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DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3
STARTUP TEST REPORT FOR CYCLE 19

Pursuant to Millstone Power Station Unit 3 Technical Specification 6.9.1.1, Dominion Nuclear Connecticut, Inc. submits the enclosed Startup Test Report for Cycle 19.

If you have any questions or require additional information, please contact Mr. Jeffry A. Langan at (860) 444-5544.

Sincerely,

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Director, Nuclear Safety and Licensing – Millstone

Enclosure: (1)

Commitments made in this letter: None

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NR R

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ENCLOSURE

STARTUP TEST REPORT FOR CYCLE 19

**DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3**

1.0 SUMMARY

Pursuant to Millstone Power Station Unit 3 (MPS3) Technical Specification (TS) 6.9.1.1, a summary of the MPS3 Cycle 19 startup testing, performed following completion of the fall 2017 refueling outage, is provided.

2.0 INTRODUCTION

The MPS3 Cycle 19 fuel reload was completed on November 2, 2017. The attached core map (Figure 1) shows the final core configuration. Reference 6.3 documents that Cycle 19 uses a low leakage loading pattern (L3P) consisting of 84 new Region 21 fuel assemblies, 85 Region 20 once-burned fuel assemblies, and 24 Region 19 twice-burned fuel assemblies. All 193 fuel assemblies in the Cycle 19 core are the Westinghouse 17x17 robust fuel assembly (RFA-2) design.

The 84 new Region 21 fuel assemblies are comprised of 44 fuel assemblies enriched to 4.10 weight percent Uranium-235 (w/o U^{235}), 32 fuel assemblies enriched to 4.80 w/o U^{235} , and eight AXIOM™ lead test assemblies (LTAs) enriched to 4.10 w/o U^{235} . The LTAs are the same mechanical design as the rest of Region 21 with the exception of the clad material. The top and bottom regions of all fuel assemblies in the Cycle 19 core are comprised of a 6-inch annular blanket region enriched to 2.6 w/o U^{235} . Placement of the new fuel assemblies in the designated fresh fuel assembly locations was made in a random fashion in order to prevent power tilts across the core due to systematic deviations in the fresh fuel composition.

The 109 re-inserted fuel assemblies were ultrasonically cleaned during the fall 2017 refueling outage. The purpose of the ultrasonic fuel cleaning was to remove adhered crud (primarily nickel and iron-based deposits) from the surface of fuel rods that have previous core exposure in order to reduce the probability of occurrence of crud-induced power shift (CIPS).

Every fuel assembly in Cycle 19 contains an insert. The inserts consist of 61 rod cluster control assemblies (RCCAs), 130 thimble plugs, and two secondary source assemblies.

Subsequent operational and testing milestones were completed as follows:

Initial Criticality	November 13, 2017
Low Power Physics Testing completed	November 13, 2017
Main Turbine Online	November 14, 2017
49% Power Testing completed	November 15, 2017
74% Power Testing completed	November 16, 2017
100% Power Testing completed	November 20, 2017

3.0 FUEL DESIGN

All of the 193 assemblies in the Cycle 19 core are of the RFA-2 design. This fuel design is the same as that used in Cycle 18.

4.0 LOW POWER PHYSICS TESTING

The Low Power Physics Testing program for Cycle 19 was completed using the procedure in Reference 6.1 which is based on the Westinghouse dynamic rod worth measurement (DRWM) technique described in Reference 6.4. This program consisted of the following: control and shutdown bank worth measurements, critical boron endpoint measurements for all rods out (ARO), and ARO moderator/isothermal temperature coefficient measurements. Low power physics testing was performed at a power level below the point of nuclear heat to avoid nuclear heating reactivity feedback effects.

4.1 Critical Boron Concentration

The critical boron concentration was measured for the ARO configuration. The measured values include corrections to account for differences between the measured critical rod configuration and the ARO configuration. The review and acceptance criteria of ± 500 and ± 1000 percent milliRho (pcm), respectively, were met for the ARO configuration.

