ATTACHMENT 1

Proposed McGuire Unit 1 and 2 Technical Specifications Changes

SURVEILLANCE REQUIREMENTS

4.2.2.1 The provisions of Specification 4.0.4 are not applicable.

4.2.2.2 For RAOC operation, $F_Q(z)$ shall be evaluated to determine if $F_Q(z)$ is within its limit by:

a. Using the movable incore detectors to obtain a power distribution map at any THERMAL POWER greater than 5% of RATED THERMAL POWER.

b. Increasing the measured $F_Q(z)$ component of the power distribution map by 3% to account for manufacturing tolerances and further increasing the value by 5%** to account for measurement uncertainties. Verify the requirements of Specification 3.2.2 are satisfied.

c. Satisfying the following relationship:

$$F_Q^M(z) \leq \frac{F_Q^{RTP} \times K(z)}{P \times W(z)} \text{ for } P > 0.5$$

$$F_Q^M(z) \leq \frac{F_Q^{RTP} \times K(z)}{W(z) \times 0.5} \text{ for } P \leq 0.5$$

where $F_Q^M(z)$ is the measured $F_Q(z)$ increased by the allowances for manufacturing tolerances and measurement uncertainty, F_Q^{RTP} is the F_Q limit, K(z) is the normalized $F_Q(z)$ as a function of core height, P is the relative THERMAL POWER, and W(z) is the cycle dependent function that accounts for power distribution transients encountered during normal operation. F_Q^{RTP}, K(z), and W(z) are specified in the CORE OPERATING LIMITS REPORT per Specification 6.9.1.9.

d. Measuring $F_Q^M(z)$ according to the following schedule:

INSERT NOTE FROM FOLLOWING PAGE HERE

1. Upon achieving equilibrium conditions after exceeding by 10% or more of RATED THERMAL POWER, the THERMAL POWER at which $F_Q(z)$ was last determined,* or

2. At least once per 31 Effective Full Power Days, whichever occurs first.

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*During power escalation at the beginning of each cycle, power level may be increased until a power level for extended operation has been achieved and a power distribution map obtained.

NOTE TO BE INSERTED ON PAGE 3/4 2-7:

** For Unit 1, cycle 7, when the number of available moveable detector thimbles is greater than or equal to 50% and less than 75% of the total, the 5% measurement uncertainty shall be increased to [5% + (3 − T/14.5)(2%)] where T is the number of available thimbles.

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e. With measurements indicating

$$\underset{\text{over } z}{\text{maximum}} \left(\frac{F_Q^M(z)}{K(z)} \right)$$

has increased since the previous determination of $F_Q^M(z)$ either of the following actions shall be taken:

1) $F_Q^M(z)$ shall be increased by 2% over that specified in Specification 4.2.2.2c. or

2) $F_Q^M(z)$ shall be measured at least once per 7 Effective Full Power Days until two successive maps indicate that

$$\underset{\text{over } z}{\text{maximum}} \left(\frac{F_Q^M(z)}{K(z)} \right) \text{ is not increasing.}$$

f. With the relationships specified in Specification 4.2.2.2c. above not being satisfied:

1) Calculate the percent $F_Q(z)$ exceeds its limit by the following expression:

$$\left\{ \left(\underset{\text{over } z}{\text{maximum}} \left[\frac{F_Q^M(z) \times W(z)}{\frac{F_Q^{RTP}}{P} \times K(z)} \right] \right) - 1 \right\} \times 100 \quad \text{for } P \geq 0.5$$

$$\left\{ \left(\underset{\text{over } z}{\text{maximum}} \left[\frac{F_Q^M(z) \times W(z)}{\frac{F_Q^{RTP}}{0.5} \times K(z)} \right] \right) - 1 \right\} \times 100 \quad \text{for } P < 0.5$$

2) One of the following actions shall be taken:

a) Within 15 minutes, control the AFD to within new AFD limits which are determined by reducing the AFD limits of Specification 3.2.1 by 1% AFD for each percent $F_Q(z)$ exceeds its limits as determined in Specification 4.2.2.2f.1). Within 8 hours, reset the AFD alarm setpoints to these modified limits, or

b) Comply with the requirements of Specification 3.2.2 for $F_Q(z)$ exceeding its limit by the percent calculated above, or

c) Verify that the requirements of Specification 4.2.2.3 for base load operation are satisfied and enter base load operation.

g. The limits specified in Specifications 4.2.2.2c, 4.2.2.2e., and 4.2.2.2f. above are not applicable in the following core plane regions:

1. Lower core region from 0 to 15%, inclusive.
2. Upper core region from 85 to 100%, inclusive.

4.2.2.3 Base load operation is permitted at powers above APL^{ND*} if the following conditions are satisfied:

a. Prior to entering base load operation, maintain THERMAL POWER above APL^{ND} and less than or equal to that allowed by Specification 4.2.2.2 for at least the previous 24 hours. Maintain base load operation surveillance (AFD within the target band about the target flux difference of Specification 3.2.1) during this time period. Base load operation is then permitted providing THERMAL POWER is maintained between APL^{ND} and APL^{BL} or between APL^{ND} and 100% (whichever is most limiting) and FQ surveillance is maintained pursuant to Specification 4.2.2.4. APL^{BL} is defined as:

$$APL^{BL} = \underset{\text{over } Z}{\text{minimum}} \left[\frac{F_Q^{RTP} \times K(Z)}{F_Q^M(Z) \times W(Z)_{BL}} \right] \times 100\%$$

where: $F_Q^M(z)$ is the measured $F_Q(z)$ increased by the allowances for manufacturing tolerances and measurement uncertainty. F_Q^{RTP} is the F_Q limit. K(z) is the normalized $F_Q(z)$ as a function of core height. $W(z)_{BL}$ is the cycle dependent function that accounts for limited power distribution transients encountered during base load operation. F_Q^{RTP}, K(z), and $W(z)_{BL}$ are specified in the CORE OPERATING LIMITS REPORT per Specification 6.9.1.9.

b. During base load operation, if the THERMAL POWER is decreased below APL^{ND} then the conditions of 4.2.2.3.a shall be satisfied before re-entering base load operation.

4.2.2.4 During base load operation $F_Q(Z)$ shall be evaluated to determine if $F_Q(Z)$ is within its limit by:

INSERT NOTE FROM FOLLOWING PAGE HERE

a. Using the movable incore detectors to obtain a power distribution map at any THERMAL POWER above APL^{ND}.

b. Increasing the measured $F_Q(Z)$ component of the power distribution map by 3% to account for manufacturing tolerances and further increasing the value by 5%** to account for measurement uncertainties. Verify the requirements of Specification 3.2.2 are satisfied.

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*APL^{ND} is the minimum allowable (nuclear design) power level for base load operation in Specification 3.2.1.

NOTE TO BE INSERTED ON PAGE 3/4 2-9 :

** For Unit 1, cycle 7, when the number of available moveable detector thimbles is greater than or equal to 50% and less than 75% of the total, the 5% measurement uncertainty shall be increased to [5% + (3 - T/14.5)(2%)] where T is the number of available thimbles.

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c. Satisfying the following relationship:

$$F_Q^M(Z) \leq \frac{F_Q^{RTP} \times K(Z)}{P \times W(Z)_{BL}} \text{ for } P > APL^{ND}$$

where: $F_Q^M(Z)$ is the measured $F_Q(Z)$. F_Q^{RTP} is the F_Q limit.

K(Z) is the normalized $F_Q(Z)$ as a function of core height. P is the relative THERMAL POWER. $W(Z)_{BL}$ is the cycle dependent function that accounts for limited power distribution transients encountered during base load operation. F_Q^{RTP}, K(Z), and $W(Z)_{BL}$ are specified in the CORE OPERATING LIMITS REPORT per Specification 6.9.1.9.

d. Measuring $F_Q^M(Z)$ in conjunction with target flux difference determination according to the following schedule:

1. Prior to entering base load operation after satisfying Section 4.2.2.3 unless a full core flux map has been taken in the previous 31 EFPD with the relative thermal power having been maintained above APL^{ND} for the 24 hours prior to mapping, and

2. At least once per 31 effective full power days.

e. With measurements indicating

$$\underset{\text{over } Z}{\text{maximum}} \left[\frac{F_Q^M(Z)}{K(Z)} \right]$$

has increased since the previous determination $F_Q^M(Z)$ either of the following actions shall be taken:

1. $F_Q^M(Z)$ shall be increased by 2 percent over that specified in 4.2.2.4.c, or

2. $F_Q^M(Z)$ shall be measured at least once per 7 EFPD until 2 successive maps indicate that

$$\underset{\text{over } z}{\text{maximum}} \left[\frac{F_Q^M(Z)}{K(Z)} \right] \text{ is not increasing.}$$

f. With the relationship specified in 4.2.2.4.c above not being satisfied, either of the following actions shall be taken:

1. Place the core in an equilibrium condition where the limit in 4.2.2.2.c is satisfied, and remeasure $F_Q^M(Z)$, or

SURVEILLANCE REQUIREMENTS (Continued)

2. Comply with the requirements of Specification 3.2.2 for $F_Q(Z)$ exceeding its limit by the percent calculated with the following expression:

$$[(\text{max. over } z \text{ of } [\frac{F_Q^M(Z) \times W(Z)_{BL}}{\frac{F_Q^{RTP}}{P} \times K(Z)}]) - 1] \times 100 \text{ for } P \geq APL^{ND}$$

g. The limits specified in 4.2.2.4.c, 4.2.2.4.e, and 4.2.2.4.f above are not applicable in the following core plan regions:

1. Lower core region 0 to 15 percent, inclusive.

2. Upper core region 85 to 100 percent, inclusive.

4.2.2.5 When $F_Q(Z)$ is measured for reasons other than meeting the requirements of specification 4.2.2.2 an overall measured $F_Q(z)$ shall be obtained from a power distribution map and increased by 3% to account for manufacturing tolerances and further increased by 5%* to account for measurement uncertainty.

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* For Unit 1, cycle 7, when the number of available moveable detector thimbles is greater than or equal to 50% and less than 75% of the total, the 5% measurement uncertainty shall be increased to [5% + (3 - T/14.5)(2%)] where T is the number of available thimbles.

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POWER DISTRIBUTION LIMITS

3/4.2.3 RCS FLOW RATE AND NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR

LIMITING CONDITION FOR OPERATION

3.2.3 The combination of indicated Reactor Coolant System (RCS) total flow rate and R shall be maintained within the region of allowable operation specified in the CORE OPERATING LIMITS REPORT (COLR) for four loop operation:

Where:

a. $$R = \frac{F^{N}_{\Delta H}}{F^{RTP}_{\Delta H} \quad [1.0 + MF_{\Delta H} \; (1.0 - P)]},$$

b. $$P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}},$$

c. $F^{N}_{\Delta H}$ = Measured values of $F^{N}_{\Delta H}$ obtained by using the movable incore detectors to obtain a power distribution map. The measured values of $F^{N}_{\Delta H}$ shall be used to calculate R since the figure specified in the COLR includes penalties for undetected feedwater venturi fouling of 0.1% and for measurement uncertainties of 1.7% for flow and 4%** for incore measurement of $F^{N}_{\Delta H}$,

d. $F^{RTP}_{\Delta H}$ = The $F^{N}_{\Delta H}$ limit at RATED THERMAL POWER (RTP) specified in the COLR, and

e. $MF_{\Delta H}$ = The power factor multiplier specified in the COLR.

APPLICABILITY: MODE 1.

ACTION:

With the combination of RCS total flow rate and R outside the region of acceptable operation specified in the COLR:

INSERT NOTE FROM FOLLOWING PAGE HERE

a. Within 2 hours either:

1. Restore the combination of RCS total flow rate and R to within the above limits, or

2. Reduce THERMAL POWER to less than 50% of RATED THERMAL POWER and reduce the Power Range Neutron Flux - High Trip Setpoint to less than or equal to 55% of RATED THERMAL POWER within the next 4 hours.

NOTE TO BE INSERTED ON PAGE 3/4 2-14:

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* For Unit 1, cycle 7, when the number of available moveable detector thimbles is greater than or equal to 50% and less than 75% of the total, the 4% measurement uncertainty shall be increased by changing the value of $F^{RTP}_{\Delta H}$ in the R equation to $[(0.0149/14.5)T + 1.4453]$ where T is the number of available thimbles.

