Janaury 12, 1995

Mr. T. C. McMeekin
Vice President, McGuire Site
Duke Power Company
12700 Hagers Ferry Road
Huntersville, North Carolina 28078

SUBJECT: ISSUANCE OF AMENDMENTS - McGUIRE NUCLEAR STATION, UNITS 1 AND 2, REACTOR COOLANT SYSTEM (RCS) FLOW RATE MEASUREMENT (TAC NOS. M88659 AND M88660)

Dear Mr. McMeekin:

The Nuclear Regulatory Commission has issued the enclosed Amendment No. 153 to Facility Operating License NPF-9 and Amendment No. 135 to Facility Operating License NPF-17 for the McGuire Nuclear Station, Units 1 and 2. The amendments consist of changes to the Technical Specifications (TS) in response to your application dated January 10, 1994, as supplemented September 15, 1994, January 5 and 10, 1995.

The amendments revise TS Table 2.2-1 and TS 4.2.5 to allow a change in the method for measuring RCS flow rate from the calorimetric heat balance method to a method based on a calibration of the RCS cold leg elbow differential pressure taps.

A copy of the related Safety Evaluation is also enclosed. A Notice of Issuance will be included in the Commission's biweekly <u>Federal</u> <u>Register</u> notice.

Sincerely,

ORIGINAL SIGNED BY:

Victor Nerses, Senior Project Manager
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket Nos. 50-369 and 50-370

Enclosures:
1. Amendment No. 153 to NPF-9
2. Amendment No. 135 to NPF-17
3. Safety Evaluation

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Janaury 12, 1995

Mr. T. C. McMeekin
Vice President, McGuire Site
Duke Power Company
12700 Hagers Ferry Road
Huntersville, North Carolina 28078

SUBJECT: ISSUANCE OF AMENDMENTS - McGUIRE NUCLEAR STATION, UNITS 1 AND 2, REACTOR COOLANT SYSTEM (RCS) FLOW RATE MEASUREMENT (TAC NOS. M88659 AND M88660)

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OFFICE	PDII-3/LA	PDII-3/PM	OGC	PDII-3/D	
NAME	L. BERRY	V. NERSES		H. BERKOW	
DATE	1/11/95	1/11/95	1/12/95	1/12/95	

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 12, 1995

Mr. T. C. McMeekin
Vice President, McGuire Site
Duke Power Company
12700 Hagers Ferry Road
Huntersville, North Carolina 28078-8985

SUBJECT: ISSUANCE OF AMENDMENTS - McGUIRE NUCLEAR STATION, UNITS 1 AND 2, REACTOR COOLANT SYSTEM (RCS) FLOW RATE MEASUREMENT (TAC NOS. M88659 AND M88660)

Dear Mr. McMeekin:

The Nuclear Regulatory Commission has issued the enclosed Amendment No.153 to Facility Operating License NPF-9 and Amendment No. 135 to Facility Operating License NPF-17 for the McGuire Nuclear Station, Units 1 and 2. The amendments consist of changes to the Technical Specifications (TS) in response to your application dated January 10, 1994, as supplemented September 15, 1994, January 5 and 10, 1995.

The amendments revise TS Table 2.2-1 and TS 4.2.5 to allow a change in the method for measuring RCS flow rate from the calorimetric heat balance method to a method based on a calibration of the RCS cold leg elbow differential pressure taps.

A copy of the related Safety Evaluation is also enclosed. A Notice of Issuance will be included in the Commission's biweekly Federal Register notice.

Sincerely,

Victor Nerses

Victor Nerses, Senior Project Manager
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket Nos. 50-369 and 50-370

Enclosures:
1. Amendment No. 153 to NPF-9
2. Amendment No. 135 to NPF-17
3. Safety Evaluation

cc w/enclosures:
See next page

Mr. T. C. McMeekin
Duke Power Company

McGuire Nuclear Station

cc:
A. V. Carr, Esquire
Duke Power Company
422 South Church Street
Charlotte, North Carolina 28242-0001

County Manager of Mecklenberg County
720 East Fourth Street
Charlotte, North Carolina 28202

Mr. J. E. Snyder
Regulatory Compliance Manager
Duke Power Company
McGuire Nuclear Site
12700 Hagers Ferry Road
Huntersville, North Carolina 28078-8985

J. Michael McGarry, III, Esquire
Winston and Strawn
1400 L Street, NW.
Washington, DC 20005

Senior Resident Inspector
c/o U. S. Nuclear Regulatory Commission
12700 Hagers Ferry Road
Huntersville, North Carolina 28078

Mr. T. Richard Puryear
Nuclear Technical Services Manager
Westinghouse Electric Corporation
Carolinas District
2709 Water Ridge Parkway, Suite 430
Charlotte, North Carolina 28217

Dr. John M. Barry
Mecklenberg County
Department of Environmental Protection
700 N. Tryon Street
Charlotte, North Carolina 28202

Mr. Dayne H. Brown, Director
Department of Environmental, Health and Natural Resources
Division of Radiation Protection
P. O. Box 27687
Raleigh, North Carolina 27611-7687

Ms. Karen E. Long
Assistant Attorney General
North Carolina Department of Justice
P. O. Box 629
Raleigh, North Carolina 27602

Mr. G. A. Copp
Licensing - EC050
Duke Power Company
526 South Church Street
Charlotte, North Carolina 28242-0001

Regional Administrator, Region II
U.S. Nuclear Regulatory Commission
101 Marietta Street, NW. Suite 2900
Atlanta, Georgia 30323

Elaine Wathen, Lead REP Planner
Division of Emergency Management
116 West Jones Street
Raleigh, North Carolina 27603-1335

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

DUKE POWER COMPANY

DOCKET NO. 50-369

McGUIRE NUCLEAR STATION, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 153
License No. NPF-9

1. The Nuclear Regulatory Commission (the Commission) has found that:

A. The application for amendment to the McGuire Nuclear Station, Unit 1 (the facility), Facility Operating License No. NPF-9 filed by the Duke Power Company (licensee) dated January 10, 1994, as supplemented September 15, 1994, January 5 and 10, 1995, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations set forth in 10 CFR Chapter I;

D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is hereby amended by page changes to the Technical Specifications as indicated in the attachment to this license amendment, and Paragraph 2.C.(2) of Facility Operating License No. NPF-9 is hereby amended to read as follows:

   Technical Specifications

   The Technical Specifications contained in Appendix A, as revised through Amendment No. 153 , are hereby incorporated into this license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of its date of issuance and shall be implemented within 30 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Herbert N. Berkow

Herbert N. Berkow, Director
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Attachment:
Technical Specification
  Changes

Date of Issuance: January 12, 1995

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

DUKE POWER COMPANY

DOCKET NO. 50-370

McGUIRE NUCLEAR STATION, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 135
License No. NPF-17

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment to the McGuire Nuclear Station, Unit 1 (the facility), Facility Operating License No. NPF-17 filed by the Duke Power Company (licensee) dated January 10, 1994, as supplemented September 15, 1994, January 5 and 10, 1995, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations set forth in 10 CFR Chapter I;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is hereby amended by page changes to the Technical Specifications as indicated in the attachment to this license amendment, and Paragraph 2.C.(2) of Facility Operating License No. NPF-17 is hereby amended to read as follows:

   Technical Specifications

   The Technical Specifications contained in Appendix A, as revised through Amendment No. **135** , are hereby incorporated into this license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of its date of issuance and shall be implemented within 30 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Herbert N. Berkow

Herbert N. Berkow, Director
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Attachment:
Technical Specification
Changes

Date of Issuance: **January 12, 1995**

ATTACHMENT TO LICENSE AMENDMENT NO. 153

FACILITY OPERATING LICENSE NO. NPF-9

DOCKET NO. 50-369

AND

TO LICENSE AMENDMENT NO. 135

FACILITY OPERATING LICENSE NO. NPF-17

DOCKET NO. 50-370

Replace the following pages of the Appendix "A" Technical Specifications with the enclosed pages. The revised pages are identified by Amendment number and contain vertical lines indicating the areas of change.

Remove Pages	Insert Pages
2-5	2-5
B 2-6	B 2-6
3/4 2-22a	3/4 2-22a
3/4 3-14a	3/4 3-14a
B 3/4 2-5	B 3/4 2-5
B 3/4 2-5a	B 3/4 2-5a

TABLE 2.2-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TRIP SETPOINT	ALLOWABLE VALUES
1. Manual Reactor Trip	N.A.	N.A.
2. Power Range, Neutron Flux	Low Setpoint - ≤ 25% of RATED THERMAL POWER High Setpoint - ≤ 109% of RATED THERMAL POWER	Low Setpoint - ≤ 26% of RATED THERMAL POWER HighSetpoint - ≤ 110% of RATED THERMAL POWER
3. Power Range, Neutron Flux, High Positive Rate	≤ 5% of RATED THERMAL POWER with a time constant ≥ 2 seconds	≤ 5.5% of RATED THERMAL POWER with a time constant ≥ 2 seconds
4. Intermediate Range, Neutron Flux	≤ 25% of RATED THERMAL POWER	≤ 30% of RATED THERMAL POWER
5. Source Range, Neutron Flux	$\leq 10^5$ counts per second	$\leq 1.3 \times 10^5$ counts per second
6. Overtemperature ΔT	See Note 1	See Note 3
7. Overpower ΔT	See Note 2	See Note 4
8. Pressurizer Pressure--Low	≥ 1945 psig	≥ 1935 psig
9. Pressurizer Pressure--High	≤ 2385 psig	≤ 2395 psig
10. Pressurizer Water Level--High	≤ 92% of instrument span	≤ 93% of instrument span
11. Low Reactor Coolant Flow	≥ 91% of minimum measured flow per loop*	≥ 90% of minimum measured flow per loop*

*Minimum measured flow is 95,500 gpm per loop.

Pressurizer Pressure

In each of the pressure channels, there are two independent bistables, each with its own trip setting to provide for a High and Low Pressure trip thus limiting the pressure range in which reactor operation is permitted. The Low Setpoint trip protects against low pressure which could lead to DNB by tripping the reactor in the event of a loss of reactor coolant pressure.

On decreasing power the Low Setpoint trip is automatically blocked by P-7 (a power level of approximately 10% of RATED THERMAL POWER with turbine impulse chamber pressure at approximately 10% of full power equivalent); and on increasing power, automatically reinstated by P-7.

The High Setpoint trip functions in conjunction with the pressurizer relief and safety valves to protect the Reactor Coolant System against system overpressure.

Pressurizer Water Level

The Pressurizer High Water Level trip is provided to prevent water relief through the pressurizer safety valves. On decreasing power the Pressurizer High Water Level trip is automatically blocked by P-7 (a power level of approximately 10% of RATED THERMAL POWER with a turbine impulse chamber pressure at approximately 10% of full equivalent); and on increasing power, automatically reinstated by P-7.

Low Reactor Coolant Flow

The Low Reactor Coolant Flow trips provide core protection to prevent DNB by mitigating the consequences of a loss of flow resulting from the loss of one or more reactor coolant pumps.

On increasing power above P-7 (a power level of approximately 10% of RATED THERMAL POWER or a turbine impulse chamber pressure at approximately 10% of full power equivalent), an automatic Reactor trip will occur if the flow in more than one loop drops below 91% of nominal full loop flow. Above P-8 (a power level of approximately 48% of RATED THERMAL POWER) an automatic Reactor trip will occur if the flow in any single loop drops below 91% of nominal full loop flow. Conversely on decreasing power between P-8 and the P-7 an automatic Reactor trip will occur on loss of flow in more than one loop and below P-7 the trip function is automatically blocked.

3/4.2.5 DNB PARAMETERS

SURVEILLANCE REQUIREMENTS

4.2.5.1 Each of the parameters of Table 3.2-1 shall be measured by averaging the indications (meter or computer) of the operable channels and verified to be within their limits at least once per 12 hours.

4.2.5.2 The RCS total flow rate indicators shall be subjected to a CHANNEL CALIBRATION at least once per 18 months.

4.2.5.3 The RCS total flow rate shall be determined by measurement at least once per 18 months.

TABLE 4.3-1 (Continued)

TABLE NOTATION

(11) - The TRIP ACTUATING DEVICE OPERATIONAL TEST shall independently verify the OPERABILITY of the undervoltage and shunt trip circuits for the Manual Reactor Trip Function.

(12) - The TRIP ACTUATING DEVICE OPERATIONAL TEST shall independently verify the OPERABILITY of the undervoltage and shunt trip attachments of the Reactor Trip Breakers.

(13) - Prior to placing breaker in service, a local manual shunt trip shall be performed.

(14) - The automatic undervoltage trip capability shall be verified operable.

