Entergy

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Attachments 1 and 3 contain **PROPRIETARY** information

GNRO-2014/00045

August 26, 2014

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Response to Request for Additional Information Regarding Maximum Extended Load Line Limit Plus Amendment Request, dated 5/19/2014.
Grand Gulf Nuclear Station, Unit 1
Docket No. 50-416
License No. NPF-29

REFERENCES:

1 Electronic Request for Additional Information Regarding "Maximum Extended Load Line Limit Plus" Amendment Request Dated 5/19/2014 (TAC MF2798)

2 Entergy Letter, "Maximum Extended Load Line Limit Analysis Plus (MELLLA+) License Amendment Request," GNRO-2013/00012, dated September 25, 2013 (ADAMS Accession No. ML13269A140).

Dear Sir or Madam:

Entergy Operations, Inc. is providing in the Attachments a response to the Reference 1 Request for Additional Information (RAI).

Attachments 1 and 3 contain proprietary information as defined by 10 CFR 2.390. General Electric-Hitachi (GEH), as the owner of the proprietary information, has executed the enclosed affidavit, which identifies that the attached proprietary information has been handled and classified as proprietary, is customarily held in confidence, and has been withheld from public disclosure. The proprietary information was provided to Entergy in a GEH transmittal that is referenced by the affidavit. The proprietary information has been faithfully reproduced in the attached such that the affidavit remains applicable. GEH hereby requests that the attached proprietary information be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. Information that is not considered proprietary is provided in Attachments 2 and 4. Attachments 5 and 6 contain affidavits which identify that the information contained in Attachments 1 and 3 have been handled and classified as proprietary to GEH. On behalf of GEH, Entergy requests that Attachment 1 and Attachment 3 be withheld from public disclosure in accordance with 10 CFR 2.390(b)(1).

**When Attachments 1 and 3 are removed from this letter, the entire document is NON-PROPRIETARY**

This letter contains no new commitments. If you have any questions or require additional information, please contact Mr. James Nadeau at 601-437-2103.

I declare under penalty of perjury that the foregoing is true and correct; executed on August 26, 2014.

Sincerely,

KJM/ras

Attachments:

1. Responses to Request for Additional Information dated 5/19/2014 Pertaining to License Amendment Request – Maximum Extended Load Line Limit Plus (Proprietary Version)

2. Responses to Request for Additional Information dated 5/19/2014 Pertaining to License Amendment Request – Maximum Extended Load Line Limit Plus (Non-Proprietary Version)

3. Responses to Request for Additional Information #8 dated 5/19/2014 Pertaining to License Amendment Request – Maximum Extended Load Line Limit Plus (Proprietary Version)

4. Responses to Request for Additional Information #8 dated 5/19/2014 Pertaining to License Amendment Request – Maximum Extended Load Line Limit Plus (Non-Proprietary Version)

5. GEH Affidavit for Attachment1

6. GEH Affidavit for Attachment 3

cc: See next page

cc: with Attachments

U.S. Nuclear Regulatory Commission
ATTN: Mr. Marc L. Dapas
Regional Administrator, Region IV
1600 East Lamar Boulevard
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U.S. Nuclear Regulatory Commission
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NRC Senior Resident Inspector
Grand Gulf Nuclear Station
Port Gibson, MS 39150

State Health Officer
Mississippi Department of Health
P. O. Box 1700
Jackson, MS 39215-1700

**Attachment 2**

**GNRO-2014/00045**

**RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION DATED 5/19/2014 PERTAINING TO LICENSE AMENDMENT REQUEST – MAXIMUM EXTENDED LOAD LINE LIMIT PLUS**

**(NON-PROPRIETARY VERSION)**

# 1.0 POWER DENSITY > 50 MEGAWATT THERMAL/MLBM/HR

*Section 2.2.1 "Safety Limit Minimum Critical Power Ratio" states that "The currently approved off-Rated Core flow (CF) uncertainty applied to the Single Loop Operation (SLO) is used for the minimum CF statepoint D and at 55.0% of CF statepoint C." Section 2.2.5 "Power-to-Flow Ratio" states that statepoint C has a power density of 57.42 Megawatts Thermal/Million Pounds/Hour (MWt/Mlbm/hr), which is larger than the MELLLA+ Licensed Topical Report (LTR) limit of 50 MWt/Mlbm/hr, and states "this limitation is resolved in the near-term by applying additional conservatism to the cycle-Specific Safety Limit Minimum Critical Power Ratio (SLMCPR)." This "additional conservatism" is not documented in Section 2.2.5 of the Safety Analysis Report (SAR). Provide:*

1. *Definition of the "additional conservatism" method.*
2. *A numerical example of the application of this conservatism.*
3. *A justification that the power distribution uncertainties at the higher power density are covered by the proposed method.*

**Response to questions 1-3**

The additional conservatism is included by incorporation of the +0.02 Safety Limit Minimum Critical Power Ratio (SLMCPR) adder specified by the Methods LTR SER Limitation and Condition 9.5 (Reference 1-1) for MELLLA+ plants with planned operation above a Power-to-Flow Ratio of 42 MWt/Mlbm/hr.

It should also be noted that the SLMCPR evaluation specified by the MELLLA+ LTR Safety Evaluation Report (SER) Limitation and Condition 12.6 (Reference 1-2) specifically requires an evaluation of the Two Loop Operation (TLO) SLMCPR using the highest NRC-approved core flow uncertainties (i.e. SLO uncertainties) at the off-rated condition that has the highest Power-to-Flow Ratio in the MELLLA+ operating domain.

Therefore, additional conservatism and justification that the power distribution uncertainties are acceptable is based on inclusion of the following:

- +0.02 SLMPCR adder for Power-to-Flow Ratio >42 MWt/Mlbm/hr,
- TLO SLMCPR evaluation at statepoint C (P-to-F = 57.42), and
- TLO SLMCPR evaluation with SLO uncertainties.

SLO is not allowed in the MELLLA+ operating domain, but the SLO uncertainties are used to evaluate the TLO SLMCPR for required statepoints in the MELLLA+ operating domain. The SLO SLMCPR evaluation will normally be lower than the TLO SLMCPR due to the off-rated evaluation with SLO uncertainties. It is anticipated that MELLLA+ plants will have the TLO SLMCPR and SLO SLMCPR be set equivalent in the technical specifications to avoid a SLO SLMCPR lower than a TLO SLMCPR.

See Figure 1.1 for a graphical depiction of the SLMCPR evaluation statepoints.

**References**

1-3. GE Hitachi Nuclear Energy, "Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P-A, Revision 4, November 2012.

1-4. GE Hitachi Nuclear Energy, "General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus Licensing Topical Report," NEDC-33006P-A, Revision 3, June 2009.

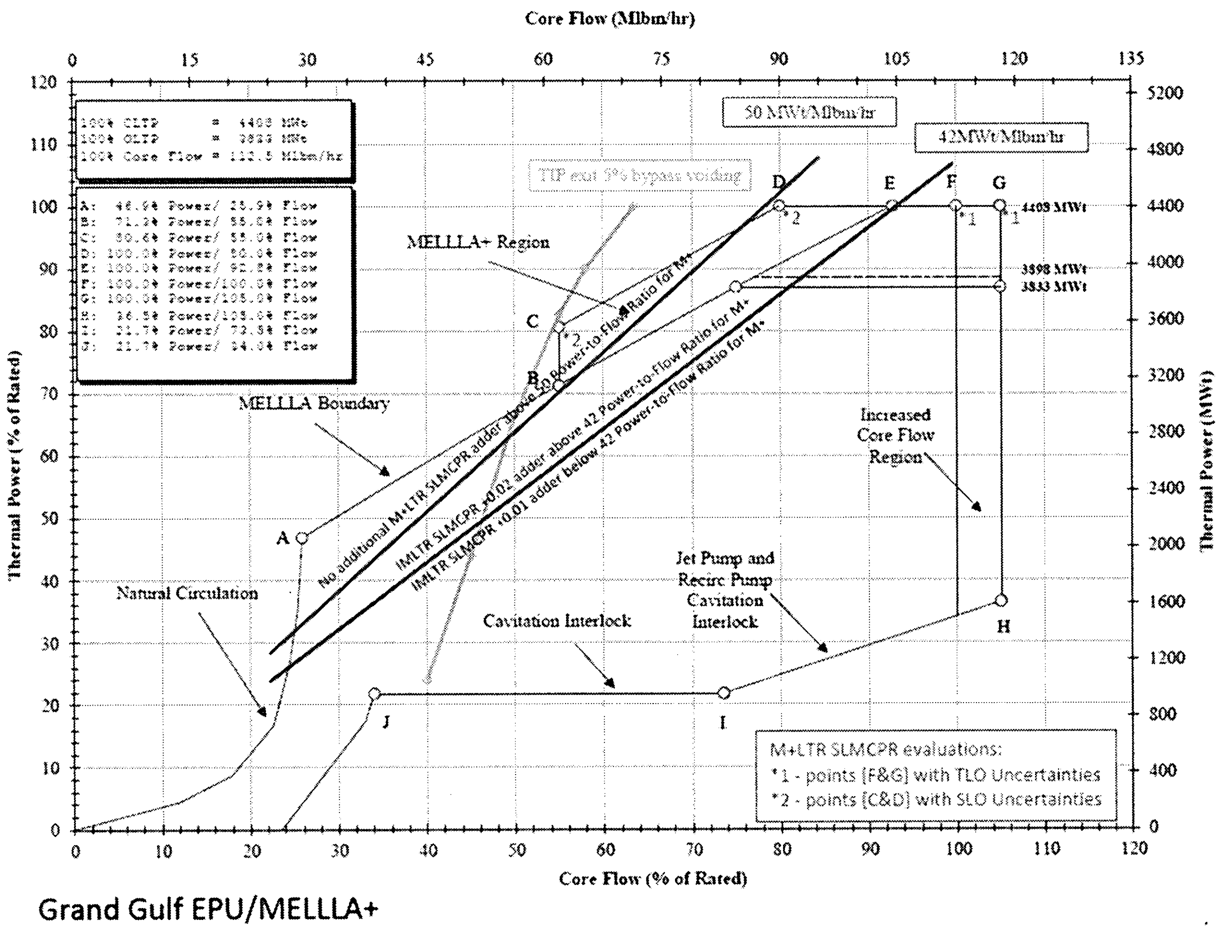


**Figure 1.1. Graphical Depiction of the SLMCPR Evaluation Statepoints**

## 2.0 SPECIFIC SAFETY LIMIT MINIMUM CRITICAL POWER RATIO ADDERS

*Section 2.2.1 "Safety Limit Minimum Critical Power Ratio" states that "a +0.02 SLMCPR adder will be added to the cycle-specific SLMCPR."*

1. *Provide a list of SLMCPR adders in MELLLA+ with respect to Operating Licensed Thermal Power (OLTP) conditions.*
2. *Specify which adders are part of the Extended Power Uprate (EPU), and which are MELLLA+ specific.*

**Response to questions 1 and 2**

Table 2.1 specifies the applicable Safety Limit Minimum Critical Power Ratio (SLMCPR) adders defined by the Methods LTR SER Limitation and Condition 9.5 (Reference 2-1) for operation with EPU/MELLLA and EPU/MELLLA+.

Figure 2.1 shows a graphical depiction of the SLMCPR evaluation statepoints and the Methods LTR penalties applied based on Power-to-Flow Ratio. Statepoints C&D [*2] in Figure 2.1 apply a +0.02 SLMCPR adder. Statepoints F&G [*1] in Figure 2.1 apply a +0.01 SLMCPR adder.

The most limiting SLMCPR of the four evaluation statepoints at BOC/MOC/EOC cycle exposure conditions will be used to set the technical specification SLMCPR. It is anticipated that MELLLA+ plants, will have the TLO SLMCPR and SLO SLMCPR be set equivalent in the technical specifications to avoid a SLO SLMCPR lower than a TLO SLMCPR.

**Reference**

2-1. GE Hitachi Nuclear Energy, "Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P-A, Revision 4, November 2012.

