AmerGen℠
AmerGen Energy Company, LLC
200 Exelon Way
Kennett Square, PA 19348
www.exeloncorp.com
An Exelon Company

March 15, 2005
5928-05-20074

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Three Mile Island, Unit 1 (TMI Unit 1)
Facility Operating License No. DPR-50
NRC Docket No. 50-289

Subject: M5™ Lead Test Rods - 15R Refueling Outage Post Irradiation Examinations

References:

(1) AmerGen letter to the NRC, dated January 18, 2001 (5928-00-20394), "Proposed Irradiation of Fuel Rods Beyond Current Lead Rod Burnup Limit"

(2) AmerGen letter to the NRC, dated April 11, 2001 (5928-01-20108), "Additional Information-Proposed Irradiation Of Fuel Rods Beyond Current Lead Rod Burnup Limit"

(3) NRC letter to AmerGen, dated May 18, 2001 (5928-01-30173), "Three Mile Island Nuclear Station, Unit 1 (TMI -1) - Re: Proposed Irradiation Of Fuel Rods Beyond Current Lead Rod Burnup Limit"

(4) AmerGen letter to the NRC, dated May 20, 2002 (5928-02-20120), "M5™ Lead Test Rods – 14R Refueling Outage Post Irradiation Examinations"

The following information is provided in accordance with the AmerGen Energy Company, LLC (AmerGen) commitment, described in References 1, 2, and 4, to provide Post Irradiation Examination (PIE) data for the M5™ lead test rods after their fourth cycle of operation to burnups in excess of 62 GWd/mtU. NRC concurrence to irradiate these rods for a fourth cycle was provided in Reference 3.

The PIE results obtained following the M5™ lead test rods' fourth cycle of operation in TMI Unit 1 Cycle 14 are presented in Framatome ANP Report BAW-2485, Revision 1, (Enclosure 1). Please note that the high burnup project was supported by the U.S. Department of Energy and the enclosed report is not proprietary.

As noted in BAW-2485, the four M5™ lead test fuel rods successfully completed four 24-month cycles of irradiation at TMI Unit 1 with a maximum fuel rod burnup of 68.0 GWd/mtU and a total reactor residence time of 2732 Effective Full Power Days (EFPD). At the end of four cycles, all measured fuel performance parameters were within the design models and no unexpected trends were observed. PIE measurements show that the M5$^{\text{TM}}$ lead test fuel rods continue to demonstrate low growth and low corrosion performance relative to Zr-4 clad fuel, as expected. The shoulder gap closure for these rods was also shown to be low.

This submittal satisfies the AmerGen commitment to provide the PIE data for the M5$^{\text{TM}}$ lead test rods and completes the high burnup test program for the M5$^{\text{TM}}$ rods at TMI Unit 1.

If any additional information is needed, please contact David J. Distel at (610) 765-5517.

Sincerely,

D. P. Helker

David P. Helker
Manager - Licensing
AmerGen Energy Company, LLC

Enclosure: (1) Framatome ANP Report BAW-2485, Revision 1, “Post Irradiation Examination for Advanced Materials at Burnups Exceeding the Current Limit,” January 2005

cc: S. J. Collins, Administrator, USNRC Region I
T. G. Colburn, USNRC Senior Project Manager, TMI Unit 1
D. M. Kern, USNRC Senior Resident Inspector, TMI Unit 1
File No. 00141

ENCLOSURE 1

Framatome ANP Report BAW-2485, Revision 1
"Post Irradiation Examination for Advanced Materials at Burnups Exceeding the Current Limit"

January 2005

The B&W
Owners Group

BAW-2485
Revision 1

The B&W OWNERS GROUP

CORE PERFORMANCE COMMITTEE

Post Irradiation Examination for Advanced Materials at Burnups Exceeding the Current Limit

FANP JOB 3664079

AREVA

FRAMATOME ANP, INC.

BAW-2485
Revision 1

AREVA

POST IRRADIATION EXAMINATION FOR ADVANCED MATERIALS AT BURNUPS EXCEEDING THE CURRENT LIMIT

FOR

NUCLEAR ENERGY PLANT OPTIMIZATION (NEPO) PROGRAM

Final Report

January 2005

Principal Investigator: John H. Strumpell
Framatome ANP, Inc.

Prepared for the U.S. Department of Energy
Under the Idaho Operations Office
Contract DE-FC07-03ID14534

Acknowledgements

This material is based upon work supported by the U.S. Department of Energy under Award No. DE-FC07-03ID14534

The contributions of the United States Department of Energy and the B&W Owners Group, consisting of Tennessee Valley Authority (TVA), FirstEnergy Nuclear Operating Company (FENOC), Entergy Operations, AmerGen Energy (Exelon), Duke Energy, and Progress Energy, are gratefully acknowledged. Recognition is also given for the support provided by Exelon at Three Mile Island Unit 1 throughout the course of this project.

Record of Revisions

Revision	Description
0	Original Issue.
1	Revised to correct typographical errors and omissions.

Table of Contents

Figures

Tables

1 Summary

Permitting fuel to be irradiated to higher burnup limits can reduce the amount of spent nuclear fuel (SNF) requiring storage and/or disposal and enable plants to operate with longer more economical cycle lengths and/or at higher power levels. Therefore, Framatome ANP (FANP) and the B&W Owner's Group (BWOG) have introduced a new fuel rod design with an advanced M5 cladding material and have irradiated several test fuel rods through four cycles. The U.S. Department of Energy (DOE) joined FANP and the BWOG in supporting this project during its final phase of collecting and evaluating high burnup data through post irradiation examination (PIE).

Four M5 fuel rods, which had previously undergone three cycles of irradiation in the Three Mile Island Unit 1 (TMI-1) reactor were removed from their host fuel assembly at the end of TMI-1 cycle 13, reconstituted into a new host fuel assembly, and irradiated for a fourth burn during cycle 14. The four M5 fuel rods were placed in the fuel assembly scheduled for insertion in the center core location to match fuel characteristics while achieving the highest practical fuel rod powers and burnups. At the end of the fourth cycle of operation, the M5 fuel rod burnups ranged from 62,858 MWd/mtU to 67,966 MWd/mtU. Cumulative core residence time for the four M5 fuel rods was 2732 effective full power days (EFPD). These are the highest burnups and exposure times for M5 fuel rods in the United States to date.

Post irradiation examinations (PIEs) were conducted to obtain fuel rod performance information at high burnups to form a baseline to justify higher burnup limits in the future. The TMI-1 four cycle M5 fuel rod measurements add to the growth, creep, and corrosion database expected to be required by the NRC before allowing burnups above the current limits. This report discusses the results of the PIE at the end of four cycles and also includes some results from earlier cycles that help to clarify trends in fuel performance.
PIE measurements were as follows:

- Full face visual examination
- Fuel assembly length
- Shoulder gap
- Fuel rod oxide
- Fuel rod diameter
- Fuel rod length

The four M5 fuel rods exhibited significant performance improvements over the Zircaloy-4 fuel rod design, confirming the applicability of the global Framatome ANP M5 database to the U.S. market. Significantly lower fuel rod growth and corrosion were observed compared to Zircaloy-4. All data were within the expected ranges and confirm the models used for the M5 rod fuel design. No adverse trends were indicated, and the performance of the M5 fuel rods was superior to that seen in the existing Zircaloy-4 experience base. These improvements in material and fuel rod performance provide a solid foundation for future increases in fuel burnup limits.

2 Mark-B10 Fuel Assembly Design

The Mark-B10 is a 15x15 fuel assembly designed for operation in Babcock & Wilcox 177 fuel assembly plants. The basic features and general design of the Mark-B10 are shown in Figure 2.1. Each fuel assembly consists of 208 fuel rods, 16 guide tubes and one instrument tube arranged in a 15x15 square array within a supporting structure.

Two lead test assemblies (LTAs) were provided by Framatome ANP in 1995 with cycle 11 fresh fuel to test the corrosion resistance of M5 cladding and other alloys in a high burnup, high residence time core. These LTAs were loaded for their third cycle of operation in cycle 13. The four M5 rods from assembly NJ07VX (core location A6) were extracted from their host assembly at the end of cycle 13, inspected, and exchanged with four Zircaloy-4 rods from a new host assembly (NJ07U9). NJ07U9, as a host for the M5 rods, became an LTA in Cycle 14. The two original LTAs, NJ07VX and NJ07VY, were discharged to the spent fuel pool at the end of cycle 13.

Figure 2.2 and Figure 2.3 show the fuel rod exchange arrangement. Figure 2.4 shows the core locations of the assemblies NJ07VX and NJ07U9 from cycle 11 through cycle 14. The NJ07U9 assembly was placed in the center position of the core for a fourth cycle of irradiation for the four M5 rods, and a third cycle of irradiation for the resident Zircaloy-4 fuel rods. The Zircaloy-4 fuel rods in NJ07U9 are 4.0 weight % ^{235}U rods, while the M5 rods reconstituted into NJ07U9 are 4.55 weight % ^{235}U fuel rods. Fuel assembly NJ07U9 had no Gadolinia absorber rods and did not have a Burnable Poison Rod Assembly in Cycle 14. The Mk-B10 fuel assembly does not utilize mixing vanes on the grids nor mid-span mixing grids.