Summary of Boron Endpoint Results

	Measured (ppm)	Predicted (ppm)	M-P (ppm)	Acceptance Criteria (pcm)
All Rods Out (ARO)	2007	1993	+14 (-90.5 pcm)	± 1000

4.2 Moderator Temperature Coefficient

Isothermal temperature coefficient (ITC) data was measured with Control Bank D at 199.5 steps withdrawn. The review criteria of ± 2 pcm/degrees Fahrenheit ($^{\circ}$ F) to the predictions were met. The ARO moderator temperature coefficient (MTC) of $+0.06$ pcm/ $^{\circ}$ F was calculated by subtracting the design Doppler temperature coefficient (-1.74 pcm/ $^{\circ}$ F) from the measured ITC of -2.25 pcm/ $^{\circ}$ F, and adding the delta (Δ) ITC correction value of $+0.57$ pcm/ $^{\circ}$ F (Δ ITC corrects the MTC at the measurement conditions to the minimum temperature for criticality value of 551° F). The TS limit of MTC $< +5.0$ pcm/ $^{\circ}$ F at ARO hot zero power (HZP) was met.

Isothermal/Moderator Temperature Coefficient Results

	Measured (pcm/°F)	Corrected Predicted (pcm/°F)	M-P (pcm/°F)	Acceptance Criteria (pcm/°F)
ARO ITC	-2.25	-3.00	0.75	NA
ARO MTC	0.06	NA	NA	MTC < +5.0

4.3 Control Rod Reactivity Worth Measurements

The integral reactivity worths of all RCCA control and shutdown banks were measured using the DRWM technique. The review criteria of the measured worth is $\pm 15\%$ or 100 pcm of the individual predicted worth, whichever is greater, and the sum of the measured worths is $\pm 8\%$ of the predicted worths. The DRWM rod worth acceptance criteria is defined as: the sum of the measured worths (M) of all banks shall be greater than or equal to 90% of the sum of their predicted worths (P).

Control Bank Integral Worth Results

	Measured (pcm)	Predicted (pcm)	M-P (pcm)	% Difference (M-P) / P
Control Bank A	877.3	873.8	3.5	0.4
Control Bank B	579.4	581.2	-1.8	-0.3
Control Bank C	729.5	757.7	-28.2	-3.7
Control Bank D	696.4	631.9	64.5	10.2
Shutdown Bank A	411.5	401.6	9.9	2.5
Shutdown Bank B	878.5	890.9	-12.4	-1.4
Shutdown Bank C	429.8	407.7	22.1	5.4
Shutdown Bank D	434.5	406.8	27.7	6.8
Shutdown Bank E	69.8	69.5	0.3	0.4
Total	5106.7	5021.1	85.6	1.7

The measured results of the individual bank worths and the total control bank worth showed excellent agreement with the predicted values. All individual and total worth review criteria were met. The acceptance criteria for the sum of the measured rod worths (greater than or equal to 90% of the sum of the predicted worths), was met.

5.0 POWER ASCENSION TESTING

Testing was performed at specified power plateaus of approximately 49%, 74% and 100% Reactor Thermal Power (RTP). Power changes were governed by operating procedures and fuel preconditioning guidelines.

Thermal-hydraulic parameters, nuclear parameters, and related instrumentation were monitored throughout the power ascension. Data was compared to previous cycle power ascension data and engineering predictions, as required, at each test plateau to identify calibration or system problems. The major areas analyzed were:

- Core Performance Evaluation: Flux mapping was performed at approximately 49%, 74% and 100% RTP using the moveable incore detector system. The resultant peaking factors and power distribution were compared to TS limits to verify that the core was operating within its design limits. All analysis limits were met and the results are summarized in Section 5.1.
- Nuclear Instrumentation Indication: Overlap data was obtained between the intermediate and power range nuclear instrumentation channels. Secondary plant heat balance calculations were performed to verify the nuclear instrumentation indications.
- Incore/Excore Calibration: Scaling factors were calculated from flux map data using the single point calibration methodology. The nuclear instrumentation power range channels were re-scaled at approximately 74% and 100% RTP.
- Reactor Coolant System (RCS) Flow: The RCS flow rate was measured at approximately 100% RTP using a secondary calorimetric heat balance for each loop with the steam generators as the control volumes. The calculated RCS flow rate met the TS requirements and is reported in Section 5.3.

