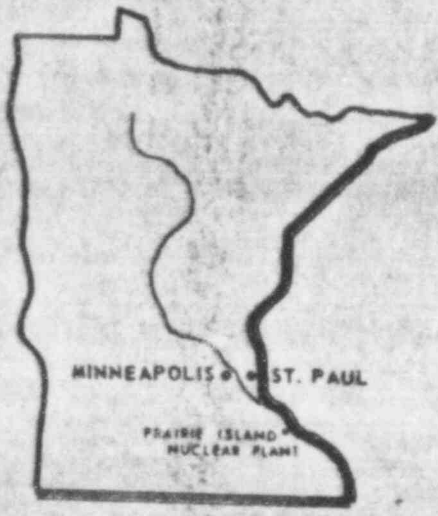
NSP

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Red Wing, Minnesota

UNITS 1 AND 2



UNIT 1, CYCLE 5

STARTUP PHYSICS TEST REPORT

AUGUST 1, 1979

558270

NORTHERN STATES POWER COMPANY
MINNEAPOLIS, MINNESOTA

TABLE OF CONTENTS

Topic	Page
1.0 Introduction	1
2.0 Startup Physics Tests - Summary	1
3.0 Startup Physics Tests - Methods/Analytical Results	2
3.1 Zero Power Isothermal Temperature Coefficient	2
3.2 At Power Moderator Temperature Coefficient	2
3.3 Control Banks' Rod Worth Measurements	3
3.4 Critical Boron Concentration	4
3.5 Differential Boron Worth Measurements	4
3.6 Power Distribution Measurements	5
4.0 Additional Startup Related Tests	6
5.0 Summary	6
6.0 References	7
7.0 Glossary	7

558271

1.0 Introduction

Section 6.7.A.1 of the Prairie Island Technical Specifications, Appendix A, specifies that a summary report shall be submitted following installation of fuel manufactured by a different fuel supplier. This report is to be submitted within 90 days following completion of the startup test program.

The Prairie Island Unit 1 reactor had 40 reload fuel assemblies manufactured by Exxon Nuclear Company installed in April 1979 during the fourth refueling for that facility.

Senior plant nuclear engineering and general office core management and licensing personnel conducted a review of the startup tests conducted for the first cycle operation to determine which tests should be conducted for the cycle 5 startup. In Reference 1, the startup physics tests and acceptance criteria were specified as well as the basis for establishment of the acceptance criteria.

2.0 Startup Physics Tests - Introduction

References 1 and 2 identified the startup related tests to be conducted for the Cycle 5 startup. Tests described in detail with analytical results in this report include the following -

(a) Zero Power Isothermal Temperature Coefficient
(b) At Power Moderator Temperature Coefficient
(c) Control Banks' Rod Worth
(d) Critical Boron Concentration
(e) Boron Worth
(f) Power Distribution Measurements

Those tests, identified by the NRC in the safety evaluation report (Reference 3) as being of significance were tests for:

(a) Critical Boron Concentration
(b) Temperature Coefficient
(c) Rod Worth
(d) Power Distribution

at lower powers and power distribution test at higher powers.

These tests are described in Section 3 of this report.

Additional tests (listed in Reference 2) conducted during the outage, though not directly related to the physics testing program, are summarized in Section 4 of this report.

3.0 Startup Physics Tests - Methods/Analytical Results

3.1 Zero Power Isothermal Temperature Coefficient

3.1.1 Method

The isothermal tempe.ature coefficient is the sum of the moderator and fuel temperature coefficients provided both fuel and moderator heat up or cool down together isothermally. The α_{iso} tests were conducted at a predetermined rod condition - all rods out, control bank D in, or control banks C and D in - in accordance with Procedure D32. In this test, RCS temperature and pressure are initially stabilized with the reactor critical in the intermediate range below the point of adding heat. A heatup (or cooldown) rate of 10F/hr is established by control of the steam dump system. The reactivity change is plotted by the reactivity computer previously calibrated in accordance with Procedure D31.