**Table 2.1. SLMCPR Adders**

| Licensing Basis | TLO & SLO SLMCPR Adder |
|---|---|
| EPU / MELLLA (PUSAR) | 0.00 |
| EPU / MELLLA+ with ≤42 MWt/Mlbm/hr (M+SAR) | 0.01 |
| EPU / MELLLA+ with >42 MWt/Mlbm/hr (M+SAR) | 0.02 |

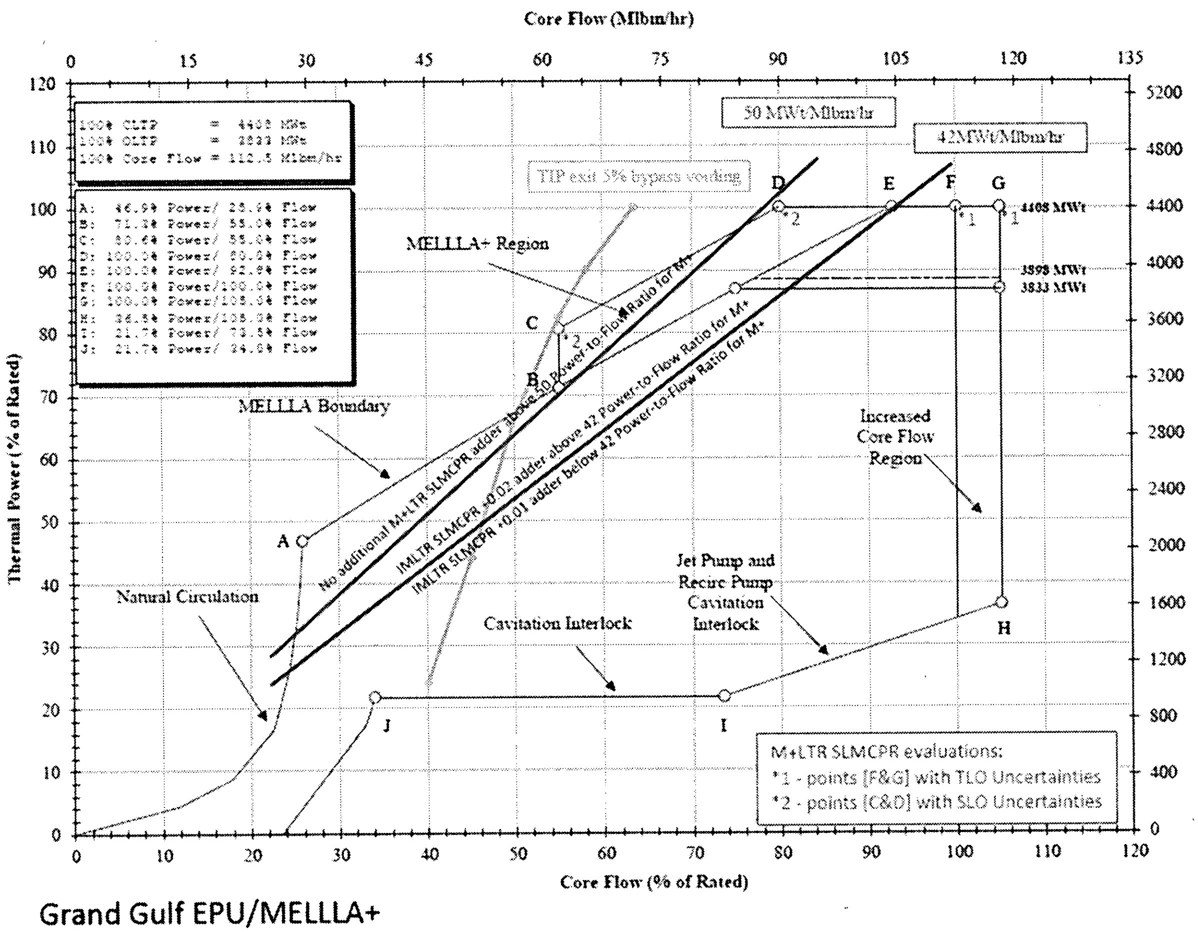


**Figure 2.1. Graphical Depiction of the SLMCPR Evaluation Statepoints**

## 3.0 VOID FRACTION

*Figures 2-3, 2-4, and 2-5 of the SAR indicate that GGNS is an outlier with respect to core exit void fraction. GGNS has the highest exit void fraction of all the plants considered, and it approaches ~88% at some points during the cycle.*

1. *Provide justification about the applicability of General Electric, Hitachi (GEH) methods at this high void fraction.*
2. *Provide justification that TGBLA06 generates accurate lattice cross sections at void fractions as high as 87%. Please refer to previous approvals that evaluated void fraction levels this high, when applicable.*

**Response to questions 1 and 2**

GGNS appears as an outlier because all the other plant data on Figures 2-3, 2-4, and 2-5 of the SAR does not include MELLLA+ operation. As shown in the noted figures, the exit void fraction curves of the GGNS PUSAR and GGNS M+SAR demonstrate the impact of MELLLA+ operation on the exit void fraction during steady-state operation is less than 5%. The maximum exit void fraction based on the peak power bundle is less than 90%. The maximum core average exit void fraction is less than 80%.

The response to several RAIs in the Methods LTR (Reference 3-1) documents the acceptability of exit void fractions greater than 90% and the specific TGBLA06 adequacy of the extrapolation of lattice parameters to in-channel 90% void fraction.

A maximum exit void fraction of less than 90% is the expectation for steady-state operation with MELLLA+ as shown in the figures provided to support Methods LTR SER Limitation and Condition 9.24 (Reference 3-1).

**Reference**

3-1. GE Hitachi Nuclear Energy, "Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P-A, Revision 4, November 2012.

## 4.0 STANDBY LIQUID CONTROL SYSTEM SHUTDOWN MARGIN

*Section 2.3.3 "Standby Liquid Control System Shutdown Margin (SLCS) Shutdown Margin" states that "The MELLLA+ operating conditions do not change the methods used to evaluate the SLCS shutdown margin."*

1. *Is SLCS shutdown margin evaluated with all rods out or with a pre-planned rod sequence pattern?*
2. *Does operation with initial conditions consistent with statepoints C or D (which correspond to the highest rod line) affect the SLCS shutdown margin?*

**Response to questions 1 and 2**

The SLCS shutdown margin is evaluated in a Cold-All-Rods-Out (CARO) configuration to identify the condition of the most core reactivity without credit for control blades, elevated moderator temperature, core voiding, or xenon inventory (i.e. ARO, Cold 160C moderator temperature, zero void fraction, and xenon free). The SLCS boron concentration and changes in core hot excess reactivity with cycle exposure will affect the SLCS shutdown margin. The initial operating conditions relative to the highest rod line have no impact on the SLCS shutdown margin based on the method of evaluation defined in GESTAR-II (Reference 4-1) on Page US.B-43 in response to SLCS Subsection 3.3.2.1.3 RAI and Page US.C-26 in the last paragraph of the Shutdown Capability subsection.

**Reference**

4-1. Global Nuclear Fuel, "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-20 and NEDE-24011-P-A-20-US, December 2013.

## 5.0 DETECT AND SUPRESS SOLUTION-CONFIRMATION DENSITY

1. *Have the Backup Stability Protection (BSP) regions been evaluated for the GGNS equilibrium cycle? Provide them if available. If not, where will they be documented? Will they be part of the Supplemental Reload Licensing Report (SRLR)?*
2. *Describe the criteria used to set the Oscillation Power Range Monitor (OPRM) armed region.*
3. *Provide justification that the OPRM armed region defined as 75% drive flow shown in Figure 2-18 is conservative for GGNS MELLLA+ cooperation.*

**<u>Response to questions 1-3</u>**

1. The Backup Stability Protection (BSP) regions are cycle-specific results. As such, they are calculated and documented in the Grand Gulf Nuclear Station (GGNS) cycle-specific Maximum Extended Load Line Limit Analysis Plus (MELLLA+) Supplemental Reload Licensing Report (SRLR). This process is described in Section 7.5.3 of the reviewed and approved Detect and Suppress Solution – Confirmation Density (DSS-CD) Licensing Topical Report (LTR) (Reference 5-1) and Section 3.3 of the Safety Evaluation for Reference 5-1.

   Sample BSP Region demonstration analyses have been performed for the GGNS equilibrium cycle. The Nominal Feedwater Temperature (NFWT) results of the Manual BSP Region I (Scram) and Region II (Controlled Entry) are shown in Figure 5.1.

2. The criteria used to set the Oscillation Power Range Monitor (OPRM) Armed Region are described in Section 4.5 of the reviewed and approved DSS-CD LTR (Reference 5-1).

   <u>Power Level</u> - As instabilities are not expected to occur below 30% OLTP, the power threshold is generically set to be the MCPR monitoring threshold of 25% OLTP, which scales to a lower value for power uprated plants. [[

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   <u>Flow Level</u> - As instabilities are not expected to occur at, or close to, rated conditions, the flow boundary threshold is generically set just below the minimum flow associated with rated power operation, specified in Reference 5-1 as 75% of Recirculation Drive Flow (RDF) for Maximum Extended Load Line Limit Analysis Plus (MELLLA+) plants. For GGNS the OPRM flow boundary of the OPRM Armed Region is set at 75% RDF. The GGNS OPRM Armed Region power and flow boundaries are generically established in the GGNS MELLLA+ Safety Analysis Report as shown in Figure 2-18 (Reference 5-2).

3. The OPRM Armed Region defined as 75% RDF shown in Figure 2-18 is conservative for Grand Gulf Nuclear Station MELLLA+ operation based on the ODYSY calculations documented in Table 4-12 of the reviewed and approved DSS-CD LTR (Reference 5-1). These calculations were performed at the ORPM Armed Region boundaries for a BWR/4 and a BWR/6 plant for the MELLLA+ and the pre-MELLLA+ operating domains. The results show both channel and core decay ratios are very low, demonstrating no

susceptibility to both core-wide and regional oscillations at or near the OPRM Armed Region boundaries. The results confirm the observation that historical thermal-hydraulic instability events in commercial BWRs have not occurred when operating at approximately 60% or higher rated core flows. The selected generic basis of 75% RDF for DSS-CD is bounding the operating experience history.

**References**

5-3. GE Hitachi Nuclear Energy, "GE Hitachi Boiling Water Reactor, Detect and Suppression Solution – Confirmation Density," NEDC-33075P-A, Revision 8, November 2013.

5-4. GE Hitachi Nuclear Energy, "Safety Analysis Report for Grand Gulf Nuclear Station Maximum Extended Load Line Limit Analysis Plus," NEDC-33612P, September 2013.

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**Figure 5.1. GGNS MELLLA+ Equilibrium Cycle Sample BSP Regions for NFWT**

## 6.0 INCREASED MOISTURE CARRY OVER

*Section 3.3.4 "Steam Line Moisture Performance Specification" states that "The highest Moisture Carryover (MCO) predicted under MELLLA+ conditions is less than 0.2 wt %" ... "The amount of time GGNS is operated with higher than the original design moisture content (0.10 wt %) is minimized by operations" ... "The maximum permissible MCO leaving the Reactor Pressure Vessel (RPV), above which Mainsteam Line (MSL) components could begin to degrade as a result of the high moisture content in the steam, was found to be 0.33 wt %".*

*Provide a summary explanation of:*

1. *What analyses were performed to determine the 0.33% permissible limit?*
2. *What analyses were performed to determine the 0.2% MCO under MELLLA+ conditions?*
3. *What plant operations are used in GGNS to minimize the MCO?*
4. *Provide a short physical explanation of what causes the increased MCO at lower flow. Is this mechanism predicted using an experimental correlation or a first principle analytical tool?*
5. *How is the MCO monitored during operation? What is the typical surveillance period?*

**<u>Response to questions 1-5</u>**

1. The 0.33 wt. % permissible limit for MCO in the steam leaving the RPV was determined using proprietary GEH methods for assessing the thermal-hydraulic performance of Boiling Water Reactors. The analysis consisted of a conservative calculation of the pressure drop across the MSLs, which transport saturated steam from the RPV to the turbine. The pressure in the MSLs decreases as the steam flows to the high-pressure turbine as a result of irreversible energy losses caused by surface friction, changes in direction and elevation, and flow through various MSL components. This reduction in pressure produces a corresponding increase in the moisture content of the steam as it flows through the MSL. The MSL hardware was designed to operate with steam moisture content based on the original steam dryer outlet moisture performance specification of 0.10 wt. %. At this value of MCO, the moisture in the steam at the Turbine Stop Valves is less than 1.0 wt. %, and all MSL components receive steam with moisture content below component design specifications.