Figure 2.1 - Mark-B10 Assembly General Arrangement

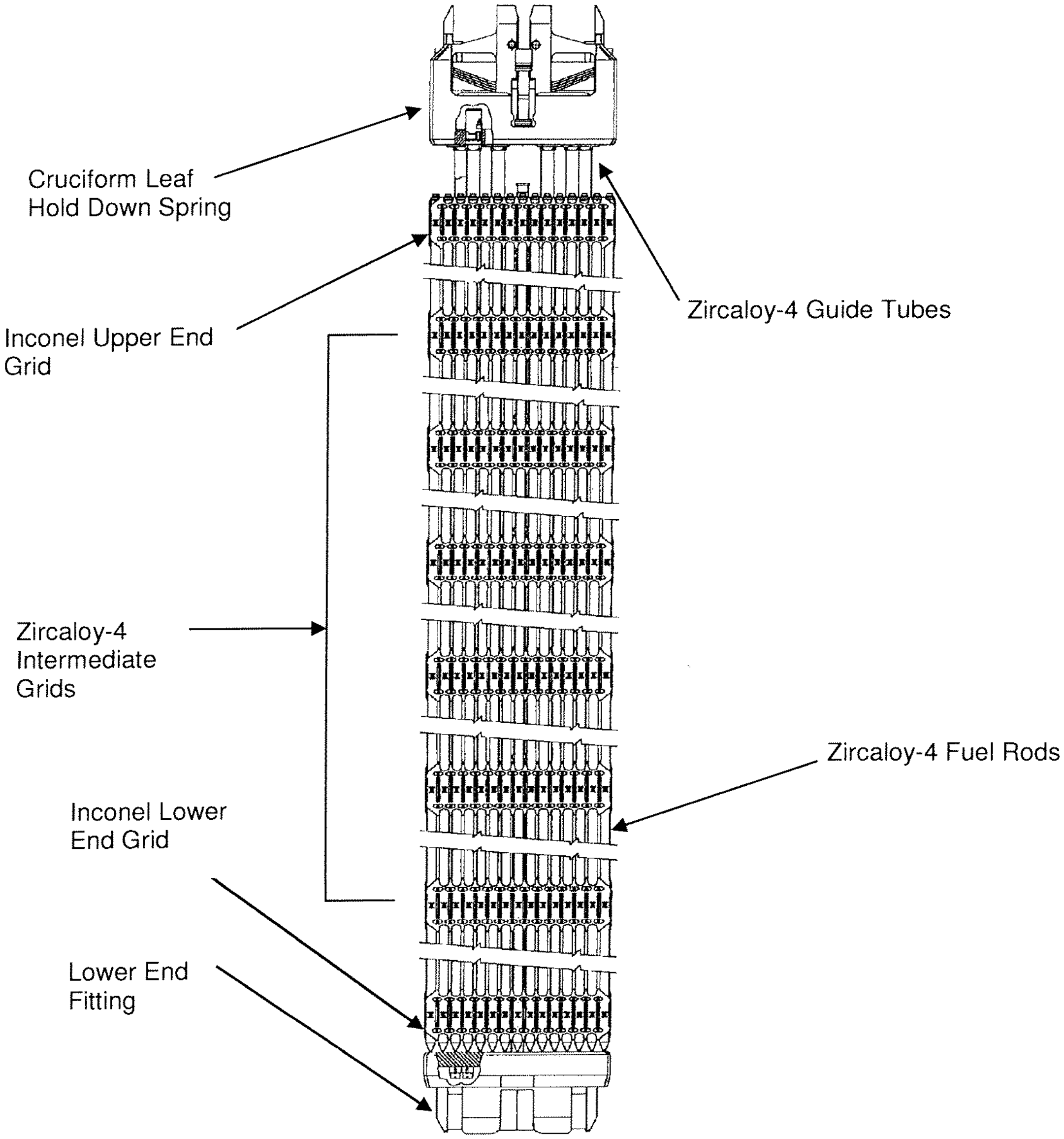


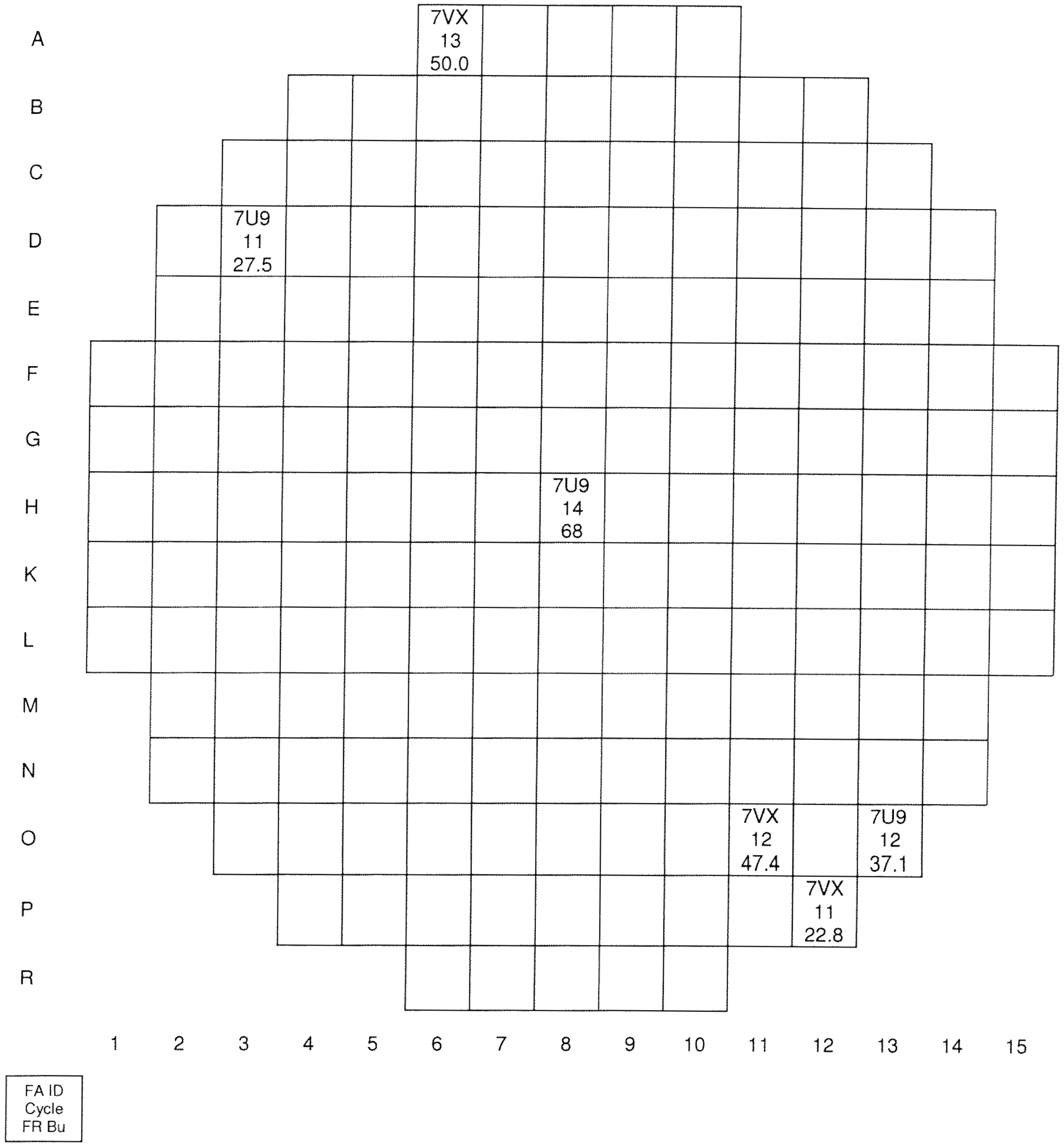
Figure 2.2 - Assembly NJ07VX, Location of M5 Fuel Rods for Cycles 11 to 13

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
A							**M5-3**								
B															
C															
D															
E															
F															
G															**M5-4**
H															
I	**M5-2**														
J															
K															
L															
M															
N															
O									**M5-1**						

Figure 2.3 – Reconstituted Assembly NJ07U9 for Cycle 14 Core Location H-08

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
A							**Zr-2a**	**M5-2**	**Zr-2b**						
B															
C															
D															
E															
F															
G	**Zr-3a**														**Zr-1a**
H	**M5-3**														**M5-1**
I	**Zr-3b**														**Zr-1b**
J															
K															
L															
M															
N															
O							**Zr-4a**	**M5-4**	**Zr-4b**						

Figure 2.4 - M5 Lead Test Assembly Core Locations for TMI-1 Cycles 11 to 14



3 Core Operation

TMI-1 is a 177 fuel assembly Babcock & Wilcox designed nuclear reactor of 2568 MW thermal power operating on a 24 month cycle between refueling shutdowns. Capacity factor has been historically high at TMI-1; thus, the resident fuel experiences long periods of continuous full power operation that is representative of bounding industry practice.

Four M5 fuel rods from NJ07VX were reconstituted into NJ07U9 for a fourth cycle of operation as described in Section 2. The reconstituted fuel was placed in the center core position. The center core location, H-8, hosts a Bank 7 (regulating bank) control rod assembly. Table 3.1 summarizes core operation history for fuel assemblies NJ07VX and NJ07U9 for core cycles 11, 12, 13, and 14.

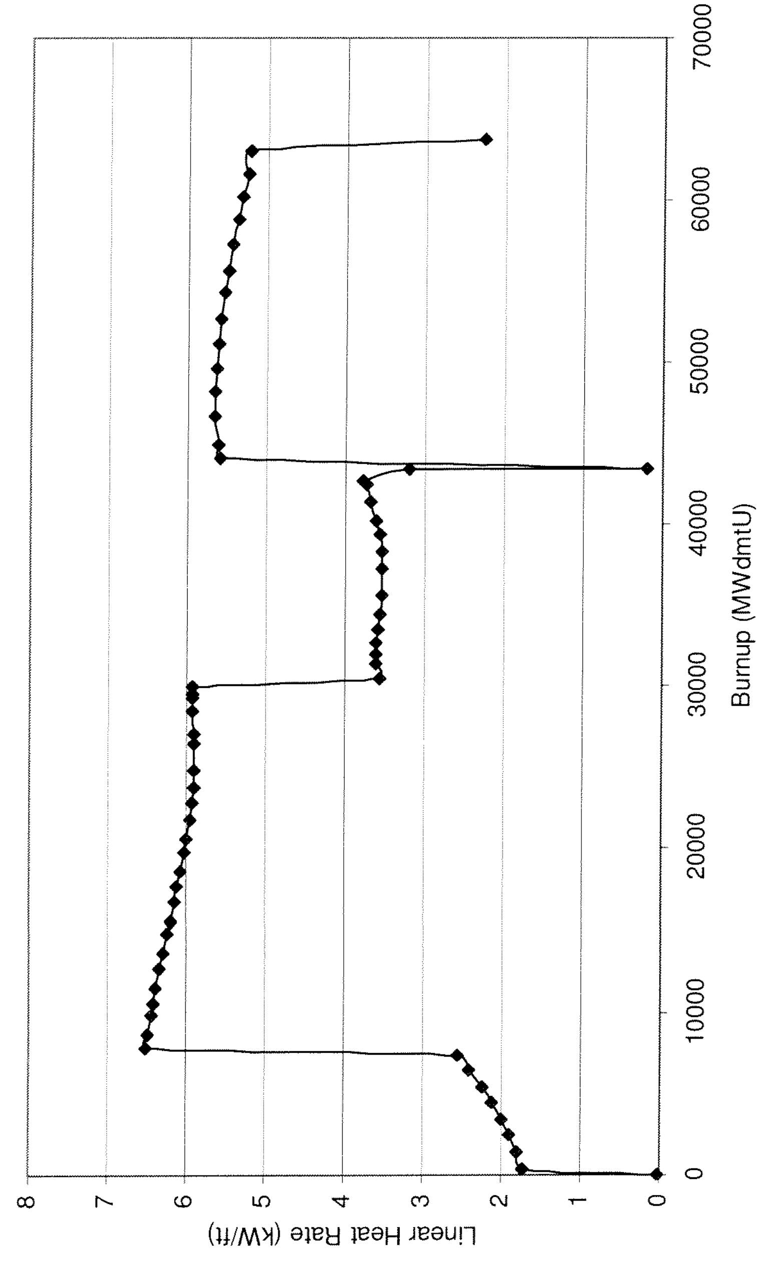
Table 3.1 - Three Mile Island Unit 1 Mark-B10 Core Operation History

TMI-1 Core Cycle	Start Date (M/D/Year)	End date (M/D/Year)	Cycle Length EFPD	Fuel ID	Core Location	Maximum Fuel Rod Burnup (MWd/mtU)	Fuel Assy Burnup (MWd/mtU)
11	10/12/1995	9/5/1997	683.04	NJ07VX	P-12	22759	13685
				NJ07U9	D-3	27428	22721
12	10/18/1997	9/10/1999	680.57	NJ07VX	O-11	47425	38143
				NJ07U9	O-13	37053	33870
13	10/18/1999	10/9/2001	691.96	NJ07VX	A-6	49978	45326
14	12/05/2001	10/18/2003	676.35	NJ07U9	H-8	67966	54375

3.1 Rod Power Histories

Figure 3.1 through Figure 3.5 provide the rod power history for the four high burnup M5 LTA rods and the eight Zircaloy-4 clad rods adjacent to the M5 rods for TMI-1 cycles 11 through 14. Comparison of the M5 and Zircaloy-4 fuel rod power histories shows that the two types of fuel rods operated at relatively similar conditions. These rod power histories will be used in follow-on analyses, described later in this report, for comparison to the measured PIE data at high burnup. These analyses will be performed using the COPERNIC fuel rod analysis code (Reference 1). COPERNIC is the most recent Framatome ANP fuel rod performance code approved by the NRC for M5 applications.