3.1.2 Results

The following results were obtained -

Condition	Boron Conc., ppm	Heatup α_{iso} Measured	pcm/F Predicted	Acceptance Criteria
HZP - ARO	1497	-2.50	-0.88	<0
HZP - D in	1435	-4.09	-2.25	<0
HZP - D + C in	1315	-6.20	-5.40	<0

3.1.3 Discussion

The tests demonstrated that the acceptance criteria were met and that there was good agreement between the predicted and measured coefficients. As expected, the lower boron concentration in conjunction with greater rod insertion caused α_{iso} to be more negative.

3.2 At Power Moderator Temperature Coefficient

3.2.1 Method

558273

The moderator temperature coefficient (α_{mod}) is the incremental change in reactivity associated with a unit change in moderator temperature (assuming other variables as power and fuel temperature are held constant).

The plant power level is stabilized ($\pm$ 2%) for a period of 72 hours prior to the test to reduce reactivity effects due to xenon variation (as expected if large power swings occur). T_{ave} is allowed to change. Rod position, power T_H, T_C, and boron concentration is measured in accordance with Procedure D51. Then corrections are then made for reactivity effects of burnup, rod worth, doppler, and boron concentration to determine the at power α_{mod}.

3.2.2 Results

Results obtained in accordance with Procedure D51 were:

Condition	Boron Conc., ppm	α_{mod}, pcm/F Measured	Acceptance Criteria
HFP (~0 MwD/MTU)	1006	-10.3	<0

3.2. Discussion

As expected the α_{mod} became more negative. This behavior could be expected since the boron concentration was lower and moderator temperature was higher for the full power case (compared to the HZP cases).

3.3 Control Banks' Rod Worth Measurements

3.3.1 Method

The control banks' rod worths were determined in accordance with Procedure D33. The worth of each individual control bank (A, B, C, and D) was determined as well as the total control banks' worth. In this test, the RCS pressure and temperature and rod position are established at the desired initial values. A constant boration or dilution rate (corresponding to a reactivity change rate of 300-1000 pcm/hr) is established. The boration or dilution is terminated when the desired final rod configuration is obtained. Rod worths are then determined.

3.3.2 Results

The bank worths obtained were as follows:

Bank	Worth, pcm Measured	Predicted	% Difference	Acceptance Criteria (%)
D	693	716	-3.3%	<15
C	1139	1203	-5.6%	<15
B	658	744	-13.1%	<15
A	1805	1777	+1.6%	<15
Total	4295	4440	-3.4%	<10

3.3.3 Discussion

The measured individual and total control bank worths agreed well with the ENC predicted values. As shown above, the acceptance criteria were met.

558274

3.4 Critical Boron Concentration

3.4.1 Method

The critical boron concentration was determined in accordance with procedure D34 (Boron Endpoint Measurements). The reactor is initialized at a critical condition. Control Rod position is adjusted with a corresponding boron concentration change (dilution or boration) to achieve the desired condition. Reactivity and boron concentration are measured.

3.4.2 Results

The boron endpoints were measured at 5 conditions with results as specified below -

Condition	ppm Measured	ppm Predicted	PCM Agreement	Acceptance Criteria
HZP - ARO	1506	1548	369	± 750 pcm
HZP - D in	1439	1457	158	± 750 pcm
HZP - D + C in	1315	1307	70	± 750 pcm
HZP - D + C + B in	1225	1216	79	± 750 pcm
HZP - D + C + B + A in	1017	996	185	± 750 pcm

3.4.3 Discussion

The results above show good agreement between the predicted and measured boron endpoints, well within the acceptance criteria.

3.5 Differential Boron Worth Measurements

3.5.1 Method

The RCS boron worth is determined in accordance with Procedure D33. Reactivity behavior is recorded during the boration or dilution conducted during the determination of rod worths. The boron worth is the reactivity change associated with a unit change in boron concentration.

