UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-369/89-21 and 50-370/89-21

Licensee: Duke Power Company
422 South Church Street
Charlotte, NC 28242

Docket Nos.: 50-369 and 50-370 License Nos.: NPF-9 and NPF-17

Facility Name: McGuire 1 and 2

Inspection Conducted: July 7 - 18, 1989

Inspector: P. T. Burnett, Reactor Inspector, TPS — 8-16-89 Date Signed

Inspector: P. K. VanDoorn, Senior Resident Inspector — 8/16/89 Date Signed

Approved by: G. A. Belisle, Chief — 8/16/89 Date Signed
Test Programs Section
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope:

This reactive, unannounced inspection addressed the operation of Unit 1 on July 5, 1989 following an improperly performed reactor heat balance and the concomitant non-conservative calibration of the power range nuclear instruments.

Results:

Unit 1 was found to have operated in excess of 101% of rated thermal power for a period of nearly three hours. Furthermore, the unit operated in excess of 102% of rated thermal power for a period of less than 10 minutes. It was determined that the licensee had an opportunity to identify the heat balance error several hours before it was identified and before rated thermal power was exceeded. Consequently, the overpower operation was identified as a violation - paragraph 4.

The miscalibration of the nuclear instruments did not lead to operation with the high flux trip setpoint greater than that used in the safety analyses of reactivity transients. The overpower-delta-temperature trip was functional throughout the event.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*N. Atherton, Compliance
*D. Baumgardner, Unit 1 Operations Manager
*D. Baxter, Operations Support Manager
*D. Bradshaw, Operations, General Offices
*K. Carmley, Operations Training
*S. Copp, Planning and Materials
*D. Ethington, Compliance Engineer
*G. Gilbert, Superintendent of Technical Services
*T. Hammond, Engineer, Instrumentation and Electrical
*G. Hart, General Supervisor, Instrumentation and Electrical
*E. Hite, Maintenance Engineer, General Offices
*R. Isenhour, Jr., Quality Assurance
*T. Kibler, Engineer, Performance
*M. Kitlan, Jr., Reactor Engineer
*M. Mallard, Operations, General Offices
*T. McConnell, Station Manager
*J. Neel, Supervisor, Instrumentation and Electrical
E. Owens, Maintenance Engineer
*B. Pitsea, Operations Engineer
*C. Roberson, Engineer, Performance
*J. Rowe, NPD Engineer, General Offices
*M. Sample, Maintenance Superintendent
R. Sharp, Compliance Manager
*G. Small, Safety Review Group
*D. Smith, Test Engineer, Performance
*J. Snyder, Performance Engineer
*W. Suslick, Engineer, Test Group
R. Travis, Operations Superintendent

Other licensee employees contacted included engineers, technicians, operators, mechanics, and office personnel.

*Attended exit interview on July 10, 1989.

Acronyms and initialisms used throughout this report are listed in the last paragraph.

2. Overpower Operation of McGuire Unit 1 (61706)

Unit 1 started up for operating cycle 6 in January 1989. On January 17, 1989, PT/0/A/4150/03, Thermal Power Output Measurement, was completed successfully. The three acceptance criteria for the test were:

Step 11.1 The primary core power level derived from the primary heat balance calculated by the OAC (Enclosure 13.2 of the PT) and that obtained by the off line computer calculation (Enclosure 13.6 of the PT and computer program MNSPHB) shall agree within ± 2% F.P. (absolute difference).

Step 11.2 The secondary core power level derived from the secondary heat balance calculated by the OAC (Enclosure 13.2 of the PT) and that obtained by the off line computer calculation (Enclosure 13.6 of the PT and computer program MNSSH1) shall agree within ± 2% F.P. (absolute difference).

Step 11.3 The Best Estimate Thermal Power calculated by the OAC (Enclosure 13.2 of the PT) shall agree with the Best Estimate Thermal Power obtained on Enclosure 13.3 (of the PT) within ±2% F.P. (absolute difference).

The Best Estimate Thermal Power is defined as:

Q = ALPHA * (secondary power) + (1-ALPHA) * (primary power).

For secondary power < 20% RTP, ALPHA = 0.0

For secondary power > 50% RTP, ALPHA = 1.0

Otherwise, ALPHA = -2/3 + (secondary power(%)/30)

At low power and low feedwater flow rates, there is considerable variation in the indicated feedwater flow and, hence, in the calculation of secondary side power. Use of the Best Estimate Thermal Power is an attempt to provide the operators with a stable and reasonable display of thermal power over the entire operating range. It can be seen in the above equation that the inherently more accurate secondary side power measurement is the sole term above 50% RTP.