The plant-specific analysis calculated the moisture content of the steam at affected MSL components as a function of steam dryer exit moisture. In the case of GGNS, the limiting MSL components were identified as the F098 Main Steam Shutoff Valves (MSSVs), which are situated just downstream of the Main Steam Isolation Valves (MSIVs). The analysis determined the MCO value in the steam leaving the dryer that would produce a maximum moisture content of 0.50 wt. % at the MSSVs. This latter value was identified as the maximum moisture that the MSSVs could be subjected to during normal operations without an unreasonable expectation that the components would perform their intended design function. With the plant operating at the 0.33 wt. % permissible MCO limit, the steam moisture content at the MSSVs is just under 0.50 wt. %. This analysis provides

reasonable assurance that all MSL components will not experience accelerated degradation as a result of the increased moisture content of the steam.

2. The Steam Dryer/Separator Performance analyses employ a proprietary methodology that evaluates the steady-state fuel cycle state points to identify the limiting MCO conditions as a function of exposure (i.e., burnup) under MELLLA+ flow conditions. The model uses a one-dimensional, two-phase, thermal-hydraulic analysis to calculate the steam quality exiting the fuel bundles based on the core power and flow distributions along with reactor operating conditions and plant hardware design information. The model considers turbulent mixing of the two-phase flow streams exiting the core in the upper plenum region between the top of the core and the inlets to the steam separators, and partitions these flow streams amongst the separators. The model then analyzes separator performance, including the effects of carryover and carryunder, using empirical separator performance data. Once the flow conditions exiting the separator have been calculated, the model then calculates the flow exiting the dryer using empirical dryer performance data and determines the resulting MCO. The limiting state point for the GGNS MELLLA+ fuel cycle yielded a predicted MCO value of 0.194 wt. %, which was rounded up to 0.2 wt. %.

3. At the operational level, monitoring is used to ensure MCO remains below the cycle-average established limit. The majority of MCO minimization is obtained as part of the core design.

   Plant operations to minimize MCO at GGNS include monitoring by Chemistry in accordance with procedure 08-S-03-10 which provides guidance for sampling and establishes limits. Chemistry Guide CLG-06-092-05 provides guidance for determination of notification of moisture carryover, and requires notification of Chemistry management and initiation of condition reports, as needed.

   The MCO is predicted to be above the limit only in a small portion of the proposed MELLLA+ power-flow region. The time that GGNS expects to spend in this region is limited. In addition, as predicted by GEH models, the MCO is highly dependent on the core power shape and peaking factors. During the development of core designs for cycles using MELLLA+ operation, estimates of MCO are developed and core designs are optimized to mitigate the impact.

4. MCO increases at lower core flow as a result of the performance characteristics of the primary steam separators under MELLLA+ operating conditions (i.e., reduced core flow). Steam dryer performance is impacted by steam separator performance.

   Two stages of steam separation are utilized to generate steam that meets the functional performance design specification of low moisture content for a BWR.

   The first stage of the separation process utilizes an assembly of steam separators. In each separator, a portion of the steam-water mixture from the upper core plenum enters the separator standpipe and passes through a set of stationary swirl vanes, which imparts rotational motion to the steam-water mixture. Centrifugal force separates the high-density liquid from the low-density vapor. The separated water is collected and exits along the

bottom of the separator barrels and returns to the reactor core shroud annulus. This water mixes with water draining from the dryer assembly along with the injected feedwater, and then flows to the jet pumps to be circulated into the reactor core. The reduced moisture steam exits at the top of the separators and passes to the dryer assembly for further moisture removal.

Separator performance is primarily affected by three parameters: (1) the immersion water level surrounding the separators; (2) the total mass flow rate passing through the separator; and (3) the inlet quality. Neglecting changes in the water level, which does not change during steady-state operation, optimal separator performance with regard to separator carryover (CO, defined as the amount of moisture in the steam exiting the separator) occurs over a relatively narrow band of steam separator inlet quality ranging from roughly 10 to 25 wt. %. This performance characteristic is illustrated by typical test results of CO versus Inlet Quality of the steam entering the separators at a constant inlet flow rate shown in Figure 6.1. CO increases rapidly when the inlet quality lies outside this optimal range, even at higher inlet qualities, despite the decreasing moisture content of the steam. Increases, or decreases, in core flow rate affects both the mass flow rate through the steam separator and the steam separator inlet quality. Increases, or decreases, in steam separator inlet quality outside the optimal band will increase CO, the amount of moisture that the steam dryer must remove.

The separators were designed for a specific range of inlet qualities and mass flow rates. At higher steam qualities exiting the core, the swirl vane design is not as effective in providing enough centrifugal force to the steam flow to remove sufficient water content to meet the original design values and thus more water passes through the separator to the dryer. If a significant number of the separators are affected in this way, high MCO conditions (>0.10 wt. %) can result. The GGNS-specific MELLLA+ evaluation, which is a hardware design basis evaluation that incorporates additional margin into the analysis for conservatism, indicated the potential for several separators to operate with elevated separator CO under MELLLA+ conditions. If the performance of a sufficient number of separators is such that they are passing high CO, the increased moisture may exceed the local capacity of the dryer to remove the additional moisture due to localized flooding of the vane channels. This condition is known as moisture breakthrough and is characterized by an abrupt increase in the moisture content of the steam exiting the dryer (i.e., MCO) above the original functional dryer performance specification of 0.10 wt. %.

When the core flow is reduced in the MELLLA+ regime, the overall effect is an increase in the quality of the steam exiting the fuel bundles in the core. The steam from the fuel bundles undergoes some mixing in the upper plenum region before entering the apertures to the separator standpipes in the shroud head. However, the mixing that occurs in the upper plenum is not sufficient to produce homogeneous conditions at the separator inlets, so the steam entering the separators will exhibit some spatial variation in the inlet quality that depends to a large extent on the exit quality of the fuel bundles directly below the separator inlets. Thus, the quality of the steam entering the central separators will generally be much

greater than the quality of the steam entering the peripheral separators due to the higher power of the central fuel bundles and the reduced core flow. This situation is illustrated in Figure 6.2, which shows degraded central separator performance for a typical plant operating under hypothetical core power and flow conditions in the MELLLA+ regime. In this figure, separators with exit CO approaching the local breakthrough condition (i.e., greater than or equal to 80% of the local breakthrough value) are highlighted in yellow whereas separators with exit CO exceeding the local breakthrough condition are highlighted in red. As can be seen in Figure 6.2, the increase in the inlet steam quality that occurs under MELLLA+ core flow conditions causes increased carryover from the central separators.

Under MELLLA+ operating conditions, the quality of the steam in the central separators may exceed the optimal range for inlet quality such that the separator CO is much higher than the 10 wt. % functional design specification. If a sufficient number of these separators have high CO, localized dryer breakthrough may occur, which leads to elevated MCO. However, also under MELLLA+ operating conditions, the quality of the steam in the peripheral separators may increase such that the separator CO is lower and thus reduce the local CO into some dryer banks and decrease the local MCO. The analyses described in Items 1 and 2 above confirm that the separator and dryer performance will remain acceptable under MELLLA+ conditions.

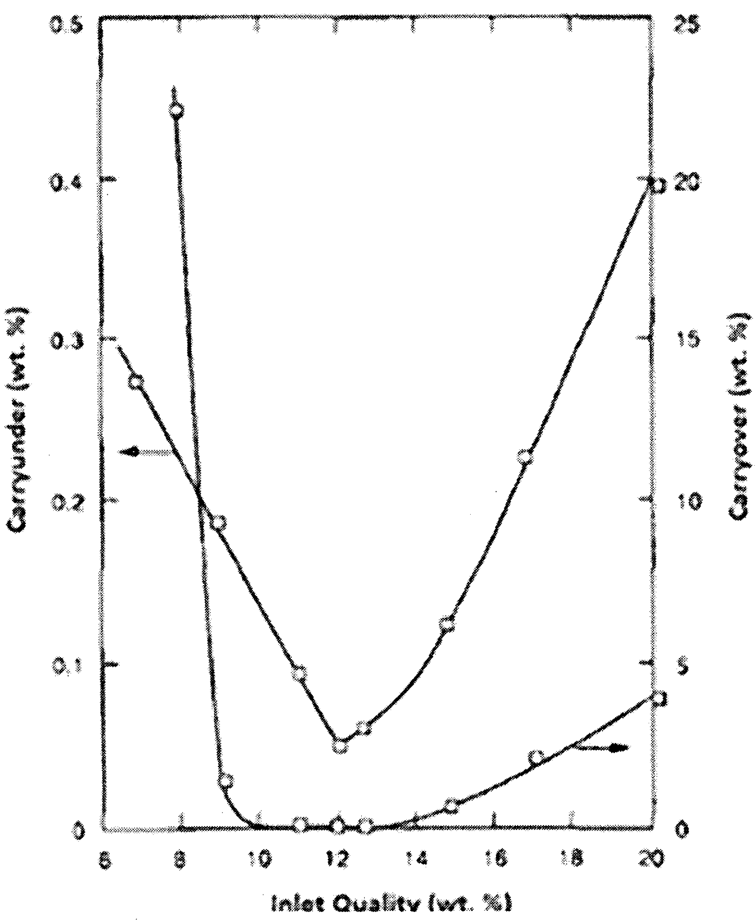

**Figure 6.1. Typical Separator Performance Characteristics with Core Effects Omitted**

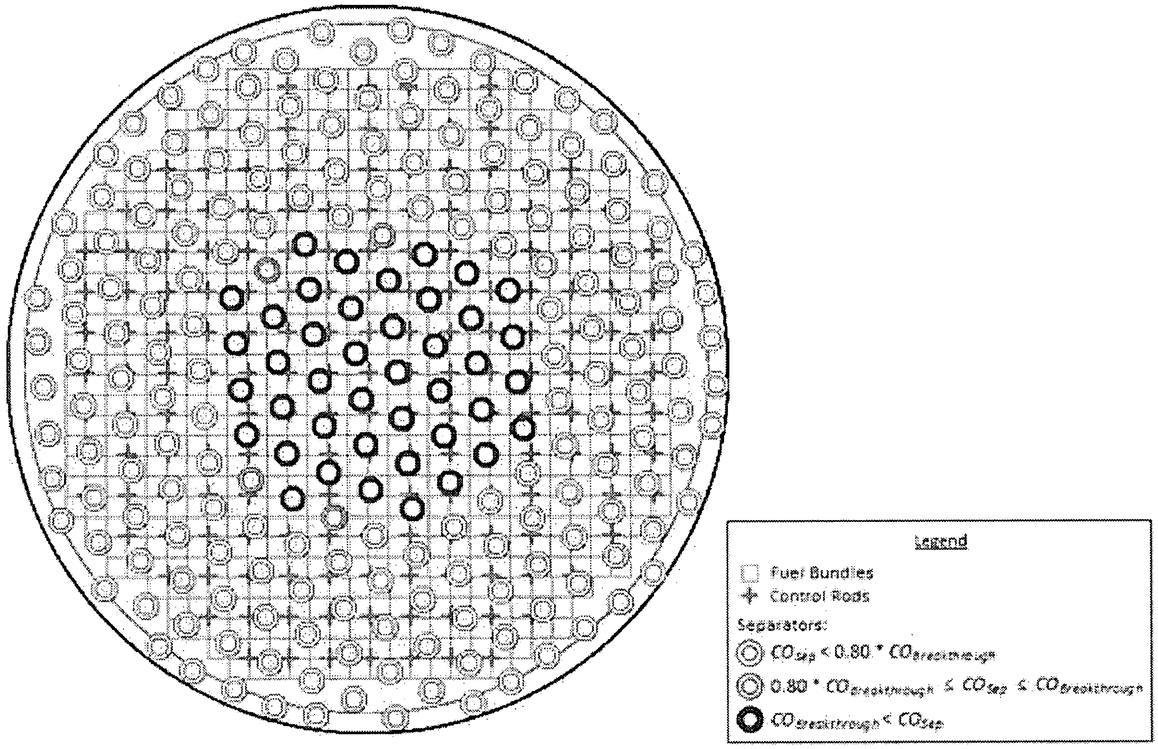


**Figure 6.2. Core-Separator Map Showing Central Separators Exhibiting Degraded CO Performance Under Hypothetical MELLLA+ Operating Conditions.**

$CO_{Sep}$ = moisture in the steam exiting the separator
$CO_{Breakthrough}$ = moisture in steam exiting the separator that exceeds localized dryer capacity to remove moisture to the dryer functional design specification of 0.10 wt. %

5. The GGNS MCO values are routinely monitored based on main condenser hotwell concentration of sodium-24 (Na-24). These measurements are taken monthly per the Chemistry sampling program, as directed in procedure 08-S-03-10.

