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<u>*Proprietary Notice*</u>
This letter forwards proprietary information in accordance with 10CFR2.390. Upon the removal of Enclosure 1, the balance of this letter may be considered non-proprietary.

MFN 07-162

Docket No. 52-010

May 14, 2007

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application – Gamma Thermometers - RAI Numbers 7.2-5 through 7.2-18 and 7.2-52 through 7.5-65**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter.

Enclosure 1 contains GE proprietary information as defined by 10 CFR 2.390. GE customarily maintains this information in confidence and withholds it from public disclosure. A non-proprietary version is provided in Enclosure 2.

The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GE. GE hereby requests that the information of Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

Reference:

1. MFN 06-392 - Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application, dated October 11, 2006

Enclosures:

1. MFN 07-162 - Enclosure 1 - Response to Portion of NRC Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application - Gamma Thermometers - RAI Numbers 7.2-5 through 7.2-18 and 7.2-52 through 7.5-65 - GE Proprietary Information
2. MFN 07-162 - Enclosure 2 - Response to Portion of NRC Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application - Gamma Thermometers - RAI Numbers 7.2-5 through 7.2-18 and 7.2-52 through 7.5-65 - Non-Proprietary Version
3. Affidavit – James C. Kinsey, dated May 14, 2007

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
RE Brown GE/Wilmington (with enclosures)

0000-0061-9458 For RAI 7.2-5
0000-0062-5840 For RAI 7.2-6
0000-0061-9458 For RAI 7.2-7
0000-0062-5840 For RAI 7.2-8
0000-0060-4078 For RAI 7.2-9
0000-0061-9458 For RAI 7.2-10
0000-0063-8636 For RAI 7.2-11
0000-0060-8799 For RAI 7.2-12
0000-0060-9548 For RAI 7.2-13
0000-0060-2299 For RAI 7.2-14
0000-0060-4089 For RAI 7.2-15
0000-0060-2301 For RAI 7.2-16
0000-0060-2304 For RAI 7.2-17
0000-0060-2304 For RAI 7.2-18
0000-0063-8636 For RAI 7.2-52
0000-0060-4117 For RAI 7.2-53
0000-0060-4717 For RAI 7.2-54
0000-0060-2305 For RAI 7.2-55
0000-0060-3861 For RAI 7.2-56
0000-0063-8636 For RAI 7.2-57
0000-0060-4805 For RAI 7.2-58
0000-0060-4266 For RAI 7.2-59
0000-0063-8636 For RAI 7.2-60
0000-0061-9458 For RAI 7.2-61

0000-0060-4131 For RAI 7.2-62
0000-0060-2307 For RAI 7.2-63
0000-0060-4137 For RAI 7.2-64
0000-0063-8636 For RAI 7.2-65

Enclosure 2

MFN 07-162

Response to Portion of NRC Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application

Gamma Thermometers

RAI Numbers 7.2-5 through 7.2-18 and 7.2-52 through 7.5-65

Non-Proprietary Information

NRC RAI 7.2-5

Provide additional information for Figure 1-1 of NEDE 33179P, specifically:
A. The materials for the jacket tube, core tube, cable pack, heater wire, the thermocouple metals,
and the thermocouple medium.
B. The radial dimensions for the jacket tube, fill gas, core tube, cable pack, and heater wire.
C. The axial length of the fill gas.
D. The position of the hot and cold junctions relative to the fill gas, jacket tube, and heater wire.
E. The expected range of pressure of the fill gas during normal operation.

GE Response

Part A:
Core Tube and Jacket Tube material:
316L SS.[[

]]
Cable Pack material:
316L SS.
Heater Cable materials:
Sheath is 316L SS.
Heater wire is Nichrome V alloy. (80% Ni, 20% Cr).
[[

]]
Thermocouple materials:
Sheath is 316L SS.
[[

]]

Part B, C, & D:
[[
]]

Part E:
[[
]]

[[

]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-6:

Is the heater wire in the gamma thermometer (GT) design electrically insulated from the thermocouple and core tube? Describe the distribution of [[ ]] in the cable pack. Provide a qualitative justification for the GT calibration technique in terms of the relative [[ ]].

GE Response:

[[

]]

[[

]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-7:

*What is the relative magnitude of the [[
]]? Is the heater wire resistance sensitive to irradiation? If so, does the calibration account for changes in resistance?*

GE Response:

[[

]]

DCD/LTR Impact:

This RAI does not require a change to any DCD Tier. No changes will be made to NEDE-33197P in response to this RAI.

NRC RAI 7.2-8

Is the thermocouple medium within the cable pack a metal? Does the interface between the heater wire and medium produce a voltage as a result of dissimilar metals? Does the heater wire current during calibration, or possible interface voltages, impact the thermocouple signal?