The results of this PT in percent of RTP were:

98.27 = primary power level from MNSPHB
100.05 = secondary power level from MNSSH1
99.79 = average secondary power level from OAC/TOP
98.01 = average primary power level from OAC/TOP

It can be seen that the differences between pairs of primary and secondary power measurements were less than 2%.

IP/0/A/3007/17, NIS Power Range Calibration to Best Estimate Thermal Power, is performed by IAE technicians upon demand by operations personnel. The demand is generated by a difference of 2% RTP between PRNIs and thermal power in steady-state conditions or a real or anticipated difference of 5% when power level is being changed. Step 10.1.3 requires the following computer points be recorded in the procedure:

P1385: BEST ESTIMATE THERMAL POWER,
P1445: SECONDARY THERMAL OUTPUT, and
P1447: PRIMARY THERMAL OUTPUT.

Step 10.1.4 and 10.1.5 require that these points be verified to be within 2% RTP by the technician, and, if not within this limit, a reactor group engineer is to be contacted to determine which OAC point is to be used in the calibration.

On July 1, 1989, with the primary thermal output indicating 34.7% RTP and secondary thermal output indicating 31.9% RTP, a reactor group engineer selected P1445 as the basis for the PRNI calibrations. Later that day, all three points read within the 2% allowance, and the technician chose to calibrate PRNIs against best estimate thermal power at 49.7%.

On July 2, 1989, with Unit 1 at about 55% RTP, work request 139042 OPS was issued for the repair of the 1C steam generator control level gauge. An IAE technician was assigned to perform the repair in accordance with IP/0/A/3001/01C, Main Steam Flow Calibration, Loop C, Channel I. Step 10.1.4 of that procedure required that the following computer points be locked out:

A1072: STEAM GENERATOR C MAIN STEAM FLOW - CHANNEL I,
A0867: STEAM GENERATOR C FEEDWATER FLOW - CHANNEL I, and
A1119: STEAM GENERATOR C MAIN STEAM PRESSURE - CHANNEL I.

To lockout a point means that the OAC does not read the instrument source, but uses a substitute value entered at lockout for all calculations using the point. Step 10.6.5 requires, as part of system restoration, that the same computer points be unlocked. That step was not performed. Hence, the OAC continued to use the substitute values in calculations rather than the actual values of these variables.

Computer point A0867 is one of two analog measurements of differential pressure across a calibrated flow venturi. Each point provides an independent measurement of feedwater flow to steam generator C. That direct measurement is the primary variable input to the OAC program FLO, which converts it to units of millions of pounds mass per hour. The converted measurement is available to other applications, including other OAC programs, at computer points P1416 and P1095. The later is a two-minute average of results calculated with ten-second periodicity. P1095 is one of two measurements of feedwater flow to steam generator C, which are averaged and used by TOP, the OAC program for calculating secondary side thermal power. The other point P1096 was not affected by the procedural error.

A1119 is one of three channels of analog input of steam pressure for each generator. In TOP, they are averaged, converted to units of psia, and the result used in determining the thermodynamic properties of the steam. Two of the three channels were unaffected by the error.

No use is made of A1072, the direct measurement of steam flow, in TOP. Absent the measurement error introduced by the procedural error of not restoring the computer points, feedwater flow measurements are inherently more accurate than the direct steam flow measurements. Hence, for heat balance calculations, equating steam flow to feedwater flow less blowdown flow is more accurate.

On July 5, 1989, IP/0/A/3007/17 was performed at over 80% RTP. The OAC power points indicated 81.1%, 81.1%, and 85.8% RTP, with primary power indicating the highest. The four as-found PRNI readings ranged from 86.6% to 87.2%. The reactor group engineer on duty was contacted, and he selected the best estimate thermal power point, the same as secondary power, as the basis for the PRNI calibrations. He later stated that, when contacted, he was heavily involved with a test on Unit 2, and the over four percent difference in power indications did not register in his mind. His reason for selecting secondary power as the basis for calibration was that secondary power is inherently more accurate than primary power above 50% RTP. This was the same engineer that had performed PT/0/A/4150/03 for Unit 1, cycle 6 in January 1989. As a result of the recalibrations, the PRNI indications were reduced to a range of 80.9% to 81.1% with secondary power indicating 80.8% RTP and primary thermal power at about 85.5% RTP. This recalibration was completed at about 8:30 a.m.

