NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

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May 3, 1983

Docket No. 50-336
A02724

Director of Nuclear Reactor Regulation
Attn: Mr. Robert A. Clark, Chief
Operating Reactors Branch #3
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

References:
(1) W. G. Counsil letter to R. A. Clark, dated March 4, 1982
(2) R. A. Clark letter to W. G. Counsil, dated August 19, 1982
(3) W. G. Counsil letter to R. A. Clark, dated November 4, 1982
(4) W. G. Counsil letter to R. A. Clark, dated February 22, 1983

Gentlemen:

Millstone Nuclear Power Station, Unit No. 2
Request for Additional Information, Measurement Uncertainties
Response to Question 6

In Reference (3), Northeast Nuclear Energy Company (NNECO) provided a partial response to the Staff's Reference (2) request for additional information concerning measurement uncertainties utilized in the Millstone Unit No. 2 safety analyses. Additional time was necessary to complete our responses to Questions 4 and 6 of Reference (2). Our response to Question 4 was docketed in Reference (4). Our response to Question 6, as per our mutually agreed upon schedule, as documented in Reference (2), is presented herein.

The results of the review of the total Axial Shape Index (ASI) uncertainty allowance have been completed and are attached. Details have been provided concerning uncertainties associated with plant calibration procedures, process equipment, the shape annealing factor, incore monitoring methodology, and ASI separability. Results of this review indicate that these uncertainties result in a total uncertainty less than that reported in Reference (1). Thus, this information continues to support the measurement uncertainties utilized in the Millstone Unit No. 2 safety analyses.

Attachments 1 and 3 present the non-proprietary and proprietary versions, respectively, of the Total Axial Shape Index Review. Portions of the material in Attachment 3 are proprietary to both the Westinghouse Electric Corporation and Combustion Engineering, Incorporated. As discussed in telephone conversations with your Staff, NNECO has included seven copies of this proprietary information and requests that it be withheld from public disclosure in accordance with the provisions of 10 CFR 2.790 and that this material be safeguarded. The reasons for the classification of this material as proprietary is delineated in the affidavits included in Attachment 3.

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In Reference (3), NNECO indicated that an evaluation of the feedwater measurement system was underway. Since that time NNECO has completed the evaluation and hereby presents a summary of this in Attachment 2. Results of the evaluation demonstrated that a reduction in temperature span in the main feedwater temperature measurement channel will provide a more accurate indication of feedwater temperature measurement. This was accomplished by recalibrating the temperature transmitter. The resulting increase in accuracy then provides smaller core power, RCS flowrate, neutron and delta-T power uncertainties. These results supercede those provided in Reference (4).

Attachment 2 also provides details concerning our Reference (4) commitment to inform the Staff of the results of NNECO's QA-verification of our response to Question 4 of Reference (1). This QA-verification was recently completed and the results support our conclusions of Reference (4). Quality assurance has, however, determined that slight differences exist with regard to the tabulation of historical drift data used for justification of the instrument span drifts as discussed in Reference (4). The QA-verified results indicate that two of the instrument span drifts are, in fact, smaller than those values reported in Reference (4).

We trust you will find this information responsive to your Reference (1) request.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

W. G. Counsil

W. G. Counsil
Senior Vice President

C. Frederick Sears

By: C. F. Sears
Vice President Nuclear and
Environmental Engineering

Docket No. 50-336

Attachment 1

Request for Additional Information
Measurement Uncertainties
Response to Question 6
(non-proprietary version)

May, 1983

The following provides the response to question 6 of the NRC letter from R. A. Clark to W. G. Counsil, Northeast Nuclear Energy Company, dated August 19, 1982.

QUESTION 6: Provide results of the review of the total axial shape index uncertainty allowance.