## 7.0 REACTOR CORE ISOLATION COOLING NET POSITIVE SUCTION HEAD

*Section 3.9.3 "Reactor Core Isolation Cooling (RCIC) Net Positive Suction Head (NPSH)" states that "The RCIC system has the capability of using the Condensate Storage Tank (CST) or the Suppression Pool (SP) as a suction source" ... "GGNS calculations demonstrate that the RCIC pump would have adequate NPSH and low suction pressure trip margins given a SP water temperature of 140°F".*

1. *Is the CST available for RCIC even under containment isolation conditions?*
2. *If the SP temperature reaches >140°F, what indication/training does the operator have to switch from SP to CST inlet?*

**Response to questions 1 and 2**

1. Yes the CST is available for RCIC under containment isolation conditions. The isolation valves for the CST are controlled by low CST level and High Suppression Pool Level.

2. Normal operations is RCIC suction from the CST and typical operations is to exhaust the inventory in the CST before allowing automatic suction swap to Suppression Pool on high SP level or low CST level. Currently, the RCIC SOI 04-1-01-E51-1 has operations normally line RCIC up to the CST, and allows using RCIC with suction temperature greater than 140 deg F for the bearings and seals consideration. During a non-LOCA accident (no depressurization of the vessel so RCIC will run) RCIC would be run to failure on temperature from the Suppression Pool.

RCIC cannot be lined up to the CST after that because the electrical circuitry is configured to keep RCIC lined up to the Suppression Pool because of High Suppression Pool Level or low CST level.

The annunciation that Operators use to make determinations and verify actions are

04-1-02-1H13-P870-3A-E3 – Suppression Pool Channel A Temperature HI > 115 deg F

04-1-02-1H13-P601-21A-B5 – CST Level Lo – automatic swap to Suppression pool

04-1-02-1H13-P601-21A-C5 – Suppression Pool Level Hi – automatic swap to suppression pool

The preferred suction source for RCIC is always the Condensate Storage Tank (CST) and RCIC is normally lined up to the CST. Although RCIC trips on low suction pressure, suction is automatically transferred to the Suppression Pool (SP) from the CST based on Suppression Pool level well before low suction trip pressure occurs. There is no operator training other than verification of swapping CST suction to Suppression Pool Suction.

## 8.0 LARGE BREAK AND SMAL BREAK LOCA

**GEH Response** See Attachments 3 and 4 to letter GNRO-2014/00045

## 9.0 ANTICIPATED OPERATIONAL OCCURANCE (AOO) IMPACT OF FLOW

*On a separate MELLLA+ submittal (GEH Report Spec: 000N2436, dated 1/12/2014), data was provided to justify that Anticipated Operational Occurrences (AOOs) have smaller ΔMCPR at 80% core flow than at 105%. However, in Table 9.1 of the SAR, most AOOs, but not the limiting one, have a larger ΔMCPR at 80% flow than at 105%. The argument presented in the past is a shift in power towards the bottom as the voids increase for then 80% flow case, which results in increased control rod performance.*

1. *Provide the initial axial power shapes for the events in Table 9-1 at 80% and 105% flow.*
2. *For all cases in Table 9.1, the transient peak power is lower at 80% than at 105% flow yet the ΔMCPR is larger. This is counterintuitive. Please provide an explanation.*

**Response to questions 1 and 2**

1. The initial axial power shapes for the events in Table 9-1 are provided in Figure 9.1 for both 80% and 105% flow. Note that the axial power shape for GGNS does not show [[

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[[

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**Figure 9.1. Initial Power Shapes for GGNS MELLLA+ and ICF Transients**

2. Peak power during the transient is only one of several factors that influence the critical power performance of a fuel bundle during a transient event. [[

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

]] The CPR response is plant and fuel type dependent and therefore the high and low flow conditions are analyzed on a cycle-specific basis.

## 10.0 BI-STABLE FLOW

*Is GGNS susceptible to bi-stable flow in the recirculation loops? If so, what is the maximum achievable recirculation flow used in normal operation to minimize bi-stable flow concerns?*

**Response to question**

Yes. Normal maximum achievable core flow at full power is approximately 102.5%. Starting as early as 1988, GGNS has occasionally experienced recirculation drive flow variations that are somewhat similar to flow changes associated with the bi-stable flow phenomenon observed at several other BWRs. Nearly all GGNS "bi-stable" flow events occur in a core flow range of 94% to 96%. Bi-stable flow pattern at other plants is attributed to a jet pump riser extending directly from the header cross in the recirculation pump discharge header piping. The GGNS piping system differs in that there are six jet pump risers with a capped cross. The flow variations at GGNS are postulated to be due to a phenomenon similar to the bi-stable flow observed at other plants. GE evaluated this condition (Reference document EAS-01-0189, Recirculation System Flow Fluctuation and Neutron Flux Noise at Grand Gulf Station Unit 1 (January 1989)) and concluded that the magnitude of the core flow fluctuations due to variations in recirculation flow is bounded by plant specific evaluations performed for other BWRs with bi-stable flow changes larger than those observed for GGNS and concluded that plant safety is not compromised. This condition was reviewed during the GGNS extended power uprate and it was concluded that the NUMAC PRNMS will significantly reduce the likelihood of nuisance alarms and rod blocks due to bi-stable flow induced "spikes". No bi-stable APRM spikes have been reported since October 2009.

The GGNS bi-stable flux responses are momentary and spike only to the range of upscale APRM alarms and rod blocks. There has been no evidence that the APRM spikes caused by bi-stable flow conditions would ever reach the upscale scram settings. Thus, the GGNS bi-stable condition presents only infrequent and momentary nuisance APRM upscale alarms. In 2009, the control rod pattern was revised to avoid the 94-96% core flow range at one point in the cycle specifically to avoid the potential for this condition and the associated alarms. There are no ongoing operational restrictions associated with GGNS bi-stable flow. As experienced through plant operation, normal maximum achievable core flow at full power is approximately 102.5%.

## 11.0 PLANT DESIGN PARAMETERS

*1. Provide plant design parameters relevant to the Anticipated Transient Without Scram (ATWS) calculations in Section 9 of the SAR. Specifically: turbine bypass capacity, sources of high pressure injection and their operability issues (e.g., steam is lost after isolation ...), sources of low pressure injection and their operability issues (e.g. CST pumps ...).*

*2. Provide vessel component elevations in units comparable to the ones used for water level in the Section 9 figures (include separators, Feedwater (FW) spargers, nominal level, level setpoints for actuations, Top of Active fuel (TAF) ...).*

*3. What is "ATWS water level" in Figure 9-8 of the SAR?*

**Response to questions 1-3**

1. The turbine bypass capacity is 30.4%.

   The sources of high pressure injection credited in the analyses include the feedwater (FW) system, when available, and Reactor Core Isolation Cooling (RCIC). RCIC is credited when FW is unavailable such as in the Main Steam Isolation Valve Closure (MSIVC) and Pressure Regulator Failure-Open (PRFO) analyses.

   In the ODYN MSIVC and PRFO analyses, additional flow is included to control reactor water level to TAF + 5 feet to avoid depressurization as required per the ODYN analysis.

   One of the limitations of the FW system following a turbine trip is the loss of FW heating. This loss of heating in included in the ATWS-Instability (ATWS-I) analysis.

   Condensate flow is the only credited source of low pressure injection which cannot be credited until pressure is sufficiently low. This is credited in the TRACG MSIVC with depressurization analysis.

2. All level readings in the figures are in units of inches in relation to the separator skirt elevation. This is 13.143 meters (517.44 inches) above vessel zero. For comparison, the following are other elevations in the same units in descending order:

| | |
|---|---|
| • Upper tap | 15.207 m (598.7 in) (81.3 inches above sep skirt) |
| • High Water Level (L8) | 14.943 m (588.3 in) (70.9 inches above sep skirt) |
| • Nominal level | 14.470 m (569.7 in) (52.3 inches above sep skirt) |
| • Low Water Level (L3) | 13.493 m (531.2 in) (13.8 inches above sep skirt) |
| • Separator Skirt Elevation | 13.143 m (517.4 in) |
| • NR tap | 13.121 m (516.6 in) (-0.8 inches above sep skirt) |
| • FW | 12.602 m (496.1 in) (-21.3 inches above sep skirt) |
| • Top of Active Fuel | 9.304 m (366.3 in) (-151.1 inches above sep skirt) |
| • WR tap | 9.285 m (365.6 in) (-151.8 inches above sep skirt) |
| • "ATWS level" tap | 5.217 m (205.4 in) (-312.0 inches above sep skirt) |

3. TRACG is modelled with both narrow-range and wide-range level instrumentation readings. For analysis purposes, a new tap is added below the wide-range tap in order to monitor levels below the wide-range tap. For lack of a better name, water levels determined with this tap are labeled "ATWS water level" in the figures.

## 12.0 ATWS SEQUENCE OF EVENTS

*Provide tables of the assumed sequence of events for the ODYN licensing calculation, the ATWS best estimate calculation, and the ATWS/Stability calculation.*

**Response to question**

Sequence-of-Events Tables are included as Tables 12.1 through 12.4.

**Table 12.1. MSIVC Sequence of Events - ODYN**

| Item | Event Response | MELLLA+ | |
|---|---|---|---|
| | | BOC Time (sec) | EOC Time (sec) |
| 1 | [[ | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | ]] |

**Table 12.2. PRFO Sequence of Events - ODYN**

| Item | Event Response | MELLLA+ | |
|---|---|---|---|
| | | BOC Time (sec) | EOC Time (sec) |
| 1 | [[ | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | ]] |

**Table 12.3. TTWBP Sequence of Events - TRACG**

| Item | Event Response | Time (sec) [(1)] |
|---|---|---|
| 1 | [[ | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | ]] |

(4) [[

]]

**Table 12.4. MSIVC Sequence of Events - TRACG**

| Item | Event | Time (sec) [(1)] |
|---|---|---|
| 1 | [[ | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | ]] |

(3) [[

]]

## 13.0 ATWS CALCULATIONS

1. *Table 9-5 specifies a Boron SLCS concentration of 269%. Please, describe the units (i.e., percent of what?).*

2. *The SLCS initiation time has been increased from 120 seconds at CLTP to 300 seconds at MELLLA+. Table 9-6 specifies that this increase is the main reason why the calculated ultimate suppression pool temperature increases significantly (165.3°F vs 197.5°F). Is there a specific reason for the increase? Is the 300 seconds consistent with operator actions in the simulator?*

3. *The Licensing Basis ODYN ATWS Analysis calculates a suppression pool temperature of 197.5°F. Are NPSH limits satisfied by all the equipment assumed operable by the ODYN calculation? If a transfer to CST as the source of Emergency Core Cooling System (ECCS) cooling is assumed, provide the timing of the transfer.*

**Response to questions 1-3**

1. The item in Table 9-5 is boron concentration of the sodium pentaborate (in % by weight) times the boron-10 enrichment (in atomic %). GGNS Technical Specifications require a minimum boron concentration (weight %) times boron enrichment (atom %) of greater than 420. The MELLLA+ analysis concentration and enrichment are conservative compared to the Technical Specification requirement and provide a good comparison to the EPU analysis.

2. Yes, the reason for the increased suppression pool temperature is the higher post-ATWS core power level. Once the recirculation pumps trip after an ATWS, the reactor is cooled by natural circulation and this natural circulation point is higher in power with MELLLA+ due to the higher rodlines associated with MELLLA+ operation.

   The 300-second SLCS initiation time was modeled to bound the operator action times observed in the simulator, and therefore is consistent with operator actions in the simulator

3. In the ODYN ATWS analyses, [[

   ]] The maximum suppression pool temperature does not exceed the saturation temperature of water (212°F). Therefore, as described in Section 4.2.6, net positive suction head (NPSH) limits are satisfied.