GE Response:

The cable pack is a tightly compacted system consisting of the central heater cable and nine thermocouples (TC's) within the cable pack housing tube, seven of which are functional, see Figure 1, below. The heater cable and thermocouples each have a 316L SS sheath. The thermocouple thermoelements are isolated from the sheath by compacted high purity Al_2O_3 (see response to NRC RAI 7.2-5). The heater cable central heater, which is an 80 percent Ni, 20 percent chrome alloy, is coaxial and isolated from the sheath by high purity Al_2O_3 except at the far end where it is welded to the 316L SS sheath. The heater cable and thermocouple sheaths, as well as the gamma thermometer structure and LPRM, are at reactor ground potential.

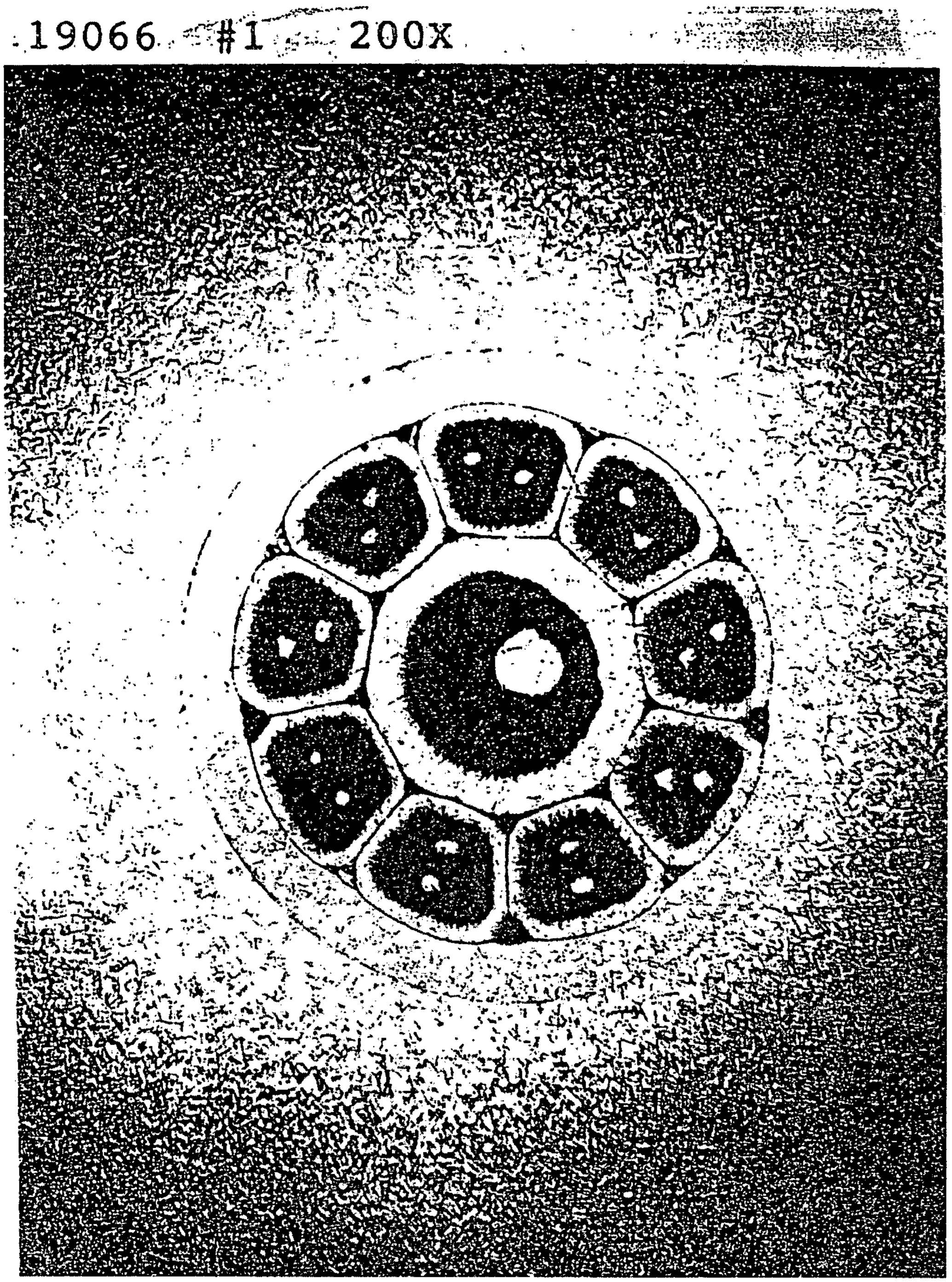
When power is applied to the heater cable, a constant current of up to three amperes flows through the heater wire and is returned to the power supply common through the gamma thermometer (GT) structure. The thermocouple signal, developed as a result of heater cable power (as well as gamma heating at reactor conditions), is isolated from any heater cable voltage by the high purity Al_2O_3 insulation material which has an insulation resistance (IR) [[ ]] or higher.