By about 11:30 a.m. on July 5, power had been increased to approximately 95% RTP as indicated by best estimate/secondary power. Power was held at that level by the operators until about 1:30 p.m.; since plant electrical output had reached previous 100% power levels and to investigate low suction pressure on the condensate booster pumps. The operators discussed the anomalous relationship between thermal and electrical power, but ascribed it to lower lake temperature, lower turbine back pressure, and reduced use of auxiliary steam. Secondary power was then increased to an indicated 96% RTP, but further increase was halted because of continued low suction pressure. The operators stated that power was not limited by condenser performance, but that they wanted it performing to expectations before increasing power further.

At about 5:50 p.m. on July 5, another reactor group engineer was consulted about the discrepancy among thermal power indicators. He initiated a Thermal Output Calculation Dump from the OAC, and that printout clearly indicated the three locked-out sensors. Upon removing the lock outs, thermal power indication increased to over 100% RTP. The operators immediately reduced power to 98.2% as indicated by best estimate/secondary thermal power and 98.7% as indicated by primary thermal power. At that time all PRNIs indicated 94%. The PRNIs were then recalibrated to best estimate thermal power using IP/0/A/3007/17.

Once discovered, the overpower operation was reported to the NRC promptly, and the licensee initiated a broad, interdepartmental review of the event, which culminated in an abnormal plant event meeting on July 10, 1989. This meeting was attended by the inspectors. Each involved department - operations, IAE, and performance/reactor group - appeared to have made a thorough evaluation of its performance and had proposed corrective action.

The licensee's evaluation of this event is continuing and will be reported in a LER. The inspectors' evaluation is addressed in the following paragraphs:

Paragraph 3 establishes the validity of both the licensee's computer program TOP and the NRC's microcomputer program TPDWR2 for analyzing plant data to determine plant thermal power for both steady-state and slowly changing power levels.

Paragraph 4 addresses the application of TPDWR2 to historical plant data for the period of 11:00 am to 5:30 pm on July 5, 1989 and the conclusions drawn from that analysis.

Paragraph 5 addresses other observations and findings pertinent to the July 5, 1989 event.

3. Independent Analysis of Thermal Power (61706)

a. References

(1) NUREG-1167, TPDWR2: Thermal Power Determination for Westinghouse Reactors, Version 2,

(2) McGuire Nuclear Station FSAR, Chapter 5,

(3) Westinghouse Technical Manual 1440-C247, Pressurizer Instructions ... ,

(4) Westinghouse Technical Manual 1440-C250, Vertical Steam Generator Instructions ... ,

(5) OAC Manual:
(a) Thermal Outputs Calculation, Section 3.2.10, and
(b) Thermal Outputs Calculation Dump, Section 3.2.14.

b. Parameter and Data Acquisition

The micro computer program, TPDWR2, developed by the NRC's Independent Measurements Program for analysis of licensee thermal power data is described in Reference (1). In order to customize the program for use at McGuire, plant specific physical and performance parameters were obtained from references (2) to (5). Those parameters are given on page 1 of Attachment 1 along with typical input data for the calculations described below.

On July 7, 1989, the inspector used the OAC to log the input data for TPDWR2. Computer logging provides better numerical resolution and contemporaneousness of the data than manual collection from MCB indicators could provide. All of the necessary data were obtained using edits from four computer point identification tables established with the help of a licensee engineer. The points were logged at five minute intervals for eight hours, and the tables were printed out after all data had been logged. For the first 33 intervals the reactor was at a nominal 100% RTP. Over the next three hours, the unit under went a slow power reduction to about 64% RTP. By the end of data collection, the unit had recovered to 70% RTP.

Most of the data were not in a form that could be used directly for input to TPDWR2. Data sources, with the loop A computer points used in the examples of loop-specific parameters, and the required manipulations are described below:

S/G pressure = pressure(psig, A1107) + atmospheric pressure (P0117)

FW flow (Mlb/hr) = average (P1412, P1413)

FW temperature = A0454 (no manipulation necessary)

BD flow (gpm, S/G conditions) = A0652(lb/hr) * 0.002514

S/G level(inches) = A1059(%) * 2.33 + 394

LD flow = A0764 (no manipulation necessary)

LD temperature = A1088 (loop C cold leg)

CHG flow (gpm) = A0758 - 32gpm (flow to the seals does not return enthalpy from the regenerative heat exchanger)

CHG temperature = A0758 (regenerative heat exchanger outlet temperature)

PZR pressure (psia) = P1389

PZR level (inches) = A0976(%) * 5.205 + 25.75

NC average temperature = P1461 (no manipulation required)

NC average cold leg temperature = average(A1064, A1076, A1088, A1100)

A SUPERCALC3 spreadsheet was used to perform all of the necessary calculations and to organize the results in an order best suited for input to TPDWR2.

