Westinghouse
Electric Corporation

Water Reactor
Divisions

Nuclear Technology Division

Box 355
Pittsburgh Pennsylvania 15230

November 13, 1984
CAW-84-84

Mr. Harold Denton, Director
Office of Nuclear Reactor Regulation
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: RCS Flow Measurement Uncertainty

REF: Public Service New Hampshire Letter, DeVincentis to Denton, dated November 1984

Dear Mr. Denton:

The proprietary material for which withholding is being requested is of the same technical type as that proprietary material previously submitted by Westinghouse concerning Reactor Protection System/Engineered Safety Features Actuation System Setpoint Methodology. The previous application for withholding, AW-76-60, was accompanied by an affidavit signed by the owner of the proprietary information, Westinghouse Electric Corporation.

Further, the affidavit submitted to justify the previous material was approved by the Commission on April 17, 1978, and is equally applicable to the subject material.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse and which is further identified in the affidavit be withheld from public disclosure in accordance with 10CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference CAW-84-84 and should be addressed to the undersigned.

Very truly yours,

for Robert A. Wiesemann, Manager
Regulatory & Legislative Affairs

JMG/bek
Attachment

cc: E. C. Shomaker, Esq.
Office of the Executive Legal Director, NRC

ITEM 2 OF W LETTER NAH-2582

AW-76-60

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:
ss
COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Robert A. Wiesemann, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Corporation ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

Robert A. Wiesemann

Robert A. Wiesemann, Manager
Licensing Programs

Sworn to and subscribed
before me this 1 day
of December 1976.

[signature]

Notary Public

(1) I am Manager, Licensing Programs, in the Pressurized Water Reactor Systems Division, of Westinghouse Electric Corporation and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing or rule-making proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Water Reactor Divisions.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse Nuclear Energy Systems in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(g) It is not the property of Westinghouse, but must be treated as proprietary by Westinghouse according to agreements with the owner.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition in those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information is not available in public sources to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in the attachment to Westinghouse letter number NS-CE-1298, Eicheldinger to Stolz, dated December 1, 1976, concerning information relating to NRC review of WCAP-8567-P and WCAP-8568 entitled, "Improved Thermal Design Procedure," defining the sensitivity of DNB ratio to various core parameters. The letter and attachment are being submitted in response to the NRC request at the October 29, 1976 NRC/Westinghouse meeting.

This information enables Westinghouse to:

(a) Justify the Westinghouse design.

(b) Assist its customers to obtain licenses.

(c) Meet warranties.

(d) Provide greater operational flexibility to customers assuring them of safe and reliable operation.

(e) Justify increased power capability or operating margin for plants while assuring safe and reliable operation.

(f) Optimize reactor design and performance while maintaining a high level of fuel integrity.

Further, the information gained from the improved thermal design procedure is of significant commercial value as follows:

(a) Westinghouse uses the information to perform and justify analyses which are sold to customers.

(b) Westinghouse sells analysis services based upon the experience gained and the methods developed.

Public disclosure of this information concerning design procedures is likely to cause substantial harm to the competitive position of Westinghouse because competitors could utilize this information to assess and justify their own designs without commensurate expense.

The parametric analyses performed and their evaluation represent a considerable amount of highly qualified development effort. This work was contingent upon a design method development program which has been underway during the past two years. Altogether, a substantial amount of money and effort has been expended by Westinghouse which could only be duplicated by a competitor if he were to invest similar sums of money and provided he had the appropriate talent available.

Further the deponent sayeth not.

RAI 492.6 (4.4)

Your letter of April 25, 1983 (J. DeVincentis, Public Service of New Hampshire to G. W. Knighton, NRC) provided a response superceding your previous response (FSAR Amendment 45, June 1982) to staff question 492.2 regarding the Reactor Coolant System (RCS) flow measurement. The current response included a Westinghouse report for the Seabrook flow measurement uncertainty similar to the gene... Westinghouse flow measurement uncertainty report (Letter NS-EPR-2577, E. P. Rahe, Westinghouse, to C. H. Berlinger, NRC, March 31, 1982). You concluded that the total flow measurement uncertainty for four loop operation is: ± 1.9% using three elbow taps per loop with digital volt meter readout, or ± 2.0% using one elbow tap per loop with computer readout. Also, you indicated that bias due to feedwater flow venturi meter fouling is not included due to methods of confirming that fouling does not exist. In addition, you indicated that crud buildup that could affect the pressure taps on the venturi and flow elbow, and that could lead to measurement errors, is not expected and has not been detected in any Westinghouse reactor.

Even though the Westinghouse response reflects the use of RdF RTD transmitters for Seabrook, other instrumentation uncertainties cited are the generic bounding values for Westinghouse instrumentation.

(a)

Plant-specific instrumentation uncertainties exceeding the bounding values cited in the Westinghouse response should be identified and used for the plant-specific analysis. Please identify any instrumentation which deviates from the Westinghouse instrumentation and provide the uncertainty value pertinent to this instrumentation and measurement arrangement with comparison to the Westinghouse generic value.

