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Dominion®

JUL 2 4 2008

U. S. Nuclear Regulatory Commission
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Serial No. 08-0443
NSS&L/GWJ R0
Docket No. 50-336
License No. DPR-65

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2
STARTUP TEST REPORT FOR CYCLE 19

Pursuant to Section 6.9.1.3 of the Millstone Unit 2 Technical Specifications, Dominion Nuclear Connecticut, Inc. hereby submits the enclosed Startup Test Report for Cycle 19.

Should you have any questions about the information provided or require additional information, please contact Mr. William D. Bartron at (860) 447-1791, extension 4301.

Very truly yours,

J. A. Price
Site Vice President

Enclosure: (1)

Commitments made in this letter: None.

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Serial No. 08-0443
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ENCLOSURE

STARTUP TEST REPORT FOR CYCLE 19

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2

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1. SUMMARY

The refueling outage preceding the Cycle 19 startup was approximately 39 days, starting on April 6, 2008 and ending on May 16, 2008.

The results of the Millstone 2, Cycle 19 low power physics testing and power ascension testing programs were in agreement with the core design predictions. All measured parameters were within the review and acceptance criteria of the tests. All Technical Specification Limiting Conditions of Operation (LCOs) were met.

Implementation of the Startup Test Activity Reduction (STAR) Program for Millstone 2 Cycle 19 has been accomplished in accordance with the steps outlined in WCAP-16011-A-P, Rev. 0 for (1) core design, (2) CEA lifetime, and (3) fuel fabrication. The STAR Applicability requirements for refueling have been accomplished for CEA coupling verification and startup testing. The application of the STAR Program allowed for the elimination of control rod worth measurements from the startup physics testing.

2. INTRODUCTION

The Millstone 2 Cycle 19 fuel loading was completed on May 7, 2008. The attached core map (Figure 6.1) shows the final core loading. The subsequent operation/testing milestones were completed as follows:

Initial Criticality	May 15, 2008
Low Power Physics Testing Complete	May 15, 2008
Turbine On-Line	May 16, 2008
30% Power Testing Complete	May 16, 2008
69% Power Testing Complete	May 17, 2008
100% Power Testing Complete	May 21, 2008

The Millstone 2 Cycle 19 core is comprised of 217 AREVA manufactured fuel assemblies.

3. LOW POWER PHYSICS TESTING RESULTS

Low Power Physics Testing was conducted at a power level of approximately 2×10^{-2} % power.

3.1 Unrodded Critical Boron Concentration

The Critical Boron Concentration (CBC) measured with CEA Group 7 at 150 steps withdrawn and an RCS temperature of 528.0°F was 1566 ppm.

Adjusted to the prediction conditions of Group 7 at 180 steps withdrawn and an RCS temperature of 532°F yields an adjusted, measured CBC of 1579.1 ppm.

Adjusted, measured unrodded CBC	=	1579.1 ppm
Predicted unrodded CBC	=	1601.0 ppm
Difference	=	-21.9 ppm (-178 pcm)

Review Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria is ± 1000 pcm of the predicted CBC.

Review and Acceptance Criteria met? Yes.

3.2 Moderator Temperature Coefficient

The Isothermal Temperature Coefficient (ITC) measurements were performed at a boron concentration of 1566 ppm, an average RCS temperature of 529.83°F, and CEA Group 7 at 150 steps.

The measured ITC at these conditions was +1.00 pcm/°F.

Adjusted to the prediction conditions for an RCS boron concentration of 1589 ppm and an RCS temperature of 532°F yields an adjusted, measured ITC of +1.15 pcm/°F.

Adjusted, measured ITC	=	+1.15 pcm/°F
Predicted ITC	=	+0.69 pcm/°F
Difference	=	+0.46 pcm/°F

Review Criteria is ± 2 pcm/°F of the predicted ITC.

Review Criteria met? Yes.

The MTC was determined by subtracting the predicted Doppler Temperature Coefficient at the test conditions from the adjusted, measured ITC. The MTC at these conditions was $+0.260 \times 10^{-4}$ $\Delta\rho$/°F. The Millstone 2 Technical Specifications require the MTC be less positive than $+0.7 \times 10^{-4}$ $\Delta\rho$/°F for power levels less than 70% power.