(15) - Overtemperature setpoint, overpower setpoint, and T_{avg} channels require an 18 month channel calibration. Calibration of the ΔT channels is required at the beginning of each cycle upon completion of the precision heat balance. RCS loop ΔT values shall be determined by precision heat balance measurements at the beginning of each cycle.

3/4.2.4 QUADRANT POWER TILT RATIO

The QUADRANT POWER TILT RATIO limit assures that the radial power distribution satisfies the design values used in the power capability analysis. Radial power distribution measurements are made during STARTUP testing and periodically during power operation.

The limit of 1.02, at which corrective action is required provides DNB and linear heat generation rate protection with the x-y plane power tilts. The peaking increase that corresponds to a QUADRANT POWER TILT RATIO of 1.02 is included in the generation of the AFD limits.

The 2-hour time allowance for operation with a tilt condition greater than 1.02 but less than 1.09 is provided to allow identification and correction of a dropped or misaligned rod. In the event such action does not correct the tilt, the margin for uncertainty on $F_Q(X,Y,Z)$ is reinstated by reducing the power by 3% from RATED THERMAL POWER for each percent of tilt in excess of 2.0%.

For purposes of monitoring QUADRANT POWER TILT RATIO when one excore detector is inoperable, the moveable incore detectors are used to confirm that the normalized symmetric power distribution is consistent with the QUADRANT POWER TILT RATIO. The incore detector monitoring is done with a full incore flux map or two sets of four symmetric thimbles.

3/4.2.5 DNB PARAMETERS

The limits on the DNB-related parameters assure that each of the parameters are maintained within the normal steady-state envelope of operation assumed in the transient and accident analyses. The limits are consistent with the initial FSAR assumptions and have been analytically demonstrated adequate to maintain a design limit DNBR throughout each analyzed transient. As noted on Figure 3.2-1, RCS flow rate and THERMAL POWER may be "traded off" against one another (i.e., a low measured RCS flow rate is acceptable if the power level is decreased) to ensure that the calculated DNBR will not be below the design DNBR value. The relationship defined on Figure 3.2-1 remains valid as long as the limits placed on the nuclear enthalpy rise hot channel factor, $F_{\Delta H}(X,Y)$, in Specification 3.2.3 are maintained. The indicated T_{avg} values and the indicated pressurizer pressure values correspond to analytical limits of 592.6°F and 2220 psia respectively, with allowance for indication instrumentation measurement uncertainty. When RCS flow rate is measured, no additional allowances are necessary prior to comparison with the limits of Figure 3.2-1 since an RCS total flow rate measurement uncertainty, greater than or equal to the value stated on Figure 3.2-1 has been allowed for in determination of the design DNBR value.

3/4.2.5 DNB PARAMETERS (Continued)

The measurement error for RCS total flow rate is based upon the performance of past precision heat balances. Sets of elbow tap coefficients, as determined during these heat balances, were averaged for each elbow tap to provide a single set of elbow tap coefficients for use in calculating RCS flow. This set of coefficients establishes the calibration of the RCS flow rate indicators and becomes the set of elbow tap coefficients used for RCS flow measurement. Potential fouling of the feedwater venturi, which might not be detected, could bias the result from these heat balances in a non-conservative manner. Therefore, a penalty of 0.1% for undetected fouling of the feedwater venturi is included in Figure 3.2-1. Any fouling which might bias the RCS flow rate measurement greater than 0.1% can be detected by monitoring and trending various plant performance parameters. If detected, action shall be taken before performing subsequent precision heat balance measurements, i.e., either the effect of the fouling shall be quantified and compensated for in the RCS flow rate measurement or the venturi shall be cleaned to eliminate the fouling.

The 12-hour periodic surveillance of these parameters through instrument readout is sufficient to ensure that the parameters are restored within their limits following load changes and other expected transient operation. Indication instrumentation measurement uncertainties are accounted for in the limits provided in Table 3.2-1.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 153 TO FACILITY OPERATING LICENSE NPF-9

AND AMENDMENT NO. 135 TO FACILITY OPERATING LICENSE NPF-17

DUKE POWER COMPANY

MCGUIRE NUCLEAR STATION, UNITS 1 AND 2

DOCKET NOS. 50-369 AND 50-370

Since a single request was made by Duke Power Company for changes to the McGuire and Catawba Nuclear Stations, Units 1 and 2, Technical Specifications, a single safety evaluation was prepared to cover the request.

1.0 INTRODUCTION

By letter dated January 10, 1994 (Ref.1), as supplemented September 15 and March 21, 1994, and January 5 and 10, 1995, Duke Power Company (DPC or the licensee) requested changes to the Technical Specifications (TSs) for the Catawba and McGuire Nuclear Stations, Units 1 and 2. These changes were related to a change in the method for measuring reactor coolant system (RCS) flow rate. The minimum RCS flow rate requirement is related to Departure from Nucleate Boiling (DNB) parameters for steady-state operation and also impacts the TS for reactor trip on low reactor coolant flow (Table 2.2-1). The September 15, 1994, January 5 and 10, 1995, letters provided clarifying information that did not change the scope of the January 10, 1994, application, the Federal Register Notice, or the initial proposed no significant hazards consideration determination.

The method of measuring the RCS flow rate proposed by DPC depends on data from past historical calorimetric heat balances (CHBs) used for calibrating the cold leg elbow taps. The proposed method results in a higher RCS flow rate as the effect from an overly conservative hot leg streaming bias is reduced.

Based upon the CHB method, the Catawba TS allows for a tradeoff of 2% power for each 1% reduction in RCS flow rate up to a 10% reduction in RCS flow rate. Catawba Unit 1 was operating at 98% of full power as it could not meet the full power RCS flow rate requirements of TS 4.2.5.3. Therefore, the proposed method was initially reviewed for Catawba Unit 1 only as a short-term solution to enable operation at full power for the remainder of the current cycle 8 operation. The short-term solution was evaluated and was found to be acceptable for the remainder of the cycle 8 (Ref. 11).

Subsequent to the short-term approval, the review continued in order to determine the acceptability as a permanent solution. Additional information was supplied by DPC in the meeting summaries of February 10, 1994 (Ref. 2) and March 16, 1994 (Ref. 3) and letters of March 21, 1994 (Ref. 9), September 15, 1994 (Ref. 10), January 5, 1995 (Ref. 12), and January 10, 1995 (Ref. 13).