It is common practice to isolate both heater power and thermocouple measurement circuitry from reactor ground. Voltage present on the heater wire, to affect the thermocouple signal, would have to leak through the Al_2O_3 insulation to the heater cable and thermocouple sheaths, then through the thermocouple Al_2O_3 insulation to the thermoelements. At the sheaths it would encounter reactor ground which would effectively shunt it off from the thermocouples. Further, since the thermocouple measurement circuitry is isolated from reactor ground, if somehow a leakage voltage was present, there is no return current path from the heater wire to the thermocouple leads that could affect the thermocouple signal. Thus the thermocouple signal is isolated from any heater cable or related voltages.

DCD/LTR Impact:

No changes will be made to NEDE-33197P in response to this RAI. This RAI does not require a change to any DCD Tier.

Figure 1 (NRC RAI 7.2-8)
Etched Micrograph of GT Cable Pack Housing Tube containing nine thermocouples and a central heater cable. Conductor dimensions and locations are not representative because of the mounting process.



NRC RAI 7.2-9:

What code is used to determine the [[ ]]? Describe how the code is used to determine the [[ ]]. Describe the process for correlating these [[ ]]. Does the gamma thermometer respond to gamma radiation emitting from bundles other than [[ ]]? If so, is this factored into the determination of the [[ ]]?

GE Response:

The method of correlating bundle power to gamma detector reading remains the same for GT as it is for gamma TIPs. The details of the methodology are described in reference NEDC-33239P. Gamma thermometer response to bundles other than the nearest four is negligible because the nearest four effectively shield the GT from other bundles. [[ ]].

DCD/LTR Impact:

There is no changes to the Tier 2 DCD required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-10:

According to NEDE-33179P, Following the [[ ]]? Are these [[ ]] reflected in the application to ESBWR?

GE Response:

[[

$R_{H_{REF}}$

]]

DCD/LTR Impact:

No changes will be made to NEDE-33197P in response to this RAI.
This RAI does not require a change to any DCD Tier.

NRC RAI 7.2-11:

[[ ]]. Provide additional details regarding the calibration procedure in Section 4.4 of NEDE-33179P, particularly [[ ]]. Describe how the [[ ]] is determined. Do the [[ ]] stated in the procedure reflect the envelope of [[ ]]? What [[ ]] is expected for ESBWR? In regards to [[ ]]? Are these criteria based on the [[ ]]?

GE Response:

The sensitivity of individual GTs can change due to a number of factors. Hydrogen [[ ]] ingress into the argon gap would increase the heat transfer within the gap, causing the sensitivity to decrease. [[ ]], causing the sensitivity to increase or decrease. To account for sensitivity changes, the GT is built with a central heater cable to measure the change in GT signal in response to a known input heating rate from the heater cable. This is the "in-plant" or "online" or "heater" calibration described in Section 4.3 of NEDE-33197P.

During the Limerick test, [[

]]

[[

]]

DCD/LTR Impact:

No DCD changes will be made in response to this RAI. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-12

What is the primary source of [[ ]]? Qualitatively describe how the [[ ]] reaches an equilibrium or saturated concentration. Do other [[ ]]? If so, do these other [[ ]] have a significant impact on the [[ ]]?

GE Response:

[[

]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-13

Figure 7-3 in NEDE-33179P shows increased [[ ]]. Explain the relationship between [[ ]].

GE Response:

The GT sensor in the reactor is heated by gamma radiation (and fast neutrons) and, when being calibrated, by electrical energy. The heat generated in the mass under the chamber (see Figure 1 in response to NRC RAI 7.2-5) is blocked by the argon filled chamber and must flow axially out of the chamber region where it can then flow radially outward to the coolant through the core tube and jacket tube. The axial heat flow results in a temperature across the chamber. Scandpower A/S has developed a model for the GT sensor which results in the equation:

$$U = \frac{Se\,\rho L^2 w}{2k_{ss}} \tag{1}$$

where: U = measured signal from differential TC, mV

Se = Seebeck coefficient, mv/°C

ρ = SS density, g/cm^3

L = chamber half length, cm

w = power, watts per gram

k_{ss} = SS thermal conductivity, w/cm°C

Equation (1) neglects heat transfer through the argon gap and thus is an approximate model. However it does serve as a useable first order approximation to illustrate the effect of coolant temperature on the sensor output.

The GT sensitivity, to a first order, is $S = \frac{U}{w}$ (2)

where: S is mv / w/g. From equation (2)

$$S = \frac{Se\rho L^2}{2k_{ss}} \tag{3}$$

This equation indicates that the GT sensitivity is inversely proportional to the thermal conductivity of the SS core. The SS thermal conductivity has a literature value of 0.148 w/cm°C at 20°C and 0.180 w/cm°C at 286°C. The current method of translating GT sensitivity at two temperatures, from the Scandpower model is

$$S(T_2) = S(T_1) \bullet \frac{k_{ss}(T_1)}{k_{ss}(T_2)} \tag{4}$$

Thus if S(20°C) = 1.60 mv / w/g, S(286°C) = 1.32 mv / w/g. This is a 20 percent change in GT sensitivity from room temperature to reactor conditions.