(b)

The bases or sources for the uncertainty value should also be provided. The sources can be from purchase specifications, manufacturing specifications, calibration data provided by instrumentation vendor or obtained on site, published industry standard or other justifiable bases.

(c)

How may elbow taps will be used per loop?

RESPONSE

(a),(b)

The measurement arrangement at Seabrook will be the same as assumed by Westinghouse with the following exceptions:

- o Feedwater flow will be monitored at the output of the transmitter using a DVM instead of a local gauge.
- o Feedwater pressure will be read directly off the Main Control Board instruments instead of assuming a pressure 100 psi above steam pressure.
- o In order to minimize the number of unisolated protection channel measurements, steam pressure and pressurizer pressure will be measured with a DVM at an isolated output. An isolator drift of .5% is included in the Seabrook specific uncertainty analysis. Also, the uncertainties for these two measurements are calculated rather than assumed.
- o If RCS flow is measured with a DVM it will be measured at the output of the transmitter and will not include any rack components.

The instrumentation used at Seabrook is the same as assumed by Westinghouse with the following exceptions:

- o Feed Pressure Transmitter - Seabrook uses a Foxboro E11GM transmitter. The calibration accuracy for this transmitter as specified by the manufacturer is 0.5% of span, [ ].[+a,c]

- o Feedwater RTDs - Seabrook has Thermo Electric platinum RTDs. The accuracy as specified by the vendor is $\pm$ 1^{o}F or $\pm$ 1/2% of reading up to 600^{o}F, whichever is largest.

- o Station Computer - The Seabrook Station computer has an A/D conversion error of $\pm$ 0.2% of full scale based on station experience with the operation of the computer.

- o Test Equipment - The test equipment presently identified in station procedures for use in calibrating some of the sensors does not always meet the accuracy ratio assumed by Westinghouse. The test equipment accuracies, as specified by the test equipment vendor, have been accounted for in the station specific analysis.

(c)

When available, three elbow taps will be used per loop. The minimum is two elbow taps per loop to meet Technical Specification Table 3.3-1.

A comparison of the uncertainties listed in our letter of April 25, 1983, and those based on Seabrook specific instrumentation and procedures is provided in the following table and accompanying notes. Only those notes applicable to Seabrook specific information are included.

Total flow measurement uncertainties based on Seabrook specific instrument uncertainties are:

Calorimetric Uncertainty	± 1.9%
Total Uncertainty (Computer) (3 Elbow Taps/Loop)	± 2.0%
Total Uncertainty (DVM) (3 Elbow Taps/Loop)	± 2.0%
Total Uncertainty (Computer) (2 Elbow Taps/Loop)	± 2.0%
Total Uncertainty (DVM) (2 Elbow Taps/Loop)	± 2.0%

Comparison Of Westinghouse Values To Seabrook Specific Values For RCS Flow Uncertainty

+a,c

Component	W Instrument Error	W RCS Flow Uncert.	Seabrook Instrument Error	Seabrook RCS Flow Uncert.
Feedwater Flow				
Venturi K				
Thermal Expansion				
Temperature				
Material				
Density				
Temperature				
Pressure				
Venturi Fouling				
Instrumentation				
dP Cell Calibration				
dP Cell Gage Readout				
Sensor Temperature Effect				
DVM Accuracy				
Total Instrument Error				
Total FW Flow Error				
Feedwater Enthalpy				
Temperature				
RTD Calibration				
Sensor Drift				
DVM Accuracy				

+a,c

Component	W Instrument Error	W RCS Flow Uncert.	Seabrook Instrument Error	Seabrook RCS Flow Uncert.
Feedwater Enthalpy (Cont'd)				
Total Temperature Error				
Pressure				
Sensor Calibration				
Sensor Drift				
Sensor Temperature Effec				
Rack Calibration				
Rack Drift				
Rack Temperature Effect				
MCB Readout				
Total Pressure Error (% Span)				
Total Pressure Error (psi)				
Total Feed Enthalpy Error				
Steam Enthalpy				
Steamline Pressure				
Pressure Cell Calibration				
Sensor Temp. Effect				
Rack Calibration				
Rack Temperature Effect				
Isolator Drift				
DVM Accuracy				
Total Electronics Error				
Pressure Error Assumed				
Pressure Error Calculated				
Moisture Carryover				
Total Steam Enthalpy Error				
Total Secondary Side Loop				
Secondary Side Loop Power Uncertainty				