In the points identified above, the A prefix refers to a directly read analog point, an unmanipulated value. The P prefix refers to a calculated point. In the case of feedwater flow, program FLO takes the square root of the basic analog measurement of differential pressure in inches of water, multiplies the root by orifice calibration factors, and increases the product by the tempering flow to the auxiliary feedwater nozzles. The resulting flow rate in mass per unit time is displayed at the appropriate P point. The feedwater flows, in units of millions of pounds mass per hour, used in these calculations were the instantaneous values calculated by the OAC program FLO every thirty seconds. The licensee's TOP program uses two-minute averages of the FLO output.

c. TPDWR2 Calculational Results

TPDWR2 can analyze single or paired sets of data. In the paired-set mode, it can account for energy stored in or transferred from the pressurizer and steam generators from the net change in mass inventory. The inspector selected seven paired sets of data (14 power sets) for analysis with the pairs separated by 15 to 25 minutes.

The comparison between TPDWR2 and the licensee's calculations of power was very good, as shown in the following table, which was arranged from the highest to the lowest power calculated with TPDWR2.

McGUIRE 1: Heat Balance Comparison for 7 July 1989

	THERMAL POWER							
	TOP		TPDWR2		S/G-C		TOP-TPD	
TIME	(Mwt)	(%)	(Mwt)	(%)	(Mwt)	(%)	(Mwt)	(%)
1755	3416.0	100.15	3422.0	100.32	860.1	25.13	-6.0	-.18
1640	3401.1	99.71	3405.4	99.84	851.0	24.99	-4.3	-.13
1655	3405.0	99.83	3402.4	99.75	860.4	25.29	2.6	.08
1540	3396.3	99.57	3382.9	99.18	843.8	24.94	13.4	.39
1525	3407.3	99.89	3374.1	98.92	839.1	24.87	33.2	.97
1820	3353.9	98.33	3347.4	98.14	839.1	25.07	6.5	.19
1920	2703.5	79.26	2677.0	78.48	670.3	25.04	26.5	.98
1935	2534.1	74.29	2522.0	73.94	641.[illegible]	25.42	12.1	.48
2320	2397.8	70.30	2392.9	70.15	601.0	25.12	4.9	.21
2305	2320.0	68.02	2306.9	67.63	585.0	25.36	13.1	.57
2050	2203.5	64.60	2200.0	64.50	560.1	25.46	3.5	.16
2150	2191.8	64.26	2200.0	64.50	560.5	25.48	-8.2	-.37
2035	2192.3	64.27	2189.9	64.20	555.1	25.35	2.4	.11
2205	2202.2	64.56	2189.0	64.17	552.7	25.25	13.2	.60
					AVERAGE =	25.20		

The mean absolute difference between results was 0.39% of the TOP value.

The good agreement between TOP and TPDWR2 calculations over a range of powers from 64% to 100% RTP, confirms that TOP is properly sampling the process variables and performing correct calculations of the thermodynamic properties of water and steam. Neither the differences in magnitude nor percent of reference (the TOP result) between TOP and TPDWR2 correlated with power. Similarly, steam generator C made a consistent contribution to total power, an average of 25.2%, regardless of power. Most of the random variations between calculations probably come from the input values of feedwater flow. The OAC samples all variables with ten-second periodicity, and the inputs to TPDWR2 were all from the ten-second snapshots recorded at five minute intervals. The feedwater flow input to TOP is a two-minute average of the ten-second snapshots. This smooths the basically noisy flow measurement. A small consistent difference between results may come from the calculation of blowdown enthalpy. TPDWR2 uses an average of steam generator saturation conditions and feedwater conditions to calculate enthalpy for bottom BD flow. TOP uses saturation conditions in the steam generator. Typical results for TPDWR2 are given on pages 2 and 3 of Attachment 1.

The licensee's calculational method is acceptable as programmed. The differences noted reflect reasonable variations in engineering judgement.