RESPONSE:

The Millstone Unit No. 2 monitoring and protection systems utilize both incore and excore detectors to monitor core axial power shape. The parameter monitored is called the Axial Shape Index (ASI) and is mathematically defined by:

$$Ie = \frac{L-U}{L+U}$$

$$Y_I = a*Ie + b$$

where

Ie = excore axial shape index

Y_I = monitored axial shape index

L = lower excore nuclear instrument detector signal

U = upper excore nuclear instrument detector signal

a = shape annealing factor

b = bias term

Incore detector derived ASIs are used in Technical Specification 3.2.6 to provide initial conditions for the accident and safety analyses and to ensure that the assumed margins to DNB are maintained. Excore ASI is used as input to the Local Power Density trip which ensures that the peak local power density which corresponds to fuel centerline melting will not occur as a consequence of an axial power maldistribution. Excore ASI is also an input parameter to the Thermal Margin / Low Pressure trip which prevents operation when the DNBR is less than 1.30. The excore detector system can be utilized as described in Technical Specification 3.2.1 to monitor linear heat rate. The excore detector ASI is calibrated to the measured incore value via Millstone Unit 2 plant procedures.

Limiting conditions for operation and limiting safety system setpoint analyses assume core average axial power shapes (characterized by ASI) in their derived setpoints. The methodology for these setpoints is described in WCAP-9660[1].

There are five contributors to the ASI uncertainty, each of which is described in the following sections. The combination of the five uncertainties is provided in Section VI of this response.

I. CALIBRATION ALLOWANCE

The Calibration Allowance is an instrument uncertainty directly related to on-site, plant calibration procedures. This allowance includes calibration accuracy, drift, and voltage setting tolerances for a voltage signal from the excore detector through the output of the linear amplifier.

Using the data provided in Reference 2, Question 1, Section II (for upper and lower detector voltage calibration errors) and Reference 3, Tables 10 and 12 (for ASI drift allowance) it has been determined that a normal distribution can be used to describe the Calibration Allowance. The data provided in Table 12 of Reference 3 allows for the determination of a two sided, 95% probability/95% confidence limit value for the standard deviation of the ASI drift allowance. The value of Ks determined is 0.00917 ASIU. Combining this allowance by Root Sum of the Squares (RSS) with the upper and lower detector voltage calibration errors results in a total uncertainty (± Ks) of 0.0093 ASIU. However, a total uncertainty of 0.01 ASIU, with a degrees of freedom of 139, is used in this evaluation for conservatism. Table 1 provides a summary of the above.

II. EQUIPMENT PROCESSING ALLOWANCE

The Equipment Processing Allowance quantifies the effect of the processing equipment upon ASI as well as the uncertainty in setting of trip or alarm values in the Reactor Protection System and the Power Ratio calculators. This allowance accounts for instrumentation or rack tolerances from the output of the linear amplifiers through the trip bistables or LCO annunciators. Also included are calibration and drift allowances for the signal comparators and setpoint settings. The allowance used in this evaluation is ± 0.02 ASIU. The uncertainty distribution can be represented by a normal distribution and the 0.02 ASIU is the equivalent ± Ks value at a 95/95 level.

III. SHAPE ANNEALING FACTOR ALLOWANCE (SAF)

The Shape Annealing Factor (a) is an experimentally measured value which relates the peripheral shape index (Ip) to the measured value of the external shape index (Ie).

$$Ip = a * Ie$$

The SAF uncertainty allowance accounts for the ability to measure the SAF experimentally on-site from xenon oscillation experiments. The Combustion Engineering report CEN-247 (N) is attached as Appendix A to provide a detailed discussion of this uncertainty allowance. CE has determined that the uncertainty distribution of this parameter can be represented by a normal distribution. CE also notes that at a 95/95 level the uncertainty (± Ks) is 0.068 *Ip. Assuming a range in Ip = ± 0.2 ASIU results in a Ks value of 0.0136 ASIU. A value of ± 0.015 ASIU has been used in this evaluation for conservatism.

