GE Nuclear Energy

A.S. Rao
Manager, New Reactor Development

General Electric Company
175 Curtner Avenue, M/C 365 San Jose, CA 95125-1014
408 925-1885 (phone) 408 925-6462 (facsimile)

Project 717

MFN 03-100
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U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20852-2738

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **Response to Request for Additional Information (RAI) numbers (25, 306, and 319) for ESBWR Pre-application Review.**

GE Nuclear Energy is submitting, in enclosures 1 and 2, response to NRC RAI numbers 25, 306, and 319, which were included in the seven referenced letters.

Enclosure 1 contains the responses with GE proprietary information as defined by 10CFR2.790. GE customarily maintains this information in confidence and withholds it from public disclosure. Enclosure 1 also includes RAI responses which contain no proprietary information in order to form a complete package. A non-proprietary version of the responses to the NRC's requests are 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 2.790 and 9.17.

If you have any questions about the information provided here, please let me know.

Sincerely,

Atambir S. Rao

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Reference:

1. MFN 03-051, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), May 30, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 3 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NO. MB6283)
2. MFN 03-054, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), July 17, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 6 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NO. MB6801)
3. MFN 03-065, Letter From Amy E. Cubbage (NRC) To Atam S. Rao (GE), July 17, 2003, SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 7 RELATED TO ESBWR PRE-APPLICATION REVIEW (TAC NO. MB6801)

Enclosures:

1. MFN 03-100 Response to NRC RAI numbers (25, 306, and 319) - Proprietary Information
2. MFN 03-100 Response to NRC RAI numbers (25, 306, and 319) - Non-proprietary Information
3. Affidavit, George B. Stramback, dated September 18, 2003

cc:	A. Cubbage	USNRC (with enclosure)
	J. Lyons	USNRC (w/o enclosure)
	G.B. Stramback	GE (with enclosure)

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, General Electric Company ("GE") and 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 the Enclosure 1 of GE letter MFN 03-100, Atambir S. Rao to NRC, *Response to Request for Additional Information (RAI) numbers (*25, 306, and 319*) for ESBWR Pre-application Review,* dated September 18, 2003. The proprietary information is in Enclosure 1, *Response to NRC RAI numbers (*25, 306, and 319*).* For text and text contained in tables, GE proprietary information is identified by a double underline inside double square brackets. 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 2.790 (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 details for licensing application of TRACG to the ESBWR passive safety system design of the BWR. This TRACG code has been developed by GE for over fifteen years, at a total cost in excess of three million dollars. The reporting, evaluation and interpretations of the results, as they relate to the ESBWR, was achieved at a significant cost, to GE.

The development of the evaluation process along with the interpretation and application of the analytical results 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 18th day of September 2003.

George B. Stramback
General Electric Company

ENCLOSURE 2

MFN 03-100

Response to NRC RAI numbers (25, 306, and 319)

Q25. General Electric (GE) topical report NEDC-33080P, "TRACG Qualification for ESBWR," dated August, 2002, describes qualification studies of the TRACG computer code performed for ESBWR. This report documents two additional validation studies performed specifically in support of ESBWR. The test data used for these studies are from the P-Series containment tests performed at the PSI PANDA test facility in Switzerland and from the elevated-pressure hydrodynamic instability tests performed at the CRIEPI/SIRIUS test facility in Japan.

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52.47(b)(2) states that certification of a standard design which differs significantly from light water reactor designs or utilizes simplified, inherent, passive or other innovative means to accomplish its safety functions will be granted only if each safety feature of the design has been demonstrated either through analysis, appropriate test programs, experience, or a combination.

Part 52.48 describes that applications filed under this subpart will be reviewed for compliance with 10 CFR Part 20, Part 50 and its appendices, ... and as those standards are technically relevant to the design proposed for the facility. Part 52.48 thus invokes appropriate aspects of Part 50, including Appendix B quality assurance (QA) requirements.

For SBWR design certification qualification test program activities GE met Part 50, Appendix B by implementing their latest NRC approved "Nuclear Energy Business Operations Quality Assurance Program Description" (topical report), NEDO-11209-04A, Revision 8. Additionally, NEDG-31831, "SBWR Design and Certification Program Quality Assurance Plan," was developed by GE to fulfill the QA requirements of the SBWR reactor design and certification program. NEDG-31831 meets the requirements of ANSI/ASME NQA-1-1983 and its NQA-1a-1983 addenda, which includes specific requirements related to "Qualification Tests." NEDG-31831 provides that design and testing work performed by international technical associates will be performed to their internal QA programs acceptable to the regulatory authorities of their respective countries as evaluated by GE for compliance with the provisions of ANSI/ASME NQA-1-1983.

