ENCLOSURE 2

MFN 12-074 Supplement 2-A

Enhanced LUC Program for NSF Channels

Non-Proprietary Information – Class I (Public)

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1, which has the proprietary information removed. Portions of the document that have been removed are indicated by white space with an open and closed bracket as shown here [[ ]]. Within the Safety Evaluation by the Office of Nuclear Reactor Regulation, Enhanced Lead Use Channel Program for NSF Channels, Global Nuclear Fuel – Americas, the portions that have been removed are indicated by a single open and closed bracket as shown here [ ].

March 29, 2013

Mr. Andrew A. Lingenfelter
Vice President, Fuel Engineering
Global Nuclear Fuel-Americas, LLC
P.O. Box 780, M/C A-55
Wilmington, NC 28401

SUBJECT: FINAL SAFETY EVALUATION FOR GLOBAL NUCLEAR FUEL – AMERICAS TOPICAL REPORT (TR) ENHANCED LEAD USE CHANNEL PROGRAM FOR NSF FUEL BUNDLE CHANNELS (TAC NO. ME9829)

Dear Mr. Lingenfelter:

By letter dated September 25, 2012, Agencywide Documents Access and Management System (ADAMS) Accession No. ML12270A245, Global Nuclear Fuel - Americas, LLC (GNF) submitted MFN 12-074, "Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels" (MFN 12-074) to the U.S. Nuclear Regulatory Commission (NRC) staff for review and endorsement in accordance with the NRC's Office Instruction LIC-500, Revision 4. Enclosed is a copy of the NRC staff's final safety evaluation (SE).

The NRC staff has found that MFN 12-074 is acceptable for referencing in licensing applications to the extent specified and under the limitations and conditions delineated in the TR and in the enclosed final SE. The final SE defines the basis for our acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that GNF publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed final SE after the title page. In addition, they must contain historical review information, including the original requesting letter dated September 25, 2012, the supplemental letter dated January 25, 2013, and any other NRC requests for additional information and your responses. The accepted versions shall include a "-A" (designating accepted) following the TR identification symbol.

Notice: When separated from Enclosure 1, this cover letter is decontrolled.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, GNF or any licensees referencing MFN 12-074 will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

If you have any questions, please contact Sheldon Stuchell at (301) 415-1847 or Stephen Philpott at (301) 415-2365.

Sincerely,

/RA/

Sher Bahadur, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 712

Enclosures:
1. Final Proprietary SE
2. Final Non-Proprietary SE

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ADAMS Accession Nos.: ML13072B159 (Cover Letter); ML13072A168 (PROP SE); ML13072B229 (NON-PROP SE); ML13078A283 (Package) *No technical changes to the original SE. NRR-106

OFFICE	PLPB/PM	PLPB/LA	DSS/SNPB*	PLPB/BC	DPR/DD
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DATE	03/13/2013	03/26/2013	02/11/2013	03/28/2013	03/29/2013

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Global Nuclear Fuel
cc:

Project No. 712

Mr. James F. Harrison
GE-Hitachi Nuclear Energy Americas LLC
Vice President - Fuel Licensing
P.O. Box 780, M/C A-55
Wilmington, NC 28401
james.harrison@ge.com

Ms. Patricia L. Campbell
Vice President, Washington Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC
1299 Pennsylvania Avenue, NW
9th Floor
Washington, DC 20004
patriciaL.campbell@ge.com

Mr. Jerald G. Head
Senior Vice President, Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC
P.O. Box 780, M/C A-18
Wilmington, NC 28401
jerald.head@ge.com

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ENHANCED LEAD USE CHANNEL PROGRAM FOR NSF CHANNELS

GLOBAL NUCLEAR FUEL - AMERICAS

1.0 INTRODUCTION

The objective of the topical report (TR) process is, in part, to add value by improving the efficiency of other licensing and inspection processes, for example, the process for reviewing license amendment requests from commercial operating reactor licensees. The purpose of the U.S. Nuclear Regulatory Commission (NRC) TR program is to minimize industry and NRC time and effort by providing for a streamlined review and approval of a safety-related subject with subsequent referencing in licensing actions, rather than repeated reviews of the same subject.

A TR is a stand-alone report containing technical information about a nuclear power plant safety topic, which meets the criteria of a TR. A TR improves the efficiency of the licensing process by allowing the NRC staff to review a proposed methodology, design, operational requirements, or other safety-related subjects that will be used by multiple licensees, following approval, by referencing the approved TR. The TR provides the technical basis for a licensing action or operational guidance.

