad thinning can be measured because 1) the RCS boron concentration will be considerably lower during this cycle, 2) the maximum fuel enrichment will be lower (4.55 w/o vs 4.75 w/o), 3) pH will be held above 6.9 for the entire cycle, 4) other RCS chemistry parameters (including suspended solid or crud concentrations) will by optimized, and 5) peak fuel temperatures should be slightly lower.

Crud samples were taken near the degraded fuel and in other locations (spent fuel pool) and were analyzed. Chemical analysis of the crud indicated that the crud taken from fuel rods showed the presence of zeolites, which are hydrated silicates of aluminum with alkali metals (calcium, magnesium). These samples also showed lower levels of nickel and iron as compared to crud samples taken elsewhere. Part of GPUN's chemistry plan for Cycle 11 is to develop onsite capability to monitor calcium, magnesium, and aluminum.

GPUN plans to perform core clad oxide crud measurements in the spent fuel pool in the near future. The staff questioned the planned actions, if any, to conduct hot cell examinations on specimens of the damaged or degraded fuel to confirm the stated root cause. GPUN did not commit to any additional testing at this time but may propose that such examinations may be sponsored by the B&W Owners Group.

The staff suggested that GPUN closely monitor radiochemistry during Cycle 11 to detect any fuel pin leaks and recommended that a fuel action plan to respond to leaks be developed in advance rather than waiting for leaks to be detected.

The staff plans to look at the procedures used by the NRC to review core designs to determine if changes need to be made to those procedures on a generic basis.

Original signed by:

Ronald W. Hernan, Senior Project Manager
Project Directorate I-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-289

Attachments: 1. List of Attendees
2. GPUN meeting handout

cc w/atts: See next page

<u>Distribution w/atts. 1 & 2</u>
Docket File
PUBLIC
PD I-3 Memo
JFRogge, RI
RHernan

<u>Distribution w/att. 1</u>
WRussell/FMiraglia
RZimmerman SWu
SVarga EKendrick
JZwolinski DBrewer
PMcKee LKopp
SNorris JTsao
OGC EWeiss
EJordan ACRS
LPhillips WDean, EDO, RI

Document Name: G:\HERNAN\10-12-95.SUM

OFFICE	LA:PDI-4	PM:PDI-4	D:PDI-4
NAME	SNorris	RHernan:cn	PMcKee
DATE	10/18/95	10/18/95	10/ /95

OFFICIAL RECORD COPY

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2. GPUN meeting handout

cc w/atts: See next page

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LIST OF ATTENDEES
OCTOBER 12, 1995 MEETING WITH GPU NUCLEAR CORPORATION

TITLE	AFFILIATION	TITLE
Bill Russell	NRC/NRR	Director. NRR
Ronald W. Hernan	NRC/NRR/PDI-3	Senior Project Manager
Michelle Evans	NRC/Region I	Senior Resident Inspector
Phil McKee	NRC/NRR/PDI-3	Director, PDI-3
John Louma	GPUN	Nuclear Fuels Engineer
Lori Hixon	GPUN	Media Relations
Pat Walsh	GPUN	Mgr., TMI Plant Engineering
Bill Connor	GPUN	Engineering, HQ
Stan Maingi	Pennsylvania DER	Inspector
R. W. Keaten	GPUN	Director, Technical Functions
Gordon Bond	GPUN	Director, Nuclear Fuel
John Fornicola	GPUN	Dir., Plng & Reg. Affairs
Richard Deveney	BWFC	
David Mitchell	BWFC	
Gary Hanson	BWFC	
George Meyer	BWFC	
Tom Coleman	BWFC	
Jim Taylor	BWNT	Manager, Regulatory Affairs
Larry Lamanna	BWNT	
Larry Phillips	NRC/NRR	Section Leader, SRXB
Shih-Liang Wu	NRC/NRR	Reviewer, SRXB
Edward Kendrick	NRC/NRR	Reviewer, SRXB
David Brewer	NRC/NRR/PSIB	Vendor Inspection Section
Larry Kopp	NRC/NRR	Reviewer, SRXB
John Tsao	NRC/NRR	Reviewer, EMCB
Eric Wiess	NRC/NRR	Section Leader, SRXB
Bill Dean	NRC/EDO	EDO Liaison, Region I

ATTACHMENT 1

TMI-1 Fuel Assembly Degradation
NRC/GPUN/BWFC Meeting - October 12, 1995

Agenda

I.	Introduction	R.W. Keaten
II.	Cycle and Outage Fuel Events Summary	P.S. Walsh
III.	Cycle 9 and 10 Comparison	J. Luoma/W. Connor
IV.	Root Cause Assessment	G. Meyer/L. Lamanna
V.	Cycle 11 Design and Monitoring	G.R. Bond
VI.	Summary and Conclusions	GPU

ATTACHMENT 2

Introduction

Degraded Fuel Advisory Panel

A. H. Rone (GPUN), Chairman
B. Cheng (EPRI)
N. Cole (MPR)
F. S. Giacobbe (GPUN)
R. Gribble (Duke Power)
L. Lammana (BWNT)
E. Plaza-Meyer (GE)
D. Shahl (BWFC)
D. Sunderland (S. M. Stoller)
J. J. Thomazet (Framatome)

Advisory Panel Charter

A. Evaluate the fuel failures observed at TMI-1 during the 10R outage and provide recommendation to Director, Technical Functions on the following matters:

1. Adequacy of current plans

2. Validity of the assumptions driving the existing plan

3. Additional actions and recommendations

B. Provide an independent assessment of the root cause based on available data.

C. Provide recommendations for longer term plans/actions to understand root cause.

D. Pre-restart review of additional inspection data to affirm restart readiness from a fuel performance perspective.

Advisory Panel Conclusions

A. Root Cause

Low pH due to high boron and low lithium concentrations caused unusual crud deposits in high temperature regions of the core where localized boiling in adjacent hot channels occurred.

B. Cycle 11 Core

If pH is controlled to greater than or equal to 6.9 and chemistry is optimized in accordance with EPRI Guidelines, there is no reason to expect a repeat of Cycle 10 fuel failures. Particular emphasis on startup chemistry should be maintained.

C. Reuse of Distinctive Crud Pattern Rods

No obvious reason why they cannot be reused but will hold final position open pending oxide thickness and crud sample analysis results.

