Global Nuclear Fuel

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Docket No. 52-010

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

Subject: Transmittal of GNF Fuel Reports NEDC-33238 Supporting the GE ESBWR Design Control Document Submittal (TAC #MC8168)

References:

1. MFN 05-115, GE Response to Results of NRC Acceptance Review for ESBWR Design Certification Application – Items 1 and 3 (TAC # MC8168), October 24, 2005.

In accordance with Reference 1, enclosed are General Electric's technical information reports NEDC-33238P, "GE14 Pressure Drop Characteristics Report," dated December 2005, which contains fuel-related information supporting the certification of the GE ESBWR.

GNF considers the information proprietary in accordance with 10 CFR 2.390. GNF customarily maintains this information in confidence and withholds it from public disclosure. The proprietary pages are indicated by the words "GNF Proprietary Information" in the top right corner.

The affidavit contained in Enclosure 1 identifies that the information contained in Enclosure 2 has been handled and classified as proprietary to GNF. GNF hereby requests that the information of Enclosure 2 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. A non-proprietary version of the information contained in Enclosure 2 is provided in Enclosure 3.

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If you have any questions about the information provided here, please contact me at (910) 675-5954 or George Stramback at (408) 779-2317.

Best regards,

Andrew A. Lingenfelter
Manager, Engineering

Global Nuclear Fuel – Americas, LLC

Enclosures

1. Affidavit, Andrew A. Lingenfelter, dated December 12, 2005
2. GE14 Pressure Drop Characteristics Report, NEDC-33238P, December 2005 (Proprietary CD ROM)
3. GE14 Pressure Drop Characteristics Report, NEDO-33238, December 2005

cc: AE Cubbage - USNRC (with enclosures)
DH Hinds - GE/Wilmington (with enclosures)
GB Stramback - GE/San Jose (with enclosures)

Affidavit

I, Andrew A. Lingenfelter, state as follows:

(1) I am Manager, Engineering, Global Nuclear Fuel – Americas, L.L.C. ("GNF-A") 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 attachments, NEDC-33238P, "GE14 Pressure Drop Characteristics Report," dated December 2005. GNF proprietary information is indicated by enclosing it in double brackets. 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 or licensee, GNF-A 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 2.390(a)(4) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information," and some portions 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 GNF-A's competitors without license from GNF-A 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 cost or price information, production capacities, budget levels, or commercial strategies of GNF-A, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future GNF-A customer–funded development plans and programs, of potential commercial value to GNF-A;

e. 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 the 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 GNF-A, and is in fact so held. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in (6) and (7) following. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GNF-A, 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.

(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, or subject to the terms under which it was licensed to GNF-A. Access to such documents within GNF-A 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 GNF-A 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) is classified as proprietary because it contains details of GNF-A's fuel design and licensing methodology.

The development of the methods used in these analyses, along with the testing, development and approval of the supporting methodology was achieved at a significant cost, on the order of several million dollars, to GNF-A or its licensor.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GNF-A's competitive position and foreclose or reduce the availability of profit–making opportunities. The fuel design and licensing methodology is part of GNF-A'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 GNF-A or its licensor.

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.

GNF-A's competitive advantage will be lost if its competitors are able to use the results of the GNF-A 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 GNF-A 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 GNF-A of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining 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 at Wilmington, NC, this 12th day of December, 2005.

Andrew A. Lingenfelter

Andrew A. Lingenfelter
Global Nuclear Fuel – Americas, LLC

NEDO-33238
eDRF Section 48-8535
December 2005

Licensing Topical Report

GE14 Pressure Drop Characteristics

B. Aktas

NON PROPRIETARY NOTICE

This is a non proprietary version of the document NEDE-33241P, which has the proprietary information removed. Portions of the document that have been removed are indicated by an open and closed bracket as shown here [[ ]].