4. Analysis of Historical Data for July 5, 1989

Selected plant data from those monitored by the OAC with ten-second periodicity are transferred with five-minute periodicity, on a snapshot basis without averaging, to a remote minicomputer. Those data are then retained for one week. The licensee recovered the Unit 1 data for the period of potential over power operation for their analysis, and provided the inspectors copies of the recovered data in the form of five ASCII files on computer disks. The files included three steam pressure measurements per steam generator, two feedwater temperatures per generator, one feedwater flow for generators A and B, and two feedwater flows for generators C and D. The feedwater flows recorded were the two minute averages. Of course, for steam generator C one steam pressure and one feedwater flow were invalid because of the locked-out points. Other recorded data pertinent to the calculation of thermal power included: one charging temperature, one charging flow, one cold leg (letdown) temperature, letdown flow, and barometric pressure.

To make a rapid first assessment of this mass of data, a correlation was made between total feedwater flow and thermal power. The data for the correlation were obtained from the thermal power analysis performed on Unit 1 using the plant data obtained on July 7, 1989 and the results of the corresponding analyses using TPDWR2. The correlation was performed using a least-squares spreadsheet and SUPERCALC3. Expressed algebraically, the correlation was:

Power(Mwth) = 238 Mwth + 207.9 * (Total feedwater flow (Mlbm/hr)).

The correlation coefficient was 1.00.

Another spreadsheet was set up to apply this correlation to the sum of all valid feedwater flow measurements for all five-minute-interval data captured between 1:55 p.m. and 6:10 p.m. on July 5, 1989. This analysis identified one time, 2:20 pm, at which thermal power exceeded 102% of RTP. TPDWR2 was then used to analyze the data for that time. Since historical records of blowdown flow rates, steam generator and pressurizer levels, and NC temperatures were not available to the inspectors; nominal values of these parameters, from the analysis for 4:55 p.m. on July 7, 1989, were used. With the exception of the assumptions of blowdown flow rates, use of these nominal values for a single set of performance data has no effect on the results from TPDWR2. Since blowdown flow has only a small effect on the calculation; the differences between actual and assumed blowdown flow rates are expected to introduce negligible error into the calculation. The input and output for the 2:20 p.m. calculation are give in Attachment 2. In that calculation, core thermal power was determined to be 102.3% of RTP, and the contribution of steam generator C to the total was 25.2%, which was in good agreement with the results of the calculations using plant data collected on July 7, 1989.

Analysis of the thermal power calculations from the power-to-flow correlation showed that during the period of 1:55 p.m. to 4:45 p.m. Unit 1 averaged over 101% RTP for the entire period. Extended operation in excess of 101% RTP as well as any operation in excess 102% RTP is considered to be a violation of the license limit. Although the event was identified by the licensee, the identification was not made at the earliest opportunity. That opportunity came when the reactor group engineer was requested to evaluate a difference greater than 2% between primary and secondary thermal power calculations on the OAC with the reactor in the 80% power range early on July 5, 1989. Identification of the locked out values in the OAC at that time would have precluded any overpower operation from the failure to properly complete IP/0/A/3001/01C on July 2, 1989. Hence this event has been identified as a violation of the license limit of a maximum core power of 3411 thermal megawatts given in License NPF-9, Paragraph 2.C(1) (VIO 50-369/89-21-01).

The licensee does not have as-found values for the high flux trip setpoints on July 5, 1989. A licensee engineer stated that setpoint drift from the 109% calibration value required by Technical Specification 2.2 is uncommon. Using the the PRNI readings of 94% and the best estimate thermal power of 98.2% RTP observed at 5:50 pm on July 5, 1989, a the high flux trip would have occurred at (98.2/94.0) * 109% = 114% RTP. This is less than the maximum overpower trip setpoint of 118% used in the FSAR Chapter 15 safety analyses of reactivity transients. (See FSAR Table 15.1.4-1.) The effect of the PRNI calibration error on positive and negative flux rate trips was judged by the inspector to be too small to require quantitative analysis. For slow power transients, the over-power-delta-temperature trip would have functioned at 108.8% RTP according to calculations by the licensee. That trip function was not affected by either the thermal power or the PRNI calibration errors.

No additional violations or deviations were identified in this inspection area.

5. Other Inspection Findings and Observations

During NRC Inspection 50-370/87-42, TPDWR2 was used with data obtained from Unit 2. One observation reported was that the reactor coolant pump efficiency used in TOP, at that time, was the lowest the inspector had ever observed and that the licensee might be incurring a power production penalty from an over-conservative calculation of core thermal power. The licensee subsequently responded by telephone that an error in pump efficiency did exist in TOP and that four units at McGuire and Catawba had each been penalized about 1 Mwe. At the start of this inspection, the inspector requested an up-to-date copy of the TOP program description. The copy provided had the revised pump power calculation on page 3.2.10.5, but the latest revision date shown on the page was 4/1/85. Review of the OAC Manual in the computer room revealed that page 3.2.10.5 had not been updated and showed the old pump heat calculation. The licensee stated that TOP had actually been revised, and that is substantiated by the agreement between TOP and TPDWR2 results for July 7, 1989.