LIMITING CONDITION FOR OPERATION

ACTION (Continued)

b. Within 24 hours of initially being outside the above limits, verify through incore flux mapping and RCS total flow rate comparison that the combination of R and RCS total flow rate are restored to within the above limits, or reduce THERMAL POWER to less than 5% of RATED THERMAL POWER within the next 2 hours.

c. Identify and correct the cause of the out-of-limit condition prior to increasing THERMAL POWER above the reduced THERMAL POWER limit required by ACTION a.2. and/or b. above; subsequent POWER OPERATION may proceed provided that the combination of R and indicated RCS total flow rate are demonstrated, through incore flux mapping and RCS total flow rate comparison, to be within the region of acceptable operation specified in the COLR prior to exceeding the following THERMAL POWER levels:

   1. A nominal 50% of RATED THERMAL POWER,

   2. A nominal 75% of RATED THERMAL POWER, and

   3. Within 24 hours of attaining greater than or equal to 95% of RATED THERMAL POWER.

SURVEILLANCE REQUIREMENTS

4.2.3.1 The provisions of Specification 4.0.4 are not applicable.

4.2.3.2 The combination of indicated RCS total flow rate determined by process computer readings or digital voltmeter measurement and R shall be within the region of acceptable operation specified in the COLR:

a. Prior to operation above 75% of RATED THERMAL POWER after each fuel loading, and

b. At least once per 31 Effective Full Power Days.

4.2.3.3 The indicated RCS total flow rate shall be verified to be within the region of acceptable operation specified in the COLR at least once per 12 hours when the most recently obtained value of R obtained per Specification 4.2.3.2, is assumed to exist.

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

4.2.3.5 The RCS total flow rate shall be determined by precision heat balance measurement at least once per 18 months.

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MOVABLE INCORE DETECTORS

LIMITING CONDITION FOR OPERATION

3.3.3.2 The Movable Incore Detection System shall be OPERABLE with:

a. At least 75%* of the detector thimbles,

b. A minimum of two** detector thimbles per core quadrant, and

c. Sufficient movable detectors, drive, and readout equipment to map these thimbles.

APPLICABILITY: When the Movable Incore Detection System is used for:

a. Recalibration of the Excore Neutron Flux Detection System,

b. Monitoring the QUADRANT POWER TILT RATIO, or

c. Measurement of $F\Delta^N_H$ and $F_Q(Z)$

ACTION:

With the Movable Incore Detection System inoperable, do not use the system for the above applicable monitoring or calibration functions. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS

4.3.3.2 The Movable Incore Detection System shall be demonstrated OPERABLE at least once per 24 hours by normalizing each detector output when required for:

a. Recalibration of the Excore Neutron Flux Detection System, or

b. Monitoring the QUADRANT POWER TILT RATIO, or

c. Measurement of $F^N_{\Delta H}$ and $F_Q(Z)$

* For Unit 1, cycle 7, the minimum percentage of detector thimbles may be reduced to 50% provided the applicable provisions for ≥ 50% and < 75% of the total detector thimbles of specifications 4.2.2.2.b, 4.2.2.4.b, 4.2.2.5, 3.2.3.c, and 3.3.3.2.b are followed.

** For Unit 1, cycle 7, when the number of available moveable detector thimbles is ≥ 50% and < 75% of the total, a minimum of four detector thimbles per quadrant is required (where quadrant includes both horizontal - vertical quadrants and diagonally bounded quadrants).

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SEISMIC INSTRUMENTATION

LIMITING CONDITION FOR OPERATION

3.3.3.3 The seismic monitoring instrumentation shown in Table 3.3-7 shall be OPERABLE.

APPLICABILITY: At all times.

ACTION:

a. With one or more seismic monitoring instruments inoperable for more than 30 days, prepare and submit a Special Report to the Commission pursuant to Specification 6.9.2 within the next 10 days outlining the cause of the malfunction and the plans for restoring the instrument(s) to OPERABLE status.

b. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS

4.3.3.3.1 Each of the above seismic monitoring instruments shall be demonstrated OPERABLE by the performance of the CHANNEL CHECK, CHANNEL CALIBRATION and ANALOG CHANNEL OPERATIONAL TEST operations at the frequencies shown in Table 4.3-4.

4.3.3.3.2 Each of the above accessible seismic monitoring instruments actuated during a seismic event greater than or equal to 0.01 g shall be restored to OPERABLE status within 24 hours following the seismic event. Data shall be retrieved from accessible actuated instruments and analyzed to determine the magnitude of the vibratory ground motion. Data retrieved from the triaxial time-history accelerograph shall include a post-event CHANNEL CALIBRATION obtained by actuation of the internal test and calibrate function immediately prior to removing data. CHANNEL CALIBRATION shall be performed immediately after insertion of the new recording media in the triaxial time-history accelograph recorder. A Special Report shall be prepared and submitted to the Commission pursuant to Specification 6.9.2, with a copy to Director, Office of Nuclear Reactor Regulation, Attention: Chief, Structural and Geotechnical Engineering Branch, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, within 10 days describing the magnitude, frequency spectrum, and resultant effect upon facility features important to safety.

ATTACHMENT 2

Justification and Safety Analysis

Background/Justification:

The Moveable Incore Detector System consists of 58 incore flux thimbles to permit measurement of the axial and radial neutron flux distribution within the reactor core. Due to problems during Cycle 6 extensive cleaning and repairs to the system were performed during the refueling outage. All tubes were flushed with acetone and then flushed twice with water. Subsequent to the flushing, location M-7 could not be accessed. After sufficient drying time, it was successfully accessed. Numerous repairs were made to the drive systems, the tubing the drives pass through before entering the instrument tubes, and the fittings on the ends of the instrument tubes.

During the final checkout of the system on May 10, 1990 all detector thimbles were accessed normally except for thimbles D3, F3, and H15. The D3 and F3 thimbles were determined to be bent and H15 was subsequently accessed during later flux mapping.

The following table illustrates the detector sticking problems encountered so far in McGuire 1 Cycle 7:

Flux Map	Date	% Power	Number of Accessed Thimbles
1	5/21/90	38.42	46*
15	5/24/90	77.21	48*
16	6/14/90	97.77	46*
17	6/28/90	99.75	45*
18	7/25/90	100.00	49
21	8/16/90	99.82	51
26	9/14/90	94.01	47
27	10/11/90	99.92	44
28	11/26/90	100.00	46**

* Note: Maps did not use Detector A due to a detector voltage problem nor Detector F in emergency due to erratic operation of its 5 path. These were repaired and used beginning with map 18.

** Note: Map 28 was taken following an extended outage during which additional maintenance was performed on the system.

Map 27 taken on October 11, 1990 originally could only access 43 thimble locations. Instrument and Electrical personnel entered the containment and adjusted clutch settings on detectors C and E and subsequently one additional trace was obtained.

The available detectors for maps 26 and 27 (see Figure 1) are well distributed throughout the core and provide a good indication of the core power distribution. At this burnup the core power distribution has been demonstrated to agree very well with the predicted power distribution as shown by the relative error in detector response provided in Figures 2a-c for maps 26-28, respectively. The predicted $F_{\Delta H}^{N}$ has already reached its maximum value for the cycle and stays fairly constant between 100 and 200 EFPD before starting to decrease.

The map taken 10/11/90 showed a margin to the F_Q surveillance limit of 6.2%. Figure 3 depicts the measured versus predicted $F_{\Delta H}^N$ and F_Q values for the cycle to date. Figure 4 shows the measured versus predicted soluble boron behavior. These figures indicate that the cycle is operating as designed.

On October 11, 1990 McGuire 1 was at a burnup of 126.6 EFPD out of a cycle nominal burnup of 420 EFPD. Based on the above detector sticking history and the length of time that the plant is expected to operate before the next scheduled outage, Duke Power proposes to change the Technical Specifications to allow Unit 1 Moveable Incore Detector System operability (and therefore continued plant operation) with less than 75% of the detectors available for the remainder of Cycle 7.

It should be noted that McGuire Unit 1 underwent approximately a four-week outage during October - November 1990. During this time, further efforts were made to improve the reliability of the Moveable Incore Detector System. These efforts included modification to lessen bending in the thimble tubing, additional soaking of the thimble tubing in acetone and subsequent water flushing, and running the detector probes through the tubing to determine if the locations could be successfully accessed. Also, current plans are to wire brush the tubes during the next refueling outage. It should also be noted that the magnitude of this problem is unique to McGuire Unit 1. Neither McGuire Unit 2 nor the two Catawba units have experienced such severe problems. The problem apparently results from Neolube interacting with the high radiation environment and subsequently clogging the inside of the thimble tubes. This problem is expected to worsen as the unit continues to operate.

Bases/Safety Analysis:

As discussed in McGuire FSAR Section 7.7, the Moveable Incore Detection System is used for confirmatory information and is not required for daily safe operation of the core (daily core power performance is monitored by the excore detectors). The measured power distribution is affected by the "true" power distribution that exists in the core and the instrument thimble pattern. The thimbles are distributed nearly uniformly over the core with approximately the same number of thimbles in each quadrant. The number and location of these thimbles have been chosen to permit measurement of $F_{\Delta H}^N$ to within 4% and F_Q to within 5%. If the measured power peaking is larger than acceptable, reduced power capability is indicated. The 75% detector thimble operability requirement was chosen by the NRC (via Westinghouse Standard Technical Specifications) to allow a reasonable amount of failures of the incore detectors, but to encourage licensees to strive for as near as 100% as possible. Reduction of operable detector thimbles to 50% does not significantly degrade the ability of the detector system to measure core power distributions. However, core peaking factor measurement uncertainties will be increased by a reduction in the number of operable detector thimbles from 75% since they were previously determined for the Technical Specifications assuming the 75% criterion.

For Cycle 7, as was the case for Cycle 6, Duke Power commissioned Westinghouse to assess the incremental peaking factor measurement uncertainties and excore calibration impact associated with a reduction to a minimum of 29 (i.e. 50%) of the 58 moveable detector thimbles in McGuire Unit 1. The study, which is based on a Westinghouse generic thimble deletion analysis, indicates that additional uncertainties of 1.0% for $F_{\Delta H}^{N}$ and 2.0% for F_Q are appropriate when the number of instrumented assemblies is reduced from 58 to 29. The additional uncertainties should be applied linearly from below 75% to greater than or equal to 50% moveable thimble locations. In addition to the uncertainty, a minimum of four thimbles per quadrant is required (where a quadrant includes both horizontal-vertical quadrants and diagonally-bounded quadrants) to establish the bounds of applicability of the study. The study concludes that operation of the moveable detector system with a minimum of 50% of the thimbles available is acceptable with the above provisions.

Due to the significant database used in the above study Westinghouse intended that the uncertainties derived are to be considered of a generic nature and should be applicable to subsequent cycles with all Westinghouse fuel. The Westinghouse generic thimble deletion analysis portion of the study was originally to support permanent reduction of the detector thimble operability requirement to 50% (29) in Westinghouse four-loop plants (note that the study also addresses measurement uncertainties for F_{xy} which McGuire does not use). However, the NRC has previously denied attempts for such permanent changes (reference Beaver Valley Power Station Facility Operating License No. DPR-66 Amendment No. 73 Safety Evaluation Report) on the grounds that reducing the number to 50% might result in a lack of incentive to keep the system operating as close to 100% as possible which could result in an unacceptably degraded ability to detect anomalous conditions in the core. Duke Power has made every effort to ensure the operability of the system through thimble tube cleaning and preventive maintenance. Since the NRC has permitted such relaxation of the 75% requirement for the duration of affected reactor cycles (including one for McGuire Unit 1 Cycle 6 and also one for Beaver Valley based on this Westinghouse generic analysis), Duke Power is proposing the Technical Specifications changes be applicable for the remainder of McGuire Unit 1 Cycle 7. Westinghouse confirmed the uncertainties are applicable to the McGuire Unit 1 Cycle 7 core. It should be noted that the study uses the INCORE computer code whereas McGuire uses SNACORE. The equivalence of SNACORE and INCORE for processing measured power distributions has been previously demonstrated in Duke Power Company's "McGuire/Catawba Nuclear Station Nuclear Physics Methodology for Reload Design", DPC-NF-2010A, approved by the NRC SER issued on March 13, 1985. It is also noted that the input factors for SNACORE are generated by Westinghouse using identical methods as used for INCORE. Therefore, the effects of deleting thimbles from SNACORE are considered as properly analyzed using the results of the generic thimble deletion analysis.

