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November 27, 2017
Serial: HNP-17-078

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

Shearon Harris Nuclear Power Plant, Unit 1
Docket No. 50-400
Renewed License No. NPF-63

Subject: Response to Request for Additional Information Regarding A License Amendment Request Proposing Changes to Emergency Diesel Generator Technical Specifications Surveillance Requirements (CAC No. MF9828)

Ladies and Gentlemen:

By application dated June 5, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17156A216), Duke Energy Progress, LLC (Duke Energy), submitted a license amendment request to change Shearon Harris Nuclear Power Plant, Unit 1 (HNP) Technical Specifications Surveillance Requirements established for the Emergency Diesel Generators (EDGs). The proposed changes would restrict the steady-state voltage and frequency limits for EDG operation to ensure that accident mitigation equipment can perform as designed. The proposed changes would also increase the voltage limit for the EDG full load rejection test.

The Nuclear Regulatory Commission (NRC) staff reviewed the request and determined that additional information is needed to complete their review. Duke Energy received a request for additional information (RAI) from the NRC staff through electronic mail on October 2, 2017, with a required response date of November 2, 2017 (ADAMS Accession No. ML17289A306). On October 26, 2017, Duke Energy informed the NRC staff that additional time was needed to provide the RAI response and proposed a new date of November 27, 2017. The NRC staff agreed to a new date of November 27, 2017, for the RAI response. Duke Energy provided a letter to the NRC staff that identifies the RAI response date of November 27, 2017, on October 30, 2017 (ADAMS Accession No. ML17303B156).

Attachment 1 to this letter provides Duke Energy's response to the RAI questions. Attachment 2 to this letter provides a table of system evaluations referenced within Attachment 1 for certain RAI responses.

In accordance with 10 CFR 50.91(b), HNP is providing the state of North Carolina with a copy of this response.

This letter does not contain any regulatory commitments.

Should you have any questions regarding this submittal, please contact Jeff Robertson, Manager – Regulatory Affairs, at (919) 362-3137.

I declare under penalty of perjury that the foregoing is true and correct. Executed on November 27, 2017.

Sincerely,

Tanya M. Hamilton

Attachments:

1. Response to Request for Additional Information

2. Table of System Evaluations

cc: J. Zeiler, NRC Sr. Resident Inspector, HNP
W. L. Cox, III, Section Chief, N.C. DHSR
M. Barillas, NRC Project Manager, HNP
NRC Regional Administrator, Region II

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SERIAL HNP-17-078

ATTACHMENT 1

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

DOCKET NO. 50-400

RENEWED LICENSE NUMBER NPF-63

By application dated June 5, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17156A216), Duke Energy Progress, LLC (Duke Energy), submitted a license amendment request (LAR) to change Shearon Harris Nuclear Power Plant, Unit 1 (HNP), Technical Specifications (TS) Surveillance Requirements (SRs) established for the Emergency Diesel Generators (EDGs). The Nuclear Regulatory Commission (NRC) staff reviewed the request and determined that additional information is needed to complete their review. Duke Energy received a request for additional information (RAI) from the NRC staff through electronic mail on October 2, 2017 (ADAMS Accession No. ML17289A306), with a required response date of November 2, 2017. On October 26, 2017, Duke Energy informed the NRC staff that additional time was needed to provide the RAI response and proposed a new date of November 27, 2017. Duke Energy provided a letter to the NRC staff that identifies the RAI response date of November 27, 2017, on October 30, 2017 (ADAMS Accession No. ML17303B156). Duke Energy provides the following response to the RAI regarding the LAR. There are no changes to the information provided in the significant hazards consideration within the LAR submitted on June 5, 2017, because of this RAI response.

RAI 1:

The licensee is proposing to revise the HNP Technical Specification EDG voltage limit from 6900 plus or minus (±) 690 volts to 6900 ± 276 volts, and frequency limit from 60 ± 1.2 Hertz (Hz) to 60 ± 0.48 Hz. In section 3.5 of the Attachment 1 to the license amendment request (LAR), the licensee stated that the final safey analysis report (FSAR) analyses of record (AOR) remain bounding with the revised EDG voltage and frequency limits. However, the FSAR AOR may be affected by the revised EDG voltage and frequency limits through their impact to the performance characteristics of the safety grade equipment and systems credited in the AOR.

Provide the following additional information to support the validity of the FSAR AOR with the new EDG voltage and frequency limits:

a) Identify the loss-of-coolant accident (LOCA) and non-LOCA events from the FSAR Chapter 15 analyses crediting the equipment and systems powered by the EDG.

b) For each of the events listed in a), identify the equipment and systems powered by the EDG and credited in the FSAR AOR. The requested information should include the input values that represent the performance characteristics of the identified equipment and systems that were credited in the AOR. For example, the input values should include the flow rates of ECCS [emergency core cooling system] pumps and emergency feedwater pumps, isolation valve closure time, automatic actuation delay time, power-operated relief valve (PORV) delay and lifting time, etc.

c) Provide the new input values representing the performance characteristics of the identified equipment and systems powered by the EDG based on the revised voltage and frequency limits to demonstrate the Chapter 15 analyses identified in a) remain bounding with the new EDG voltage and frequency proposed values. The new input values should include the flow rates of ECCS pumps and emergency feedwater pumps, isolation valve closure time, automatic actuation delay time, PORV delay and lifting time, etc. Provide a discussion of the methodology used to determine the new input values based on the new EDG voltage and frequency limits and address the adequacy of the methodology used.

HNP Response:

1.a and 1.b) Equipment and systems powered by the EDG and credited in the FSAR AOR have been evaluated to ensure that the performance characteristics of these safety-grade equipment and systems are acceptable with the new voltage and frequency limits. Induction motors in the safety-related pumps, fans, and valves considered in the accident analyses do not see any significant impact from variations in voltage for the requested EDG voltage tolerance of ± 4%. EDG frequency variations can affect pump and fan flow rates, as well as motor-operated valve (MOV) stroke times. Engineering evaluations show that safety-related pumps will continue to perform their design function. A summary of the evaluation of the ± 0.8% frequency tolerance on safety-related pumps is provided in Attachment 2. In addition, engineering evaluations show that the allowed stroke times of safety-related MOVs are not impacted by the proposed ± 0.8% EDG frequency tolerance (described further in response to RAI 1.c). The safety-related pressurizer PORVs are pneumatically operated valves and the control power for these valves is provided by direct current (DC) buses; therefore there is no impact to the operation of these valves with the new EDG voltage and frequency limits. The steam generator (SG) PORVs each have an electro-hydraulic operator and the control power for these valves is provided by alternating current (AC) motor control centers (MCCs), but there is no discernable impact to the SG PORV operation due to the new EDG voltage and frequency limits. Therefore, isolation valve closure times used in FSAR Chapter 15 analyses are not affected as a result of the revised TS voltage and frequency limits. In addition, there is no impact to any automatic actuation delay times with the new EDG voltage and frequency limits.

The impact of changing the EDG frequency tolerance to ± 0.8% (60 ± 0.48 Hz) on the accident analyses in the HNP FSAR Chapter 15, “Accident Analysis,” is limited to the inputs used for Safety Injection (SI) flow and Auxiliary Feedwater (AFW) flow. The FSAR Chapter 15 events that involve either SI flow and/or AFW flow were evaluated accordingly. Events that use minimum SI or AFW flow were evaluated relative to the EDG frequency tolerance on the low side, and events that use maximum SI or AFW flow were evaluated relative to the tolerance on the high side. From the evaluation results presented in Attachment 2, calculations were not completed for each system parameter evaluated. The basis for dispositoning each parameter is described within comments column of the Attachment 2 table.

