Westinghouse

Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Direct tel: 412/374-5282
Direct fax: 412/374-4011
e-mail: Sepp1ha@westinghouse.com

Our ref: LTR-NRC-02-24

Attention: J. S. Wermiel, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

May 1, 2002

Subject: Issuance of Approved Version of WCAP-12472-P-A, Addendum 2-A/WCAP-12473-A, Addendum 2-A of "BEACON Core Monitoring and Operation Support System," (Proprietary / Non-proprietary)

Dear Mr. Wermiel:

Enclosed are copies of the Approved Version of WCAP-12472-P-A, Addendum 2-A/WCAP-12473-A, Addendum 2-A of "BEACON Core Monitoring and Operation Support System, "Revision to Design Criteria," (Proprietary/ Non-proprietary).

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-02-1526 with Proprietary Information Notice and Copyright Notice.

2. One (1) copy of Affidavit, AW-02-1526.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

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Correspondence with respect to any Application for Withholding should reference AW-02-1526 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Copy to:
R. Caruso, NRR
S. L. Wu, NRR
U. Shoop, NRR
G. Shukla, NRR

Westinghouse

Westinghouse Electric Company
Nuclear Services
P.O. Box 355
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USA

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Attention: J. S. Wermiel, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

Direct tel: 412/374-5282
Direct fax: 412/374-4011
e-mail: Sepp1ha@westinghouse.com

Our ref: AW-02-1526

May 1, 2002

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Issuance of Approved Version of WCAP-12472-P-A, Addendum 2-A/WCAP-12473-A, Addendum 2-A of "BEACON Core Monitoring and Operation Support System," (Proprietary / Non-proprietary)

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-02-24, dated May 1, 2002

Dear Mr. Wermiel:

The application for withholding is submitted by Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse"), pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.790, Affidavit AW-02-1526 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

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

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-02-1526 and should be addressed to the undersigned.

Very truly yours,

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

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COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, 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 Company LLC, a Delaware limited liability company ("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:

MARGARET L. GONANO
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 2nd day
of May, 2002.

Margaret L. Gonano
Notary Public

Notarial Seal
Margaret L. Gonano, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 3, 2006
Member, Pennsylvania Association Of Notaries

(1) I am Manager, Regulatory and Licensing Engineering, in the Nuclear Services, of the Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse") 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 and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company.

(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 the Westinghouse Electric Company 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.

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 of 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 sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method 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 "Issuance of Approved Version of WCAP-12472-P-A, Addendum 2-A/WCAP-12473-A, Addendum 2-A of 'BEACON Core Monitoring and Operation Support System,' (Proprietary / Non-proprietary)" May 1, 2002, for submittal to the Commission, being transmitted by Westinghouse Electric Company (W) letter (LTR-NRC-02-24) and Application for Withholding Proprietary Information from Public Disclosure, Henry A. Sepp, Westinghouse, Manager Regulatory and Licensing Engineering to the attention of J. S. Wermiel, Chief, Reactor Systems Branch, Division of Systems Safety and Analysis. The proprietary information as submitted by Westinghouse Electric Company is that associated with the approved version of WCAP-12472-P-A, Addendum 2-A/WCAP-12473-A, Addendum 2-A (Proprietary/Non-proprietary).

This information is part of that which will enable Westinghouse to:

(a) The proposed criteria replace indirect performance correlations with direct performance correlations that are more readily measured and provide direct feedback to design.

(b) The revised criteria conform to both NUREG-0800 and to current industry guidelines.

(c) These updated criteria will promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

(a) Westinghouse can continue to ensure the highest quality of fuel since the proposed criteria is more readily measurable and thus provides direct feedback to fuel designs.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed improved core thermal performance methodology.

Further the deponent sayeth not.

Proprietary Information Notice

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC. In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

Westinghouse Non-Proprietary Class 3

WCAP-12473-A
Addendum 2-A

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BEACON
Core Monitoring and Operation Support System

Westinghouse Electric Company LLC
Nuclear Fuel

WCAP-12473-A
Addendum 2-A

BEACON
Core Monitoring and Operation Support System (WCAP-12473-A) Addendum 2

Original: March 2001
Approved: April 2002

Toshio Morita

Approved: BR Beebe FOR
T. J. Collier, Manager
Nuclear Fuel Core Technologies

Table of Content

Section A

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

February 1, 2002

RECEIVED
FEB 18 2002
H. A. SEPP, JR.

Mr. Henry Sepp
Westinghouse Electric Company
Post Office Box 355
Pittsburgh, PA 15230-0355

SUBJECT: ACCEPTANCE FOR REFERENCING OF LICENSING TOPICAL REPORT WCAP-12472-P-A, ADDENDUM 2, "BEACON–CORE MONITORING AND OPERATIONS SUPPORT SYSTEM" (TAC NO. MB1711)

Dear Mr. Sepp:

By letter dated March 29, 2001, Westinghouse submitted WCAP-12472-P-A, Addendum 2, "BEACON–Core Monitoring and Operations Support System," for staff review and approval. The main topical report (TR) was approved by the staff on February 16, 1994. Addendum 2 extends the previously licensed BEACON power distribution monitoring methodology to plants containing platinum self-powered fixed incore detectors and Vanadium self-powered fixed incore detectors.

The NRC staff held a meeting with Westinghouse representatives on June 25, 2001, to discuss the review of the TR. On July 11, 2001, the staff issued a request for additional information. By letter dated August 31, 2001, Westinghouse responded to the staff's questions.

The NRC staff has completed its review of the subject TR. The report is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in the report and in the associated NRC safety evaluation (SE), which is enclosed. The enclosed SE defines the basis for acceptance of the TR.

Pursuant to 10 CFR 2.790, we have determined that the enclosed SE does not contain proprietary information. However, we will delay placing the SE in the public document room for a period of ten working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

We do not intend to repeat our review of the matters described in the subject report, and found acceptable, when the report appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. Our acceptance applies only to matters approved in the report.

In accordance with procedures established in NUREG-0390, the NRC requests that Westinghouse publish an accepted version within 3 months of receipt of this letter. The accepted version shall incorporate (1) this letter and the enclosed SE between the title page and the abstract, (2) all requests for additional information from the staff and all associated responses, and (3) a "-A" (designating "accepted") following the report identification symbol.

Should our criteria or regulations change so that our conclusions as to the acceptability of the report are invalidated, Westinghouse and/or the applicants referencing the TR will be expected to revise and resubmit their respective documentation, or submit justification for the continued applicability of the TR without revision of their respective documentation.

Sincerely,

Stuart A. Richards, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 700

Enclosure: Safety Evaluation

cc w/encl:
Mr. Gordon Bischoff, Project Manager
Westinghouse Owners Group
Westinghouse Electric Company
Mail Stop ECE 5-16
P.O. Box 355
Pittsburgh, PA 15230-0355

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-12472-P-A, ADDENDUM 2

"BEACON–CORE MONITORING AND OPERATIONS SUPPORT SYSTEM"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 BACKGROUND

By letter dated March 29, 2001, the Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-12472-P-A, Addendum 2, "BEACON–Core Monitoring and Operations Support System," for review and approval (Reference 1). The Best Estimate Analyzer for the Core Operations-Nuclear (BEACON) system was developed by Westinghouse to improve the operational support for pressurized-water reactors (PWRs). It is a core monitoring and support package that uses Westinghouse standard instrumentation in conjunction with an analytical methodology for on-line generation of three-dimensional power distributions. The system provides core monitoring, core measurement reduction, core analysis and core predictions. The initial TR, WCAP-12472-P, "BEACON--Core Monitoring and Operations Support System," was approved by the NRC staff on February 16, 1994 (Reference 2). The key aspects of WCAP-12472-P are: (1) the methodology used to obtain the measured power distribution from the Westinghouse standard instrumentation system, that is, movable incore detectors, core exit thermocouples and excore detectors, and (2) the methodology for assessing uncertainties to be applied to the measured power distribution and technical specifications with BEACON as the source of the measured power distribution.

Westinghouse submitted an addendum (designated Addendum 1) to the TR stated above which was submitted to the NRC in May 1996, for staff review and approval (Reference 3). The key aspects of Addendum 1 were the inclusion in BEACON of the capability to predict the rhodium (RH) self-powered neutron detector responses and the methodology to assess uncertainties to be applied to the measured power distributions. The current operating Westinghouse PWR plants are equipped with movable incore detectors to monitor core performance. Addendum 1 extended the BEACON system to other PWR designs such as the Babcock and Wilcox plants and the Combustion Engineering plants. These plants are typically equipped with fixed incore RH self-powered neutron detectors.

The latest submittal, Addendum 2, of WCAP-12472-P, extends the previously licensed BEACON power distribution monitoring methodology to plants containing platinum and vanadium fixed incore self-powered detectors (SPDs).