5.1 Power Distribution, Power Peaking and Tilt Measurements

The core power distribution was measured through the performance of a series of flux maps during the power ascension, as specified in Reference 6.2. The results from the flux maps were used to verify compliance with the power distribution TSs.

A low power flux map at approximately 49% RTP was performed to determine if any gross neutron flux abnormalities existed. At the 74% RTP plateau flux map, data necessary to perform an excore to incore calibration via the single point methodology was obtained. Per TS surveillance 4.3.1.1, Table 4.3-1, Functional Unit 2, Note 6, a flux map at approximately 100% RTP was performed for an excore to incore calibration. The 100% RTP map also verified core power distributions were within the design limits.

A summary of the measured axial flux difference (AFD) and incore tilt for the flux maps, performed during the power ascension, is provided below. Additional tables provide comparisons of the most limiting measured heat flux hot channel factor (F_Q) and nuclear enthalpy rise hot channel factor ($F_{\Delta h}$), including uncertainties, to their respective limits from each of the flux maps performed during the power ascension. The most limiting F_Q reported is based on minimum margin to the steady state limit that varies as a function of core height.

As shown below, all TS limits were met and no abnormalities in core power distribution were observed during power ascension.

Summary of Measured Axial Flux Difference and Incore Tilt

Power (%RTP)	Burnup (MWD/MTU)	Rod Position (steps)	AFD (%)	Incore Tilt
48.5	13.0	216	5.420	1.0085
73.8	27.5	216	3.297	1.0097
99.9	203.6	216	0.642	1.0087

Comparison of Measured F_Q to F_Q^{RTP} Limit

Power (%RTP)	Burnup (MWD/MTU)	Measured F_Q	F_Q^{RTP} steady state limit	Margin to Transient Limit
48.5	13.0	N/A	N/A	N/A
73.8	27.5	1.8884	3.3983	13.6 %
99.9	203.6	1.8588	2.6026	17.1 %

Comparison of Measured $F_{\Delta h}$ to $F_{\Delta h}$ Limit

Power (%RTP)	Burnup (MWD/MTU)	$F_{\Delta h}$	$F_{\Delta h}$ Limit
48.5	13.0	1.486	1.831
73.8	27.5	1.446	1.711
99.9	203.6	1.421	1.586

Figures 2, 3 and 4 are the measured power distribution maps showing percent difference from the predicted power for approximately 49%, 74% and 100% RTP plateaus. These figures show there is good agreement between the measured and predicted assembly powers.

5.2 Boron Measurements

Hot full power ARO boron concentration measurements were performed after reaching equilibrium conditions. The measured ARO, hot full power, equilibrium xenon, boron concentration was 1344 ppm with a predicted value of 1372 ppm. The predicted to measured difference was -163 pcm which met the acceptance criteria of ± 1000 pcm.

5.3 Reactor Coolant System Flow Measurement

The RCS flow rate was determined using a secondary calorimetric heat balance for each loop with the steam generators as the control volumes. The following parameters were measured:

- RCS pressure
- Hot leg temperatures
- Cold leg temperatures
- Feedwater temperatures
- Feedwater flow rates
- Feedwater pressure
- Steam generator pressure

Steam generator blowdown was not isolated during the data acquisition period.

Per TS surveillance 4.2.3.1.3, the RCS flow was measured within 7 days after exceeding 90% RTP. The measured flow at 100% RTP was 404,664 gallons per minute (gpm) with a minimum required flow of 379,200 gpm. All TS limits were met.