The licensee requested that the following TSs be modified to reflect the changes required from the proposed method of measuring RCS flow:

A. Catawba, Units 1 and 2:

1) Table 2.2-1, Reactor Trip System Instrumentation Trip Setpoints, Functional Unit 11: The trip setpoint for the minimum measured flow rate limit per loop was changed from equal or greater than 90% to equal or greater than 91%. The allowable value was changed from equal or greater than 88.9% to equal or greater than 89.7%.

2) TS 3/4.2.5 DNB Parameters: for 4.2.5.3. For the method of measuring RCS flow rate, the "precision heat balance" requirement was removed.

3) Figure 3.2-1, Reactor Coolant System Total Flow Rate Versus Rated Thermal Power - Four Loops in Operation. The flow measurement uncertainty value was changed from 2.2% to 1.9%.

4) TS B 3/4.2.5 DNB Parameters:

Remove "measurement error of 2.1%" and add "measurement uncertainty, greater than or equal to the value stated on Figure 3.2-1".

Remove discussion on obtaining RCS total flow rate from precision heat balance.

Insert the following:

"The measurement error for RCS total flow rate is based upon the performance of past heat balances. Sets of elbow tap coefficients, as determined during these heat balances, were averaged for each elbow tap to provide a single set of elbow tap coefficients for use in calculating RCS flow. This set of coefficients establishes the calibration of the RCS flow rate indicators and becomes the set of elbow tap coefficients used for RCS flow measurement. Potential fouling of the feedwater venturi, which might not be detected, could bias the result from these heat balances in a non-conservative manner."

B. McGuire, Units 1 and 2:

1) Table 2.2-1, Reactor Trip System Instrumentation Trip Setpoints, Functional Unit 11: The trip setpoint for minimum measured flow limit per loop was changed from equal or greater than 90% to equal or greater than 91%. The allowable value was changed from equal or greater than 88.8% to equal or greater than 90%.

2) TS 3/4.2.5 DNB Parameters: for 4.2.5.3. For the method of measuring RCS flow rate, the "precision heat balance" requirement was removed. Also removed were the phrases, "of Surveillance 4.2.3.5" and "in connection with Surveillance 4.2.3.5" under Table Notation in Table 4.3-1.

3) Figure 3.2 -1, Reactor Coolant System Total Flow Rate Versus Rated Thermal Power - Four Loops in Operation. The flow measurement uncertainty value was changed from 1.7% to 1.8%.

4) TS B 3/4.2.5 DNB Parameters:

   Remove "measurement error of 1.7%" and add "measurement uncertainty, greater than or equal to the value stated on Figure 3.2-1". Remove discussion on obtaining RCS total flow rate from precision heat balance.

   Insert the following:

   "The measurement error for RCS total flow rate is based upon the performance of past heat balances. Sets of elbow tap coefficients, as determined during these heat balances, were averaged for each elbow tap to provide a single set of elbow tap coefficients for use in calculating RCS flow. This set of coefficients establishes the calibration of the RCS flow rate indicators and becomes the set of elbow tap coefficients used for RCS flow measurement. Potential fouling of the feedwater venturi, which might not be detected, could bias the result from these heat balances in a non-conservative manner."

2.0 BACKGROUND

Because of the effect of the current use of low leakage core loading in the DPC plants, there is increased hot leg temperature streaming. The lower leakage core designs have a higher percentage of the core power produced in the inner core regions. This leads to an increased temperature distribution (skewing) within the hot leg due to incomplete mixing in the upper plenum. Therefore, the CHB method for obtaining RCS flow rate now has more uncertainty.

Because of the skewing of the temperature profile from the increased hot leg streaming, the three resistance temperature devices (RTDs) in each hot leg have overstated the average bulk temperature, resulting in an overly conservative temperature bias. This results in a reduced RCS flow rate value. This problem from increased hot leg temperature streaming is common in various degrees to other plants using low leakage core loading. Therefore DPC has proposed another method using the cold leg elbow taps to measure the RCS flow rate.

In addition to the added conservatism from hot leg temperature streaming, there are other effects that are adversely affecting the RCS flow rate, such

as the degradation of the steam generator (SG) tubes. This necessitates that tubes be plugged or sleeved, which increases the pressure drop in the steam generators and consequently reduces flow rate through the core. Other changes that can affect the RCS flow rate are changes in fuel design and possibly pump wear. As a result of these effects it is more difficult to ensure meeting the Technical Specification (TS) minimum flow requirements. These effects contributed to the inability of Catawba Unit 1 to meet the TS minimum RCS flow requirement using the CHB method.
The evaluation of the proposed method includes the following topics below: (1) introduction, (2) current method of RCS flow rate measurement, (3) DPC-proposed new method for RCS flow measurement, (4) assessment of the long-term solution for DPC RCS flow rate measurement, (5) the flow measurement uncertainty, and (6) changes to the reactor trip setpoints.

3.0 EVALUATION

3.1 Introduction

The RCS flow rate is one of the inputs for calculation of the Departure from Nucleate Boiling Ratio (DNBR). The transient and accident analyses include as inputs initial conditions of RCS thermal design flow. The minimum RCS flow rate requirement in the Technical Specifications is consistent with the assumed RCS thermal design flow.

The criteria established in 10 CFR 50, Appendix A, require a high degree of assurance that specified acceptable fuel design limits (SAFDL) are not exceeded. The SAFDLs for anticipated operational occurrences (AOO) are that neither DNB nor melting at the fuel centerline occurs. The results of the safety analyses calculation are used to assure that the SAFDLs are met. The nuclear industry has developed Limiting Safety System Settings (LSSS) methodologies which combine uncertainties statistically. The validity of such methodologies requires that input uncertainties be statistically valid.

The various aspects of RCS flow rate measurement using both the DPC current and proposed methodology are discussed below.

3.2 Aspects of Current DPC Method of RCS Flow Rate Measurement

3.2.1 Current Method for RCS Flow Rate Measurement

In the current method, the RCS flow rate is obtained from a calorimetric heat balance (CHB) which is taken on each side of the steam generator. The flow rate on the secondary side is measured by the laboratory calibrated feedwater venturi meters. The primary side heat balance in conjunction with the secondary side heat balance is used to derive the RCS flow rate.