The purpose of the Addendum 2 submittal is to validate the BEACON monitoring system using platinum and vanadium detectors. The basic principle of power distribution inference of the BEACON system is not changed, i.e., the measured power distribution can be obtained by adjusting the predicted power distribution by the amount of difference between measured and predicted detector responses. The only new aspect of the SPD BEACON methodology is how to predict the detector response from the platinum or vanadium currents. The platinum reaction rate is predicted by the licensed PHOENIX-4 methodology. Westinghouse has chosen to retain the licensed "PHOENIX-P" and "PHOENIX-4" methodologies to predict the detector current. Westinghouse stated that the benefits of this approach are:

a. This is a proven and licensed PHOENIX methodology, which is supported by many critical experiments and plant data.

b. The method is based on basic neutron physics and to the extent possible avoids the use of empirical correlations and data.

c. The platinum or vanadium detectors will replace existing RH detectors and will not require new cabling runs or hardware configurations for data measurements.

2.0 TECHNICAL EVALUATION

Westinghouse submitted Addendum 2 to WCAP-12472 in order to seek implementation of additional features (Reference 1). The features are the use of platinum and vanadium fixed incore detectors instead of the RH detectors, and the use of the licensed PHOENIX-P and the PHOENIX-4 methodologies to predict the detector current.

The primary function of the BEACON core monitoring system is the determination of the three-dimensional core power distribution (Reference 1). In BEACON, this calculation is performed with the NRC-approved Westinghouse SPNOVA nodal method. SPNOVA employs a single effective fast group (EFG) calculation to determine the global flux solution and then uses a local correlation to determine the thermal flux and power distribution. The SPNOVA data libraries and core models are consistent with the NRC-approved Westinghouse PHOENIX/Advanced Nodal Code (ANC) design models and have been extensively benchmarked against operating reactor measurements.

The SPD system has been widely used by the nuclear industry. It is used in place of the moveable incore detectors, thermocouples, incore exit, and excore detectors. However, the primary function of the BEACON methodology, which is to determine the core power distribution, remains the same.

Until now, the BEACON monitoring system utilized the SPNOVA neutronic methodology, employing a one-node-per-assembly (radial) representation to achieve the rapid running times required by hardware platforms available in the late 1980s (Reference 3). The decision to extend the BEACON monitoring capability to utilize incore detectors enables Westinghouse to use the NRC-approved PHOENIX/ANC methodology (Reference 4). This option was available to Westinghouse at the time of the initial BEACON approval, but inadequate computational capabilities at the time necessitated the development of simplified diffusion equation methods in order for the BEACON system to function properly. However, recent workstation advancements, coupled with improvements in numerical solution techniques of the nodal expansion method, have permitted the optional use of the ANC neutronic engine in the BEACON system while maintaining BEACON functionality.

The PHOENIX/ANC is a proven and licensed methodology that is supported by many critical experiments and plant data. The method is based on basic neutron physics and avoids (as much as possible) the use of empirical correlations and data. Another advantage of utilizing the PHOENIX/ANC methodology is that the method can be applied to a wider range of design/operating conditions.

2.1 Platinum Self Powered Detectors

The platinum detectors are very sensitive to gamma flux and mildly sensitive to neutron flux. The depletion rate of platinum is very small and Westinghouse has stated that analysis of data has shown that it could be neglected. Both the gamma and neutron signals are proportional to the assembly power. The gamma response is combined with the neutron response to provide the full detector response to the signal. The responses are obtained from the PHOENIX-4 code. The gamma and neutron responses are generated as a function of assembly enrichment and burnup.

Westinghouse pointed out that the platinum detectors are sensitive to gamma rays emitted by the fuel rods in close proximity to the detectors. Because of this selective response and the power gradients in the assemblies, the actual power distributions in the core environments must be accounted for in determining the detector response. This leads to using fuel pin weighting factors to represent the various fuel pins in the assembly. The power distribution for the various fuel pins are obtained by the ANC methodology.

In this methodology, after each radial node is determined, the 3-D power distribution is normalized to unity. The ratio of the measured to predicted power in each node is defined as the incore calibration constant for that node. This constant is then multiplied by the node fluxes and the node peak powers to generate the adjusted values of these parameters.

2.2 Vanadium Detectors

Vanadium detectors are typically neutron sensitive with similar reaction time as that of an RH detector. The benefit of vanadium over RH is its low depletion, which is a factor of 20 times less than that of RH. The BEACON system determines the detector current I_p as a function of the microscopic cross section. The microscopic cross section is a function of the vanadium number density and is obtained from the PHOENIX code. The instrumentation thimble flux is determined by the pin power reconstruction methodology of the ANC solution code.

BEACON determines the measured power distribution by monitoring the predicted power distribution and multiplying it by the ratio of measured to predicted currents. The current ratio is indicative of the flux distribution, as such. The best estimate of measured power distribution is obtained by adjusting the predicted power distribution by the current ratio.

In this methodology, after each radial node is determined, the 3-D power distribution is normalized to unity. The ratio of the measured to predicted power in each node is defined as the incore calibration constant for that node. This constant is then multiplied by the node fluxes and the node peak powers to generate the adjusted values of these parameters.

2.3 Qualifications of the SPD Model and Measurement Variability

To qualify the BEACON system methodology, plant measurement data were obtained from operating plants and analyzed (References 1 and 4). Data provided in tabular form in this submittal compared measured and predicted detector currents and indicate the plants involved in the qualification process, the RH detector design features, and the history of the SPD flux maps used for the analysis. Westinghouse conducted analyses to verify that the proposed SPD model is capable of predicting the magnitude of the detector current and of determining the detector measurement variability in the operating detector system.

SPD qualification analysis procedures were used to determine the ratio of the core average predicted currents to the core averaged measured currents for all of the SPD maps. Westinghouse pointed out that the averaging process eliminates detector-to-detector variation and provides accurate evaluation of the overall SPD model. Results of the analysis showed that the SPD model is very capable of predicting the magnitude of the detector currents with acceptable accuracy.

2.4 Detector Monitoring Uncertainty

Since the BEACON monitoring system is statistical in nature, the determination of the measured peaking factor is affected by such things as the detector measurement variability, the number and layout of detectors, interpolation techniques, and any differences between predicted and true power distribution. Consequently, Westinghouse analyzed the BEACON system uncertainty using a statistical method in which the detector behavior is simulated on the basis of measurement variability statistics. The details of the simulation methodology are described are WCAP-12472-P-A (Reference 2).

The simulation methodology consists of defining the monitoring uncertainty for a given set of detector configurations as a function of the detector measurement variability and the fraction of inoperable detectors. A bounding uncertainty value is determined from a series of simulation analyses, leading to a bounding 95/95 upper tolerance limit in the assembly power and peak node power. The total uncertainty is obtained by a convolution of components, such as the uncertainty in the power-to-reactor rate ratio and the uncertainty in the hot rod power-to-assembly average evaluation (Reference 1). Review of the analyses conducted by Westinghouse indicates that the SPD methodology can be integrated with the existing BEACON system to provide power distribution monitoring capability for SPD plants. The staff agrees with the analysis and the results obtained by Westinghouse.

The Westinghouse analysis indicated that the platinum and vanadium detectors can be mixed with each other or with RH detectors. A bounding measurement variability will be used by the BEACON system. As an example, the platinum detector measurement variability listed in the submittal is less than the bounding measurement variability used by the BEACON system for the RH detectors. So, during the transition from the RH detectors to the platinum and the vanadium detectors, the BEACON system measurement variability uncertainty will always be bounding. Consequently, the power distribution measurement uncertainties used by the BEACON system with the platinum and the vanadium detectors will bound the power distribution measurement uncertainties as determined by the RH detectors.

2.5 Plant and Cycle-Specific Applications

The BEACON power distribution accuracy is dependent on the accuracy and reliability of both the calculation models and the plant instrumentation system. The BEACON uncertainty analysis includes components that are typically constant and are considered generic, such as the model calibration and the thermocouple cross-flow, as well as plant-cycle-specific components that depend on the condition and performance of the instrumentation systems.

In response to Question 1 (Reference 4), it is indicated that the plant-cycle-specific components will be determined on a plant-specific basis and confirmed each cycle. It is also concluded that in order to ensure that the assumptions made in the BEACON uncertainty analysis remain valid, the generic uncertainty components may require reevaluation when BEACON is applied to plant or core designs that differ sufficiently to have a significant impact on the WCAP-12472-P and the WCAP-12472-P-A, Addendum 2, data bases.