Advisory Panel Recommendations

1. Fuel rods with a distinctive crud pattern should be loaded into low power locations. **By Startup**

or

2. Distinctive crud pattern thickness should be measured

   - Measure a few rods (5-10) to determine if unusual oxide thickness exists within 90 days of startup (focus on a spectrum of indications [2% to 100%]. **Near Term**

3. Ensure crud levels and chemistry are in spec prior to startup. Look at chemistry practices to achieve crud levels ALARA. Reference the new EPRI primary water chemistry guideline. **By Startup**

4. Obtain crud sample and perform chemical analysis (try to get results before reactor head goes on). **By Startup**

5. Advisory panel (as many as possible) review results of Items 2, 4 & 7. **When Available**

6. Continue to look at fuel manufacturer records. **Long Term**

7. Obtain creepdown data to determine when in the fuel cycle failure occurred. **Long Term**

8. Monitor axial power imbalance to determine if same symptoms exists as were present in Cycle 10. **Long Term**

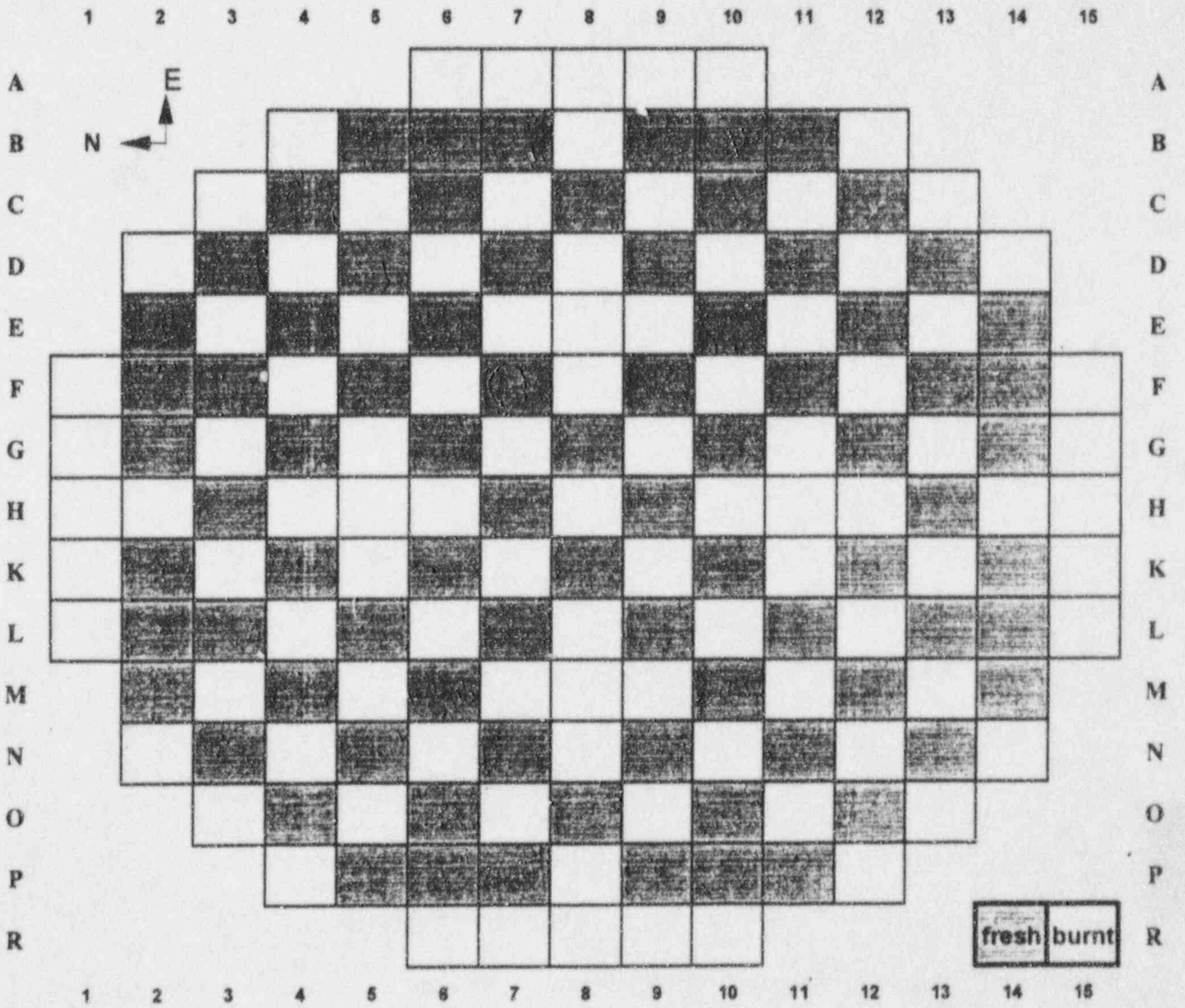
Cycle and Outage Fuel Events Summary

- Cycle 10 Fuel Operating History
- Fuel Inspection Summary
- Fuel Repair Summary

Cycle 10 Fuel Operating History

- 692 Calendar Days 10/16/93 - 9/8/95
- 660 EFPD
- 95.3% Thermal Capacity Factor
- 20,663 MWD/MTU Burnup
- 6-8 Pin Failures Predicted Prior to Shutdown