Figure 3.1 - M5-1 Rod Power History



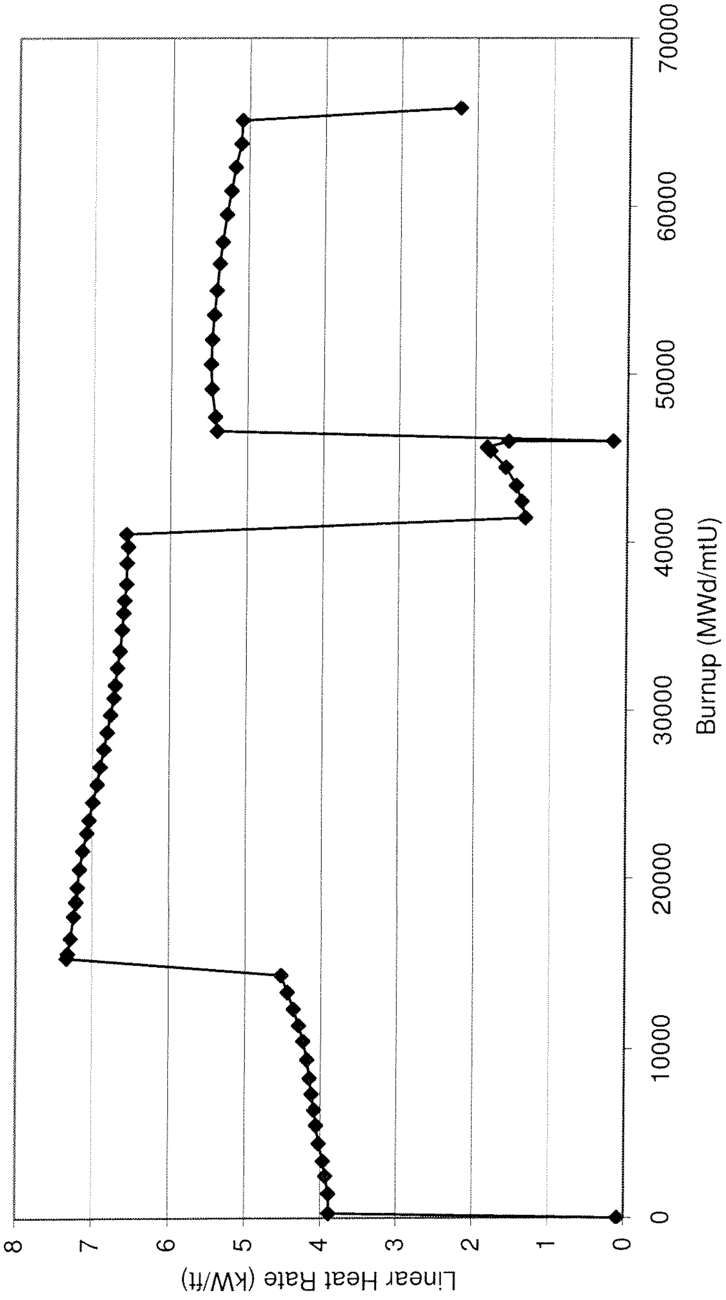


Figure 3.2 - M5-2 Rod Power History

Figure 3.3 - M5-3 Rod Power History

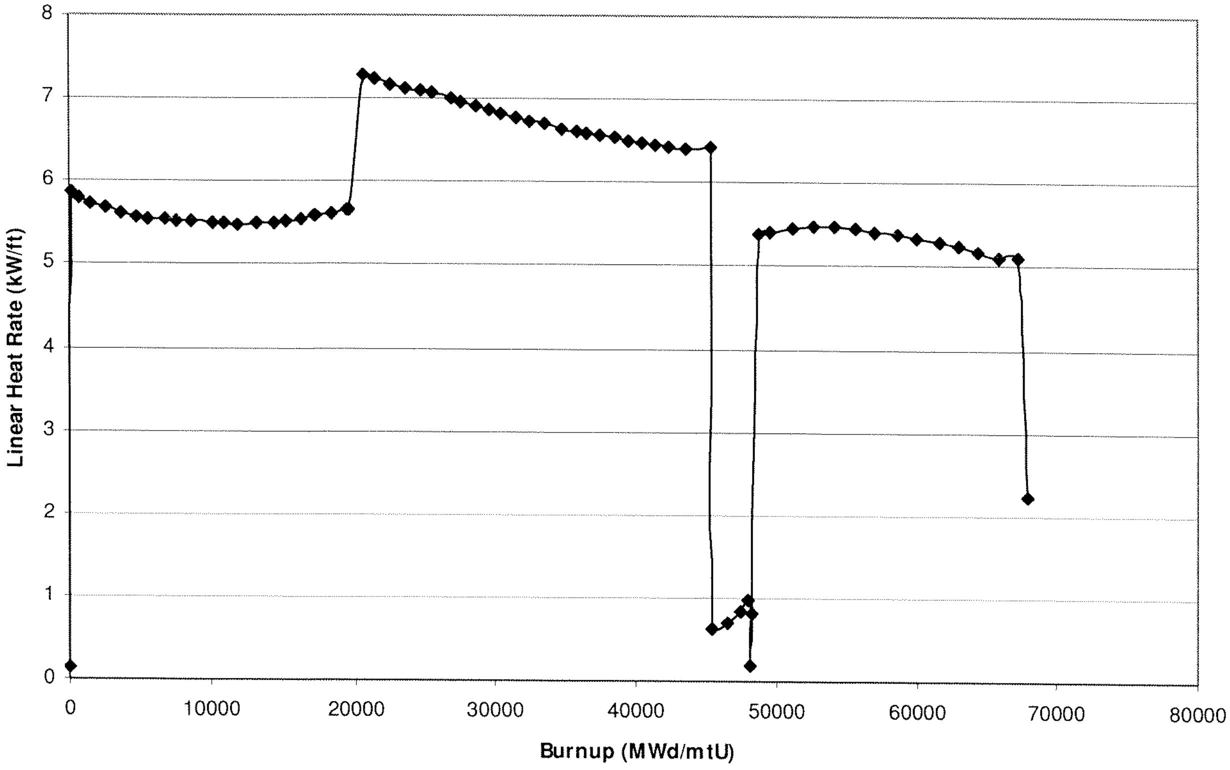


Figure 3.4 - M5-4 Rod Power History

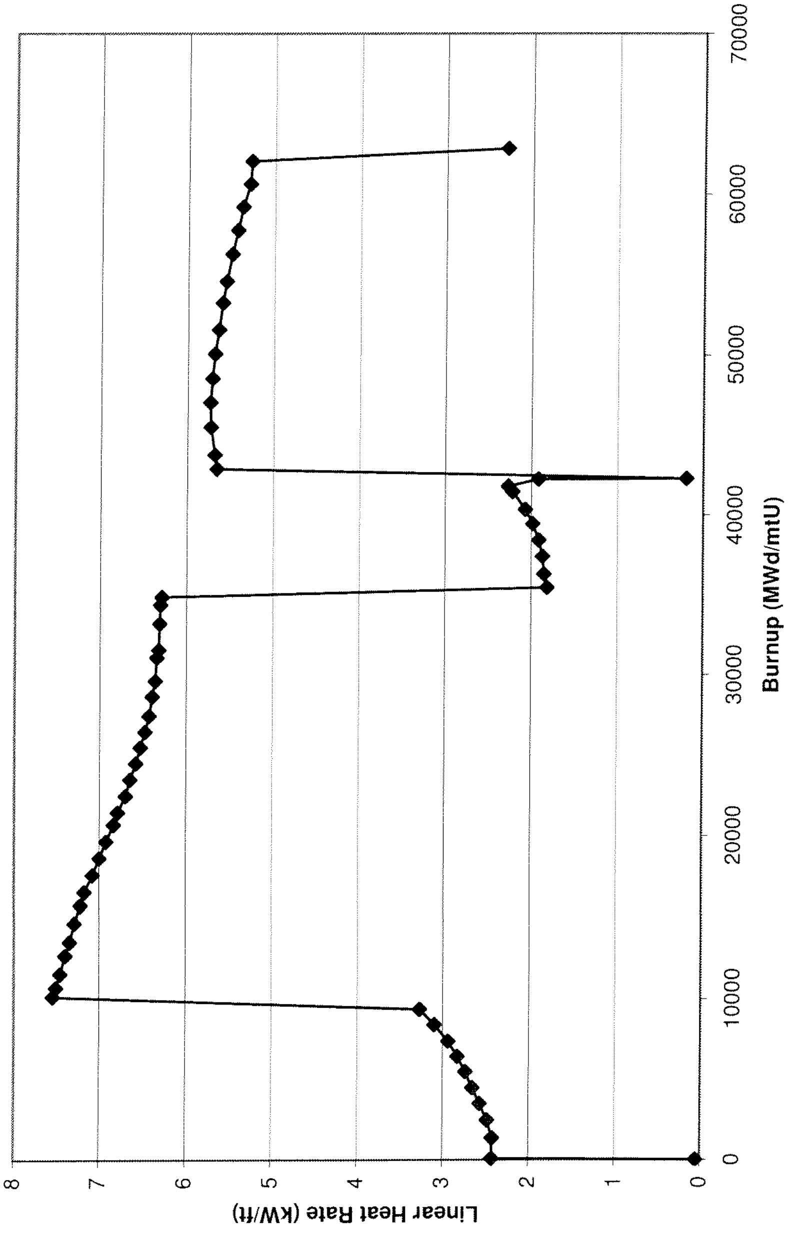
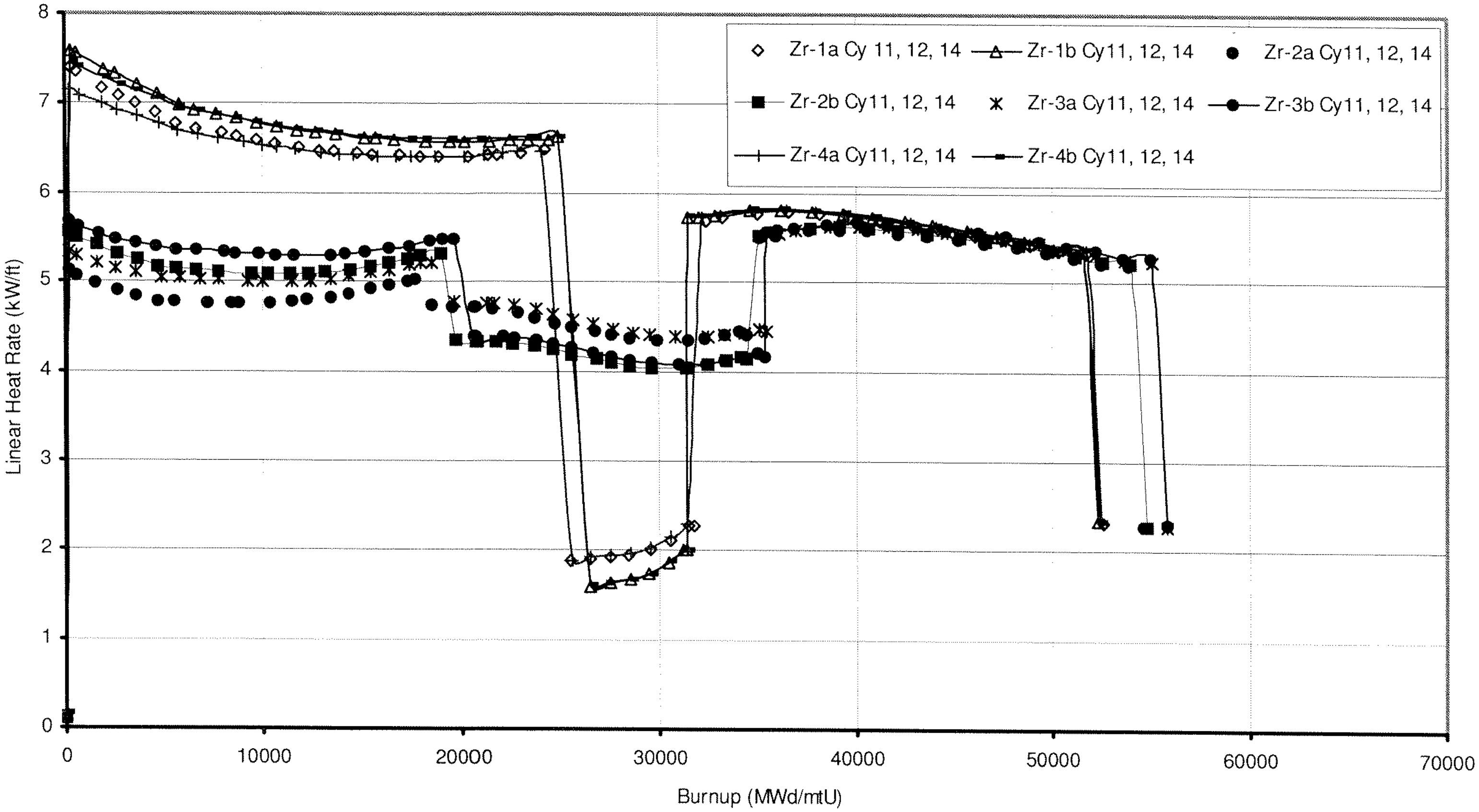


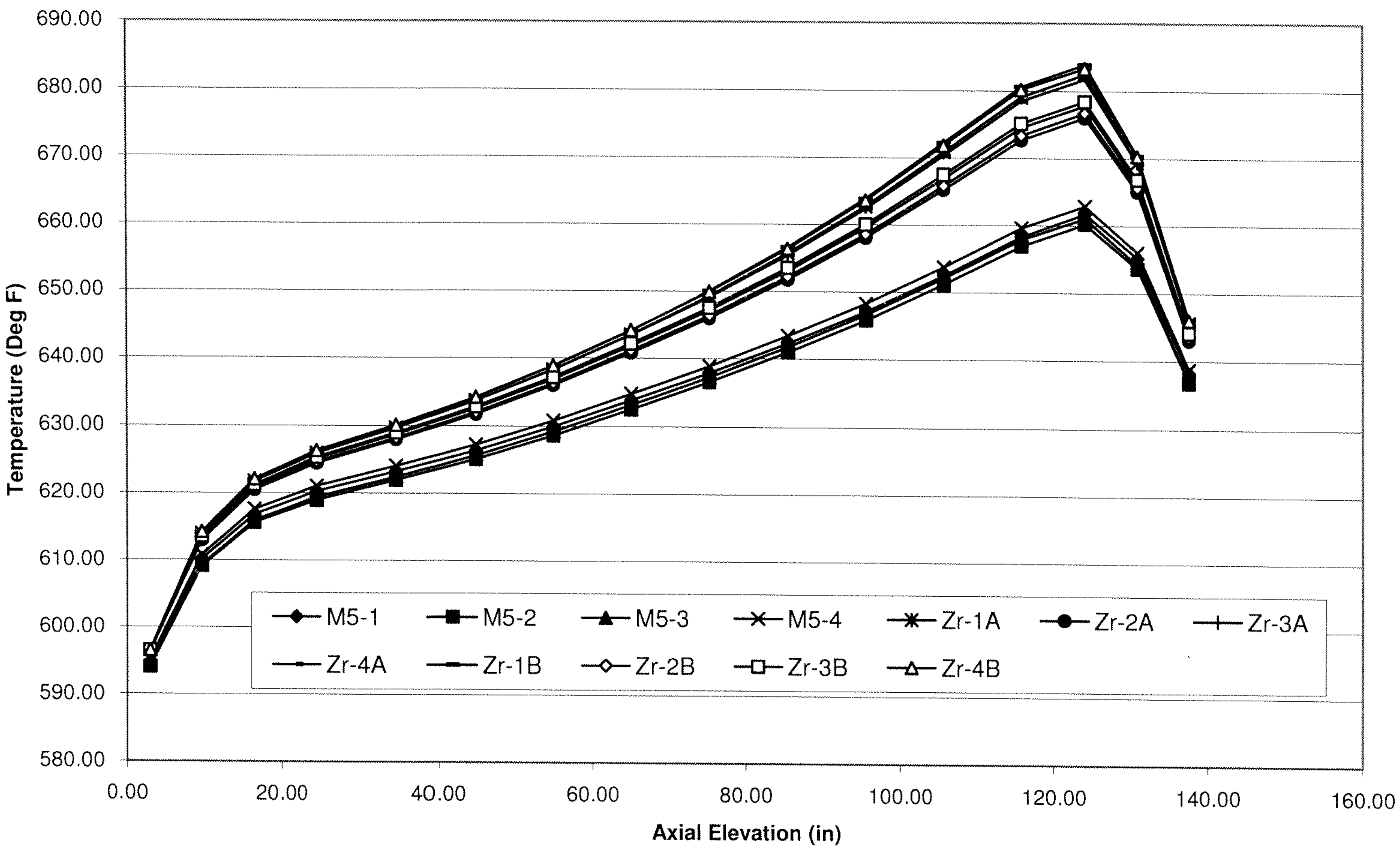
Figure 3.5 - Zircaloy-4 Rod Power Histories



3.2 Axial Temperature Profiles

The COPERNIC code is used to predict cladding temperatures for the Zircaloy-4 and M5 fuel rods over the lifetime of the fuel. The cladding temperature affects the evolution of fuel rod performance during exposure and is used in making analytical oxide layer predictions for comparison to PIE data. An example of the cladding temperature predictions is shown in Figure 3.6. The average clad temperature at end of life is higher for the Zircaloy-4 clad primarily due to higher oxide layer thickness compared to the M5 rods. As M5 cladding experiences less oxide formation, the clad temperatures remain lower than for Zircaloy-4. This behavior helps M5 to resist the run-away corrosion at high burnups seen in Zircaloy-4 clad fuel. Excessive fuel rod corrosion and associated hydrogen absorption (embrittlement) are two key concerns that limit future increases in fuel rod design burnups.

