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Dominion™

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DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2
STARTUP TEST REPORT FOR CYCLE 16

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 16.

There are no regulatory commitments contained within this letter.

If you have any questions or require additional information, please contact Mr. David W. Dodson at (860) 447-1791, extension 2346.

Very truly yours,

Stephen E. Scace, Director
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IE26

Enclosures: (1)

Commitments made in this letter: None.

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Enclosure

Startup Test Report for Cycle 16

Millstone Power Station, Unit 2
Dominion Nuclear Connecticut, Inc. (DNC)

Table of Contents

1. SUMMARY

The refueling outage preceding the Cycle 16 startup was approximately 46 days, starting on October 11, 2003 and ending on November 26, 2003.

The results of the Millstone 2, Cycle 16 low power physics testing and power ascension testing programs were in good agreement with the core design predictions. With the exception of azimuthal power tilt, all other measured parameters were within the review and acceptance criteria of the tests. The azimuthal power tilt exceeded the Technical Specification Limiting Condition of Operation (LCO), however, all Technical Specification Action Statement requirements were met.

2. INTRODUCTION

The Millstone 2 Cycle 16 fuel loading was completed on October 28, 2003. The attached core map (Figure 6.1) shows the final core loading. The subsequent operation/testing milestones were completed as follows:

Initial Criticality	November 26, 2003
Low Power Physics Testing Complete	November 26, 2003
Turbine On-Line	November 26, 2003
30% Power Testing Complete	December 1, 2003
69% Power Testing Complete	December 2, 2003
100% Power Testing Complete	December 5, 2003

The Millstone 2 Cycle 16 core is comprised of 217 Framatome ANP 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The Critical Boron Concentration measured with CEA Group 7 at 133 steps withdrawn and an RCS temperature of 533.0°F was 1656 ppm.

Adjusted to the prediction conditions of Group 7 at 140 steps withdrawn and an RCS temperature of 532°F yields an adjusted, measured CBC of 1661 ppm.

Adjusted, measured unrodded CBC	=	1661 ppm
Predicted unrodded CBC	=	1666 ppm
Difference	=	-5 ppm

Review Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria is ± 100 ppm 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 1655 ppm, an average RCS temperature of 532.5°F, and CEA Group 7 at 132 steps.

The measured ITC at these conditions was $+0.130 \times 10^{-4}$ Δρ/°F.

Adjusted to the prediction conditions for an RCS boron concentration of 1666 ppm and an RCS temperature of 532°F yields an adjusted, measured ITC of $+0.144 \times 10^{-4}$ Δρ/°F.

Adjusted, measured ITC	=	$+0.144 \times 10^{-4}$ Δρ/°F
Predicted ITC	=	$+0.182 \times 10^{-4}$ Δρ/°F
Difference	=	-0.038×10^{-4} Δρ/°F

Review Criteria is $\pm 0.2 \times 10^{-4}$ $\Delta\rho$/°F of the predicted ITC.

Review Criteria met? Yes.

The Moderator Temperature Coefficient was determined by subtracting the predicted Doppler Temperature Coefficient at the test conditions. The MTC at these conditions was $+0.288 \times 10^{-4}$ $\Delta\rho$/°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 measured using the "rod swap" method. Figure 6.2 shows the CEA group configuration.

CEA Group "A" was used as the "reference" group and its reactivity worth was measured using the "boron exchange" method (dilution results are shown below). The reactivity worth of the remaining CEA groups was measured by establishing a critical condition with the "test" group fully inserted and the "reference" group partially withdrawn.

The results of the CEA worth measurements were:

Group	Measured	Prediction	Difference	% Difference
A	0.881%Δρ	0.957 %Δρ	0.076 %Δρ	7.94 %
B	0.511 %Δρ	0.470 %Δρ	-0.041 %Δρ	-8.72 %
1	0.684 %Δρ	0.674 %Δρ	-0.010 %Δρ	-1.48 %
2	0.826 %Δρ	0.837 %Δρ	0.011 %Δρ	1.31 %
3	0.507 %Δρ	0.481 %Δρ	-0.026 %Δρ	-5.41 %
4	0.695 %Δρ	0.681 %Δρ	-0.014 %Δρ	-2.06 %
5	0.356 %Δρ	0.327 %Δρ	-0.029 %Δρ	-8.87 %
6	0.358 %Δρ	0.328 %Δρ	-0.030 %Δρ	-9.15 %
7	0.754 %Δρ	0.746 %Δρ	-0.008 %Δρ	-1.07 %
Total	5.573 %Δρ	5.502 %Δρ	-0.071 %Δρ	-1.29 %

The Review and Acceptance Criteria are:

1. The measured "reference" group worth is within ± 10% of the predicted worth.
2. The measured worth of the individual CEA groups is within ± 0.1%Δρ or ± 15% of the predicted worth, *whichever is larger.*
3. The sum of the measured CEA worths is within ± 10% of the sum of the predicted CEA worths.