IV. INCORE MONITORING METHODOLOGY UNCERTAINTY

In addition to statistical fluctuations and instrument uncertainties which are evaluated in the previous sections, the use of four section fixed incore detector strings to reconstruct ASI can introduce a component of error.

To determine this error term, ( ) +a,b,c axial shapes were reconstructed utilizing the INCA algorithms. The mean error, standard deviation, and distribution type were determined. The data base is the full power subset of those shapes previously used in WCAP-9660-Addendum 1 (4) to determine the Fq uncertainty. The full power subset is used because the error values are more conservative than for all cases together. Figure 1 provides the result. The mean error is ( )+a,b,c and a standard deviation of ( )+a,b,c. The histogram of errors shows a range of +1 to -1.5 and can be characterized as normal with a mean of ( ) +a, b, c and a standard deviation of ( ) +a, b, c. The number of degrees of freedom is ( )+a,b,c with N equal ( )+a,b,c. The two sided, 95/95 tolerance factor K equals ( )+a,b,c and K_{SI} equals ( )+a,b,c.

V. SEPARABILITY

This component of the ASI uncertainty accounts for the relationship between the core average ASI used in the safety analyses and the peripheral fuel assembly shape indices which directly affect the excore detector response. (See Figure 2.) The major subcomponents of this uncertainty are control rod shadowing effects, variations in the relationship between core average ASI (I) and peripheral ASI (I_p) caused by off nominal conditions such as xenon oscillations, and the ability of the design methods themselves to correctly account for the nominal relationship between I and I_p.

The differences in peripheral assembly ASI's relative to core average ASI has been evaluated by performing a large number of 3-D neutronics calculations. Cycles 4 through 6 of Millstone Unit 2 were evaluated. Power levels between 90% and 100% were modeled using various control rod depletion histories consistent with Technical Specification 3.1.3.6, CEA power dependent insertion limits (PDIL). Xenon oscillations were induced at the most limiting times in the cycle with respect to DNB. Control rod shadowing and xenon oscillation effects are thus implicitly included in these evaluations.

The results of these calculations provide the differences between core average and peripheral assembly ASIs. The results are summarized in Table 2 and Figure 2 provides the core map and excore detector locations. The excore detector response will be related to a weighted sum of peripheral assembly powers. It is conservatively assumed that the ASI variation in the "weighted" detector response assembly equals that of the population of peripheral ASI variations. Figure 3 compares the histogram of % ASI differences to a normal distribution with the same mean and standard deviation. The peripheral assembly power distributions are generally more bottom skewed than the core average power shapes. This

bias is accounted for in the limiting conditions for operation and the limiting safety system setpoint analyses and is also measured as part of the determination of the shape annealing factor. (This is the bias term b as discussed in the Introduction.)

For this uncertainty component, it is conservative to assign a normal distribution with a standard deviation of ( ) +a,b,c and ( ) +a,b,c degrees of freedom with N equal ( ) +a,b,c. The two sided, 95/95 tolerance factor K equals ( ) +a,b,c and Ks_{SAF} equals ( ) +a,b,c.

VI. ALLOWANCE AND UNCERTAINTY COMBINATION

Table 3 summarizes the information noted in Sections I through V concerning means, standard deviations, degrees of freedom, and determined values for tolerance factors for those uncertainties where a Ks value must be calculated. In all cases, the population distributions are known to be normal or near normal and the Ks values are determined to be the standard deviation at a 95% probability and 95% confidence level.

Based on the data summarized in Table 3, the sum of the means can be calculated by:

$$x_T = \Sigma x_i = (\quad)^{+a,b,c}$$

It is possible to conservatively determine the value for s for the Shape Annealing Factor Allowance and the Equipment Processing Allowance. However, the data required to determine the proper tolerance factors to arrive at a 95/95 value for S_T are not presently available.