3.0 CONCLUSION

The staff has reviewed the analyses presented in WCAP-12472-P-A, Addendum 2, "BEACON–Core Monitoring and Operations Support System," as well as the responses to the staff's request for additional information, and concludes that, on the basis of the application of the licensed PHOENIX-P/ANC code for the prediction of the SPD currents, the qualification analysis performed against multiple operating plant data, and observed detector behavior consistent with operating plant data, WCAP-12472-P-A, Addendum 2, is acceptable for licensing applications, subject to the pertinent restrictions imposed on WCAP-12472-P-A; WCAP-12472-P-A, Addendum 2; and the associated responses to requests for additional information provided in Reference 5.

4.0 REFERENCES

1. Letter from H.A. Sepp to the U.S. Nuclear Regulatory Commission submitting WCAP-12472-P-A, Addendum 2, March 29, 2001.

2. Beard, C. L., Morita, T., "BEACON–Core Monitoring and Operations Support System," WCAP-12472-P-A, August 1994.

3. Letter from N.J. Liparulo to the U.S. Nuclear Regulatory Commission submitting WCAP-12472-P-A, Addendum 1, May 13, 1996.

4. Nguyen, T.Q. et al., "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," WCAP-11596-P-A, June 1988.

5. Letter from H.A. Sepp, Acting Manager, to the U.S. Nuclear Regulatory Commission, entitled "Responses to Request for Additional Information on WCAP-12472-P-A Addendum 2, 'BEACON–Core Monitoring and Operations Support System'," August 31, 2001.

Principal Contributors: A. Attard
H. Li

Date: February 1, 2002

Section B

Westinghouse Electric Company LLC

Box 355
Pittsburgh Pennsylvania 15230-0355

March 29, 2001
LTR-NRC-01-7

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Attention: J. S. Wermiel, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

Subject: Addendum 2 to WCAP-12472-P-A / WCAP-12473-A, "BEACON Core Monitoring and Operation Support System"

Dear Mr. Wermiel:

Enclosed are five copies of the Proprietary and Non-Proprietary versions of Addendum 2 to WCAP-12472-P-A / WCAP-12473-A, "BEACON Core Monitoring and Operation Support System," being submitted for review and approval.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-01-1445 with Proprietary Information Notice and Copyright Notice.

2. One (1) copy of Affidavit, AW-01-1445.

Addendum 2 extends the previously licensed BEACON power distribution monitoring methodology to plants containing self-powered fixed incore detector types other than rhodium. Calvert Cliffs Nuclear Power Plant intends to use this methodology shortly and a timely review and approval of Addendum 2 is requested.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

Correspondence with respect to any Application for Withholding should reference AW-01-1445 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

H. A. Sepp, Manager
Regulatory and Licensing Engineering

cc: R. Wharton, NRR

Westinghouse Electric Company LLC

Box 355
Pittsburgh Pennsylvania 15230-0355

March 29, 2001
AW-01-1445

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Attention: J. S. Wermiel, Chief, Reactor Systems Branch
Division of Systems Safety and Analysis

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-01-7, dated March 29, 2001

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Addendum 2 to WCAP-12472-P-A, "BEACON Core Monitoring and Operation Support System" [Proprietary]

Dear Mr. Wermiel:

The application for withholding is submitted by Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse"), pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.790, Affidavit AW-01-1445 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

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

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-01-1445 and should be addressed to the undersigned.

Very truly yours,

H. A. Sepp, Manager
Regulatory and Licensing Engineering

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, 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 Company LLC, a Delaware limited liability company ("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:

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 2ND day
of April, 2001.

Lorraine M. Piplica

Notary Public

LORRAINE M. PIPLICA
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

Notarial Seal
Lorraine M. Piplica, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Dec. 14, 2003
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory and Licensing Engineering, in the Nuclear Services Division, of the Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse"), 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 and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company LLC.

(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 the Westinghouse Electric Company LLC 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.

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.

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(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 of 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 sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method 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 Westinghouse Electric Company LLC letter (LTR-NRC-01-7) and Application for Withholding Proprietary Information from Public Disclosure, H. A. Sepp, Westinghouse, Manager Regulatory and Licensing Engineering to the attention of J. S. Wermiel, Chief, Reactor Systems Branch. The proprietary information as submitted by Westinghouse Electric Company LLC is Addendum 2 to WCAP-12472-P-A which provides information on additional fixed incore detector types.

This information is part of that which will enable Westinghouse to:

(a) Improve core monitoring methodology

(b) Assist customers to obtain license changes resulting from the improvements

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of the information to its customers for purposes of improving core monitoring techniques

(b) Westinghouse can use this information to further enhance their licensing position with their competitors

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar licensing services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed information.

Further the deponent sayeth not.

Proprietary Information Notice

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC. In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

Copyright Notice

05158261

WCAP-12473-A
Addendum 2

BEACON

Core Monitoring and Operation Support System

March 2001

W. A. Boyd

Approved:

T. J. Collier, Manager
Core Engineering

R. W. Miller, Manager
Advanced Software Development

Westinghouse Electric Company
Nuclear Fuel
4350 Northern Pike
Monroeville, PA 15146

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1.0 BACKGROUND

A topical report on "BEACON Core Monitoring and Operations Support System," was submitted to the USNRC in April, 1990 and was approved in February, 1994.[1] The key aspects of the report are 1) the methodology used to obtain the measured power distribution from the Westinghouse standard instrumentation system, i.e., the movable incore detectors, core exit thermocouples and excore detectors, and 2) the methodology for assessing uncertainties to be applied to the measured power distribution and Technical Specifications with BEACON as the source of the measured power distribution.

An addendum to the topical report was submitted to the USNRC in May, 1996 and was approved in September, 1999.[2] The key aspects of this addendum are 1) the new methodology in BEACON to predict the Rhodium self-powered neutron detector (SPD) responses and 2) the methodology to assess uncertainties to be applied to the measured power distribution and Technical Specifications for SPD plants using BEACON as the source of the measured power distribution.

2.0 NEW FEATURES ADDED TO BEACON

The purpose of this addendum is to summarize the following additional optional features implemented into the BEACON system.

> The use of Platinum and the use of Vanadium Fixed Incore non-depleting Self-Powered Detectors for incore monitoring.

The basic principle of power distribution inference of the BEACON system is unchanged, i.e., the measured power distribution can be obtained by adjusting the predicted power distribution by the amount of difference between measured and predicted detector responses.

The only new aspect of the SPD BEACON methodology is how to predict the detector response, i.e., the Platinum or Vanadium detector currents. The Westinghouse methodology chosen to predict the detector current or Vanadium reaction rate is the licensed PHOENIX-P methodology.[3] The Platinum reaction rate is predicted by the licensed PHOENIX-4 methodology.[4]

The benefits of this approach and detectors are:

(i) Proven and licensed PHOENIX methodology, which is supported by many critical experiments and plant data

(ii) The method is based on basic neutron physics and to as great an extent as possible avoids the use of empirical correlations and data

(iii) These non-depleting detectors will replace existing Rhodium detectors and will not require new cabling runs or hardware configurations for data measurements.

3.0 WESTINGHOUSE MONITORING METHODOLOGY

3.1 Platinum Self-Powered Detector

The platinum detectors are most sensitive to the gamma flux with 80% of the detector response due to the gamma's. The detectors are also weakly sensitive to the neutron flux which provides the other 20% of the response. The depletion rate of the platinum is relatively small and can be neglected because natural platinum contains 5 stable isotopes in which most of the depletion comes from Pt-195 which depletes into the stable isotope Pt-196. Both the gamma and neutron signals are proportional to the assembly power.

The gamma response must be combined with the neutron response to provide the full detector response signal. These responses are obtained from the PHOENIX-4 code. The neutron and gamma response functions are enrichment and burnup dependent due to their impact on the flux. The gamma and neutron response functions are generated as a function of assembly enrichment and burnup.

The platinum detectors are sensitive to gamma rays emitted by fuel rods in close proximity to the detector. Because of this selective response and the power gradients in the assemblies, the actual power distributions in the core environments must be accounted for in determining the detector response. This is done by using pin weighting factors which represent the contribution of the various fuel pins to the detector signal. The pin powers are determined by the pin power reconstruction methodology of the nodal neutronic solution. The ANC[3] nodal solutions method is used in BEACON.

The BEACON system will predict the Pt-SPD current given by the following function:

a,c

The W_i factors are obtained from Monte Carlo calculation performed by the MCNP code. They depend on the fuel pin and assembly geometries, but not on the pin type, enrichment, burnup or power.

3.2 Vanadium Self-Powered Detector

The Vanadium detectors are neutron sensitive with a similar reaction as the commonly used Rhodium incore detector. Neutrons interact with the emitter material to produce electrons through an N-β reaction. The flow of electrons to the outer sheath produces an electrical current that is proportional to the number of neutron interactions in the emitter.

Vanadium is one of several well known neutron detector materials and has been used in both Light Water Reactors (LWR) and the AECL CANDU type reactors for many years. The benefit of Vanadium is its low depletion, which is a factor of twenty times less than Rhodium. Due to a relatively small absorption cross section, and the lack of a neutron resonance structure, a simple SPF model can predict the output current very accurately.