By letter dated September 25, 2012 (Reference 1), as supplemented by a letter dated January 25, 2013 (Reference 2), Global Nuclear Fuel (GNF) requested review and approval of an expanded lead use channel (LUC) program for their developmental zirconium alloy NSF. The NRC is treating this letter submittal as a TR. NSF derives its name from its primary alloying elements: niobium (Nb), tin (Sn), and iron (Fe). The expanded LUC program would allow greater numbers of channels to be exposed to varying in-reactor operating strategies, nuclear conditions, and water chemistry, in order to gain experience and gather data for batch application. Once approved, the enhanced NSF LUC program will be incorporated into NEDE-24011-P, entitled “General Electric Standard Application for Reactor Fuel (GESTAR II).”

The NRC staff found that, in general, the submittal meets the objectives of a TR and reinforces previously established NRC regulations and guidelines as noted within this safety evaluation (SE). The NRC has evaluated this submittal against the criteria of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, and has determined that it does not represent a backfit to a licensee. Specifically, NRC staff technical positions outlined in this SE are consistent with the aforementioned regulations and established staff positions.

2.0 REGULATORY EVALUATION

Regulatory guidance for the review of fuel system materials and designs and adherence to General Design Criteria (GDC) -10, GDC-27, and GDC-35 is provided in NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants” (SRP), Section 4.2, “Fuel System Design” (Reference 3). In accordance with SRP Section 4.2, the objectives of the fuel system safety review are to provide assurance that:

- the fuel system is not damaged as a result of normal operation and anticipated operational occurrences (AOOs),
- fuel system damage is never so severe as to prevent control rod insertion when it is required,
- the number of fuel rod failures is not underestimated for postulated accidents, and
- coolability is always maintained.

The main focus of the limited SRP guidance with respect to boiling water reactor (BWR) fuel bundle channels is control blade interference and insertability. SRP Section 4.2.II.1.A.v states:

> Control blade/rod, channel, and guide tube bow as a result of (1) differential irradiation growth (from fluence gradients), (2) shadow corrosion (hydrogen uptake results in swelling), and (3) stress relaxation, which can impact control blade/rod insertability from interference problems between these components. For BWRs, the effects of shadow corrosion should be considered for new control blade or channel designs, dimensions (e.g., the distance between control blade and channel is important), or materials. The effects of channel bulge should also be considered for interference problems for BWRs. Design changes can alter the pressure drop across the channel wall, thus necessitating an evaluation of such changes. Channel material changes can also impact the differential growth, stress relaxation, and the amount of bulge and therefore must be evaluated. If interference is determined to be possible, tests are needed to demonstrate control blade/rod insertability consistent with assumptions in safety analyses. Additional in-reactor surveillance (e.g., insertion times) may also be necessary for new designs, dimensions, and materials to demonstrate satisfactory performance.

With respect to ensuring control blade insertability under externally applied loads (i.e., Safe Shutdown Earthquake and loss of coolant accident (LOCA)), SRP 4.2 Appendix A Section IV states:

> For a BWR, several conditions must be met to demonstrate control blade insertability (1) combined loads on the channel box must remain below the allowable value defined above for components other than grids (otherwise, additional analysis is needed to show that the deformation is not severe enough to prevent control blade insertion) and (2) vertical liftoff forces must not unseat the lower tieplate from the fuel support piece such that the resulting loss of lateral fuel bundle positioning could interfere with control blade insertion.

Standard Technical Specifications include the following allowance for lead test assemblies (LTAs), which would apply to LUCs:

> Fuel assemblies shall be limited to those fuel designs that have been analyzed with NRC staff approved codes and methods and have been shown by tests or analyses to comply with all safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

Provisions within GESTAR II limit the number of lead use elements to approximately 2% of the core. Hence, the "limited number" within the Standard Technical Specifications allowance would be 2% of the core. GNF's NSF LUC program proposes to expand the limited number allowance from 2% to 8% based upon operating experience with the NSF channels.

The term "nonlimiting core regions" was included to build in safety margin (relative to the legacy fuel) for unproven design features. In practice, compliance to this provision has meant that LTA fuel rods operated at no more than 95% of the peak fuel rod in the core. It's not clear that this provision applies to LUCs. With respect to the safety function of fuel assembly channels, a limiting core location would be in a control cell location since these channels would be more susceptible to shadow corrosion-enhanced bow. However, avoiding control cell locations would undermine the intent of the program, which is to gain in-reactor experience and gather data on channel bow. Based on the NSF LUC program's objectives, the staff finds the unrestricted placement of NSF LUC channels within the core (including control cell locations) acceptable.