For the LOCA event in FSAR Section 15.6.5, the assumed pump and fan performance characteristics for SI, AFW, Containment Fan Coolers (CFC), and Containment Spray (CT) were examined for the impact of a ± 0.8% EDG frequency tolerance. The Large Break LOCA (LBLOCA) analysis in FSAR Section 15.6.5.2 assumes maximum CFC performance and CT flow in order to minimize containment backpressure and maximize break flow. The assumed CFC performance in the FSAR Section 15.6.5.2 analysis exceeds the design capability of the fan coolers by a significant margin; this analytical margin is more than sufficient to accommodate a ±0.8% change in CFC fan speed due to the proposed variations in EDG frequency. A maximum two-pump CT flow of 5,000 gpm is assumed in the FSAR Section 15.6.5.2, LBLOCA analysis. This maximum flow rate bounds the calculated CT flow rates for the EDGs operating with an increased EDG frequency tolerance of 0.8%. The table in Attachment 2 identifies this limit, the nominal value, and the frequency adjusted value.

The FSAR Section 15.6.5.3, Small Break LOCA (SBLOCA) analysis supports a minimum AFW flow rate of 374 gpm, which remains bounding for the requested EDG frequency tolerance (also identified in Attachment 2). Minimum SI flow delivery curves were calculated for both high head safety injection (HHSI) and low head safety injection (LHSI) to account for an increased EDG frequency tolerance of ± 0.8%. The minimum SI flow curves were used to analyze the LBLOCA and SBLOCA events in FSAR Sections 15.6.5.2 and 15.6.5.3 AOR, respectively.

The evaluation of the non-LOCA FSAR Chapter 15 analyses determined that the following events could potentially be impacted by the EDG frequency tolerance increase due to the impact to SI and/or AFW flow. The evaluations described below were performed and no changes to the FSAR AOR were required.

1. Steam System Piping Failure (FSAR Section 15.1.5):
   The steam line break (SLB) event involves both AFW flow and SI flow; therefore, both were evaluated for the effect of EDG frequency tolerance. The EDG frequency tolerance on the high side may affect maximum AFW flow, while the EDG frequency tolerance on the low side may affect the minimum HHSI flow and timing of boron delivery to the core. This event assumes maximum AFW flow to the affected SG starting at event initiation and continuing throughout the event. A maximum AFW flow rate of 3000 gallons per minute (gpm) is used in the AOR, which bounds the effect of the EDG frequency tolerance on the high side (also identified in Attachment 2). Therefore, the requested EDG frequency tolerance on the high side for AFW flow has no effect on the SLB analysis.

   This event assumes a minimum SI flow rate to delay boron injection to the core, resulting in a conservative core power response during the return to power. The minimum HHSI flow rate from the AOR was compared to the minimum HHSI flow rate that includes the effect of the EDG frequency tolerance. This comparison shows that the HHSI flow rate with EDG frequency adjusted low produced only slightly less flow than the HHSI flow used in the SLB AOR, particularly over the range of Reactor Coolant System (RCS) pressure during a SLB event.

   The return to power for the Hot Full-Power (HFP) case with Reactor Coolant Pumps (RCPs) on is mitigated by boron injection. However, the increase in power at the time of boron injection (which is at or approximately the time of peak power) is very small. A small delay in boron injection as a result of a slightly lower HHSI flow rate will not significantly affect the peak return to power. Similar behavior exists for the HFP RCPs-off case and the Hot Zero-Power (HZP) RCPs-on case. For the HZP RCPs-off case, the peak return to power occurs well before boron reaches the core. Therefore, for this case, any minor delay in boron injection will have no effect on the peak return to power. In summary, the EDG frequency tolerance on the high side for AFW flow and low side for HHSI flow will have no significant effect on the FSAR Section 15.1.5, SLB AOR.

2. Loss of Non-Emergency AC Power to the Station Auxiliaries (FSAR Section 15.2.6):
   This event involves AFW and the effect of the EDG frequency tolerance on the low side for the assumed AFW flow has been addressed. The loss of non-emergency AC power AOR supports a minimum AFW flow rate of 374 gpm (total to three SGs). This minimum flow rate bounds the effect of the EDG frequency tolerance on the low side. Therefore, the AOR supports an EDG frequency tolerance of ± 0.8%.

3. Loss of Normal Feedwater Flow (FSAR Section 15.2.7):
   This event involves AFW and the effect of the EDG frequency tolerance on the low side for the assumed AFW flow has been addressed. The loss of normal feedwater flow AOR supports a minimum AFW flow rate of 374 gpm (total to three SGs). This minimum flow rate bounds the effect of the EDG frequency tolerance on the low side. Therefore, the AOR supports an EDG frequency tolerance of ± 0.8%.

4. Feedwater System Pipe Break (FSAR Section 15.2.8):
   The feedwater line break event involves both HHSI and AFW flow, and the effect of the EDG frequency tolerance on the assumed AFW and HHSI flow rates has been addressed. The

feedwater line break AOR supports a minimum AFW flow rate of 374 gpm (total to three SGs). This minimum flow rate bounds the effect of the EDG frequency tolerance on the low side.

The AOR limiting case uses a maximum HHSI flow rate. Within the analysis, the HHSI flow rate is modeled with a flow rate versus RCS pressure curve. A comparison of the AOR maximum HHSI flow rate to HHSI flow rates adjusted for an EDG frequency tolerance of + 0.8% shows the values are equivalent up to an RCS pressure of 1915 pounds per square inch absolute (psia). Above 1915 psia, the AOR values are higher than the values adjusted for the requested EDG frequency tolerance. Therefore, the feedwater line break AOR supports an EDG frequency tolerance of ± 0.8%.

5. Inadvertent Operation of the Emergency Core Cooling System During Power Operation (FSAR Section 15.5.1):
   The inadvertent operation of the ECCS during power operation event is initiated by spurious actuation of SI and assumes continuous SI throughout the event. This event does not involve AFW. This event is potentially affected by the EDG frequency tolerance for both the low and high side of the tolerance. There are three cases in the FSAR Section 15.5.1 AOR. This includes two cases to analyze departure from nucleate boiling (DNB) at beginning-of-cycle (BOC) and end-of-cycle (EOC) conditions, and a third case to address pressurizer overfill. The FSAR Section 15.5.1 analyses demonstrate that DNB is not challenged for this event, with the DNB ratio generally increasing throughout the transient. Small changes to HHSI from a ±0.8% EDG frequency tolerance do not affect this conclusion. For the pressurizer overfill case, the analysis biases HHSI flow high.

   Within the analysis, HHSI flow is modeled with a flow rate versus RCS pressure curve. A comparison of the AOR maximum HHSI flow rates to HHSI flow rates adjusted for an EDG frequency tolerance of + 0.8% shows the values are equivalent up to an RCS pressure of 1915 psia. Above 1915 psia, the AOR values are higher than the values adjusted for the requested EDG frequency tolerance, except for the data point at 2515 psia. However, the data point at 2515 psia has no significance for the pressurizer overfill analysis that bias HHSI flow high since the pressure range for this case is between 1935 psia and 2250 psia.