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

The information contained in this document is furnished as reference material for GE14 fuel rod thermal-mechanical design. The only undertakings of Global Nuclear Fuel (GNF) with respect to information in this document are contained in the contracts between GNF and the participating utilities in effect at the time this report is issued, and nothing contained in this document shall be construed as changing those contracts. The use of this information by anyone other than that for which it is intended is not authorized; and with respect to any unauthorized use, GNF makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

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ABSTRACT

In this report, the pressure drop characteristics of the following fuel assembly components are summarized for use in the GE14 fuel assembly. A detailed description of tests performed to measure the pressure drop across these components, as well as the analyses of the associated test data, are also provided.

1) Spacers
2) Debris Shield Lower Tie Plate
3) Upper Tie Plate
4) Water Rods

ACRONYMS AND ABBREVIATIONS

Term	Definition
FLR	Fuel Length Rod
LTP	Lower Tie Plate
OPWR	One-Piece Water Rod
PLR	Part Length Rod
UTP	Upper Tie Plate

1. INTRODUCTION

The GE core thermal hydraulics methodology expresses the fuel assembly pressure drop as the sum of frictional, acceleration, gravity-head, and local loss components of a total pressure drop.[1] Among them, the local losses play a key role in ensuring that the calculated pressure drops across a fuel assembly are in good agreement with the measured pressured drop data while a set of seemingly simple pressure drop formulas are used for two-phase flows in the rather complex geometry of a nuclear fuel assembly. These local losses, which are defined at various axial locations along the fuel assembly consistent with the expected irreversible pressure losses due to area changes, e.g. the orifice, lower tie plate, and spacers, are correlated using a single-phase form loss coefficient and a two-phase pressure drop multiplier. A set of form loss coefficients are determined from an estimated local loss component of measured pressure drop after the well-known frictional and acceleration components are subtracted from the measured pressure drop data. Separate effects tests targeting the fuel assembly components, which are the sources of these local pressure losses, are performed to determine the associated form loss coefficients. In this report, the pressure drop characteristics of the following fuel assembly components are summarized for use in the analysis of the GE14 fuel assembly:

1. Spacers
2. Debris Shield Lower Tie Plate
3. Upper Tie Plate
4. Water Rods

This report provides a description of tests performed to measure the pressure drop across these components of the GE14 fuel assembly, which has been widely deployed in the current fleet of BWRs, as well as the form loss coefficients which describe the local losses associated with these components.

2. EXPERIMENTAL BASIS

This section describes the pressure drop experiments that form the bases for the pressure drop loss coefficients of the GE14 fuel assembly components.

2.1 Upper Tie Plate

Differential pressure drop measurements of the standard GE14 upper tie plate (UTP) were performed under various power conditions in the ATLAS facility to obtain two-phase pressure losses under normal BWR operating conditions. The upper region of the fuel bundle design was simulated so as to preserve the normal flow paths. Short sections of a 10x10 bundle were constructed with simulated stainless steel rods, a simulated lower tie plate, spacers and the fuel rod springs, lock tabs, hex nuts and upper end plugs. The dimensions of the fuel bundle components were preserved through the first spacer in the heated zone below the bundle exit. Pressure taps were strategically located above and below the UTP. Figure 2-1 shows the configuration of the test assembly and instrumentation. A fuel channel of standard inside dimensions, modified with pressure tap nipplets, was used to define the flow stream through the test section. The simulated fuel assembly was contained inside the auxiliary ATLAS pressure vessel that was then mounted directly to the top of the ATLAS test vessel. A 10x10 heated bundle inside the ATLAS test vessel generated two-phase fluid conditions.

Pressure drop data were recorded at [[ ]]. This covered a flow quality range [[ ]], which is adequate for determining the single-phase UTP pressure drop loss coefficient..