The accuracy of this method of obtaining the RCS flow rate is based on a detailed flow measurement uncertainty (FMU) analysis for the plant-specific instrumentation which requires evaluation and approval by the NRC. Originally most plants used a FMU of 3.5% which was considered to be a very conservative value. Currently, most plants have a FMU uncertainty value less that 3.5% based on approved methods for combining uncertainties, such as related to setpoint methodology (Ref. 4, 5, 6 and 7) and other guidance for assessing uncertainties provided by NRC (Ref. 8). The RCS flow rate is measured within the desired probability and confidence level. The errors in parameters for obtaining flow measurement include errors classified as precision (random) errors and bias (fixed) errors. These are combined to obtain the overall uncertainty. The FMU value is documented in the Technical Specifications and is needed to assure that the minimum RCS measured flow rate is above the RCS thermal design flow.

3.2.2 Elbow Tap Configuration

The DPC cold leg elbow tap configuration for RCS flow rate measurement is not calibrated in advance in a laboratory. However, the cold leg elbow pressure drop is benchmarked (normalized) against the established RCS flow rate for each cycle based on the single full power data point calculated from the precision calorimetric heat balance (CHB) at each refueling. Although DPC benchmarked RCS flow at 100% power to flow, a benchmark at 90% power to flow to coincide with the Low Flow Trip would provide more conservatism. However, the impact of this change would be minimal.

The purpose of the elbow tap reading for the CHB method is to ascertain that the full-power steady-state flow rate has not decreased during the cycle. The elbow tap pressure drop is also used to measure the reduced RCS flow rate for the low flow reactor trip. This is accomplished by using the relationship between pressure drop and flow rate from the full-power calorimetric heat balance data point to obtain an elbow tap flow correlation coefficient from which to extrapolate a flow rate value.

The licensee provided information (Ref. 3) regarding the use of the cold leg elbow taps for the Catawba and McGuire plants. The pressure drops are obtained from three sets of pressure taps in each of the cold leg elbows. After a short pipe run from the steam generator exit, the RCS flow from the steam generator flows through a 31" inside diameter pipe in a relatively short pipe run to the RCS pump. This pipe run includes two 90 degree pipe bends separated by a short straight pipe run. The elbow taps are located in a plane 22 degrees and 30 seconds after the start of the first 90 degree elbow turn. One tap is located on the outside pipe radius. This tap is used as a common tap to obtain three sets of pressure drop data in connection with three other taps located close to each other on the inside pipe radius.

3.3 DPC Proposed New Method for RCS Flow Rate Measurement

3.3.1 RCS Flow Rate Compared to Hydraulic Calculations

The licensee presented the results of a study relating to their proposed new method for RCS flow rate measurement. This study included pertinent data compiled from the past refuelings that related to the RCS flow rate measurement. The data and information for each cycle included:

1. the FMU value,
2. RCS flow rate obtained from the calorimetric heat balance,
3. elbow tap pressure drop (inches of water),

4. the cold leg water density
5. calculated elbow tap flow coefficient from the CHB,
6. amount of steam generator tube plugging,
7. hot leg temperature for each RTD in each of the three loops,
8. delta T temperature (Thot- Tcold),
9. modifications (such as, steam generator tube plugging, changes in fuel type, upflow modifications, elbow tap transmitters replaced),

The licensee made hydraulic calculations to demonstrate their ability to accurately obtain the estimated RCS flow rate for each cycle using the initial RCS pump flow rate test data. The RCS pump test data was used with pressure drop calculations of the primary loop to predict the best estimate RCS flow rate for each cycle. The calculations included those for the primary system in its original condition during the first cycle and then for succeeding cycles. The calculations for each cycle included the cumulative effects of changes from modifications such as steam generator tube plugging, fuel type, upflow modifications, etc.

The licensee compared the RCS flow rates for the previous cycles from three methods: (1) predictions from hydraulic calculations, (2) the current CHB method, and (3) a proposed elbow tap method explained in Section 3.3.2.

As an example, the results from the first two methods applied to Catawba Unit 1 (the methods are also applicable to McGuire) are shown in Figure 1 and indicate that when the plant was initially started there was a relatively close agreement between the RCS flow rate predicted from the hydraulic calculation and the RCS flow rate calculated from the CHB. This relatively close agreement (except for the data point between 1988 and 1990) follows until 1991. In succeeding cycles after 1991, the two methods deviate, with the CHB method showing less RCS flow rate than that from the hydraulic calculation method. The difference is understood to be due to the overly conservative effects on the CHB method from hot leg streaming introduced with low leakage core loading.

Figure 1 indicates that the RCS flow rate for Catawba Unit 1 for the current cycle 8 using the CHB method for RCS flow rate is less than the TS limit of 382,000 gpm for full power operation. Figure 1 also indicates that the flow rate obtained by the use of the proposed elbow tap method has a value that is greater than the TS limit.

3.3.2 <u>Proposed New Method for RCS Flow Measurement Using Elbow Taps</u>

In the new method proposed by DPC, the RCS flow rate is measured by using the elbow tap ΔPs and the cold leg density to calculate the flow rate. The flow rate is proportional to the square root of the ΔP as measured by the elbow taps.

In the new method proposed by DPC, the flow correlation coefficient is first obtained from the equation below for each elbow tap using data from past calorimetric heat balances.

$$K_i = m_i/\sqrt{(\Delta P_i)(\rho_i)}$$

where: K_i = the elbow tap flow correlation coefficient,

m_i = the RCS flow rate measured with the precision CHB,

ΔP_i = the elbow tap pressure drop measurement, and

ρ_i = the cold leg density.

This past data is used as a standard to obtain a flow correlation coefficient for the elbow tap readings. The final flow coefficient value for each elbow tap is based on the average value from past cycles.

The flow rate is calculated for each of the three elbow taps in a loop. Then the three flows are averaged to obtain the loop flow. The loop flows are then added to obtain the total RCS flow rate.

The flow coefficients (per loop elbow tap) as obtained from the above method are proposed to be "frozen" for all future cycles. The selection of the "frozen" K value (elbow tap coefficient) is influenced by the number of cycles chosen on which to base the K value. The flow coefficients from the previous cycles include the early ones, which did not have the conservatism due to hot leg streaming, as well as the later flow coefficients, which have added conservatism from hot leg streaming. The flow coefficients proposed by DPC for the Catawba and McGuire plants are listed in Table 1.

3.3.3 Approaches for Elbow Tap Based Flow Indication

3.3.3.1 Use of Elbow Taps

In using elbow taps for indication of RCS flow rate, one should assure that:

1. There is reasonable confirmation that the elbow tap correlation used to determine RCS flow rate is accurate to within a known uncertainty and bias or that the perceived rate (correlation determined rate including uncertainty and bias) is less than the actual flow rate.