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-14

Describe how automatic fixed in-core probes (AFIPs) allow for axial power shape monitoring. Describe any procedural or calculational controls that ensure accurate axial power distribution monitoring. Is it possible to misrepresent the axial power shape within 3D MONICORE for operating power shapes with multiple local axial peaks (for example, double-hump power shapes) based on the proposed adaption techniques?

GE Response:

The BWR Core Simulator code (PANACEA) calculates a core power distribution on a nodal basis. This will continue to be the case with AFIPS. When using a TIP system, the PANACEA calculated axial power shape is [[

.]]

When AFIPs are used in place of the TIP system, the Core Simulator Code will only be able to obtain measured adaption in axial locations where the AFIPs are placed. Each GT string will contain [[ ]] GT detectors. This provides sufficient coverage to measure the axial shape for all anticipated operating conditions and transients (see Ref. 1). The exact procedure for adapting the Core Simulator Code to AFIP readings has not yet been finalized. Uncertainties in the power peaking due to the adaptation method chosen will be accounted for in the AFIP uncertainty analysis.

The qualification basis will also address the acceptable fraction of AFIPs which are required to ensure uncertainties are acceptable.

As is the case with the current TIP adaption process, AFIP adaption will be [[

]].

Testing of the GTs at Kashiwazaki-Kariwa 5 with a core simulator code adapted to use gamma thermometers demonstrated the accuracy of monitoring with an AFIP system in comparison to a TIP-based system. Gamma scans were performed at Kashiwazaki-Kariwa 5 following one cycle of operation with the GTs. The GTs populated one octant of the core and gamma scan measurements were taken of the 104 fuel bundles in that quadrant. RMS error in nodal power distribution was [[ ]] using GTs, very similar to the [[ ]] RMS error exhibited with the TIP system.

Specifics of the local power uncertainty from the results of the Kashiwazaki-Kariwa 5 gamma scans were documented in RAI response 4.2-12. The uncertainty was shown to be bound by the [[ ]] MLHGR power uncertainty design basis

Reference 1:
Rombough, et al., "Accuracy of Power Peaking Monitoring Using Fixed Incore Detector Systems," ANS Topical Meeting on Advances in Reactor Physics and Core Thermal Hydraulics, Kiamesha Lake, New York, September 22- 24, 1982.

<u>DCD/LTR Impact:</u>

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-15

Describe, mathematically, the relationship between the [[ ]]. Describe, mathematically, the relationship between the [[ ]].

GE Response:

The GT specific power will be proportional to the gamma flux at the sensor. In other words,

Gamma Flux = A x GT specific power, where A is a proportionality constant

The value of the proportionality constant is not important because it is the [[ ]] that are needed to obtain the relative power distribution. The relationship between the [[ ]] is very complicated mathematically and is determined from nodal and lattice codes for the operating conditions being measured (see our response to 7.2-9).

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-16

In Table 9-6 of NEDE-33197P, additional uncertainties are included for [[ ]]. Describe the procedure used to determine these additional uncertainties. Justify any assumptions made in the calculation of these additional uncertainties.

GE Response:

In order to estimate the additional uncertainty and bias of alternate GT designs involving [[ ]] installed at Tokai 2, core power distribution calculations were performed involving simulated GT readings. In these calculations, [[

.]] Since it is only the axial shape that is affected by the use of fewer than [[ ]], the use of simulated readings in the balance of the core has negligible impact on the results of the power distribution surrounding the two gamma thermometers installed at Tokai 2.

The adaptive core monitoring calculations, covering a full cycle, were performed for three different sensor configurations. The first was the [[

]]

The resulting nodal power uncertainties are tabulated in the "Simulated Value" column of Table 9-6. The additional uncertainties were calculated by assuming a statistical combination of the base 9 GT uncertainty and the additional uncertainty (AU) associated with having fewer than 9 GTs. For example,

[[

]]

This calculation assumes that the simulator used to simulate the GT readings is representative of power distributions that will be encountered in a boiling water reactor.

This calculation measures the error as the difference between the TIP-based power distribution and the GT-based power distribution. It assumes that any differences are errors that increase GT uncertainty due to having fewer than [[.]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-17

In Table 9-12 of NEDE-33179P, the [[ ]], however, in the preceding paragraph it is stated that the [[ ]]. Explain this [[ ]]. How are power distribution uncertainties accounted for in the determination of the [[ ]]? It is stated that the [[ ]] is based on engineering judgment. Provide a more detailed explanation to justify this criterion.

GE Response:

The statement regarding the [[ ]] case in the preceding paragraph is not correct and should be deleted. The [[ ]].

Details of how power distribution uncertainties are accounted for in the determination of MLHGR are described in the response to RAI 4.2-12.

The [[ ]] criterion is a figure of merit based on an index value (of 5.2%) that is used in the regulatory analysis in Japan, called "uncertainty of TIP readings" (reference H. Shiraga, et al., "Verification of Core Monitoring System with Gamma Thermometer," International Conference on Global Environment and Advanced Nuclear Power Plants, GENES4/ANP2003, Sep. 15-19, 2003, Kyoto, Japan). Its introduction comes from the fact that much of the gamma thermometer testing was conducted in Japan. It does not constitute the basis for any power distribution uncertainty.