Figure 3.6 - Temperature of Fuel Rods at End of Cycle 14



4 Post Irradiation Examination and Analytical Results

The TMI-1 PIE took place in July 2004. The purpose was to obtain fuel rod performance information at high burnups on the four M5 fuel rods in NJ07U9 to form a baseline to justify higher burnups than the current licensing limit of 62 GWd/mtU burnup.

4.1 Scope of Inspection

The scope of the TMI-1 end-of-cycle 14 PIE campaign is summarized in below. The PIE included visual examination, fuel assembly length, shoulder gap, fuel rod diameter, fuel rod oxide thickness, and fuel rod length measurements. The analytical work included generating power histories of the four high burnup M5 rods and the eight Zircaloy-4 rods adjacent to the M5 rods, steady state rod pressure, axial temperature profiles, clad creep, clad outer diameter, and oxide thickness for the four M5 rods. The analytically determined clad outer diameter, and oxide thickness for the four M5 rods is compared with the clad outer diameter and the oxide thickness measurements from the PIE campaign.

Table 4.1 - PIE Scope

Examination	Scope
Visual	4 Faces per assembly
Assembly Length	4 Guide Tubes per assembly
Shoulder Gap	4 M5 rods 16 Zircaloy-4 rods
Fuel Rod Oxide and Fuel Rod Diameter	4 M5 rods 4 Zircaloy-4 rods
Fuel Rod Length	4 M5 rods 4 Zircaloy-4 rods

4.2 Visual Examination

Full-length visual examinations were performed in the spent fuel pool on the LTA at the end of Cycle 14. In-mast sipping confirmed that the fuel assembly NJ07U9 was leaker-free following the fourth irradiation cycle. Representative photographs of assembly NJ07U9 are shown in Figures A1 through A9 in Appendix A. The M5 cladding is clean and smooth throughout the active fuel length on all four faces.

4.3 Fuel Assembly Length and Growth

The length of assembly NJ07U9 was measured using standard Framatome ANP procedures. Table 4.2 summarizes the fuel assembly length and growth data. The fuel assembly length data coupled with the shoulder gap measurements are used to determine the fuel rod growth.

Table 4.2 - Fuel Assembly Length and Growth

Fuel Assembly ID	End of Core Cycle	Maximum Fuel Rod Burnup MWd/mtU	Fuel Assembly Burnup MWd/mtU	As Built Length l (in)	Total Growth dl (in)	% Growth (dl/l)*100
NJ07U9	14	67966	54375	153.596	.576	.38

4.4 Shoulder Gap and Fuel Rod Growth

The fuel assembly design includes a "shoulder gap", that is, the space between the upper ends of the fuel rods and the lower surface of the grillage of the upper end fitting. The shoulder gap accommodates fuel rod growth during irradiation. Since the fuel rods are seated, by design, on the top surface of the lower end fitting, some shoulder gap must be maintained because large forces could result if fuel rods contact the upper end fitting at high burnup.

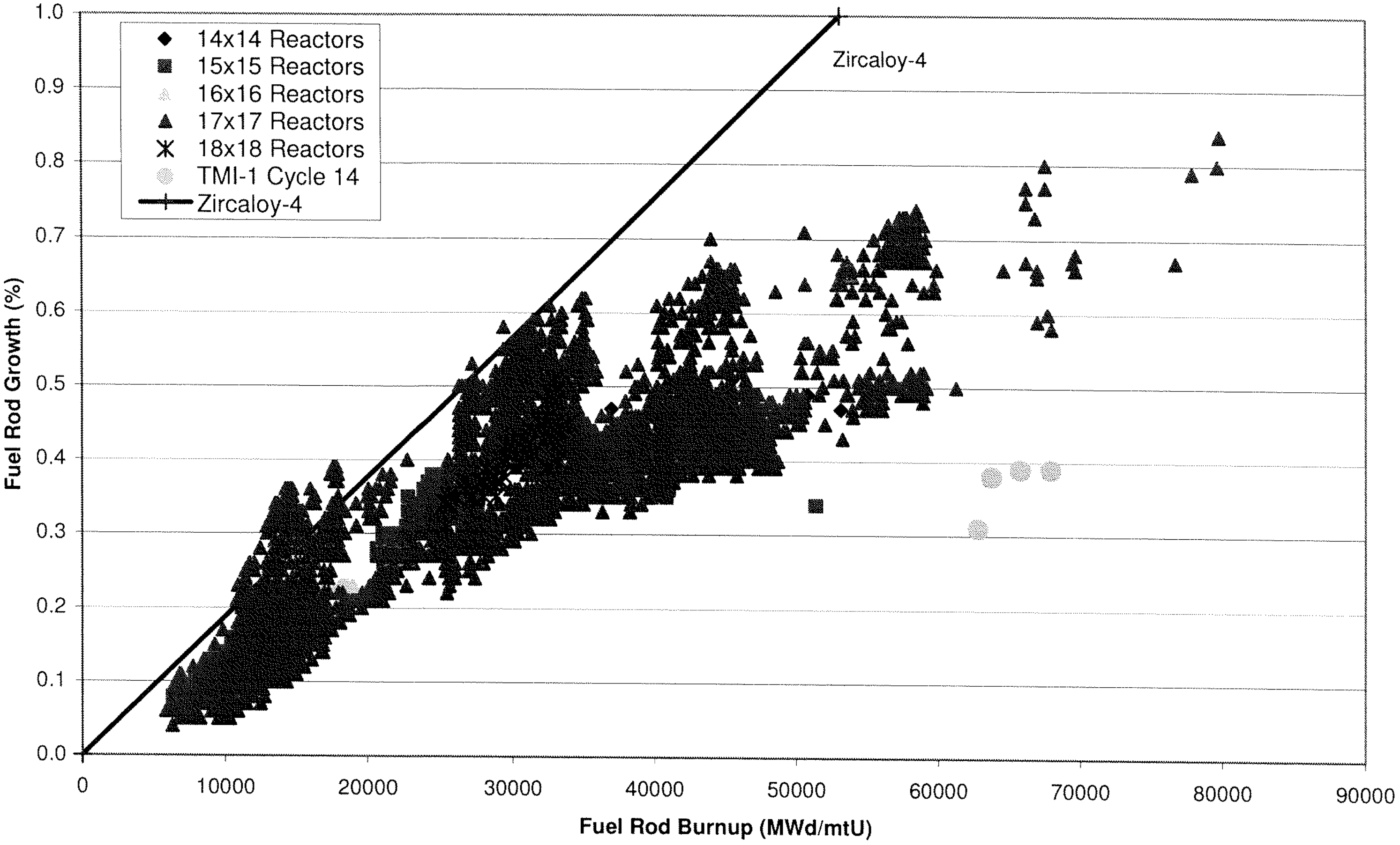
Shoulder gap measurements were made on fuel assembly NJ07U9 using standard Framatome ANP procedures. These measurements take into account the fuel rod exchange and are summarized in Table 4.3. The negative shoulder gap closure for the M5 fuel rods indicates that the Zircaloy-4 guide tubes in the fuel assembly NJ07U9 grew more than the M5 fuel rods resulting in a shoulder gap increase.

Table 4.3 - Shoulder Gap and Fuel Rod Growth

Fuel Assembly	Guide Tube Material	Fuel Rod Cladding Material	Number of Cycles of Irradiation	Average Shoulder Gap Closure (in)	Average Fuel Rod Growth (%)
NJ07U9	Zircaloy-4	Zircaloy-4	3	0.41106	0.64
		M5	4	-0.21450	0.37

As expected, more shoulder gap closure was observed on the Zircaloy-4 fuel rods than on the M5 fuel rods in fuel assembly NJ07U9. The average Zircaloy-4 fuel rod growth in NJ07U9 after three cycles of irradiation is about twice the average growth of the M5 fuel rods after four cycles of irradiation. Figure 4.1 shows Framatome ANP M5 fuel rod growth data as a function of fuel rod burnup. The average TMI-1 M5 LTA fuel rod growth is on the low end of the observed data to date. This data confirms that fuel designed with M5 cladding can achieve significantly higher burnups than present designs with Zircaloy-4 based on fuel rod growth considerations.

Figure 4.1 - Fuel Rod Growth Versus Burnup



4.5 Fuel Rod Oxide Measurements

The cladding oxide thickness is measured by determining the distance from the surface of the rod to the conductive metal. An eddy current contact probe is used to determine that distance, which is made up of the oxide layer and the crud film. The probe and system generate a voltage that is dependent on the offset from the metal surface. The eddy current probe is calibrated by measuring a standard made of four pieces of cladding with different thicknesses of oxide layers. The thickness of the oxide layer on each section has been determined by metallographic examination of a cross section. A measurement is taken with the oxide probe on each section. Based on the voltage produced by each reading, the system then fits a curve through the calibration points to produce a curve of offset vs. voltage, which is then used to convert the digital signal from the analog-to-digital converter to an oxide thickness as the scan is performed.

Four M5 peripheral fuel rods (one per face – see Figure 2.3) were measured for oxide thickness on fuel assembly NJ07U9 at the end of cycle 14. The oxide thickness was determined using an eddy current probe passed down the fuel rod outside diameter. The inspections were performed on all seven inter-grid spans of the fuel assemblies. To reduce noise, the measured data are smoothed with an 11-point moving average. This gives a moving average over approximately a 0.193 inch axial length of the fuel rod. A sample scan is shown in Figure 4.2. Note that displacements are measured relative to an arbitrary axial location and a displacement of about 4.6 inches is the beginning of a span. Figure 4.3, compares the TMI-1 end-of-cycle 14 PIE fuel rod oxide data to the worldwide M5 and Zircaloy-4 fuel rod oxide data. At the end of four cycles, all measured fuel rod oxide thicknesses are consistent with the design models, and no unexpected trends are observed. As expected, the M5 fuel rod oxide thickness is well below that of the Zircaloy-4 fuel rod oxide thickness; therefore, fuel rods using M5 cladding can achieve significantly higher burnups than Zircaloy-4 clad fuel.