2. There is reasonable confirmation to assure that the proposed method of determining RCS flow rate remains within acceptable bounds of accuracy.

Reasonable confirmation that the originally determined RCS flow rate is accurate to within a known uncertainty and/or that it is less than the actual flow rate should be supported by either:

- Applicable flow test data that correlates RCS flow instrumentation to flow rate, or

- Some other method of correlating RCS flow rate to the RCS flow instrumentation.

3.3.3.2 <u>Assurance to Show that Correlation Remains Viable</u>

With an elbow tap correlation and an acceptance bound established, there is need is to assure that the correlation remains viable. A reasonable approach is to provide an analysis program that correlates all physical changes in the RCS flow path to the RCS flow rate and use this for confirmation of the elbow tap measurements of flow rate.

To confirm this, one should demonstrate that the elbow tap-based flow rate indication is within the uncertainty bound that was established for the elbow tap correlation when compared to an analysis prediction. Primary emphasis upon the analysis is acceptable since no change in elbow tap correlation is anticipated when physical changes are made in the plant.

An acceptable analysis program is one that accurately calculates plant changes in pump performance, core bundle changes, SG tube plugging, SG tube sleeving, SG replacement, and any other physical changes in the RCS that affect the RCS flow rate (the same criteria as applied to the above confirmation process).

Acceptability is established by comparing analysis results with available plant data.

1. If the proposed elbow tap correlation is "best-estimate," then the staff will expect a direct comparison of elbow tap determined flow rate based upon the proposed elbow tap correlation.

2. If the elbow tap correlation is conservative, then the staff will expect two comparisons - one with a best-estimate correlation coefficient that provides the best fit to the analysis and the other with the proposed correlation.

3. If the elbow tap determined flow rate crosses over and becomes less conservative than the analytically determined flow rate, the NRC should be contacted for further review of acceptability.

3.4 <u>Assessment of the DPC Proposed Method for RCS Flow Rate Measurement</u>

The staff believes that the most important potential safety need directly associated with RCS flow rate is maintenance of an adequate margin to prevent departure from nucleate boiling. The next safety need is providing reactor trip due to a low RCS flow rate, with the concerns being departure from nucleate boiling and an overtemperature condition. However, the importance of RCS flow rate to reactor trip is diminished by other trip parameters, such as loss of pump power, too large a temperature difference between the hot and cold legs, or high pressure; trip parameters that will often cause trip prior to a flow rate trip.

The inaccuracy of the current method of obtaining RCS flow rate by a CHB is due to hot leg streaming. In regard to this, DPC stated (Ref. 10) that the only information available regarding the temperature distribution in the hot leg is from the hot leg RTDs themselves. This information does not provide enough data points to give an accurate temperature profile.

The DPC-proposed method uses the cold leg elbow taps to measure the RCS flow rate as an equivalent but more accurate method than the CHB method. This is the basis on which the staff evaluation is made. The DPC method uses a number of previous determinations of elbow tap correlation coefficients, K_i to "freeze" the value of K_i. It uses the K_i to obtain RCS loop flow rates without further calorimetric calibrations. These elbow tap coefficients are listed in Table 1 and are based on 6 cycles of data for Catawba Units 1 and 2, and 5 and 8 cycles of data for McGuire Units 1 and 2, respectively (Ref. 13).

3.4.1 <u>Review of Possible Detrimental Effects in the Use of Elbow Taps</u>

The licensee presented information (Ref. 10) to support the conclusion that the components exposed to water in the elbow tap differential pressure instrumentation do not change over the life of the plant. Deposits in the RCS from impurities in the reactor coolant are expected to be small or nonexistent. Most deposits of impurities in the reactor coolant are expected to occur in the hottest portions of the RCS and in regions experiencing the lowest flow. If preferential deposits were to occur in the region of the taps, the reduction in pipe diameter would be extremely small in comparison to the diameter of the cold leg (31"). Fouling or deposits within the instrument tubing between the elbow tap and the differential pressure instrument is not a concern since no flow is transmitted within the tubing.

In addition, DPC stated (Ref. 10) that erosion (flow accelerated corrosion) is not a concern since the velocity of the RCS fluid is small relative to velocities known to cause erosion in stainless steel. Erosion of the RCS piping will be small or nonexistent during plant life.

The licensee stated (Ref. 10) that the elbow taps have been positioned on the elbow in such a manner that velocity pressure components and turbulence effects are minimized while not impacting the differential pressure indications. Since the piping between the elbow tap and the differential pressure instrument is used to transmit the pressure signal only, any velocity component of the turbulent RCS flow which is imparted to the tap location will result in random noise in the pressure signal. To check for effects which may affect the calibration of the elbow meter, comparisons to the analytical flow model prediction of flow will be used to determine the extent to which the elbow tap calculated flow reflects actual flow changes.

The staff has judged that the DPC explanations are reasonable and has therefore accepted the DPC explanations as to why the above effects, including crud buildup, fouling, erosion and turbulence, do not affect the accuracy of the flow rate values for the Catawba and McGuire plants.

3.4.2 <u>DPC Analytic Model for Flow Rate Prediction</u>

As stated in Section 3.3.3, a reasonable analytic RCS flow model is one that accurately predicts flow meter indication changes following known changes to the RCS configuration. The flow model must correctly calculate the effect of changes such as those from steam generator tube plugging and sleeving and from replacing fuel bundles with bundles having different flow characteristics.

The licensee presented information (Ref. 10) on their analytic RCS flow model for application to the Catawba and McGuire plants. This information included the applicable equations. The licensee stated (Ref. 12) that the analytic model was formulated and reviewed under a quality assurance program which meets the requirement of 10 CFR Appendix B (QA Condition 1). Tables of information were presented of: (1) detailed RCS loop pressure drops, (2) flow fractions used to adjust the ΔPs in the downcomer and the core regions, (3) pressure drops for several types of fuel in different regions (bottom nozzle, core, top nozzle) for full and partial cores, (4) steam generator input for pressure drop calculations, (5) reactor coolant pump head curves, and (6) information on tube plugging. Duke Power provided information showing that the RCS flow rates from the analytic model predict the flow rate from the first cycle to the current cycle.