The TOP program description is well written and the flow of operations from data input to analysis to output is relatively easy to follow. The same observation is not true of the FLO program description in any aspect. Both programs are, effectively, part of required surveillance procedures, but FLO is not auditable.

Licensee control and documentation of computer programs used in the performance of required surveillances will be addressed in a later inspection.

6. Followup of Previous Violations (92702)

(Closed) Violation 50-369/87-42-01: Failure to make a required report of overpower operation within the required time. On January 5, 1988, the licensee submitted LER 369/87-35, which was a complete and adequate description of the event. The licensee's response to the violation, dated February 15, 1988, was reviewed in the Region II office and found acceptable. The licensee acknowledged a need to be more thorough in their evaluations of potentially reportable events, but no programatic changes were identified.

7. Exit Interview (30703)

The inspection scope and findings were summarized on July 10, 1989, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. The licensee was informed at that time that no decision had been reached with respect to the issuance of a notice of violation. No dissenting comments were received from the licensee. The licensee did not identify as proprietary any of the materials provided to or reviewed by the inspectors during this inspection.

The licensee was informed on August 14, 1989, that a decision had been made by Region II management to issue a violation for overpower operation.

8. Initialisms and Acronyms Used in This Report

ASCII	-	American Standard Code for Information Interchange
BD	-	blowdown
CHG	-	charging
FLO	-	OAC program for calculating feedwater flow
FSAR	-	Final Safety Analysis Report
FW	-	feedwater
gpm	-	gallons per minute
IAE	-	Instrumentation and Electrical Department
IP	-	instrument procedure
LD	-	letdown
LER	-	licensee event report
MCB	-	main control board
Mlbm/hr	-	million pounds mass per hour
Mwe	-	megawatts electrical
Mwth	-	megawatts thermal
NC	-	nuclear coolant system (reactor coolant system)
NIS	-	nuclear instrument system
OAC	-	operator assist computer, the plant computer
PRNI	-	power range nuclear instrument
psia	-	pounds per square inch gauge
psig	-	pounds per square inch absolute
PT	-	periodic test
PZR	-	pressurizer
RTP	-	rated thermal power
TOP	-	thermal outputs program
TPS	-	Test Programs Section

Attachments:
1. Typical Output from TPDWR2
2. Analysis of Overpower Operation on July 5, 1989

HEAT BALANCE DATA
McGuire 1
7-7-89

PLANT PARAMETERS:

REACTOR COOLANT SYSTEM

Pump Power (MW each)	5.2
Pump Efficiency (%)	82.7
Pressurizer Inside Diameter (inches)	84.0

STEAM GENERATORS

Dome Inside Diameter (inches)	168.50
Riser Outside Diameter (inches)	21.00
Number of Risers	12
Moisture Carry-over (%) in A	0.070
Moisture Carry-over (%) in B	0.070
Moisture Carry-over (%) in C	0.070
Moisture Carry-over (%) in D	0.070

REFLECTIVE INSULATION

Inside Surface Area (sq ft)	15,958
Heat Loss Coefficient (BTUs/hr sq ft)	55.00

NONREFLECTIVE INSULATION

Inside Surface Area (sq ft)	11,575
Thickness (inches)	4.0
Thermal Conductivity (BTUs/hr ft F)	0.035

LICENSED THERMAL POWER (MWt) 3411

DATA:

	SET 1	SET 2
TIME	1755	1820

STEAM GENERATOR A

	SET 1	SET 2
Steam Pressure (psia)	995.2	1004.6
Feedwater Flow (E6 lb/hr)	3.797	3.670
Feedwater Temperature (F)	438.5	436.1
Surface Blowdown (gpm)	0.0	0.0
Bottom Blowdown (gpm)	118.5	120.6
Water Level (inches)	548.0	548.0

STEAM GENERATOR B

	SET 1	SET 2
Steam Pressure (psia)	1002.1	1012.0
Feedwater Flow (E6 lb/hr)	3.882	3.840
Feedwater Temperature (F)	436.6	434.2
Surface Blowdown (gpm)	0.0	0.0
Bottom Blowdown (gpm)	136.1	133.6
Water Level (inches)	545.9	545.2