Component	W Instrument Error	W RCS Flow Uncert.	Seabrook Instrument Error	Seabrook RCS Flow Uncert.
				+a,c
RCP Heat Adder Uncertainty				
Total Secondary Side Loop Power Uncertainty				
Primary Side Enthalpy				
T_H (Electronics)				
RTD Calibration				
Sensor Drift				
DVM Accuracy				
T_H Instrumentation Error				
T_H Streaming Error				
T_H Temperature Error				
T_C (Electronics)				
RTD Calibration				
Sensor Drift				
DVM Accuracy				
T_C Instrumentation Error				
Pressurizer Pressure				
Pressure Cell Calibration				
Sensor Temperature Effect				
Sensor Drift				
Rack Calibration				
Rack Drift				
Rack Temperature Effect				
Isolator Drift				
DVM Accuracy				
Total Error				
Pressurizer Pressure Error (Calculated)				
Pressurizer Pressure Error (Assumed)				
T_H Pressure Effect				
T_H Total Error				
T_C Pressure Effect				

	W		Seabrook	
Component	Instrument Error	RCS Flow Uncert.	Instrument Error	RCS Flow Uncert. +a,c
T_C Total Error				
Total Δh Uncertainty				
Primary Side Loop Flow Uncertainty				
Total RCS Flow Uncertainty				

NORMALIZED ELBOW TAP INSTRUMENTATION UNCERTAINTIES

COMPUTER MEASUREMENT

Component	W		Seabrook	
	% dp Span	% RCS Flow	% dp Span	% RCS Flow +a,c
PMA				
PEA				
SD				
RCA				
RD				
ID				
A/D				
Readout				
CSA				

DVM MEASUREMENT

Component	W		Seabrook	
	% dp Span	% RCS Flow	% dp Span	% RCS Flow
PMA				
PEA				
SD				
RCA				
RD				
DVM				
Readout				
CSA				

Notes

1. The primary element accuracy for feed flow includes an uncertainty of $\pm$0.1% for the ability to detect fouling of the venturi.

2. Sensor calibration accuracy for feed flow includes an allowance for the test equipment used to calibrate the transmitter. Present station procedures call for the use of a Heise gauge with a range of 0-60 psi and an accuracy of $\pm$0.1% or $\pm$.06 psi. The span of the feed flow transmitter is 830" H_2O (30 psi). The test equipment accuracy is $\pm$ .2% (.06 psi/30 psi) of feedwater flow transmitter span. Therefore, the .2% test equipment accuracy must be added to the $\pm$ [ ]$^{+a,c}$ calibration accuracy of the transmitter.

3. Seabrook will not use a local gauge to read dP on the feedwater flow venturi, hence, the sensor temperature effect which [ ]$^{+a,c}$ neglects because of the local gauge must be accounted for. Also, the DVM is normally accurate to $\pm$0.05% of span, but an allowance of $\pm$0.5% span has been used because of the difficulty in reading the rapidly fluctuating dP signal. [( )]$^{+a,c}$

4. Span of the Feedwater flow transmitter is 132% instead of the 120% assumed by Westinghouse.

5. The feedwater RTD accuracy from the vendor is $\pm$ 1.0^{o}F or 1/2% of reading up to 600^{o}F. Hence, at 440^{o}F the error is $\pm$2.20^{o}F.

6. Sensor calibration accuracy for feed pressure includes an allowance for the test equipment used to calibrate the transmitter. Present station procedures call for the use of a Heise gauge with a range of 0-3000 psi and an accuracy of $\pm$0.1% or $\pm$3.0 psi. The span of the feed pressure transmitter is 1500 psi. The test equipment accuracy is $\pm$.2% (3.0 psi/1500 psi) of feed pressure span. Therefore, the .2% test equipment accuracy must be added to the [ ]$^{+a,c}$ calibration accuracy of the transmitter.

7. The most inaccurate means to read feedwater pressure is to use the Main Control Board indication. That is what is assumed here.

8. Span of the steam pressure transmitter is 1300 psi instead of the 1200 psi assumed by Westinghouse.

9. SCA for steam pressure includes an allowance for the test equipment used to calibrate the transmitter. Present station procedures call for the use of a Heise gauge with a range of 0-1500 psi and an accuracy of ±0.1% or ±1.5 psi. The span of the steam pressure transmitter is 1300 psi. The test equipment accuracy is ±.12% (1.5 psi/1300 psi) of steam pressure span. Therefore, the ±0.12% test equipment accuracy must be added to the [ ]$^{+a,c}$ calibration accuracy of the transmitter.

10. Station procedures call for the DVM measurement of this instrument at the output of the transmitter, thus bypassing the rack and errors associated with the rack.

11. SCA for pressurizer pressure includes an allowance for the test equipment used to calibrate the transmitter. Present station procedures call for the use of a Heise Ashcroft Digigage with a range of 0-3000 psi and an accuracy of ±0.05% or ±1.5 psi. The span of the pressurizer pressure transmitter is 800 psi. The test equipment accuracy is ±0.19% (1.5 psi/800 psi) pressurizer pressure span. Therefore, the ±0.19% test equipment accuracy must be added to the [ ]$^{+a,c}$ calibration accuracy of the transmitter.

12. In order to minimize the number of unisolated protection channel measurements, an additional ±0.5% isolator drift has been added to the analysis.