3.0 TECHNICAL EVALUATION

The main safety functions of the BWR fuel channel are to (1) establish the pathway through which the control blade moves (i.e., maintain ability to insert control blades), and (2) provide structural stiffness to the fuel bundle during lateral loading applied during design basis events, such as an earthquake.

Recent operating experience has shown that channel distortion and associated control blade interference continues to be a major issue in the U.S. BWR commercial fleet. GNF has been studying and testing distortion-resistant channel alloys to address this operating experience. The developmental NSF zirconium alloy has shown promising results. The purpose of any lead use program is to gain in-reactor experience and gather data necessary for NRC approval of batch application for the new design feature or material. According to current provisions of GESTAR II, the total quantity of test assemblies is limited to less than 2% of the core. The expanded NSF LUC program would allow greater numbers of channels to be exposed to varying in-reactor operating strategies, nuclear conditions, and water chemistry. Specifically, GNF has requested that the NSF LUC limit be increased to 8% of the core exclusive of other lead assembly programs.

The staff's review of the expanded NSF LUC program will be to ensure that the introduction of the proposed limited number of NSF channels will not result in an unreasonable level of risk to public health and safety.

3.1 NSF Channel Design Evaluation

It's important to note that GNF has not requested approval of the NSF channels, but instead approval of an expanded LUC program. Almost by definition, any LUC is not approved since the required in-reactor experience and data has not yet been acquired. However, knowledge of the LUC design and materials is important in order to assess risk.

3.1.1 Design Specifications and Requirements

As-fabricated channel performance is dictated by its design and material properties. NSF channels will be manufactured with a new zirconium alloy which is outside of the ASTM specifications for Zircaloy-2 and Zircaloy-4. Differences in material properties may necessitate changes in physical dimensions. Currently, several different approved fuel channel designs are utilized in the U.S. BWR commercial fleet. For example, GNF2 fuel bundle design includes a thick corner / thin wall channel design comprised of Zircaloy-2 or Zircaloy-4 (See Reference 4). In response to a request for information regarding NSF channel designs (Request for Additional Information (RAI) #2, Reference 2), GNF stated that all design specifications remain unchanged from currently approved channels.

Given identical design specifications, only differences in material properties between the existing alloys, Zircaloy-2 (ASTM nominal Zr-1.5%Sn-0.15%Fe-0.1%Cr-0.05%Ni) and Zircaloy-4 (ASTM nominal Zr-1.5%Sn-0.2%Fe-0.1%Cr), and the developmental NSF (Zr-Ni-Sn-Fe) alloy will impact as-fabricated channel performance. In response to an RAI regarding NSF material properties (RAI #1, Reference 2), GNF provided a comparison of relevant elastic, thermal, mechanical, and nuclear properties. A majority of the NSF's material properties are equivalent to Zircaloy. Where differences exist, these differences have been factored into channel design evaluations. GNF concludes that NSF channels will satisfy all design requirements. GNF's design evaluation of NSF channels was informed by limited in-reactor experience and irradiated data. See Section 3.1.2.

3.1.2 Operating Experience

Enclosure 1 of Reference 1 describes GNF's operating experience with NSF channels beginning in 2002. To date, a total of [ ] NSF LUCs have been irradiated in commercial BWRs including C-, D-, and S-Lattice core configurations. Figure 1 of Enclosure 1 provides measured irradiation growth of NSF channels compared against the existing Zircaloy-2 database as a function of neutron fluence. Figure 2 of Enclosure 1 provides measured fluence gradient-induced bow for NSF and Zircaloy-2 channels as a function of exposure. [

]

Figure 3 of Enclosure 1 (Reference 1) provides inferred shadow corrosion-induced bow of NSF channels compared against the existing Zircaloy-2 database as a function of effective control blade exposure (ECBE). [ ]

Figure 4 of Enclosure 1 (Reference 1) provides measured irradiation assisted creep bulge of NSF channels compared with the existing Zircaloy-2 database. [ ]

Figures 5 and 6 of Enclosure 1 (Reference 1) provide pool-side photos of irradiated NSF channels compared with Zircaloy-2 and Zircaloy-4 channels. [ ]

3.2 NSF Channel Surveillance Program

The expanded NSF LUC program (Enclosure 1, Reference 1) includes a monitoring plan that is designed to provide a reasonable level of assurance against unanticipated channel distortion. The monitoring plan dictates specific requirements on the number of NSF LUCs that must be included in scram-time testing or settle time testing within each normal Technical Specification testing interval. In response to an RAI regarding abnormal cell friction indications (RAI #3, Reference 2), GNF stated that in the event of friction observations in cells containing NSF channels, the plant will immediately go into established augmented surveillance procedures. Furthermore, if friction indications at any plant suggest an unexpected systemic condition with NSF lead use channels, then all plants participating in the LUC program will enter the augmented surveillance procedures.