   For the pressurizer overfill case, RCS pressure remains relatively constant near 2250 psia out to the time that the pressurizer PORVs and safety relief valves (SRVs) open. The AOR maximum HHSI flow rate is slightly higher at 2250 psia than the HHSI flow rate that accounts for the requested EDG frequency tolerance. As a result, the pressurizer would fill at a slightly later time using the HHSI flow rates adjusted for the EDG frequency tolerance. However, the temperature of the fluid in the pressurizer when the pressurizer fills and the PORVs and SRVs open will not be significantly different and remains within the acceptable range. Therefore, the AOR remains bounding for the pressurizer overfill case.

6. Steam Generator Tube Rupture (FSAR Section 15.6.3):
   The steam generator tube rupture (SGTR) margin-to-overfill (MTO) analysis credits both HHSI and AFW flow, and the effect of the EDG frequency tolerance on the assumed AFW and HHSI flow rates has been addressed. In the SGTR MTO thermal-hydraulic analysis, the limiting case assumes a maximum AFW flow rate of 1,500 gpm. This maximum flow rate does not account for the effect of the EDG frequency tolerance on the high side or a single-failure of the Turbine Driven (TD) AFW speed controller. Accounting for both an increase in EDG frequency and TDAFW speed controller failure, the impact of a higher maximum AFW flow rate on the SGTR MTO analyses was evaluated, where the higher AFW flow rate was offset with a shorter time to isolate a faulted SG (also identified in Attachment 2).

The AOR limiting case uses maximum HHSI flow. A comparison of the AOR maximum HHSI flow rate curve to HHSI flow rates adjusted for an EDG frequency tolerance of + 0.8% shows the EDG frequency adjusted flow rates will exceed the AOR values at certain pressure points. Evaluations performed concluded that the differences in HHSI flow will have a negligible impact on the MTO analysis. More specifically, the AOR maximum HHSI flow rate curve remains bounding below 1950 psia. The EDG-frequency adjusted HHSI flow curve is higher between 2000 and 2300 psia. For the limiting SGTR case, RCS pressure remains between 1900 and 2100 psia from the time of SI actuation to the time of RCS depressurization. As such, the HHSI flow rates during this time period remain approximately the same. Therefore, the SGTR MTO analysis supports a ± 0.8% EDG frequency tolerance.

1.c) The new input values representing the performance characteristics of the equipment and systems powered by the EDG (as described in RAI 1.a and RAI 1.b response above) based on the revised voltage and frequency limits include SI flow rates, AFW flow rates, and MOV stroke times. A description of the methodology used to determine these new input values based on the new EDG voltage and frequency limits is provided below. Duke Energy considers these methods subject to change, at Duke Energy's discretion, in establishing future inputs to the accident analyses.

SI Flow Rates: The FSAR Chapter 15 analyses model SI flow with either maximum or minimum flow performance. The methods used to recalculate maximum and minimum SI flow rates with an EDG frequency tolerance of ± 0.8% are described below.

Maximum SI Flow: The FSAR Chapter 15 analyses that model maximum SI flow only consider the HHSI system. The maximum flow delivery of the HHSI system is derived from a bounding HHSI single-pump total dynamic head (TDH) versus flow performance curve, which is based on data collected from testing performed at HNP. To account for parallel HHSI pump operation associated with maximum SI flow conditions, the single-pump flow rates are doubled. The TDH and two-pump flow rate values in the bounding pump performance curve are increased using pump affinity laws to account for the increased EDG frequency. The specific pump affinity relationships used are shown below, where flow is proportional to shaft speed and pump total head is proportional to the square of the shaft speed:

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

$$\frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2$$

Q = volumetric flow rate
N = pump shaft rotational speed
H = pump total head

Since the pump shaft rotational speed is proportional to the EDG frequency, the ratio N_2/N_1 is 1.008 for the EDG operating at increased frequency of +0.8%, or 60.48 Hz. The EDG frequency-adjusted maximum two-pump HHSI TDH versus flow curve is used to develop an RCS pressure versus total pump flow curve for use in the accident analyses by including the elevation head between the pump suction source and the RCS injection location, as well as accounting for irrecoverable hydraulic losses in the SI system.

Minimum SI Flow: The minimum SI flow delivery curves were calculated for the HHSI and LHSI systems for FSAR Chapter 15 acident analyses considering the revised EDG frequency tolerance. The baseline single-pump HHSI and LHSI TDH versus flow performance curves are based on data collected from testing performed at HNP. The TDH values in the baseline HHSI curve are reduced to match the minimum pump performance criteria specified in HNP TS SRs 4.5.2.f.1 and 4.1.2.4, in order to account for degraded pump performance. Similarly, the TDH values in the baseline LHSI curve are reduced to meet the minimum performance criteria identified in HNP TS SR 4.5.2.f.2. The TDH and flow rate values in the degraded HHSI and LHSI pump performance curves are both adjusted downward using the pump affinity laws described above to account for the EDG operating at the lower frequency band of -0.8%.

The degraded EDG frequency-adjusted HHSI and LHSI performance curves are used in an S-RELAP5 hydraulic model of the SI system to calculate the delivered flow to the RCS as a function of RCS pressure. S-RELAP5 is a general purpose thermal-hydraulic code that is maintained by HNP's nuclear fuel analysis vendor AREVA NP, Inc. Example applications of the S-RELAP5 code for HNP are identified in License Amendment 138 issued on May 30, 2012 (ADAMS Accession No. 12076A103). Hydraulic losses in the S-RELAP5 SI model are further adjusted such that the calculated flow delivered to the RCS is reduced to match the minimum flow rate requirements in HNP TS SR 4.5.2.h.

AFW Flow Rates: As input into the HNP safety analyses, a minimum required total AFW delivery of 374 gpm from one motor-driven (MD) AFW pump to three SGs is assumed. This input is validated in a calculation that is a PROTO-FLO model of the AFW system. PROTO-FLO is an engineering product for safety-related calculations and is part of the Duke Energy software quality assurance program. PROTO-FLO performs steady-state analyses of thermal-hydraulic systems by iteratively solving an array of the same type of modified Bernoulli pressure-drop equations that would otherwise be solved manually. The calculation for minimum flow assumes the 'B' Train MDAFWP is delivering water from the Condensate Storage Tank to all three SGs. The nominal pump performance curve is first reduced until it meets the minimum pump performance criteria specified in HNP TS 3/4.7.1.2, in order to account for degraded pump performance. The speed of the pump is then reduced from a nominal 4,100 revolutions per minute (rpm) to 4,067 rpm, and the pump curve adjusted accordingly using the pump affinity laws, to account for an EDG frequency tolerance of 0.8%. The pressure in the SGs is set to 1,217 pounds per square inch gauge (psig), which bounds the set point of the lowest-pressure Main Steam Safety Valve (MSSV) plus 3% setpoint tolerance. The pump's minimum recirculation line is assumed to be open. The resulting calculation shows that one MDAFWP will deliver 379 gpm to three SGs under the conditions described above. This verifies that the AFW flow rate inputs remain conservative for the HNP safety analyses considering a ± 0.8% EDG frequency tolerance.