It is concluded that since all five uncertainties are independent, normal, two-sided distributions, with Ks values known at the 95/95 level, it is conservative to determine a combined Ks value using:

$$Ks_T = [\Sigma (Ks_i)^2]^{1/2}$$

The resulting value for Ks_T is therefore at least a 95% probability, 95% confidence level value. Using the above noted equation, $\pm$ Ks_T = ( ) +a,b,c. Therefore, the total uncertainty for ASI is ( ) +a,b,c which is less than the $\pm$ 0.06 ASIU noted in Reference 2.

REFERENCES

1. Jacobs, G. V., et al. "Basic Safety Report - Millstone Nuclear Power Station Unit 2", WCAP-9660 (Proprietary), WCAP-9661 (Non-Proprietary), February, 1980.

2. W. G. Counsil letter to R. A. Clark, NRC, "Millstone Unit 2, Measurement Uncertainties," dated March 4, 1982.

3. W. G. Counsil letter to R. A. Clark, NRC, "Millstone Unit 2, Additional Information on Measurement Uncertainties," dated February 22, 1983.

4. Alsop, B. H., "Basic Safety Report - Millstone Nuclear Power Station Unit 2 - Power Peaking Factor Uncertainty Analysis," WCAP-9660 Addendum 1 (Proprietary), WCAP-9661 Addendum 1 (Non-Proprietary), May, 1980.

TABLE 1

Calibration Allowance

A) ASI Drift Allowance

s_D = 0.0042 ASIU n = 140

for n = 140, two sided, 95/95 tolerance factor, K = 2.184

Ks_D = 0.00917 ASIU

B) Upper detector voltage calibration error: Ks_u = 0.00096 ASIU

Lower detector voltage calibration error: Ks_ℓ = 0.0008 ASIU

Total Uncertainty, $Ks_{CA} = [\quad]^{1/2}$

Ks_{CA} = 0.0093 ASIU

For conservatism Ks_{CA} is rounded to 0.01 ASIU.

TABLE 2

BREAKDOWN OF INDIVIDUAL ASSEMBLIES ASI RELATIVE TO
THE CORE AVERAGE ASI FOR ASI UNCERTAINTY

+a,b,c

Condition	Assembly	n	Mean*	Variance	s
Xe Osc. HFP Cycles 5 and 6					
Xe. Osc 90% Power Cycles 5 and 6					
HFP, All Rods Out (ARO) Cycles 4, 5, and 6					
HFP, Rod Insertion Limit (RIL) Cycles 4, 5, and 6					

TABLE 2 (Cont)

BREAKDOWN OF INDIVIDUAL ASSEMBLIES ASI RELATIVE TO

THE CORE AVERAGE ASI FOR ASI UNCERTAINTY

+a,b,c

Condition	Assembly	n	Mean*	Variance	s
90% Power RIL Cycles 4, 5, and 6					
Cycle 5 Depleted with CEA7 in 12 Percent, then Cycle 6 ARO					
All Data					