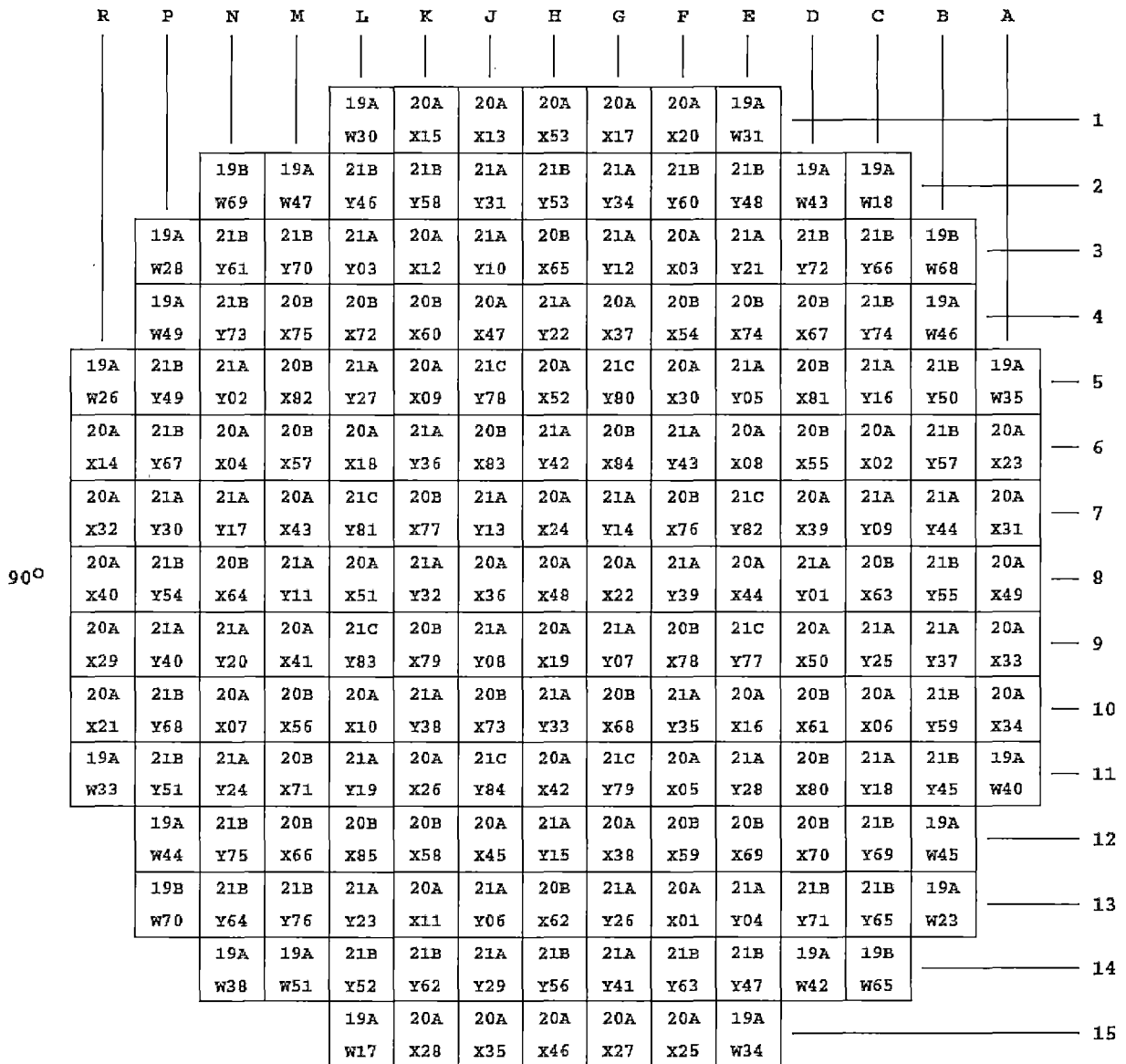
6.0 REFERENCES

- 6.1 SP 31008, Rev. 010-00, "Low Power Physics Testing (ICCE)"
- 6.2 EN 31015, Rev. 006-00, "Power Ascension Testing of Millstone Unit 3"
- 6.3 ETE-NAF-2017-0125, Rev. 000, "Millstone Unit 3 Cycle 19 Nuclear Design Report"
- 6.4 WCAP-13360-P-A, Revision 1, "Westinghouse Dynamic Rod Worth Measurement Technique"