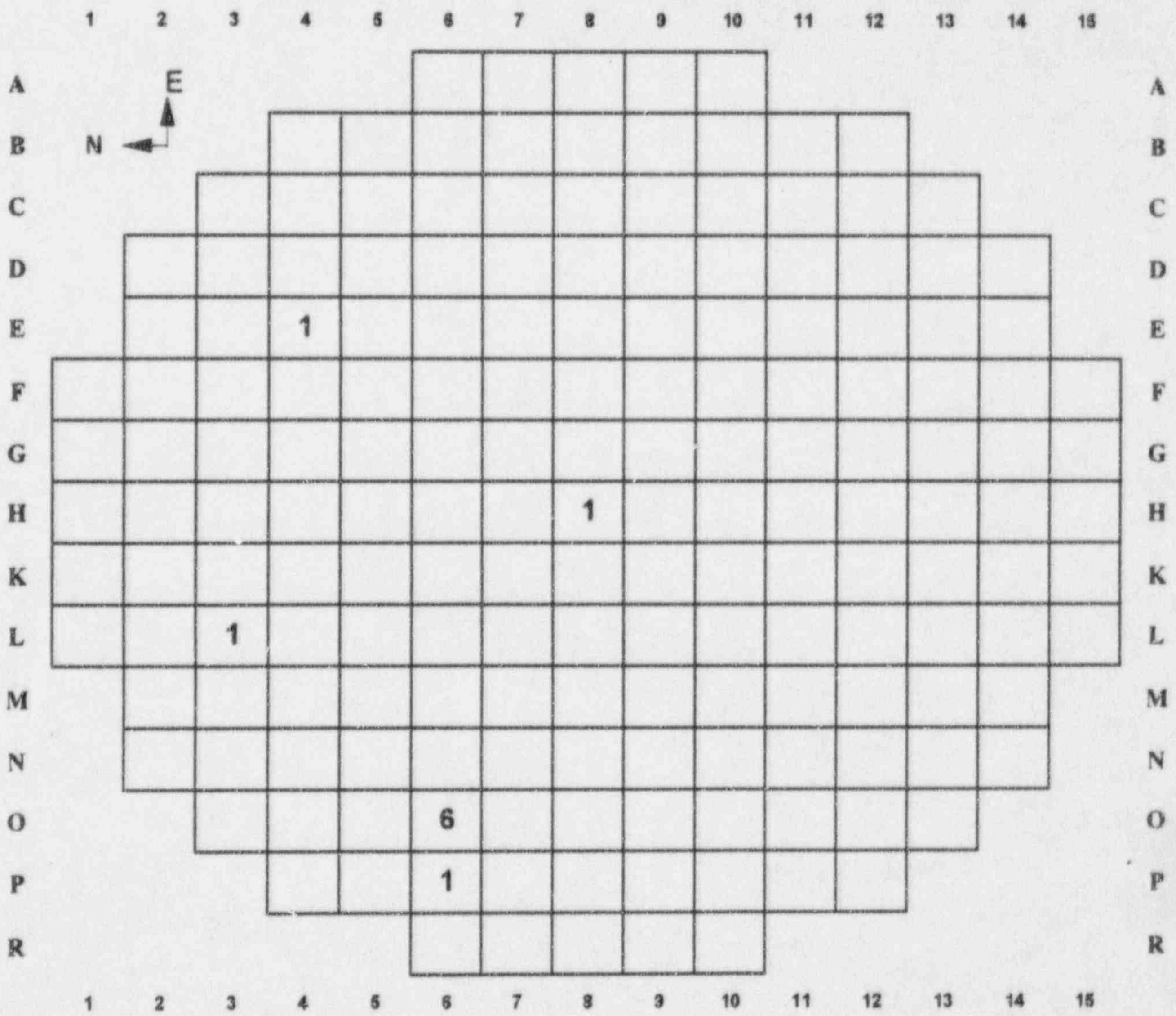
New Fuel Locations in Cycle 10



Fuel Inspection Summary

- Ultrasonic Test of 177 Fuel Assemblies
- 9 UT Failed Pins and 1 ECT Not Identified by UT
- 21 Assemblies Reconstituted with Rod ECTs
- 266 Pins EC Tested
- 94 Pins with Positive EC Indications
- Pin ECT Included 34 Internal Pins w/o Crud Pattern
- Visual Inspection of All Reinserted Fuel
- Two Highest Power Assemblies from Cycle 9 Inspected

Pin Failure by Core Location



Pin ECT Indication By Core Locations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A															
B							2								
C						12				10					
D					1										
E				1											
F			9										3		
G		6													
H															
K		2		1											
L			9		4		1						4		
M						1									
N															
O						11				4					
P						10	1		2						
R															

Fuel Repair Summary

- 19 Cycle 11 Assemblies Repaired with 87 Dummy SS Pins
- 8 New Assemblies Substituted for Cycle 11
- 4 Previously Discharged Assemblies Substituted

Cycle 9 and 10 Comparison

- Core Design/Operation
- Chemistry

TMI-1 Operating History

Cycle	Thermal Average Power Factor	Cycle EFPD	Operating Calendar Days
1	74.8	467.36	625
2	86.0	256.97	299
3	93.3	287.47	308
4	93.2	273.96	294
5	76.9 93.5 (w/o NRC power escalation) (w/o required 5M outage)	302.37	393
6	93.1	421.18	452
7	93.2	474.68	508
8	88.7	508.80	574
9	96.1	639.39	665
10	95.3	660.30	693

Average TAP factor: 90.7%

Note: 18 month cycle: 477 EFPD @ 95% TAP factor
2 year cycle: 650 EFPD @ 95% TAP factor
Assuming a 45 day outage

Cycle Design Characteristics Comparison

Parameter	Cycle 9	Cycle 10
Nominal Design Length (at full power) EFPD	590 (Actual 639.4 with power coastdown)	646 (actual 660.3)
Fresh Fuel - Batch Size Enrichments wt% Fuel Types -	 80 4.00, 3.90, 3.63 76 MkB8 4 W LTA	 80 4.75, 4.65, 4.00 8 Mk B8V 44 Mk B9 28 MkB9-Gd
Burnable Poison - BPRAs wt % B_4C Gd Rods wt % Gd_2O_3	 64 2.1, 1.7, 1.1, 0.8 None N/A	 64 2.1, 2.0, 0.2, 0.0 112 2.0
Maximum Pin RPD in Cycle	1.50	1.51
Maximum Pin RPD in "Interface" FAs	1.39 @ 100 EFPD	1.51 @ 125 EFPD
HFP BOC Boron Concentration, ppm	1672	1851