Burnup on Cycle 7 is currently about 5400 MWD/MTU of a 17,500 MWD/MTU cycle. At this point in cycle operation, the core characteristics have been well established and, specifically, core power distribution is well behaved. Reaction rate error distributions from flux map measurement indicate that the core is operating as designed. All power distribution surveillance parameters ($F_{\Delta H}^{N}$, F_{Q}) currently have sufficient margin to their limits after the current Technical Specification required uncertainties are applied. From the flux map taken on October 11, 1990, it is calculated that there is approximately 5.9% margin in $F_{\Delta H}^{N}$ (i.e., measured $F_{\Delta H}^{N}$ plus its measurement uncertainty in comparison to its Technical Specification Limit) and approximately 6.2% margin in $F_{Q}(z)$. The predicted peaks (F_{Q} and $F_{\Delta H}^{N}$) decrease in value the remainder of the cycle. It is also expected that the core will continue to behave as designed. Therefore, adequate margin exists for implementation of the Westinghouse study additional measurement uncertainties.

Description of Proposed Technical Specifications Changes:

The proposed Technical Specifications changes are based on guidance provided by Westinghouse with the commissioned McGuire 1 Cycle 7 thimble reduction study.

T.S. 3/4.2.2 is modified by adding a footnote to surveillance Specifications 4.2.2.2.b, 4.2.2.4.b, and 4.2.2.5, where the measurement uncertainties are addressed. The footnotes, which are applicable only for McGuire Unit 1 Cycle 7, for reasons discussed above, instruct that the 5% $F_{Q}(z)$ measurement uncertainty be increased linearly (with the maximum 2%) when the number of available detector thimbles is less than 75% of the total (with the minimum 50%). This additional uncertainty is in accordance with the results/bounds of the McGuire Unit 1 Cycle 7 Westinghouse study discussed above, and will result in a maximum $F_{Q}(z)$ measurement uncertainty of 7% at the 50% available detector thimble level. No other changes to Specification 3/4.2.2 are required for the reduction in the number of available moveable incore detector thimbles. Note that a footnote is added to Specification 4.2.2.4 which applies for base load operation, even though no base load operation analysis was performed for McGuire Unit 1 Cycle 7 and thus the specification would not be used for Unit 1 Cycle 7. This was done for conservatism in case base load operation is subsequently analyzed and implemented on Unit 1 Cycle 7 for some reason, since failure to increase the measurement uncertainties under the specified conditions (i.e., base load operation and less than 75% available detector thimbles) would be non-conservative.

T.S. 3/4.2.3 is modified by adding a footnote to limiting condition for operation Specification 3.2.3.c, where measurement uncertainties are addressed. The footnote, which is applicable only for McGuire Unit 1 Cycle 7 as discussed above, instructs that the 4% $F_{\Delta H}^{N}$ measurement uncertainty be increased linearly (with the maximum 1%) when the number of available detector thimbles is less than 75% of the total (with the minimum 50%). This additional uncertainty is in accordance with the results/bounds of the McGuire Unit 1 Cycle 7 Westinghouse study discussed above, and will result in a maximum $F_{\Delta H}^{N}$ measurement uncertainty of 5% at the 50% available detector thimble level. No other changes to Specification 3/4.2.3 are required for the reduction in the number of available moveable incore detector thimbles. Note that the $F_{\Delta H}^{N}$ measurement uncertainty would be increased by adjusting the $F_{\Delta H}^{N}$ limit of $F_{\Delta H}^{RTP}$ (linearly by 1% from 75% to 50% thimbles available), rather than adjusting the measured value $F_{\Delta H}^{N}$. The method used is equivalent to adjusting the 4% $F_{\Delta H}^{N}$ measurement uncertainty by [4% + (3 - T/14.5) (1%)], where T is the number of available thimbles, similarly to the method used in Specification 3/4.2.2. This was deemed the best way to accomplish incorporating the additional uncertainty into Specification 3/4.2.3. Specification 3.2.3.c states that the figure specified in the Core Operating Limits Report includes the 4% $F_{\Delta H}^{N}$ measurement uncertainty. Since both the $F_{\Delta H}^{N}$ limit of $F_{\Delta H}^{RTP}$ and $F_{\Delta H}^{N}$ are used in the R equation (defined in Specification 3.2.3.a) which is utilized with the figure specified in the Core Operating Limits Report, adjusting the $F_{\Delta H}^{RTP}$ value to reflect the additional uncertainty accomplishes the same thing as adjusting $F_{\Delta H}^{N}$. No changes to Specification 3.2.3.a or the figure specified in the Core Operating limits Report (which specify the R equation) are needed since the $F_{\Delta H}^{N}$ utilized in the equation is defined in Specification 3.2.3.c which includes the additional uncertainty adjustment footnote.

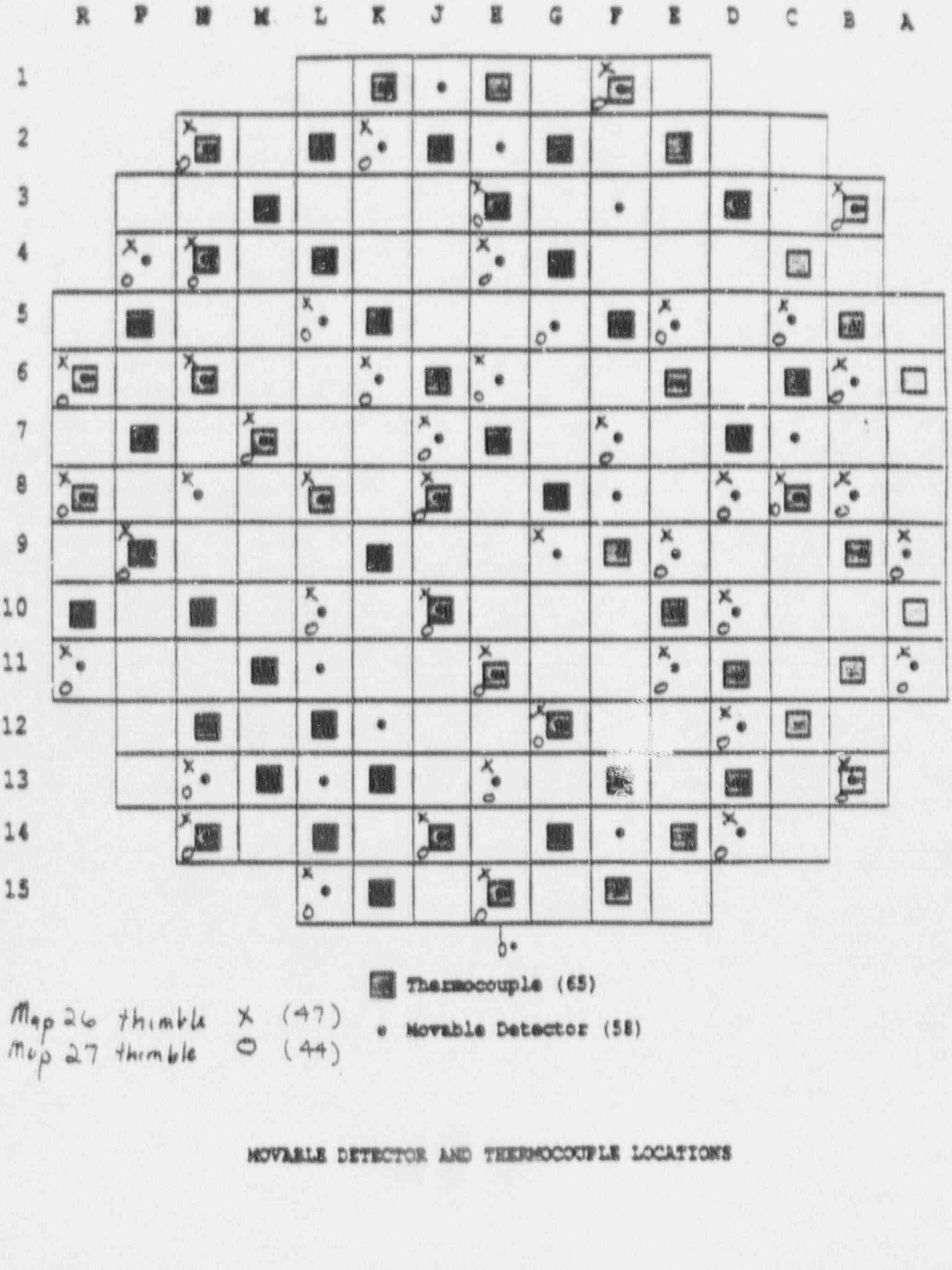
T.S. 3/4.3.3.2 is modified by adding footnotes to limiting condition for operation Specifications 3.3.3.2.a and 3.3.3.2.b, where the minimum percentage of detector thimbles and minimum number of detector thimbles per core quadrant are specified for operability of the Moveable Incore Detection System. The Specification 3.3.3.2.a footnote states that the minimum percentage of available detector thimbles may be reduced from 75% down to 50%, provided that any necessary adjustments are made to peaking factor measurement uncertainties and the minimum number of detector thimbles per core quadrant is appropriately adjusted. This reduction to 50% (with attendant provisions) is in accordance with the results/bounds of the McGuire 1 Cycle 7 Westinghouse study discussed above. The Specification 3.3.3.2.b footnote states that the minimum number of available detector thimbles per core quadrant, where quadrant includes both horizontal-vertical quadrants and diagonally-bounded quadrants, must be raised from two to four for a reduction of the number of available detector thimbles below 75% of the total (with the minimum 50%). This increased minimum (with quadrant proviso) is in accordance with the results of the Westinghouse study discussed above and is required to establish the bounds of applicability of the study. Both of the above footnotes are applicable only for McGuire Unit 1 Cycle 7 for reasons previously discussed. No other changes to Specification 3/4.3.3.2 are required for the reduction in the number of available moveable incore detector thimbles.

No other changes to Technical Specifications are required for the reduction in the number of available moveable incore detector thimbles. The Moveable Incore Detection System is also utilized for Specifications 3/4.2.4 (i.e., surveillance Specification 4.2.4.2) and 3/4.3.1 (i.e., Surveillance Table 4.3-1 Item 2). While these specifications will be impacted by the reduction (i.e., the changes to Specification 3/4.3.3.2 will allow performance of the surveillances of Specifications 3/4.2.4 and 3/4.3.1 with the Moveable Incore Detection System having less than 75% of the detector thimbles available), there are no peaking factor measurement uncertainties or other factors referenced in the specifications which require changing. The changes to Specification 3/4.3.3.2 are all that are needed to handle the Specification 3/4.2.4 and 3/4.3.1 aspects of the reduction in the number of available moveable incore detector thimbles. Further, since this is a temporary change which will expire at the end of Unit 1 Cycle 7, the Bases sections of the affected Technical Specifications are not being changed to reflect the temporary provisions. The bases for these temporary provisions will be documented via this submittal and the NRC Safety Evaluation Report approving these proposed amendments.

Conclusions:

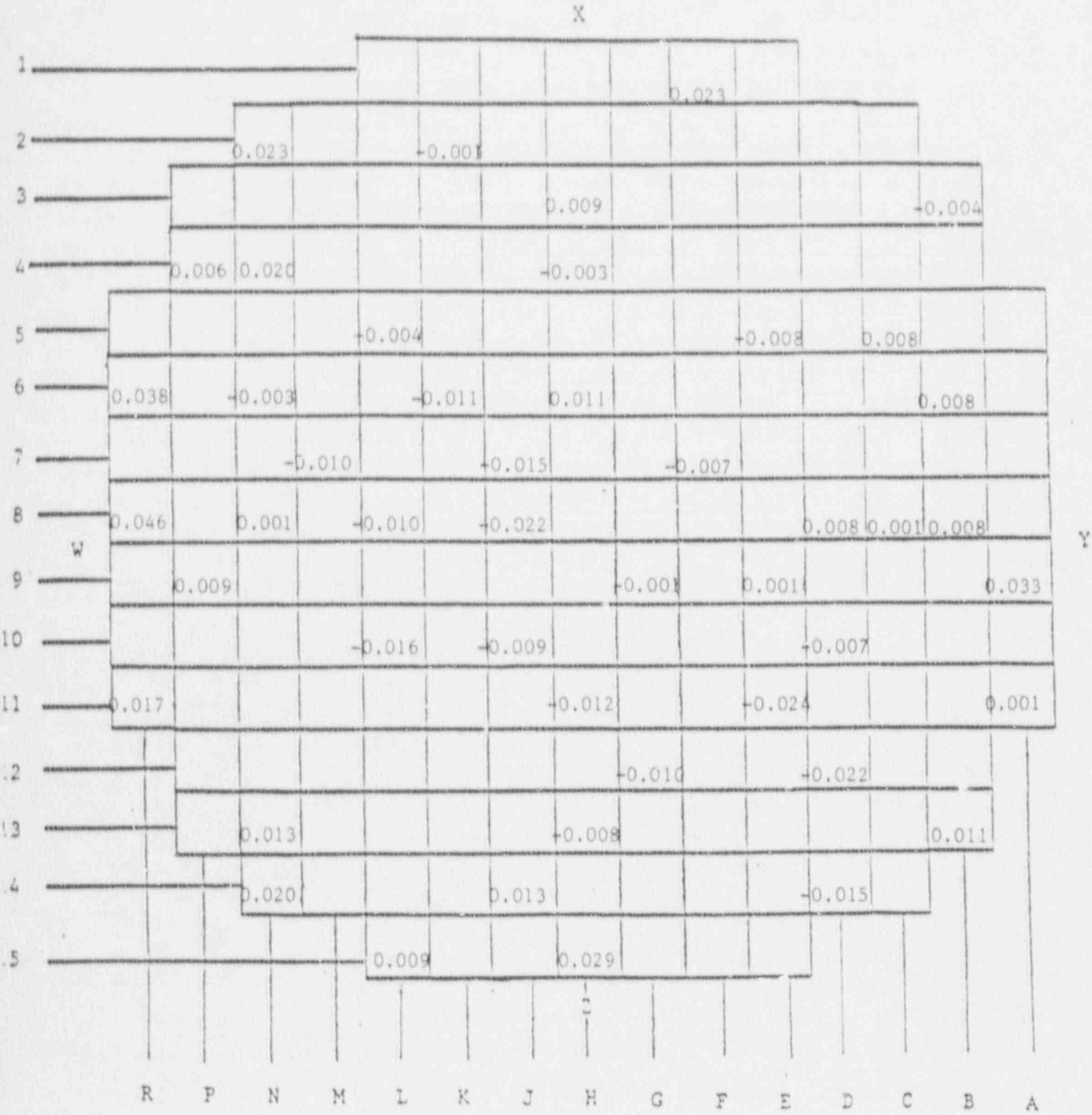
This proposed Technical Specifications change would allow an increase in plant operating flexibility (for Unit 1 Cycle 7) while maintaining sufficient data collection capability to ensure that the operation of the core is within licensed limits. This change would be utilized only if further failures of the detector thimbles occur. Based upon the preceding justification, Duke Power Company concludes that the proposed amendments are necessary to avoid an unnecessary potential shutdown of McGuire Unit 1 which has real benefits in terms of availability, component lifetime (avoiding an unnecessary thermal cycle on the reactor and associated systems), and safety. Based upon the preceding safety analysis, Duke Power Company concludes that the proposed amendments will not be inimical to the health and safety of company personnel or the public. Further, such amendments have been granted by the NRC for McGuire Unit 1, Cycle 6 and for other plants in similar situations in the past (e.g., Yankee Nuclear Power Station, Facility Operating License No. DPR-3 Amendment No. 100; and Beaver Valley Power Station, Facility Operating License No. DPR-66 Amendment No. 61).

Figure 1
Recently Accessible and Inaccessible Detector Thimbles
McGuire Unit 1 Cycle 7



MOVABLE DETECTOR AND THERMOCOUPLE LOCATIONS

Figure 2a
Relative Error in Detector Response
((Calc-meas)/meas)
McGuire Unit 1 Cycle 7
September 14, 1990 Flux Map



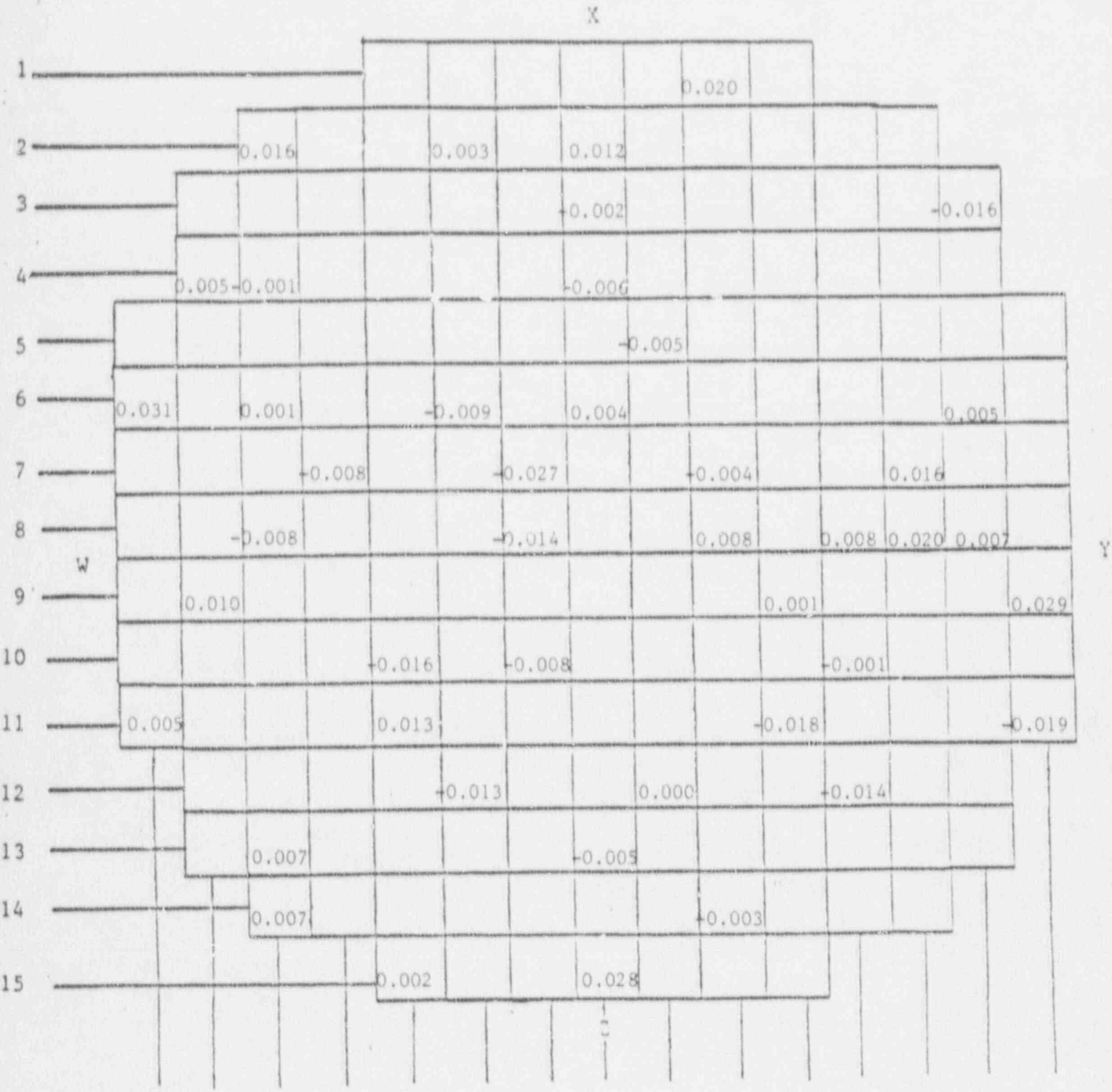
RMS Error Of Instrumented Locations = 0.0159

Figure 2b
Relative Error in Detector Response
((Calc-meas)/meas)
McGuire Unit 1 Cycle 7
October 11, 1990 Flux Map

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1										0.023					
2			0.015			0.004									
3								-0.001						-0.012	
4		0.006	0.007					-0.005							
5					-0.010				0.003		-0.018		0.014		
6	0.033					-0.008		0.002						-0.002	
7				-0.006			-0.029			-0.001					
8	0.047						-0.019					0.011	0.006	0.009	
9		0.009									-0.009				0.027
10					-0.014		-0.006					-0.001			
11	0.009							-0.003			-0.020				0.002
12									-0.003			-0.021			
13			0.015					-0.001						0.008	
14			0.013				0.025					-0.016			
15					0.005			0.029							

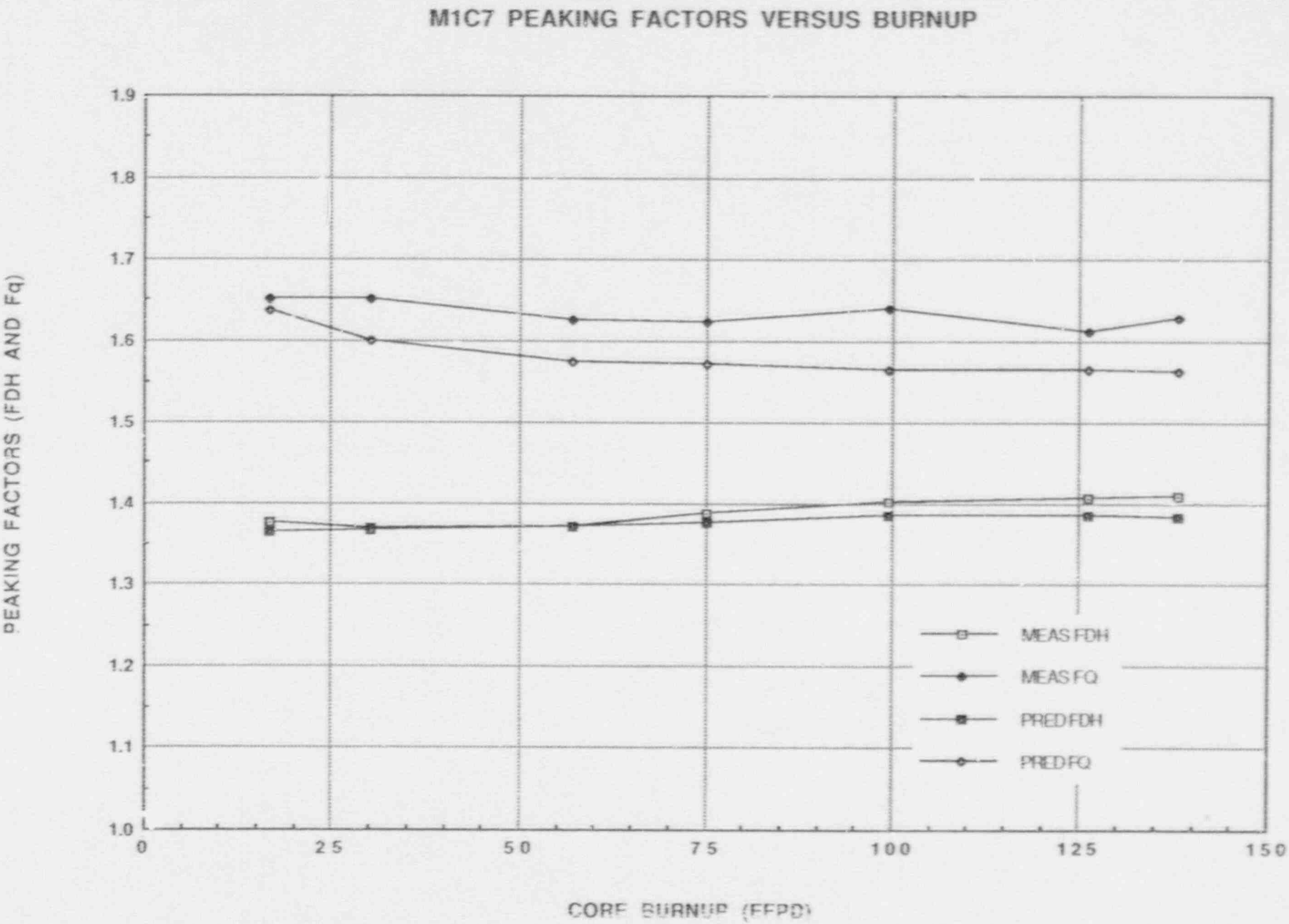
RMS Error Of Instrumented Locations = 0.0156

Figure 2c
Relative Error in Detector Response
((Calc-meas)/meas)
McGuire Unit 1 Cycle 7
Novmeber 26, 1990 Flux Map



RMS ERROR OF INSTRUMENTED LOCATIONS = 0.0131

FIGURE 3



M1C7 PEAKING FACTORS VERSUS BURNUP
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
PEAKING FACTORS (FDH AND Fq)
0
25
50
75
100
125
150
CORE BURNUP (EFPD)
MEAS FDH
MEAS FQ
PRED FDH
PRED FQ