DCD/LTR Impact:

No changes to the DCD will be made in response to this RAI. Section 9.3.3 of LTR NEDE-33197P will be revised in response to this RAI. This LTR will be submitted to the NRC by September 28, 2007.

NRC RAI 7.2-18

Section 5.1 and 5.2 of NEDE-33179P describe [[ ]]. Section 5.1 states that the [[ ]]; section 5.2 states that [[ ]] (as in the ESBWR design, as shown in DCD Tier 2, Revision 1, Section 7.2). Describe how [[ ]] is performed in the ESBWR design.

GE Response:

The ESBWR design will use Automated Fixed In-core Probes (AFIPs) to replace the function of the TIP system. The gamma thermometer (GT) design planned for use as AFIPs will employ [[ ]]. The AFIP will be employed for the purpose of LPRM calibration in the ESBWR in a similar manner to TIPs in existing BWRs.

The overall process would be as follows:

[[

]]

LPRM correction factors will be calculated by 3D Monicore (or its replacement) by the above process to provide accurate core power distribution calculations when LPRMs are used during transients or during GT calibrations.

The LPRM calibration process will be fundamentally the same as the existing process with two differences:

1. AFIPs will replace TIPs
2. Use of AFIPs to calibrate LPRM will be more convenient, making it possible to perform the calibration on a more frequent basis.

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-52

Describe the influence of fuel spacers on gamma thermometer signals. Explain how the presence, or absence, of spacers near GT locations is accounted for. If no such compensation exists in the modeling, discuss any influences the spacers have on gamma flux indication, and subsequent uncertainties [[ ]]. Include this information in the LTR.

GE Response:

Fuel spacers will have minimum impact on gamma thermometer signals because the fuel spacers perturb the gamma flux significantly less than they perturb the neutron flux.

[[

]]

DCD/LTR Impact:
No DCD changes will be made in response to this RAI.

Since corrections for fuel spacers are not anticipated to be needed, no changes will be made in the LTR at this time.

NRC RAI 7.2-53

The [[ ]] are combined such that [[ ]] in the model, and subsequently to perform [[ ]]. Describe how these [[ ]] are determined. Are they a function of [[ ]]? Explain the terms in the calculated signal that are related to the [[ ]]. Why are these terms based on the [[ ]]? How are these [[ ]] determined given that the nature of this calculation is [[ ]]? How are the uncertainties in the calculation of the [[ ]] captured in the uncertainty analysis? Include this information in the LTR.

GE Response:

The relationship between GT response and relative nodal power will be based on a correlation like the one provided in the response to RAI 21.6-89 (reference NEDC-33239P). The correlation is a function of [[ ]].

The uncertainty in the ability of the nodal model to predict the GT responses can be determined from comparisons of predicted and measured power distributions at operating reactors. The response to RAI 4.2-12 describes the components of the uncertainty and provides the uncertainty for a 7-sensor GT design.

DCD/LTR Impact:

No DCD changes will be made in response to this RAI.

The following changes will be made in the next revision of LTR NEDE-33197P:

In Section 5.2, insert the following text after equation 5.2-1 – [[ ]]

LTR NEDE-33197P will be submitted to the NRC by September 28, 2007.

<u>NRC RAI 7.2-54</u>

How does the use of GT indications reduce [[ ]] in Table 9-15 for the [[ ]] determination? Include this information in the LTR.

<u>GE Response:</u>

While Table 9-15 shows that the [[ ]] for the GT system is less than it is for the TIP system, these results are valid only for a limited data set at Kashiwazaki-Kariwa 5 and only show that the GT to TIP comparison at this plant was less than the *maximum* uncertainty expected for a TIP system.

The power allocation and four bundle power uncertainties used for the OLMCPR determination are based on thousands of measurements and are not expected to change by using GTs instead of TIPs. Table 9-15 does not provide an explicit calculation of all the components of uncertainty for gamma thermometers. While it does list the [[ ]] uncertainty for TIPs, that TIP uncertainty is compared to the overall GT uncertainty determined by gamma scans at the Kashiwazaki-Kariwa 5 plant. The gamma scan results, also shown in Table 7-18 of the LTR, include the effect of [[ ]]. Those results are listed in the "TIP Integral" row for gamma thermometers. Only uncertainties that are not captured in the gamma scan comparison are further added to the GTs' TIP integral uncertainties in Table 9-15.

<u>DCD/LTR Impact:</u>

No DCD changes will be made in response to this RAI.

The following changes will be made in the next revision of LTR NEDE-33197P:

After the paragraph below Table 9-14 which discusses Table 9-15, insert the following text – While Table 9-15 shows that the [[ ]] for the GT system is less than it is for the TIP system, these results are valid only for a limited data set at Kashiwazaki-Kariwa 5 and only show that the GT to TIP comparison at this plant was less than the *maximum* uncertainty expected for a TIP system. This LTR will be submitted to the NRC by September 28, 2007.