The staff review of the results indicate that the analytic model has inputs for calculating RCS flow rates that account for changes in the configuration, such as changes in type of fuel and various degrees of steam generator tube plugging. Since the results of the flow rate from the analytic model compare reasonably well to the data, as indicated below in Section 3.4.3, the results confirm the validity of the analytic model. We, therefore, find the analytic flow model to provide an acceptable prediction of the RCS flow rate.

3.4.3 <u>DPC Flow Calibration Process and Comparison to Analytic Prediction</u>

The licensee presented the results for the RCS flow rate obtained for each of the 4 loops for both the Catawba and McGuire plants from two methods: (1) the elbow tap ΔP readings, using the proposed elbow tap coefficients shown in Table 1, and (2) the analytic model.

For example, for Catawba Unit 1, the data for individual loop flows as determined by elbow tap ΔP's from the period from 1985 to 1993 were presented for each of the 4 loops (Figure 14 of Ref. 10). Similar data were presented for the individual loop flows as determined by the analytic flow model (Figure 17 of Ref. 10). The cycles during this period included changes due to SG tube plugging and changes in fuel type.

The licensee pointed out that some of the data from the elbow tap readings were bad due to excessive drifting of some of the pressure transmitters and therefore were eliminated. The staff understands that DPC continually examines the elbow tap data carefully in order to obtain the correct RCS flow values.

The licensee noted that since the startup of Catawba Unit 1, the calorimetric flows following the November 1987 calorimetric have basically trended downward consistent with the trend in ΔT, but in excess of that expected by plant geometry changes. Since plant startup, the calorimetrics have indicated that the total RCS flow has dropped approximately 21,000 gpm (Figure 13 of Ref. 12), whereas the elbow tap and analytic model flow have indicated a drop in total flow of approximately 9,000 gpm and 5,000 gpm respectively (Figures 14 & 16 of Ref. 12). The difference between these flow indications is the excess elbow tap ΔP transmitter drift during the early calorimetrics which caused the unsubstantiated indicated flow increase. This indicates a significant impact from hot leg streaming as it shows that 12,000 to 16,000 gpm of the calorimetric flow decrease can be attributed to the hot leg streaming phenomenon.

The individual loop flows varied. However, for the Catawba Unit 1 plant, the two methods for obtaining RCS flow (elbow tap ΔP and analytic model) were shown to agree within a band of approximately 2%. The two methods are in closer agreement in the early cycles when there was less effects from hot leg streaming. The method using the elbow tap flow rate provided the more conservative values. As long as the elbow tap flow rate values are more conservative than the values from the analytic method, the staff finds the use of the elbow tap method for RCS flow rate measurement to be acceptable.

The licensee also provided results, using the same comparisons as above, for the Catawba Unit 2 and McGuire Units 1 and 2 plants.

With respect to the calorimetric heat balance (CHB) test, the staff agrees that its usage for calibration of elbow tap instrumentation can be discontinued. However, DPC committed (Ref. 12) to continue the CHB. This is used for other needs and it can be used as part of the program to assure discovery of unexpected behavior.

3.4.4 Conclusions on Use of Elbow Taps for RCS Flow Measurement

The staff has reviewed the DPC proposed method for measuring RCS flow rate by means of the cold leg elbow taps for the Catawba and McGuire plants. Both plants use the elbow tap coefficients shown in Table 1 of this evaluation which were obtained from Reference 1. The licensee is to submit for NRC review and approval any future changes for the elbow tap coefficients as documented in Table 1.

In general, the licensee should follow the approaches listed in Section 3.3.3. This includes the need for an analytic program which correlates all physical changes in the RCS flow path to the RCS flow rate in advance and which will be used for the confirmation of the elbow tap measurements of flow rate. Also, if the elbow tap-determined flow rate approaches crossing over and becoming less conservative than the analytically determined flow rate, the NRC must be contacted for further review of the methodology. The licensee committed to this action and also committed to the following:

- continue to perform calorimetric heat balance testing as before,
- notify the NRC of any changes to the hydraulic flow model in a manner which affects the results of the model,
- notify the NRC of any change in the use of the calorimetrics and fuel cycles data.

These committments were documented in letters from DPC dated January 5 (Ref. 12) and January 10, 1995 (Ref. 13).

The elbow taps provide a pressure of several hundred inches of water. The elbow tap configuration makes it less precise over a range of flow conditions than a venturi, but the restricted usage to the small range of Reynold's Numbers associated with variation within normal power operations should help alleviate such concerns. Once calibrated, and provided uncertainty and any potential hardware changes are correctly considered, the staff finds the elbow tap method of obtaining RCS flow rate to be acceptable.

3.5 Flow Measurement Uncertainty

The DPC request for a change in the flow measurement uncertainty (FMU) value was not reviewed by the staff. The licensee withdrew the request for this change (Ref. 12). Therefore, it is not necessary to address any changes to Figure 3.2-1 related to flow measurement uncertainty.

3.6 Changes to Reactor Trip Setpoints

The staff also reviewed the changes in the reactor trip setpoints in Table 2.2-1 for both the Catawba and McGuire plants. These changes were to account for the new method of measuring the RCS flow rate. These changes account for an increase in the channel statistical allowance for the low flow trip signal attributable to the inclusion of allowances for elbow tap uncertainties since these will no longer be normalized each 18 months by the CHB process. Based on the review of the reactor trip measurement uncertainties, the staff finds the proposed low flow trip setpoints and allowable values to be acceptable.

4.0 Technical Specification Changes

The Technical Specifications changes proposed by DPC are noted in Section 1.0. Except for the TS on Figure 3.2-1 relating to the FMU, which DPC withdrew as noted in Section 3.5, all were found to be acceptable based on the above evaluations by the staff.

Based on the evaluation in Section 3.0, the staff has found the TS changes to be acceptable for the Catawba and McGuire plants.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the North Carolina State official was notified of the proposed issuance of the amendments. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

The amendments change requirements with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding (59 FR 7688 dated February 16, 1994). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: H. Balukjian

Date: January 12, 1995

8.0 REFERENCES

1. Letter from M. S. Tuckman, DPC, to USNRC, dated January 10, 1994.

2. NRC Summary of February 10, 1994, meeting with Duke Power Company on RCS Flow Measurement Methodology, dated April 13, 1994 (includes DPC answers to request for additional information).

3. NRC Summary of March 16, 1994, meeting with Duke Power Company on RCS Flow Measurement Methodology, dated April 6, 1994 (includes DPC responses to request for additional information, dated March 7, 1994).