As input into the HNP safety analyses, a limiting case for the SGTR MTO thermal-hydraulic analysis assumes a maximum AFW flow rate of 1,500 gpm to three SGs. The maximum AFW flow rate for this event was re-calculated to account for a single-failure of the TDAFWP speed controller and an increased EDG frequency. The new maximum AFW flow rate for the SGTR MTO analysis is 2,250 gpm (also identified in Attachment 2). This delivery is calculated from a PROTO-FLO hydraulic model of the AFW system and is based on TDAFWP operation at a maximum controlled speed of 4,100 rpm and MDAFWP performance that is adjusted for +0.8% EDG frequency. The existing MTO volume of 66 cubic feet (ft) is maintained based upon a reduction in the time limit to isolate AFW to the faulted SG from 12 minutes to 8.8 minutes.

As input into the HNP safety analyses, a maximum total AFW flow rate of 3000 gpm to the faulted SG is assumed for the SLB analysis. This flow rate value has significant margin and no change was deemed necessary to accommodate the impact of the frequency tolerance. By inspection, a small increase in MDAFW flow from the EDG at a higher frequency would not consume the existing maximum flow rate margin (also identified in Attachment 2).

MOV Stroke Times: MOV isolation valve closure times used in FSAR Chapter 15 analyses are not affected as a result of the revised TS voltage and frequency limits. Steady-state speed of a motor is influenced by effects on torque, which in turn is affected by changes in voltage and frequency. Changes in voltage have a proportional effect on torque, which is equal to adjusted voltage divided by nominal voltage, squared, times torque at nominal voltage. Changes in frequency have a similar, inversely proportional effect on torque. The adjusted torque value is equal to the nominal frequency divided by adjusted frequency, squared, times torque at nominal frequency. The resultant minimum and maximum torque values and the driven equipment determine the valve stroke time.

The methodology used for calculating MOV torque is contained in the Duke Energy procedure for electrical calculations of motor output torque for MOVs. This procedure supports the implementation of the Duke Energy Nuclear Generation Group's MOV Program developed to address Generic Letter 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," with respect to MOV design-basis capability. MOV minimum and maximum torque values that are calculated in accordance with procedure guidance are contained in Calculation E5-0001, “Analysis of Motor Output Torque for AC Motor Operated Valves.” The results of this calculation are summarized in Table B1 of Calculation E5-0001, which was provided in the LAR within Attachment 3. As described in Attachment 1 of the LAR, Section 3.4.5, Table B.1 shows the minimum and maximum steady-state torque for each MOV for four cases (1) Offsite Power Available; (2) EDG operating at (current) T/S Variation Levels (values of 6900 VAC ± 690 VAC at 60 Hz ± 1.2 Hz); (3) EDG operating at EC [engineering change] 84102 Variation Levels (which are equal to the proposed TS limit values of 6900 ± 276 VAC at 60 Hz ± 0.48 Hz); and (4) the EDG at Voltage Regulator Levels (6500 VAC at the current TS upper frequency limit of 61.2 Hz).

Referring to Table B.1, MOV tag numbers are shown in a column on the left side of the table. Each tag identifies a system and a number (i.e., 1CC-99 is component cooling water valve 99). When Offsite Power is Available (Case 1), each MOV terminal voltage is calculated using the supply MCC voltage at the minimum transient voltage criteria (“Trans” column), at minimum steady state voltage criteria (“Lo SS” column), and at maximum voltage criteria (“Hi” column). For analysis when the EDGs are providing power (Cases 2, 3 and 4), each MOV terminal voltage is calculated using the supply MCC voltage at the minimum and maximum steady state voltages (“Lo SS” and “Hi” columns, respectively). For each Case, the calculated MOV terminal voltage is used to calculate the motor locked rotor amps (LRA) at each voltage level. The calculated motor terminal voltage and LRA are used to calculate the motor output torque during the various scenarios (“Trans”, “Lo SS” and “Max” columns). The summary column determines the ‘worst case’ motor torques from all of the scenarios evaluated.

A review of the Summary column data indicates that none of the motor torque steady-state minimum or maximum values are a result of the Case 3, EDG operating at EC 84102 Variation Levels (i.e. proposed TS voltage and frequency limits). Following implementation of the proposed EDG voltage and frequency variation TS changes, the values shown in Table B1, Case 2, EDG operating at (current) T/S Variation Levels, will no longer be applicable and the values presented in the Summary column will no longer be bounding**.** The remaining applicable data shown on Table B1 shows that the “EDG Operating at EC 84102 Variation Levels” motor torque minimum and maximum values calculated are bounded by, or equal to, the Case 1, Offsite Power Available motor torque minimum and maximum values. Therefore, following the change to the EDG steady-state voltage and frequency TS proposed limits, all analyzed MOV minimum and maximum torque values will be represented by the results of the evaluated “Offsite Power Available” case**.** As a result, MOV stroke times are bounded by Case 1, Offsite

Power Available. Therefore, MOV isolation valve closure times are not adversely affected as a result of the revised TS voltage and frequency limits.

RAI 2:

It is stated in Section 3.3 of the LAR, “The engineering evaluation and calculations demonstrate that the proposed frequency tolerance of ± 0.8% ensures safety-related pumps meet their design functions, and the accident analyses inputs and assumptions are maintained. The available net positive suction head and the required available net positive suction head of the safety-related pumps was considered for this evaluation.” Provide a list of the safety-related pumps that were evaluated. For each pump, provide the following, in order to demonstrate they will continue to perform their design function with the EDG proposed frequency tolerance: (1) flow rate at 59.52 Hz, 60 Hz, and 60.48 Hz; (2) the discharge pressure at 59.52 Hz, 60 Hz, and 60.48 Hz; and (3) required net positive suction head and available net positive suction head at 59.52 Hz, 60 Hz, and 60.48 Hz.

HNP Response:

The effects of a ± 0.8% frequency tolerance are incorporated into analyses for the following safety-related pumps:

- AFW Motor-Driven Pumps and Turbine-Driven Pump
- Component Cooling Water (CCW) Pumps
- CT Pumps
- Diesel Fuel Oil (DFO) Transfer Pumps
- Emergency Service Water (ESW) Pumps, Booster Pumps, and Screenwash Pumps
- Essential Services Chilled Water (ESCW) P-4 Pump and P-7 Pump
- Residual Heat Removal / Low Head Safety Injection (RHR) Pumps
- Charging and Safety Injection / High Head Safety Injection Pumps (CSIPs)
- Boric Acid Transfer (BAT) Pumps
- Spent Fuel Pool Cooling (SFPC) Pumps

A summary of the evaluation of the ± 0.8% frequency tolerance on system parameters (flow, pressure, and net positive suction head), the respective system parameter limits, and any low pressure alarms is provided in Attachment 2. In most cases, values for all three frequencies of 59.52 Hz (under-frequency), 60 Hz (nominal), and 60.48 Hz (over-frequency) were not calculated for the systems identified above and are not available. Only the limiting case of either over-frequency or under-frequency was calculated, and these values are provided.

RAI 3:

It is stated in Section 3.4.5 of the LAR, “In addition, the impact to the Auxiliary Feedwater (AFW), Emergency Service Water (ESW), Component Cooling Water (CCW), Spent Fuel Pool Cooling (SFPC), Boric Acid Transfer (BAT), and ESCW systems have been evaluated, and the conclusion reached for each of these systems is that equipment functions and limits are maintained with the ± 0.8% frequency tolerance value.” Provide the following data that was evaluated for each pump in these systems: (1) flow rate at 59.52 Hz, 60 Hz, and 60.48 Hz; (2) the discharge pressure at 59.52 Hz, 60 Hz, and 60.48 Hz; and (3) required net positive suction head and available net positive suction head at 59.52 Hz, 60 Hz, and 60.48 Hz. Also provide the minimum required flow rate, the minimum required discharge pressure, and any low-pressure alarm settings for each pump.