13. A rack drift of ±0.5% is added for additional conservatism.

14. The Seabrook Station computer has an A/D conversion error of ±0.2% full scale based on operating experience.

RAI 492.7 (4.4)

For the RCS flow measurement, the Westinghouse generic response states: "It is assumed for this error analysis, that this flow measurement is performed within seven days of calibrating the measurement instrumentation, therefore, drift effects are not included (except where necessary due to sensor location)". Does your plant operating procedure have provisions that require the RCS flow measurement be performed within seven days of calibrating the measurement instrumentation? If not, what are the drift uncertainty values associated with each component such as dP cell, local meter, RTD, thermocouple, process rack and sensors? What is the effect on the overall flow measurement uncertainty?

RESPONSE

Station procedures will require that the process measurement instrumentation which Westinghouse assumed calibrated within seven days of the flow measurement be calibrated or calibration checked within that time frame. Where the Westinghouse submittal indicated that the DVM had been recently calibrated, this may not always be the case, but a DVM of sufficient accuracy within its calibration period will be used so that the error assumed by Westinghouse for the DVM will not be exceeded.

RAI 492.8 (4.4)

The Westinghouse report states: "It is also assumed that the calorimetric flow measurement is performed at the beginning of a cycle, so no allowance has been made for feedwater venturi crud buildup"; and "If venturi fouling is detected by the plant, the venturi should be cleaned, prior to performance of the measurement. If the venturi is not cleaned, the effect of the fouling on the determination of the feedwater flow and, thus, the steam generator power and RCS flow should be measured and treated as a bias, i.e., the error due to venturi fouling should be added to the statistical summation of the rest of the measurement errors".

(a) How do you assure that the venturi is clean at the beginning of a cycle? Is the venturi cleaned at the beginning of every cycle?

(b) How do you detect the venturi fouling and to what extent of uncertainty can you detect fouling?

(c) Describe the design provisions and procedures to clean the venturi if fouling is detected.

(d) How do you determine the error on feedwater flow measurement due to the fouling effect if the venturi is not cleaned or if the venturi fouling is not detected?

(e) If the venturi is not cleaned prior to the calorimetric flow measurement because no fouling is detected an error component should be added. The magnitude of the error component should depend on the minimum detectable value of fouling.

RESPONSE

(a),(b),(d),(e)

The present intent of the station is to determine if venturi fouling exists by trending plant performance. Data that will be trended include:

- Venturi flow measurement versus flow measurement by the sonic flow meter in series with each venturi.
- Feed flow versus steam flow.
- Reactor power versus core differential temperature.
- Reactor power versus generator output with consideration for secondary cycle efficiency.

The plant performance monitoring program will evaluate the trends in the above parameters to determine if venturi fouling exists and what the consequences are on the measured RCS flow rate. It is anticipated that the parameters being monitored, especially the sonic flow meters in series with the venturies, will provide a high degree of confidence in the detection of venturi fouling.

The sonic flow meters have a repeatability of 0.1% as specified by the manufacturer. Based on the anticipated performance of the sonic flow meter, an uncertainty of 0.1% for our ability to determine whether venturi fouling exists has been included in the response to RAI 492.6. The performance of the sonic flow meters will be monitored and evaluated in the power ascension phase of startup testing.

If and when venturi fouling is detected, either the venturies will be cleaned prior to the next fuel cycle measurement, or corrections to the feed flow measurement will be applied as a bias.

(c)

The feedwater piping does not include design features to specifically clean the venturies. Provisions and procedures to clean the venturies will be established when or if fouling is detected and it is determined that cleaning is warranted.

RAI 492.9 (4.4)

The Topical Report WCAP-8691, Revision 1, "Fuel Rod Bow Evaluation", has been approved by the staff. If you plan to reference this, you are requested to provide a new table of rod bow DNBR penalty vs. fuel burnup based on the approved method which will be used in the Technical Specifications.

RESPONSE

We do intend to reference the Topical Report WCAP-8291, Revision 1. Accordingly FSAR Sections 4.2 and 4.4 were revised in Amendment 53. Technical Specifications 3/4.2.3 and BASES 3/4.2.3 will be revised. We have attached a copy of Amendment 53 that is marked-up to correct a typographical error and to provide clarification and a draft copy of the Technical Specification change.

Metallographic examination of irradiated commercial fuel rods have shown occurrences of fuel/clad chemical interaction. Reaction layers of < 1 mil in thickness have been observed between fuel and clad at limited points around the circumference. Metallographic data indicates that this interface layer remains very thin even at high burnup. Thus, there is no indication of propagation of the later and eventual clad penetration.

Stress corrosion cracking is another postulated phenomenon related to fuel/clad chemical interaction. Out of pile tests have shown that in the presence of high clad tensile stresses, large concentrations of selected fission products (such as iodine) can chemically attack the Zircaloy tubing and can lead to eventual clad cracking. Extensive post-irradiation examination has produced no inpile evidence that this mechanism is operative in Westinghouse-produced commercial fuel.

d. Rod Bowing

Reference (11) presents the model used for evaluation of fuel rod bowing. Also refer to Subsection 4.4.2.2.e. 53

e. Consequences of Power-Coolant Mismatch

This subject is discussed in Chapter 15.

f. Creep Collapse and Creepdown

This subject and the associated irradiation stability of cladding have been evaluated using the models described in Reference (6). It has been established that the design basis of no clad collapse during planned core life can be satisfied by limiting fuel densification and by having a sufficiently high initial internal rod pressure.