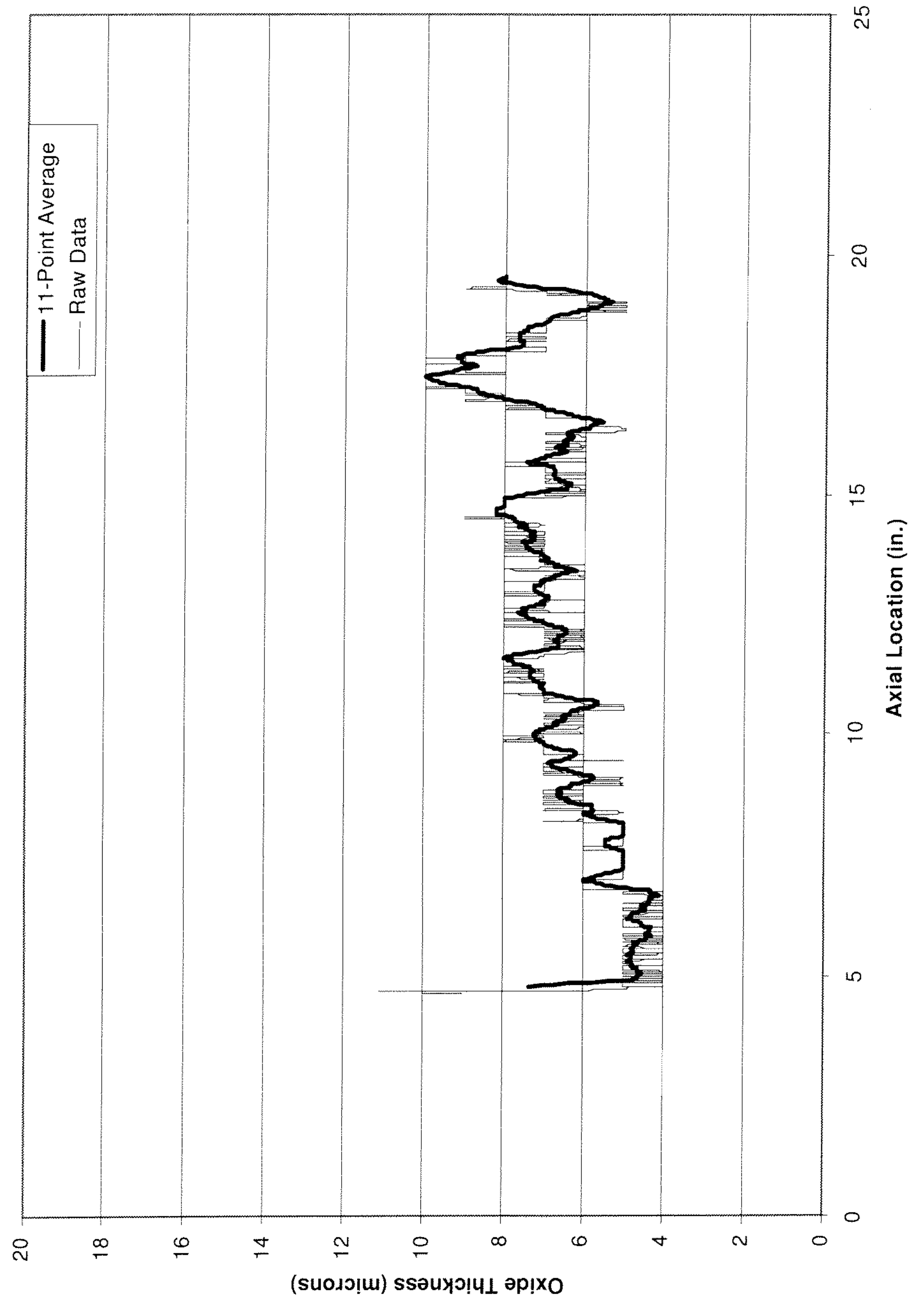
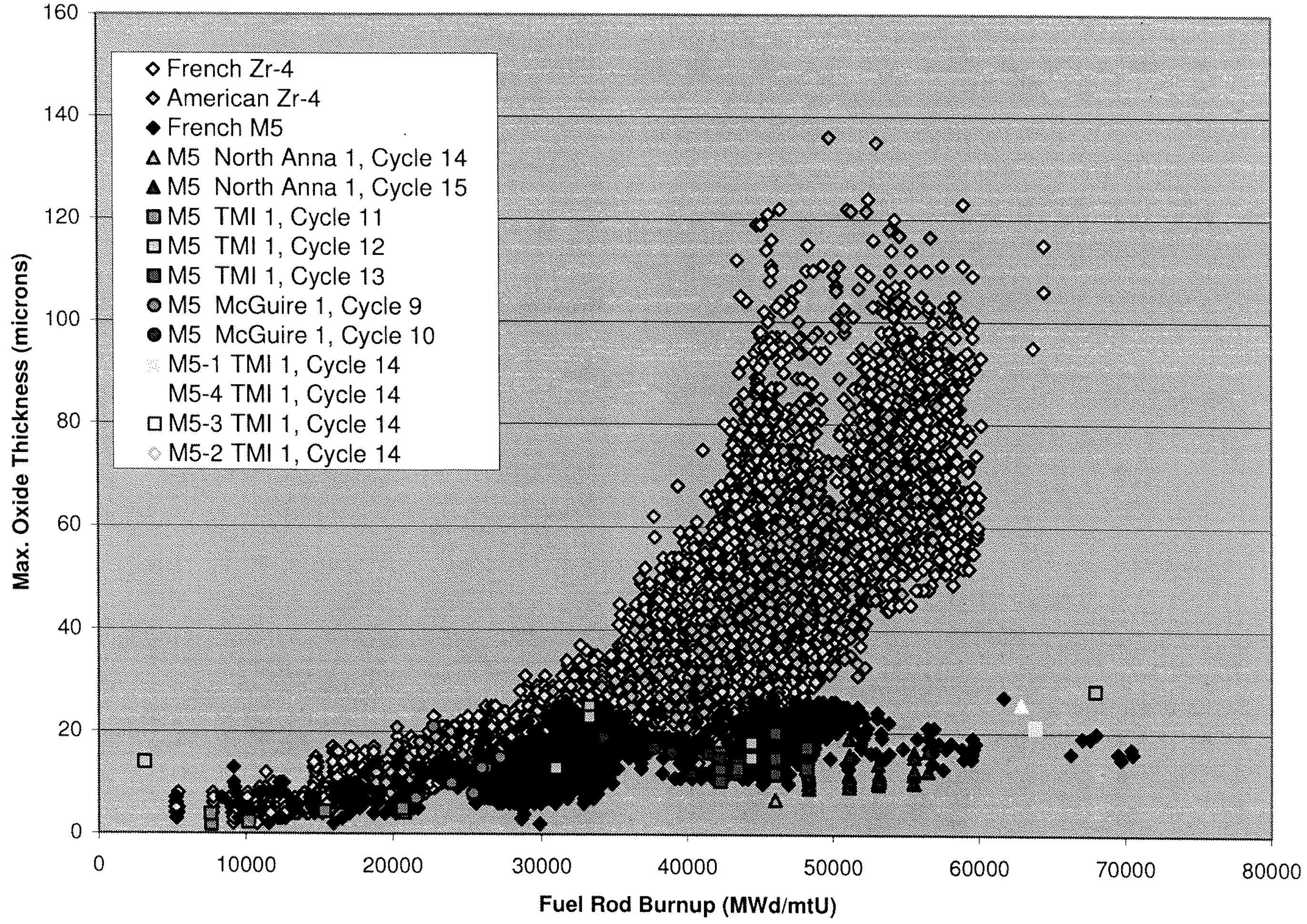


Figure 4.2 - Oxide Thickness for NJ07U9, Face D, Span 7, Rod 8, Scan 1

Figure 4.3 - Worldwide M5 Oxide Database Compared to Zircaloy-4 Oxide Thickness



4.5.1 Predicted Fuel Rod Oxide

A COPERNIC (Reference 1) analysis was performed using rod specific data for each of the four M5 fuel rods of interest. The COPERNIC model was executed to analyze fuel rod performance including axial temperature profiles, clad corrosion and diameter. The predicted oxide thickness and the measured oxide thickness data for the four M5 rods are shown in Figure 4.4 through Figure 4.7. It can be observed that the analytical oxide prediction in COPERNIC is conservative. Also, the data suggests that the M5 corrosion is less sensitive to temperature than predicted. Note that COPERNIC predicts the oxide thickness over an axial span and is, therefore, representative of the average oxide thickness. As a result, the localized maximum oxide measurement may, in some instances, exceed the COPERNIC predicted value as seen in Figure 4.6 and Figure 4.7.

Fuel rod oxide performance at high burnup is an important aspect in the integrity of the primary fission product barrier during normal and off-normal operation. M5 cladding shows low oxide levels at high burnup and COPERNIC allows for conservative oxide layer predictions. This provides the cladding material and design analysis tool for high burnup application.

Figure 4.4 - Measured and Analytical Oxide Thickness Comparison for Fuel Rod M5-1

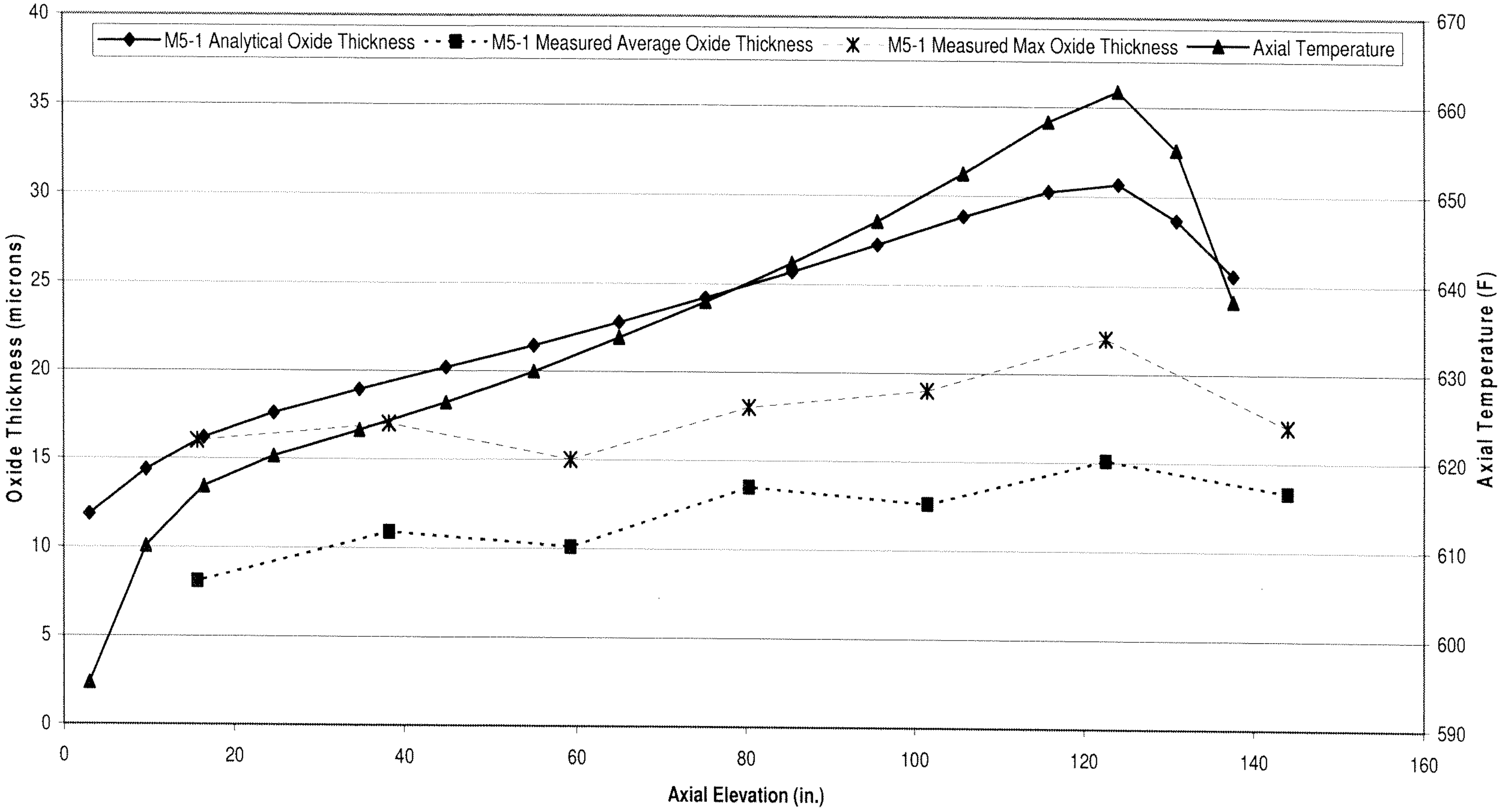
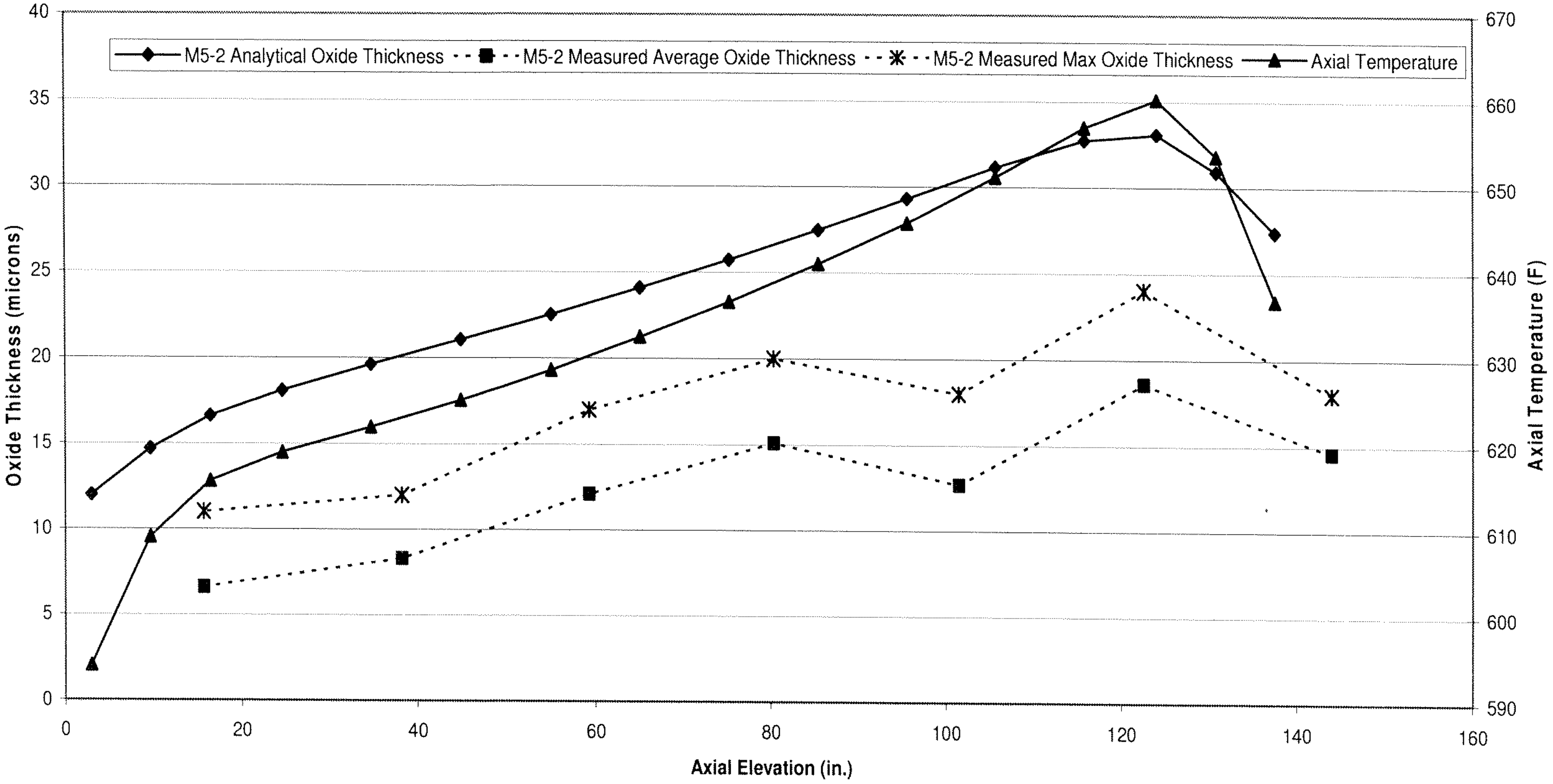


Figure 4.5 - Measured and Analytical Oxide Thickness Comparison for Fuel Rod M5-2