The expanded NSF LUC program (Enclosure 1, Reference 1) includes a post-irradiation inspection plan that is designed to gather data during subsequent reload cycles to identify negative trends and confirm expected performance. The inspection plan dictates specific requirements on the number and type of inspections to be performed on NSF LUCs.

The expanded NSF LUC program (Enclosure 1, Reference 1) also states that GNF will summarize the progress and results from each NSF LUC program to the NRC annually.

4.0 CONCLUSION

In their proposal, GNF requested an expansion of the existing LUC program for their developmental zirconium alloy NSF. The expanded LUC program would allow greater numbers of NSF channels to be exposed to varying in-reactor operating strategies, nuclear conditions, and water chemistry, in order to gain experience and gather data for batch application. The focus of the staff's review was to ensure that the introduction of the proposed, limited number of NSF channels would not result in an unreasonable level of risk to public health and safety. Based upon (1) existing operating experience and data that shows improved resistance to channel bow, (2) design evaluations that account for differences in material properties and satisfy design requirements, and (3) the prescribed monitoring and inspection plan, the staff finds the expanded NSF LUC program acceptable.

As described in Enclosure 1 of Reference 1, GNF intends to incorporate the expanded NSF LUC program into GESTAR II. The staff finds this acceptable.

Licensees referencing the expanded NSF LUC program will need to comply with the conditions and limitations listed in Section 5.

With regard to the expanded NSF LUC program, the staff has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the commission's regulations, and (3) issuance of this safety evaluation will not be inimical to the common defense and security or to the health and safety of the public.

5.0 CONDITIONS AND LIMITATIONS

Licensees referencing the expanded NSF LUC program must ensure compliance with the following conditions and limitations:

1) NSF lead use channels are restricted to currently approved channel design specifications with NSF alloy compositions that meet current GNF specifications, which target the nominal composition listed in Enclosure 1 of Reference 1.

2) NSF lead use channels may be used in quantities up to 8% of the total number of channels in the core. This limit is exclusive of other lead assembly programs.

3) The NSF LUC program monitoring and inspection plan, detailed in Section 3.2, must be fulfilled.

4) As further in-reactor experience and measurements are collected, GNF will continue to demonstrate that NSF LUCs satisfy design requirements.

6.0 REFERENCES

1. GNF Letter MFN 12-074, "Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels," September 25, 2012, Agencywide Documents Access and Management System (ADAMS) Accession No. ML12270A245.

2. GNF Letter MFN 12-074, Supplement 1, "Supplemental Information for Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels," January 25, 2013, ADAMS Accession No. ML130280676.

3. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants” (SRP), Section 4.2, “Fuel System Design,” Revision 3, March 2007, ADAMS Accession No. ML070740002.

4. GNF Letter MFN 11-194, “GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II),” NEDC-33270P, Revision 4, October 6, 2010, ADAMS Accession No. ML100740145.

Principal Contributor: Paul M. Clifford

Date: March 29, 2013

Global Nuclear Fuel

A Joint Venture of GE, Toshiba, & Hitachi

Andy Lingenfelter
Vice President, Fuel Engineering

Global Nuclear Fuel – Americas, LLC
Castle Hayne Road, Wilmington, NC 28401
(910) 819-5954 Fax: (949) 221-6961
Andy.Lingenfelter@gnf.com

Proprietary Notice

This letter transmits proprietary information in accordance with 10 CFR 2.390. Upon removal of Enclosure 1, the balance of the letter may be considered non-proprietary.

MFN 12-074
September 25, 2012

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

Subject: Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels

GNF has been studying and testing a distortion-resistant zirconium alloy for use in BWR fuel bundle channels. This alloy, known as NSF, is a zirconium (Zr) based alloy with niobium (Nb), tin (Sn) and iron (Fe) as the primary alloying elements. Similar Zr-Nb-Sn-Fe alloys are commonly used in PWRs and Russian plants for cladding, spacer grids and guide tubes, but not commercially used in BWRs. Channel distortion with current channel materials has resulted in increased control blade friction and consequently resulted in increased monitoring and surveillance in operating plants. The in-reactor experience to date with NSF channels indicates that NSF holds great promise to greatly reduce or eliminate the levels of distortion causing increased friction.