STEAM GENERATOR C

	SET 1	SET 2
Steam Pressure (psia)	1002.4	1012.7
Feedwater Flow (E6 lb/hr)	3.822	3.721
Feedwater Temperature (F)	436.6	434.4
Surface Blowdown (gpm)	0.0	0.0
Bottom Blowdown (gpm)	110.6	113.6
Water Level (inches)	551.3	551.0

STEAM GENERATOR D

	SET 1	SET 2
Steam Pressure (psia)	992.6	1002.9
Feedwater Flow (E6 lb/hr)	3.811	3.716
Feedwater Temperature (F)	437.5	435.4
Surface Blowdown (gpm)	0.0	0.0
Bottom Blowdown (gpm)	131.4	142.1
Water Level (inches)	545.2	545.9

LETDOWN LINE

	SET 1	SET 2
Flow (gpm)	101.6	101.6
Temperature (F)	559.7	559.8

CHARGING LINE

	SET 1	SET 2
Flow (gpm)	66.7	62.5
Temperature (F)	489.1	499.9

PRESSURIZER

	SET 1	SET 2
Pressure (psia)	2280.0	2275.0
Water Level (inches)	343.3	342.2

REACTOR

	SET 1	SET 2
T ave (F)	587.8	587.8
T cold (F)	558.9	559.5

HEAT BALANCE
McGuire 1
7-7-89

DATA SET 1 OF 2 1755 hours	ENTHALPY (BTUs/lb)	FLOW (E6 lb/hr)	POWER (E9 BTUs/hr)	POWER (MWt)
STEAM GENERATOR A				
Steam	1192.7	3.749	4.472	
Feedwater	417.8	-3.797	-1.586	
Surface Blowdown	541.8	0.00000	0.00000	
Bottom Blowdown	477.5	0.04715	0.02251	
Power Dissipated			2.9078	851.6
STEAM GENERATOR B				
Steam	1192.4	3.828	4.565	
Feedwater	415.7	-3.882	-1.614	
Surface Blowdown	542.9	0.00000	0.00000	
Bottom Blowdown	476.9	0.05418	0.02584	
Power Dissipated			2.9768	871.8
STEAM GENERATOR C				
Steam	1192.4	3.778	4.505	
Feedwater	415.7	-3.822	-1.589	
Surface Blowdown	542.9	0.00000	0.00000	
Bottom Blowdown	476.9	0.04403	0.02100	
Power Dissipated			2.9369	860.1
STEAM GENERATOR D				
Steam	1192.8	3.757	4.482	
Feedwater	416.7	-3.811	-1.588	
Surface Blowdown	541.4	0.00000	0.00000	
Bottom Blowdown	476.7	0.05231	0.02494	
Power Dissipated			2.9186	854.8
OTHER COMPONENTS				
Letdown Line	558.6	0.03772	0.02107	
Charging Line	475.0	-0.02693	-0.01279	
Pressurizer	704.8	-0.00021	-0.00015	
Pumps			-0.06568	
Insulation Losses			0.00147	
Power Dissipated			-0.05608	-16.4
REACTOR POWER				3422.0

HEAT BALANCE
McGuire 1
7-7-89

DATA SET 2 OF 2 1820 hours	ENTHALPY (BTUs/lb)	FLOW (E6 lb/hr)	POWER (E9 BTUs/hr)	POWER (MWt)
STEAM GENERATOR A				
Steam	1192.3	3.621	4.318	
Feedwater	415.2	-3.670	-1.524	
Surface Blowdown	543.3	0.00000	0.00000	
Bottom Blowdown	476.8	0.04802	0.02289	
Power Dissipated			2.8171	825.1
STEAM GENERATOR B				
Steam	1192.0	3.787	4.514	
Feedwater	413.1	-3.840	-1.586	
Surface Blowdown	544.4	0.00000	0.00000	
Bottom Blowdown	476.2	0.05323	0.02535	
Power Dissipated			2.9535	865.0
STEAM GENERATOR C				
Steam	1192.0	3.676	4.381	
Feedwater	413.3	-3.721	-1.538	
Surface Blowdown	544.5	0.00000	0.00000	
Bottom Blowdown	476.4	0.04525	0.02156	
Power Dissipated			2.8651	839.1
STEAM GENERATOR D				
Steam	1192.4	3.658	4.362	
Feedwater	414.4	-3.716	-1.540	
Surface Blowdown	543.0	0.00000	0.00000	
Bottom Blowdown	476.3	0.05661	0.02696	
Power Dissipated			2.8490	834.4
OTHER COMPONENTS				
Letdown Line	559.4	0.03768	0.02108	
Charging Line	487.4	-0.02496	-0.01216	
Pressurizer	704.2	-0.00021	-0.00015	
Pumps			-0.06568	
Insulation Losses			0.00147	
Power Dissipated			-0.05544	-16.2
REACTOR POWER				3347.4