FIGURE 4
BORON CONCENTRATION VERSUS CORE AVERAGE BURNUP

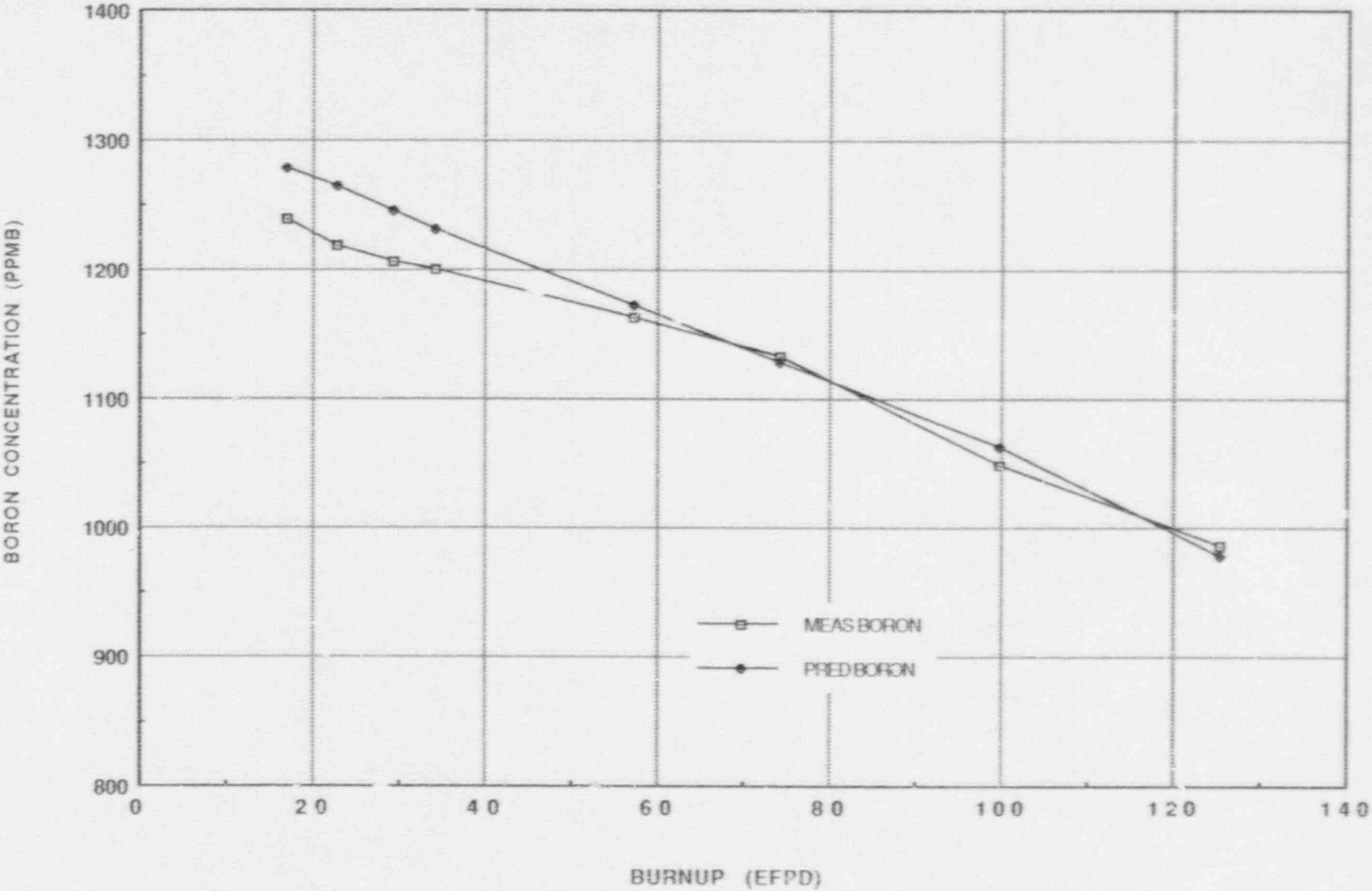


Table 1
McGuire Unit 1 Cycle 7
Zero Power Physics Testing Results

Predicted data and acceptance criteria were obtained from the McGuire Nuclear Station Unit 1 Cycle 7 Startup and Operational Report, MCNE-1553.05-00-0005. The value in parentheses indicates the acceptance criterion.

Parameter	Measured Value	Predicted Value/ (Acceptance Criterion)
Point of adding nuclear heat (on N42) per picoammeter	1.7×10^{-6} amps	------
ZPPT Range (on N42) per picoammeter	1.0×10^{-7} to 1.0×10^{-8} amps	------
ARO Boron Endpoint	1746 ppm	1755 ppm (1705 to 1805 ppm)
ARO ITC	+2.658 pcm/°F	+3.05 pcm/°F (1.05 to 5.05 pcm/°F)
ARO MTC	+4.418 pcm/°F	+4.81 pcm/°F (2.81 to 6.81 pcm/°F)
Reference Bank (S/D Bank B) Worth by Dilution	922 pcm	930 pcm (790 to 1070 pcm)
WORTH OF BANKS BY ROD EXCHANGE		
Control Bank A	327 pcm	332 pcm (32 to 532 pcm)
Control Bank B	729 pcm	738 pcm (517 to 959 pcm)
Control Bank C	745 pcm	759 pcm (532 to 986 pcm)
Control Bank D	496 pcm	486 pcm (286 to 686 pcm)
Shutdown Bank A	304 pcm	290 pcm (90 to 490 pcm)
Shutdown Bank C	449 pcm	435 pcm (235 to 635 pcm)
Shutdown Bank D	449 pcm	435 pcm (235 to 635 pcm)
Shutdown Bank E	429 pcm	402 pcm (202 to 602 pcm)
Total Bank Worth	4850 pcm	4807 pcm (> 4326 pcm)

NOTES:

1. Control Rod Withdrawal Limits were not required.
2. Zero Power Flux Map was not taken.
3. The same chemistry standard was used for all ZPPT.
4. Reference Bank Worth reactivity change was 230 pcm/hr.
5. All Acceptance Criteria were met.

MCGUIRE UNIT 1

EVALUATION OF THIMBLE DELETION ON PEAKING FACTORS

Introduction

This study was undertaken to assess incremental peaking factor measurement uncertainties associated with a reduction to a minimum of 29 of the 58 of the movable detector (M/D) thimbles in McGuire Unit 1. Due to the significant database used in the study, it is intended that the uncertainties quantified herein is to be considered of a generic nature and should be applicable to subsequent cycles.

Section 1 of this study presents the methodology and results of randomly deleting thimbles from actual INCORE maps to quantify the uncertainties. Section 2 quantifies the minimum number of thimbles per quadrant required in order to improve the ability to distinguish between random and systematic thimble deletion events and to establish the bounds of applicability of Section 1.

For McGuire Unit 1 Cycle 7, an evaluation was performed to confirm applicability of this cycle to the study described herein. Review of current cycle flux maps indicate that measurement to predicted peaking factors are well within the required measurement uncertainties and indicate the core is behaving as predicted. Based on this, it is not anticipated that the core will not perform as expected for the remainder of the cycle. It is not expected that the additional uncertainties on the peaking factors will result in any violation of the limits. Even with the increased measurement uncertainty applied as a result of the thimble delection study, the McGuire Unit 1 F_Q Surveillence Technical Specification will provide additional protection. The Tech. Spec. is designed to reduce the operating band (AFD) resulting from violations of the limiting condition of operation (LCO).

In order to address thimble deletion in four loop plants, flux maps were chosen from plants with the maximum of 58 thimbles. When referring to percentages in Sections 1 and 2 they refer to the percentage from a total of 58 thimbles unless otherwise specified.

SECTION 1

METHODOLOGY - GENERAL

To assess the additional peaking factor measurement uncertainties associated with as few as 50% of the M/D thimbles available, twenty-one full core INCORE flux maps from various plants and cycles were used. The selection of these maps was made to reflect the wide variety of loading pattern types such as annual reload cycles, low leakage, first cores, and eighteen month reload cycles. For each of the INCORE maps, five separate random deletions were made, giving a total of 105 thimble deletion cases with 50% of the thimbles available. Five separate random deletions were also done with this same set of 21 INCORE maps giving 105 thimble deletion cases with 75% of the thimbles available. The INCORE code was used to randomly delete thimble locations. The measured peaking factors for the thimble deletion maps were then compared with the measured peaking factors in the reference maps, i.e., the INCORE maps employing all or most of the 58 movable detector thimbles. Figure 1 shows the movable detector (M/D) locations for the four-loop plants considered and Table 1 provides additional information on the twenty-one maps used in the study. For those maps with less than 100% of available thimbles (e.g., 89.7%), thimble deletion cases to 50% of available thimbles were run utilizing 50% of the available thimbles in the reference map (e.g. 44.8%). These comparisons yielded the additional measurement uncertainties to be applied to $F_{\Delta H}$, F_Q, and F_{XY}. Thimble deletion effects on the INCORE measured axial offset and quadrant tilt were addressed in a similar manner.

To examine the effect of thimble deletion on measurement of off-normal power distributions, a pseudo dropped rod map was generated with random deletions such that maps with 50 and 75% of the available detector thimbles were obtained. The measured peaking factors from the thimble deletion maps were then compared to the reference map as for the normal operation maps described above.

METHODOLOGY - STATISTICAL

The percent error between the reference peaking factor value, F_α (Reference), and the thimble deletion case peaking factor value, F_α (T.D.) is defined in Equation 1 as

$$\%\ \text{Error (T.D.)} = \left(1 - \frac{F_\alpha\ \text{(T.D.)}}{F_\alpha\ \text{(Reference)}} \right) \times 100 \qquad \text{(Eq. 1)}$$

where F_α is $F_{\Delta H}$, F_{XY}, or F_Q and T.D. refers to 75% or 50% of available thimbles in the reference case. A positive value of error implies that the peaking factor from the thimble deletion map is non-conservative relative to the reference. In the following paragraphs the error will be denoted X_{ij} where i refers to one of the 21 flux maps and j refers to one of the 5 thimble deletion cases for each map. The percent error between the reference value and the thimble deletion case value for quadrant tilt and axial offset are defined in Equations 2 and 3 as

Error (T.D.) = (Ref. - Deleted) x 100 for QUAD Tilt (Eq. 2)

Error (T.D.) = (Ref. - Deleted) for A.O. (Eq. 3)

The mean error for map i, $\overline{X}_i$ and the percent relative sample standard deviation for map i, S_i, are defined in Equations 4 and 5, respectively.

$$\overline{X}_i = \frac{1}{5} \sum_{j=1}^{5} X_{ij} \quad \text{(Eq. 4)}$$

$$S_i = \left(\frac{\sum_{j=1}^{5} (X_{ij} - \overline{X}_i)^2}{5-1} \right)^{1/2} \quad \text{(Eq. 5)}$$

After computing $\overline{X}_i$ and S_i for each map, for each parameter of interest, and for both 50% and 75% thimble deletion cases, the data is combined. The combined mean for all maps, $\overline{X}_{combined}$, is given by Equation 6 as:

$$\overline{X}_{combined} = \frac{1}{21} \sum_{i=1}^{21} \overline{X}_i \quad \text{(Eq. 6)}$$

The combined percent relative sample standard deviation of all maps is given by Equation 7 as:

$$S_{combined} = \left(\left(\frac{\sum_{n=1}^{21} \left((N_i - 1)\ S^2_i\ + N_i\ \overline{X}^2_i \right)}{N_T} - \overline{X}^2_{comb.} \right) \frac{N_T}{N_T - 1} \right)^{1/2} \quad \text{(Eq. 7)}$$

where:

N_i = Number of random deletion cases of each map = 5 and
N_T = Total number of datapoints = 21 maps x 5 deletions/map = 105

Equations 6 and 7 are constructed in such a manner that if one were to directly compute the mean and standard deviation for all 105 datapoints, the same numeric results would be obtained.

After $\overline{X}_{combined}$ and $S_{combined}$ have been obtained for each parameter of interest, and for both 50% and 75% thimble deletion cases, 95% confidence/ 95% probability one-sided upper tolerance limits are constructed to quantify the thimble deletion uncertainty component (See Equation 8).

$$\text{Thimble Deletion Uncertainty Component (\%)} = \overline{X}_{combined} + kS_{combined} \quad \text{(Eq. 8)}$$

where k = the one-sided 95% confidence/95% probability tolerance limit factor for 104 degrees of freedom = 1.919.

Application of the above methodology is presented in the "Results" section of this report. The statistical combination of the thimble deletion uncertainty component with INCORE measurement is discussed in the "Thimble Deletion Uncertainty" section of this report.

RESULTS

Table 2a provides the peaking factors sample mean (%) for each map (see Equation 4) and the sample standard deviation (%) for each map (see Equation 5) for the 50% thimbles available case. The combined sample mean (%) and the combined standard deviation (%) for each parameter of interest, as calculated per Equations 6 and 7, is also shown. Table 2b presents the analagous information for the 75% thimbles available case. Tables 2c and 2d provide the sample mean and the sample standard deriation for quadrant tilt and axial offset over the same database.