Historically, GNF has used the provisions of GESTAR II to install LUCs in various plants. These provisions were written generally for fuel assemblies and limit the numbers of lead use elements to approximately 2% of the core. Enclosure 1 describes a LUC program specifically for NSF channels that allows for an expanded number of NSF channels. This will allow greater numbers of channels to be exposed to varying in-reactor operating strategies, nuclear conditions, and water chemistry, and build upon the successful in-reactor experience to date.

GNF requests that the NRC review and approve the NSF lead use program described in Enclosure 1. The initial application of the program is for selected Fall 2013 reloads. GNF has customers prepared to commit to include NSF channels in the quantities described in the enhanced lead use program. In order to support this goal GNF needs NRC acceptance by approximately March 2013. GNF realizes this is quite a short review cycle request, and GNF will support the review in any way necessary. The program description, monitoring, and post irradiation examinations are described in Enclosure 1.

Please note that Enclosure 1 contains proprietary information of the type that GNF-A maintains in confidence and withholds from public disclosure. The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GNF-A. GNF-A hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17.

Enclosure 2 is a non-proprietary version of Enclosure 1.

If you have any questions about the information provided here, please contact me at (910) 819-5954 or Jim Harrison at (910) 819-6604.

Sincerely,

Andrew A. Lingenfelter
Vice President, Fuel Engineering
Global Nuclear Fuel – Americas, LLC

Project No. 712

Enclosures

1. Enhanced LUC Program for NSF Channels – GNF-A Proprietary Information – Class III (Confidential)
2. Enhanced LUC Program for NSF Channels – Non-Proprietary Information – Class I (Public)
3. Affidavit

cc: SS Philpott, USNRC
PL Campbell, GEH/Washington
JG Head, GEH/Wilmington
JF Harrison, GEH/Wilmington
eDRF Section 0000-0152-9211 R1

Document Components:

001 MFN 12-074 Cover Letter.pdf
002 MFN 12-074 Enclosure 1 Proprietary.pdf
003 MFN 12-074 Enclosure 2 Non-Proprietary.pdf
004 MFN 12-074 Enclosure 3 Affidavit.pdf

Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels

Objectives

Increasing the number of NSF channels that may be inserted using the traditional LUC process, which allows utilities to insert non-licensed materials using a 10 CFR 50.59 evaluation. This will expand GNF's experience base with statistically significant quantities in varied environments while decreasing cell friction concerns in the reactors implementing the enhanced LUC program.

This stepwise / measured approach to increasing the quantities of NSF channels in operating BWRs provides a bridge to inserting reload quantities, which are ultimately necessary for a bow-resistant channel to provide the greatest safety benefit.

Material Description

GNF fuel channels will be manufactured with a channel-bow-resistant material known as NSF. The term NSF reflects the presence of niobium (Nb), tin (Sn) and iron (Fe) as the primary alloying metals combined with zirconium in the following weight percentages: 1% niobium; 1% tin; and 0.35% iron. Similar zirconium alloys containing niobium are commonly used in PWRs and Russian plants for cladding, spacer grids and guide tubes, but have not been commercially used in BWRs.

Experience Base of NSF Channels

GNF's experience with NSF channel began in 2002 when four LUCs were inserted in Limerick Unit 1 Cycle 10 (a C-Lattice plant). Based on evidence of low irradiation growth of Zr-Nb-Sn-Fe alloys, NSF was considered an improved channel material that would be resistant to fluence gradient-induced bow that occurs at bundle locations near the periphery. Between 2003 and 2005, GNF determined a new channel bow mechanism called shadow corrosion-induced bow that could also occur when fresh fuel assemblies were controlled early in life. Shadow corrosion-induced bow was found to be related to increased hydrogen on channel sides that exhibited shadow corrosion. In 2005 and 2006, GNF inserted four NSF LUCs into Perry Cycle 11 and three NSF LUCs into Clinton Cycle 11; [[
]] Both Perry and Clinton are S-Lattice plants that have the smallest gap between the blade and the channel and thus the greatest susceptibility to shadow corrosion. In 2007, GNF inserted four additional NSF LUCs into Hatch Unit 2 Cycle 20 (a D-Lattice plant with the largest gap between the blade and the channel).

[[ ]] were discharged. Coupons were cut from one channel and sent to a hot cell for post-irradiation examination. [[

]] In addition, four additional NSF LUCs were inserted into Hatch Unit 2 prior to Cycle 22. [[

]] NSF channels operating in three different plants (one S-Lattice, one C-Lattice and one D-Lattice).