HEAT BALANCE DATA
McGuire 1
7-5-89

PLANT PARAMETERS:

REACTOR COOLANT SYSTEM

Pump Power (MW each)	5.2
Pump Efficiency (%)	92.7
Pressurizer Inside Diameter (inches)	84.0

STEAM GENERATORS

Dome Inside Diameter (inches)	168.50
Riser Outside Diameter (inches)	21.00
Number of Risers	12
Moisture Carry-over (%) in A	0.070
Moisture Carry-over (%) in B	0.070
Moisture Carry-over (%) in C	0.070
Moisture Carry-over (%) in D	0.070

REFLECTIVE INSULATION

Inside Surface Area (sq ft)	15,958
Heat Loss Coefficient (BTUs/hr sq ft)	55.00

NONREFLECTIVE INSULATION

Inside Surface Area (sq ft)	11,575
Thickness (inches)	4.0
Thermal Conductivity (BTUs/hr ft F)	0.035

LICENSED THERMAL POWER (MWt) 3411

DATA:

TIME 1420

STEAM GENERATOR A

Steam Pressure (psia)	981.9
Feedwater Flow (E6 lb/hr)	3.848
Feedwater Temperature (F)	439.2
Surface Blowdown (gpm)	0.0
Bottom Blowdown (gpm)	111.7
Water Level (inches)	548.0

TIME 1420

STEAM GENERATOR B

Steam Pressure (psia)	988.0
Feedwater Flow (E6 lb/hr)	3.966
Feedwater Temperature (F)	437.5
Surface Blowdown (gpm)	0.0
Bottom Blowdown (gpm)	136.5
Water Level (inches)	544.8

STEAM GENERATOR C

Steam Pressure (psia)	981.5
Feedwater Flow (E6 lb/hr)	3.895
Feedwater Temperature (F)	437.5
Surface Blowdown (gpm)	0.0
Bottom Blowdown (gpm)	113.3
Water Level (inches)	550.6

STEAM GENERATOR D

Steam Pressure (psia)	978.3
Feedwater Flow (E6 lb/hr)	3.903
Feedwater Temperature (F)	438.2
Surface Blowdown (gpm)	0.0
Bottom Blowdown (gpm)	137.3
Water Level (inches)	545.5

LETDOWN LINE

Flow (gpm)	102.4
Temperature (F)	558.5

CHARGING LINE

Flow (gpm)	57.1
Temperature (F)	493.0

PRESSURIZER

Pressure (psia)	2282.0
Water Level (inches)	343.8

REACTOR

T ave (F)	588.3
T cold (F)	559.6

HEAT BALANCE
McGuire 1
7-5-89

DATA SET 1 OF 1 1420 hours	ENTHALPY (BTUs/lb)	FLOW (E6 lb/hr)	POWER (E9 BTUs/hr)	POWER (MWt)
STEAM GENERATOR A				
Steam	1193.1	3.803	4.538	
Feedwater	418.6	-3.848	-1.610	
Surface Blowdown	539.8	0.00000	0.00000	
Bottom Blowdown	477.0	0.04446	0.02120	
Power Dissipated			2.9484	863.5
STEAM GENERATOR B				
Steam	1192.9	3.911	4.666	
Feedwater	416.7	-3.966	-1.652	
Surface Blowdown	540.7	0.00000	0.00000	
Bottom Blowdown	476.4	0.05436	0.02590	
Power Dissipated			3.0393	890.1
STEAM GENERATOR C				
Steam	1193.2	3.850	4.593	
Feedwater	416.7	-3.895	-1.623	
Surface Blowdown	539.7	0.00000	0.00000	
Bottom Blowdown	476.0	0.04514	0.02148	
Power Dissipated			2.9918	876.2
STEAM GENERATOR D				
Steam	1193.3	3.849	4.593	
Feedwater	417.5	-3.903	-1.629	
Surface Blowdown	539.2	0.00000	0.00000	
Bottom Blowdown	476.1	0.05469	0.02604	
Power Dissipated			2.9891	875.4
OTHER COMPONENTS				
Letdown Line	557.8	0.03807	0.02123	
Charging Line	479.5	-0.02295	-0.01100	
Pumps			-0.06568	
Insulation Losses			0.00147	
Power Dissipated			-0.05398	-15.8
REACTOR POWER				3489.5