Review Criteria met for "reference" CEA group? Yes.

Review Criteria met for individual CEA groups? Yes.

Acceptance Criteria met for sum of CEA group worths? Yes.

3.4 Rodded Critical Boron Concentration

The Critical Boron Concentration measured with CEA Group A at 0 steps withdrawn and an RCS temperature of 533.5°F was 1558 ppm.

Adjusted to the prediction conditions of Group A at 0 steps withdrawn and an RCS temperature of 532°F yield an adjusted, measured CBC of 1556 ppm.

Adjusted, measured rodded CBC	=	1556 ppm
Predicted rodded CBC	=	1565 ppm
Difference	=	-9 ppm

Review Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria is ± 100 ppm of the predicted CBC.

Review and Acceptance Criteria met? Yes.

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 535°F with all 4 reactor coolant pumps operating. The average control rod drop time was 2.26 seconds to 90% insertion, with the fastest and slowest drop times being 2.16 seconds and 2.34 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%	1.630	9.58 KW/ft	0.0226
100%	1.609	13.15 KW/ft	0.0210

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? No. Incore tilt calculated by INPAX shows a higher than expected azimuthal power tilt value of about 0.021 at BOC. All requirements of the Technical Specification Action Statement were met. Incore tilt trended below the Technical Specification limit at approximately 352 MWD/MTU. Further investigation by Millstone and the vendor is ongoing.

4.2 Critical Boron Measurements

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

The CBC measured at 99.8% power with CEA Group 7 at 166 steps withdrawn and an RCS temperature of 572.5°F was 1175 ppm. The cycle average exposure at the time of this measurement was 240 MWD/MTU.

Adjusted to the prediction conditions of 100% power at an All Rods Out (ARO) condition and an RCS temperature of 572°F yields an adjusted, measured CBC of 1178 ppm.

Adjusted, measured 100% power CBC	=	1178 ppm
Predicted 100% power CBC	=	1191 ppm
Difference	=	-13 ppm

Review Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria is ± 100 ppm of the predicted CBC.

Review and Acceptance Criteria met? Yes.

4.3 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 –5.42% to +5.00%.

Review Criteria is ± 10% (deviation between the highest and lowest values in symmetric incore locations).

Review Criteria met? Yes.

4.4 Moderator Temperature Coefficient

The Isothermal Temperature Coefficient (ITC) measurements were performed at a power level of 97.8 %, an RCS boron concentration of 1192 ppm, an average RCS temperature of 570.9°F, and CEA Group 7 at 180 steps.

The measured ITC at these conditions was -0.430×10^{-4} Δρ/°F.

The predicted ITC was determined for a power level of 100%, an RCS boron concentration of 1201 ppm, an average RCS temperature of 573.8°F, and at an All Rods Out (ARO) condition.

The predicted ITC at these conditions was -0.693×10^{-4} Δρ/°F.

The predicted ITC adjusted for an actual RCS boron concentration of 1192 ppm and an RCS temperature of 570.9°F yields an adjusted, predicted ITC of -0.678×10^{-4} Δρ/°F.

Measured ITC	=	-0.430×10^{-4} Δρ/°F
Predicted ITC	=	-0.678×10^{-4} Δρ/°F
Difference	=	-0.248×10^{-4} Δρ/°F

Review Criteria is ± 0.3×10^{-4} Δρ/°F of the predicted ITC.

Review Criteria met? Yes.

The Moderator Temperature Coefficient (MTC) was determined by subtracting the predicted Doppler Temperature Coefficient at the test conditions. The MTC at these conditions was -0.307×10^{-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.

4.5 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 380,017 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 367,017 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.

4.6 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 67% power and 100% to determine if the measured and predicted core power distributions are consistent.