The operational experience in this LUC phase supports the conclusions that [[

]]

Fluence Gradient-Induced Bow Performance

The irradiation growth of the NSF channels was determined by measuring channel length during the outages. These measurements are plotted in Figure 1 and compared to Zircaloy-2 channel length data and other growth data for Zircaloy-2 and NSF. [[

]]

The corresponding fluence gradient-induced bow of NSF channels is plotted in Figure 2 and compared to Zircaloy-2 channels. In this plot, positive bow is toward the control blade and negative bow is away from the control blade. [[

]]

Shadow Corrosion-Induced Bow Performance

Shadow corrosion-induced bow is inferred from the measured bow by subtracting out the predicted fluence bow. This inferred shadow bow is then correlated to a metric that quantifies the amount of early life control a specific bundle experiences. This metric is called the Effective Control Blade Exposure (ECBE) and is a weighted average of insertion length and insertion time giving it units of inch-days. The available data on the inferred shadow bow of NSF is plotted in Figure 3 and compared to the Zircaloy-2 database. [[

]]

Creep Bulge

The creep bulge is calculated from poolside measurements of channel deflection. The available data on the creep bulge of NSF is compared to the Zircaloy-2 database in Figure 4. The observations indicate [[ ]]

Corrosion Performance

The corrosion performance requirement for channels relates to metal thinning as this is accounted for in the mechanical design. Overall, the [[ ]]

The visual observations of channels under normal corrosion conditions [[ ]] Examples of typical surface conditions of NSF [[ ]] are provided in Figure 5. The measured oxide thickness of NSF after [[ ]] For comparison, the measured oxide thickness of Zircaloy-2 channels after [[ ]] Measurements on Zircaloy-4 channels after [[ ]]

Oxide thicknesses of [[ ]]

<u>Proposed LUC Program</u>

GNF has operated LUCs to [[ ]] These test programs were performed in accordance with the provisions of GESTAR II which limit the total quantity of test assemblies to less than 2% of the core. Thus, GNFs LUC programs have typically included [[ ]] and therefore can provide an operational benefit to the plant.

To take advantage of the proven performance of NSF channels prior to licensing, GNF proposes the LUC limit be increased to 8% exclusive of other lead assembly programs. This proposal is prudent because of the proven ability of NSF to operate as expected both from current BWR LUC experience as well as previous PWR and Russian experience. In other words, other lead use programs would not be impacted by this proposed increase in Lead Use material and continue to be allowed up to the 2% limit of GESTAR II. For example, the 8% NSF LUC limit would allow insertion of ~60 LUCs for a 764 bundle core.

Sixty (60) channels is considered a sufficient number of assemblies to allow utilities to use these channels in various core configurations (control cells, center cells, outer cells) so that diverse channel distortion drivers (fluence gradient, shadow corrosion, channel bulge) can be experienced and quantified. The amount of data obtained from similar quantities in several plants would be sufficient to support re-evaluation of current channel distortion operational challenges and provide an expanded basis to assess the cell friction of future core reloads.

Safety Analysis

The channel component includes general design functions and safety related design functions. The general design functions include:

1 The channel forms the flow path shell for fuel bundle coolant flow.

2 The channel provides surfaces for control rod guidance in the reactor core.

3 The channel provides structural stiffness to the fuel bundle during lateral loadings applied from fuel rods through the fuel spacers.

4 The channel forms the coolant flow leakage path at the channel/lower tie plate interface.

5 The channel transmits fuel assembly seismic loadings to the top guide and fuel support of the core internal structure.

The safety functions of the fuel channels include:

1 The four channels in a cell establish the pathway through which the control blade moves. The lateral stiffness of the channel prevents channel buckling and ensures that the pathway remains available during design basis events, such as an earthquake. Excessive bulge and bow of channels may affect the movement of rods and the scram time. Therefore, the fuel channels impact the capability to shut down the reactor and maintain it in a safe shutdown condition.

2 The channel provides a barrier to allow parallel coolant flow paths and provides a heat sink which cools the outer row of fuel rods during a LOCA event.

3 The channel provides a barrier to fuel rod failure propagation from one fuel assembly to others by maintaining separation of fuel rods and by restricting the movement of debris that may be associated with the initial failure. Therefore, the fuel channel may help to mitigate the consequences of certain severe accidents.

The NSF alloy has demonstrated improved bow characteristics in smaller quantity lead use programs, as noted above in the experience section. Hence, the operational experience in these lead use programs supports the conclusions that NSF is [[

]] Further, the previous LUC programs provide a degree of confidence that there will be no unanticipated issues in the behavior and performance as compared to Zircaloy.