Technical Specification limit met? Yes.

3.3 Control Element Assembly Rod Worth Parameters

Control Element Assembly (CEA) Rod Worth Parameters were not measured as allowed by WCAP-16011-P-A, "Startup Test Activity Reduction Program."

3.4 Rodded Critical Boron Concentration

The Critical Boron Concentration (CBC) measured with CEA Group A inserted was not performed during Cycle 19 startup testing due to application of the STAR Program.

3.5 Control Rod Drop Time Measurements

The Millstone 2 Technical Specifications require that all CEAs drop in less than or equal to 2.75 seconds to the 90% inserted position, with RCS conditions at greater than or equal to 515°F and full flow (all reactor coolant pumps operating).

Control rod drop time testing was done at an RCS temperature of 530°F with all 4 reactor coolant pumps operating. All drop times were within Technical Specification requirements. The average control rod drop time was 2.22 seconds to 90% insertion, with the fastest and slowest drop times being 2.13 seconds and 2.30 seconds, respectively.

Technical Specification limits met? Yes.

4. POWER ASCENSION TESTING RESULTS

4.1 Power Peaking, Linear Heat Rate and Incore Tilt Measurements

The following core power distribution parameters were measured during the power ascension to ensure compliance with the Technical Specifications:

- Total Unrodded Integrated Radial Peaking Factor (F_r^T) is the ratio of the peak fuel rod power to the average fuel rod power in an unrodded core. This value includes the effect of Azimuthal Power Tilt.
- Linear Heat Rate (LHR) is the amount of power being produced per linear length of fuel rod.
- Azimuthal Power Tilt is the maximum difference between the power generated in any core quadrant (upper or lower) and the average power of all quadrants in that half (upper or lower) of the core divided by the average power of all quadrants in that half (upper or lower) of the core.

The measurements of these parameters were:

Power Level	F_r^T	Peak Linear Heat Rate	Incore Tilt
69%	1.655	9.61 KW/ft	0.0070
100%	1.612	13.44 KW/ft	0.0062

The corresponding Technical Specification limits for all power levels for these parameters are:

- $F_r^T \leq 1.69$ (Note - larger values of F_r^T are permissible at less than 100% power)
- Peak Linear Heat Rate ≤ 15.1 KW/ft
- Azimuthal Power Tilt ≤ 0.02

Technical Specification limit for F_r^T met? Yes.

Technical Specification limit for LHR met? Yes.

Technical Specification limit for Tilt met? Yes.

4.2 Critical Boron Measurements

Critical Boron Concentration (CBC) measurement was performed at 100% power at equilibrium xenon conditions.

The CBC measured at 100% power with CEA Group 7 at 180 steps withdrawn and an RCS cold leg temperature of 544.1°F was 1101 ppm. The cycle average exposure at the time of this measurement was 150 MWD/MTU.

Adjusted to the prediction conditions of 100% power at an All Rods Out (ARO) condition and an RCS cold leg temperature of 545 °F yields an adjusted, measured CBC of 1102 ppm.

Adjusted, measured 100% power CBC	=	1102 ppm
Predicted 100% power CBC	=	1118 ppm
Difference	=	-16 ppm (-125 pcm)

Review Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria is ± 1000 pcm of the predicted CBC.

Review and Acceptance Criteria met? Yes.

4.3 Hot Zero Power (HZP) to Hot Full Power (HFP) Critical Boron Concentration Difference

The difference in the adjusted measured Critical Boron Concentrations (CBC) performed at HZP and HFP was determined and compared to the design prediction.

Predicted change in CBC from HZP to HFP	=	483 ppm
Adjusted, measured change in CBC from HZP to HFP	=	477 ppm
Difference	=	6 ppm

Review Criteria is ± 50 ppm of the predicted CBC difference.

Review Criteria met? Yes.

4.4 Flux Symmetry Measurements

The core neutron flux symmetry was measured at approximately 30% power using the fixed incore detector monitoring system. The differences between measured and calculated signals in operable incore detector locations ranged from –0.032 to +0.023

Review Criteria is ± 0.10.

Review Criteria met? Yes.