3.5.2 Results

The boron worth averaged over the range of individual control bank worth measurements was -8.79 pcm/ppm. This compared favorably with the acceptance criteria established (± 10%).

3.5.3 Discussion

558275

There was good agreement between the predicted 8.0 pcm/ppm boron worth value and the measured value.

3.6 Power Distribution Measurements

3.6.1 Method

Flux maps were taken at HZP, 48%, 90%, and 100% power in accordance with Test No. 1116, Revision 2.

3.6.2 Results

The flux maps provided the following results for relative assembly power (% error) and quadrant tilt.

Power	% error Measured	Quadrant Tilt
0	11.53	1.0151
48	5.62	1.0100
90	4.86	1.0128
100	6.75	1.0105

The corresponding acceptance criteria were -

Relative assembly power, ρ_i, % error	$\pm$ 15%, ρ_i <.9
	$\pm$ 10%, $\rho_i \geq .9$
Quadrant Tilt	$\leq$ 1.02

3.6.3 Discussion

All acceptance criteria were met. No anomalous behavior was noted.

4.0 Startup Tests - Systems Related

Reference 2 reported startup tests that NSP planned to conduct as appropriate for refueling with fuel from a different supplier. The following systems related tests were specified:

(a) Verification of proper core loading
(b) Rod drop times
(c) Source and intermediate range calibrations
(d) Rod position indication calibrations

4.1 Verification of Proper Core Loading

Core loading in accordance with the final ENC specified core loading plan was verified in accordance with Procedure SP1177. A videotape was taken and is available for review at the plant until the next scheduled refueling.

4.2 Rod Drop Times

Rod drop times measured were in accordance with Technical Specification requirements.

4.3 Source and Intermediate Range Calibrations

No anomalous behavior was noted.

4.4 Rod Position Indication Calibrations

No anomalous behavior was noted.

4.5 Plant Heat Balance

No anomalous behavior was noted.

5.0 Summary

This report summarizes startup physics test data obtained during the Unit 1 Cycle 5 refueling outage conducted between April 6 (off line) and May 6, 1979 (on line). During this outage, 40 unirradiated Exxon Nuclear Company and 1 irradiated Westinghouse fuel assemblies were placed in the core and 41 spent Westinghouse fuel assemblies were transferred to the spent fuel storage pool.

As shown in this report, there was good agreement between the measured physics parameters and those predicted by Exxon Nuclear Company. To provide added confidence in the ability to predict reactor physics behavior, the NSP Core Analysis Section conducted backup calculations for comparison to the ENC derived values. In general, there was excellent agreement for comparisons made between measured and NSP predicted 3DP5 calculated values of boron endpoints, control rod worths, and isothermal temperature coefficient. These comparisons are expected to be included in a future topical report supporting the NSP core management and analytical capabilities.

558277

6.0 References

(1) Letter, L O Mayer (NSP) to Director of Nuclear Reactor Regulation (NRC), dated March 30, 1979

(2) Letter, L O Mayer (NSP) to Director of Nuclear Reactor Regulation (NRC), dated December 29, 1979

(3) Letter, A Schwencer (NRC) to L O Mayer (NSP), dated April 20, 1979

7.0 Glossary

In this report, various symbols and acronyms are used. The definitions are listed below.

Symbols

α_{iso}	Isothermal Temperature Coefficient, expressed in pcm/F.
α_{mod}	Moderator Temperature Coefficient, expressed in pcm/F.

Acronyms

RCS	Reactor Coolant System
HZP	Hot Zero Power
HFP	Hot Full Power
D in	Control Bank D at 0 steps, Control Banks A, B, C at 228 steps
D + C in	Control Banks C and D at 0 steps Control Banks A and B at 228 steps
D + C + B in	Control Banks B, C, and D at 0 steps Control Bank A at 228 steps
D + C + B + A in	Control Banks A, B, C and D at 0 steps

558278