[[

]]

The safety basis for the proposed 8% LUC quantity is [[

]] a lead use quantity that would allow utilities to use these channels in various core configurations, increasing operational diversity and providing an expanded basis for channel performance quantification while progressing to full reload applications of NSF.

Monitoring Plan

GNF proposes that each plant with an expanded NSF LUC program where the number of NSF channels is greater than 2% will comply with a monitoring plan sufficient to protect the core against unanticipated channel distortion. Control rod cells with NSF channels will be evaluated as part of the normal scram-time testing population. The plant technical specifications (TS) require scram-time testing of 10% of the control rods every 120 days (nominally). During operation beyond the first cycle, at least [[ ]] of the NSF LUC program channels must be scram-time tested or settle tested within each normal TS testing interval. If cells with NSF channels are selected in the conduct of normal TS testing, then they would be counted as part of the [[ ]] requirement for NSF LUC testing. If the TS testing does not include at least [[ ]] of the NSF LUC program channels, additional scram testing or settle testing would be required until the prerequisite quantities have been reached. As the testing progresses through the operating cycle, the deliberate selection of specific control rod drive cells containing NSF channels is acceptable to maximize coverage and ensure inclusion of cells suspected to have increased friction. The settle testing may be performed while operating, during scheduled power reduction or while shutdown.

Post-Irradiation Inspection Plan

During fuel outages, a subset [[ ]] of the expanded NSF LUC program channels will be inspected visually to evaluate corrosion performance and to measure the length change. After discharge a subset [[ ]] of the expanded NSF LUC program channels will be [[ ]] In addition after discharge, [[ ]] of the NSF LUC channels to confirm that [[ ]]

Reporting Results

GNF will summarize the progress and results from each of the NSF LUC programs to the NRC annually.

Incorporation Into GESTAR II

When approved by the US NRC, the enhanced NSF LUC program will be incorporated by reference into Section 1.2.1 General Criteria, Subsection B. The following paragraph and references will be added.

> GNF proposed in Reference 1-14 an enhanced lead use program for the use of channels made of the niobium-tin-iron (NSF) zirconium alloy. The US NRC has reviewed and approved the program by Reference 1-15. This program allows NSF Lead Use Channels (LUC) to be used in quantities up to 8% of the total number of channels in the core. The NSF LUC limit of 8% is exclusive of other lead assembly programs. In other words, other lead use programs are not affected and continue to be allowed up to the ~2% limit of GESTAR II.

References

1-14 Letter from A.A Lingenfelter (GNF) to Document Control Desk (US NRC), Subject: Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels, September 25, 2012, MFN 12-074.

1-15 NRC Safety Evaluation for Reference 1-14.

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Figure 1 Irradiation growth response of Zircaloy-2 and NSF under both BWR and BOR60 reactor conditions. The fluence from BOR60 has been corrected to correspond to BWR conditions.

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Figure 2 The measured bow of Zircaloy-2 and NSF channels as a function of exposure.

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Figure 3 The inferred shadow corrosion-induced bow of Zircaloy-2 and NSF channels plotted as a function of ECBE.

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[[

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Figure 4 Creep bulge data for NSF channel compared to the Zircaloy-2 database.

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[[ ]]

Figure 5 NSF channel surfaces for normal corrosion conditions.

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Figure 6 NSF cycle channel surfaces following shadow corrosion conditions.

Global Nuclear Fuel

A Joint Venture of GE, Toshiba, & Hitachi

Andy Lingenfelter
Vice President, Fuel Engineering

Global Nuclear Fuel – Americas, LLC
Castle Hayne Road, Wilmington, NC 28401
(910) 819-5954 Fax: (949) 221-6961
Andy.Lingenfelter@gnf.com

Proprietary Notice

This letter transmits proprietary information in accordance with 10 CFR 2.390. Upon removal of Enclosure 1, the balance of the letter may be considered non-proprietary.

MFN 12-074 Supplement 1
January 25, 2013

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

Subject: Supplemental Information for Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels

By Reference 1 GNF-A submitted to the US NRC a proposed enhanced LUC program for NSF channels. In subsequent discussions with the NRC staff, several questions have been expressed. This supplement provides information responding to those questions.

Please note that Enclosure 1 contains proprietary information of the type that GNF-A maintains in confidence and withholds from public disclosure. The affidavit contained in Enclosure 3 identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GNF-A. GNF-A hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17.

Enclosure 2 is a non-proprietary version of Enclosure 1.

If you have any questions about the information provided here, please contact me at (910) 819-5954 or Jim Harrison at (910) 819-6604.