   [[

   ]] However, note that even if

RCIC/HPCS were aligned with the suppression pool, NPSH limits would be met as the maximum suppression pool temperature does not exceed 212°F.

## 14.0 SAFETY RELEIF VALVE SETPOINTS AND OUT OF SERVICE ALLOWANCE

*Table 9-5 specifies that the ATWS transient was run with 20 total Safety Relief Valves (SRVs) with five SRVs out of service for both CLTP and MELLLA+, and Section 9.3.1.1 states "With the safety function of at least nine SRVs and the relief function of at least six SRVs operable".*

1. *Describe the difference between "safety function" and "relief function." Describe why the safety valve flow in Figure 9-1 is ~25% of the relief valve flow. How many valves are open in the case of Fig 9-1?*
2. *Has the number of allowed SRVs out of service been changed as a result of the MELLLA+ operating domain extension?*
3. *The SRV Analytical Opening Setpoint in Table 9-5 has been increased from 1,183 to 1,246 psig, which is greater than the 3% drift tolerance described in the text? Please elaborate and justify the change.*

**Response to questions 1-3**

1. The SRVs can actuate by either of two modes: the safety mode or the relief mode. In the safety mode (or spring mode of operation), the direct action of the steam pressure in the main stem lines will act against a spring loaded disk that will pop open when the valve inlet pressure exceeds the spring force. In the relief mode (or power actuated mode of operation), a pneumatic piston or cylinder and mechanical linkage assembly are used to open the valve by overcoming the spring force.

   The licensing basis ODYN Anticipated Transient Without Scram (ATWS) analysis, described in Section 9.3.1.1, was performed with five of the total 20 SRVs out of service. Of the remaining 15 SRVs, nine were assumed to operate in safety mode while six were assumed to operate in relief mode.

   [[

   ]]

2. The number of allowed SRVs out of service has not been changed as a result of the MELLLA+ operating domain extension. For Extended Power Uprate (EPU), Technical Specification 3.4.4 requires that the safety function of nine SRVs and the relief function of six additional SRVs be operable. This is the number of SRVs that were assumed operable for the MELLLA+ analyses.

3. The number of operable SRVs and their actual opening setpoints are not being changed for MELLLA+. The EPU analysis included 15 SRVs operable, all operating in relief mode. The MELLLA+ analysis includes 15 SRVs operable, with nine SRVs functioning in safety mode and six SRVs functioning in relief mode. The modeling of the nine valves in safety mode results in a change in the upper value of the analyzed opening setpoints.

The MELLLA+ LTR SE includes discussion and a limitation (12.23.3) related to RAI 11-4 addressing a potential need to update the number of Safety Relief Valve-Out of Service (SRVOOS) allowed in Technical Specifications in order to meet ATWS overpressure at MELLLA+. The resulting limitation contains the following:

"The ATWS peak pressure response would be dependent upon SRVs upper tolerances assumed in the calculations. For each individual SRV, the tolerances used in the analysis must be consistent with or bound the plant-specific SRV performance."

Based on this limitation, the MELLLA+ ATWS analyses more accurately model the available SRVs as required per the Technical Specifications.

## 15.0 ATWS WATER LEVEL STRATEGY

*Section 9.3.1.1 "ATWS (Licensing Basis)" specifies "Water level control per procedures." Section 9.3.1.2 "ATWS (Best-Estimate Calculation)" specifies "Water level control using the designated water level control strategy." Section 9.3.3 "ATWS with Core Instability" states that "Reactor water level was controlled at approximately TAF after a 90-second delay following indication of no scram."*

1. *Provide a detailed description of what water level control strategy (with emphasis on timing) was used for each calculation.*
2. *Describe the sources of water used to control the level. If FW pumps were used, describe automated actions (i.e., loss of extraction steam), and assumptions about operability (i.e., residual steam volume, if used) after the Main Steam Isolation Valve (MSIV) isolation occurs.*
3. *The best-estimate ATWS calculations (Figures 9-8 and 9-10) show some degree of high-pressure injection before time ~500 sec. Is this injection consistent with the available plant equipment?*
4. *Has the water level control strategy and timing changed as a result of the MELLLA+ domain extension?*
5. *Are there any operator training concerns/changes as part of the MELLLA+ domain extension and the 90-second delay?*
6. *Have the 90-second water level control and 40-second depressurization delays been tested in the plant simulator?*
7. *Figures 9-8 and 9-10 appear to show flow injection (red line) for times between 500-1000 during the depressurization. Do GGNS Emergency Operator Procedures (EOPs) require the termination of all high pressure flow injection except SLCS during the depressurization phase? Is the calculation consistent with EOPs?*

**Response to questions 1-7**

1. The water level control strategy is basically reducing water level during an ATWS event below the feedwater (FW) spargers in order to decrease subcooling and power. This is consistent with SRP 15.8. The level below the FW spargers to which water level is reduced is not as important as the timing for when this occurs. The following tabulates the timing for several events:

   a. ATWS-MSIVC (licensing) – FW pumps trip 30 seconds from the start of the MSIV isolation resulting in the lowering of the water level.

   b. ATWS-MSIVC (best-estimate) – FW pumps trip 30 seconds from the start of the MSIV isolation resulting in the lowering of the water level.

   c. ATWSI-TTWBP – Water level is reduced in 91 seconds.

d. ATWSI-RPT – Water level is conservatively reduced in 120 seconds after indication of no scram, which is 60 seconds after the RPT (Water level is reduced in 180 seconds after RPT).

2. The following are the sources of water for each event:

   a. ATWS-MSIVC – FW pumps trip after 30 seconds. RCIC is used for the remainder of the analysis. The RCIC flow enthalpy is 108 Btu/lbm. As a TRACG sensitivity study, a case was performed such that depressurization occurs. For this case, condensate water is assumed.

   b. ATWSI-TTWBP – FW is used during this event. After the turbine trip, FW heating is lost, so FW temperatures drop to the lowest expected main condenser temperature.

   c. ATWSI-RPT – FW is used during this event. As a consequence of the reduction in steam flow, FW temperature is reduced accordingly.

3. The injection before 500 seconds is the Reactor Core Isolation Cooling (RCIC) flow. This is consistent with available plant equipment.

4. The water level control strategy (reduce water level below FW spargers) is unchanged. The timing for water level reduction is reduced from a generic 120 seconds to 90 seconds consistent with operator action.

5. No significant training changes are necessary for the MELLLA+ domain extension. GGNS is currently reviewing any needed operator training changes for the 90-second delay. The priority for level reduction and its impact on ATWS instability mitigation for the higher rodlines associated with MELLLA+ will be re-emphasized in the operator training associated with MELLLA+ implementation.

6. The 90-second water level control and 40-second depressurization delays have not yet been tested in the plant simulator. However, per section 10.6 of Attachment 4 to GNRO-2013/00012, the description of the Operator Training and Human Factors topic in the M+LTR describes that the operator training program and plant simulator will be evaluated to determine the specific changes required. The classroom training will cover various aspects of MELLLA+ operating domain expansion, including changes to the TSs, changes to the power/flow map, changes to important setpoints, changes associated with the confirmation density stability solution, changes to plant procedures, and startup test procedures. The classroom training may be combined with simulator training for normal operational sequences unique to operation in the MELLLA+ domain. Because the plant dynamics do not change substantially for operation in the MELLLA+ domain, specific simulator training on transients is not anticipated.

The 90-second water level control delay is based on existing simulator timing exercises performed for EPU that were audited by the NRC staff and transmitted to the NRC in GNRO-2012/00017. The Emergency Procedures call for operator compliance with the HCTL curve and simulator scenarios confirmed this compliance at all times. The operators generally begin depressurization early with significant margin to the HCTL curve. The 40-second assumption was based on the longest delay assumption in the GEH experience base.

7. The flow just after 500 seconds is the RCIC flow. The EOPs require the termination of all high-pressure flow injection prior to depressurization except Standby Liquid Control System (SLCS), Control Rod Drive (CRD) flow and RCIC; therefore, this is not terminated prior to depressurization and is consistent with EOPs. After the Automatic Depressurization System (ADS) valves open and pressure is sufficiently low, condensate is used.

## 16.0 PRESSURE CONTROL STRATEGY

*Operators may choose to perform a controlled partial depressurization to: (1) obtain a larger Heat Capacity Temperature Limit (HCTL) margin and avoid emergency depressurization, and (2) allow the use of mid-to-low pressure injection sources like the CST pumps. Have operator actions in the simulator and training been reviewed to ensure that the licensing ATWS calculations are conservative?*

**Response to question**

Yes. To support its review and approval of the GGNS EPU, on October 27, 2011 the NRC staff conducted an on-site audit of the implementation of stability long-term solutions and the impact of EPU on instability and an Anticipated Transient without Scram (ATWS) event as documented in GNRO-2012/00017. One of the scenarios in this audit was an MSIV closure transient which trips the steam-driven feed pumps. In this scenario, the operators were observed, per procedure, to partially depressurize and inject from the condensate system via the condensate booster pumps.

## 17.0 BORON MIXING AND TRANSPORT

*Figure 9-8 shows the boron reactivity stabilizing at ~500 seconds, then increasing at ~1000 seconds followed by a significant decrease. However, Figure 9-10 shows a significant decrease in boron reactivity at ~1000 seconds. Please explain the phenomena that lead to such significantly different behavior.*

**Response to question**

Depressurization is limited to a [[ ]], and is controlled by the Automatic Depressurization System (ADS) valves. For the End of Cycle (EOC) case (Figure 9-8),
[[

]]

[[
]] (Figure 9-10); therefore, the same phenomenon is not noted.

It should be noted that during this time, the core neutronic power is very low (~14.8 Watts) resulting in very few slow neutrons such that the reactivity worth of boron is low.

## 18.0 DETAILED PLOTS

*The plots provided in Section 9 are difficult to read.*

1. *Provide enhanced neutron flux plots, where the axis is limited to 100% CLTP for all best estimate ATWS calculations.*
2. *The neutron flux provided for the ATWS-Instability (ATWS-I) calculation is core-average. Provide additional plots with hot channel powers at symmetric core locations showing the amplitude of the regional oscillations for the ATWS-I calculation.*

**Response to questions 1 and 2**

1. The neutron flux is moved from the right axis to the left axis, and Figures 9-8, 9-10, and 9-12 from the M+SAR report are regenerated and shown below with the same figure numbers.

   In addition to the revised figures, the figure titles for Figures 9-8 through 9-13 are changed to remove the incorrect statement, "at 120% OLTP."
2. Additional plots showing all hot channel powers in opposite regions are provided in Figures 18.1a through 18.1c. Three comparison plots are provided: hot channels 113 and 114, hot channels 115 and 116, and hot channels 111 and 112.