HNP Response:

A summary of the evaluation of the ± 0.8% frequency tolerance on system parameters, the respective system parameter limits, and any low pressure alarms is provided in Attachment 2. Only the limiting case of either over-frequency or under-frequency was calculated, and these values are provided.

RAI 4:

In its LAR, the licensee did not provide the following information that addresses EDG performance for the EDG new proposed frequency. For the EDG lube oil pump and jacket water pump on the EDG skid, provide the (1) flow rate at 59.52 Hz, 60 Hz, and 60.48 Hz, (2) the discharge pressure at 59.52 Hz, 60 Hz, and 60.48 Hz, and (3) required net positive suction head and available net positive suction head at 59.52 Hz, 60 Hz, and 60.48 Hz. Also provide the minimum required flow rate, the minimum required discharge pressure, and any low-pressure alarm settings for each pump.

HNP Response:

By design, the engine-driven lube oil pump and engine-driven jacket water pump supply 100% of the lubricating oil and jacket water cooling requirements, respectively, of the EDG during normal and emergency operation. The motor-driven lube oil keep-warm pump and motor-driven jacket water pumps operate to supply warmed oil and jacket water, respectively, to the EDG while it is in standby to facilitate EDG starts. During a normal or emergency start, the EDG control system automatically deenergizes the motor-driven lube oil keep-warm pump and motor-driven jacket water keep-warm pump once the engine speed reaches 200 rpm.

Both the engine-driven lube oil pump and the engine-driven jacket water pump are mechanically driven by the engine; therefore, their speed is directly proportional to the speed of the engine. At 60 Hz, the corresponding engine speed is 450 rpm. Based on a pump drive gear ratio of 4.357:1, the corresponding engine-driven lube oil pump speed is 1960.7 rpm (4.357×450). The corresponding engine-driven jacket water pump speed is 1470 rpm. For the new proposed frequency limits of 60 Hz ± 0.8% (i.e. 60 ± 0.48 Hz), the engine and pump speeds will also vary by ± 0.8% as follows:

- Engine: 450 rpm ± 0.8% or 446.4 rpm (450×59.52/60) to 453.6 rpm (450×60.48/60);
- Lube Oil Pump: 1960.7 rpm ± 0.8% or 1945 rpm (4.357×446.4) to 1976.3 rpm (4.357×453.6);
- Jacket Water Pump: 1470 rpm ± 0.8% or 1458.2 rpm (1470×446.4/450) and 1481.8 rpm (1470×453.6/450)

Both the engine-driven lube oil pump and the engine-driven jacket water pump were provided by the EDG original equipment manufacturer, Transamerica Delaval Enterprise, as part of the EDG skid package, which did not contain the flow characteristics of these pumps.

<u>Engine-Driven Lube Oil Pump</u>: The engine-mounted lubrication system piping and components meet the guidelines described by the Diesel Engine Manufacturers Association (DEMA) standards. From DEMA Standard Practices for Low and Medium Speed Stationary Diesel and Gas Engines, Sixth Edition, 1972, an engine-driven pump “must have sufficient capacity to maintain the minimum allowable pressure when the engine is operated at reduced speeds. This results in a pump which may have a substantial excess capacity at rated speed. In some instances the resulting excess of oil is bypassed around the engine and is returned directly to the sump. The bypassed amount is controlled by a pressure regulating valve.”

The engine-driven lube oil pump is a positive-displacement screw type pump. Its nominal flow capacity is 500 gpm. Any changes in oil temperature and, therefore, lube oil viscosity over the proposed EDG operating speed range of 450 rpm ± 0.8% are expected to be minimal; therefore, given that the lube oil pump is a positive displacement pump, its discharge flow will essentially be directly proportional to pump speed. Lubricating header oil pressure is regulated by two pressure regulating valves nominally set to 50 psig. The pressure regulating valves are connected to the discharge pipe of the lube oil pump and have sensing lines connected to the main lube oil header. The pressure regulating valves regulate main lube oil header pressure by diverting excess flow from the lube oil pump back to the lube oil sump tank. As such, changes in lube oil viscosity and lube oil pump flow are compensated for by varying the flow of lube oil returned to the lube oil sump tank. The Lube Oil System main header low lube oil pressure alarm and trip setpoints are nominally set for 40 psig and 31 psig, respectively. The low lube oil pressure trip is bypassed during emergency operation. From EDG operating procedure guidance, the expected lube oil pressure during EDG operation is between 45-55 psig, which is at a minimum of 12.5% above the nominal alarm setpoint and approximately 45% above the trip setpoint. There are no flow-related alarms or trips.

Qualification testing by the EDG OEM showed that lube oil pressure remains essentially constant between 400 rpm and 450 rpm. From operating experience, lube oil pressure does not approach the lube oil system trip setpoints until the EDG reaches a speed well under 350 rpm. During the monthly surveillance test runs, Operations procedurally verifies proper operation of the governor controls by manually lowering frequency to 59 Hz and raising frequency to 61 Hz. There are no Lube Oil System pressure alarms actuated during this evolution.

<u>Engine-Driven Jacket Water Pump</u>: The engine-driven jacket water pump is a centrifugal pump and its nominal flow capacity is 1550 gpm at a TDH of 48.5 ft. Based on pump affinity laws for the centrifugal engine-driven jacket water pump, pump flow will be directly proportional to pump speed, and pump head will change by the square of the change in pump speed. Therefore, for a pump speed range of ± 0.8%, pump flow would be expected to change approximately ± 0.8%, and pump head would be expected to change approximately ± 1.6%. Based on the nominal rating of 1550 gpm, pump flow would be expected to be on the order of 1538 gpm (1550×0.992) at an engine speed of 446.4 rpm (59.52 Hz) and on the order of 1562 gpm (1550×1.008) at an engine speed of 453.6 rpm (60.48 Hz). As such, the flow rate changes are approximately ± 12 gpm, which is small compared to the total flow. From the Diesel Engine Instruction Manual, a reduction in jacket water flow of 250 gpm would result in an increase in temperature differential across the engine of approximately 1.6 degrees Fahrenheit (°F), with several °F of margin remaining. As such, it is reasonable to conclude that a 12 gpm change in flow rate will result in an insignificant change in engine differential temperature.

The design maximum jacket water temperature differential across the engine is 15 °F. The high jacket water inlet and outlet temperature alarms are nominally set at 175 °F and 190 °F, respectively. The jacket water high temperature trip is nominally set at 195 °F. The jacket water high temperature trip is bypassed during emergency operation. Based on operating history, the jacket water temperature differential across the engine is consistently less than 10 °F up to 110% load. Furthermore, jacket water outlet temperature is consistently less than 170 °F. In conclusion, a change in flow rate on the order of 12 gpm associated with the proposed frequency limits will not challenge the substantial margin available with regard to the allowed engine differential temperature.