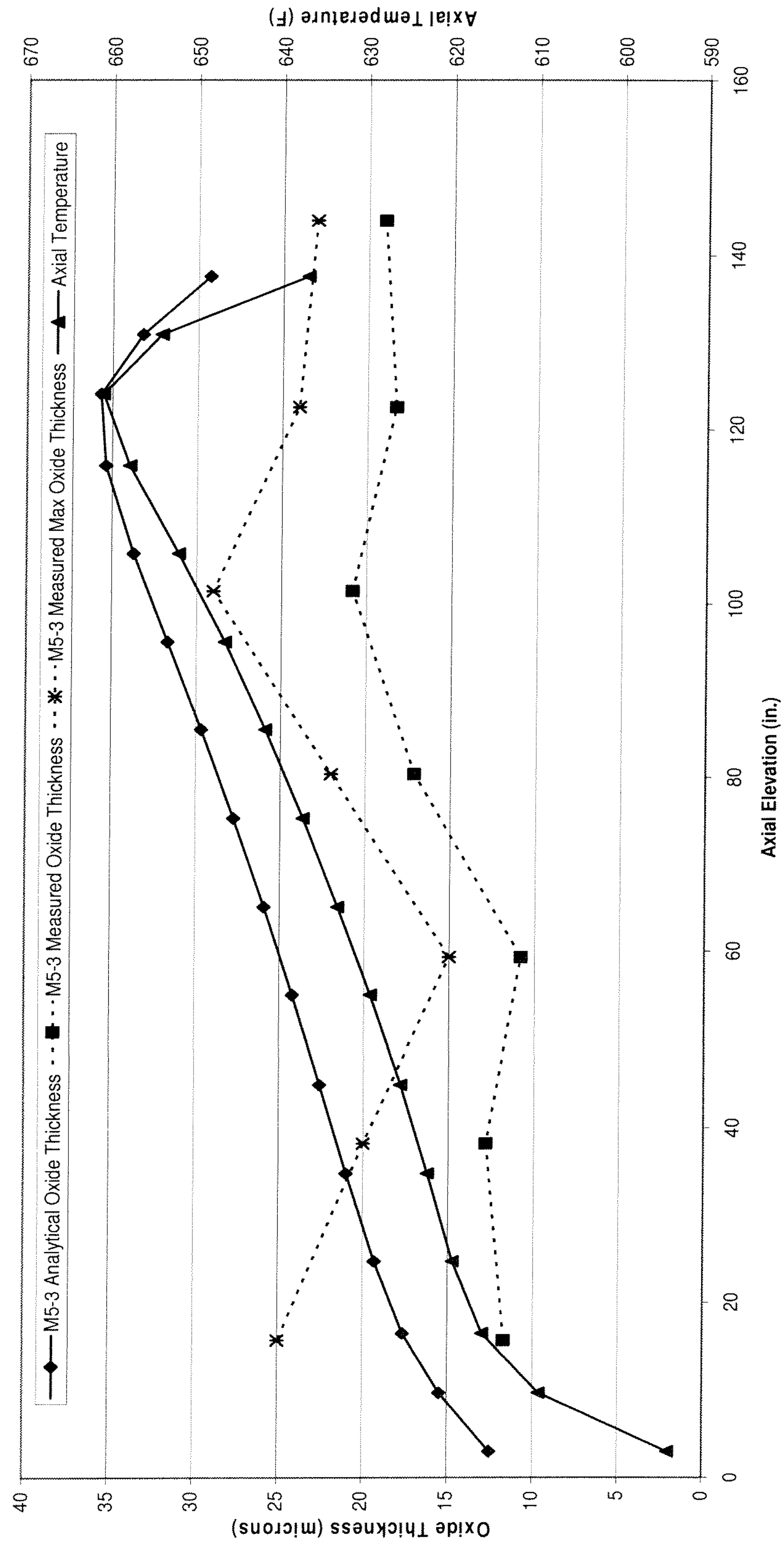
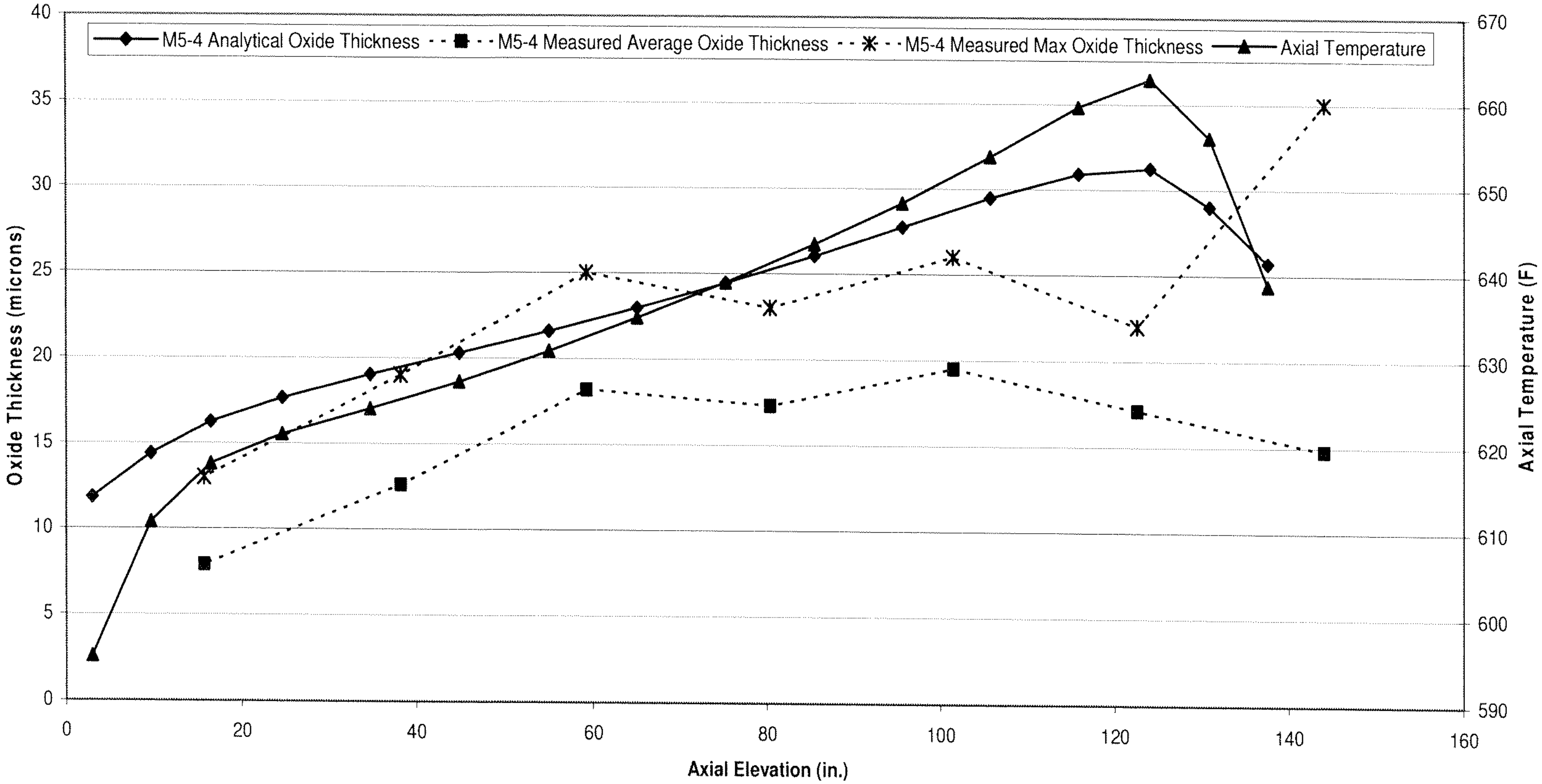


Figure 4.6 - Measured and Analytical Oxide Thickness Comparison for Fuel Rod M5-3

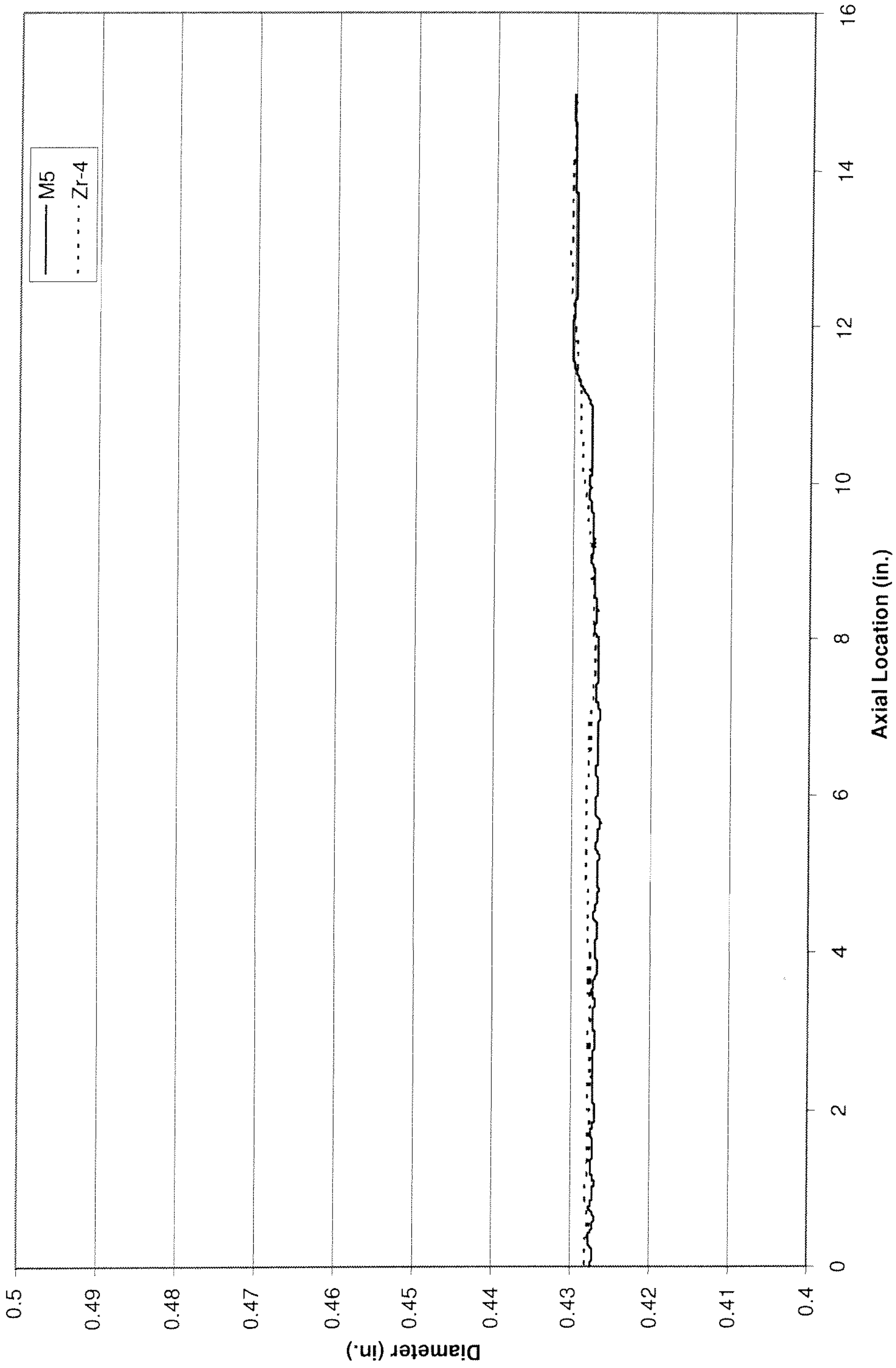
Figure 4.7 - Measured and Analytical Oxide Thickness Comparison for Fuel Rod M5-4



4.6 Fuel Rod Diameter Measurements

Cladding diameter is measured with a contact probe that has spring-loaded fingers attached to a linear voltage differential transformer (LVDT). The diameter of the rod at a specific axial location provides a unique output voltage, which is converted to the measured value. For fuel assembly NJ07U9, the diameter measurements were taken on all four M5 rods and adjacent Zircaloy-4 fuel rods. The minimum, maximum, and average diameters were calculated for each fuel assembly face at each span. The cladding diameter after irradiation is somewhat smaller than the nominal as-fabricated outside diameter (0.430 in.) of the cladding. A representative plot of the diameter measurements for NJ07U9, Face A, Span 1, M5 and Zircaloy-4 fuel rods is shown in Figure 4.8.

Figure 4.8 - Diameter Measurements for NJ07U9, Face A, Span 1, M5 Rod/Zr-4, Scan 1



4.6.1 Predicted Fuel Rod Diameter

A COPERNIC analysis was performed using rod specific data for each of the four fuel rods of interest. The COPERNIC model was executed to analyze fuel rod performance including rod internal rod pressure, axial temperature profiles, clad corrosion and diameter. Accurate prediction of fuel rod diameter, coupled with other fuel rod parameters, is needed to predict the fuel rod internal pressure, a key factor in maintaining cladding integrity at high burnup. The predicted fuel rod diameter and the measured fuel rod diameter data for the four M5 rods are shown in Figure 4.9 through Figure 4.12. It can be observed that there are no unexpected trends in the comparison of analytical fuel rod diameter predictions and measured data. Therefore, COPERNIC is a viable tool for the prediction of fuel rod diameter at high burnups.