Thimble deletion uncertainty components (i.e. the 95% probability, 95% confidence tolerance limit) for $F_{\Delta H}$, F_{xy}, and F_Q are calculated in Appendix A using Equation 8 and are based upon the data of Tables 2a and 2b. The Thimble Deletion Uncertainty Component (%) is plotted in Figure 2 as a function of Percentage of Thimbles Available. This figure is provided for information only and is not directly used in the uncertainty application.

Table 3a and 3b show the pseudo-dropped rod map data and will be discussed in more detail in a later section.

THIMBLE DELETION UNCERTAINTY

Current flux map peaking factor measurement uncertainties include allowance for down to 75% thimbles available. Accordingly, an incremental thimble deletion uncertainty component penalty from 75% to 50% of thimbles available could be considered to be appropriate. However, for conservatism and simplicity, the full thimble deletion uncertainty component penalty from 100% to 50% thimbles available will be used. The Thimble Deletion Uncertainty Component (50% T.D.) discussed in the preceding section is combined with the appropriate flux map measurement uncertainty to obtain a total uncertainty.

$F_{\Delta H}$ UNCERTAINTY, $F_{\Delta H}^{U}$

The appropriate equation for combining statistically independent uncertainty components is

$$F_{\Delta H}^{U}\ (50\%) = 1 + \underset{\text{T.D. Bias}}{F_{\Delta H}} + \left((F_{\Delta H}^{MU} - 1)^2 + (KS)^2_{T.D.}\right)^{1/2} \qquad \text{(Eq. 9)}$$

For conservatism, a negative value of T.D. Bias will be treated as zero. Analagous equations apply to F_Q^{U} and F_{xy}^{U}. Evaluating the above expression yields the following result

[ ] (a,c)

For conservatism to support generic application to subsequent cycles, $F_{\Delta H}^{U}$ (50%) will be rounded up to 1.05. This value can be interpreted as a 95% probability tolerance limit at a high confidence level. This one percent incremental thimble deletion penalty is linearly applied from 75% to 50% thimbles available (i.e., 1.04 at 44 thimbles and 1.05 at 29 thimbles available).

F_Q UNCERTAINTY, F_Q^U

[ ]$^{(a,c)}$

For conservatism to support generic application to subsequent cycles, F_Q^U (50%) will be rounded to 1.07. This 2% incremental thimble deletion penalty is linearly applied from 75% to 50% thimbles available (i.e., 1.05 at 44 thimbles and 1.07 at 29 thimbles available).

F_{xy} UNCERTAINTY, F_{xy}^U

The appropriate F_{xy} Uncertainty for as few as 29 thimbles remaining is

[ ]$^{(a,c)}$

For conservatism, to support generic application to subsequent cycles, F_{xy}^U (50%) will be rounded to 1.07. This 2% incremental thimble deletion penalty is linearly applied from 75% to 50% thimbles available (i.e., 1.05 at 44 thimbles and 1.07 at 29 thimbles available).

OFF-NORMAL POWER DISTRIBUTIONS

Thimble deletion uncertainty component tolerance limits are constructed in Appendix B based upon the pseudo-dropped rod data from Table 3a. It is interesting to note that the pseudo-dropped rod results are generally less limiting than typical flux map results. For example, for $F_{\Delta H}$, the thimble deletion uncertainty component (50%) is [ ]$^{(a,c)}$

AXIAL OFFSET AND QUADRANT TILT

The mean change in quadrant tilt with 29 of the thimbles available was found to be only [ ]$^{(a,c)}$ Similarly, the mean change in axial offset with 50% of the thimbles available was also quite small at [ ]$^{(a,c)}$ Note that all uncertainties on A.O. and tilt are absolute values and not percentages of A.O. nor tilt. These values indicate that thimble deletion has a negligible impact on the core average axial power shape measurement. Changes of this magnitude are not significant and will not adversely affect excore detector calibration.

CONSERVATIVE ASSUMPTIONS

For convenience a summary of conservative assumptions employed in this study are provided below:

1) The total thimble deletion penalty from 100% to 50% of the available thimbles was utilized rather than the incremental penalty from 75% to 50% of the available thimbles.

2) Thimble deletion uncertainty results were rounded up and negative bias values were set to zero.

3) [ ](a,c)

4)

5)

SECTION 2

This section quantifies the number of thimbles per quadrant required for McGuire Unit 1 in order to improve the ability to distinguish between random and systematic thimble deletion events and to establish the bounds of applicability of the incremental peaking factor uncertainties.

The current Technical Specification requirement of a minimum of 2 M/D thimbles per core quadrant is not sufficient to distinguish between random and systematic deletion events with high confidence. By increasing the required minimum number of M/D thimbles per quadrant, and by defining quadrant in such a manner as to essentially place a requirement on each 1/8th core, the ability to distinguish between random and systematic events will be significantly enhanced.

If, for example, for 50% thimbles remaining, the requirement of 4 or more thimbles per quadrant is satisfied, then in all likelihood a random deletion occurred and incremental thimble deletion peaking factor measurement uncertainties are appropriate. On the other hand, if there are less than four thimbles per quadrant, then it is possible that a systematic thimble deletion occurred and that the impact on measured quadrant peaking factors, may be larger than quantified in Section 1.

METHODOLOGY - ANALYTIC SOLUTION

Recall that the number of combinations of n events taken r at a time, C_n^r, is the number of ways of selecting r out of n elements without regard to order. For example, the number of ways of selecting 29 elements out of 58 is $C_{58}^{29} = 3.01 \times 10^{16}$. Ratios of different combinations can be interpreted as probabilities. For convenience the notation C(n,r) will be used to represent C_n^r.

In the actual thimble deletion problem of interest some thimbles lie on the axis or diagonals and hence are common to two quadrants. Solving this type of problem analytically is quite complex. A somewhat simpler problem type that can be solved exactly is described below.

(a,c)

(a,c)

The total probability of 0 through [illegible] thimbles remaining in a particular quadrant is of course 1.0. This method will be applied to the test problem described later in this report.

METHODOLOGY - COMPUTER SIMULATION

A short computer program for determining the probability distribution of thimbles remaining was written. The program allows for different number of thimbles per quadrant and keeps track of interior, axis, and diagonal thimbles (see 4-loop description).

Starting with n_T thimbles in the core and randomly deleting down to r_T thimbles constitutes one case. After deleting $n_T - r_T$ thimbles from the core, the number of thimbles remaining in each of the eight quadrants is determined. The minimum number of thimbles remaining over all 8 quadrants is then found. A large number of cases is run in order to determine the probability distribution of thimbles remaining.

TEST PROBLEM DESCRIPTION

The test problem selected was chosen to be sufficiently complex so as to adequately test the simulation code, but also simple enough as to permit an exact analytic solution.

The problem consisted of a core with an initial compliment of 60 thimbles total with 15 thimbles in each of the 8 quadrants. All thimbles are defined to be in interior locations, i.e. no common thimbles exist within the four vertical-horizontal quadrants and no common thimbles exist within the four diagonally bounded quadrants. Thirty (30) thimbles are randomly deleted for each case. The above information is depicted in Figure 3.

TEST PROBLEM RESULTS

For the analytic solution the method described earlier in the text was used to calculate the percent probability of 0 thimbles left in a particular quadrant, 1 thimble left, etc. up to 15 thimbles left. Results are summarized in Table 4.

The computer simulation was performed using two different methods. Method 1 is analogous to the "real" 4-loop problem in that the minimum number of thimbles left over all 8 quadrants was used to obtain the probability distribution. Method 2 is the computer analog to the analytic solution in that the probability distribution for a particular quadrant was obtained. Results for both of these methods are provided in Table 4.

TEST PROBLEM CONCLUSIONS

1. For Method 2 (count cases for Q1 only) the computer simulation and analytic solution using ratios of combinations agree very well. Therefore, for this type of problem, the program can be considered to be verified.

2. For the problem type of actual interest (Method 1) the program must calculate the minimum number of thimbles over all 8 quadrants.

   The probability distribution from the Method 1 simulation is skewed more toward fewer numbers of thimbles remaining. Intuitively this makes sense. For small number of thimbles remaining, if the analytic probabilities for Method 2 are multiplied by 4, the resulting values are close to the Method 1 simulation.

Because an exact analytic solution for Method 1 is very complex the computer simulation results are relied upon to determine the minimum number of thimbles per quadrant for the 4-loop core problem.

4-LOOP PROBLEM DESCRIPTION

The maximum possible number of available thimbles for a 4-loop Westinghouse PWR is 58. The initial distribution of these thimbles is provided in the following table. Figures 4 and 5 should also help in visualization.

No. of Interior Thimbles in Q1	11
No. of Interior Thimbles in Q2	10
No. of Interior Thimbles in Q3	11
No. of Interior Thimbles in Q4	11
No. of Axis Thimbles Q1-Q2	4
No. of Axis Thimbles Q2-Q3	4
No. of Axis Thimbles Q3-Q4	3
No. of Axis Thimbles Q4-Q1	4
	58 Total

No. of Interior Thimbles in QA	11
No. of Interior Thimbles in QB	14
No. of Interior Thimbles in QC	12
No. of Interior Thimbles in QD	12
No. of Diagonal Thimbles QA-QB	1
No. of Diagonal Thimbles QB-QC	[illegible]
No. of Diagonal Thimbles QB-QD	2
No. of Diagonal Thimbles QD-QA	3
	58 Total

Note that all thimbles are counted as whole values even if they lie on an axis or diagonal. Provided the technical specification value and computer simulation are consistent this is appropriate. Twenty-nine (29) thimbles are randomly deleted from each case.

4-LOOP PROBLEM RESULTS

A 3000 case simulation was run to obtain the probability distribution of the minimum number of thimbles left after having reduced to 29 thimbles available. Results are summarized in Table 5.

[

]^{a,c} Therefore, a requirement that 4 or more thimbles per quadrant be available is appropriate. Assuming random thimble deletion, it is unlikely that with 29 thimbles remaining overall fewer than 4 thimbles will be available over the 8 quadrants.

CONCLUSION

With the inclusion of the additional peaking factor uncertainties, it is concluded that operation of the movable detector system with a minimum of 50% of the thimbles available is acceptable provided that an additional 1.0% for $F_{\Delta H}$ and 2.0% for F_Q and F_{XY} be applied to the INCORE measured peaking factors. However, when fewer than 75% of the thimbles are available there should be a minimum of 4 thimbles per quadrant where quadrant includes both horizontal-vertical quadrants and diagonally bounded quadrants. This requirement increases the ability to distinguish between random and systematic thimble deletion events. In addition, the confidence on the appropriateness of the incremental thimble deletion peaking factor uncertainty values is increased provided that 4 or more thimbles per quadrant are observed to be available, and counting thimbles on the axis and diagonal as whole values.

TABLE 1

INCORE DETECTOR THIMBLE REDUCTION STUDY MAPS

	Burnup (MWD/MTU)	Core Power %	Percent Thimble Available (Ref.)
Plant A Cyc 2			
MAP 1	2,111	99.7	89.7
MAP 2	6,760	100.0	86.2
MAP 3	11,598	100.0	87.7
Plant A Cyc 3			
MAP 1	304	100.0	98.3
MAP 2	10,322	100.0	100.0
MAP 3	13,105	100.0	100.0
Plant B Cyc 1			
MAP 1	2,950	90.5	98.3
MAP 2	7,386	98.8	94.8
MAP 3	10,924	98.8	91.4
Plant C Cyc 3			
MAP 1	200	100.0	93.1
MAP 2	5,050	100.0	87.9
Plant C Cyc 4			
MAP 1	5,335	100.0	93.1
Plant D Cyc 3			
MAP 1	500	100.0	100.0
MAP 2	5,200	97.0	96.6
MAP 3	8,806	75.0	81.0
Plant D Cyc 4			
MAP 1	180	84.0	96.6
MAP 2	3,715	100.0	93.1
MAP 3	4,998	100.5	81.0
Plant E Cyc 1			
MAP 1	2,966	96.0	87.9
MAP 2	9,280	100.0	94.8
MAP 3	14,594	100.0	84.5

TABLE 2a

SAMPLE STANDARD DEVIATION AND MEAN FOR INCORE MAPS
WITH 50% OF THE THIMBLE AVAILABLE FOR FOUR LOOP
REACTOR CORE PARAMETERS

(a,c)

			F_Q		$F_{\Delta H}$		F_{xy}	
Plant	Cycle	MAP	S_i (%)	$\overline{X}_i$ (%)	S_i (%)	$\overline{X}_i$ (%)	S_i (%)	$\overline{X}_i$ (%)
A	2	1						
A	2	2						
A	2	3						
A	3	1						
A	3	2						
A	3	3						
B	1	1						
B	1	2						
B	1	3						
C	3	1						
C	3	2						
C	4	1						
D	3	1						
D	3	2						
D	3	3						
D	4	1						
D	4	2						
D	4	3						
E	1	1						
E	1	2						
E	1	3						
S_{comb}	$\overline{X}_{comb}$							

TABLE 2b

SAMPLE STANDARD DEVIATION AND MEAN FOR INCORE MAPS
WITH 75% OF THE THIMBLE AVAILABLE FOR FOUR LOOP
REACTOR CORE PARAMETERS

			F_Q*		$F_{\Delta H}$		F_{xy}	
Plant	Cycle	MAP	S_i (%)	$\overline{X}_i$ (%)	S_i (%)	$\overline{X}_i$ (%)	S_i (%)	$\overline{X}_i$ (%)
A	2	1						
A	2	2						
A	2	3						
A	3	1						
A	3	2						
A	3	3						
B	1	1						
B	1	2						
B	1	3						
C	3	1						
C	3	2						
C	4	1						
D	3	1						
D	3	2						
D	3	3						
D	4	1						
D	4	2						
D	4	3						
E	1	1						
E	1	2						
E	1	3						
S_{comb}	$\overline{X}_{comb}$							

(a,c)

* Plant D Cycle 4 Map 3 S_i and $\overline{X}_i$ based on 3 random deletions. All others based on 5 deletions.