Data recorded for pressure drop cells 1 and 2 were analyzed to determine the UTP loss coefficients. The region between the taps was divided into two parts above and below the UTP. The hydraulic parameters reflected the geometry of the test at the high or low end pressure tap positions. In each region, elevation and friction losses were calculated. Acceleration losses due to the transition from the fuel channel region to the upper plenum region were defined and calculated at the UTP. Adiabatic pressure losses were assumed.

The loss coefficient for the standard GE14 UTP was determined to be [[ ]]. The ratio of the predicted pressure drop, using this loss coefficient, to the measured pressure drops for pressure drop cells 1 and 2 is 1.003±0.047. This indicates that the derived loss coefficient predicts the data well.

2.2 Spacers

The GE14 fuel assembly design incorporates the use of Zircaloy ferrule type spacers. The spacer loss coefficients have been derived based on testing in ATLAS of a full scale GE14 fuel assembly, including heated part length rods. The test spacers were reactor grade production quality. The measured pressure drops include static head, wall friction, acceleration pressure drop and singular losses. The loss coefficients have been evaluated in a manner consistent with the steady state thermal hydraulic analysis methodology of GNF.

The test assembly and the measurement scheme for obtaining differential pressures are shown in Figure 2-2. ATLAS test data were obtained at an inlet temperature of 525 °F, at a pressure of 1000 psia, and over a range of mass fluxes [[ ]] and power levels [[ ]]. The pressure drop loss coefficients were determined separately for the fully rodded region [[ ]] and for the upper partially rodded region [[ ]] as [[ ]] and [[ ]], respectively.

Measured pressure drops for pressure drop cell 2, as well as comparisons against the predictions using constant form loss coefficients for spacers are provided in Appendix A. Figure 2-3 summarizes the results graphically. With a mean and standard deviation of [[ ]], it is concluded that the derived loss coefficients accurately predict the test data over a wide range of power and flow conditions.

2.3 One-Piece Water Rods

The one-piece water rod (OPWR) is designed for simplified manufacturing while maintaining the overall form, fit and function of the standard multi-piece water rod. The OPWR, shown in Figure 2-4, is designed to have the same flow characteristics as the standard water rod.

OPWR flow characteristics tests were performed in a single-phase portion of the GE ATLAS test facility in San Jose, California. The test configuration and measurement scheme are summarized in Figure 2-5. Two different water rods were tested to characterize two inlet hole sizes, [[ ]]. The range of test conditions is described in Table 2-1. Resolved local loss coefficients for the water rod inlet and outlet were evaluated from the pressure measurements and then adjusted to be consistent with the design models (i.e., axially uniform cross-section geometry for flow path from inlet to outlet).

Figure 2-6 indicates the range of water rod flows obtained during the OPWR tests. From these results and comparisons to similar data for the standard water rod, an inlet hole diameter of [[ ]] was chosen for the final OPWR design. Figure 2-7 provides the resolved inlet loss coefficients from the OPWR flow tests, with a comparison to the extrapolated loss coefficient established for the final OPWR design. Figure 2-8 provides the resolved outlet loss coefficients from the OPWR tests.

2.4 Bundle Inlet

Bundle inlet tests were performed in a single-phase portion of the GE ATLAS test facility in San Jose, California. The test loop provided fluid conditions (pressure, flow, and temperature) to match reactor conditions for these single-phase tests. No bundle power was required.

An integral test configuration was used to simulate the entire inlet region, including the inlet orifice/nosepiece and lower tie plate (LTP). This test configuration provided the overall pressure drop and flow coefficients with full reactor simulations. The test section was comprised of a simulated fuel bundle section assembled in a channel with the LTP of interest, the inlet nosepiece, the core support plate simulation with the orifice size of interest, and a section of the lower plenum geometry as needed for orifice inlet pressure measurement and simulation of the flow cross section approaching the inlet orifice. The bundle section simulated the lower part of a standard GE14 assembly and was approximately 5 ft long with two spacers, water rod lower sections, an upper tie plate, a lower tie plate grid, and a lower section of the channel. All of the bundle parts affecting the applicable flow geometry of the test were actual production fuel parts such that the flow geometry of an actual GE14 bundle was maintained. These parts included the nosepiece, fuel rod and water rod lower end plugs, LTP, and lower section of the channel. Production parts used above the measurement area of interest included the spacers and upper tie plate. Solid stainless steel simulated fuel rods, water rods, and upper end plugs simulated BWR parts but were not actual reactor hardware. The core support plate simulation, flow inlet orifices, and lower plenum inlet geometry were accurate representations of those flow paths.