7.0 FIGURES

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FIGURE 1
CORE LOADING PATTERN
MILLSTONE UNIT 3 - CYCLE 19



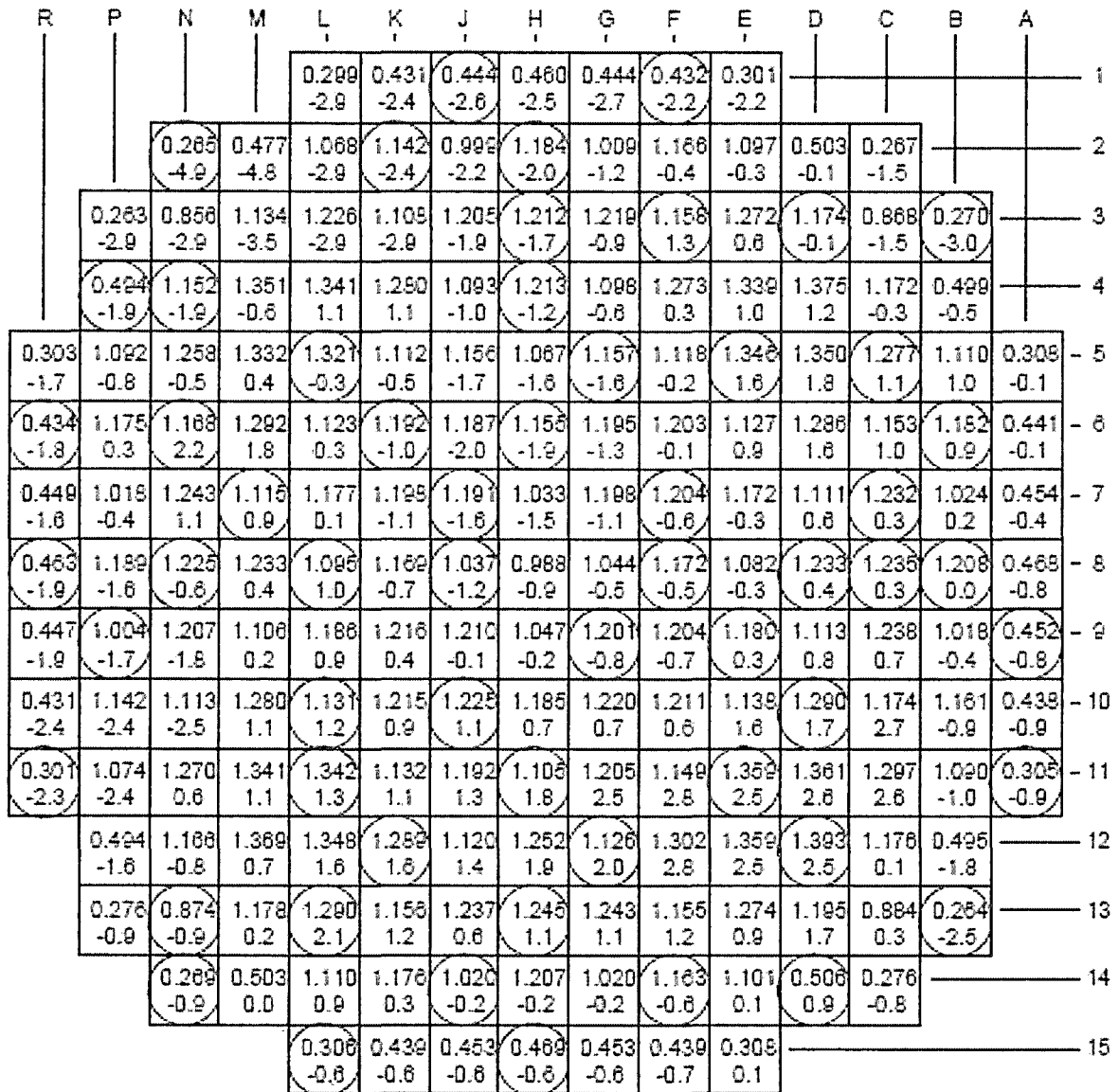
LEGEND

R	Region Identifier
ID	Fuel Assembly Identifier

REGION ASSEMBLIES ENRICHMENT

