UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BLVD.
KING OF PRUSSIA, PA 19406-2713

August 9, 2017

EA-17-023

Mr. Brian Sullivan
Site Vice President
Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360-5508

SUBJECT: PILGRIM NUCLEAR POWER STATION – FINAL SIGNIFICANCE DETERMINATION FOR A GREEN FINDING AND RESULTS OF REGULATORY CONFERENCE - INSPECTION REPORT 05000293/2017008

Dear Mr. Sullivan:

This letter provides you the final significance determination for the preliminary greater-than-Green finding discussed in the U.S. Nuclear Regulatory Commission (NRC) letter dated May 10, 2017, which included NRC Inspection Report Number 05000293/2016011 (ML17129A217).[1] As described in the May 10, 2017, letter, the finding was associated with an apparent violation of 10 CFR Part 50, App. B, Criterion III, "Design Control." It involved the failure by Entergy Nuclear Operations, Inc. (Entergy), in May 2000, to account for potential new failure mechanisms on a new component, a replacement gearbox that included an oil relief valve, on the right angle drive for the 'A' Emergency Diesel Generator (EDG) radiator blower fan. As a result, Entergy did not consider the need to periodically monitor or maintain the valve, which subsequently failed, as identified by Entergy on September 28, 2016, when licensee staff noted oil on the deck and identified that the oil level in the radiator fan gearbox was below the vendor's minimum recommended level. This resulted in the 'A' EDG apparently being inoperable for a period greater than its technical specification allowed outage time.

To ensure that the NRC used the best available information in its final significance determination, the May 10, 2017, letter provided Entergy the option to attend a regulatory conference or reply in writing to provide its position on the facts and assumptions the NRC used to arrive at the finding's preliminary safety significance. At Entergy's request, a regulatory conference (which was open for public observation) was conducted on July 13, 2017, at the NRC's Region I office in King of Prussia, Pennsylvania. During the conference, Entergy provided a presentation (ML17191A787) that described its assessment of the significance of the finding and the corrective actions being taken to prevent recurrence. Entergy agreed with the finding and violation, but considered the finding was of very low (Green) safety significance.

[1] Designation in parentheses refers to an Agency-wide Documents Access and Management System (ADAMS) accession number. Documents referenced in this letter are publicly-available using the accession number in ADAMS.

Specifically, Entergy presented the results of a 24-hour endurance test of the affected gearbox and related components that was performed on June 5-6, 2017, by an independent third-party vendor and observed by NRC inspectors. For the test, the gearbox was placed in conditions that approximated the parameters identified in September 2016. The conditions included oil level, temperature, physical set-up, etc. Entergy stated that the gearbox successfully performed its function of transmitting power to the EDG blower fan for the entire 24-hour run-time, and that temperature and vibration data reached acceptable steady-state values within a few hours of initiation of the test. Entergy stated that the test demonstrated the gearbox would have fulfilled its safety function for at least the required 24 hours and that the finding should be Green because the 'A' EDG was only unavailable while Entergy evaluated and corrected the low oil condition. A summary of the information presented by Entergy at the Regulatory Conference and the NRC's evaluation of that information, as well as a list of the NRC and Entergy attendees, is provided in Enclosure 1.

After careful consideration of the information developed during the inspection and the information provided at the Regulatory Conference, the NRC has concluded that the finding is of very low safety significance and is, therefore, appropriately characterized as Green. This conclusion was primarily based on the NRC's independent observation and review of the endurance test, and resulting NRC conclusion that the gearbox was functional for the 24 hour test and that, therefore, the 'A' EDG was likely functional at any time prior to September 2016 with respect to the as-found degradation of the gearbox. The finding, including a brief description of the revised risk analysis to reach the final significance determination, is provided in Enclosure 2. A more detailed description of the NRC's independent review of Entergy's endurance test and assessment, and the quantitative criteria used in the final detailed risk evaluation are provided in Enclosure 3. As documented in Enclosure 2, the NRC determined that the finding involved a violation of Title 10 of the Code of Federal Regulations, Part 50, Appendix B, Criterion III, "Design Control." Because the issue is of very low safety significance (Green) and is not willful, and because Entergy restored compliance within a reasonable period of time and entered this issue into its Corrective Action Program (CR-PNP-2016-9706 & CR-PNP-2016-07443), the violation is being treated as a non-cited violation (NCV) consistent with Section 2.3.2.a of the NRC Enforcement Policy.

If you contest the violation or significance of the NCV, you should provide a response within 30 days of the date of this letter, with the basis for your denial, to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001, with copies to: (1) the Regional Administrator, Region I, 2100 Renaissance Boulevard, Suite 100, King of Prussia, PA 19406; (2) the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001; and (3) the NRC resident inspectors at Pilgrim Nuclear Power Station.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice and Procedure," a copy of this letter, its enclosure, and your response, if you choose to provide one, will be made available electronically for public inspection in the NRC Public Document Room or from the NRC's Agency-wide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction.

Should you have any questions regarding this matter, please contact Mr. Arthur Burritt, Chief, Projects Branch 3, Division of Reactor Projects, at (610) 337-5069.