NRC RAI 7.2-55

Are there any controls, statistical or otherwise, within PANACEA for allowable changes to the [[ ]] based on [[ ]]?

GE Response:

The current version of PANACEA (PANAC11) [[

]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-56

Discuss the preferred [[ ]] for the control rod patterns of beginning of cycle (BOC), middle of cycle (MOC), and end of cycle (EOC) based on their influence on [[ ]]. Are there any controls in place, administrative or calculational, to ensure the preferred technique is used given the [[ ]]?

GE Response:

The relationship between GT response and relative nodal power will be based on a correlation like the one provided in the response to RAI 21.6-89 (reference NEDC-33239P). [[

.]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-57

Discuss the influence of gamma streaming through fuel bundles (i.e. between fuel rods through the inter-pin water or steam) on gamma indication from [[ ]]. Include this information in the LTR.

GE Response:

A small portion of the total gamma flux at the GT location will originate from [[ ]] This influence will have minimum impact on the GT-derived power distributions for the following reasons -

1) The vast majority of gammas at the GT originate from the four bundles surrounding the GT. [[ ]]

2) The influence of [[ ]] would be present for all GT strings in the core and so the effect, although small, is essentially normalized out.

DCD/LTR Impact:

No DCD changes will be made in response to this RAI.

The following changes will be made in the next revision of LTR NEDE-33197P:

Add the following paragraphs at the end of Section 7.2.5.1 -

A small portion of the total gamma flux at the GT location will originate from [[ ]] This influence will have minimum impact on the GT-derived power distributions for the following reasons -

1) The vast majority of gammas at the GT originate from the four bundles surrounding the GT. [[ ]]

2) The influence of [[ ]] would be present for all GT strings in the core and so the effect, although small, is essentially normalized out.

This LTR will be submitted to the NRC by September 28, 2007.

NRC RAI 7.2-58

Describe the procedure for calculating the [[ ]]. Provide the data used to make this determination. Justify the applicability of this value given that it is based on [[ ]]. Provide additional information regarding the cycle specific adaption employed during any [[ ]], and describe the influence of [[ ]]. If available provide comparisons of [[ ]] to justify that this uncertainty is not dependent on the [[ ]]. Provide additional descriptive detail explaining the unexpected results shown in Table 9-13. Specifically explain the nature of the [[ ]], as well as the calculations that were performed (in [[ ]] as well as using statistical analysis) to determine the observed difference. Explain why the [[ ]] is lower than any values shown in Table 9-13. Include this information in the LTR.

GE Response:

NRC: Describe the procedure for calculating the [[ ]].

The procedure for determining the [[ ]] was the following (see Section 8.1 of the LTR and Tables 8-1 through 8-4) –

1) Adapt the PANAC10 axial shape to the n-TIP axial shape. The powers in the 4 bundles surrounding the TIP were predicted by PANAC10 and the axial shapes were adjusted to the n-TIP axial shape. The relative power in each axial node of the 4 bundles was then tabulated in Tables 8-1 through 8-4 under the column "TIP Power".
2) Adapt the PANAC10 axial shape to the GT axial shape. The resulting relative power in each axial node of the 4 bundles surrounding the TIP were then tabulated in Tables 8-1 through 8-4 under the column "GT Power."
3) The average of all 24 nodes is the bundle average power and this average is tabulated under the column "Bundle" for both the TIP Power and the GT Power. For example, from Table 8-3 at 99.7% power, the TIP power for bundle (23,34) was 1.191 while the GT power for the same bundle was 1.205, a difference of 1.2%.
4) By averaging the bundle differences over all power levels and all maps, the average difference between TIP bundle power and GT bundle power was found to be 1.1% (see Table 8-7, Bundle, Mean, All). This is the value reported in Table 9-14.

NRC: Provide the data used to make this determination.

The data is from Tokai-2. Representative data for two maps (one at 29.2% power and one at 99.7% power) is tabulated in Tables 8-1 through 8-4. The data from all of the maps is not shown because it is voluminous and describing the procedure of calculation and representative data should be sufficient.

NRC: Justify the applicability of this value given that it is based on [[ ]].

This value will not be used to determine overall uncertainties (the statement below Table 9-14 that bundle power uncertainty from Table 9-14 will be used in safety limit analyses is not correct and will be deleted in the next revision of the LTR). The value is provided in Table 9-14 only as an indication that GT uncertainty is comparable to TIP uncertainty.

NRC: Provide additional information regarding the cycle specific adaption employed during any [[ ]], and describe the influence of [[ ]].

In order to estimate some of the uncertainty inputs to Table 9-14, core power distribution calculations were performed involving [[

.]]

NRC: If available provide comparisons of [[ ]] to justify that this uncertainty is not dependent on the [[ ]].