[[

]]

[[

]]

**Figure 9-8 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – Main Steam Isolation Valve Closure – EOC, Hard-Bottom Burn**

Figure 9-9 title should be changed from

**Figure 9-9 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – Main Steam Isolation Valve Closure at 120% OLTP / 80% Core Flow Initial Condition – EOC, Hard-Bottom Burn**

to

**Figure 9-9 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – Main Steam Isolation Valve Closure – EOC, Hard-Bottom Burn**

[[

]]

**Figure 9-10 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – Main Steam Isolation Valve Closure – BOC**

Figure 9-11 title should be changed from

**Figure 9-11 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – Main Steam Isolation Valve Closure at 120% OLTP / 80% Core Flow Initial Condition – BOC**

to

**Figure 9-11 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – Main Steam Isolation Valve Closure – BOC**

[[

]]

**Figure 9-12 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – TTWBP – BOC with Regional Instability**

Figure 9-13 title should be changed from

**Figure 9-13 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – TTWBP at 120% OLTP / 80% Core Flow Initial Condition – BOC with Regional Instability**

to

**Figure 9-13 Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – TTWBP – BOC with Regional Instability**

[[

]]

**Figure 18.1a. TRACG ATWS Analysis – TTWBP – BOC with Regional Instability**

[[

]]

**Figure 18.1b. TRACG ATWS Analysis – TTWBP – BOC with Regional Instability**

[[

]]

**Figure 18.1c. TRACG ATWS Analysis – TTWBP – BOC with Regional Instability**

## 19.0 PCT

1. *The ATWS plots of PCT (Figures 9-9 and 9-11) show two distinct PCT heat up ramps. One occurs early in the transient, and a second one occurs at~500 sec in Figure 9-9 and 9-11 when depressurization starts, with a period of low temperature in between. Are the hot rods in dryout condition during the heat up ramps? Describe what phenomena causes the rewetting (low temperature) at ~500 sec.*

2. *The ATWS-I calculation shows a PCT heat up at ~80 sec when the power oscillations initiate. The PCT recovers and the rods seem to rewet at ~130 sec when the oscillations are mitigated by the flow reduction. What mechanism allows for heatup and rewet?*

3. *Provide plots similar to Figures 9-9, 9-11, and 9-13 that shows PCT superimposed with the calculated minimum stable film boiling temperature ($T_{min}$) value.*

4. *Provide plots showing the calculated margin between PCT and $T_{min}$ for Figures 9-9, 9-11, and 9-13.*

**Response to questions 1-4**

1. During the Main Steam Isolation Valve Closure (MSIVC) event for GGNS, the feedwater (FW) pumps trip following the closure of the MSIVs. With the loss of the FW, Reactor Core Isolation Cooling (RCIC) is the only assumed source of makeup water while the reactor vessel is pressurized. Due to GGNS' high core power density and limited source of make-up water during the event,
[[

]]

[[
]], and operators depressurize the vessel. This blowdown results in a temporary increase in channel flow. The increased flow increases the heat transfer, and the fuel clad temperatures decrease accordingly. Once the blowdown slows sufficiently, the channel flow decreases, and the clad temperature once again increases around 470 seconds.

[[

]]

With the reduction in power and the continual steam cooling, the PCT decreases.

2. [[

]]

3. The "Peak Clad Temperature" in M+SAR Figures 9-9, 9-11, and 9-13 show the highest clad temperature in the core at each time-step. The location of the highest PCT can vary from different channels and/or levels. To address this RAI, The PCT, $T_{min}$, and total flow rate at a single location is provided. The chosen location is the location that resulted in the highest overall PCT. This location is shown in each new figure below. The new figures are Figures 19.2 (9-9 in M+SAR), 19.3 (9-11 in M+SAR), and 19.4 (9-13 in M+SAR).

4. [[

]]

Figure 19.4 shows the PCT, $T_{min}$ and margin for the Turbine Trip With Bypass (TTWBP) case.

[[

]]

**Figure 19.1. The Effect of the TRACG Quench Model on the TRACG ATWS Analysis – TTWBP – BOC with Regional Instability**

[[

]]

**Figure 19.2. PCT and Tmin from the TRACG ATWS Analysis – MSIVC – EOC, Hard-Bottom Burn**

[[

]]

**Figure 19.3. PCT and Tmin from the TRACG ATWS Analysis – MSIVC – BOC**

[[

]]

**Figure 19.4. PCT and $T_{min}$ from the TRACG ATWS Analysis – TTWBP – BOC with Regional Instability**

## 20.0 CODE-TO-CODE COMPARISON

*Events leading to reactor instabilities cause oscillations in PCT over time. The magnitude of these oscillations has been seen to vary from code to code. Analyses completed by the Office of Nuclear Regulatory Research at the NRC have documented TRACE results for ATWS-I that lead to reactor instabilities with high PCT.*

1. *Develop a synonymous model using TRACG.*
2. *Compare TRACG results with TRACE results for an ATWS-I turbine trip with 100% bypass event initiated from 120% Originally Licensed Thermal Power (OLTP) and 85% reactor core flow at the beginning of cycle and the peak hot excess point in the cycle. Provide discussion of differences between the two calculation results, in particular, wherever possible, identify candidate constitutive models, modeling procedures, input assumptions, or other factors that contribute to the differences.*
3. *Provide results in tabular form and in plots of the same two cases in RAI 20.2 above (ATWS-I turbine trip with 100% bypass event initiated from 120% Originally Licensed Thermal Power (OLTP) and 85% reactor core flow at beginning of cycle and the peak hot excess point in the cycle) using a constant $T_{min}$ of 900K.*

**Response to questions 1-3**

To be addressed later. [GEH has requested NRC data from a case performed with Tmin set at 900].

## 21.0 STEAM DRYER STRUCTURAL INTEGRITY

*1.* *Are the moisture carryover values or steam quality for steam (a) entering the steam separator, (b) exiting the steam separator, (c) entering the steam dryer, and (d) exiting the steam dryer affected by MELLLA+ core flow conditions?*

*2.* *Are the boundary conditions used in Acoustic Plant Based Load Evaluation (PBLE) model affected by MELLLA+ flow? Is there any impact on reactor water level & boundary conditions for annular region between dryer skirt and separator stand pipes; and annual region between RPV wall and dryer skirt? Is there any impact on dryer pressure loading used and on dryer structural analysis?*

*3.* *Are the stresses in the steam dryer evaluated for EPU conditions bounding for plant operation at EPU conditions combined with MELLLA+ conditions?*

**Response to questions 1-3**

1. In general, the reduced core flow conditions in the MELLLA+ regime increase the quality of the steam exiting the fuel bundles, which in turn increases the quality of the steam entering the steam separators.

Depending on the radial position of the separators with respect to the core axis, the increase in inlet quality to the separators can either improve or exacerbate separator performance. In the case of the peripheral separators, the increase in inlet steam quality can improve separator performance by shifting the inlet conditions towards the region of optimal performance to reduce carryover (see response to item 4 under RAI 6, *Increased Moisture Carryover*). In the case of the central separators, the increase in inlet steam quality can degrade the ability of the separator to remove moisture by shifting the inlet conditions away from the optimal performance region to increase carryover. Central separators typically dominate the aggregate separator performance under MELLLA+ flow conditions causing an overall increase in the moisture content of the steam entering the dryer relative to rated flow conditions.

Steam leaves the separators as turbulent jets and enters the plenum created by the steam dryer skirt. Although some limited mixing of these jet streams occurs in the dryer plenum, this mixing is not adequate to homogenize flow conditions at the dryer inlet headers. Therefore, the quality of the steam entering the dryer inlet headers will exhibit spatial variations that is determined by the flow conditions exiting the separators directly below the dryer. Moisture breakthrough occurs when high carryover from a sufficient number of separators exceeds the local capacity of the dryer vanes to remove the moisture due to vane channel flooding. This condition is a nonlinear process that produces an abrupt increase in the moisture content of the steam exiting the dryer (i.e., moisture carryover (MCO)) above the original functional dryer performance specification of 0.10 wt. %.

Consequently, MELLLA+ core flow conditions affect the steam quality at all locations in the steam dryer/separator system. Although MELLLA+ core flow conditions do not necessarily lead to moisture breakthrough, some highly peaked core designs can generate

elevated MCO above the original 0.10 wt. % specification. As discussed in Section 3.3.4 of the GGNS M+SAR, the effect of increased MCO on plant operation has been analyzed to verify acceptable steam separator/dryer performance under MELLLA+ operating conditions. The highest MCO predicted under MELLLA+ conditions is less than 0.20 wt. %; however, analyses were performed to support a maximum steam moisture content of 0.33 wt. % leaving the reactor pressure vessel (RPV). MCO is monitored during operation to ensure adequate operating limitations are implemented as required to maintain MCO within analyzed conditions. A number of evaluations in the M+SAR were performed assuming a conservatively high bounding MCO of 0.35 wt. %.

2. MELLLA+ operation may affect the boundary conditions and acoustic properties that determine the acoustic loading acting on the steam dryer. [[

]]

First, sensitivity studies using acoustic models are discussed to show the worst case possible effect of the acoustic properties on the acoustic pressure loads acting on the dryer at MELLLA+ conditions. [[

]]

The amount of steam carryunder increases for MELLLA+ operating conditions, which increases the steam content in the bubbly water. As part of the PBLE model development, sensitivity studies were performed [[

]] These studies are documented in Appendix C of NEDC-33601 App. B (Reference 21-2). [[

]]

MELLLA+ operation will also increase the moisture entrained in the steam both upstream and downstream of the dryer. Sensitivity studies were also performed to address the effect of upstream and downstream moisture and droplet size on the dryer acoustic loads for

MELLLA+ conditions (Reference 21-1). [[

]]

In addition to the potential effects on the acoustic pressure loading, there will be [[

]] taken during power ascension testing (Reference 21-4, page 3-14). [[

]] Therefore, the steam dryer stresses meet the acceptance criteria at EPU MELLLA+ operating conditions.

3.The limiting steam dryer stress reported in Reference 21-4 [[

]] The overall results of the EPU MELLLA+ dryer structural analysis show that the dryer stresses expected during EPU MELLLA+ operation are less than the ASME fatigue limit, and that the ASME acceptance criteria for the normal, upset and faulted service levels are satisfied over the EPU MELLLA+ operating domain.

**References:**

21-5. GEH Nuclear Energy, "GGNS Plant Based Load Evaluation Methodology, Supplement 1," NEDC-33601P, Revision 1, Appendix C.

21-6. GEH Nuclear Energy, "GGNS Plant Based Load Evaluation Methodology," NEDC-33601P, Revision 1, Appendix B.

21-7. GEH Nuclear Energy, "Grand Gulf Nuclear Station Replacement Steam Dryer EPU Full Re-Analysis and Benchmarking Report," NEDC-33765 Supplement 4P, Revision 1, July 2013.

21-8. GEH Nuclear Energy, "Safety Analysis Report for Grand Gulf Nuclear Station Maximum Extended Load Line Limit Analysis Plus," NEDC-33612P, Revision 0, September 2013.

## 22.0 CORE DESIGN

1. *The SRLR will validate that the power distribution in the core is achieved while maintaining individual fuel bundles within the allowable limits as defined in the Core Operating limits Report (COLR). When will the SRLR and the COLR will be available for GGNS MELLLA+ operation?*

2. *Provide the details to obtain a final loading pattern including procedure, guidance, criteria, and approved methodologies used for this analysis in relation to GESTAR II.*

3. *Table 2-1 and Figures 2-1 through 2-6 indicate the core design and fuel monitoring parameters for each exposure statepoint. Table 2-1 shows the peak nodal exposures starting from 38.849 to 56.660 GWd/ST (54.272 GWd/ST for GGNS M+ SAR at equilibrium 115% OLTP) and Figure 2-1 through 2-6 only shows cycle exposure up to 18 GWd/ST.*

    a. *Why do the figures only show the data up to 18 GWd/ST?*

    b. *Provide values for maximum bundle power, flow for peak bundle, exit void fraction for peak power bundle, maximum channel exit void fraction, core average exit void fraction, and peak linear heat generation rate (LHGR) at peak nodal exposure.*

    c. *Why isn't the peak nodal exposure data for GGNS M+ at equilibrium – 120% OLTP included in Table 2-1?*

4. *Provide core maps to show the bundles that experienced the 0.1% boiling transition criterion.*

5. *Provide a detailed description of the GGNS MELLLA+ core design in response to the core instability and fuel bundles which experienced boiling transition. Include any relationship among hot channels, regional instability experienced in Figure 9-13, and core loading pattern.*

6. *Since the SRLR is not ready at this moment, please provide a detailed description and basis that the operational conditions for GGNS in the MELLLA+ operating domain are within expected parameters based on the data shown in Figures 2-7 through 2-15.*

**Response to questions 1-6**

1. The Supplement Reload Licensing Report (SRLR) and Core Operating Limits Report (COLR) for the GGNS cycle that implements MELLLA+ operation at the beginning of the cycle will be available before the start of the implementation cycle consistent with normal reload design practice. GGNS intends to implement MELLLA+ within the current operating cycle if approved. The reload core design details used in the cycle-specific SLMCPR evaluation to be included in the Technical Specification change request to support MELLLA+ implementation in the current operating cycle (Cycle 20) are available now. The SRLR and COLR activities are still in-progress with an expected October, 2014 completion. If GGNS Cycle 21 implements MELLLA+ at the start of the

cycle, the Technical Specification change request to support MELLLA+ operation will be available approximately 6 months before the start of the cycle.

2. The details to obtain a final loading pattern are cycle-specific. The equilibrium core loading should not be interpreted as a cycle specific final loading pattern. The licensing procedure, guidance, criteria, and approved methodologies are defined by GESTAR-II (Reference 22-1) to support the cycle-specific reload licensing. The equilibrium core design information provided in the M+SAR is representative of expected conditions if the MELLLA+ core flow capability is used continuously cycle after cycle (i.e. equilibrium).