The maximum azimuthal asymmetry in the neutron flux from measurements of the variation in incore detector signals from symmetric incore detectors was 5.37%

Review Criteria is ± 10%.

Review Criteria met? Yes.

4.5 Moderator Temperature Coefficient

The Isothermal Temperature Coefficient (ITC) measurements were performed at a power level of 98.98 %, an RCS boron concentration of 1101 ppm, and an average RCS temperature of 569.91°F, and CEA Group 7 at 180 steps.

The measured ITC at these conditions was –7.879 pcm/°F.

The predicted ITC was determined for a power level of 100%, an RCS boron concentration of 1118 ppm, an average RCS temperature of 570°F, and at an All Rods Out (ARO) condition.

The predicted ITC at these conditions was –8.02 pcm/°F.

The predicted ITC adjusted for 98.98% power, an actual RCS boron concentration of 1101 ppm and an RCS temperature of 569.91°F yields an adjusted, predicted ITC of –8.214 pcm/°F.

Adjusted, Predicted ITC	=	–8.214 pcm/°F
Measured ITC	=	–7.879 pcm/°F
Difference	=	-0.335 pcm/°F

Review Criteria is ± 2 pcm/°F of the predicted ITC.

Review Criteria met? Yes.

The MTC was determined by subtracting the predicted Doppler Temperature Coefficient at the test conditions from the adjusted, measured ITC. The MTC at these conditions was -0.664×10^{-4} $\Delta\rho$/°F. The Millstone 2 Technical Specifications require the MTC be less than or equal to $+0.4 \times 10^{-4}$ $\Delta\rho$/°F for power levels greater than 70% power.

Technical Specification limit met? Yes.

4.6 Reactor Coolant System Flow

The RCS flow rate was measured using the secondary calorimetric method, in which the RCS flow rate is inferred by performing a heat balance around the steam generators and RCS to determine reactor power, and measuring the differential temperature across the reactor core to determine the enthalpy rise.

The measured RCS flow rate at 100% power was 383,176 GPM.

When 13,000 GPM is subtracted from the measured flow rate to account for measurement uncertainties, the Minimum Guaranteed Safety Analysis RCS Flow Rate is 370,176 GPM. This value is used to satisfy the Technical Specification surveillance requirement.

The Millstone 2 Technical Specifications require the RCS flow rate to be greater than 360,000 GPM.

Technical Specification limit met? Yes.

4.7 Core Power Distributions

The core power distribution measurements were inferred from the signals obtained by the fixed incore detector monitoring system. These measurements were performed at 69% power and 100% to determine if the measured and predicted core power distributions are consistent.

The core power distribution map for 69% power, cycle average exposure of 12 MWD/MTU, *non*-equilibrium xenon conditions is shown in Figure 6.2. This map shows that there is agreement between the measured and predicted values.

The core power distribution map for 100%, cycle average exposure of 29 MWD/MTU, non-equilibrium xenon conditions is shown in Figure 6.3. This map also shows that there is agreement between the measured and predicted values.

The Review Criteria for these measurements are:

1. The difference between the measured and predicted Relative Power Densities (RPDs) for core locations with an operable incore detector is less than 0.1.
2. The Root Mean Square (RMS) deviation for radial and axial power distributions between the measured and predicted values is less than 0.05.

Review Criteria met? Yes, for both 69% and 100% power.

4.8 Reactor Coolant System Radiochemistry

RCS radiochemistry analysis during the power ascension testing program and during subsequent power operation indicate activity levels with Iodine-131 values of about 3.3×10^{-4} μCi/ml. These RCS activity levels show that all failed fuel assemblies have been discharged from the core.