There is a jacket water low pressure alarm nominally set at 9 psig and a jacket water low pressure trip nominally set a 7 psig. The jacket water low pressure trip is bypassed during emergency operation. There are no high jacket water high pressure alarms or trips. Based on operating history, the jacket water pressure is consistently between 13-14 psig and is not EDG load dependent. Based on pump affinity laws, the pump head or differential pressure would be expected to change approximately ± 1.6% from nominal over the proposed frequency range. The engine-driven jacket water pump has a nominal flow capacity of 1550 gpm at a TDH of 48.5 ft. A 48.5 ft TDH equates to a 21 psig (0.433 psig per ft water column × 48.5 ft) differential pressure across the pump. A ± 1.6% change in pressure equates to a pressure range of 21 ± 0.34 psig. Assuming this pressure change results in the same magnitude change at the jacket water supply header where the alarm and trip pressure switches and pressure indicator tap is located, the resultant range in jacket water pressure would be from 12.66 (13-0.34) psig to 14.34 (14+0.34) psig. From EDG operating procedure guidance, the expected jacket water pressure during EDG operation is between 10-20 psig. The margin to the alarm and trip setpoints would be 3.66 psig and 5.66 psig, respectively; and the margin to operating limits is 2.66 (12.66-10) psig and 5.66 (20-14.34) psig. From these values, the minimum margin is 26.6% (2.66/10×100), which is deemed to be acceptable. In conclusion, the 0.34 psig change in pressure associated with the proposed frequency limits will not challenge the margin available with regard to the allowed EDG jacket water pressure.

RAI 5:

In order to demonstrate that the EDG fuel oil consumption is not affected by the proposed frequency tolerances, for the fuel oil transfer pump, provide the (1) flow rate at 59.52 Hz, 60 Hz, and 60.48 Hz, (2) the discharge pressure at 59.52 Hz, 60 Hz, and 60.48 Hz, and (3) required net positive suction head and available net positive suction head at 59.52 Hz, 60 Hz, and 60.48 Hz.

HNP Response:

The EDG fuel oil consumption is driven by engine load. Although the load is increased by a small amount when the frequency increases, the increase in load has a minimum impact on its margin to capacity. A summary of the evaluation of the ± 0.8% frequency tolerance on the DFO transfer pump parameters and limits associated with these parameters is included in Attachment 2. Values for all three frequencies of 59.52 Hz, 60 Hz, and 60.48 Hz were not calculated for the DFO transfer system. Only the limiting case of either over-frequency or under-frequency was calculated, and these values are provided.

RAI 6:

Discuss whether or not any relief valves on the affected pumps' discharge piping will lift due to the higher discharge pressure when the EDG is operating at 60.48 Hz. If a relief valve will lift, explain how the affected pumps will continue to perform their design function at the higher frequency.

HNP Response:

The EDG operation at 60.48 Hz and the impact to the relief valves on discharge piping for affected pumps in the systems identified in Attachment 2 have been evaluated. The evaluation concludes that relief valves on the affected discharge piping in these systems will not lift.

SERIAL HNP-17-078

ATTACHMENT 2

TABLE OF SYSTEM EVALUATIONS

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

DOCKET NO. 50-400

RENEWED LICENSE NUMBER NPF-63

System Evaluations	*Nominal Value*	*Frequency-Adjusted Value*	*Limit*	*Comments*
Auxiliary Feedwater				
Under-Frequency (-0.8%) and Flow				
In-Service Test (IST) Program Limits	No change to IST limits			TS limits continue to bound frequency-adjusted design-basis limits.
Minimum SG Delivery	See comments	379 gpm	≥ 374 gpm	The EDG frequency tolerance was incorporated with a separate change to analyses for changes to MSSV setpoint tolerance, which decreased the minimum AFW flow rate from 390 gpm to 374 gpm (implemented by License Amendment 151), so the prior nominal value of 390 gpm is not directly comparable to the frequency-adjusted value.
Minimum Motor-Driven Pump Flow During Pump Start-up	49 gpm	See comments	≥ 50 gpm	Minimum nominal flow rate is conservatively calculated at the high-flow/low-pressure end of pump curve (~420 gpm). The increase in pressure at low flow is credited to meet the 50 gpm vendor requirement without reanalysis for EDG frequency.
Under-Frequency (-0.8%) and Pressure				
No limits or analyses identified	-	-	-	
Over-Frequency (+0.8%) and Flow				
Maximum SG Delivery – SGTR MTO	66 ft^3	66 ft^3	≥ 66 ft^3	MTO is unchanged with EDG frequency tolerance since a decrease in allowed time to isolate the faulted SG was incorporated into the calculation. MTO analysis is based upon a 2,250 gpm total AFW delivery, which includes the motor-driven pump +0.8% speed adjustment.
Maximum SG Delivery – SLB	2,513 gpm	See comments	≤ 3,000 gpm	Existing margin is sufficient to compensate for EDG frequency tolerance without reanalysis.
Over-Frequency (+0.8%) and Pressure				
Minimum Recirculation Flow Discharge Pressure	1,606 psig	1,631 psig	≤ 1,700 psig	1,700 psig is the discharge pipe design pressure.
Motor-Driven Pump Pressure Control Valves	580 gpm	See comments	≤ 600 gpm	Pressure Control Valves will control pump flow below a runout value of 600 gpm. By inspection, EDG frequency tolerance will not have an adverse effect on valve control.

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
Low Suction Pressure Alarm	8.62-10.1 psig	See comments	≥ 9 psig ± 1	Alarm for indication only of potential low available net positive suction head (NPSHA). Nominal high-flow/minimum pressure conditions may result in alarm, as it should. By inspection, small frequency impact will not significantly affect alarm likelihood or function.
Low Suction Pressure Trip	8.62-10.1 psig	See comments	≥ 6 psig ± 1	By inspection, small frequency impact would not result in trip based on available margin.
Steady-State Net Positive Suction Head (NPSH) for Motor-Driven Pumps	41.93 ft (A Train) 40.90 ft (B Train)	See comments	≥ 17 ft	By inspection, small frequency impact is acceptable based on available margin.
Steady-State NPSH for Turbine-Driven Pump	51.54 ft	See comments	≥ 12 ft	By inspection, small frequency impact is acceptable based on available margin.
Transient NPSH for Turbine-Driven Pump	50.79-63.89 ft	49.7-63.11 ft	See comments	This is the NPSHA range for this pump in the initial ~37 seconds following a main steam or feedwater line break. Acceptance of the nominal and adjusted ranges is based on the short duration of the transient and a small difference between low end of the range and a vendor test, which successfully ran the pump at runout flow for two minutes with a NPSHA of 51 ft.
Component Cooling Water				
Under-Frequency (-0.8%) and Flow				
IST Program Limits	87.9 psi pump dP (A, B, & C Trains)	89.7 psi pump dP	See comments	The minimum required CCW pump differential pressure (dP) raised as shown to ensure minimum flows will continue to be supplied. The actual pump dP is between 95-97 psi.
Single Failures	See comments	See comments	See comments	Since alignment of CCW to the essential flow loop involves some operator action, various inadvertent valve manipulations were analyzed for effects on flow and pressure. The analyses applied a conservative 7% adjustment to the calculated results, which is credited to compensate for EDG frequency tolerance.
Under-Frequency (-0.8%) and Pressure				
Low Header Pressure Alarm	83.23 psig	See comments	≥ 57 psig ± 1	By inspection, small frequency impact is acceptable based on available margin.