Figure 4.9 - M5-1 Measured and Analytical Fuel Rod Diameter Comparison

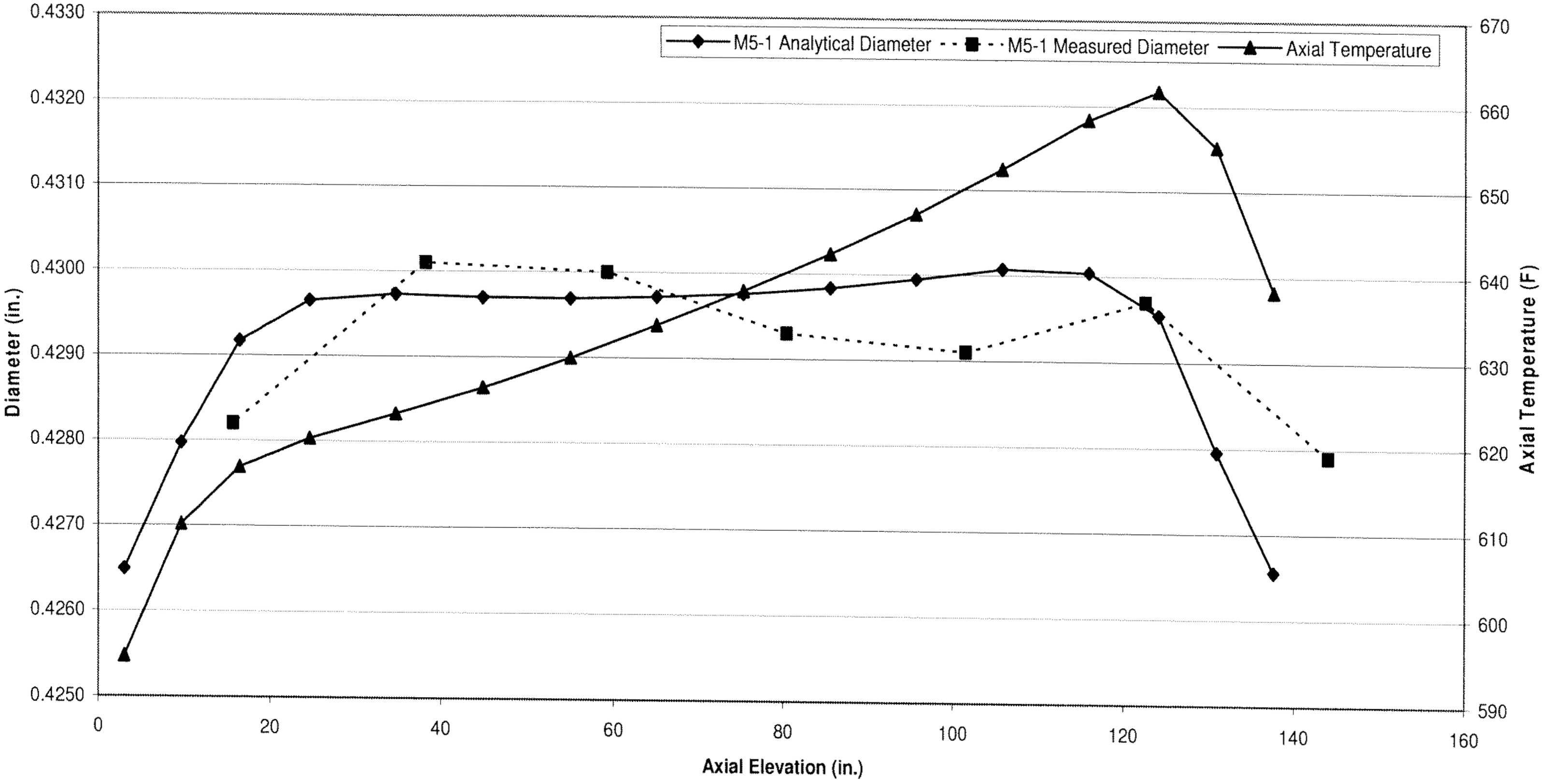


Figure 4.10 - M5-2 Measured and Analytical Fuel Rod Diameter Comparison

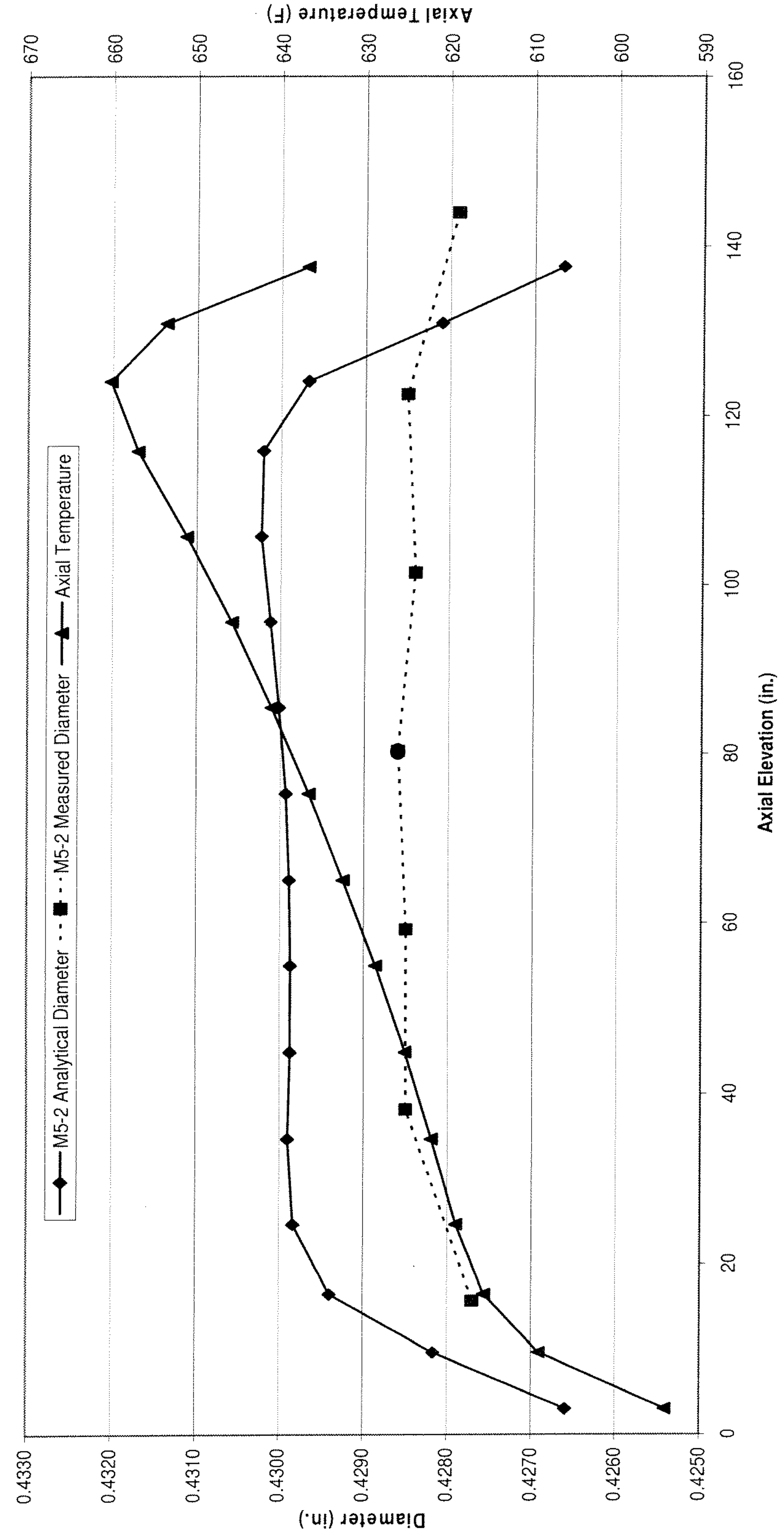


Figure 4.11 - M5-3 Measured and Analytical Fuel Rod Diameter Comparison

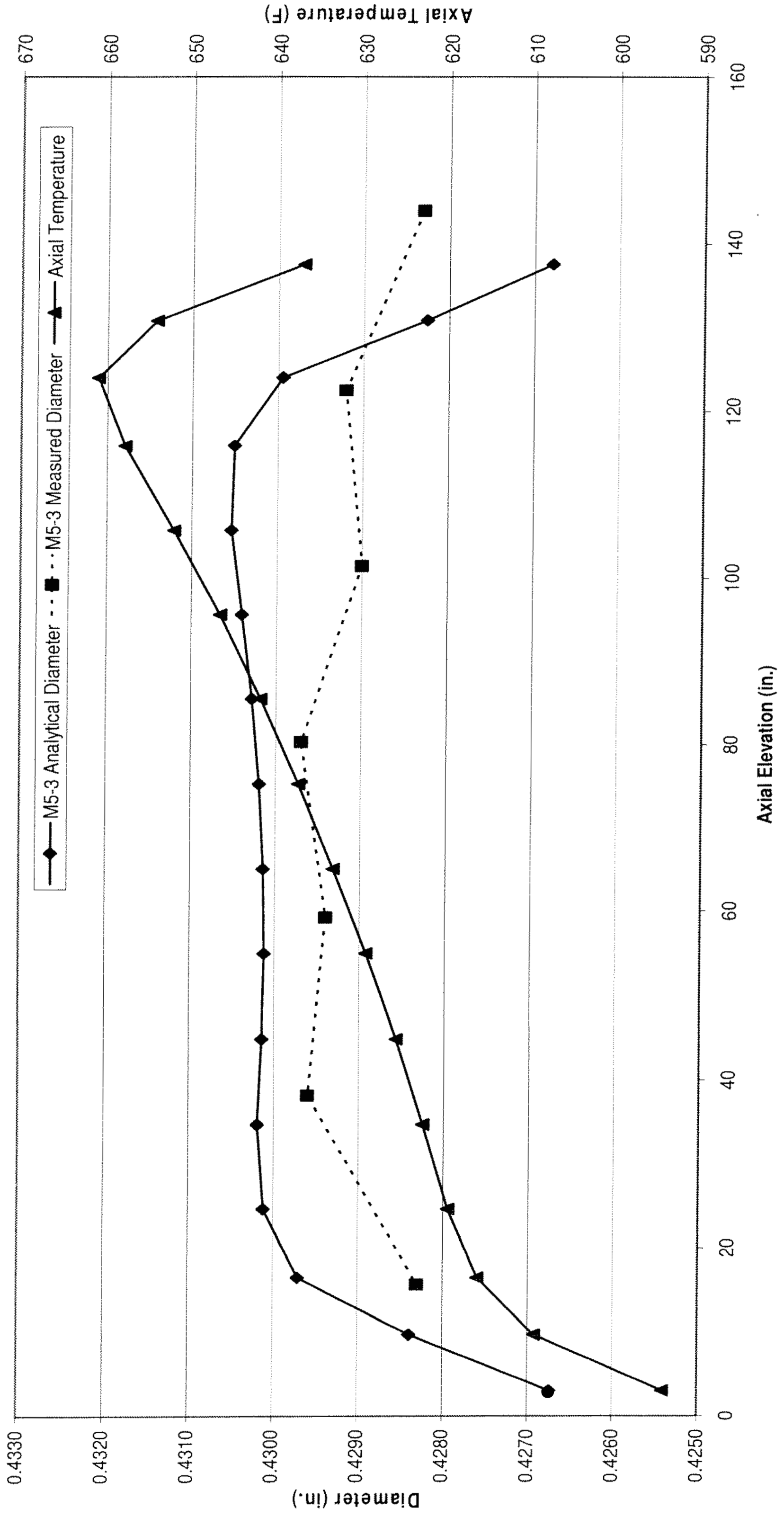
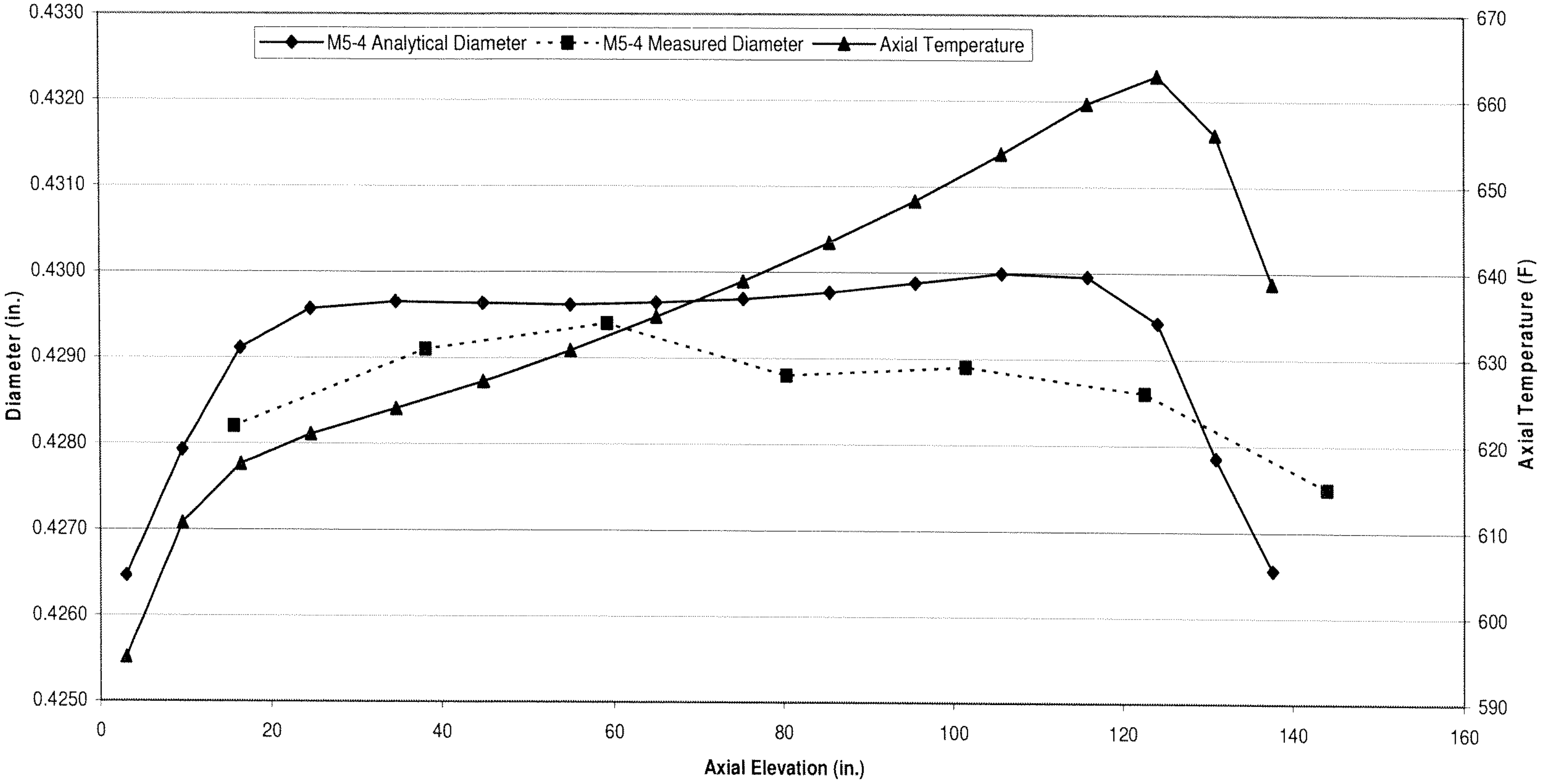