19A	20	4.10
19B	4	4.95
20A	53	4.10
20B	32	4.95
21A	44	4.10
21B	32	4.80
21C	8	4.10

FIGURE 2
INCORE Power Distribution - 49.5%
MILLSTONE UNIT 3 - CYCLE 19





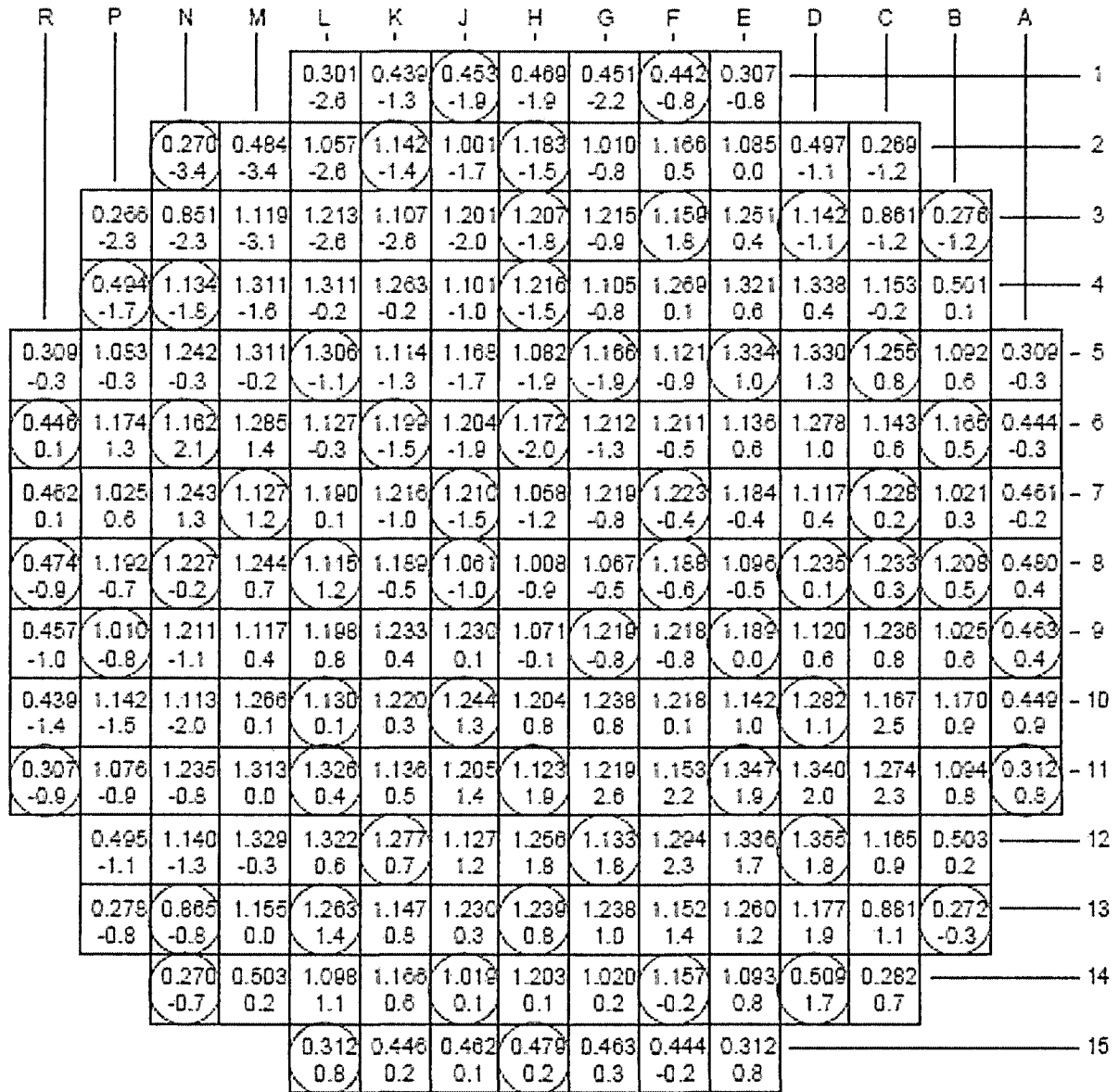
 Measured Power
% Difference (M-P)/P
 Measured Location