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
Low Header Pressure Auto-Start	83.23 psig	See comments	≥ 52 psig ± 1	By inspection, small frequency impact is acceptable based on available margin.
Over-Frequency (+0.8%) and Flow				
No limits or analyses identified	-	-	-	
Over-Frequency (+0.8%) and Pressure				
NPSH – Single Pump Operation	91.56 ft	See comments	≥ 26.24 ft	By inspection, small frequency impact is acceptable based on available margin.
NPSH – Dual Pump Operation	107.7 ft	See comments	≥ 16.39 ft	By inspection, small frequency impact is acceptable based on available margin.
Containment Spray				
Under-Frequency (-0.8%) and Flow				
IST Limits	No change to IST limits			TS limits continue to bound frequency-adjusted design-basis limits.
Spray Header Fill Time	32.18 seconds (A Train) 31.40 seconds (B Train)	32.67 seconds (A Train) 31.82 seconds (B Train)	≤ 33.1 seconds	A 33.1-second fill time used as input in containment analysis.
Offsite/Main Control Room Dose Analysis	No change to analysis – see comments			Credit taken for existing 10% margin already applied to CT system resistance curve.
Containment Sump/Spray pH	No change to analysis – see comments			Credit taken for existing 5% adjustments made to pump performance curves. For containment spray, sensitivity analysis also found sodium hydroxide injection rates insensitive to moderate changes in CT pump performance.
Under-Frequency (-0.8%) and Pressure				
CT Pump Discharge Low Pressure Alarm	See comments	See comments	≥ 170 psig ± 5	This alarm serves to indicate a valve alignment problem, pipe rupture, or pump malfunction and does not result in any automatic action. EDG frequency will not affect these alarm causes or their diagnoses.

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
Over-Frequency (+0.8%) and Flow				
Refueling Water Storage Tank (RWST) Minimum Required Switchover Volume Margin	20,620 gallons	19,316 gallons	≥ 0 gallons	Volume margin is the usable water remaining in the RWST following transition from injection to recirculation. This margin is a function of CT, LHSI (RHR), and HHSI (CSIP) pump demands.
Injection Mode Duration – Minimum Time (Maximum Safeguards)	23.68 minutes	23.26 minutes	≥ 20 minutes	20 minutes is used as input in containment analyses. This time is a function of CT, RHR, and CSIP pump demands.
Injection Mode Duration – Maximum Time (Minimum Safeguards)	2,210 seconds	2,215 seconds	≥ 2,210 seconds	2,210 seconds is used as input in containment analyses. This time is a function of CT, RHR, and CSIP pump demands. The slight increase in time is due to margin credited from existing nominal RHR and CSIP pump flow rates.
Maximum CT Injection (Dual Train)	4,104 gpm	4,422 gpm	≤ 5,000 gpm	5,000 gpm is used as input into LBLOCA analysis. Total CT flow is the sum of A and B Train injection flow rates. Revised analysis to incorporate EDG frequency tolerance also corrected latent system resistance error.
RWST Vortex Formation – Minimum Depth Margin	2.00 ft	1.87 ft	≥ 0 ft	This margin is a function of CT, RHR, and CSIP pump demands, as well as gravity flow from the RWST to the containment sump.
Over-Frequency (+0.8%) and Pressure				
CT Pump Low Suction Pressure Alarm	See comments	See comments	≥ 12 psig ± 1	This alarm serves to indicate a valve alignment problem or an instrument malfunction and does not result in any automatic action. EDG frequency will not affect these causes or their diagnoses.
NPSH – Injection Mode	92.3 ft	91.99 ft	≥ 13 ft	
NPSH – Recirculation Mode	25.71 ft	25.57 ft	≥ 12.4 ft	
Diesel Fuel Oil Transfer				
Under-Frequency (-0.8%) and Flow				
IST Limits	No change to IST limits			ASME Code limitations continue to bound frequency-adjusted design-basis limits.

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
Minimum Fuel Oil Delivery to EDG	25.5 gpm	25.4 gpm	≥ 7.6 gpm	
Under-Frequency (-0.8%) and Pressure				
No limits or analyses identified	-	-	-	
Over-Frequency (+0.8%) and Flow				
EDG Fuel Consumption	See comments	See comments	See comments	Maximum EDG fuel consumption is driven by load, not speed and the application of an EDG frequency tolerance does not change engine load. The fuel consumption rate used in the calculation is the full-load rated (nameplate) fuel consumption rate, which will not be exceeded.
Over-Frequency (+0.8%) and Pressure				
NPSH	34.88 ft	34.82 ft	≥ 4.06 ft	
Emergency Service Water				
Under-Frequency (-0.8%) and Flow				
IST Limits – ESW Pumps	100.7 psi (A Train) pump dP	102.4 psi (A Train) pump dP	See comments	Minimum required A Train ESW pump dP raised as shown to ensure that minimum flows and pressures would continue to be supplied. Actual pump dP is approximately 105 psi. The original margin was later restored by subsequent analysis. The B Train ESW Pump dP unchanged by EDG frequency tolerance.
IST Limits – ESW Booster Pumps	No change to IST limits			
Under-Frequency (-0.8%) and Pressure				
IST Limits – ESW Screenwash Pumps / Screenwash Nozzle Pressure	66 psig (A & B Trains)	67.2 psig (A & B Trains)	See comments	The minimum required screenwash nozzle pressure raised as shown. Actual nozzle pressures are in excess of 78 psig.
ESW Pump Low Discharge Pressure Alarm	63 psig	See comments	≥ 53 psig ± 2	This alarm serves to indicate failure of an ESW Pump to start and does not result in any automatic action. By inspection, small frequency impact will not result in alarm.

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
ESW Booster Pump Low Discharge Pressure Alarm	140 psig	See comments	≥ 90 psig ± 5	This alarm serves to indicate possible valve misalignment or pipe rupture and does not result in any automatic action. By inspection, EDG frequency will not result in alarm.
Over-Frequency (+0.8%) and Flow				
No limits or analyses identified	-	-	-	
Over-Frequency (+0.8%) and Pressure				
ESW Pump Discharge Strainer High dP Alarm	3.6 psi	See comments	≤ 8 psi ± 0.5	Margin is sufficient to conclude by inspection that EDG frequency will not result in alarm. Note that automatic strainer backwash occurs at 5 psi and strainer backwash flow is accounted for in system design calculations.
Submergence – ESW Pumps	11.9 ft (A & B Trains)	See comments	≥ 6 ft	By inspection, small frequency impact is acceptable based on available margin.
NPSH – ESW Booster Pumps	166 ft (A Train) 182 ft (B Train)	See comments	≥ 22 ft	By inspection, small frequency impact is acceptable based on available margin.
NSPH – ESW Screenwash Pumps	~ 200 ft (A & B Trains)	See comments	≥ 6 ft	By inspection, small frequency impact is acceptable based on available margin.
Essential Services Chilled Water				
Under-Frequency (-0.8%) and Flow				
IST Limits	No change to IST limits			P-4 pumps circulate chilled water through system. Existing P-4 Pump IST limits ensure minimum chilled water flows are maintained.
P-7 Pump Flow	1,000 gpm	See comments	≥ 971 gpm	P-7 pumps recirculate service water through chiller condenser under low-flow conditions for thermal mixing. P-7 Pumps are not in the IST Program. Original P-7 pump design margin of ~3% is sufficient to account for EDG frequency tolerance.
Under-Frequency (-0.8%) and Pressure				
No limits or analyses identified	-	-	-	