The BEACON system has the capability of predicting Vanadium SPD current, which is given by:

a,c

The effective microscopic cross section is a function of the Vanadium density and is obtained from the PHOENIX code. Instrumentation thimble flux is determined by the pin power reconstruction methodology of the nodal neutronic solution.

3.3 Inferred Power Distribution

Once the predicted power distribution and detector currents are calculated, the power distribution inference can be performed by using the existing BEACON flux map power distribution methodology.[1] The monitored power distribution determined by BEACON is defined by:

a,c

The ratio of I_M/I_P indicates the difference between the measured and predicted flux distribution. The best estimate measured power distribution is obtained by adjusting the predicted power distribution by the I_M/I_P current ratio.

a,c

After each radial node power has been interpolated, the 3-D power distribution will be normalized to unity. The ratio of the measured to predicted power in each node is defined as the incore calibration constant for that node. This constant is then multiplied by the node fluxes and node peak powers to generate the measured values of these parameters.

4.0 QUALIFICATION OF SPD MODEL AND MEASUREMENT VARIABILITY

In order to qualify the Westinghouse methodology, the plant measurement data acquired from operating plants were analyzed and the measured and predicted detector currents were compared. Table 1 shows the qualification plants, detector design features and the history of the SPD measurement data used for the analysis.

The purpose of this analysis is two fold, i.e.,

(i) To verify that the proposed Platinum and Vanadium SPD models are capable of predicting the magnitude of the detector current

(ii) To evaluate the detector measurement variability in the operating detector systems

Figure 1 shows the flow of the SPD Qualification Analysis Procedures. The averaged Platinum predicted detector currents are normalized to the measured results. The standard deviation of the measured to predicted detector current errors are determined for each map measurement. The results are shown in Figure 2.

The ratio of the core average predicted currents to the core averaged measured currents were determined over all Vanadium SPD measured data at each map measurement. The averaging process eliminates detector to detector variation and provides an accurate evaluation of the overall SPD model. The results are shown in Figure 3. The detector currents are proportioned to the reactor thermal power, therefore the accuracy of the thermal power measurement directly affects these results. Considering this inherent uncertainty, it is seen that the proposed SPD models are capable of predicting the magnitude of the Platinum or Vanadium detector currents (item i) with acceptable accuracy.

For the detector measurement variability (item ii), comparisons were made between measurement and prediction for each of the individual detectors. The measured and predicted currents are normalized to eliminate the difference due to the thermal power measurement uncertainty. The standard deviation of the detector measurement variability, σ_m, is shown in Table 2.

The variability is consistent with the variability shown for the 40 cm length rhodium detectors evaluated in Addendum 1 to WCAP-12472-P-A.[2] considering the number of data points.

Thus, it is concluded that the BEACON SPD methodology is generally consistent with the detector behavior observed in the operating plants.

5.0 POWER PEAKING FACTOR MONITORING UNCERTAINTY

The uncertainty of the BEACON "measured" peaking factor is affected by

- Detector Measurement Variability
- Number and Layout of Detectors and their Availability
- Interpolation Technique
- Differences between Predicted and True Power Distribution

The simulation methodology is described in detail in the WCAP-12472-P-A.[1] The BEACON power distribution uncertainty methodology is designed to determine the power peaking factor measurement uncertainty for a wide range of the SPD detector operating conditions. The measured peaking factor uncertainty is defined as a function of the fraction of inoperable detectors and the detector measurement variability as given by Equation 3 and Equation 4 of Addendum 1 to WCAP-12472-P-A.[2] The methodology of the power peaking factor uncertainty determination is described in Section 5 of Addendum 1 to WCAP-12472-P-A.[2] This methodology is unchanged and is applicable to any required peaking factor parameter.

The Platinum and Vanadium incore detectors can be mixed in the core with each other or with Rhodium incore detectors. A bounding measurement variability will be used by the BEACON system for the limiting detector design. For example, the Platinum detector measurement variability listed in Table 2 is less than the bounding measurement variability used by the BEACON System for the comparable Rhodium detector design. If the current rhodium detector assemblies are gradually replaced by the similarly configured Platinum detector assemblies, the BEACON System power distribution measurement uncertainty remains bounding. Therefore, the current power distribution measurement uncertainty equations used by the BEACON System will bound the uncertainty of the transition from the Rhodium detector assemblies to the Platinum detector assembly design.

6.0 TECHNICAL SPECIFICATION MODIFICATIONS

Each vendor has power distribution Technical Specifications that require surveillance of parameters related to hot rod power and local power density. BEACON can easily provide any required surveillance of these limits. There is no need to change the actual power distribution related Technical Specifications requirements if the BEACON System is used with SPD's at Westinghouse, Babcock and Wilcox or Combustion Engineering designed plants. It will be necessary, however, to include a BEACON Operability specification in the Technical Requirements Manual (TRM) associated with either the NUREG-1430 or NUREG-1432 format Technical Specifications. This TRM specification will address the minimum number and distribution, as applicable, of plant sensor inputs required for BEACON to properly monitor the core power distribution. The minimum number and distribution of incore detectors required to insure that the core peaking factor measurement uncertainties remain bounded by the values assumed in the reactor design limits will be ascertained for the plant specific detector configuration as described in Section 5.0 of Addendum 1 to WCAP-12472-P-A.[2]

The sample TRM associated with BEACON operability included in Addendum 1 of WCAP-12472-P-A[2] requires that measurements be obtained from at least 75% of the incore detectors for the initial power ascension at the beginning of each operating cycle. After this time period, BEACON is considered operable as long as 50% of the incore detectors are available.

There is no requirement for the minimum number of operable detectors in a string or a minimum number of measured symmetric locations. The minimum number of incore detectors for quadrant tilt and axial offset monitoring recommended in Addendum 1 of WCAP-12472-P-A(2) is defined below.

a,c

7.0 DETECTOR GEOMETRY

The incore detector assembly contains the detector elements (Platinum or Vanadium wires) distributed in several axial locations. The detector assemblies are installed in the instrument thimbles of selected fuel assemblies in a reactor core.

The NSSS vendor defines the detector locations to obtain the maximum information for a given number of detector assemblies. The actual detector configuration and layout in operating reactors varies by reactor vendor and plant. Implementation of the BEACON System with Platinum or Vanadium incore detectors will not require a change to the reactor core detector geometry configuration or layout.

Examples of possible Platinum and Vanadium detector axial locations are shown in Figures 4 and 5 respectively.

8.0 CONCLUSION

Westinghouse has applied the licensed PHOENIX-P/ANC and PHOENIX-4 Code Systems for the prediction of the Platinum and Vanadium Self-Powered Detector (SPD) currents. The qualification analysis has been performed for the plant measurement data acquired from multiple operating plants. The results indicate the proposed methodology is consistent with the detector behavior observed in the operating plants.

The qualified SPD methodology integrated with the existing BEACON System will provide the power distribution monitoring capability for SPD plants.

REFERENCES

1. Beard, C. L., Morita, T., "BEACON -- Core Monitoring and Operations Support System," WCAP-12472-P-A, August 1994.

2. Morita, T., "BEACON -- Core Monitoring and Operations Support System," WCAP-12472-P-A Addendum 1-A, January 2000.

3. Nguyen, T. Q. et al, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," WCAP-11596-P-A, June 1988.

4. "The Advanced PHOENIX and POLCA Codes for Nuclear Design of Boiling Water Reactors," CENPD-390-P, April 1999.