5. REFERENCES

5.1 EN 21004K, "Cycle 19, Low Power Physics Test"

5.2 EN 21004J, "Cycle 19, Power Ascension Testing"

5.3 "Millstone Unit 2, Cycle 19, Startup and Operations Report"

5.4 SP 21010, "CEA Drop Times,"

5.5 WCAP-16011-P-A Revision 0. "Startup Test Activity Reduction Program", February 2005

5.6 M2-EV-08-0013, Rev 0, "Application of the Startup Test Activity Reduction (STAR) Program for Cycle 19," May 1, 2008

6. FIGURES

6.1 Cycle 19 Core Loading Map

6.2 69% Core Power Distribution Map

6.3 100% Core Power Distribution Map

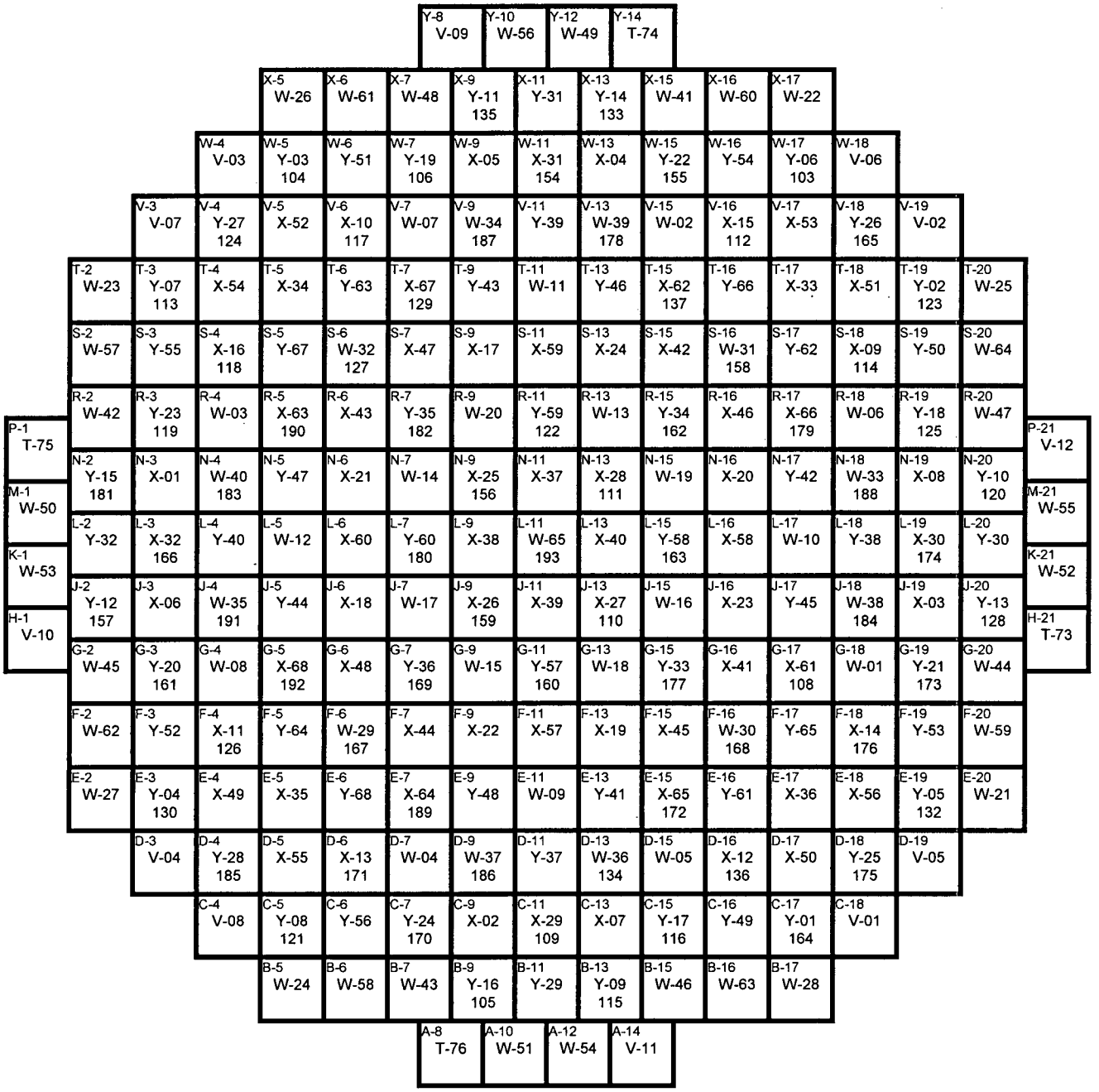
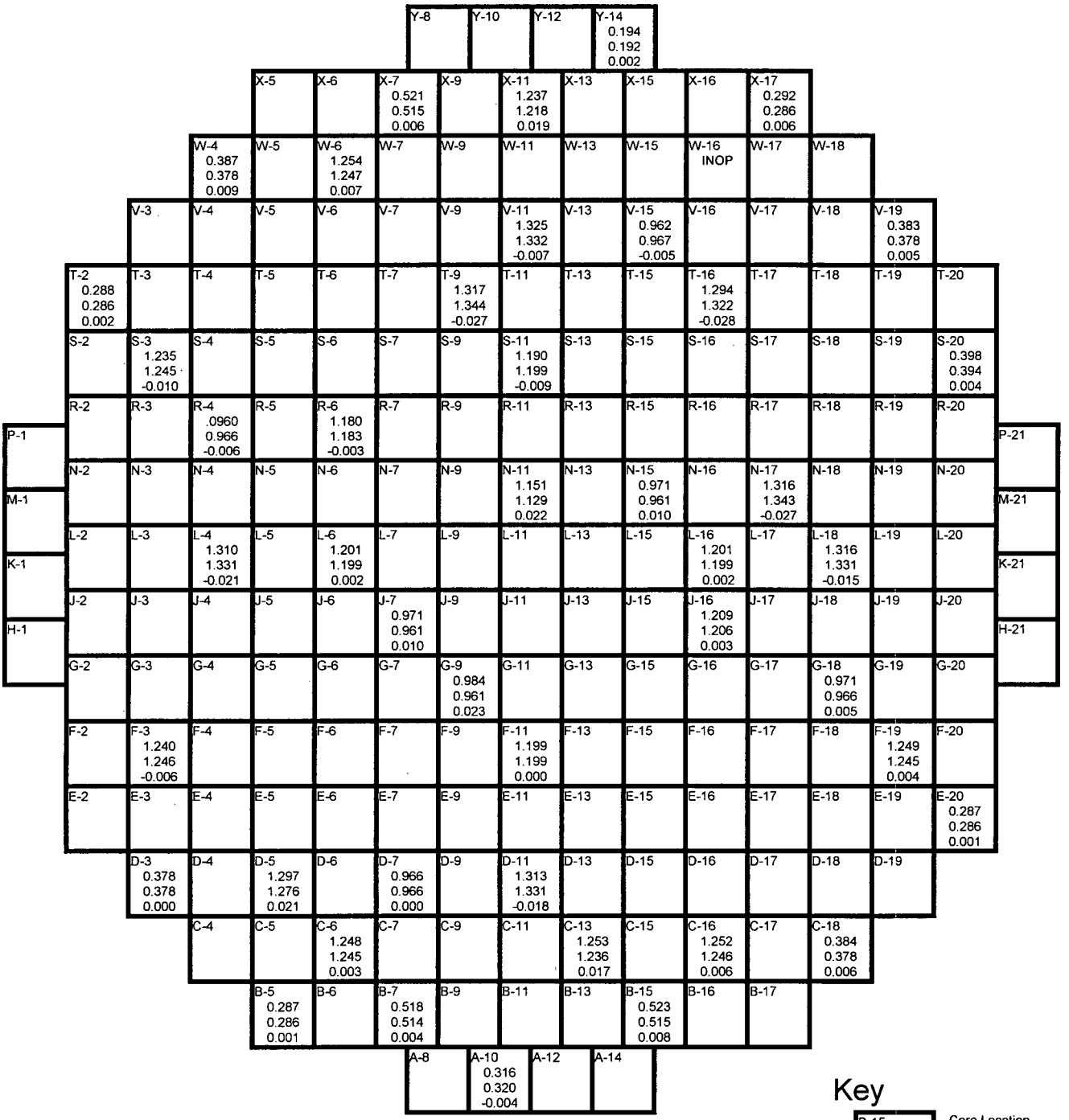
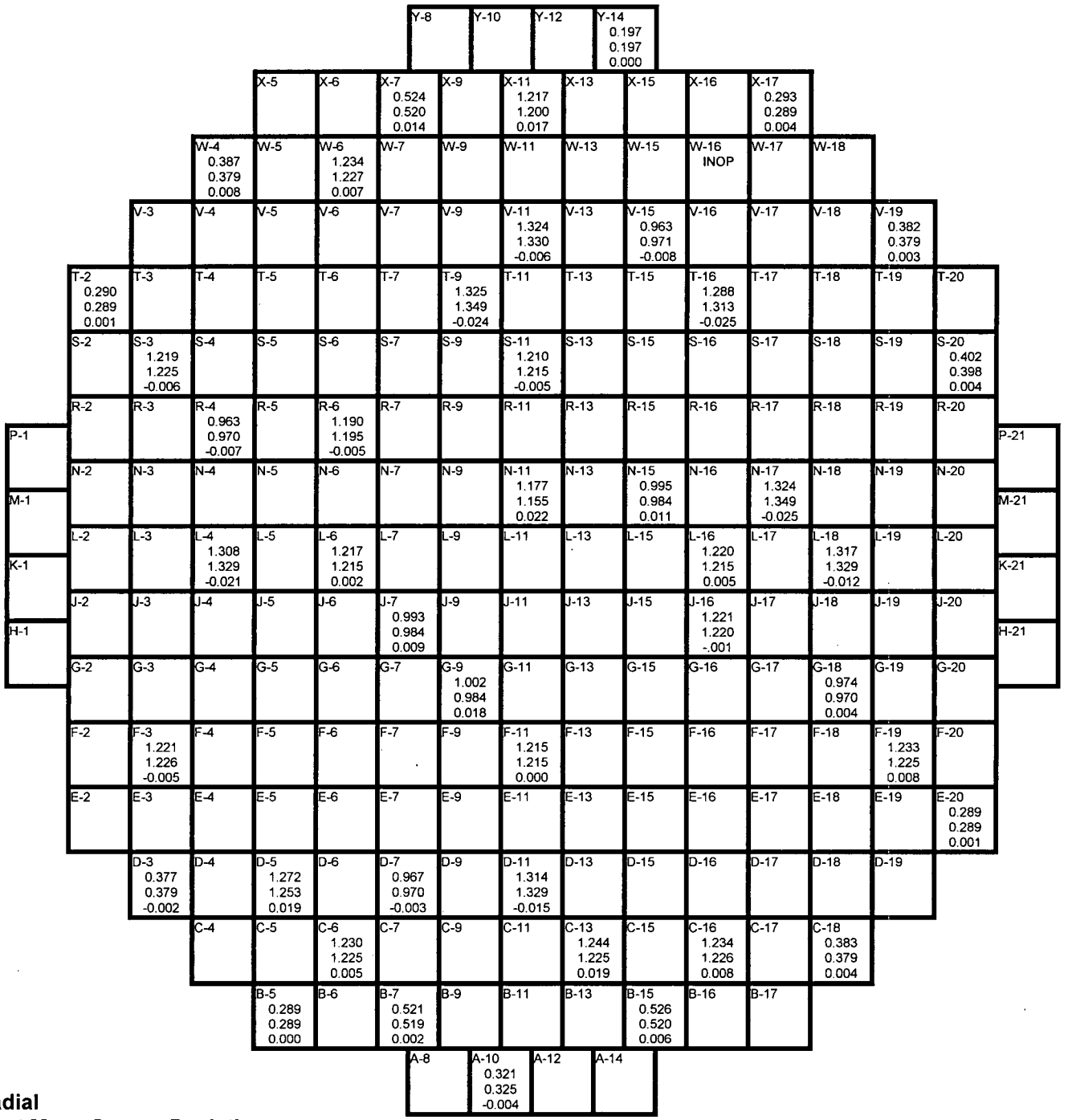


Figure 6.1
Millstone Unit No. 2
Cycle 19 Core Map



Root Mean Square Deviation for all Core Locations = 0.012

Figure 6.2
69% Power Distribution Map
All Rods Out, Non-Equilibrium Xenon, 12 MWD/MTU



Radial
Root Mean Square Deviation
for all Core Locations = 0.011

Axial
Root Mean Square Core Average
Deviation = 0.017

Key

B-15	Core Location
0.526	Measured RPD
0.520	Calculated RPD
0.006	Difference

Figure 6.3
100% Power Distribution Map
All Rods Out, Non-Equilibrium Xenon, 29 MWD/MTU