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The Northeast Utilities System

AUG 14 2000

Docket No. 50-336
B18193

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Millstone Nuclear Power Station, Unit No. 2
Startup Test Report for Cycle 14

Pursuant to Section 6.9.1.3 of the Millstone Unit No. 2 Technical Specifications, Northeast Nuclear Energy Company hereby submits the enclosed Unit No. 2 Startup Test Report for Cycle 14.

There are no regulatory commitments contained within this letter.

If you have any additional questions concerning this submittal, please contact Mr. David W. Dodson at (860) 447-1791, Ext. 2346.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

Stephen E. Scace - Director
Nuclear Oversight and Regulatory Affairs

Enclosure (1)

cc: H. J. Miller, Region I Administrator
J. I. Zimmerman, NRC Project Manager, Millstone Unit No. 2
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Enclosure

Millstone Nuclear Power Station, Unit No. 2

Startup Test Report - Cycle 14

Table of Contents

1. SUMMARY

The refueling outage preceding the Cycle 14 startup was approximately 40 days, starting on April 22, 2000 and ending on June 1, 2000.

The results of the Millstone 2, Cycle 14 low power physics testing and power ascension testing programs were in excellent agreement with the core design predictions and all measured parameters were within the acceptance criteria of the tests.

2. INTRODUCTION

The Millstone 2 Cycle 14 fuel loading was completed on May 8, 2000. The attached core map (Figure 6.1) shows the final core loading. The subsequent operation/testing milestones were completed as follows:

Initial Criticality	May 30, 2000
Low Power Physics Testing Complete	May 30, 2000
Turbine On-Line	June 1, 2000
65% Power Testing Complete	June 5, 2000
96% Power Testing Complete	June 10, 2000
100% Power Testing Complete	June 16, 2000

The Millstone 2 Cycle 14 core is comprised of 217 Siemens Power Corporation manufactured fuel assemblies. The design of the 72 new fuel assemblies is identical to the fuel assemblies installed in Cycle 13.

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The Critical Boron Concentration measured with CEA Group 7 at 159 steps withdrawn and an RCS temperature of 533.4°F was 1679 ppm.

Adjusted to the prediction conditions of Group 7 at 180 steps withdrawn and an RCS temperature of 532°F yields an adjusted, measured CBC of 1684 ppm.

Adjusted, measured unrodded CBC	=	1684 ppm
Predicted unrodded CBC	=	1699 ppm
Difference	=	-15 ppm

Acceptance Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria met? Yes

3.2 Moderator Temperature Coefficient

The Moderator Temperature Coefficient (MTC) measurements were performed at a boron concentration of 1679 ppm, an average RCS temperature of 534.2°F, and CEA Group 7 at 159 steps.

The measured MTC at these conditions was $+0.349 \times 10^{-4}$ $\Delta\rho$/°F.

Adjusted to the prediction conditions for an RCS boron concentration of 1699 ppm and an RCS temperature of 532°F yields an adjusted, measured MTC of $+0.378 \times 10^{-4}$ $\Delta\rho$/°F.

Adjusted, measured MTC	=	$+0.378 \times 10^{-4}$ $\Delta\rho$/°F
Predicted MTC	=	$+0.385 \times 10^{-4}$ $\Delta\rho$/°F
Difference	=	-0.007×10^{-4} $\Delta\rho$/°F

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

Acceptance Criteria met? Yes

Additionally, per the Millstone 2 Technical Specifications, the MTC must 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	0.964 %Δρ	1.030 %Δρ	0.066 %Δρ	6.41 %
B	0.490 %Δρ	0.466 %Δρ	-0.024 %Δρ	-5.15 %
1	0.663 %Δρ	0.692 %Δρ	0.029 %Δρ	4.19 %
2	0.708 %Δρ	0.709 %Δρ	0.001 %Δρ	0.14 %
3	0.414 %Δρ	0.409 %Δρ	-0.005 %Δρ	-1.22 %
4	0.623 %Δρ	0.645 %Δρ	0.022 %Δρ	3.41 %
5	0.379 %Δρ	0.369 %Δρ	-0.010 %Δρ	-2.71 %
6	0.364 %Δρ	0.346 %Δρ	-0.018 %Δρ	-5.20 %
7	0.717 %Δρ	0.732 %Δρ	0.015 %Δρ	2.05 %
Total	5.322 %Δρ	5.398 %Δρ	0.076 %Δρ	1.41 %

The 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.