Sincerely,

James J. Harrison for

Andrew A. Lingenfelter
Vice President, Fuel Engineering
Global Nuclear Fuel – Americas, LLC

Project No. 712

References

1. Letter from A. A. Lingenfelter (GNF-A) to Document Control Desk (US NRC), Subject: Enhanced Lead Use Channel (LUC) Program for NSF Fuel Bundle Channels, MFN 12-074, September 25, 2012.

Enclosures

1. Supplemental Information for Enhanced LUC Program for NSF Channels – GNF-A Proprietary Information – Class III (Confidential)
2. Supplemental Information for Enhanced LUC Program for NSF Channels – Non-Proprietary Information – Class I (Public)
3. Affidavit

cc: SS Philpott, USNRC
PL Campbell, GEH/Washington
JG Head, GEH/Wilmington
JF Harrison, GEH/Wilmington
eDRF Section 0000-0152-9211 R3

Document Components:

001 MFN 12-074 Supplement 1 Cover Letter.pdf
002 MFN 12-074 Supplement 1 Enclosure 1 Proprietary.pdf
003 MFN 12-074 Supplement 1 Enclosure 2 Non-Proprietary.pdf
004 MFN 12-074 Supplement 1 Enclosure 3 Affidavit.pdf

NRC RAI 1

Please provide a comparison of NSF to Zircaloy-4 material and mechanical properties and show that the appropriate design calculations were completed.

GNF Response

The specific properties of NSF will be communicated to the NRC in a Licensing Topical Report (LTR) in early 2013. An executive summary is provided herein.

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]] Based upon these evaluations, channels manufactured with NSF alloy will satisfy all design requirements.

GNF has designed channels to meet the required functions of fuel channels as defined in the relevant LTRs NEDE-21354-2-P (Reference 1-1) and NEDE-21175-3-P-A (Reference 1-2), which are referenced in GESTAR II. [[

]] Early in 2013, GNF will submit the LTR supporting the use of NSF material. It will include a full discussion of NSF properties.

References

1-1 GE Nuclear Energy, "BWR Fuel Channel Mechanical Design and Deflection," NEDE-21354-2-P, July 1977.

1-2 GE Nuclear Energy, "Fuel Assembly Evaluation of Combined Safe Shutdown Earthquake (SSE) and Loss-of-Coolant Accident (LOCA) Loadings (Amendment No. 3)," NEDE-21175-3-P-A, October 1984.

NRC RAI 2

The LUC program (as described) is limited in scope to the use of NSF alloy as a substitute material for Zry-2 or Zry-4. This implies that all other design specifications remain unchanged from currently approved channels. Is this correct?

GNF Response

Yes, all other design specifications remain unchanged from currently approved channels. GNF has designed channels to meet the required functions of fuel channels as defined in the relevant LTRs NEDE-21354-P (Reference 2-1) and NEDE-21175-3-P-A (Reference 2-2), which are referenced in GESTAR II. NSF channels will be fully recrystallized similar to Zircaloy-2 and Zircaloy-4 channels.

References

2-1 GE Nuclear Energy, "BWR Fuel Channel Mechanical Design and Deflection," NEDE-21354-2-P, July 1977.

2-2 GE Nuclear Energy, "Fuel Assembly Evaluation of Combined Safe Shutdown Earthquake (SSE) and Loss-of-Coolant Accident (LOCA) Loadings (Amendment No. 3)," NEDE-21175-3-P-A, October 1984.

NRC RAI 3

Should the monitoring requirements include a commitment for increased inspection frequency and/or population in the event a problem is identified? This revised monitoring program could emulate the current augmented inspection program.

GNF Response

If there is a friction observation in a cell containing an NSF channel, the plant will immediately go into MFN 10-245 R5 (Reference 3-1) and MFN 08-420 (Reference 3-2) testing. Part of that testing in BWR/2-5 plants is to test symmetric cells for an extent of condition evaluation. If friction indications at any plant (including BWR/6 plants) suggest an unexpected systemic condition with NSF channels inserted under this expanded LUC program, the monitoring program for all plants will enter the MFN 10-245 R5 (Reference 3-1) and MFN 08-420 (Reference 3-2) monitoring program for cells containing NSF.

References

3-1 Letter from D. E. Porter (GEH) to Document Control Desk (US NRC), Subject: Update to Part 21 Reportable Condition Notification: Failure to Include Seismic Input in Channel-Control Blade Interference Customer Guidance, MFN 10-245 R5, February 7, 2012.

3-2 Letter from D. E. Porter (GEH) to Document Control Desk (US NRC), Subject: Update to GEH Surveillance Program for Channel-Control Blade Interference Monitoring, MFN 08-420, December 19, 2008.