Extrapolated GT data to n TIP data is not available. We agree that it is not realistic to conclude that the uncertainty is not dependent on the number of GT sensors per string. The BWR core simulator code PANAC10 was run and adapted to both TIP and *simulated* GT readings to perform the testing described in the LTR. [[

]] Although Table 9-8 indicates that having fewer GT sensors per string results in smaller uncertainties, this result arose only because the study was not realistic and based only on *simulated* GT readings. In practice, the uncertainty *will* be larger with fewer GT sensors per string. Table 9-8 will be deleted in the next revision of the LTR.

NRC: Provide additional descriptive detail explaining the unexpected results shown in Table 9-13. Specifically explain the nature of the [[ ]], as well as the calculations that were performed (in [[ ]] as well as using statistical analysis) to determine the observed difference.

The Limerick calibration error is summarized in Table 7-2 of the LTR. GT2 sensor D is a statistical outlier. When compared to the average error of the other sensors, its average error lies more than 3 standard deviations from the mean error of the other 7 sensors. Also note that Sensor GT2-D's standard deviation is not significantly larger than the other sensors', indicating that its average error is a consistent bias. This type of response is indicative of the GT being mis-calibrated at the factory. It could be the result of the heater rating not being correctly determined. The error would result in a consistent bias throughout the detector's life.

NRC: Explain why the [[ ]] is lower than any values shown in Table 9-13. Include this information in the LTR.

The [[ ]] in Table 9-14 is based on the average difference in bundle powers between TIP and GT for the two strings installed at Tokai-2 (see the response to the first part of this RAI). Since this is an average bundle power difference and the data base is limited, this value cannot be compared to the expected nodal RMS differences shown in Table 9-13. The observed differences in Table 9-13 are based on *nodal* RMS differences (between GT and TIP derived power). Therefore, they include additional errors such as the determination of axial power shape adapted to the nuclear instrumentation. It is expected that *nodal* differences would be greater in magnitude than bundle average differences. The word "nodal" will be added to the title of Table 9-13 in the next revision of the LTR.

DCD/LTR Impact:

No DCD changes will be made in response to this RAI.

The following changes will be made in the next revision of LTR NEDE-33197P:

1) Delete the statement below Table 9-14 regarding safety limit analyses
2) Delete Table 9-8 and associated text
3) Add the word "nodal" to the title of Table 9-13

This LTR will be submitted to the NRC by September 28, 2007.

NRC RAI 7.2-59

Provide the reference for the [[ ]] shown in Table 4-1 of NEDE-33197P. If these values were measured or calculated provide details of these measurements or calculations. Include this information in the LTR.

GE Response:

The [[ ]] and the constants in Table 4-1 were based on ANSI/ANS-5.1-1994, Decay Heat Power in LWRs, Table 9: parameters for U235 thermal fission (alpha and lambda in 23 groups). [[

]]

Extensive comparisons were performed during transient power operation, comparing LPRM to GT responses as described in NEDE-33197P Section 7.2.6. The [[ ]] significantly improved the response of the gamma thermometers under transient conditions.

However, as discussed in the response to RAI 7.2-18, the GTs will be used only to calibrate the LPRMs and not be used for core monitoring under transient conditions (the LPRMs will be used for core monitoring during transient conditions). Therefore the [[ ]] is not likely to be needed.

If GTs are chosen as AFIPs for the BWR and the [[ ]] is utilized, its uncertainties will be factored into the total uncertainty analysis.

DCD/LTR Impact:

No DCD changes will be made in response to this RAI.

The following changes will be made in the next revision of LTR NEDE-33197P:

Below Table 4-1, insert the following text – [[

]]

This LTR will be submitted to the NRC by September 28, 2007.

NRC RAI 7.2-60

Explain [[ ]].

Figures 8-1 through 8-4 show [[ ]], in Figures 8-3 and 8-4, the areas beneath the curves do not appear the same, explain why the [[ ]] appears consistently larger than the [[ ]].

GE Response:

The areas beneath the curves are not the same because [[

.]]

The curves shown in Figures 8-3 and 8-4 of NEDE-33197P are *not* a comparison of GT readings to TIP readings but rather are comparisons of GT-derived bundle power distributions to the TIP-derived bundle power distributions. [[

]]

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-61

How often must GT instruments be replaced? How is this replacement frequency determined?

GE Response

The replacement frequency of the Gamma Thermometer in the ESBWR is linked to the need to replace the LPRM assemblies, not to a predetermined replacement frequency of the Gamma Thermometer itself. The replacement frequency for the GERS GT is then linked to the LPRM detector burn-up and not related to any conditions that are met with regards to the GT. [[

]] The total fluence for the 14 years in ANO-Unit Two is 2.04×10^{22} nvt which compares well with the specified maximum life of the LPRM of 1.9×10^{22} nvt, according to GE Reuter-Stokes specification No. 304A3596.

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-62

Section 7.2.5.1 refers to [[ ]]. Provide these [[ ]] and the methods used to determine them. Justify why these [[ ]]. If different [[ ]] will be applied for the ESBWR, provide these as well, and justify why those [[ ]] are suitable.