Acceptance Criteria met for "reference" CEA group? Yes

Acceptance 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 532.8°F was 1570 ppm.

Adjusted to the prediction conditions of Group A at 0 steps withdrawn and an RCS temperature of 532°F yields an adjusted, measured CBC of 1571 ppm.

Adjusted, measured rodded CBC =		1571 ppm
Predicted rodded CBC	=	1570 ppm
Difference	=	1 ppm

Acceptance Criteria is ± 50 ppm of the predicted CBC.

Acceptance Criteria met? Yes

3.5 Control Rod Drop Time Measurements

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

Control rod drop time testing was done at an RCS temperature of 532°F with all 4 reactor coolant pumps operating. The average control rod drop time was 2.24 seconds to 90% insertion, with the fastest and slowest drop times being 2.13 seconds and 2.38 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 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
65%	1.587	8.53 KW/ft	0.0062
96%	1.585	12.58 KW/ft	0.0088
100%	1.587	12.89 KW/ft	0.0101

These measurements were obtained with all control rods fully withdrawn.

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 ≤ 14.6 KW/ft
- Azimuthal Power Tilt ≤ 0.02

Technical Specification limits met? Yes

4.2 Critical Boron Measurements

Critical Boron Concentration (CBC) measurements were performed at 96% power and 100% power at equilibrium xenon conditions.

The CBC measured at 96% power with CEA Group 7 at 155 steps withdrawn and an RCS temperature of 570.5°F was 1205 ppm. The cycle average exposure at the time of this measurement was 160 MWD/MTU.

Adjusted to the prediction conditions of 96% power with CEA Group 7 at 155 steps withdrawn and an RCS temperature of 572.5°F yields an adjusted, measured CBC of 1204 ppm.

Adjusted, measured 96% power CBC = 1204 ppm

Predicted 96% power CBC = 1219 ppm

Difference = -15 ppm

Acceptance Criteria is ± 50 ppm of the predicted CBC

Acceptance Criteria met? Yes

The CBC measured at 100% power with CEA Group 7 completely withdrawn and an RCS temperature of 572.5°F was 1186 ppm. The cycle average exposure at the time of this measurement was 342 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 1186 ppm.

Adjusted, measured 100% power CBC	=	1186 ppm
Predicted 100% power CBC	=	1203 ppm
Difference	=	-17 ppm

Acceptance Criteria is ± 50 ppm of the predicted CBC

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 measured deviation between the highest and lowest values in operable symmetric incore detector locations ranged from 0.5% to 10.0%.

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

Acceptance Criteria met? Yes

4.4 Moderator Temperature Coefficient

The Moderator Temperature Coefficient (MTC) measurements were performed at a power level of 96%, an RCS boron concentration of 1205 ppm, an average RCS temperature of 566.9°F, and CEA Group 7 at 155 steps.

The measured MTC at these conditions was -0.427×10^{-4} $\Delta\rho$/°F.

Adjusted to the prediction conditions for an RCS boron concentration of 1219 ppm and an RCS temperature of 572.5°F yields an adjusted, measured MTC of -0.465×10^{-4} $\Delta\rho$/°F.

Adjusted, measured MTC	=	-0.465×10^{-4} Δρ/°F
Predicted MTC	=	-0.445×10^{-4} Δρ/°F
Difference	=	-0.020×10^{-4} Δρ/°F

Acceptance Criteria is $\pm 0.3 \times 10^{-4}$ Δρ/°F of the predicted MTC.

Acceptance Criteria 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 378,319 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 365,319 GPM. This value is used to satisfy the Technical Specification surveillance requirement.

The measurement uncertainty value of 13,000 GPM is 4% of the Design Flow Rate value of 324,800 GPM.

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 65% power and 100% power at an All Rods Out (ARO) condition to determine if the measured and predicted core power distributions are consistent.

The core power distribution map for 65% power, cycle average exposure of 28 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 247 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 Acceptance 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%.