Table 1

SPD Measurement Data for BEACON Qualification

Plant ID	Maker of Reactor	Detector Material	Detector Configuration	Age of Detector at BOC	# of SPD MAPS Analyzed	Max BU GWD/MTU
Plant A	CE	Platinum	2 x 5 40 cm	Fresh	15	16.1
Plant B	CE	Platinum	1 x 4* 40 cm	Fresh	14	18.9
Plant C	CE	Vanadium	2 x 5 66 cm	Fresh	230	5.3

M x N and L denotes M Detector Strings: each made of N Detectors of L cm length
* 1 detector excluded because of systematic measurement errors

Table 2

Statistics of $\left(\frac{I_p^N(I,J,K)}{I_m^N(I,J,K)} - 1\right)$ Standard Deviation in Percent

Plant	Detector Material	Detector Length (cm)	Age of Detector at BOC	# of Data Points	Measurement Variability σ_m

a,b, c

Figure 1
SPD QUALIFICATION ANALYSIS PROCEDURE

a,c

Figure 2
Platinum
Standard Deviation of Prediction to Measurement Errors

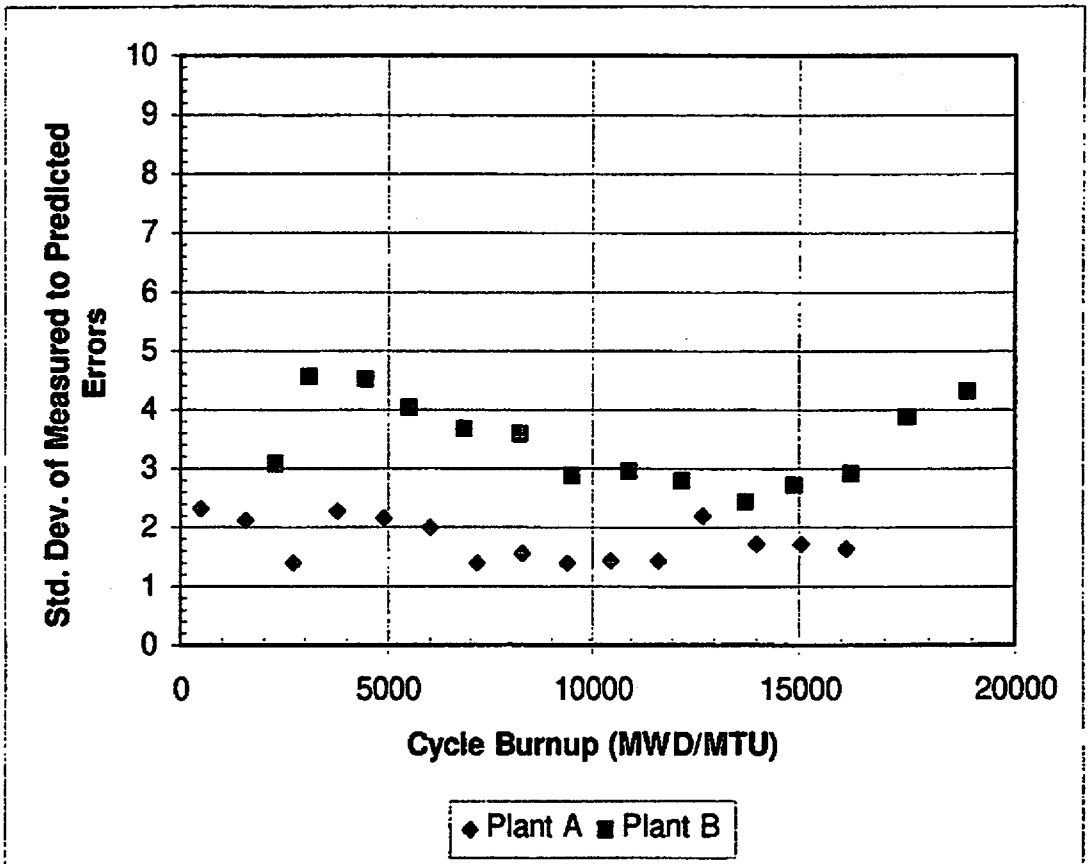


Figure 3
Vanadium
Average Ratio of Prediction to Measurement

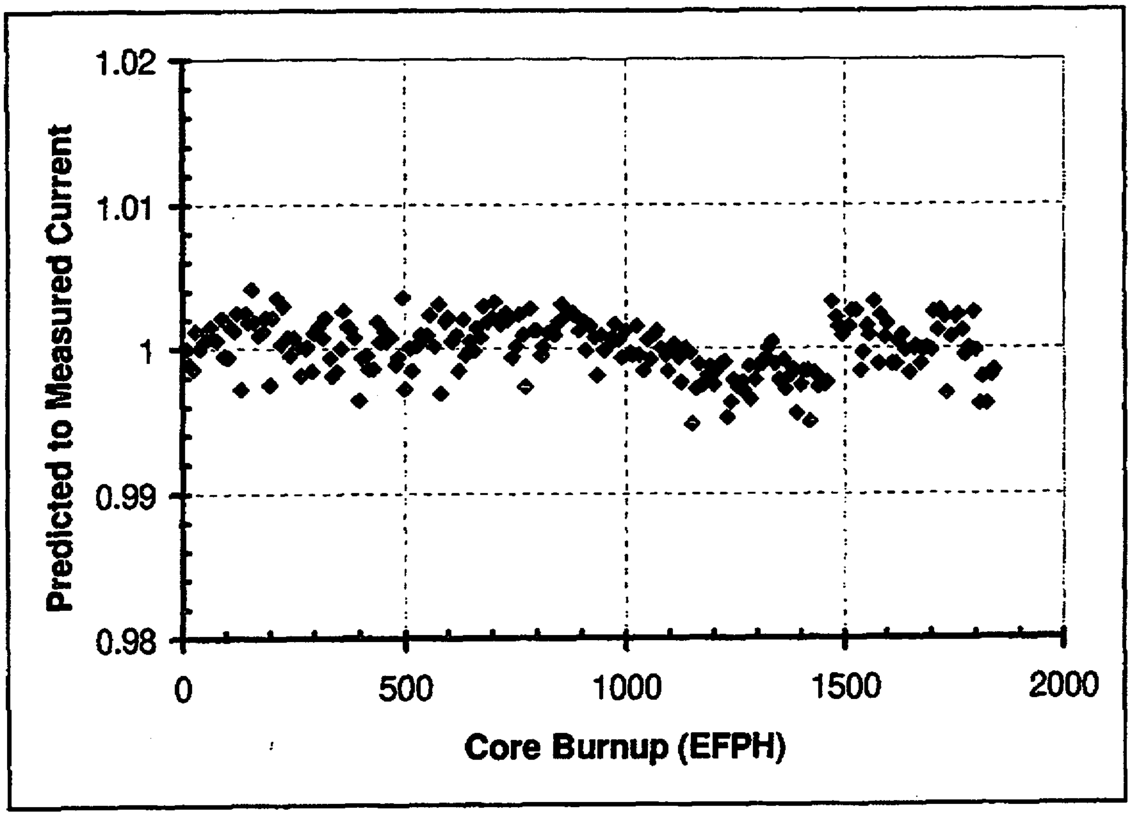
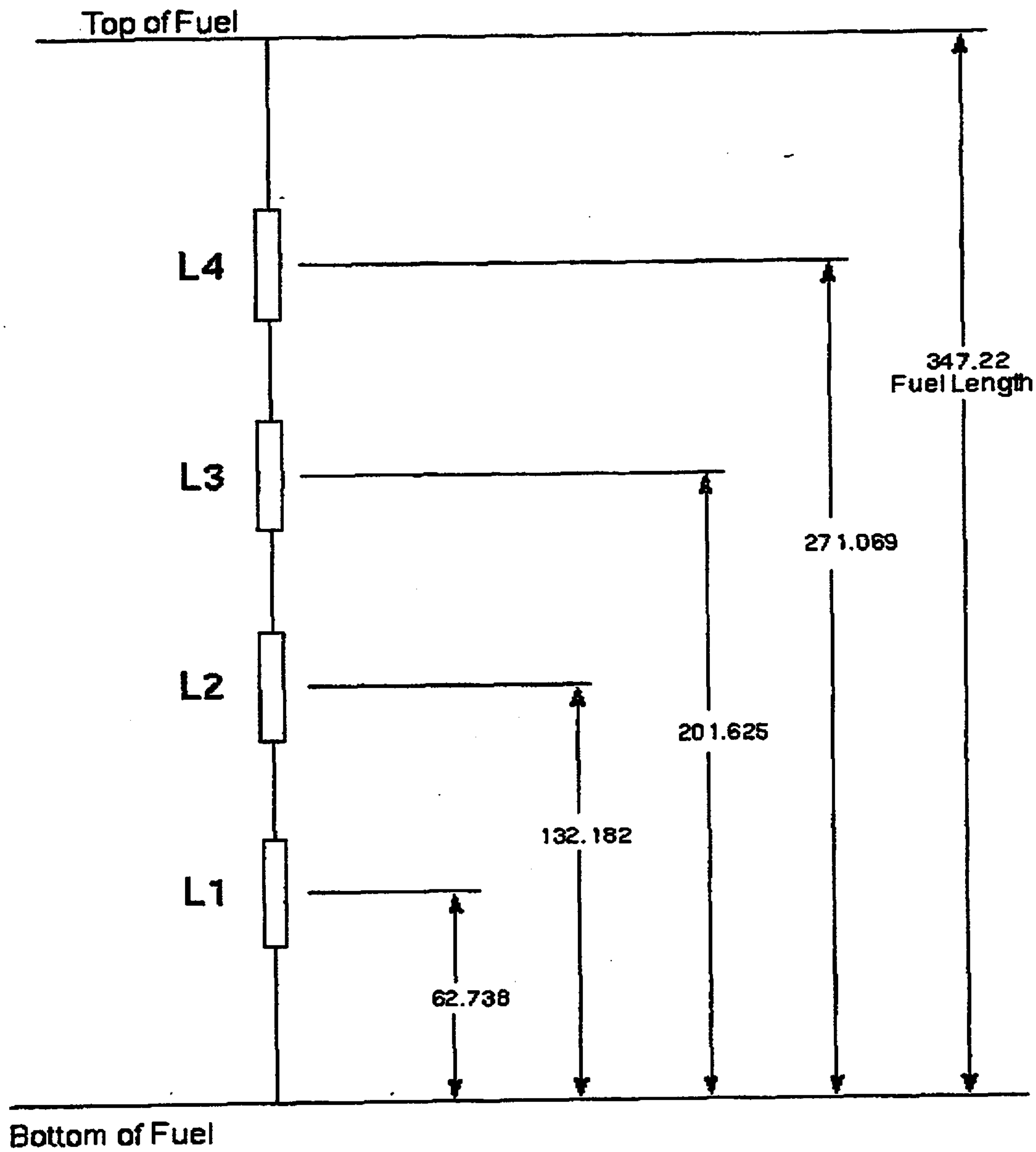
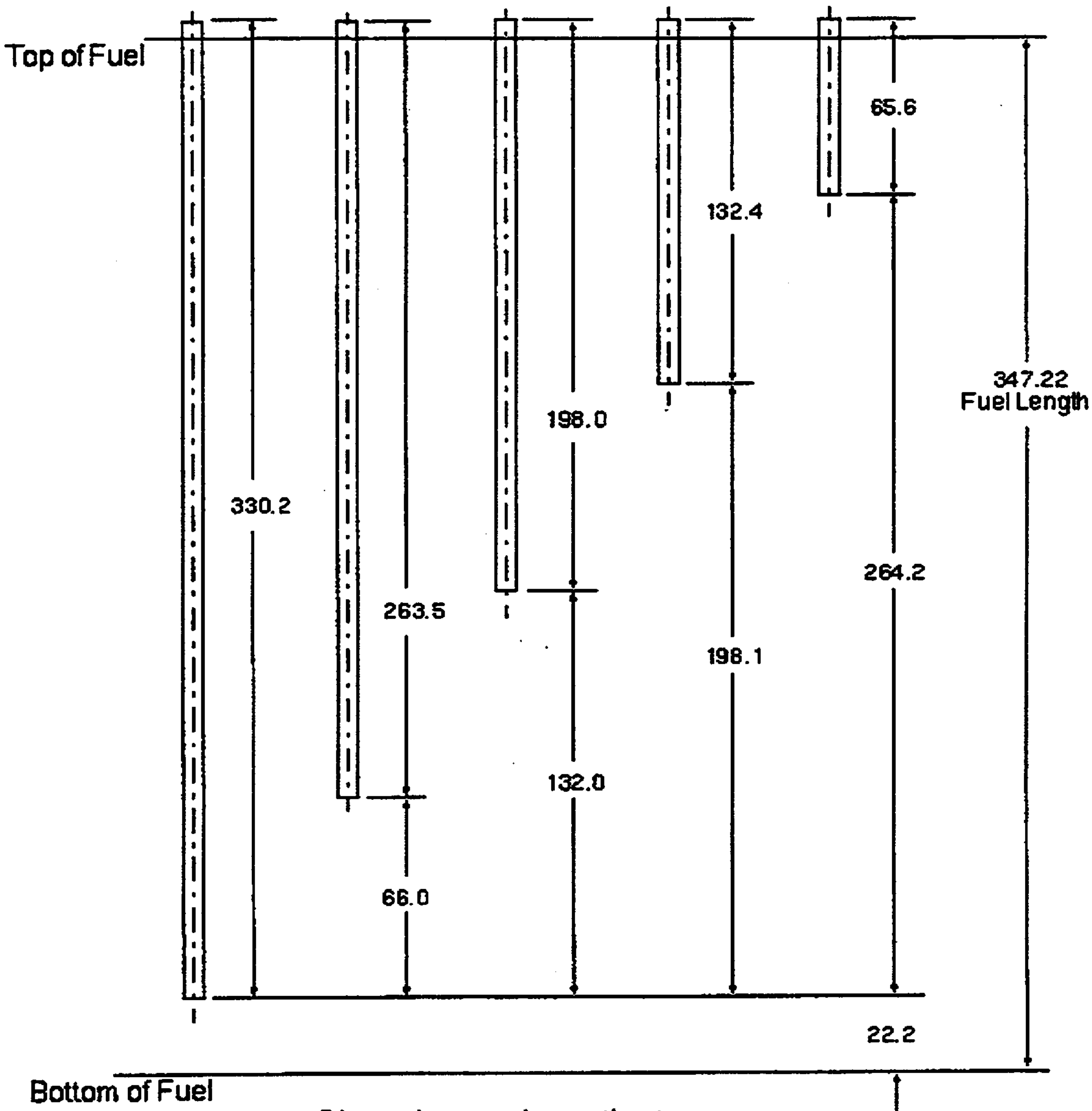