TABLE 2c

SAMPLE STANDARD DEVIATION AND MEAN FOR INCORE MAPS WITH 50% THIMBLES AVAILABLE FOR FOUR LOOP REACTOR CORE PARAMETERS

Plant	Cycle	MAP	QUAD TILT+ S_i (%)	QUAD TILT+ $\overline{X}_i$ (%)	A.O.* S_i (%)	A.O.* $\overline{X}_i$ (%)
A	2	1				
A	2	2				
A	2	3				
A	3	1				
A	3	2				
A	3	3				
B	1	1				
B	1	2				
B	1	3				
C	3	1				
C	3	2				
C	4	1				
D	3	1				
D	3	2				
D	3	3				
D	4	1				
D	4	2				
D	4	3				
E	1	1				
E	1	2				
E	1	3				
S_{comb}	$\overline{X}_{comb}$					

(a,c)

\+ Standard deviation for QUAD TILT about ΔTilt = (Ref. - Deleted) x 100%.

* Standard deviation for A.O. about ΔA.O. = (Ref. - Deleted).

TABLE 2d

SAMPLE STANDARD DEVIATION AND MEAN FOR INCORE MAPS
WITH 75% OF THE THIMBLE AVAILABLE FOR FOUR LOOP
REACTOR CORE PARAMETERS

			QUAD TILT+		A.O.*		
Plant	Cycle	MAP	S_i (%)	$\overline{X}_i$ (%)	S_i (%)	$\overline{X}_i$ (%)	(a,c)
A	2	1					
A	2	2					
A	2	3					
A	3	1					
A	3	2					
A	3	3					
B	1	1					
B	1	2					
B	1	3					
C	3	1					
C	3	2					
C	4	1					
D	3	1					
D	3	2					
D	3	3					
D	4	1					
D	4	2					
D	4	3					
E	1	1					
E	1	2					
E	1	3					
S_{comb}	$\overline{X}_{comb}$						

+ Standard deviation for QUAD TILT about ΔTilt = (Ref. - Deleted) x 100%.

* Standard deviation for A.O. about ΔA.O. = (Ref. - Deleted).

TABLE 3a

COMPARISON OF DROPPED ROD AND THIMBLE DELETION INCORE MAPS

Burnup	Thimble Run	Meas. F_Q	F_Q Location	F_Q % Diff.*	Meas. $F_{\Delta H}$	$F_{\Delta H}$ Location	$F_{\Delta H}$ % Diff.*	Meas. F_{xy}	F_{xy} Elevation	F_{xy} % Diff.*
200 MWD/MTU	0									
	.50A									
	.50B									
	.50C									
	.50D									
	.50E									
200 MWD/MTU	0									
	.75A									
	.75B									
	.75C									
	.75D									
	.75E									

(a,c)

$$* \ \% \text{ Diff.} = \frac{\text{Ref.} - \text{Deleted}}{\text{Ref.}} \times 100\%$$

TABLE 3b

COMPARISON OF DROPPED ROD AND THIMBLE DELETION INCORE MAPS

Burnup	Thimble Run	Quad Tilt	Δtilt+	Meas. A.O.	ΔA.O.**
200 MWD/MTU	0				
	.50A				
	.50B				
	.50C				
	.50D				
	.50E				
200 MWD/MTU	0				
	.75A				
	.75B				
	.75C				
	.75D				
	.75E				

(a,c)

+ ΔTilt = (Ref. - Deleted) x 100%
** ΔAO = (Ref. - Deleted)

TABLE 4

TEST PROBLEM SUMMARY

Min. # Thim. Left in Method 1 or # Thimbles Left in Q1 is Method 2	Simulations Method 1 % Cases	Simulations Method 2 % Cases	Analytic Solution Method 2* Probability %

(a,c)

* Analytic Solution for Method 1 is not available.

TABLE 5

4-LOOP CORE SUMMARY

3000 CASE THIMBLE DELETION SIMULATION

29 THIMBLES DELETED

Minimum No. of Thimbles Left	Number of Cases	Percent of Cases	Cumulative Percentage

(a,c)

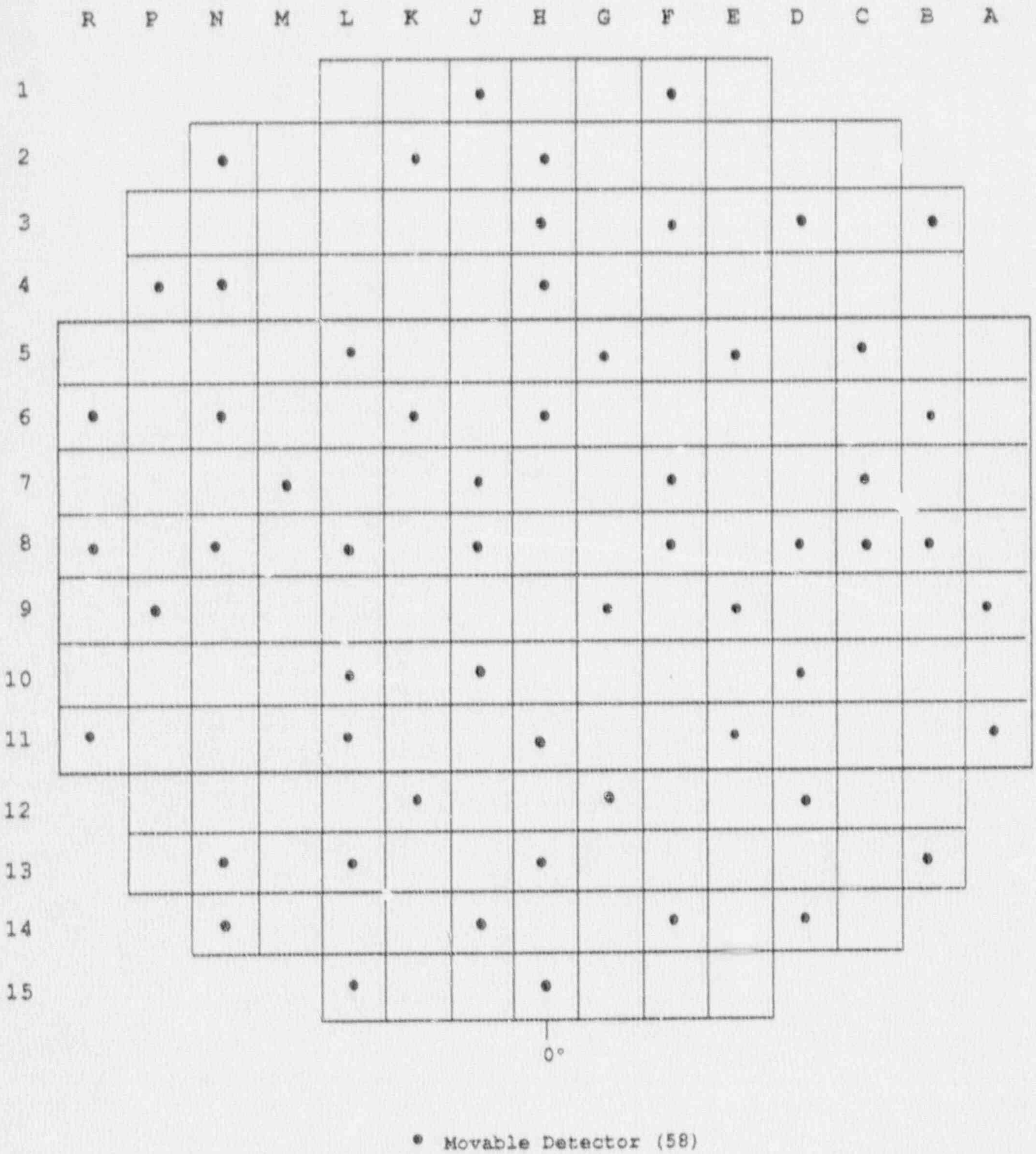


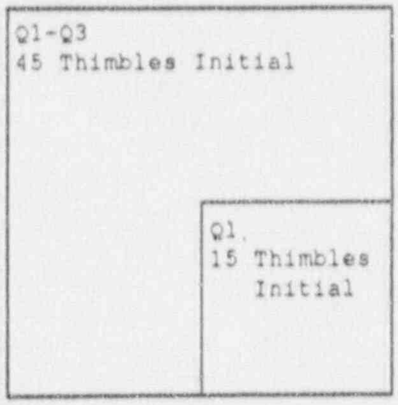
Figure 1. Movable Detector Locations for Four Loop Plants

(a,c)

Figure 2. Thimble Deletion Uncertainty Component Versus Percentage of Thimbles Available

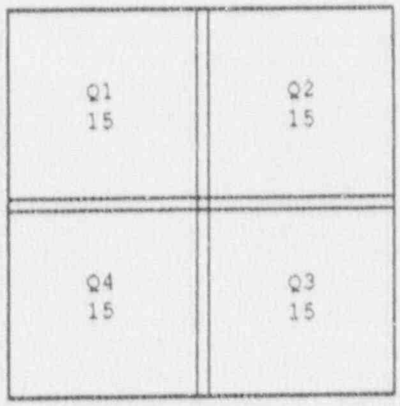
Analytic Solution:

60 Thimbles Initial Total
30 Thimbles Remaining



Computer Simulation:

No Thimbles on Axis
60 Thimbles Initial Total
30 Thimbles Remaining



No Thimbles on Diagonal
60 Thimbles Initial Total
30 Thimbles Remaining

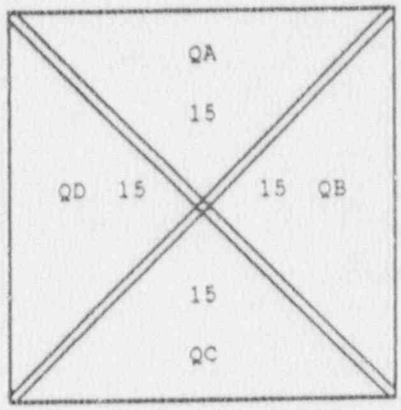


Figure 3. Test Problem Description

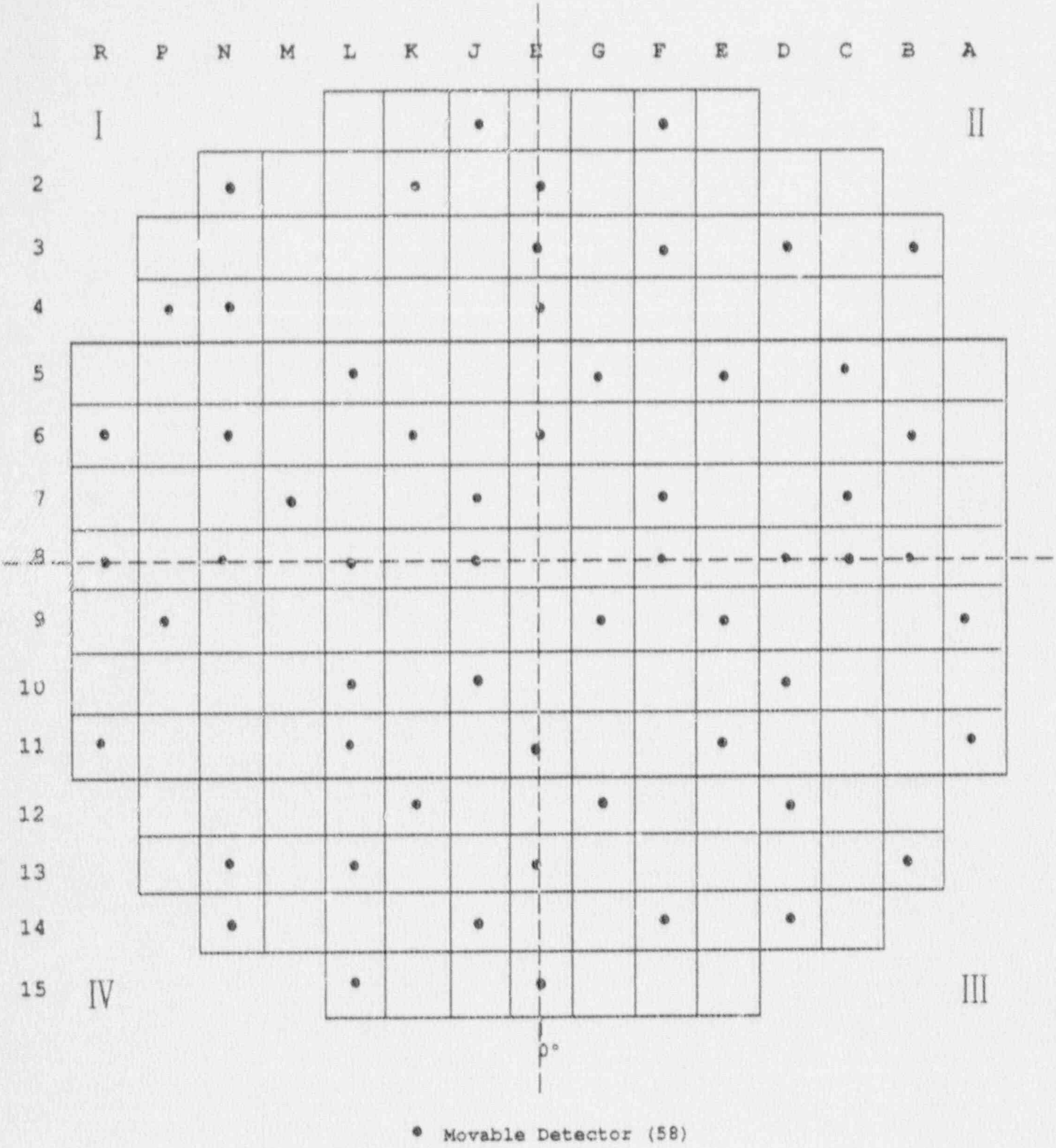


Figure 4. Horizontal Vertical Quadrants Movable Detector Thimble Number Scheme

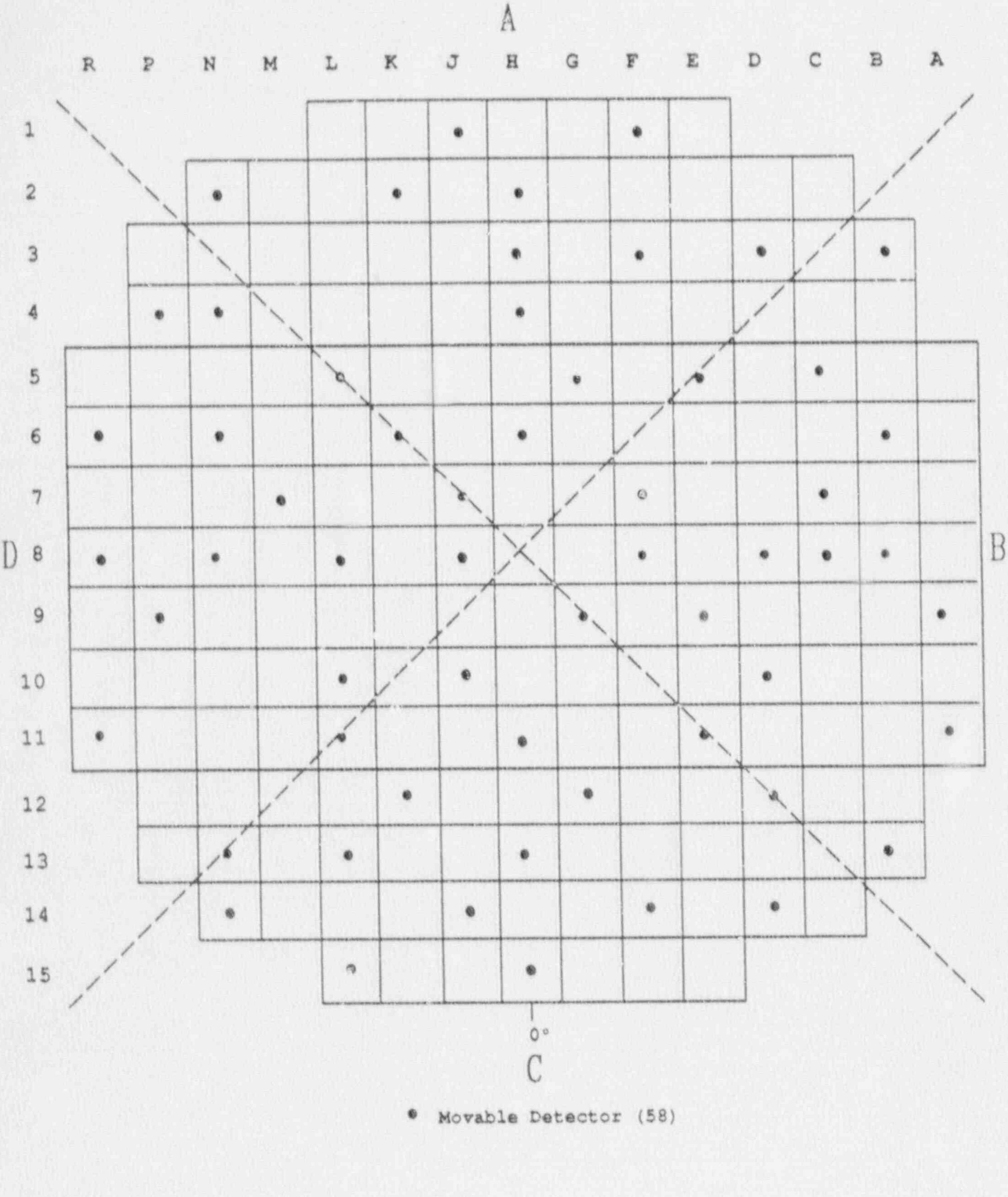


Figure 5. Diagonal Quadrants Movable Detector Thimble Number Scheme

APPENDIX A

THIMBLE DELETION UNCERTAINTY COMPONENTS

95% PROBABILITY AND 95% CONFIDENCE $(\overline{X}_{comb.} + KS_{comb.})$

NORMAL (TYPICAL) FLUX MAPS

$F_{\Delta H}$

T. D. Uncert. Component (50%)

T. D. Uncert. Component (75%)

F_Q

T. D. Uncert. Component (50%)

T. D. Uncert. Component (75%)

F_{xy}

T. D. Uncert. Component (50%)

T. D. Uncert. Component (75%)

(a, c)

APPENDIX B

THIMBLE DELETION UNCERTAINTY COMPONENTS

95% PROBABILITY AND 95% CONFIDENCE ($\overline{X}_{comb.}$ + $KS_{comb.}$)

PSEUDO DROPPED ROD FLUX MAPS

(a,c)

$F_{\Delta H}$

T. D. Uncert. Component (50%)

T. D. Uncert. Component (75%)

F_Q

T. D. Uncert. Component (50%)

T. D. Uncert. Component (75%)

F_{xy}

T. D. Uncert. Component (50%)

T. D. Uncert. Component (75%)

APPENDIX C

TWO-SIDED 95% CONFIDENCE LIMITS ON MEAN ΔTILT AND MEAN ΔA.O

$\bar{X}_{comp.}$ tilt or A.O. $\pm$ $t_{.025}$ $s_{comp.}$ tilt or A.O. / $\sqrt{N}$ (approximate t by z)

QUADRANT TILT:

[ ] (a,c)

AXIAL OFFSET:

[ ] (a,c)

PROPOSED TECHNICAL SPECIFICATION and COLR MODIFICATIONS

INSERT A

When the number of available movable detector thimbles is less than 75% of the total, the 5% measurement uncertainty shall be increased to [5% + (3-T/14.5)(2%)] where T is the number of available thimbles.

INSERT B

When the number of available movable detector thimbles is less than 75% of the total, the 4% measurement uncertainty shall be increased linearly by 1% as specified by the COLR.

INSERT C

When the number of available movable detector thimbles is less than 75% of the total the 4% measurement uncertainty shall be increased to [4% + (3-T/14.5) (1%)] where T is the number of available thimbles.

INSERT D

a)

$F_{\Delta H}^{RTP}$ = 1.49 for % of available thimbles ≥75%

$F_{\Delta H}^{RTP}$ = [(0.0149/14.5)T + 1.4453] for % of available thimbles ≥50% and <75%

where T is the number of available thimbles.

ATTACHMENT 3

Analysis of Significant Hazards Consideration

Analysis of Significant Hazards Consideration:

As required by 10CFR 50.91, this analysis is provided concerning whether the proposed amendments involve significant hazards considerations, as defined by 10CFR 50.92. Standards for determination that a proposed amendment involves no significant hazards considerations are if operation of the facility in accordance with the proposed amendment would not: 1) involve a significant increase in the probability or consequences of an accident previously evaluated; or 2) create the possibility of a new or different kind of accident from any accident previously evaluated; or 3) involve a significant reduction in a margin of safety.

The proposed amendments are a change for McGuire Unit 1 Cycle 7 to reduce from 75% to 50% the number of available moveable incore detector thimbles required for the Moveable Incore Detection System to be operable, thus allowing continued operation of Unit 1 should a current problem with sticking detector thimbles become worse.

The proposed amendments would not involve an increase in the probability of an accident previously evaluated. The Moveable Incore Detection System is used only to provide confirmatory information on the neutron flux distribution and is not required for the day-to-day safe operation of the core. Its information is not considered in the accident analyses. The system is not a process variable that is an initial condition in FSAR Chapter 15 analyses. The only previously evaluated accident the system could be involved in is breaching of the detector thimbles (due to wear by the detectors for example) which would be enveloped by the small break loss of coolant accident (LOCA) analysis. As the proposed changes do not involve any changes to the system's equipment and no equipment is operated in a new or more deleterious manner, there is no increase in the probability of such an accident. The proposed amendments would not involve an increase in the consequences of an accident previously evaluated. The Moveable Incore Detection System is not used for accident mitigation (the system is not used in the primary success path for mitigation of a Design Basis Accident). The system is a control system not required for safety. The ability of the Reactor Protection System or Engineered Safety Features System instrumentation to mitigate the consequences of an accident have not been impaired. The small break LOCA analysis (and thus its consequences) continues to bound potential breaching of the system's detector thimbles. Therefore, the change does not involve an increase in the probability or consequences of an accident previously evaluated.

The proposed amendments would not create the possibility of a new or different kind of accident from any accident previously evaluated as they only affect the minimum complement of equipment necessary for operability of the Moveable Incore Detection System. As discussed above, no new equipment is introduced and no equipment is operated in a new manner. Thus the changes could create no new or different accident causal mechanisms. Therefore, the proposed amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated since it does not modify plant operation or components.

The proposed amendments would not involve a significant reduction in a margin of safety. The reduction in the minimum complement of equipment necessary for operability of the Moveable Incore Detection System could only impact the monitoring/calibration functions of the system. Reduction of the number of available moveable incore detector thimbles to the 50% level does not significantly degrade the ability of the Moveable Incore Detection System to measure core power distributions. Core peaking factor measurement uncertainties will be increased, but will be compensated for by conservative measurement uncertainty adjustments in the Technical Specifications to ensure that pertinent core design parameters are maintained. Sufficient additional penalty is added to the power distribution measurements such that this change does not impact the safety margins which currently exist. Also, available detector thimble reduction has negligible impact on the quadrant tilt and core average axial power shape measurement. Sufficient detector thimbles will be available to ensure that no quadrant will be unmonitored. Based on these factors, the margin of safety is not reduced as the core will continue to be adequately monitored.

In addition, similar changes for other plants in the past (as well as for McGuire Unit 1 Cycle 6) have been determined not to involve Significant Hazards Considerations.

Based upon the preceding analysis, Duke Power Company concludes that the proposed amendments do not involve a Significant Hazards Consideration.