FIGURE 3
 INCORE Power Distribution - 73.9%
 MILLSTONE UNIT 3 - CYCLE 19





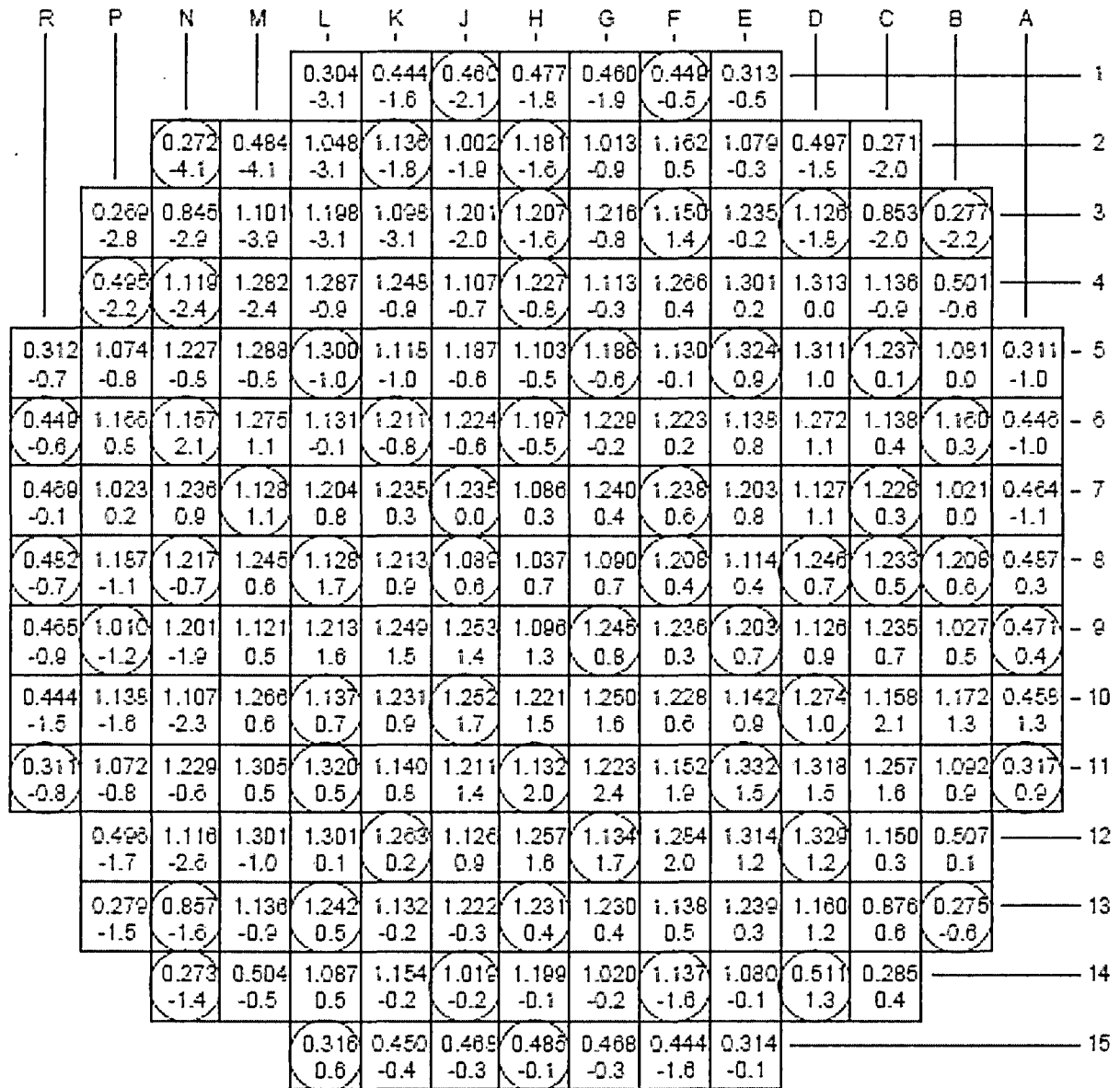


 Measured Power
 % Difference (M-P)/P
 Measured Location

FIGURE 4
INCORE Power Distribution - 99.9%
MILLSTONE UNIT 3 - CYCLE 19



 Measured Power
% Difference (M-P)/P
 Measured Location