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.

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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

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AW-01-1479

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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-01-31, dated August 31, 2001

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Responses to Request for Additional Information on WCAP-12472-P-A Addendum 2, "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-01-1479 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-01-1479 and should be addressed to the undersigned.

Very truly yours,

H. A. Sepp, Manager
Regulatory and Licensing Engineering

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

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:

Henry A. Sepp, Manager
Regulatory and Licensing Engineering

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

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 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 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.

(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 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.

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.

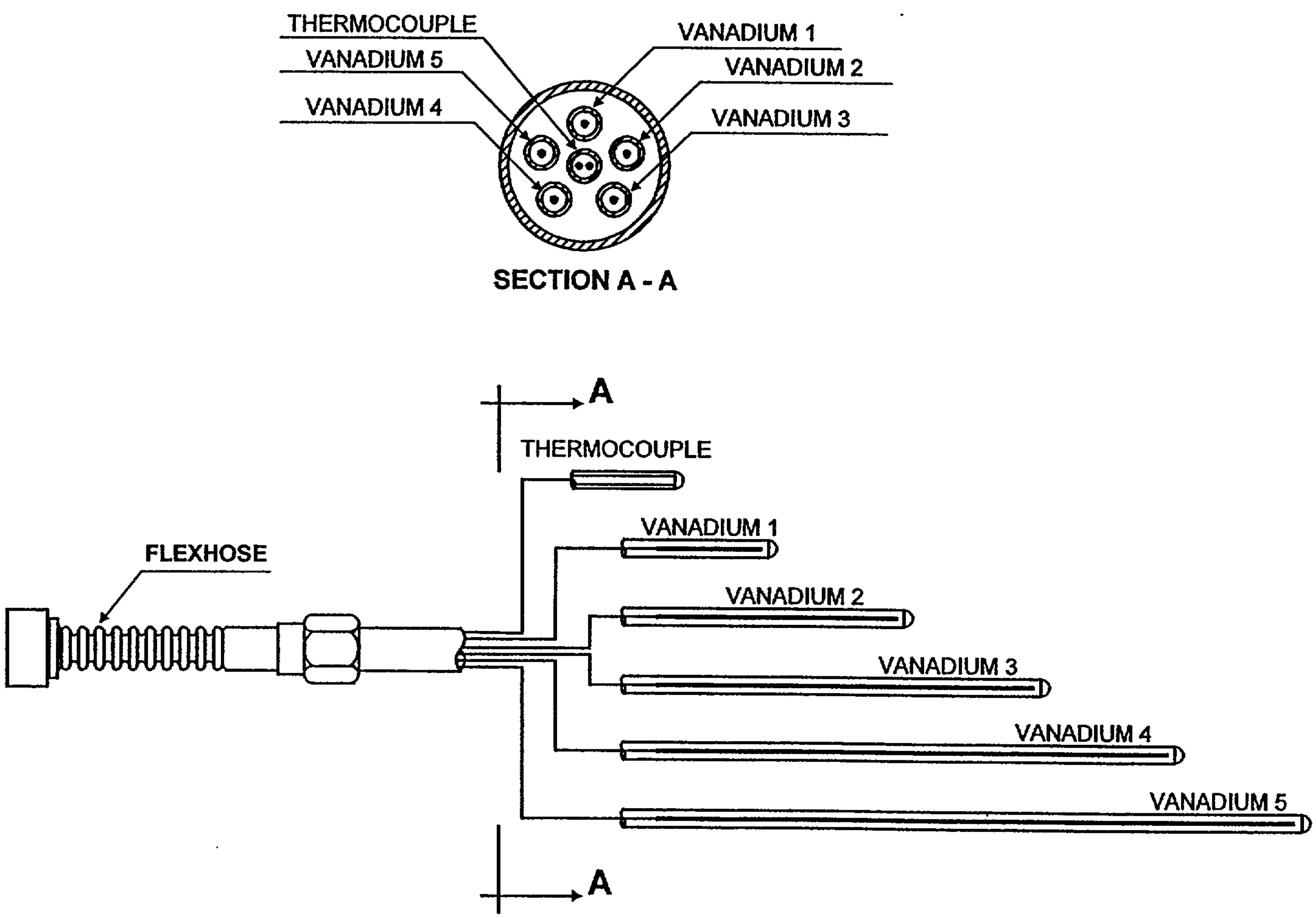
Equation 1:

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 I600) 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.