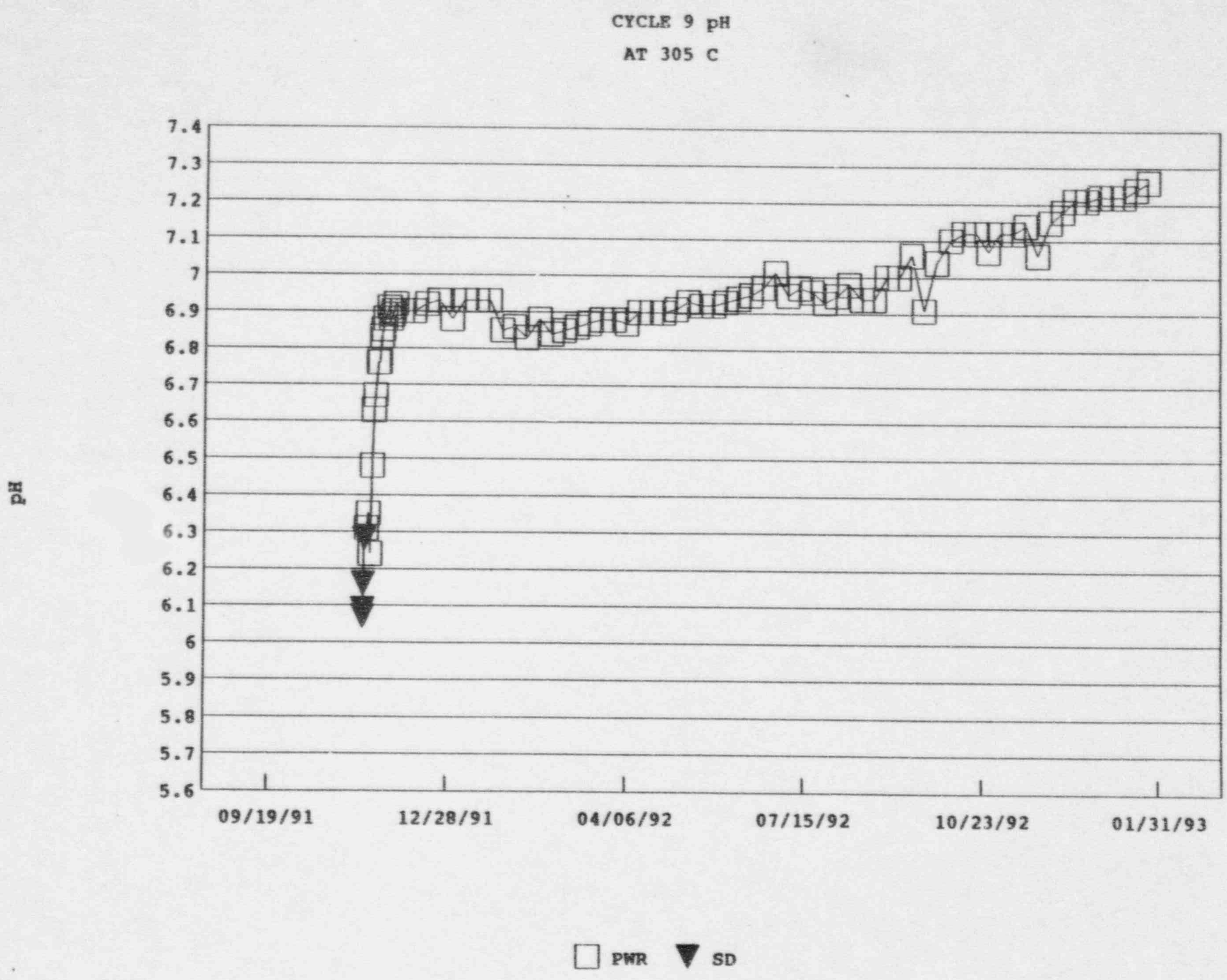
TMI-1 Cycle 10
Core Operation Summary

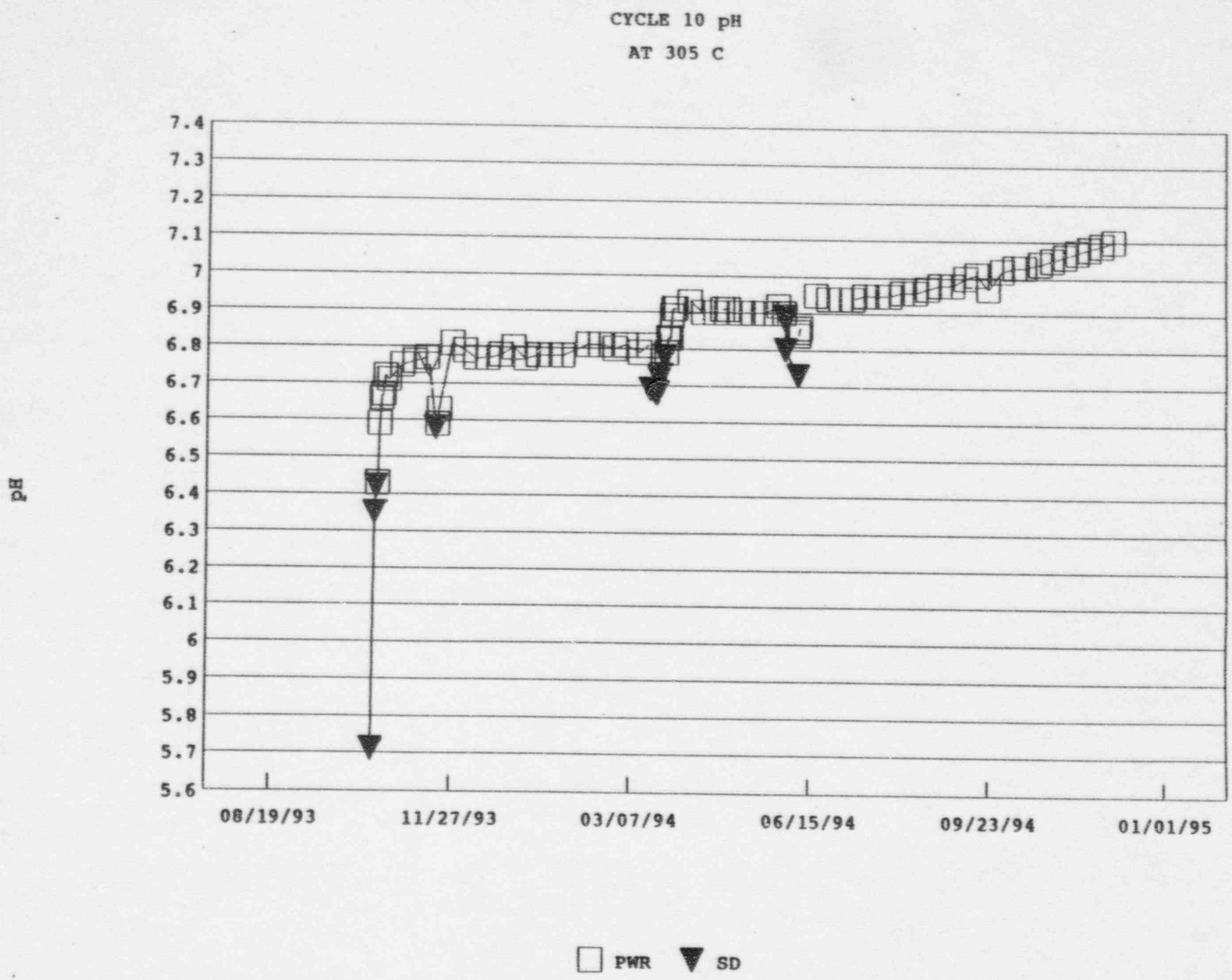
Observed Behavior:

- Quadrant Tilt Not Particularly High (~ 2% @BOC in Z-W Quadrant)
- Level Dependent Quadrant Tilt Behavior Unusual (top 2 spans) in Z-W Quadrant
- Measured Maximum Radial Power Distribution Agrees with Predictions Throughout Cycle (within 2%)
- Measured Maximum Total Segment Power Agreement Diverged Reaching 3% @ 300 EFPD
- Measured Power Imbalance Deviates From Predictions in Mid-cycle Period (between 150 to 575 EFPD; maximum difference ~ 3% @ 300 EFPD)
- Upper Segment Peaking Shows Unusual Behavior (top 2 spans) in Fresh Fuel with Observed DCP

Conclusion:

- Indications of Deviation From Expected Behavior in Top Area of Some Higher Power Assemblies


CYCLE 9 pH
AT 305 C
pH
7.4
7.3
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
09/19/91
12/28/91
04/06/92
07/15/92
10/23/92
01/31/93
PWR
SD


CYCLE 10 pH
AT 305 C
pH
7.4
7.3
7.2
7.1
7
6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
08/19/93
11/27/93
03/07/94
06/15/94
09/23/94
01/01/95
PWR
SD

BWFC Root Cause Evaluations

- Manufacturing/Materials
- Fuel Assembly Design
- Analytical Methods
- Fuel Cycle Design and Operation
- Water Chemistry

Manufacturing and Materials

- Review of Manufacturing, Shipping, Storage Records
  - No Indications of Manufacturing-related Problems
  - No Indications of Contaminants
  - Affected Fuel was from Two Manufacturing Campaigns
- Conclusion: No Correlation to Manufacturing or Materials

Fuel Assembly Design

- All Fuel in Core is Mark-BZ
  - B8, B9 Versions
- All Fuel Assembly Design Features have a Proven Operating Record
- Only New Feature for Cycle 10 is Gadolinia
  - 28 Fuel Assemblies, 4 Rods Each @ 2 wt%

Analytical Methods

- All Methods are NRC-approved; All are Consistent with BAW-10179P-A

- Core Physics - CASMO/NEMO

  - Approved in 1992; Revised for Gd in 1993; Good Agreement with Benchmarks, Including TMI-1 Cycle 10 Startup

- Core Thermal-Hydraulics - LYNXT, BWC

  - LYNXT Approved in 1985

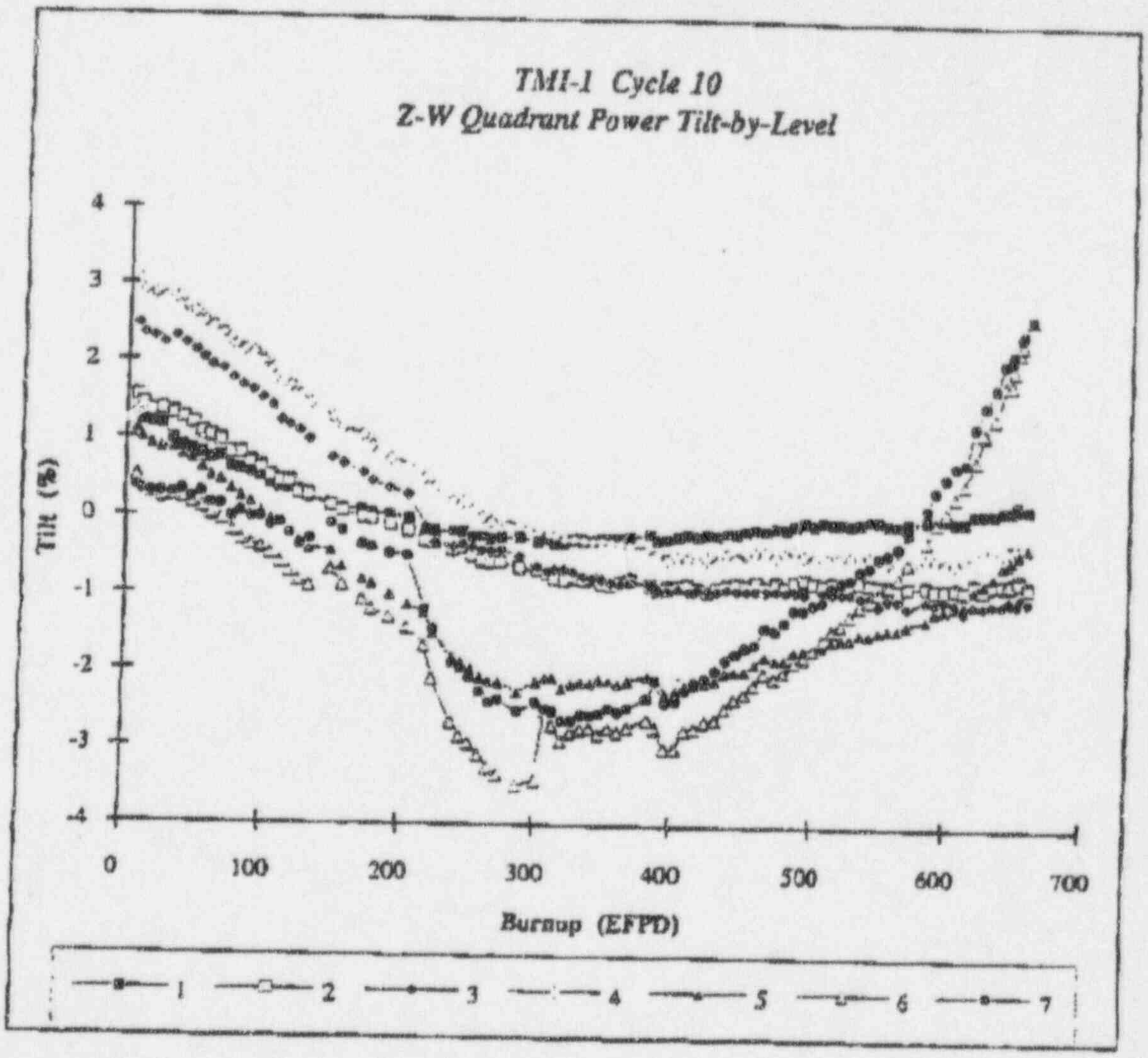
  - BWC CHF Correlation Approved in 1985