The staff is not clear as to what GE considers tests being "*confirmatory in nature.*" Please describe what "*confirmatory in nature*" encompasses and how GE plans to use the data from the PANDA-P series tests conducted at PSI in Switzerland and the SIRIUS two-phase flow instability tests conducted in CRIEPI, Japan. It is our understanding that data from these tests is going to be used to support the ESBWR design and be part of the ESBWR design certification application. If this is the case, please describe how these tests and test data meet the GE topical report and NQA-1 quality requirements for testing related activities.

R25. Rev 1.
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Q306. Equation 6.5-28 in NEDE-32176P is used for mass and heat exchange at a free surface, and is reported to be taken from "Heat Transfer," Third Edition, J.P. Holman.

Q306.1. Provide the specific text (page) in Holman from which the equation is taken, or provide its derivation. Discuss the units as this form does not appear to be consistent with standard formulations.

R306.1. The correlation for the free natural convection in air above a horizontal surface comes from J. P. Holman, Heat Transfer, 3rd Edition, New York: McGraw-Hill, Inc. 1972, Table 7-2, and is in British units given by:

$$h = 0.22(\Delta T)^{1/3}$$

Converting this expression to SI units gives:

$$h = 5.6783 * 0.22(1.8 * \Delta T)^{1/3} = 1.52(\Delta T)^{1/3}$$

In 4th Edition of Holman, Table 7-2 the coefficient has been reduced slightly and gives the same equation in SI units as:

$$h = 1.43(\Delta T)^{1/3}$$

This correlation was modified to simulate natural free convection in a medium other than air by multiplying by the ratio of the conductivities:

$$h = 1.43\frac{k_v}{k_{air}}(\Delta T)^{1/3}$$

Using a value of 0.03171 for the conductivity of air at 373K, the above expression becomes:

$$h = 1.43\frac{k_v}{0.0317}(\Delta T)^{1/3} = 45.11 k_v(\Delta T)^{1/3}$$

This above coefficient matches Equation 6.5-28 in NEDE-32176P (45.04) to within 0.2%.

The original model as implemented into TRAC, contained a unit conversion error and also used an unrealistic low value for the

1 This conductivity is consistent with the expression in TRACM (NUREG/CR-6724), where the conductivity of air is given by $k_v = 2.091E-4 * T_v^{0.846}$. A value of 0.0313 is obtained at a temperature of 373K.

conductivity of air. The original expression from 3rd Edition of Holman was converted incorrectly to metric units as:

$$h = 5.6783 * 0.22(\Delta T / 1.8)^{1/3} = 1.027(\Delta T)^{1/3}$$

It also used an unrealistic low value of the 0.0228 for the conductivity of air that originated from TRAC-PF1/MOD1 (NUREG/CR-5069). Using this value with the above equation gives:

$$h = 1.027 \frac{k_v}{0.0228} (\Delta T)^{1/3} = 45.04 k_v (\Delta T)^{1/3}$$

Q306.2. How was the Sparrow-Uchida degradation factor obtained? Does the correction factor include any bias based on the Sparrow or Uchida data? Is it a "best-estimate" correction? What is the uncertainty in this correction factor and is it considered in the calculations?

R306.2. The precise origin of the tabulated values that are referred to as the Sparrow-Uchida degradation factors is not known. There is reason to believe (as will be demonstrated) that these values were obtained by merging the separate results from Sparrow and Uchida. The tabulated values in the code are used to degrade the condensation heat transfer at the free surface between the mixture and vapor regions when a water level is predicted. The values are tabulated in the code as the ratio of air-to-steam density and are presented graphically in Figure 6.5-1 of NEDE-32176P, Rev. 2. That figure has been reproduced here as Figure 306-1 and additional curves have been added to allow the Sparrow-Uchida degradation curve to be compared with the curves attributed individually to Uchida and Sparrow.

The curve marked "Sparrow 100" in Figure 306-1 is obtained from Figure 10.4 from Collier's book. Collier's book is cited in NEDE-32176P, Rev. 2 as Reference [6.5-11]. Collier attributes this and 3 other curves shown in his Figure 10.4 to Minkowycz and Sparrow. The "Sparrow 100" curve that is shown here is the forced convection curve corresponding to a bulk mixture temperature of 100 C. It is clear that all four of the "Sparrow" curves are for relatively low mass fractions for air in steam over the range from 0.0 to 0.1. Here in Figure 306-1, the lowest point in the Sparrow curve has been extrapolated assuming the same slope as suggested by the previous two points.