The test configuration is summarized in Figure 2-9. A total of seven differential pressure transducers were used to measure bundle inlet losses and the in-core flow coefficients. These were arranged to provide measurement redundancy although only the pressure drop measurements from pressure drop cell #1 which extends from upstream of side entry orifice (SEO) to upstream of the first spacer is used to determine the form loss coefficient for LTP. The measurement elevations extended from the reference flow coefficient tap in the lower plenum to an elevation just below the bottom spacer in the bundle.

Test parameters were varied as follows:

Parameter	Range	Comment
Mass Flow	[[ ]] Klb/hr	Data points taken in about eight equal steps at full temperature.
Temperature	[[ ]] °F	Some data taken at three temperatures to extend Reynolds number range.

Basic measurement accuracies were as follows:

Parameter	Accuracy
Mass Flow	± 1.0%
Temperature	± 1.0 °C
Pressure	± 0.7 bar
Differential Pressure	± (0.2% + 0.001 bar)

The ATLAS test results for the GE14 Debris Filter LTP are provided in Appendix B. The pressure drop data for mass flows ranging from [[ ]] Klb/hr at 525 °F were used to derive a pressure drop loss coefficient for the local losses across the pressure drop cell #1 shown in Figure 2-9 (i.e. $\Delta P_{SEO+LTP}$). The sum of debris filter LTP and the 2.20 inches diameter SEO loss coefficients was then determined to be [[ ]] for a reference flow area of 10 in^2. Based on this overall loss coefficient, an increment of [[ ]] was identified for the debris filter LTP loss coefficient over the loss coefficient of [[ ]] for the standard GE14 LTP. Thus, the debris filter LTP loss coefficient was determined to be [[ ]].

Table 2-1. One-Piece Water Rod Local Loss Coefficients Data Base

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Figure 2-1. UTP Test Configuration

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Figure 2-2. Spacer Test Configuration

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Figure 2-3. Spacer Test Results and Predictions using Constant Loss Coefficients

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Figure 2-4. One-Piece Water Rod Design

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Figure 2-5. One-Piece Water Rod Test Configuration

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Figure 2-6. OPWR Test Flow Rates vs. Standard Water Rod at 525 °F

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Figure 2-7. OPWR Inlet Loss Coefficients at 525°F

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Figure 2-8. OPWR Outlet Loss Coefficients at 525 °F

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Figure 2-9. GE14 DFLTP Test Setup

3. SUMMARY

The experimental basis for the pressure drop loss coefficients used in GE methods to predict pressure drops across the GE14 fuel assembly were described. These loss coefficients, when used together with the methods used in determining them, can predict the pressure drops of the GE14 fuel assembly very accurately over a wide range of temperature, pressure, and mass flow conditions. The following table summarizes the loss coefficients of the GE14 fuel assembly UTP, Water Rods, 10x10 Zircaloy Ferrule Spacers, and the Debris Filter LTP.

Table 3-1. GE14 Fuel Assembly Component Pressure Drop Loss Coefficients for 10 in^2 Flow Area†

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† For use only with GE Methods

REFERENCES

1. "Steady State Nuclear Methods," NEDE-30130P-A, April 1985

Appendix A Pressure Drop Data of 10x10 Ferrule Spacers for Application to GE14 Fuel

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Appendix B GE14 Debris Filter LTP Pressure Drop Data

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