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
Over-Frequency (+0.8%) and Flow				
No limits or analyses identified	-	-	-	
Over-Frequency (+0.8%) and Pressure				
NPSH for P-4 Pumps	43 ft	See comments	≥ 9 ft	P-4 pumps circulate chilled water through system. By inspection, small frequency impact is acceptable based on available margin.
NPSH for P-7 Pumps	~ 185 ft	See comments	See comments	Vendor limit for P-7 required NPSH is not readily available. However, as P-7 pump suction comes from the ESW supply header, a frequency increase will also increase P-7 pump suction pressure through a ESW Pump speed increase. From inspection, there is no significant impact on P-7 Pump NPSH margin.
Residual Heat Removal (Low Head Safety Injection)				
Under-Frequency (-0.8%) and Flow				
IST Limits	No change to IST limits			For RHR, EDG frequency was incorporated into a calculation that requires the minimum RHR performance curve to be adjusted by ±0.8% Hz for use in safety analyses. As a result, IST limits are unaffected.
Containment Sump/Spray pH	No change to analysis – see comments			Credit taken for existing 5% adjustments made to pump performance curves.
Under-Frequency (-0.8%) and Pressure				
RHR Pump Low dP Pressure Alarm	See comments	See comments	≥ 114 psig ± 0.75	Alarm is used as indicator of vortexing at reduced inventory and is not applicable to emergency conditions.
Over-Frequency (+0.8%) and Flow				
RWST Minimum Required Switchover Volume Margin	Refer to Containment Spray summary			
Injection Mode Duration – Minimum Time (Maximum Safeguards)	Refer to Containment Spray summary			
Injection Mode Duration – Maximum Time (Minimum Safeguards)	Refer to Containment Spray summary			

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
RWST Vortex Formation – Minimum Depth Margin	Refer to Containment Spray summary			
Over-Frequency (+0.8%) and Pressure				
RHR Pump High Discharge Pressure Alarm	180 psig	See comments	≤ 580 psig ± 3.5	This alarm serves to indicate high RCS pressure, valve misalignment, thermal expansion with pump discharge isolated (RHR Pump secured), or RHR discharge check valve back-leakage (RHR Pump secured). EDG frequency will not affect the alarm causes or their diagnoses and, by inspection, large margin will prevent an alarm.
NPSH – Injection Mode	83.46 ft (A Train) 79.21 ft (B Train)	See comments	≥ 19 ft	Existing (nominal) analysis is based on RHR run-out flow rate of 4,500 gpm that bounds predicted maximum frequency-adjusted RHR flow rate of 4,410 gpm. Thus, there is no frequency-adjusted NPSH result.
NPSH – Recirculation Mode	20.85 ft (A & B Trains)	See comments	≥ 19 ft	Existing (nominal) analysis is based on RHR run-out flow rate of 4,500 gpm that bounds predicted maximum frequency-adjusted RHR flow rate of 4,410 gpm. Thus, there is no frequency-adjusted NPSH result.
Charging and Safety Injection (High Head Safety Injection)				
Under-Frequency (-0.8%) and Flow				
IST Limits	No change to IST limits			For HHSI, EDG frequency was incorporated into a calculation that requires the minimum CSIP performance curve to be adjusted by ±0.8% Hz for use in safety analyses. As a result, IST limits are unaffected.
Containment Sump/Spray pH	No change to analysis – see comments			Credit taken for existing 5% adjustments made to pump performance curves.
CSIP Minimum Flow (Alternate Minimum Flow) – RCS Pressure Setpoint	2,200 psig	2,000 psig	See comments	Alternate minimum flow path opens at RCS pressure setpoint to protect weaker of two CSIPs operating in parallel (to ensure 60 gpm minimum flow). The adjustment of the stronger CSIP for +0.8% Hz and weaker CSIP for -0.8% Hz changed the setpoint as shown.
Under-Frequency (-0.8%) and Pressure				
No limits or analyses identified	-	-	-	

System Evaluations	Nominal Value	Frequency-Adjusted Value	Limit	Comments
Over-Frequency (+0.8%) and Flow				
RWST Minimum Required Switchover Volume Margin	Refer to Containment Spray summary			
Injection Mode Duration – Minimum Time (Maximum Safeguards)	Refer to Containment Spray summary			
Injection Mode Duration – Maximum Time (Minimum Safeguards)	Refer to Containment Spray summary			
RWST Vortex Formation – Minimum Depth Margin	Refer to Containment Spray summary			
Maximum CSIP Injection-Mode Flow	880 gpm	892 gpm	≤ 1,000 gpm See comments	1,000 gpm is a value originally supplied by Westinghouse that was used as input into certain analyses.
Maximum CSIP Recirculation-Mode Flow	660 gpm	665 gpm	See comments	An injection-mode limit of ≤ 685 gpm per TS SR 4.5.2.h.b is conservatively applied to the recirculation-mode analysis.
Over-Frequency (+0.8%) and Pressure				
NPSH – Injection Mode	33.35 ft	33.34 ft	≥ 30 ft	Frequency-adjusted CSIP maximum flow rates remain bounded by the original assumed flow rate of 710 gpm. As a result, there is no significant change in injection-mode NPSH.
Boric Acid Transfer				
Under-Frequency (-0.8%) and Flow				
IST Limits	No change to IST limits.			ASME Code limitations continue to bound frequency-adjusted design-basis limits.
Under-Frequency (-0.8%) and Pressure				
No limits or analyses identified	-	-	-	
Over-Frequency (+0.8%) and Flow				
No limits or analyses identified	-	-	-	

System Evaluations			Nominal Value	Frequency-Adjusted Value	Limit	Comments
	Over-Frequency (+0.8%) and Pressure					
		BAT Pump Discharge Filter High dP Alarm	See comments	See comments	≤ 20 psi	This alarm serves to provide local indication to initiate manual filter backwash. Clean and dirty dP values are typically 5 psi and 20 psi respectively. By inspection, EDG frequency will have no significant impact on alarm frequency or impact of alarm.
		NPSH	25 ft	See comments	≥ 6 ft	By inspection, small frequency impact is acceptable based on margin.
Spent Fuel Pool Cooling						
	Under-Frequency (-0.8%) and Flow					
		IST Limits	No change to IST limits.			ASME Code limitations continue to bound frequency-adjusted design-basis limits.
	Under-Frequency (-0.8%) and Pressure					
		SFPC Pump Low Discharge Pressure Alarm	≥ 53 psig	See comments	≥ 50 psig	This alarm serves to provide indication of a possible pipe rupture or a pump suction valve misposition. By inspection, the minimum available pressure margin will not lead to an alarm. Alarm function and diagnosis is not affected by EDG frequency tolerance.
	Over-Frequency (+0.8%) and Flow					
		No limits or analyses identified	-	-	-	
	Over-Frequency (+0.8%) and Pressure					
		SFPC Pump Suction Strainer High dP Alarm	See comments	See comments	≤ 10 psi	This alarm serves to provide local indication to initiate manual filter backwash. The normal dP range is between 1-10 psi. By inspection, EDG frequency will have no significant impact on alarm frequency or the impact of this alarm.
		NPSH	60 ft	See comments	≥ 19 ft	By inspection, small frequency impact is acceptable based on available margin.