Figure 4
Platinum
Axial Detector Location



* Dimensions are in centimeters

Figure 5
Vanadium Detector Axial Layout



Dimensions are in centimeters

Section C

Westinghouse Electric Company LLC

Box 355
Pittsburgh Pennsylvania 15230-0355

August 31, 2001
LTR-NRC-01-31

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Attention: J. S. Wermiel, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

Subject: Responses to Request for Additional Information on WCAP-12472-P-A Addendum 2, "BEACON Core Monitoring and Operation Support System"

Reference: (1) Letter from S. D. Bloom (NRC) to H. A. Sepp (Westinghouse), Request for Additional Information for Westinghouse Topical Report WCAP-12472-P-A, Addendum 2, "BEACON Core Monitoring and Operation Support System", (TAC No. MB1711) July 11, 2001

Dear Mr. Wermiel:

Enclosed are copies of the Proprietary and Non-Proprietary versions of the Westinghouse responses to additional information requested in Reference 1.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-01-1479 with Proprietary Information Notice and Copyright Notice.

2. One (1) copy of Affidavit, AW-01-1479.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

Correspondence with respect to any Application for Withholding should reference AW-01-1479 and should be addressed to H. A. Sepp, Manager of Regulatory and Licensing Engineering, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

H. A. Sepp, Manager
Regulatory and Licensing Engineering

cc: S. D. Bloom, NRR

Westinghouse Electric Company LLC

Box 355
Pittsburgh Pennsylvania 15230-0355

August 31, 2001
AW-01-1479

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Division of Systems Safety and Analysis

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-01-31, dated August 31, 2001

APPLICATION FOR WITHHOLDING PROPRIETARY
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Regulatory and Licensing Engineering

AW-01-1479

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, 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 Company LLC, a Delaware limited liability company ("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:

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

Sworn to and subscribed
before me this 4th day
of September, 2001.

Lorraine M. Piplica

Notary Public

Notarial Seal
Lorraine M. Piplica, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Dec. 14, 2003
Member, Pennsylvania Association of Notaries

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(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 sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method 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 Westinghouse Electric Company LLC letter (LTR-NRC-01-31) and Application for Withholding Proprietary Information from Public Disclosure, H. A. Sepp, Westinghouse, Manager Regulatory and Licensing Engineering to the attention of J. S. Wermiel, Chief, Reactor Systems Branch. The proprietary information as submitted by Westinghouse Electric Company LLC is in response to questions on WCAP-12472-P-A Addendum 2, "BEACON Core Monitoring and Operation Support System."

This information is part of that which will enable Westinghouse to:

(a) Improve core monitoring methodology

(b) Assist customers to obtain license changes resulting from the improvements

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of the information to its customers for purposes of improving core monitoring techniques

(b) Westinghouse can use this information to further enhance their licensing position with their competitors

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar licensing services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed information.

Further the deponent sayeth not.

Proprietary Information Notice

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC. In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

Copyright Notice

REQUEST FOR ADDITIONAL INFORMATION ON WCAP-12472, ADDENDUM 2,

BEACON CORE MONITORING AND OPERATION SUPPORT SYSTEM

1. In response to the staff's request for additional information (RAI) for Addendum One review, Westinghouse stated that if the BEACON System were to be used at Babcock or Combustion Engineering plants, it will be necessary to include a BEACON Operability specification in the Technical Requirement (TR) Manual associated with either the NUREG-1430 or NUREG-1432 format Technical Specifications. This TR specification will address the minimum number and distribution of plant sensor inputs required for BEACON to properly monitor the core power distribution. Please provide sample TR manual information for you Addendum Two application.

   Response: As in the case of Addendum 1, this addendum is a generic application for the methodology associated with the use of fixed incore detectors of various materials. This is not the application for a specific plant or vendor. When a plant specific application is submitted by a utility, the minimum compliment and distribution of detectors will be provided. In most cases it is anticipated that these requirements will be the same as those for the Rhodium detectors being replaced. However, the final determination will be based upon the need to insure that core peaking factor measurement uncertainties remain bounded by the values assumed in the reactor design limits.