4.2.3.2 Fuel Materials Considerations

Sintered, high density uranium dioxide fuel reacts only slightly with the clad at core operating temperatures and pressures. In the event of clad defects, the high resistance of uranium dioxide to attack by water protects against fuel deterioration although limited fuel erosion can occur. As has been shown by operating experience and extensive experimental work, the thermal design parameters conservatively account for changes in the thermal performance of the fuel elements due to pellet fracture which may occur during power operation. The consequences of defects in the clad are greatly reduced by the ability of uranium dioxide to retain fission products, including those which are gaseous or highly volatile. Observations from several operating Westinghouse supplied pressurized water reactors (Reference (9)) have shown that fuel pellets can densify under irradiation

4. Hellman, J. M. (Ed.), "Fuel Densification Experimental Results and Model for Reactor Application," WCAP-8218-P-A (Proprietary) and WCAP-8219-A (Non-Proprietary), March, 1975.

5. Miller, J. V. (Ed.), "Improved Analytical Models Used in Westinghouse Fuel Rod Design Computations," WCAP-8720 (Proprietary) and WCAP-8785 (Non-Proprietary), October, 1976.

6. George. R. A., Lee, Y. C. and Eng. G. H., "Revised Clad Flattening Model," WCAP-8377 (Proprietary) and WCAP-8381 (Non-Proprietary), July, 1974.

7. Risher, D. H., et al., "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis," WCAP-8963 (Proprietary), November, 1976 and WCAP-8964 (Non-Proprietary), August, 1977.

8. Cohen, J., "Development and Properties of Silver Base Alloys as Control Rod Materials for Pressurized Water Reactors," WAPD-214, December, 1959.

9. Eggleston, F. T., "Safety-Related Research and Development for Westinghouse Pressurized Water Reactors, Program Summaries-Winter 1977-Summer 1978," WCAP-8768, Revision 2, October 1978.

10. Demario, E. E., "Hydraulic Flow Test of the 17 x 17 Fuel Assembly," WCAP-8278 (Proprietary) and WCAP-8279 (Non-Proprietary), February, 1974.

11. Skaritka, J. (Ed.), "Fuel Rod Bow Evaluation," WCAP-8691 Revision 1 (proprietary) and WCAP-8692, Revision 1 (non-proprietary), July 1979. 53

12. O'Donnell, W. J. and Langer, B. F., "Fatigue Design Basis for Zircaloy Components," Nuclear Science and Engineering, 20, 1-12, 1964.

13. Gesinski, L., and Chiang, D., "Safety Analysis of the 17 x 17 Fuel Assembly for Combined Seismic and Loss-of-Coolant Accident," WCAP-8236 (Proprietary) and WCAP-8288 (Non-Proprietary) December, 1973.

14. "Nuclear Fuel Division Quality Assurance Program Plan," WCAP-7800, Revision 4-A, March, 1975.

15. Skaritika, J. (Ed), "Hybrid B_4C Absorber Control Rod Evaluation Report," WCAP-8846-A, September, 1976.

while the fuel rod diameter, pitch and bowing variation including inpile effects is considered in the preparation of the THINC input values such as axial flow area, equivalent hydraulic diameter and lateral crossflow area for the hot channel.

(b) Inlet Flow Maldistribution

The consideration of inlet flow maldistribution in core thermal performances is discussed in Subsection 4.4.4.2b. A design basis of 5 percent reduction in coolant flow to the hot assembly is used in the THINC-IV analysis.

(c) Flow Redistribution

The flow redistribution accounts for the reduction in flow in the hot channel resulting from the high flow resistance in the channel due to the local or bulk boiling. The effect of the non-uniform power distribution is inherently considered in the THINC analysis for every operating condition which is evaluated.

(d) Flow Mixing

The subchannel mixing model incorporated in the THINC Code and used in reactor design is based on experimental data, Reference (17), discussed in Subsection 4.4.4.5a. The mixing vanes incorporated in the spacer grid design induce additional flow mixing between the various flow channels in a fuel assembly as well as between adjacent assemblies. This mixing reduces the enthalpy rise in the hot channel resulting from local power peaking or unfavorable mechanical tolerances.

(e) Effects of Rod Bow on DNBR

The phenomenon of fuel rod bowing, as described in Reference (80), must be accounted for in the DNBR safety analysis of Condition I and Condition II events for each plant application. Applicable generic credits for margin resulting from retained conservatism in the evaluation of DNBR and/or margin obtained from measured plant operating parameters (such as $F^N_{\Delta H}$ or core flow), which are less limiting than those required by the plant safety analysis, can be used to offset the effect of rod bow.