The core power distribution map for 67% power, cycle average exposure of 29 MWD/MTU, *non*-equilibrium xenon conditions is shown in Figure 6.3. This map shows that there is good agreement between the measured and predicted values.

The core power distribution map for 100%, cycle average exposure of 211 MWD/MTU, equilibrium xenon conditions is shown in Figure 6.4. This

map also shows that there is good 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) of all of the differences between the measured and predicted RPDs is less than 5%.

Review Criteria met? Yes, for both 67% and 100% power.

4.7 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 1.1×10^{-3} 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 16, Low Power Physics Test"

5.2 EN 21004J, "Cycle 16, Power Ascension Testing"

5.3 "Millstone Unit 2, Cycle 16, Startup and Operations Report"

5.4 SP 21010, "CEA Drop Times,"

6. FIGURES

6.1 Cycle 16 Core Loading Map

6.2 CEA Group Configuration

6.3 67% Core Power Distribution Map

6.4 100% Core Power Distribution Map

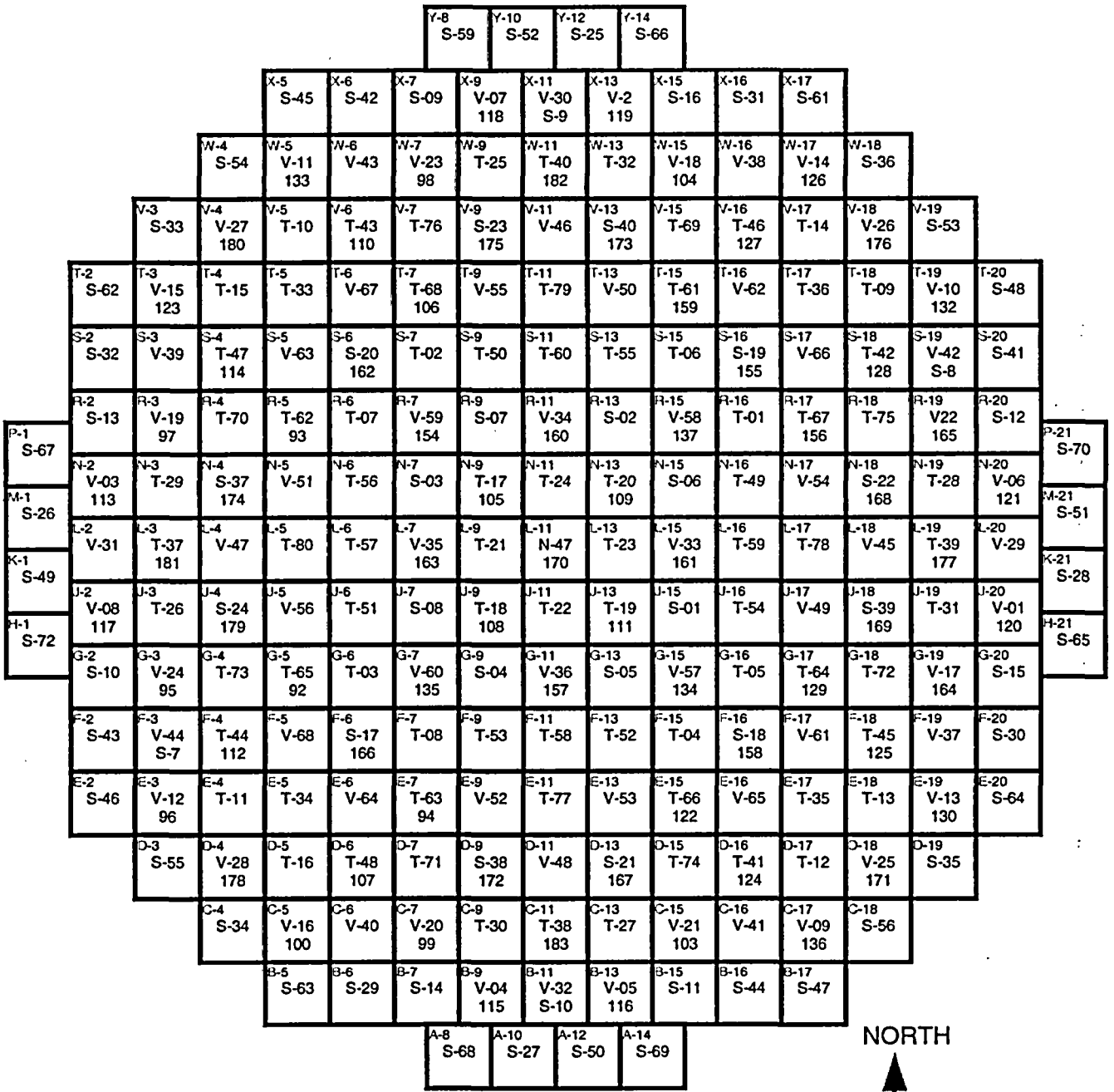


Figure 6.1
Millstone Unit No. 2
Cycle 16 Core Map

Source	Core Location	Guidetube
7	F-3	SW
8	S-19	SE
9	X-11	NW
10	B-11	SW

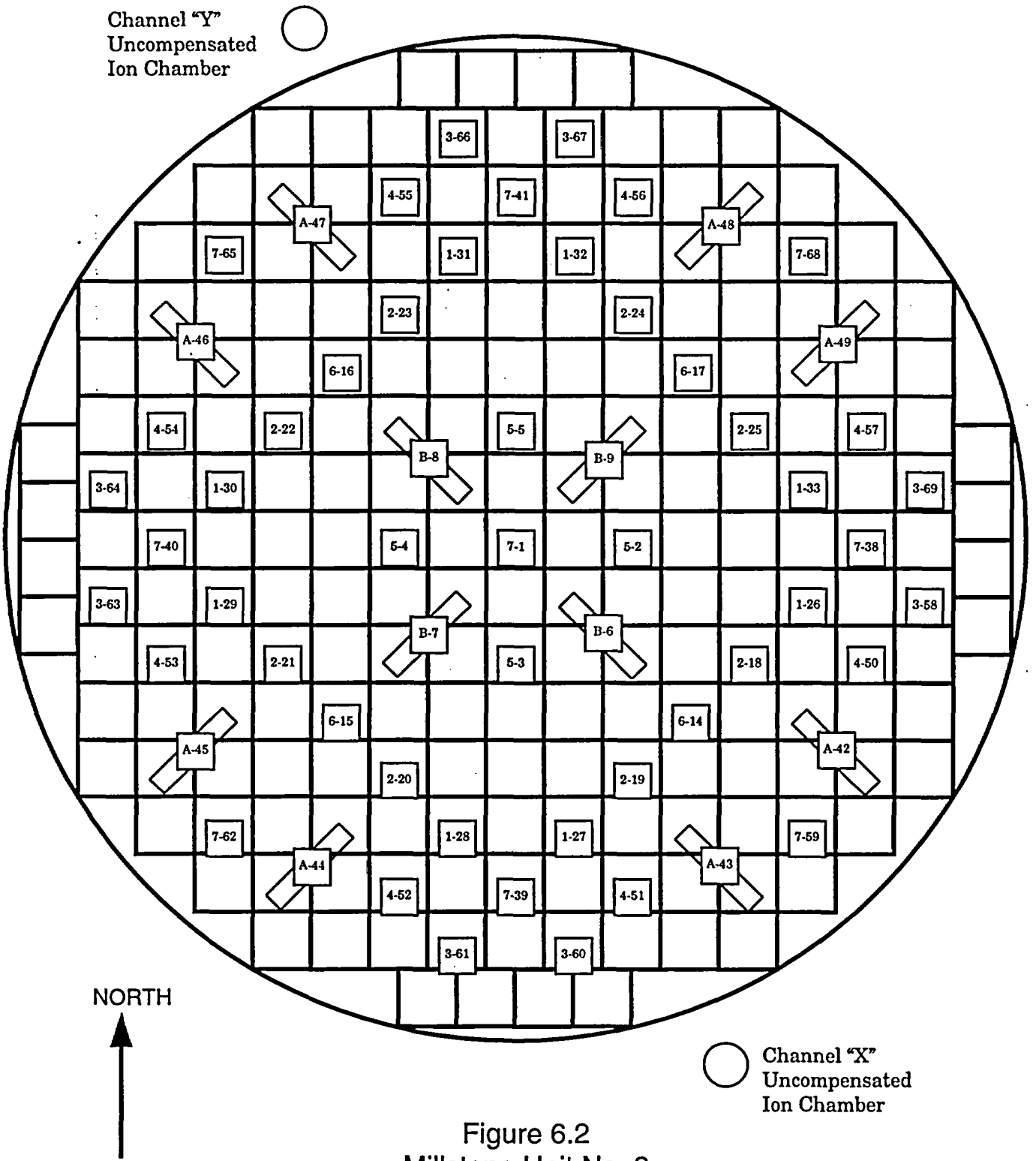