*% ASI core -% ASI assembly

TABLE 3

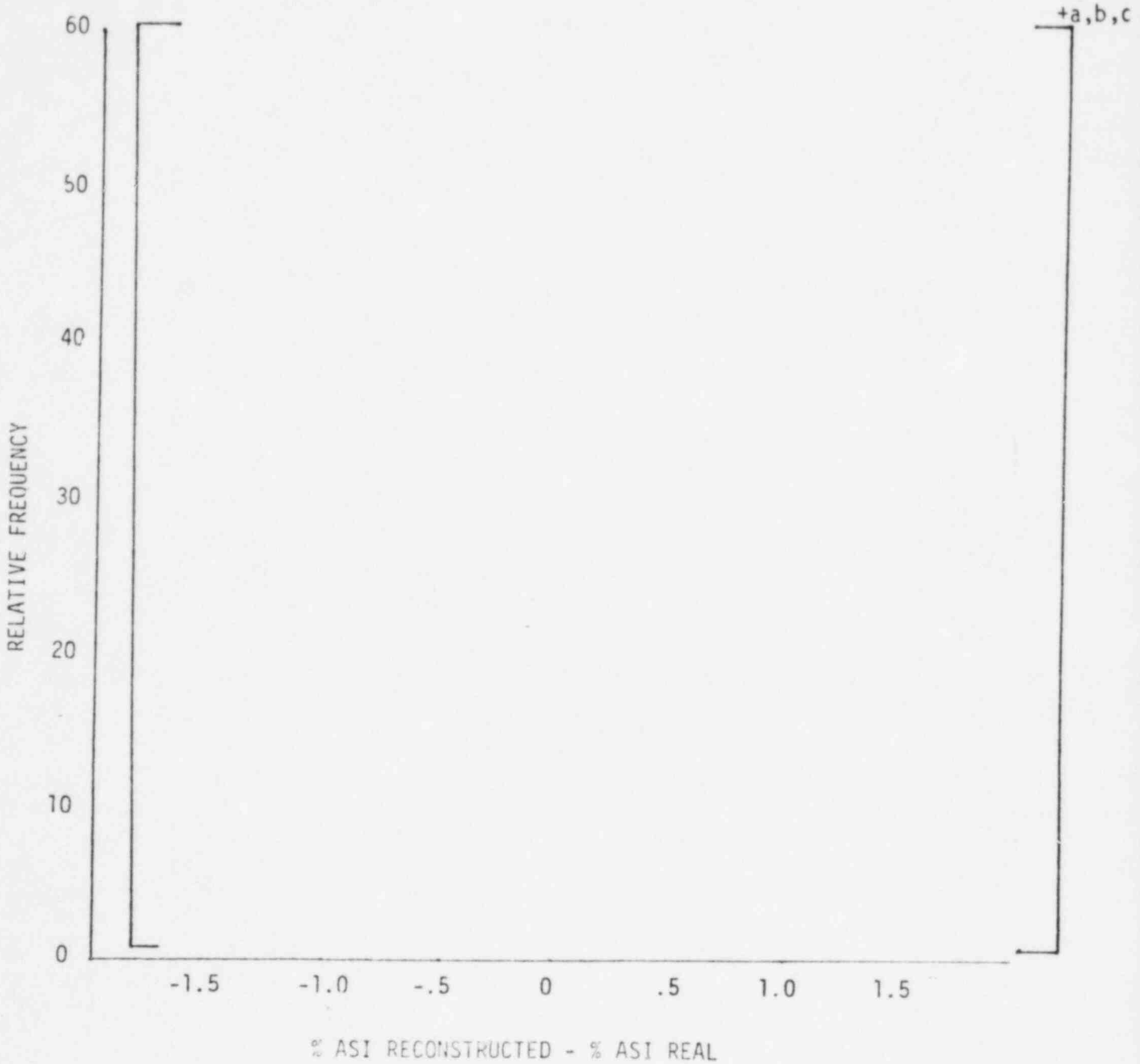
ALLOWANCE AND UNCERTAINTY SUMMARY

UNCERTAINTY	$\bar{x}$*	s*	n	ν	k**	± Ks*
1. Calibration Allowance	0.0	0.0046	140	139	2.184	0.01
2. Equipment Processing Allowance	0.0					0.02
3. Shape Annealing Factor Allowance	0.0					0.015
4. Incore Monitoring Methodology Uncertainty	[					] +a,b,c
5. Separability Allowance						

* in ASIU

** determined from Tolerance Factors for Normal Distributions, CRC Handbook of Tables for Probability and Statistics, 2nd Edition, 1976
p = 95% λ = 95%