For the safety analysis of Seabrook Unit 1, sufficient margin was maintained ~~(9.1%)~~* to accommodate full and low flow DNBR penalties identified in Reference (81). (LESS THAN 3% FOR THE WORST CASE WHICH IS A BURNUP OF 33,000 MWD/MTU)

(9.17%)*

53

The maximum rod bow penalties accounted for in the design safety analysis are based on an assembly average burnup of 33000 MWD/MTU. At burnups greater than 33000 MWD/MTU, credit is taken for the effect of $F^N_{\Delta H}$ burndown, due to the decrease in fissionable isotopes and the buildup of fission product inventory, and no additional rod bow penalty is required. 53

4.4.2.3 Linear Heat Generation Rate

The core average and maximum LHGRs are given in Table 4.4-1. The method of determing the maximum LHGR is given in Subsection 4.3.2.2.

4.4.2.4 Void Fraction Distribution

The calculated core average and the hot subchannel maximum and average void fractions are presented in Table 4.4-3 for operation at full power with design hot channel factors. The void fraction distribution in the core at various radial and axial locations is presented in Reference (18). The void models used in the THINC-IV computer code are described in Subsection 4.4.2.7c. Normalized core flow and enthalpy rise distributions are shown in Figures 4.4-5 through 4.4-7.

* Design Limit DNBR of 1.30 vs. 1.28
Grid Spacing (K_s) of 0.046 vs. 0.059
Thermal Diffusion Coefficient of 0.038 vs. 0.059
DNB Multiplier of 0.86
Pitch Reduction 53

77. Ohtsubo, A., and Uruwashi, S., "Stagnant Fluid due to Local Flow Blockage," J. Nucl. Sci. Technol., 9, No. 7, 433-434, (1972).

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POWER DISTRIBUTION LIMITS

3/4.2.3 RCS FLOW RATE AND R

LIMITING CONDITION FOR OPERATION

3.2.3 The combination of ~~indicated Reactor Coolant System (RCS)~~ RCS total flow rate and R_1 ~~& R_2~~ shall be maintained within the region of allowable operation shown on Figure 3.2-3 for 4 loop operation.

Where:

a. $R_1 = \dfrac{F^N_{\Delta H}}{1.49\ [1.0 + 0.2\ (1.0 - P)]}$

~~b. $R_2 = \dfrac{R_1}{1 - RBP(BU)}$~~

b ~~c~~. $P = \dfrac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

c ~~d~~. $F^N_{\Delta H}$ = 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_1 since Figure 3.2-3 includes measurement uncertainties of ~~3.5%~~ 2.0 for flow and 4% for incore measurement of $F^N_{\Delta H}$, and

~~e. RBP (BU) = Rod Bow Penalty as a function of region average burnup as shown in Figure 3.2-4, where a region is defined as those assemblies with the same loading date (reloads) or enrichment (first core).~~

APPLICABILITY: MODE 1

ACTION:

With the combination of RCS total flow rate and R_1 ~~& R_2~~ outside the region of acceptable operation shown in Figure 3.2-3:

POWER DISTRIBUTION LIMITS

ACTION: (Continued)

a. Within 2 hours:

1. Either restore the combination of RCS total flow rate and R_1 R_2 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.

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_1 R_2 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 items a.2 and/or b. above; subsequent POWER OPERATION may proceed provided that the combination of R_1 R_2 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 shown on Figure 3.2-3 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 and R_1 R_2 shall be determined to be within the region of acceptable operation of Figure 3.2-3:

POWER DISTRIBUTION LIMITS

SURVEILLANCE REQUIREMENTS (Continued)

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 of Figure 3.2-3 at least once per 12 hours when the most recently obtained value~~s~~ of R_1 ~~and R_2~~, obtained per Specification 4.2.3.2, ~~are~~ is assumed to exist.

4.2.3.4 The RCS ~~total~~ LOOP 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 measurement at least once per 18 months.