The so-called Uchida correlation as presented in Eq. 6.6-81 of NEDE-32176P, Rev. 2 cannot apply for relatively low mass fractions because it obviously predicts the wrong trend as the mass of air approaches zero and in fact is undefined in the limit of zero air mass. For Uchida, the functional form of the degradation factor is obvious but the composite

heat transfer coefficient (HTC) must be divided by the undegraded heat transfer coefficient (HTCo) to obtain the degradation function. Appropriate values for HTCo are in the range from around 40 to 70 ($W/m^2/K$). The plots presented here uses HTCo = 64.19 to covert the Uchida heat transfer coefficient expression into the degradation function.

Notice from Figure 306-1 that a transition from the Uchida to the Sparrow degradation functions is needed because the degradation factor due to Uchida alone increases unrealistically for the smaller air mass fractions. The suggested Uchida-Sparrow form does not have this undesirable behavior.

The three curves from Figure 306-1 are replotted in Figure 306-2 using a different abscissa. The abscissa and the V-S and KSP curves in Figure 306-2 are the same as those from Figure 6.6-14 of NEDE-32176P, Rev. 2 except the scale has been expanded to illustrate the similarity between the correlations for very low air mass fractions. As seen in Figure 306-2, the Uchida-Sparrow form predicts the same trend as the Vierow-Schrock (V-S) and Kuhn-Schrock-Peterson (KSP) forms as the air mass fraction becomes smaller except that Uchida-Sparrow gives less degradation than V-S and KSP. Some difference is expected since Uchida-Sparrow is based on a flat surface where V-S and KSP are based on flow inside tubes.

The additional "Sparrow 25" curve in Figure 306-2 corresponds to the curve from Figure 10.4 of Collier's book that represents forced convection at a bulk mixture temperature of 25 C. Notice the similarities between the "Sparrow 25" and KSP curves. The difference between "Sparrow 25" and "Sparrow 100" suggests that the degradation of heat transfer at the mixture-vapor surface due to the presence of air becomes less important as the bulk temperature increases. Similarly, the degradation becomes less important as the pressure is increased. For general TRACG applications, the higher Sparrow-Uchida curve corresponding to higher pressures and temperatures is expected to be more appropriate.

The Uchida-Sparrow degradation factor is intended for use as a best-estimate (unbiased) correlation for stratified mixture-vapor surfaces corresponding to a water level. The uncertainty for Uchida-Sparrow is estimated to be roughly the same as the uncertainty for KSP. Since KSP has an overall uncertainty of 17.6% for steam-air tests but only 7.4% for pure steam tests, the RMS difference attributed to the degradation factor is estimated to be 16%. (A 20% value is suggested as an appropriate uncertainty for KSP on page 6.6-44 of NEDE-32176P, Rev. 2.)

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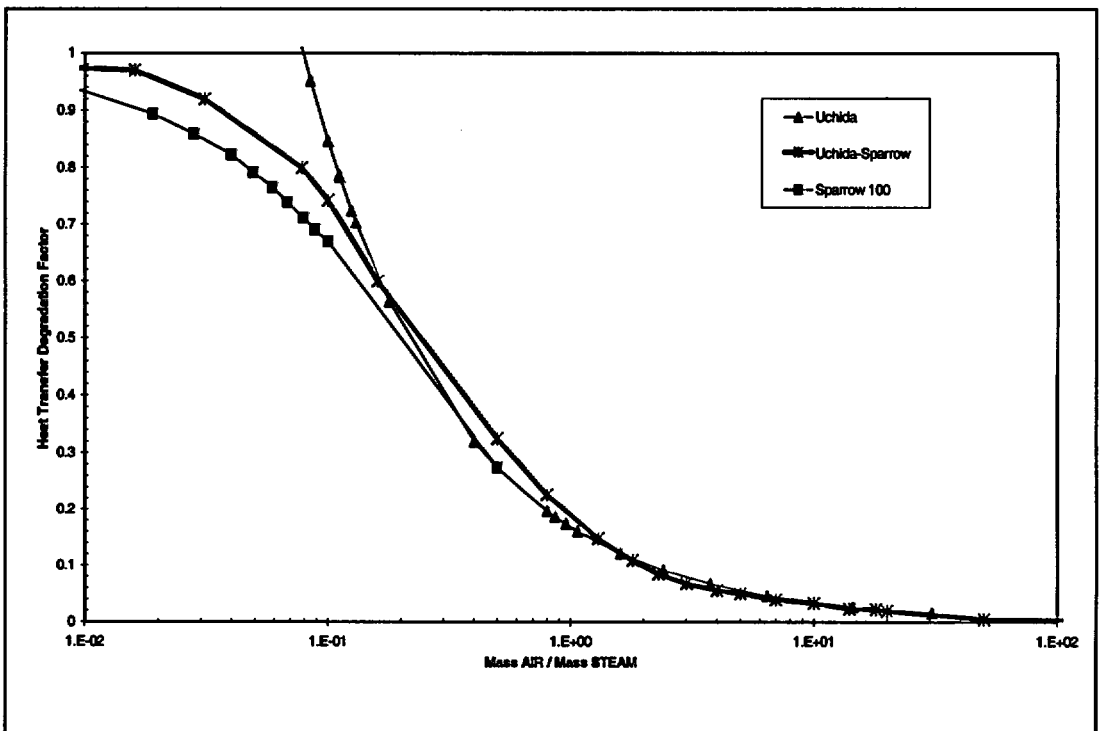