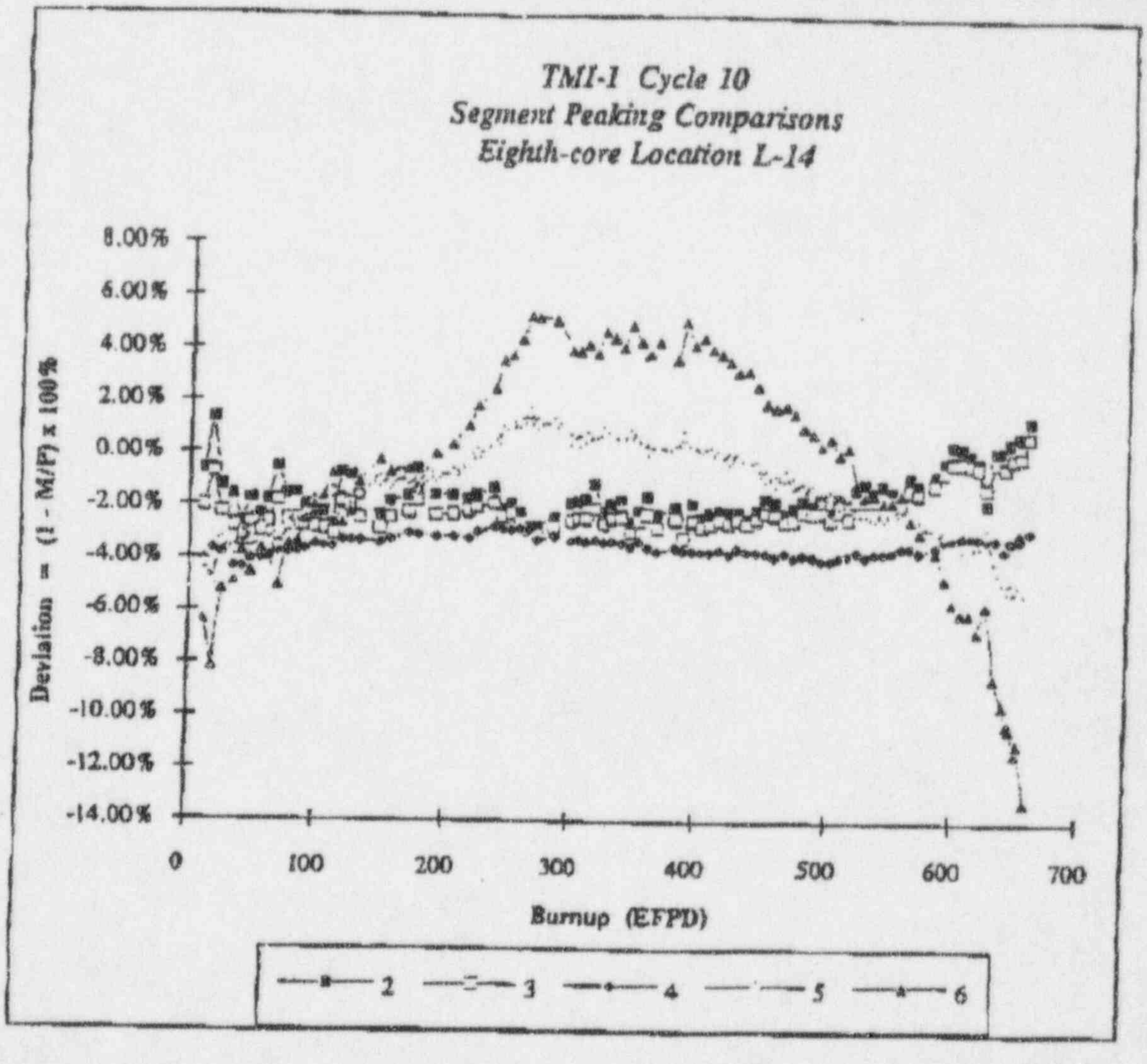
    - Specifically Included Mk-BZ Bundle Intersection in CHF Database

  - Subchannel Hydraulic Models Developed from LDV Tests of Bundle Intersection Geometry

Fuel Cycle Design and Operation

- Cycle 10 Design - Core Physics
  - BOC Boron, Max Enrichment, Use of Gd
  - Power in Fresh Assemblies Near Periphery Slightly Higher than in Other Cycles
- Cycle 10 Design - Core Thermal-Hydraulics
  - Consistent with Other Cores
- Startup Testing Results
  - All Zero Power Tests Within Expected Ranges
  - Initial Power Distributions Showed Good Agreement
- Operating Data Assessment
  - Radial Power Distribution Agrees with Predictions
  - Quadrant Tilt Not Excessive but Upper Level Detectors in Outer Ring Show Unusual Behavior with Burnup


TMI-1 Cycle 10
Z-W Quadrant Power Tilt-by-Level
Tilt (%)
4
3
2
1
0
-1
-2
-3
-4
0
100
200
300
400
500
600
700
Burnup (EFPD)
1
2
3
4
5
6
7


TMI-1 Cycle 10
Segment Peaking Comparisons
Eighth-core Location L-14
8.00%
6.00%
4.00%
2.00%
0.00%
-2.00%
-4.00%
-6.00%
-8.00%
-10.00%
-12.00%
-14.00%
Deviation = (1 - M/P) x 100%
0
100
200
300
400
500
600
700
Burnup (EFPD)
2
3
4
5
6

Fuel Cycle Design and Operation

- Thermal-Hydraulic Evaluation

  - Core-Wide Analysis Shows Temperatures Slightly Higher in Outer Ring Fresh Fuel Locations

  - Local Conditions Analyses Show Clad Surface Temperatures Among Highest in Core; Local Velocities Lower in Peripheral Channels than in Bundle Interior

  - Both Core-Wide and Local Conditions are Similar to or Bounded by Those in Other Similar Cores

- Correlates to High Temperature, Low Velocities but These Conditions Would Not in Themselves Lead to Fuel Degradation