   The sample TR manual example shown in Exhibit A of Addendum 1 is equally applicable to the case of Platinum or Vanadium detectors.

2. As stated in Addendum Two to WCAP-12472, the Platinum detectors are sensitive to the gamma flux and the Vanadium detectors are neutron sensitive. It also stated that the Platinum and Vanadium detectors can be mixed in the core with each other or with Rhodium incore detectors. Please explain how to predict the detector responses with different detector configurations at the plant

   Response: First it should be emphasized that operation with mixed detector types is not an expected condition at a reactor site. Commercial PWRs today are operated with Rh SPDs. The driving force to change the detectors is the fact that the detectors have a relatively short life (a few operating cycles) while Platinum and Vanadium detectors have a 10-20 year expected lifetime, making them basically "life of the plant" detectors for many operating plants. Depending on the condition (age and operability) of the Rh detectors, a utility may choose to change all the detectors during one refueling outage or to spread the changeout over several cycles changing a third to a half of the detector strings each cycle. Note that all the detectors in a given string are the same material. There can be no mixing axially. In addition, it is expected that the utility would select one of the long-lived detector types (Platinum or vanadium) as their detector of choice. Therefore it is not expected that there would exist any combination of detectors other than Rhodium and one other detector, each of the two detector types would have a significant presence in the core, and the co-existence the two detector types would only exist during the transition cycles.

   Note that fixed incore detector plants today already run with a "mixed core". This mixed core consists of detectors in different enrichment and different burnup fuel, which can significantly impact the detector responses. More importantly, the detectors are of different age. As mentioned above the rhodium detectors are replaced, not all at once, but over a period of two or three cycles. Therefore the stage of depletion of the rhodium detectors can be significantly different.

   So whether the detector response is different because of different detector material or because of different stages of burnup or because of different fuel surroundings, BEACON must be able to correctly relate the detector signal to the power distribution in the core.

BEACON can make use of different detector types and different detector burnups in the core because it does not require the fitting of the actual response of the detectors or the normalization of one detector type with another. This fitting / normalization type of methodology is not possible with a mixed detector type because the magnitudes of the signals from the each of the detector types can be significantly different. The BEACON power distribution measurement methodology is based on

.][a,c] Since the predicted current is based on the actual physical and neutronics characteristics of each detector and since the model's ability to predict that current has been demonstrated in Addendum 1 and 2, it is normally the case that the measured to predicted current ratio is a number very close to 1.0. The deviation from a value of 1.0 is therefore indicative of a measured vs predicted difference in the core power at the measured location. This will be the case no matter which type of detector is used in the particular assembly.

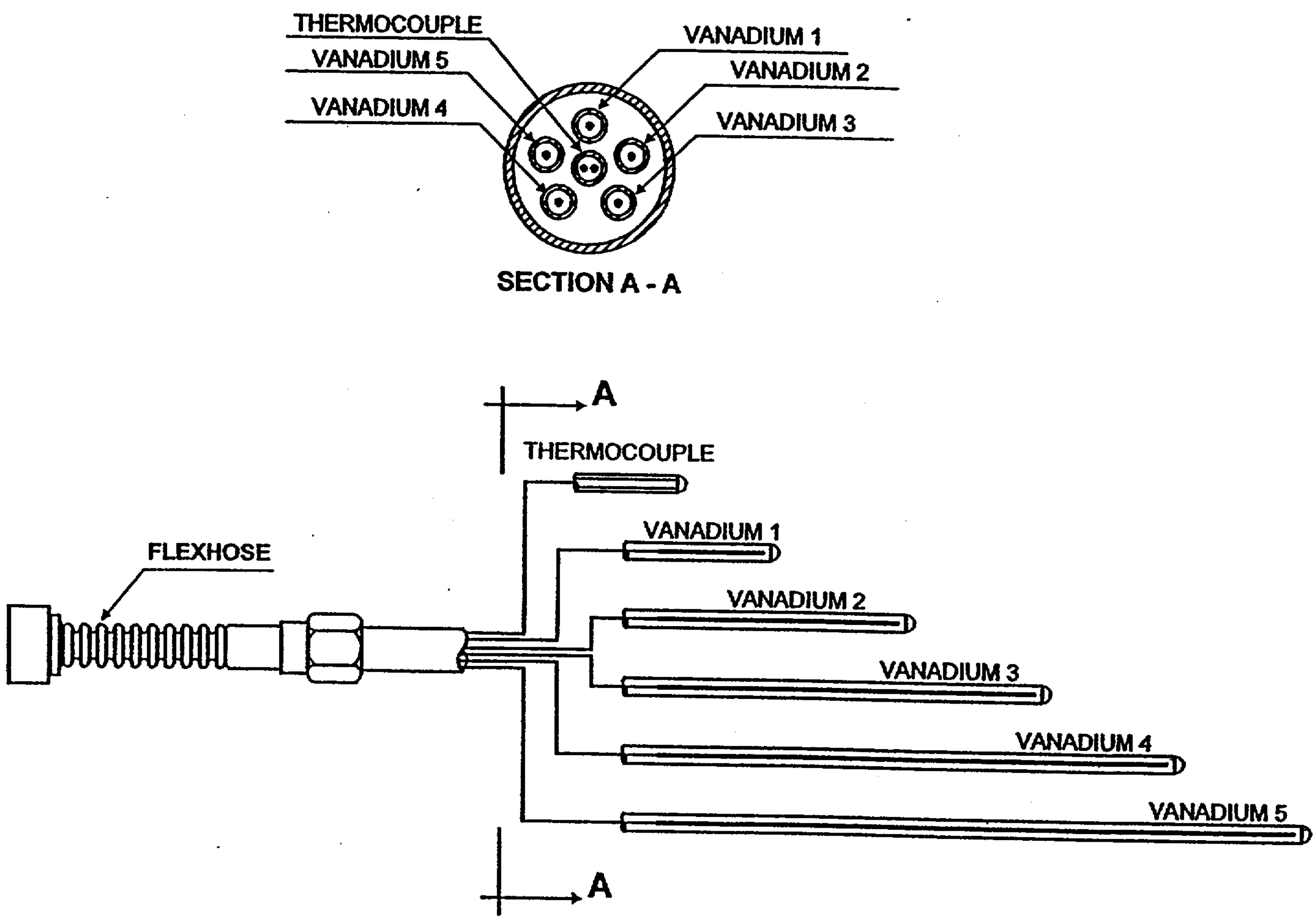
Equation 1:

[ ] a,c

3. Figure Four shows that the Platinum detectors are arranged with four detectors in a string. It is not clear from Figure Five how the Vanadium detectors are arranged.

Response: The detectors are as illustrated in Figure 5 of Addendum 2. The detectors are of unequal lengths. The first detector is a full-length detector covering the entire core. The second detector is 80% of full length; the third detector is 60%, and so on. Individual axial segment measurements are obtained by subtracting the currents of each successive detector. This configuration has several benefits for fixed incore detectors. First, since the vanadium current is lower than Rhodium, this longer detector configuration gives a stronger signal. Because there is no exposed lead wires in this configuration, no background wire is required, meaning no manipulation of background data is required. Finally because no background wire is used, the connector for the background wire can be used to add an additional detector. Therefore a plant that had only 4 Rhodium detectors in a string can increase the number of detectors to 5 with the Vanadium design, thus improving the axial resolution of the measurement.

A more detailed picture is shown below.



OPARSSEL SELF-POWERED NEUTRON DETECTOR GENERAL ARRANGEMENT

Note that in Addendum 2, we show the vanadium detectors arranged in this overlapping OPARSSEL arrangement and the Platinum arranged in the more traditional equal length arrangement. The BEACON methodology is not limited to these configurations of detector and material. BEACON can address any number of detectors in a string and any configuration of detector material.

4. Please explain why the surface spline fitting methodology does not require a minimum number of detectors in a detector string to obtain predicted power.

   Response: The requirement for a minimum number of detectors per detector string in other methodologies is based on the interpolation of the detector data in the axial direction used in those methodologies. These interpolations typically require a 3 out of 4, a 4 out of 5, or a 5 out of 7 requirement.

   [ ]a,c

5. Table One listed three plants that had installed experimental self-powered detectors (SPDs). Plants A and B had Platinum detectors, while plant C had Vanadium detectors. The number of SPD maps analyzed at plants A and B are 15 and 14 respectively. The number of SPD maps analyzed at plant C is 230. Why does the Vanadium detectors take so many maps to be analyzed in comparison to so few for Platinum detectors? What is the meaning of the number listed in the last column of Table One, "Max BU =GWD/MTU"?