FIGURE 1   COMPARISON OF INCA RECONSTRUCTED ASI WITH REAL ASI



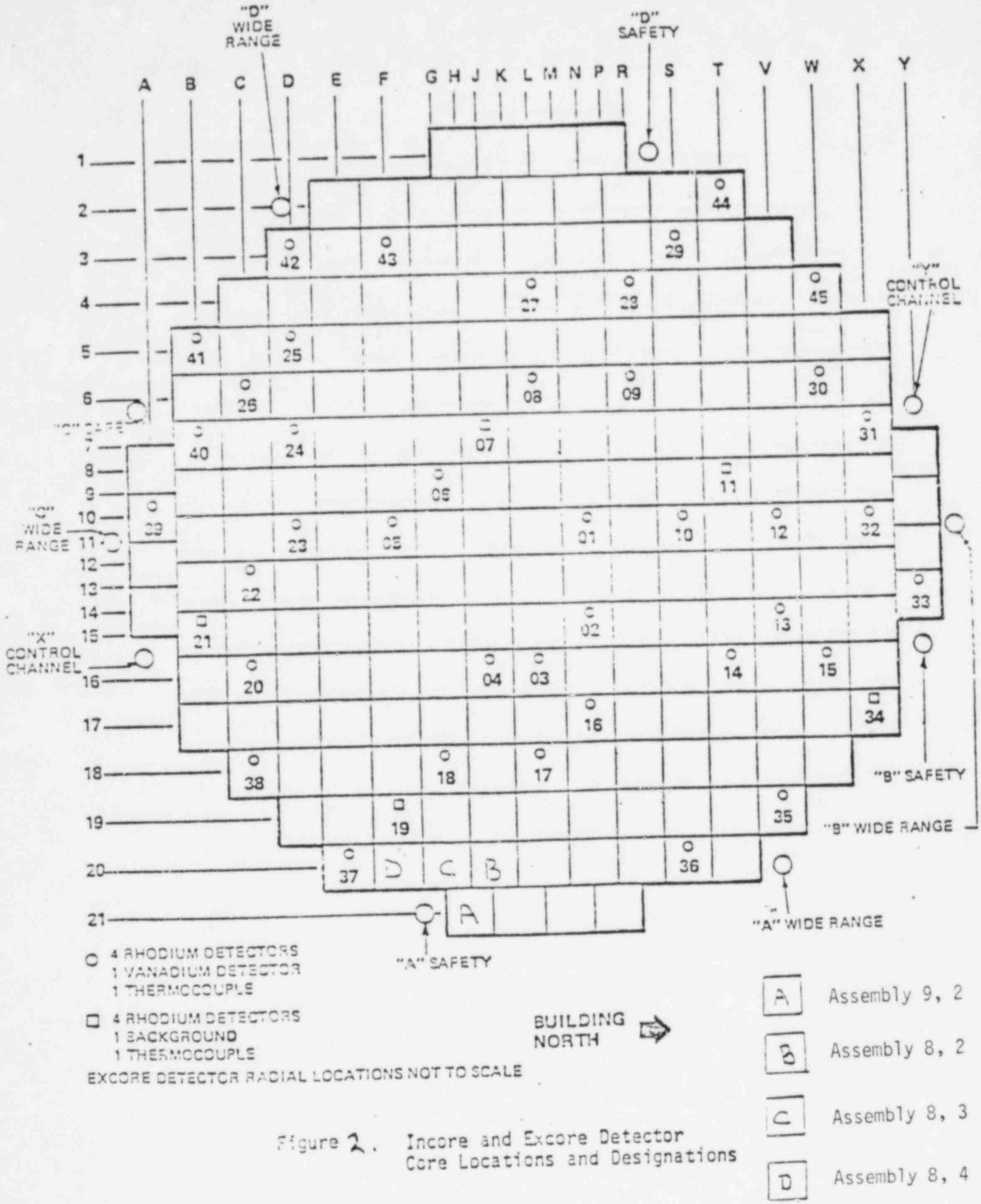
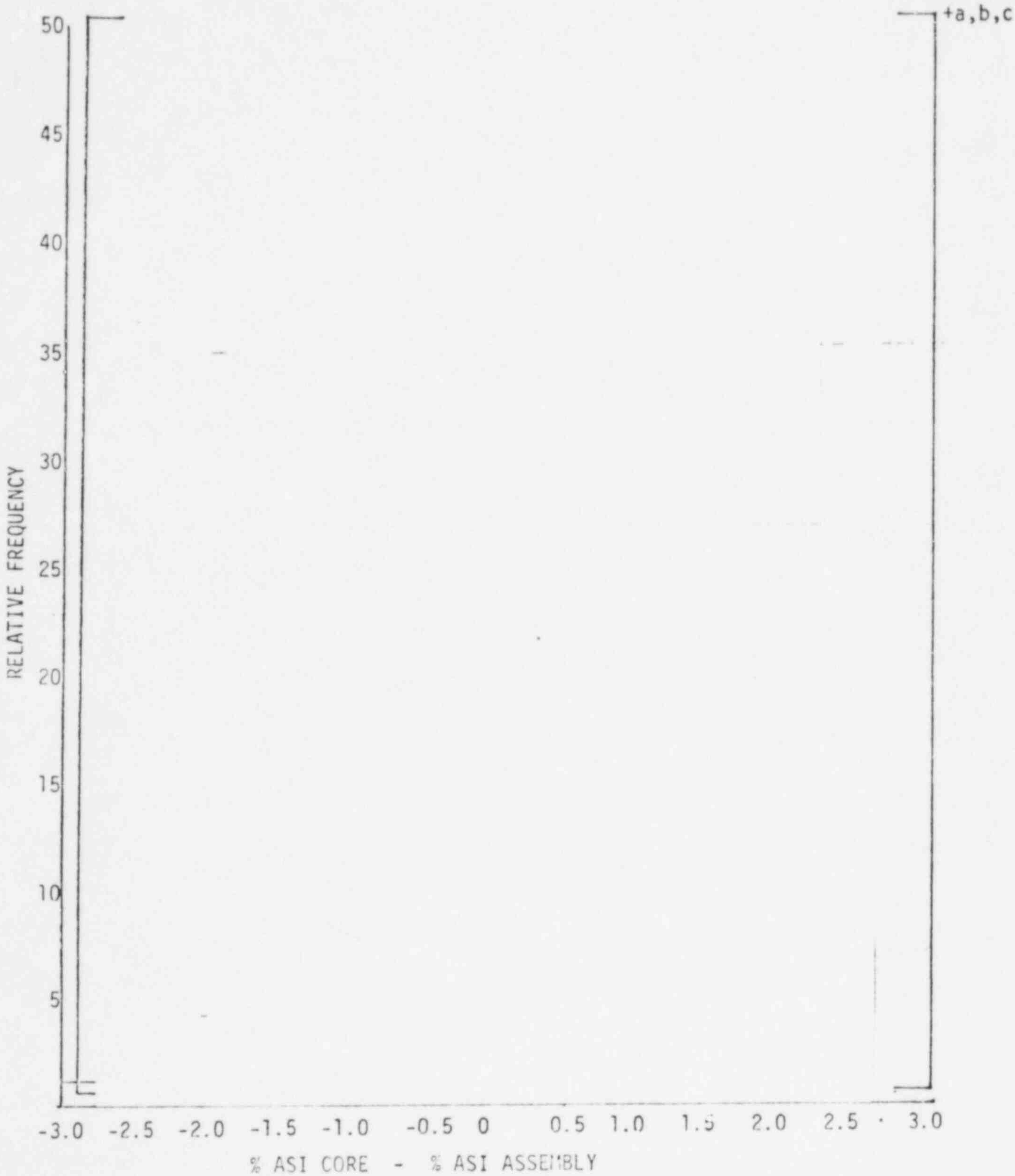


Figure 2. Incore and Excore Detector Core Locations and Designations

FIGURE 3 COMPARISON OF CORE AVERAGE AND PERIPHERAL ASSEMBLY ASI'S



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Appendix A

The Shape Annealing Factor Component of the Axial Shape Index Uncertainty at Millstone Project Unit 2

May, 1983