3. The GGNS M+SAR Figures 2-1 through 2-6 are plotted as a function of cycle exposure for the equilibrium core design consistent with the GGNS PUSAR and other plant EPU applications based on the Methods LTR SER Limitation and Condition 9.24 (Reference 22-2).

    a. The GGNS M+SAR equilibrium core design has a maximum cycle exposure of 18.615 GWd/ST (20.520 GWd/MT), a maximum bundle exposure of 47.239 GWd/ST (52.072 GWd/MT), and a maximum nodal exposure of 54.272 GWd/ST (59.825 GWd/MT).

    b. Table 22.1 includes the requested data values for the GGNS M+SAR curve supporting SAR Figures 2-1 through 2-6. The requested peak Linear Heat Generating Rate (LHGR) at peak nodal exposure is different than the data in SAR Figure 2-6. The bundle with peak nodal exposure is typically third cycle bundles on the periphery during most of the cycle and then third cycle bundles in the center of the core near End of Cycle (EOC). The reload core design may or may not have a third cycle bundles in the center of the core. The maximum LHGR for a third cycle bundle in GGNS is <8 kw/ft on the interior and <5 kw/ft on the periphery. The Thermal-Mechanical Operating Limit (TMOL) curve for GNF2 as defined by GESTAR-II (Reference 22-1) is satisfied independent of the operating domain using bundle design (pin-by-pin enrichment and gadolinia configuration) and core design (loading of fresh, once, and twice burnt streams). Figure 22.1 shows the peak nodal LHGR by bundle versus peak nodal exposure by bundle for the GGNS M+SAR equilibrium core design operation from Beginning of Cycle (BOC) to EOC.

    c. Peak nodal exposure data for GGNS MELLLA+ at equilibrium – 120%-OLTP is not included in GGNS M+SAR Table 2-1 because GGNS is only licensed at 115% OLTP consistent with the previously approved PUSAR.

4. No bundles in the GGNS MELLLA+ equilibrium core design experience boiling transition at steady-state conditions. The GGNS MELLLA+ equilibrium core design will not be used to establish a cycle-specific Safety Limit Minimum Critical Power Ratio (SLMCPR). The cycle-specific reload licensing activity will statistically determine the 0.1% rods in boiling transition using GESAM to establish the required SLMCPR for TLO and SLO conditions. The SLMCPR evaluation process to support MELLLA+ operation is performed at several power/flow statepoints as defined by MELLLA+ LTR SER Limitation and Condition 12.6 (Reference 22-3) at BOC/MOC/EOC cycle exposure conditions. Since the limiting rod

pattern used in the SLMCPR evaluation may be different at each of the evaluation conditions, the bundles that may experience boiling transition will be different. It is also expected that the SLMCPR results observed in the GGNS MELLLA+ equilibrium will be different from the reload core design that implements MELLLA+.

5. The GGNS MELLLA+ equilibrium core design was established independent of knowing the results of stability or ATWS-I activities. No specific changes were made to the fuel design or core design in the equilibrium core to change the stability behavior. The data in SAR Figure 9-13 is based on the GGNS MELLLA+ equilibrium core design.

6. The 2D core data in SAR Figures 2-7 through 2-15 are representative of the GGNS MELLLA+ equilibrium core design showing bundle power, LHGR, and MCPR results. LHGR and MCPR are satisfied on a cycle- specific basis by design because these Specified Acceptable Fuel Design Limits (SAFDLs) are required. The equilibrium core design details shown in GGNS M+SAR Figures 2-7 through 2-15 are an example of what to expect for GGNS for MELLLA+ operating domain. The actual reload cycle that implements MELLLA+ is expected to be similar.

**References**

22-1 Global Nuclear Fuel, "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-20 and NEDE-24011-P-A-20-US, December 2013.

22-2 GE Hitachi Nuclear Energy, "Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P-A, Revision 4, November 2012.

22-3 GE Hitachi Nuclear Energy, "General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus Licensing Topical Report," NEDC-33006P-A, Revision 3, June 2009.

[[

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**Figure 22.1 Peak Nodal LHGR by Bundle Versus Peak Nodal Exposure by Bundle**

**Table 22.1. Requested Data Values Supporting GGNS M+SAR**

[[

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## 23.0 TECHNICAL SPECIFICATIONS

1. *Please provide justification for changing the pump discharge pressure of the SLCS from 1340 to 1370 psig in Surveillance Requirement 3.1.7.7.*

2. *Provide approved methodologies used to support the proposed addition of TS 5.6.5.a.6.*

**Response to questions 1 and 2**

1. The maximum reactor upper plenum pressure for MELLLA+ operation during the limiting ATWS event, when SLCS is credited for operation, is 1222.3 psig (1237 psia), as reported in Section 6.5.3 of Reference 23-1. The maximum expected SLCS pump discharge pressure for the limiting ATWS event is 1369.3 psig, based on a reactor upper plenum pressure of 1222.3 psig and a SLCS pressure drop of 147 psi. Adding the line losses gives the required pump discharge pressure (1222.3+147=1369.3 psig) as reported in Section 6.5.3 of Reference 23-1. Thus, the technical specification (TS) change recommendation provides the pump discharge value of >1370 psig.
2. The proposed addition of TS 5.6.5.a.6 is supported by the methodology described in the reviewed and approved Detect and Suppress Solution - Confirmation Density (DSS-CD) Licensing Topical Report (LTR) (Reference 23-2) as follows:

   4) Manual Backup Stability Protection (BSP) Region I and II: Section 7.2 in Reference 23-2

   5) BSP Boundary: Section 7.3 in Reference 23-2

   6) Automated BSP (ABSP): Section 7.4 in Reference 23-2

   The proposed addition is consistent with the example TS changes provided in Appendix A of the DSS-CD LTR (Reference 23-2).

**Reference**

23-2. GEH Nuclear Energy, "Safety Analysis Report for Grand Gulf Nuclear Station Maximum Extended Load Line Limit Analysis Plus," NEDC-33612P, Revision 0, September 2013.

23-2 GE Hitachi Nuclear Energy, "GE Hitachi Boiling Water Reactor, Detect and Suppression Solution – Confirmation Density," NEDC-33075P-A, Revision 8, November 2013.

## 24.0 TURBINE TRIP EVENTS

*Results for TTNBP during an AWTS-I event are not included in the SAR. Provide results for TTNBP in the MELLLA+ operating domain..*

**Response to question**

Typically, the Turbine Trip Without Bypass (TTNBP) case is not performed for Anticipated Transient Without Scram (ATWS) for the following reasons:

- The event is extremely unlikely by coupling the improbable event of a complete scram failure with an additional complete failure of the bypass,
- The TTWBP event displays similar results for ATWS-Instability (ATWS-I), and
- The Main Steam Isolation Valve Closure (MSIVC) event is performed and is generally more limiting than the TTNBP event during the initial pressurization part of the transient as discussed in NEDE-24222.

For purposes in responding to this request, the TTNBP with scram failure is analyzed for instabilities and the results are shown in Figure 24-1. It is noted the depressurization is not accounted for in this analysis. [[

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**Figure 24.1. Comparison of TTWBP and TTNBP Events - Best-Estimate TRACG ATWS Analysis in MELLLA+ Operating Domain – BOC with Regional Instability**

## 25.0 SIMULATOR UPDATE

1. *Describe up-to-date training status of the key operator actions credited in the TRACG ATWS instability analysis.*

2. *Provide the schedule when the GGNS Simulator will be completely updated for operators' training in the MELLLA+ operating domain.*

**Response to questions 1 and 2**

1. The key operator actions credited in the ATWS instability analysis are unchanged from those actions that are in the current GGNS ATWS response procedures. As prescribed in the existing emergency procedures, these actions consist of controlling reactor vessel level, core power, and reactor pressure. Since these same operator actions are applicable for the higher rodlines associated with MELLLA+ operation and are credited in the ATWS instability analyses in NEDO-33612 (Attachment 4 to GNRO-2013/00012), no significant changes to these actions are anticipated for MELLLA+ implementation.

   To support its review and approval of the GGNS EPU, on October 27, 2011 the NRC staff conducted an on-site audit of the implementation of stability long-term solutions and the impact of EPU on instability and an Anticipated Transient without Scram (ATWS) event as documented in GNRO-2012/00017. GGNS recognizes that the Staff may want to perform a similar simulator audit for the post-MELLLA+ operator actions associated with ATWS instability mitigation.

2. The schedule when the GGNS Simulator will be completely updated for operators' training in the MELLLA+ operating domain has not yet been completed. However, Simulator modifications associated with the MELLLA+ modifications and associated operator actions will be completed prior to operation in the MELLLA+ region.

**Attachment 4**

**GNRO-2014/00045**

**RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION #8 DATED 5/19/2014 PERTAINING TO LICENSE AMENDMENT REQUEST – MAXIMUM EXTENDED LOAD LINE LIMIT PLUS**

**(NON-PROPRIETARY VERSION)**

## 8.0 LARGE BREAK AND SMAL BREAK LOCA

*Section 4.3.1 "Break Spectrum Response and Limiting Single Failure" states that "A number of small break sizes were evaluated at the rated Current Licensed Thermal Power (CLTP)/Rated Core Flow (RCF)."*

1. *Prove a list of cases evaluated and indicate the limiting case.*
2. *The evaluation was performed at RCF. Provide an explanation why the results will not be significantly different at minimum (80%) or maximum (105%) core flow.*
3. *The Small-Break Loss-Of-Coolant Accident (SBLOCA) results in Table 4-4 show the top-peaked axial power shape is limiting compared to the mid-peaked power shape. The results for Large-Break Loss-Of-Coolant Accident (LBLOCA) in Table 4-3 show the mid-peaked axial power shape being limiting. Explain the difference in these results.*
4. *In Section 4.3.2, explain the following regarding Table 4-3:*
    a. *Why the mid-peaked axial power shape is analyzed and a calculation for the toppeaked or bottom-peaked axial power shape is not shown.*
    b. *Why the mid-peaked axial power shape is limiting in terms of the Peak Cladding Temperature (PCT) difference between the value of first peak at mid-peak and the value at top-peaked axial power shape.*
    c. *Why the first peak is lower than the second peak for the mid-peaked axial power shape calculation at 100% power MELLLA+ condition and the second peak is higher than first peak at the Appendix K condition.*
    d. *Provide a plot of PCT versus time for the LBLOCA top- and mid-peaked axial power shape cases.*

**Response**

1. The text referenced is from Section 4.3.1 second paragraph regarding M+LTR SER Limitation and Condition 12.14 requiring a sufficient number of small recirculation line break sizes being analyzed at CLTP and RCF. A list of the small break size cases evaluated is listed in Table 4-4 and below as well. These reported small break cases are deemed sufficient in identifying the break area associated with the limiting small break PCT. The break area is incrementally adjusted until the largest PCT is identified and reported along with the adjacent small break size results showing lower PCT values. The limiting small break case is a recirculation suction line break with an area of 0.08 $ft^2$ and evaluated with Appendix K assumptions and top peak axial power shape. The resultant PCT is 1363 °F. The mid peak axial power shape is also examined for the limiting small break scenario to ensure the top peak axial power shape remains limiting.

| Power / Flow % CLTP / % RCF | Nominal PCT (°F) | |
|---|---|---|
| | 1st Peak | 2nd Peak |
| 100 / 100 | 636 (top-peak, 0.07 $ft^2$) | 1067 (top-peak, 0.07 $ft^2$) |
| | 675 (top-peak, 0.08 $ft^2$) | 1133 (top-peak, 0.08 $ft^2$) |
| | 686 (top-peak, 0.09 $ft^2$) | 1088 (top-peak, 0.09 $ft^2$) |

| Power / Flow % CLTP / % RCF | Appendix K PCT (°F) | |
|---|---|---|
| | 1st Peak | 2nd Peak |
| 100 / 100 | 609 (top-peak, 0.07 $ft^2$) | 1335 (top-peak, 0.07 $ft^2$) |
| | 643 (top-peak, 0.08 $ft^2$) | 1363 (top-peak, 0.08 $ft^2$) |
| | 713 (top-peak, 0.09 $ft^2$) | 1293 (top-peak, 0.09 $ft^2$) |

| Power / Flow % CLTP / % RCF | Appendix K PCT (°F) | |
|---|---|---|
| | 1st Peak | 2nd Peak |
| 100 / 100 | 604 (mid-peak, 0.08 $ft^2$) | 1244 (mid-peak, 0.08 $ft^2$) |

2. The fuel remains in nucleate boiling until core uncovery for the small recirculation line break. Therefore, MELLLA+ will not adversely affect the small break LOCA response (Reference 8-1 Section 4.3).