Core Exit Temperatures

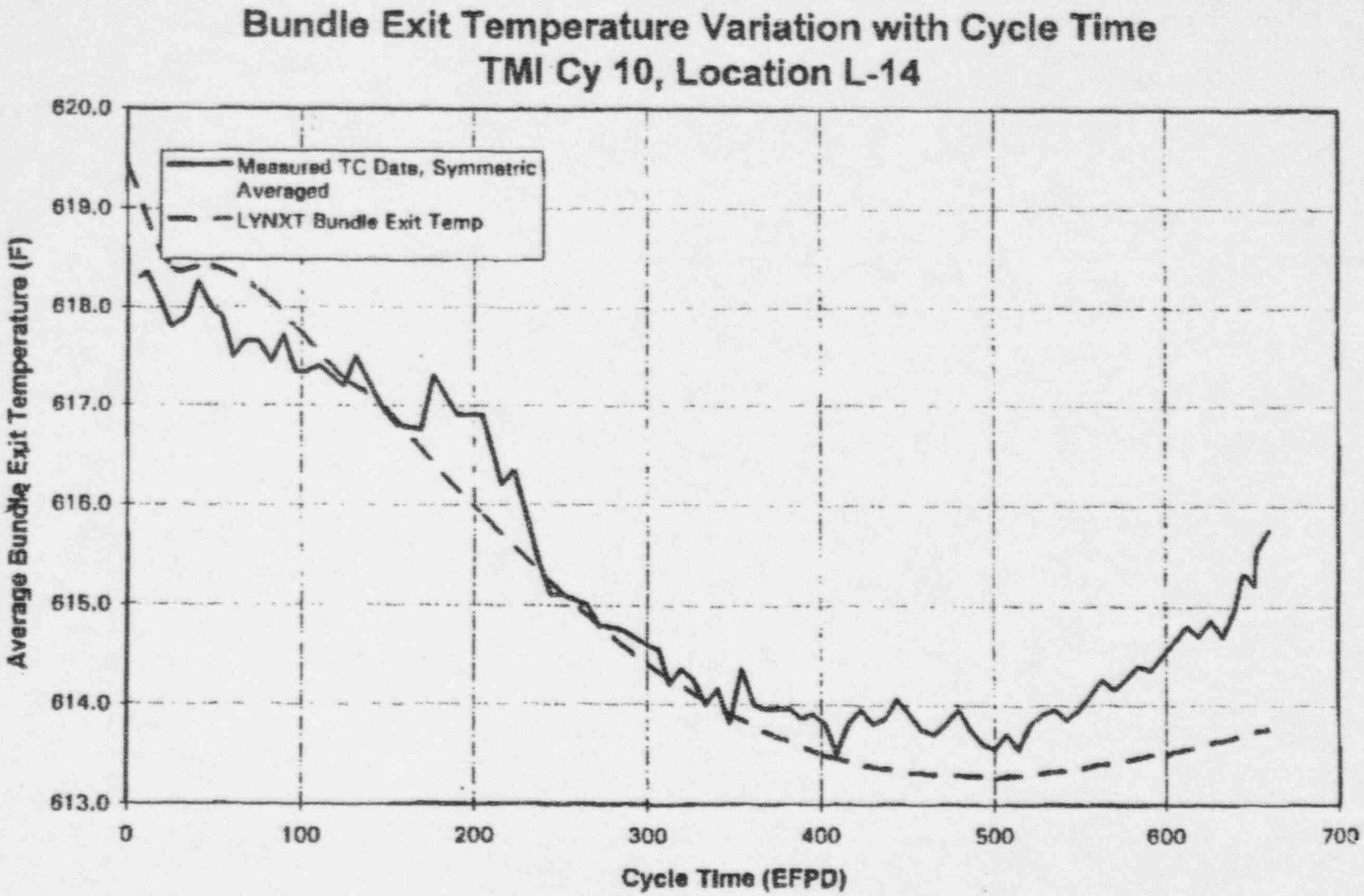
	8		9		10		11		12		13		14		15
H	599.0	608.5	613.9	609.2	604.5	608.2	607.8	608.3	608.8	613.0	617.2	610.3	603.5	588.2	572.8
			608.3		610.6		606.9		612.6		614.3		610.0		573.6
K			602.7	609.7	616.8	611.4	606.0	611.2	616.4	613.8	611.3	613.9	616.4	595.5	574.5
					612.5		612.7		611.1		615.1		617.9		574.4
L					608.2	613.8	619.4	612.6	605.8	612.4	618.6	618.3	619.5	596.9	574.3
							614.5		613.1		613.3		613.5		
M							609.5	614.9	620.4	614.0	607.7	607.7	607.6		
									616.0		612.2		594.1		
N									611.6	614.2	616.8	598.7	580.6		
											600.3				
O											583.8				

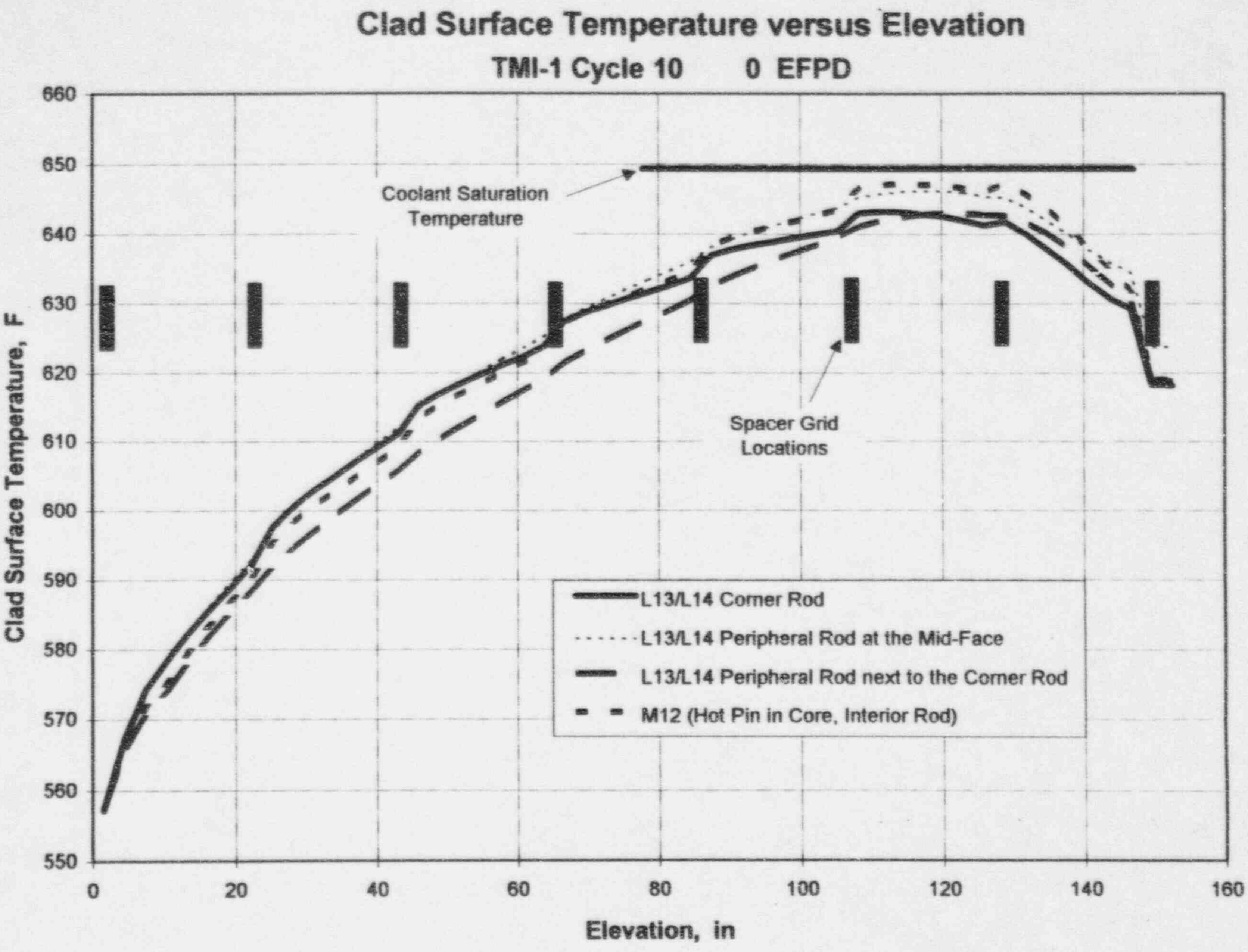
Highlighted regions with temperatures > 617 F.