   Response: The development of the Vanadium and Platinum detectors was performed by then separate companies, using different philosophies. The vanadium detector was developed from the beginning with the intent of continuous monitoring using the BEACON system. The platinum detector was developed initially with the intent of near steady state monitoring. Because of these differing philosophies, flux maps were taken at different intervals. Since the merging of these product lines, data is being collected at plant B on a more frequent basis. It is expected that as this additional data is collected it will serve to reduce the variability seen in Plant B. The column labeled Max Burnup is the maximum cycle burnup for which data had been collected. Since the detectors were all new, this is in effect a measure of the exposure of the detectors.

6. What is the meaning of the number listed at the last column of Table Two, "Measurement Variability σ_m"? What is the bounding measurement variability used by the BEACON system?

   Response: σ_m is the variability of the measured vs. predicted detector currents. As discussed in Addendum 1, this, along with the detector layout, are the key variables in determining the overall measurement uncertainty for a given detector type. σ_m tends to increase with increasing exposure due to the depletion of the detector material. Therefore this is a concern only in Rhodium detector plants. For these plants the bounding variability is set to conservatively upper bound the expected variability over the life of the detector in the specific plant. This will also be done for the Vanadium and Platinum detectors; however, the change with burnup will be significantly less.

7. What are the failure rates of the Platinum detectors and Vanadium detectors? Do you have sufficient data to support that these detectors can be considered as non-depleting detectors?

   Response: The mechanical properties of the Vanadium and Platinum detector designs eliminate the 2 major sources of Rhodium detector failures. Reliability of the Pt and Vd detectors will therefore be superior to the Rhodium detectors.

   Two types of fixed Incore Instrument (ICI) systems are associated with PWRs.

   The first consists of the bottom entry plants such as the Combustion Engineering System 80 units, a Westinghouse unit such as Seabrook, and B&W units. The failure history of fixed Rhodium ICIs in the CE System 80 units has been checked and has been found to be trivial over the life of the detector, normally about 2 to 3 fuel cycles. Replacement is almost never due to physical deterioration, but to depletion of the Rhodium. In bottom entry designs, the individual detectors are sealed in a dry tube and the guide tubes leading to the reactor have a very large bend radius, contributing to physical longevity of the detectors. Changing to

Platinum in these plants requires only a material change of the emitter. The same set of Platinum detectors has been operating in Seabrook since startup.

The second ICI system is the top entry design found in some CE units. Both dry and wet detector designs are employed depending on the plant vintage. In the case where the detector sheath is in contact with the coolant, a change to Inconel Alloy 690 (from 1600) is being implemented whenever Platinum or Vanadium is specified as the emitter material. Thus, Westinghouse expects to improve the detector sheath resistance to stress corrosion cracking, such that physical deterioration does not limit life expectancy unnecessarily. Also, the ductility of the Platinum and Vanadium detector emitters is very much greater than the ductility of Rhodium, so the likelihood of a detector emitter developing a crack that causes the detector to fail during operation is extremely small – even after extended irradiation. Vanadium and Platinum detector elements used in CANDU reactors have proven lifetimes in excess of 10 years of continuous operation. The other proven features of the ICI assemblies are retained, except that Platinum or Vanadium is substituted for Rhodium.

8. Reference 4, "The Advanced PHOENIX and POLCA Codes for Nuclear Design of Boiling Water Reactor" methodology was used to predict the Platinum reaction rate as a new feature added to BEACON. Please explain the applicability of this code for the Pressurized Water Reactor application.

   Response: The response function for the platinum detectors is determined, in part, from lattice calculations using the PHOENIX 4 code. While the topical report referenced licensed the total PHOENIX / POLCA code package for BWR use, the only part of the methodology used for BEACON is the lattice code results. Applicability of the PHOENIX 4 code to PWR type fuel lattices was demonstrated in this reference. Numerous benchmarks that are representative of a PWR type lattice include the BIBLIS core, IAEA benchmark, as well as calculations for a number of fully moderated critical assemblies. These benchmark results show good agreement in predicted reactivity and power distribution at the assembly level.

9. On page 5 of the submittal, Equation 3, how does the power distribution calculated by BEACON at the current core conditions differ from the measured power distribution?

   Response: The power distribution calculated by BEACON at the current core conditions is the predicted power distribution from the BEACON neutronics model with calibration factors applied. It is the P_P shown in Equation 1 above and is based on the burnup distribution from the actual core monitoring and uses the current plant statepoint conditions (relative power, rod insertion, temperature). It is therefore the best estimate of the actual core power distribution. It is also this power distribution from which the predicted incore currents are obtained. However, this predicted power distribution can not model unknown conditions such as misaligned rods or other anomalies. This information is obtained from the core instrumentation (In the context of this addendum, the platinum or vanadium fixed incore detectors). The BEACON best estimate predicted power distribution is corrected by the measured to predicted detector current ratio to obtain the measured power distribution, P_M, as shown in Equation 1 above.

10. On the same page as question nine, the last sentence of the fourth paragraph states that "no minimum No. of detectors in a detector string is required." How is the interpolation carried out if there are no detectors in a string (presumed to have failed).

    Response: That detector string is not used. BEACON does not rely on a "replacement" methodology. See response to RAI 4.

11. Will the different type of detectors have an impact on the BEACON interpolation scheme?

    Response: There is no impact on the interpolation scheme. The interpolation is based on the ratio of measured to predicted currents. Since the prediction is made very close to the true reactor conditions (See response to RAI 9), this ratio is close to 1.0 independent of the detector type. Therefore the interpolation scheme can be used independent of the type and mix of the detector types.

12. In the case of mixed cores, will the removal and installation of the same detectors from one type of fuel into a different type of fuel effect the detector response?

    Response: Yes different fuel types will impact the detector response. To account for this, the various cross sections and response functions used are determined as a function of the type of fuel into which the detector is placed. Physical characteristics of the fuel such as enrichment, burnup, presence of burnable absorbers, etc have an impact on the detector response and must be accounted for in the predictions. This is true for all detector types, both fixed and moveable.

13. With the inclusion of three different types of detectors (and possibly more), what is the probability that the wrong detector string is loaded into BEACON?? How can the staff be assured that this situation cannot occur, and what would be the consequences if it did?

    Response: Both the BEACON software and the BEACON models are developed under the same QA procedures/processes as are used for the reload design of the plant. So the same type of verification process is used to confirm that the correct detectors are input into BEACON as is used to insure that the fuel is correctly loaded into the reload design neutronics model. The process includes interfacing with the customer to assure that the model properly addresses the actual plant configuration. Independent testing of the model is performed prior to the model being implemented at the plant site.

    Should an incorrect loading of detector data into BEACON still occur, the situation would be immediately obvious during the initial startup of the plant since the magnitude of the detector currents are significantly different for each detector type. The measured to predicted current ratio would be significantly distorted if an incorrect model is used for the predicted current.

    It should be pointed out that a physical misloading of the detectors at the actual plant site is not possible. Each detector has a unique insertion path that requires each detector string to be custom made to the required total length. The detectors can therefore only be correctly assembled one way.

14. Figures two and three provide some insight into the uncertainties associated with the Platinum and Vanadium detectors. However, no data was provided as to the uncertainties associated with the "combined uncertainties" associated with the case of having Rhodium, Vanadium, and Platinum detectors in the same core. Please provide statistics associated with different combined configurations. i.e., measurability uncertainty, standard deviations, etc., etc.

    Response: While the BEACON methodology would permit assembly by assembly (or more appropriately, detector by detector) variabilities, this methodology is not currently used. For mixed cores, the variability is determined for each detector type. At his time, the overall variability used in BEACON is conservatively based on bounding the maximum variability for all the detector types. This can be changed in the future to apply the variability and resulting uncertainty by detector.

15. On page 7 of 16 of the submittal, in the middle of paragraph 2, it is stated that "If the current rhodium detector assemblies are gradually replaced by the similarly configured platinum detector assemblies -----" what if the detector configuration is not the same, will the BEACON power distribution measurement uncertainty remain the same?

Response: The BEACON uncertainty is determined by two key characteristics, the detector variability and the number/location of the detectors within the core. The statement on "similarly configured" can be related to either characteristic. The current demonstration assemblies for the platinum detectors used detectors at the same elevation and the same length as the rhodium detectors in the core. Should the length of the detector change (made longer for example) this would potentially impact the detector variability. Similarly, a change in the axial location of the detectors could impact the uncertainty as determined in the uncertainty methodology. It is also possible that the number of detectors might change, as is the case for the Vanadium detectors shown in this addendum. The Vanadium detectors used five detectors per string rather than four. While this does not necessarily change the variability of the detectors, it does change the total number of detectors in the core, which in turn impacts the uncertainty.

The BEACON uncertainty methodology can handle all these situations and determine the appropriate uncertainty to apply to power distribution measurements. The statement here about "similarly configured" simply means that we have shown through the demonstration assemblies that if the detectors are similar, the uncertainty will remain bounded by the existing detector analysis.