   The small recirculation line break evaluation was performed at rated core flow (100%) rather than minimum MELLLA+ core flow because the core flow reduction generally yields a reduced maximum PCT. Operating at full power with reduced core flow yields increased subcooling in the downcomer region, which tends to increase the break flow for breaks drawing coolant from the affected region (exemplified by recirculation line breaks discharging from the downcomer). The increased break flow resulting from higher subcooling in the downcomer region reduces the vessel level more quickly than in the case of rated core flow such that the automatic depressurization system (ADS) actuates at an earler time in the event and subsequently earlier low pressure ECCS injection occurs. Differences in core inlet subcooling and core average void fraction resulting from the reduced core flow will, however, tend to produce a first PCT peak (i.e. the PCT occurring prior to ADS actuation) greater in value when compared to the rated core flow case. The second PCT peak, occurring after ADS and low pressure ECCS injection when fuel heatup is dominated by decay heat, determines the maximum PCT, as shown in the values reported in Table 4-4. Given the behavior of the second PCT peak being much larger than the first PCT peak and the fact that the second PCT peak is predominantly established by ECCS injection timing, which occurs earlier for the minimum core flow case and results in lower PCT values, the small recirculation line break evaluations were performed at rated core flow.

   As opposed to reduced core flow, increased core flow (105%) conditions are characterized by a slight reduction in downcomer subcooling when compared to rated core flow conditions. For the small break scenario, the reduced downcomer subcooling results in a lower initial break flow and correspondingly small delay in ADS actuation and ECCS injection. For the magnitude of the subcooling difference case by the 105% increased core

flow, the change in second PCT peak between rated core flow and increased core flow is insignificant, such that the rated core flow case sufficiently represents the increased core flow condition as well.

3. Historically the LOCA analysis assumed a mid peak axial power shape only for both large and small recirculation line breaks. It was determined by the nature of the small break with its gradual depressurization and extended period of uncovered fuel in the upper elevation of the core that a top peak axial power shape could result in a higher PCT. A study was performed to determine the impact on the PCT for both large and small breaks using a top peak axial power shape with the results reported to licensees in Notification Letter 2006-01. The difference in PCT results between the mid peak and top peak axial power shape in Table 4-3 and Table 4-4 as shown for Grand Gulf are consistent with that study. In general the mid peak axial power shape is limiting for the large recirculation line breaks and the top peak axial power shape is limiting for the small recirculation line breaks but the limiting axial power shape must be confirmed based on the limiting case for both large and small recirculation line breaks, which is required by Limitation and Condition 12.11 of the SER for LTR NEDC-33006P-A.

4a. Table 4-3 provides large recirculation line break Appendix K PCT results for both mid peak and top peak axial power shape at %CLTP / %RCF conditions of 100 / 100 and 100 / 93 and 100 / 80. In general the mid peak axial power shape is limiting for the large recirculation line breaks. The limiting large break is analyzed with a top peak axial power shape to confirm the mid peak axial power shape is more limiting. The bottom peak axial power shape is bounded by the mid peak and top peak axial power shape and therefore not analyzed.

4b. Table 4-3 provides large recirculation line break Appendix K PCT results for first PCT peak and second PCT peak using both mid peak and top peak axial power shapes at %CLTP / %RCF conditions of 100 / 100 and 100 / 93 and 100 / 80.

The difference between the Appendix K second PCT peak with mid peak axial power shape and the Appendix K second PCT peak with top peak axial power shape is consistent with Notification Letter 2006-01, as described in Response 3 above.

The Appendix K PCT results are consistent for all three core flows with the second PCT peak larger than the first PCT peak for both axial power shapes. The second PCT peak is larger than the first PCT peak because a portion of the fuel is completely uncovered for an extended period of time during the second PCT peak where a portion of the fuel is partially uncovered for a brief period of time during the first PCT peak.

4c. The large recirculation line break results for Appendix K assumptions in Table 4-3 show the second PCT peak is larger than the first PCT peak for both mid peak and top peak axial power shape. This is an expected trend for the limiting Appendix K results.

The first PCT peak occurs in the first 10 seconds during the rapid depressurization of the vessel due to the large break and rapid core flow decrease due to the recirculation pump in the broken loop losing suction and ceasing to pump almost immediately. The core flow decrease may cause boiling transition to occur in the upper portion of the fuel requiring film boiling or transition boiling heat transfer rates to apply. The cladding temperature

rapidly increases with the drop in heat transfer driven by the stored energy in the fuel. This initial heat up forms the first PCT peak.

The second PCT peak occurs approximately 150 seconds into the event when the water level inside the shroud decreases due to the large recirculation line break and uncovers the core for an extended period of time from 20 seconds to 100 seconds into the event. The vessel blowdown ends around 30 seconds into the event with the vessel essentially empty and only a few feet of water remaining in the lower plenum. The ECCS is initiated on low water level and begins injecting around 80 seconds into the event to fill the lower plenum and then the core. The heat up due to the core uncovering forms the second PCT peak, which is larger than the first PCT peak.

The large recirculation line breaks for nominal assumptions shown in Table 4-3 are calculated for methodological purposes only to determine compliance with the licensing basis PCT and are not limiting as compared to the results with Appendix K assumptions. The large break results for nominal assumptions in Table 4-3 show the second PCT peak is larger than the first PCT peak for pre CLTP and rated core flow. However, the cases along the MELLLA+ boundary to CLTP and rated core flow show the second PCT peak is smaller than the first PCT peak. The methodology allows the possibility for the first PCT peak, occurring early in the transient, to be larger than the second PCT peak and is possible for nominal assumptions.

4d. The plot of Appendix K PCT versus time for the large break cases with mid peak and top peak axial power shape at %CLTP / %RCF conditions of 100 / 100, 100 / 93 and 100 / 80 are provided. The table below lists the order of the plots for the large break.

| **Power / Flow % CLTP / % RCF** | **Figure** | **Appendix K PCT (°F)** | |
|---|---|---|---|
| | | **1st Peak** | **2nd Peak** |
| 100 / 100 | 8.1 | 1239 (mid-peak) | 1692 (mid-peak) |
| | 8.2 | 1053 (top-peak) | 1560 (top-peak) |
| 100 / 93 | 8.3 | 1250 (mid-peak) | 1700 (mid-peak) |
| | 8.4 | 1061 (top-peak) | 1561 (top-peak) |
| 100 / 80 | 8.5 | 1304 (mid-peak) | 1671 (mid-peak) |
| | 8.6 | 1080 (top-peak) | 1484 (top-peak) |

**Reference:**

8-1. NEDC-33006P-A, "Licensing Topical Report General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus", Revision 3, June 2009.

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**Figure 8.1 Grand Gulf MELLLA+ Large Break - 100 %CLTP / 100 %RCF – Mid Peak**

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**Figure 8.2 Grand Gulf MELLLA+ Large Break - 100 %CLTP / 100 %RCF – Top Peak**

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**Figure 8.3 Grand Gulf MELLLA+ Large Break - 100 %CLTP / 93 %RCF – Mid Peak**

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**Figure 8.4 Grand Gulf MELLLA+ Large Break - 100 %CLTP / 93 %RCF – Top Peak**

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**Figure 8.5 Grand Gulf MELLLA+ Large Break - 100 %CLTP / 80 %RCF – Mid Peak**

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**Figure 8.6 Grand Gulf MELLLA+ Large Break - 100 %CLTP / 80 %RCF – Top Peak**

**Attachment 5**

**GNRO-2014/00045**

**GEH AFFIDAVIT FOR ATTACHMENT 1**

## GE-Hitachi Nuclear Energy Americas LLC

## AFFIDAVIT

**I, Peter M. Yandow,** state as follows:

(1) I am the Vice President, Nuclear Plant Projects/Services Licensing, Regulatory Affairs, of GE-Hitachi Nuclear Energy Americas LLC ("GEH"), 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 Enclosure 1 of GEH letter, GEH-GGNS-AEP-638, "GEH Responses to MELLLA+ Reactor Systems Branch," dated June 19, 2014. The GEH proprietary information in Enclosure 1, which is entitled "GEH Response to NRC RXSB RAIs in Support of GGNS MELLLA+ LAR," is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]] 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, GEH relies upon the exemption from disclosure set forth in the *Freedom of Information Act* ("FOIA"), 5 U.S.C. Sec. 552(b)(4), and the *Trade Secrets Act*, 18 U.S.C. Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for trade secrets (Exemption 4). The material for which exemption from disclosure is here sought also qualifies 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, 975 F.2d 871 (D.C. Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F.2d 1280 (D.C. Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. Some examples of categories of information that 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 GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information that, if used by a competitor, would reduce their expenditure of resources or improve their competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

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

d. Information that discloses trade secret or potentially patentable subject matter for which it may be desirable to obtain patent protection.

(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 GEH,

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 GEH, not been disclosed publicly, and not been made available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary or confidentiality agreements that provide for maintaining the information in confidence. The initial designation of this information as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in the following paragraphs (6) and (7).

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, who is the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or who is the person most likely to be subject to the terms under which it was licensed to GEH.

(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 for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH 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 or confidentiality agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains the detailed GEH methodology for pressure-temperature curve analysis for the GEH Boiling Water Reactor (BWR). These methods, techniques, and data along with their application to the design, modification, and analyses associated with the pressure-temperature curves were achieved at a significant cost to GEH.

The development of the evaluation processes along with the interpretation and application of the analytical results is derived from the extensive experience databases that constitute a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH'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 GEH. 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. GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH 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 GEH 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 GEH 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 is true and correct.

Executed on this 19th day of June 2014.

Peter M. Yandow

**Peter M. Yandow**
Vice President, Nuclear Plant Projects/Services
Licensing, Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC
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**Attachment 6**

**GNRO-2014/00045**

**GEH AFFIDAVIT FOR ATTACHMENT 3**

# GE-Hitachi Nuclear Energy Americas LLC

## AFFIDAVIT

**I, James F. Harrison,** state as follows:

(1) I am the Vice President, Regulatory Affairs, Fuels Licensing, of GE-Hitachi Nuclear Energy Americas LLC ("GEH"), 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 Enclosure 1 of GEH letter, GEH-GGNS-AEP-639, "GEH Response to MELLLA+ Reactor Systems Branch RAI 8," dated June 25, 2014. The GEH proprietary information in Enclosure 1, which is entitled "GEH Response to NRC RXSB RAI 8 in Support of GGNS MELLLA+ LAR," is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]] 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, GEH relies upon the exemption from disclosure set forth in the *Freedom of Information Act* ("FOIA"), 5 U.S.C. Sec. 552(b)(4), and the *Trade Secrets Act*, 18 U.S.C. Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for trade secrets (Exemption 4). The material for which exemption from disclosure is here sought also qualifies 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, 975 F.2d 871 (D.C. Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F.2d 1280 (D.C. Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. Some examples of categories of information that 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 GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information that, if used by a competitor, would reduce their expenditure of resources or improve their competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

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

d. Information that discloses trade secret or potentially patentable subject matter for which it may be desirable to obtain patent protection.

(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 GEH,

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 GEH, not been disclosed publicly, and not been made available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary or confidentiality agreements that provide for maintaining the information in confidence. The initial designation of this information as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in the following paragraphs (6) and (7).

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, who is the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or who is the person most likely to be subject to the terms under which it was licensed to GEH.

(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 for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH 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 or confidentiality agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains the details of GEH methodology. These methods, techniques, and data along with their application to the design, modification, and analyses were achieved at a significant cost to GEH.

The development of the evaluation processes along with the interpretation and application of the analytical results is derived from the extensive experience databases that constitute a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH'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 GEH. 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. GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH 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 GEH 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 GEH 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 is true and correct.

Executed on this 25th day of June 2014.

James F. Harrison
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