Acceptance Criteria met? Yes, for both 65% and 100% power

4.7 Reactor Coolant System Radiochemistry

RCS radiochemistry analysis during the power ascension testing program and during subsequent power operation indicate low activity levels with Iodine-131 values of about 8×10^{-4} μCi/ml. These low RCS activity levels are indicative of defect free fuel cladding.

5. REFERENCES

5.1 SPROC ENG00-2-02, "Cycle 14, Low Power Physics Test"

5.2 SPROC ENG00-2-01, "Cycle 14, Power Ascension Test"

5.3 EMF-2390(P), "Millstone Unit 2, Cycle 14, Startup and Operations Report"

5.4 SP 21010-001, "CEA Drop Times"

6. FIGURES

6.1 Cycle 14 Core Loading Map

6.2 CEA Group Configuration

6.3 65% Core Power Distribution Map

6.4 100% Core Power Distribution Map

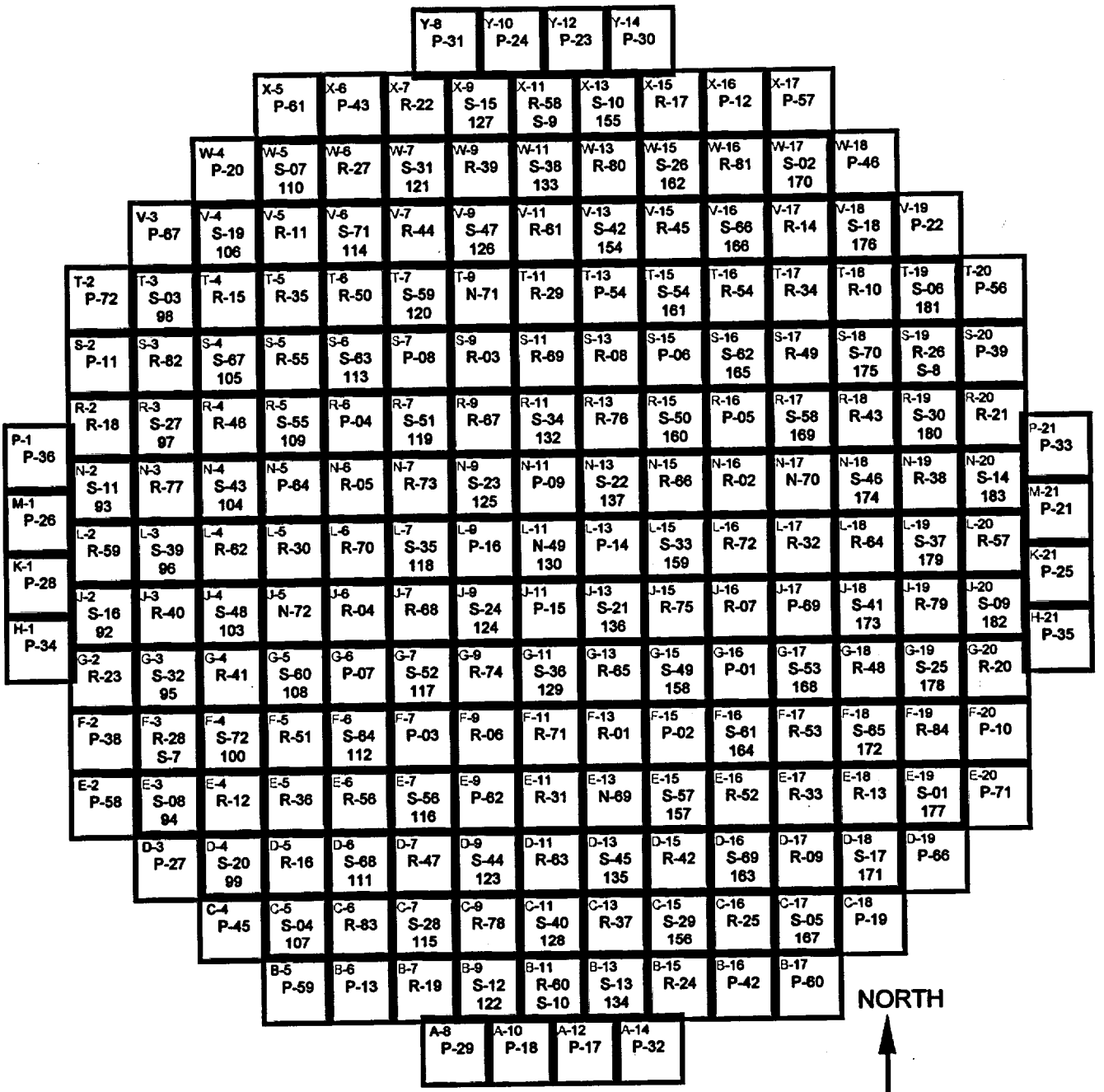


Figure 6.1
Millstone Unit No. 2
Cycle 14 Core Map

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

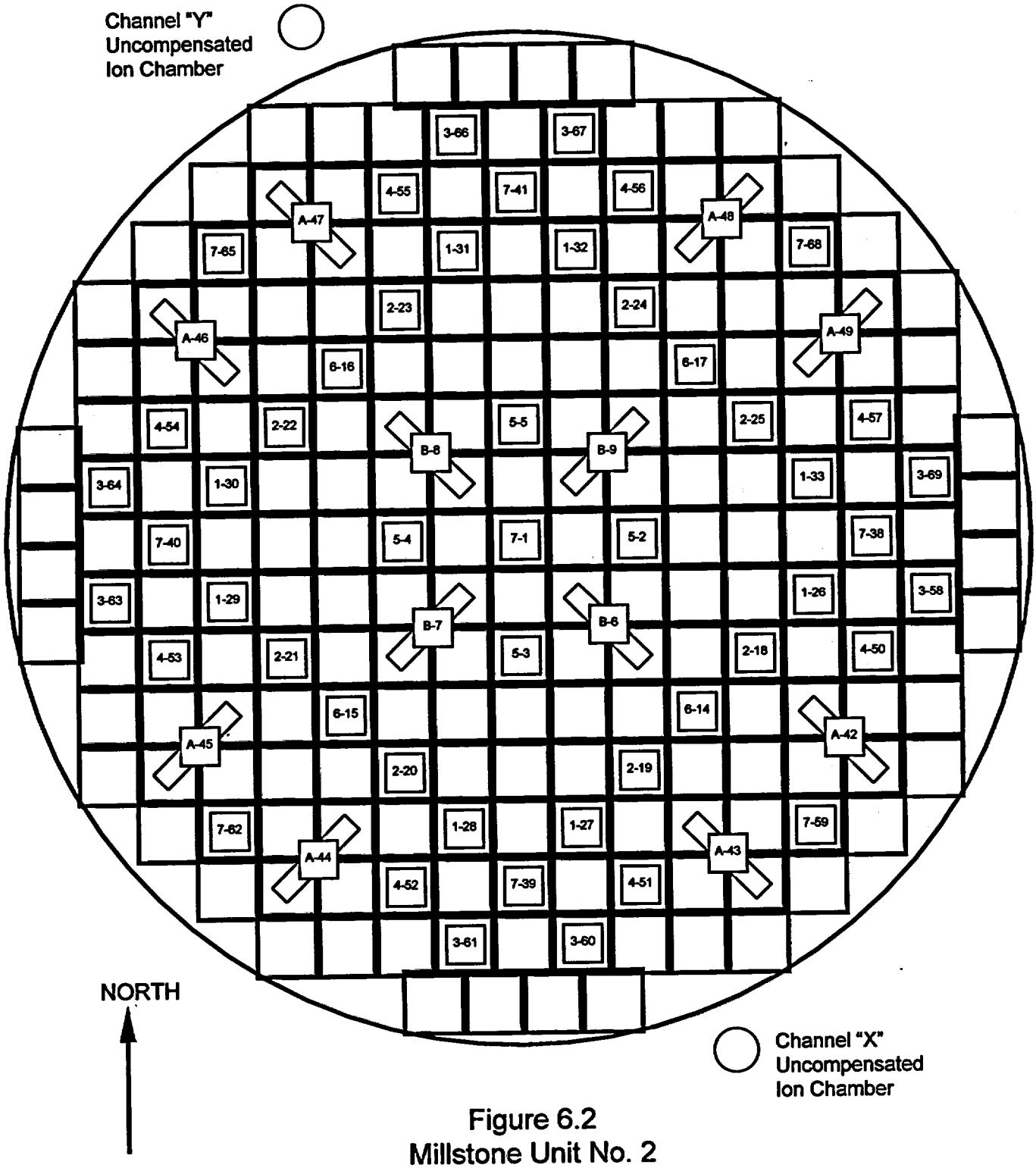
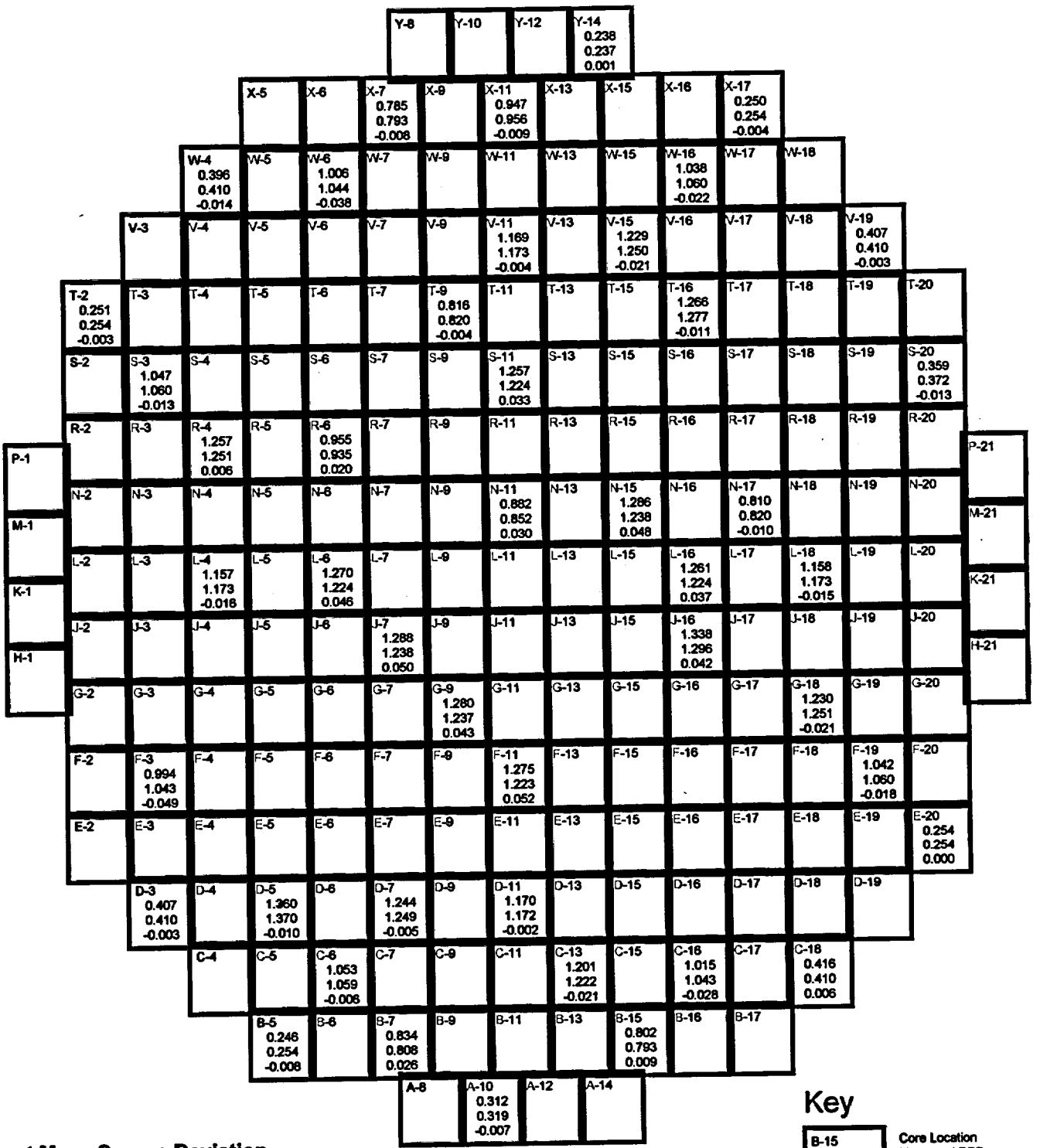
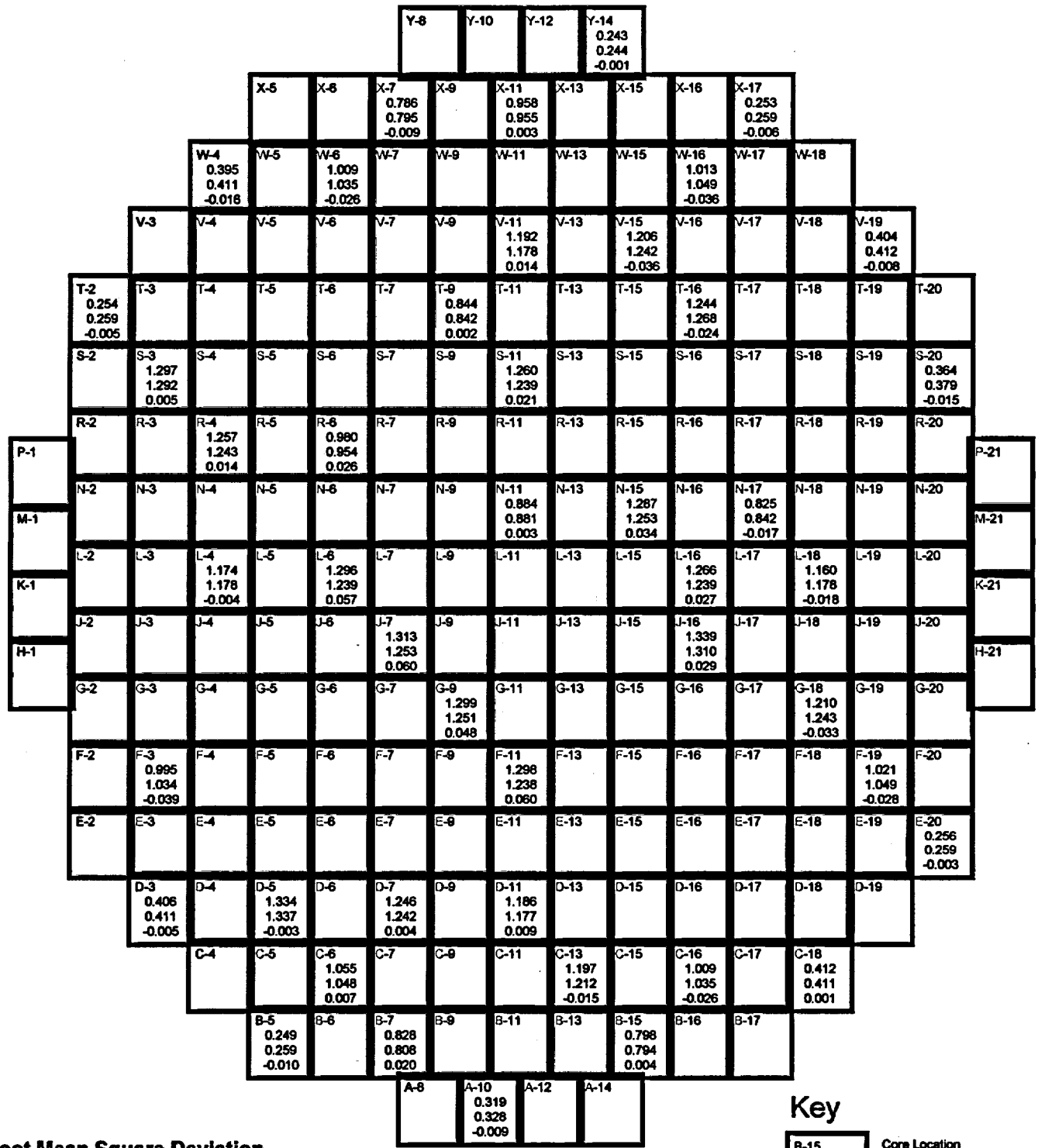


Figure 6.2
Millstone Unit No. 2
CEA Group Configuration



Root Mean Square Deviation for all Core Locations = 1.89 %

Figure 6.3
65% Power Distribution Map
All Rods Out, Non-Equilibrium Xenon, 28 MWD/MTU



Root Mean Square Deviation for all Core Locations = 1.92 %

Figure 6.4
100% Power Distribution Map
All Rods Out, Equilibrium Xenon, 247 MWD/MTU