4. USNRC Regulatory Guide 1.105, "Instrument Setpoints for Safety-Related Systems."

5. Criterion 13, "Instrumentation and Control," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50.

6. Criterion 20, "Protection System Function," of Appendix A to 10 CFR 50.

7. ISA-S67.04-1982, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

8. NUREG/CR-3659, A Mathematical Model for Assessing the Uncertainties of Instrumentation Measurements for Power and Flow of PWR Reactors, 1984.

9. Letter from M. S. Tuckman, DPC, to USNRC, dated March 21, 1994.

10. Letter from M. S. Tuckman, DPC, to USNRC, dated September 15, 1994.

11. Letter from R. E. Martin, NRC, to D. Rehn, DPC, dated March 30, 1994, transmitting Amendments 110 and 116 to licenses NPF-35 and NPF-52 for Catawba Units 1 and 2, respectively.

12. Letter from M. S. Tuckman, DPC, to USNRC, dated January 5, 1995.

13. Letter from M. S. Tuckman, DPC, to USNRC, dated January 10, 1995.

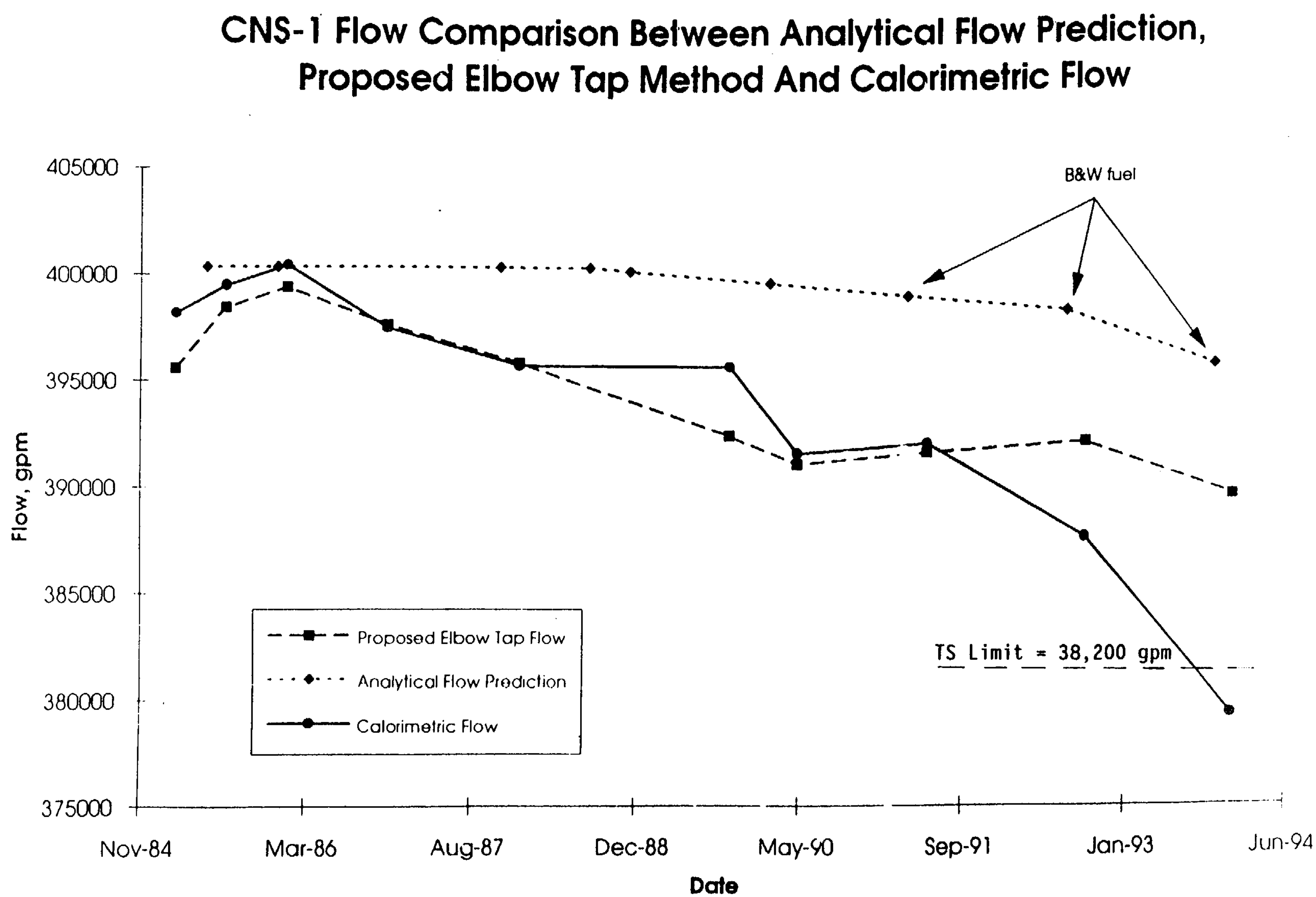
CNS-1 Flow Comparison Between Analytical Flow Prediction,
Proposed Elbow Tap Method And Calorimetric Flow
405000
400000
395000
390000
385000
380000
375000
Flow, gpm
B&W fuel
Proposed Elbow Tap Flow
Analytical Flow Prediction
Calorimetric Flow
TS Limit = 38,200 gpm
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Date

Figure - 1

TABLE - 1

Elbow Tap Coefficients

Taps	McGuire Unit 1	McGuire Unit 2	Catawba Unit 1	Catawba Unit 2
Loop A, Tap I	0.30695	0.30174	0.29773	0.30365
Loop A, Tap II	0.29821	0.29183	0.29348	0.29183
Loop A, Tap III	0.30203	0.29781	0.29515	0.30020
Loop B, Tap I	0.28441	0.29909	0.30410	0.30021
Loop B, Tap II	0.28409	0.29163	0.30803	0.28332
Loop B, Tap III	0.28722	0.29173	0.30444	0.30258
Loop C, Tap I	0.28624	0.29155	0.28915	0.31370
Loop C, Tap II	0.31312	0.29399	0.28489	0.29362
Loop C, Tap III	0.29923	0.29250	0.29097	0.30150
Loop D, Tap I	0.30704	0.30037	0.30331	0.29698
Loop D, Tap II	0.29401	0.29755	0.29932	0.29685
Loop D, Tap III	0.30174	0.29844	0.31051	0.29886