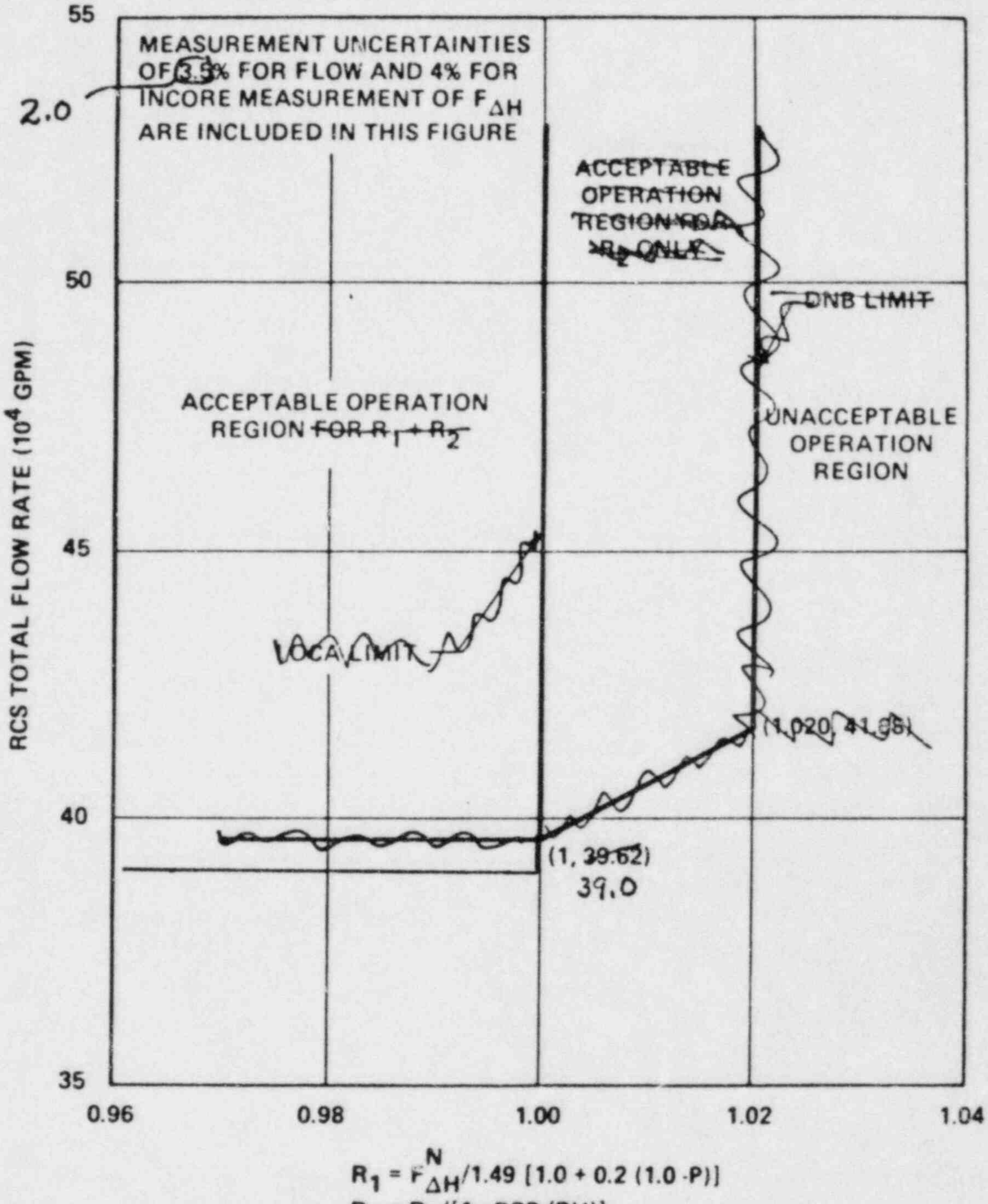

FIGURE 3.2-3
RCS TOTAL FLOW RATE VERSUS R_1
FOUR LOOP OPERATION

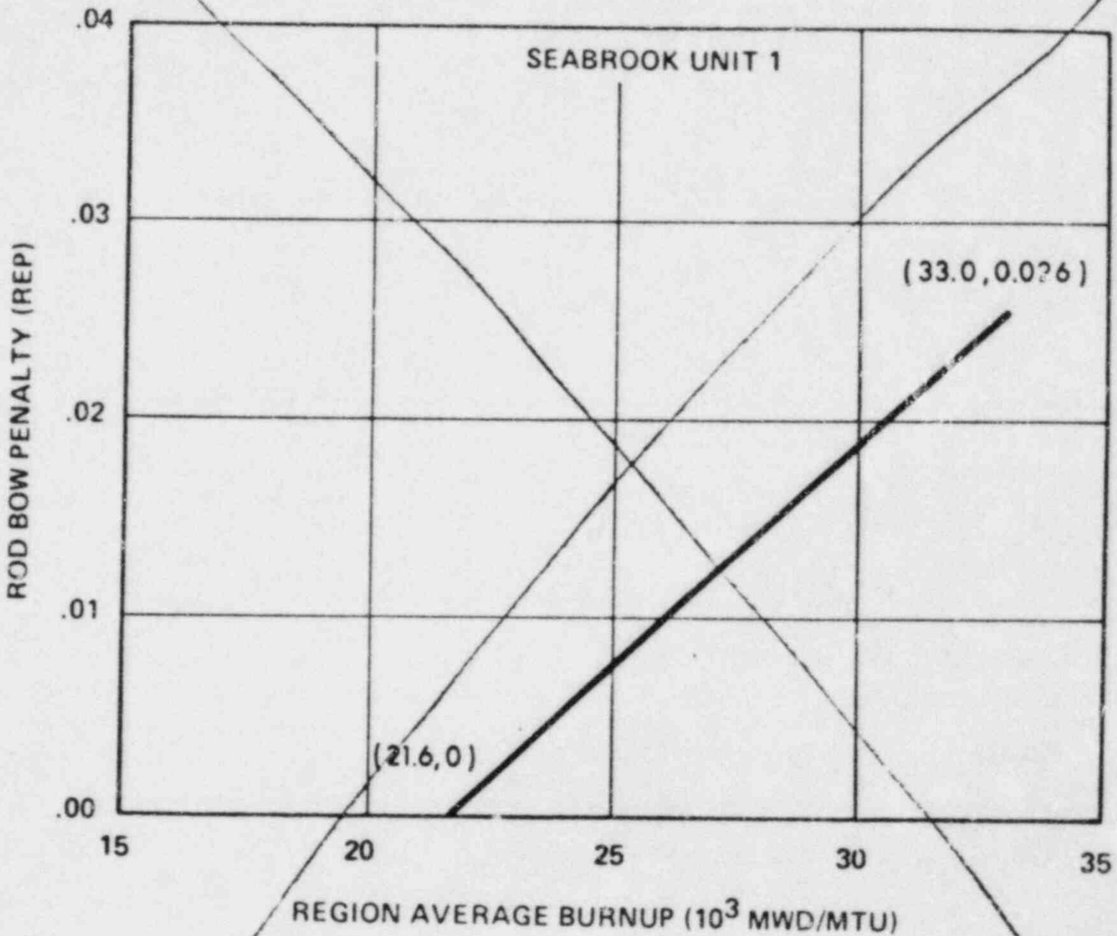

FIGURE 3.2-4
ROD BOW PENALTY
AS A FUNCTION OF BURNUP

POWER DISTRIBUTION LIMITS

BASES

Each of these is measurable but will normally only be determined periodically as specified in Specifications 4.2.2 and 4.2.3. This periodic surveillance is sufficient to insure that the limits are maintained provided:

a. Control rods in a single group move together with no individual rod insertion differing by more than ± 12 steps, indicated, from the group demand position.

b. Control rod groups are sequenced with overlapping groups as described in Specification 3.1.3.6.

c. The control rod insertion limits of Specifications 3.1.3.5 and 3.1.3.6 are maintained.

d. The axial power distribution, expressed in terms of AXIAL FLUX DIFFERENCE, is maintained within the limits.

$F^N_{\Delta H}$ will be maintained within its limits provided conditions a. through d. above are maintained. As noted in Figures 3.2-3 and 3.2-4, RCS flow rate and $F^N_{\Delta H}$ may be "traded off" against one another (i.e., a low measured RCS flow rate is acceptable if the measured $F^N_{\Delta H}$ is also low) to ensure that the calculated DNBR will not be below the design DNBR value. The relaxation of $F^N_{\Delta H}$ as a function of THERMAL POWER allows changes in the radial power shape for all permissible rod insertion limits.

R_1 as calculated in 3.2.3 and used in Figure 3.2-3, accounts for $F^N_{\Delta H}$ less than or equal to 1.49. This value is used in the various accident analyses where $F^N_{\Delta H}$ influences parameters other than DNBR, e.g., peak clad temperature, and thus is the maximum "as measured" value allowed. R_2, as defined, allows for the inclusion of a penalty for rod bow on DNBR only, thus knowing the "as measured" values of $F^N_{\Delta H}$ and RCS flow allows for "tradeoffs" in excess of R equal to 1.0 for the purpose of offsetting the rod bow DNBR penalty.