TMI-1 Cycle 10 at 0 EFPD

Radial Power Distribution

	8	9	10	11	12	13	14	15
H	0.850	1.204	0.999	1.060	1.087	1.245	0.870	0.259
K		0.967	1.261	1.041	1.249	1.124	1.163	0.279
L			1.087	1.322	1.030	1.305	1.188	0.258
M				1.113	1.342	1.040	1.028	
N					1.135	1.187	0.416	
O						0.500		


Bundle Exit Temperature Variation with Cycle Time
TMI Cy 10, Location L-14
Measured TC Data, Symmetric Averaged
LYNXT Bundle Exit Temp
Average Bundle Exit Temperature (F)
620.0
619.0
618.0
617.0
616.0
615.0
614.0
613.0
0
100
200
300
400
500
600
700
Cycle Time (EFPD)


Clad Surface Temperature versus Elevation
TMI-1 Cycle 10 0 EFPD
660
650
640
630
620
610
600
590
580
570
560
550
0
20
40
60
80
100
120
140
160
Clad Surface Temperature, F
Elevation, in
Coolant Saturation Temperature
Spacer Grid Locations
L13/L14 Corner Rod
L13/L14 Peripheral Rod at the Mid-Face
L13/L14 Peripheral Rod next to the Corner Rod
M12 (Hot Pin in Core, Interior Rod)

Crud Sampling from TMI-1 Batch 12 Fuel

- Crud Sampling Performed on Fuel Rods at Various Elevations and From Various Assemblies
  - Six Different Locations
  - Pool Water
  - DI Water Blank
- Also Examined Crud From TMI CRDM at LTC
- All Crud From Fuel Rods Shows the Presence of Zeolites (Si, Al, Ca, Mg)
- Crud From Non-fuel Sources Does Not Show Zeolites
- Crud From Fuel with DCP Shows
  - Higher Activity
  - Lower Ratios of Nickel Activity (Co-57 & Co-58) to Co-60
  - Lower Levels of Nickel and Iron
- Non-DCP Samples Have Similar Radiochemistry as Samples From
  - TMI Cycle 4
  - Oconee 1
  - ANO-1 Cycle 4

Probable Root Cause
(Advisory Panel)

Water Chemistry Related

Low pH due to high boron and low lithium concentrations caused unusual crud deposits in high temperature regions of the core where localized boiling in adjacent hot channels occurred.

Scenarios That "Bound" The Cause(s)

- Nickel-Windows That Promoted Localized Hydrogen Transport to the Zr-clad

- Crud Deposits on the Fuel Pins Resulted in Elevated Temperatures in Localized Areas

- A Species May Have Been Concentrated in the Hot Areas that Resulted in Clad Corrosion/Damage

Cycle 11 Operations

- Minimize The Source of Crud to the Fuel
- Minimize Risk of Nickel-Windows
- Minimize Levels of Contaminants in the RCS
- Minimize the Potential Risk for Localized Oxidizing Environments

Cycle 11 Design and Monitoring

- Cycle 11 Key Parameters
- Core Monitoring After Startup
- Chemistry Plan
- Additional Investigations
- Safety Analyses/Safety Evaluation

Cycle 11 Key Parameters

In Comparison to Cycle 10

	Cycle 11	Cycle 10
Cycle Length (EFPD)	665	660
Initial Boron Concentration (ppm)	1669	1851
Maximum Feed Enrichment (%)	4.55	4.75
Maximum Pin Peak	1.51	1.51
Maximum Pin Peak (hot interface)	1.46	1.51
15-Pin Average (hot interface)	1.32	1.43

Core Monitoring After Startup

- Reactor Coolant System Activity
- Power Distributions, Imbalance and Tilt
- Exit Thermocouples

Cycle 11 Chemistry Plan

Prior to Restart

- Maximize Letdown Flowrate - Target for Suspended Solids $\leq$ 150 ppb Prior to Power Operation
- Establish Lithium Concentration Required for Power Operation Prior to Criticality
- Verify Ca,Mg,Al Low in Sources Feeding RCS

Power Operation

- Operate with Modified Lithium Program to Control pH
- Increase Scope and Frequency of Chemistry Monitoring
- Develop On-site Capability to Monitor Ca,Mg,Al in Makeup Sources

Additional Investigations

- Crud Scrape Samples
- Oxide Thickness Measurements
- Failed Fuel Rod Diameter Measurements
- Further Visual Examinations
- Additional Examinations as Indicated

Safety Analysis/Evaluation Reports Have Been Completed

- Limits Established Using Approved Reload Methods
- Margins to Safety Limits Maintained
- BWFC Cycle 11 Redesign Verification Report
- BWFC TMI Fuel Investigation Report
- GPUN Safety Evaluation
- Core Operating Limits Report

Conclusion: TMI-1 Cycle 11 Can Be Operated Safely

Summary and Conclusions

- Prudent actions were taken to investigate the unusual crud appearance, and to identify and replace the degraded fuel rods.
- Probable root cause has been determined and is consistent with observations and analysis.
- Corrective actions have been identified to prevent recurrence and implementation is underway.
- Additional fuel inspections and measurements are planned to provide a more complete understanding of the degradation mechanism.
- Extended chemistry monitoring will enable preventive actions. More detailed power monitoring will provide means of detection of similar conditions in Cycle 11.
- The level and character of the fuel failures in Cycle 10 had minimal nuclear safety significance; Cycle 11 should have less significance.
- All necessary safety analysis and safety evaluation reports have been completed and show that TMI-1 Cycle 11 can be operated safely.