Figure 4.12 - M5-4 Measured and Analytical Fuel Rod Diameter Comparison



5 Conclusion

Four M5 fuel rods successfully completed four 24-month cycles of irradiation at TMI-1 with a maximum fuel rod burnup of 68.0 GWd/mtU and a total reactor residence time of 2732 EFPD. At the end of four cycles, all measured fuel performance parameters are within the design models and no unexpected trends have been observed. The M5 fuel rod growth and oxide deposition is minimal. The shoulder gap closure for these fuel rods is low. M5 cladding performance remains excellent at high burnup and high residence time conditions with significant improvements over Zircaloy-4. These improvements in material performance provide a solid foundation for future increases in fuel burnup limits.

6 References

1. BAW-10231(NP)A, Revision 1, *COPERNIC Fuel Rod Design Computer Code*, January 2004.

7 Appendix A – Fuel Assembly Visual Inspection Images

Figure A1: Photograph of Assembly NJ07U9 Showing Fuel Rods Seated on Lower End Fitting (M5 Fuel Rod eighth from left)

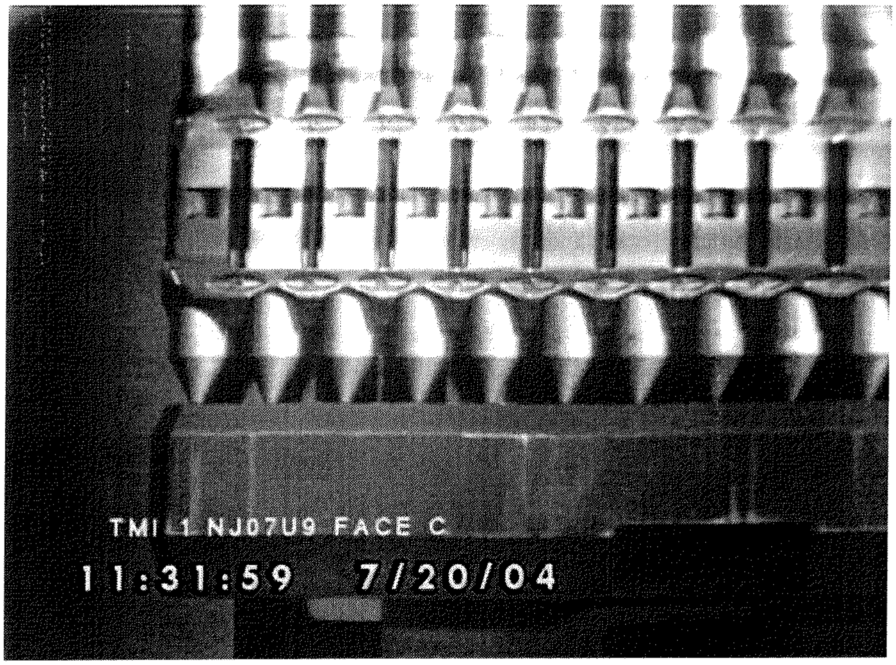


Figure A2: Photograph of Assembly NJ07U9 First (Bottom) Grid Span (M5 Fuel Rod Eighth From Left)

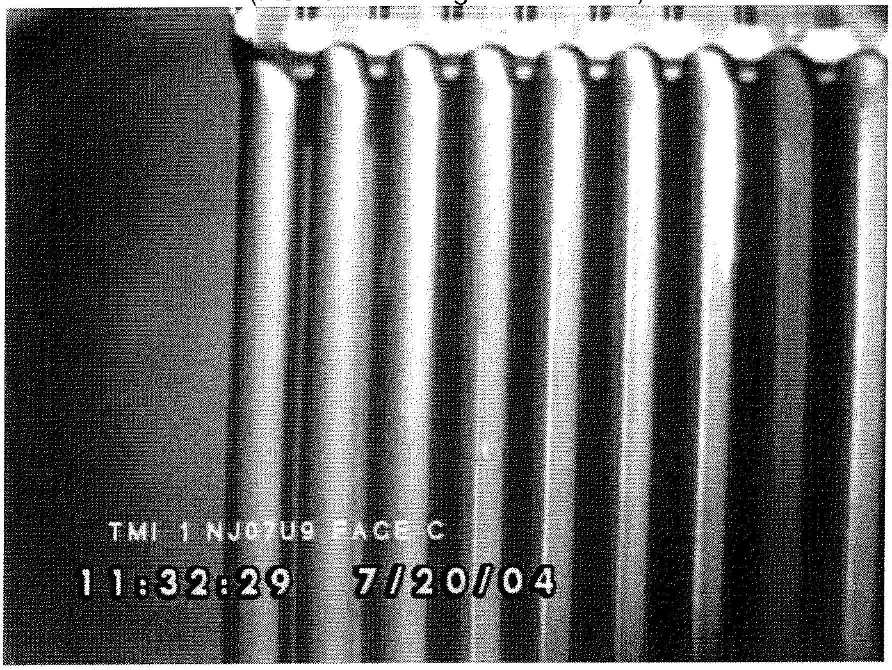


Figure A3: Photograph of Assembly NJ07U9 Second Grid Span
(M5 Fuel Rod Eighth From Left)

Figure A4: Photograph of Assembly NJ07U9 Third Grid Span
(M5 Fuel Rod Eighth From Left)

Figure A5: Photograph of Assembly NJ07U9 Fourth Grid Span
(M5 Fuel Rod Eighth From Left)

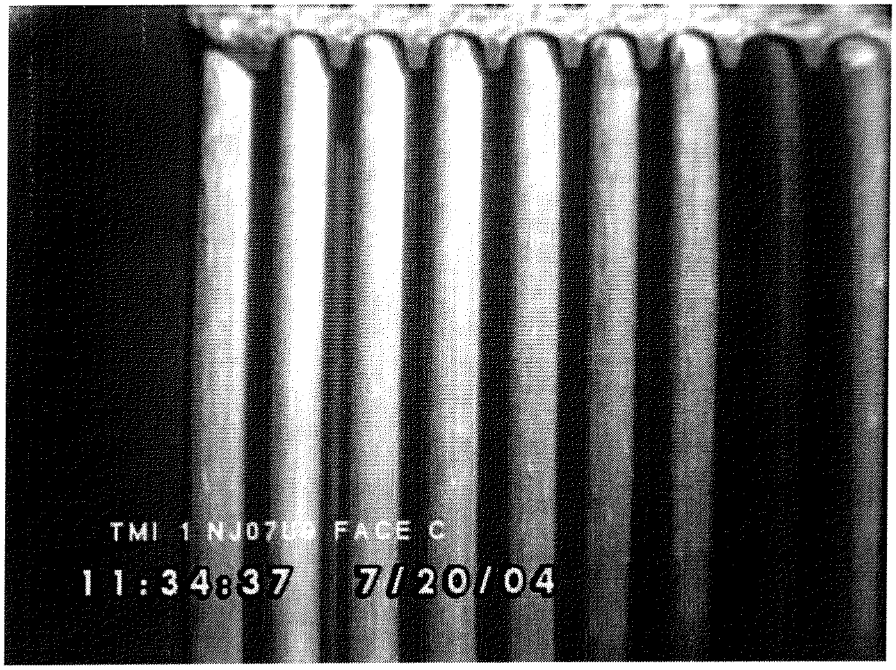


Figure A6: Photograph of Assembly NJ07U9 Fifth Grid Span
(M5 Fuel Rod Eighth From Left)

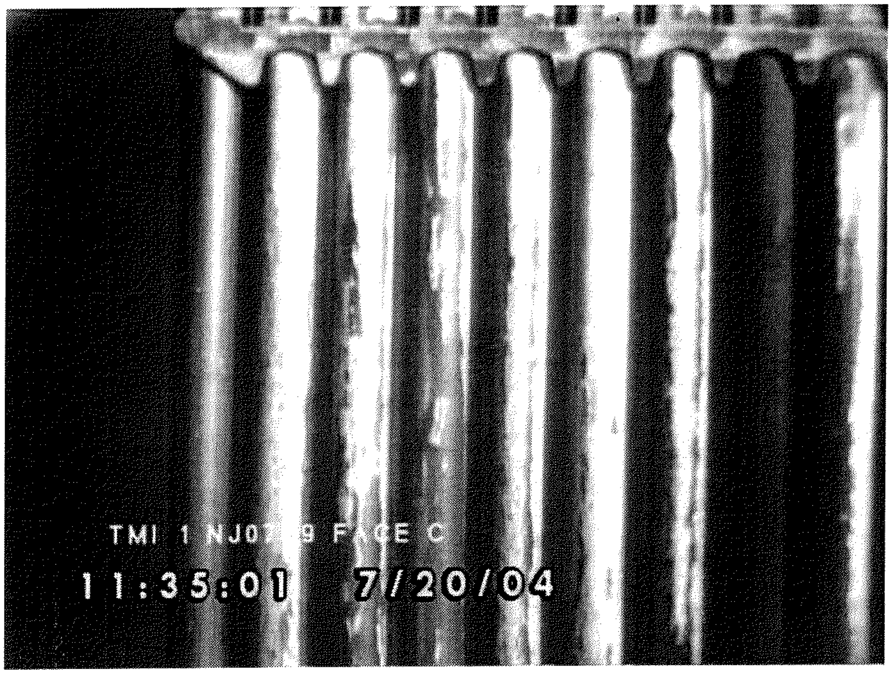


Figure A7: Photograph of Assembly NJ07U9 Sixth Grid Span
(M5 Fuel Rod Eighth From Left)

Figure A8: Photograph of Assembly NJ07U9 Seventh (Top) Grid Span
(M5 Fuel Rod Eighth From Left)

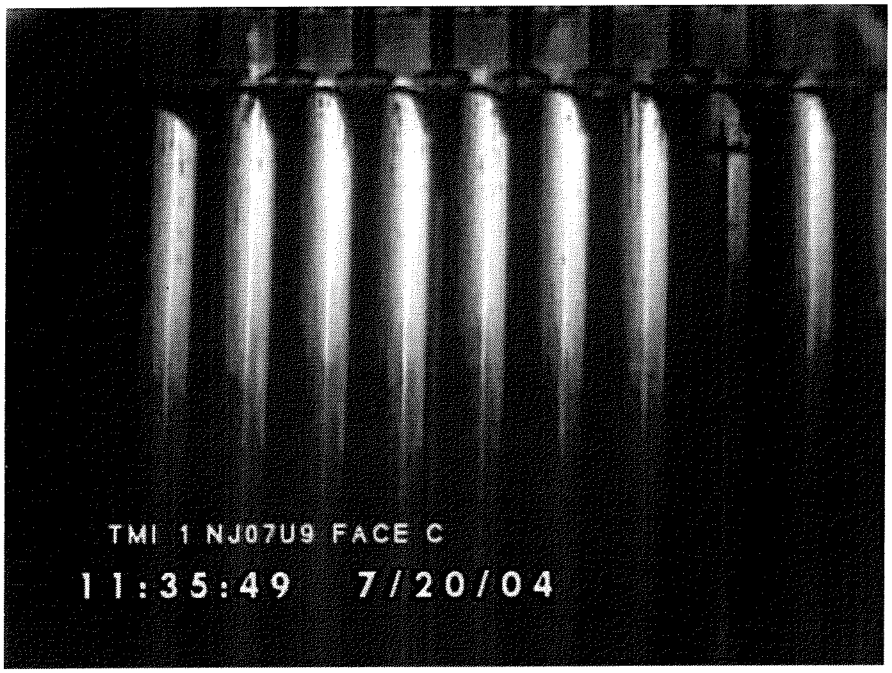


Figure A9: Photograph of Assembly NJ07U9 Shoulder Gap Showing Smaller Growth of M5 Fuel Rod (M5 Fuel Rod Eighth From Left – Level With Top of Upper End Grid)