Fuel rod bowing reduces the value of DNB ratio. Sufficient credit is available to offset this reduction. This credit comes from generic design margins totalling 9.1% and 3% margin in the difference between the 1.3 DNBR safety limit and the minimum DNBR calculated for the Complete Loss of Flow event. The penalties applied to $F^N_{\Delta H}$ to account for Rod Bow (Figure 3.2-4) as a function of burnup are consistent with those described in Mr. John F. Stolz's (NRC) letter to T. M. Anderson (Westinghouse) dated April 5, 1979 and W 8691 Rev. 1 (partial rod bow test data).

POWER DISTRIBUTION LIMITS

BASES

When an F_Q measurement is taken, an allowance for both experimental error and manufacturing tolerance must be made. An allowance of 5% is appropriate for a full core map taken with the incore detector flux mapping system and a 3% allowance is appropriate for manufacturing tolerance.

When RCS flow rate and $F^N_{\Delta H}$ are measured, no additional allowances are
2.0 necessary prior to comparison with the limits of Figures 3.2-3 ~~and 3.2-4~~. Measurement errors of 3.5% for RCS total flow rate and 4% for $F^N_{\Delta H}$ have been allowed for in determination of the design DNBR value.

The 12 hour periodic surveillance of indicated RCS flow is sufficient to detect only flow degradation which could lead to operation outside the acceptable region of operation shown on Figure 3.2-3.

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 x-y plane power tilts.

The two 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 control rod. In the event such action does not correct the tilt, the margin for uncertainty on F_Q is reinstated by reducing the maximum allowed power by 3 percent for each percent of tilt in excess of 1.0.

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 minimum DNBR of 1.30 throughout each analyzed transient.

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.