GE Response:

The relationship between GT response and relative nodal power are based on a correlation like the one provided in the response to RAI 21.6-89 (reference NEDC-33239P). These methods have been extensively benchmarked by comparisons of measured and predicted power distributions in operating BWRs. The same methods will be used for the ESBWR.

Response to RAI 4.2-12 describes the uncertainty associated with use of the GT and these methods and shows that the uncertainty associated with the methods will be acceptable in the ESBWR application.

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-63

Justify all assumptions made to determine the [[ ]]. Provide additional justification in light of the [[ ]]. List the physical phenomena that affect [[ ]] and compare the relevant operating conditions at [[ ]], and the expected conditions for the ESBWR.

GE Response:

Until additional data is collected and the sensitivity behavior of gamma thermometers (GTs) thoroughly understood, the GTs will be [[ ]]

The overall process for using the GTs in the power distribution calculation will be as follows:

1. GTs will be calibrated using built-in heater elements. This will establish the sensitivity of the GTs.
2. Core power distribution data will be collected from the GTs directly following their calibration. This will preclude the need for any sensitivity adjustments to the detector readings.
3. At the same time, the core simulator software (PANACEA or its replacement) will calculate a power distribution and adapt it to the GT readings. Output will include:
   - A calculation of power distribution and margin to thermal limits.
   - Correction factors for LPRM readings
   - Until the next time GTs are used for calibration and adaption, the core monitoring code will function in the same manner as the existing design, adapting to LPRM indication in determining core power distribution.

As benchmarking results for gamma thermometers is collected from operating reactors, and sensitivity behavior is analyzed, a sensitivity adjustment model (with inherent uncertainties) may be added to allow the gamma thermometers to be used without a concurrent calibration.

DCD/LTR Impact:

No DCD changes will be made in response to this RAI.

The following changes will be made in the next revision of LTR NEDE-33197P:

Insert the following text at the end of Section 4.4 – Until additional data is collected and the sensitivity behavior of GTs thoroughly understood, the GTs will be [[ ]] This LTR will be submitted to the NRC by September 28, 2007.

NRC RAI 7.2-64

In the comparisons of [[ ]], provide additional descriptive details of how the [[ ]] were calculated. Provide details of which [[ ]] were employed, including any [[ ]]. Describe the [[ ]] used in 3D MONICORE for these calculations. Which version of [[ ]] is being used to perform these calculations? How are GT signals processed within this version of [[ ]]?

GE Response:

Version 10 of PANACEA was used for the calculations in the LTR. As described in Section 8 of NEDE-33197P, "Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring", the axial shape predicted by 3D MONICORE was adapted to the GT readings [[ ]] The interpolation scheme for LPRMs used in 3D MONICORE is summarized as follows –

[[ ]]

[[ ]]

The critical power correlation used in 3D MONICORE is the same as the correlation used in PANACEA. These methods have been benchmarked and used in operating BWRs and they will be used for the ESBWR.

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

NRC RAI 7.2-65

Provide the basis for the]] and the [[ ]]. Specifically address any anticipated operational occurrences (AOOs) or accident conditions which could lead to [[ ]] that exceed the range. For any conditions in which these values are exceeded, discuss the instrument response. What is the limit for the highest [[ ]] where a GT would fail to produce a signal indicative of the local power?

GE Response:

The 2.4 W/g value was based on [[

]] However, GTs will not be used during transients. They will be used only during normal steady-state conditions.

DCD/LTR Impact:

No changes to any DCD Tier are required by this response. No changes to LTR NEDE-33197P are required by this response.

MFN 07-162

Enclosure 3

AFFIDAVIT

General Electric Company

AFFIDAVIT

I, James C. Kinsey, state as follows:

(1) I am Project Manager, ESBWR Licensing, General Electric Company ("GE") have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of GE letter MFN 07-162, Mr. James C. Kinsey to U.S. Nuclear Regulatory Commission, entitled *Response to Portion of NRC Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application – Gamma Thermometers - RAI Numbers 7.2-5 through 7.2-18 and 7.2-51 through 7.5-65*, dated May 14, 2007. The proprietary information in Enclosure 1, *Response to Portion of NRC Request for Additional Information Letter No. 78 Related to ESBWR Design Certification Application - Gamma Thermometers - RAI Numbers 7.2-5 through 7.2-18 and 7.2-52 through 7.5-65* is in dark red font delineated by a [[dotted underline inside double square brackets.{3}]]. Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GE relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.790(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

b. Information which, if used 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 of a similar product;

c. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, resulting in potential products to General Electric;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a, and (4)b, above.

(5) To address 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GE, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GE is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it identifies detailed GE ESBWR procedures and assumptions related to its setpoint methodology. The information is consistent in its scope of application with information in NEDC-31336P-A, September 1996, "General Electric Instrument Setpoint Methodology," which is maintained as proprietary.

The development of the evaluation process along with the interpretation and application of the regulatory guidance is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's

comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GE.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GE would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 14th day of May 2007.

James C. Kinsey

James C. Kinsey
General Electric Company