Figure 306-1 Degradation Factors for Steam Condensation with Air Present

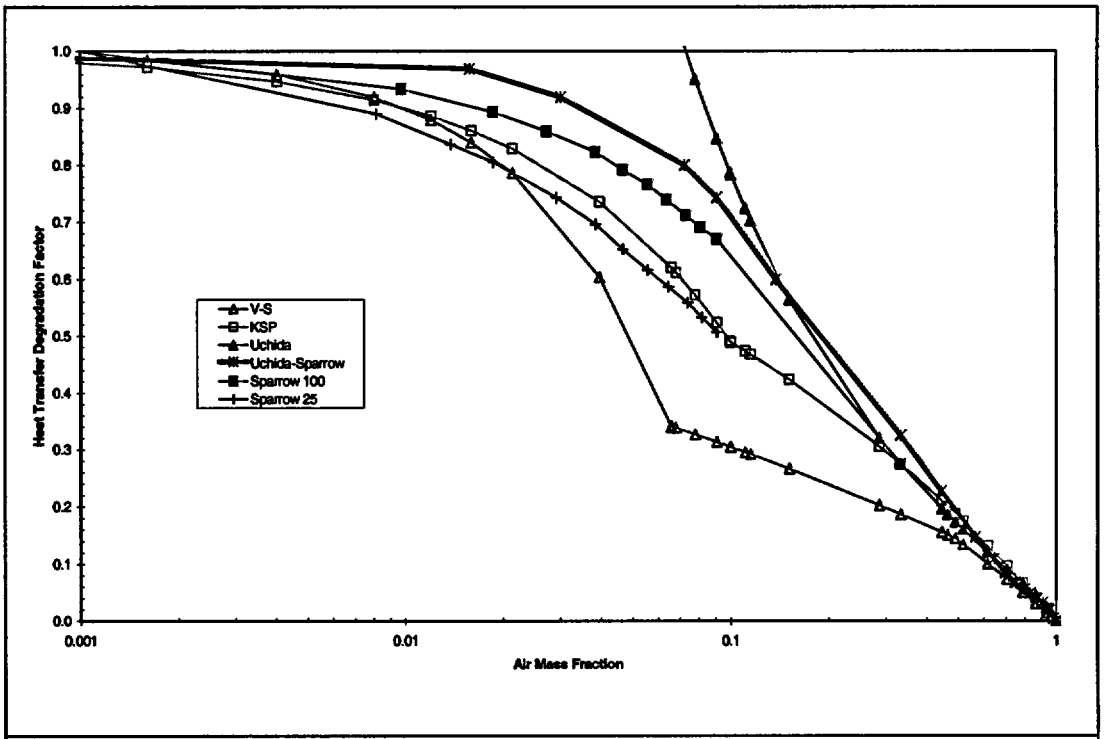

Figure 306-2 Comparison of Uchida-Sparrow with Other Degradation Curves

Q319. The TRAC-BD1 code from which TRACG was derived had an error such that a junction placed other than at the center of a volume would result in an incorrect hydrostatic head. Please confirm that this error does not exist in TRACG.

R319. TRACG does not contain this error. TRACG explicitly accounts for the static head difference in defining the boundary pressure for the 1D components when a junction is not connected to the center of a vessel cell. In addition TRACG contains internal checking of all loops and generates an error message if an elevation mismatch exists. For a loop it is required that:

$$\oint_{Loop} g\,dz = 0$$