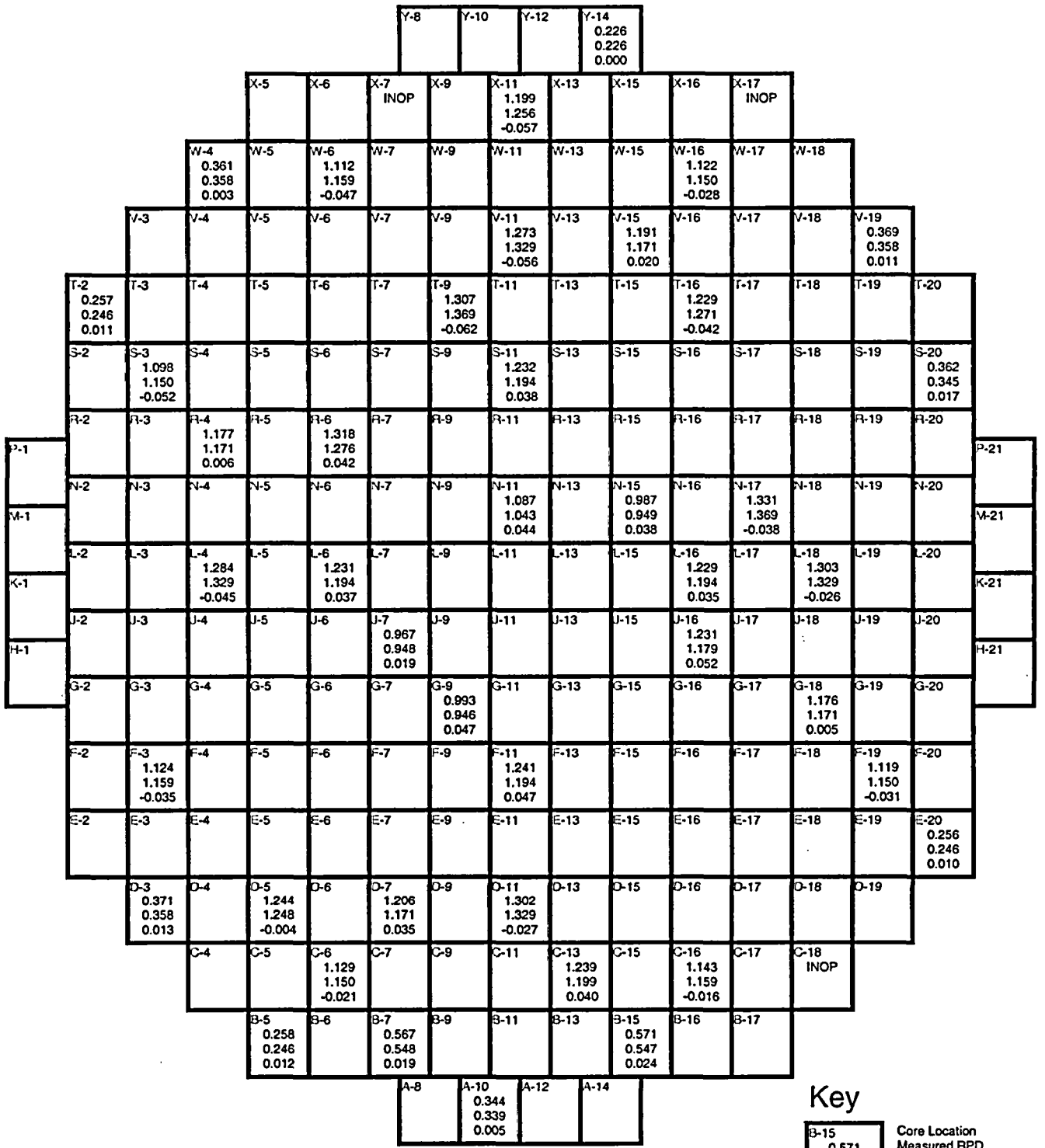
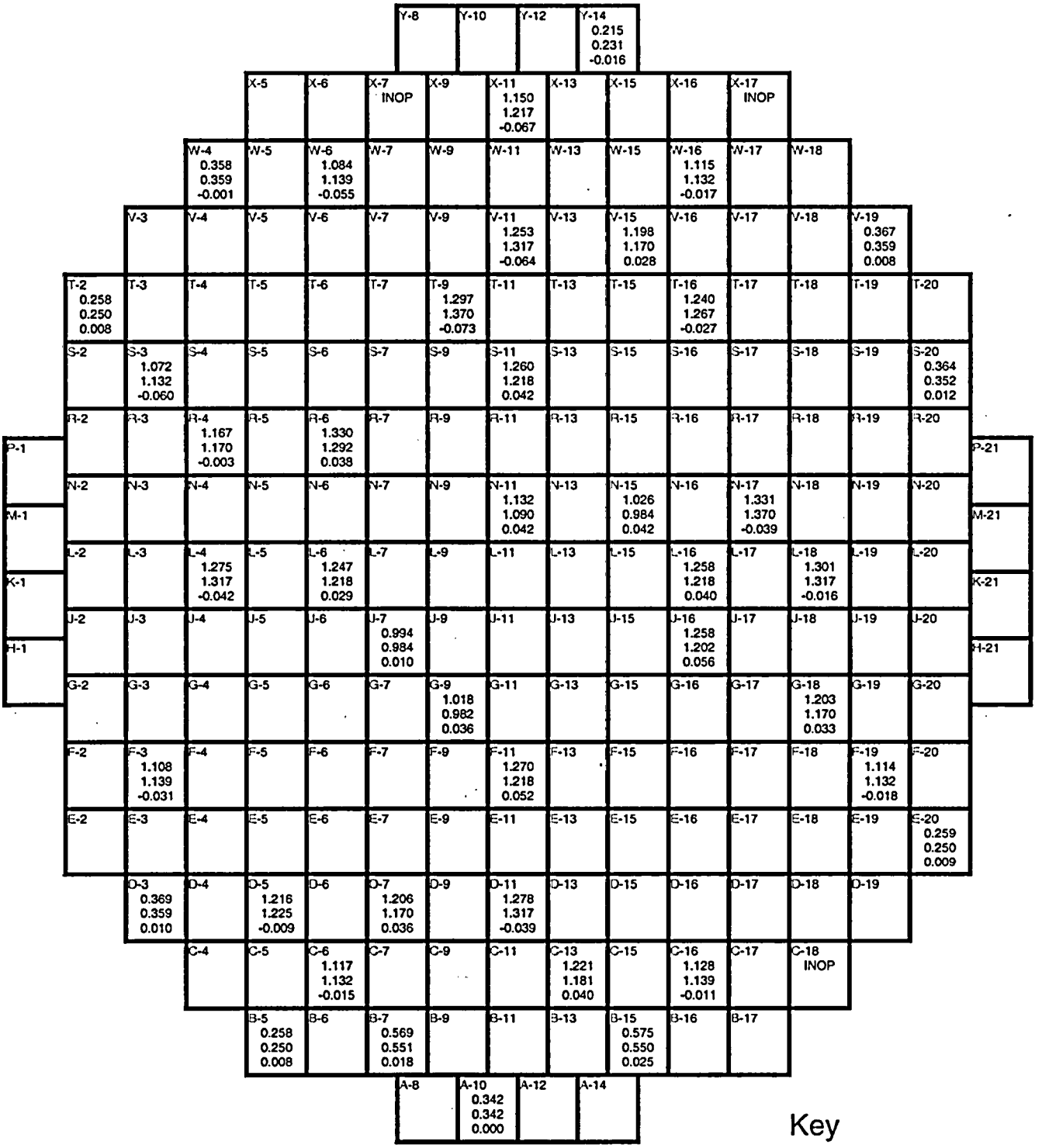


Figure 6.2
Millstone Unit No. 2
CEA Group Configuration



Root Mean Square Deviation for all Core Locations = 2.35 %

Figure 6.3
67% Power Distribution Map
All Rods Out, Non-Equilibrium Xenon, 29 MWD/MTU



Root Mean Square Deviation for all Core Locations = 2.48 %

Figure 6.4
100% Power Distribution Map
166 Steps, Equilibrium Xenon, 211 MWD/MTU