Sincerely,

Daniel H. Dorman
Regional Administrator

Docket No. 50-293
License No. DPR-35

Enclosures:
1. Summary of July 13, 2017, Regulatory Conference with Entergy and list of attendees
2. Description of NRC finding with revised risk evaluation
3. NRC Independent review of Entergy's endurance test and assessment

cc w/encl: Distribution via ListServ

ENCLOSURE 1

SUMMARY OF JULY 13, 2017, REGULATORY CONFERENCE WITH ENTERGY AND LIST OF NRC AND ENTERGY ATTENDEES

REGULATORY CONFERENCE SUMMARY

On July 13, 2017, the NRC and representatives of the Entergy Nuclear Operations, Inc. (Entergy) Pilgrim Nuclear Power Station participated in a regulatory conference in the NRC's Region I office. The conference was open for public observation. Entergy requested the conference to discuss a finding that the NRC described in Inspection Report No 05000293/2016011 issued on May 10, 2017, as having been preliminarily determined to be greater-than-Green (GTG), a finding of greater than very low safety significance. The report documented that the finding also involved an apparent violation (AV 05000293/2016011-06; EA-17-023) of 10 CFR Part 50, App. B, Criterion III, "Design Control." It involved Entergy's failure, in May 2000, to account for potential new failure mechanisms on a new component (a relief valve) on the right angle drive for the 'A' Emergency Diesel Generator (EDG) radiator blower fan. As a result, Entergy did not consider the need to periodically monitor or maintain the valve, which subsequently failed, as identified by Entergy on September 28, 2016, resulting in the 'A' EDG apparently being inoperable for a period greater than its technical specification allowed outage time. As described below, during the conference, Entergy staff agreed with the finding and violation, but considered the finding was of very low (Green) safety significance.

At the conference, Entergy presented the results of a 24-hour endurance test of the affected gearbox and related components that was performed on June 5-6, 2017, by an independent third-party vendor and observed by NRC inspectors. For the test, the gearbox was placed in conditions that approximated the parameters identified in September 2016 for oil level, temperature, physical set-up, etc. Entergy stated that the gearbox successfully performed its function of transmitting power to the EDG blower fan for the entire 24-hour run-time, and that temperature and vibration data reached acceptable steady-state values within a few hours of initiation of the test. Further, the test showed that, although oil leaked from the relief valve during the first 20 minutes of the test, no further leakage occurred. Following the test, Entergy performed a detailed inspection and did not identify any damage or degradation to the gearbox that would have impacted its ability to operate for 24 hours. Entergy also presented information about the gearbox design and operating conditions. Namely, Entergy stated that the gearbox was a robust component, and designed to transmit approximately three times more power than was needed to drive the radiator fan. Additionally, Entergy stated that the high air flow (>30 mph) generated by the 'A' EDG cooling fan provided convective cooling that could remove any additional heat generated by operation of the gearbox in the low oil operation. Finally, Entergy stated that the oil contained additives that created a permanent film on the surfaces of the internal components, thereby maintaining lubrication even under low oil conditions.

Based on these considerations, Entergy stated that the test demonstrated that the gearbox would have fulfilled its safety function for at least the required probabilistic risk assessment (PRA) mission time of 24 hours. Entergy also postulated that, based on extrapolation of the test results, the gearbox would have continued to operate with the low oil condition for an extended period of time; potentially 30 days. Entergy stated that the risk significance of the finding should be Green based on the amount of time the 'A' EDG was unavailable only being limited to the time required for Entergy to evaluate and correct the low oil condition.

Entergy also discussed the results of its two root cause evaluations (RCEs) related to the gearbox issue. The first evaluation (RCE-2016-07443) examined the specific low oil condition of the gearbox and the resultant impact on the 'A' EDG function. The second evaluation (RCE-

2016-09706) examined potential programmatic deficiencies, including those pertaining to the initial installation of the gearbox without appropriate design control considerations. Entergy discussed planned and completed corrective actions identified through each evaluation, including the status of an extent of cause and condition for similar equipment which identified no other similar concerns. The specific corrective actions discussed by Entergy are described in the Enforcement section of the NRC finding that is documented in Enclosure 2.

NRC inspectors observed the test and reviewed its results and confirmed that the gearbox components and configuration and the test conditions were substantially similar to or representative of the as-found conditions for the affected gearbox. The NRC inspectors verified that bearing temperatures and gearbox vibrations were monitored during the entire 24-hour endurance run and observed that vibrations reached steady-state within about one hour and bearing temperatures reached steady-state within approximately two hours. The inspectors also obtained information from the vendor that suggested the gearbox is rated for 2.5 times the design speed and 3 times the horsepower used in the actual in-service conditions in the plant. The inspectors determined that the gearbox was designed to operate in conditions exceeding its application at Pilgrim.

Based on its independent observations, the NRC agreed with the licensee's conclusion that the gearbox was functional for the 24-hour test and that, therefore, the 'A' EDG was functional for its PRA mission time at any time prior to September 28, 2016 with respect to the as-found degradation of the gearbox. Therefore a detailed risk evaluation (Enclosure 3) was performed to consider the risk increase attributed to the unavailability of the 'A' EDG during the repair of the relief valve and assessment of the gearbox. However, the NRC determined that the test results did not provide conclusive evidence that the gearbox would have continued to function for the 30 day stated mission time referenced within Licensed Event Report 2016-008-00.

NRC AND ENTERGY REGULATORY CONFERENCE ATTENDEES

NRC Attendees:
Daniel H. Dorman, Regional Administrator, Region I (RI)
Michael L. Scott, Director, Division of Reactor Projects (DRP), RI
Raymond K. Lorson, Director, Division of Reactor Safety (DRS), RI
Mike King, Deputy Director, Division of Inspection and Regional Support, Office of Nuclear Reactor Regulation, (NRR)
Paul Peduzzi, Deputy Director, Office of Enforcement (OE)
Arthur L. Burritt, Chief, DRP Branch 5
Frank J. Arner, Senior Reactor Analyst, DRS, RI
Niklas Floyd, Reactor Inspector, DRS, RI
Matthew S. Leech, Reliability & Risk Analyst, Division of Risk Assessment, NRR
Marjorie McLaughlin, Senior Enforcement Specialist, RI

Entergy Attendees:
Brian Sullivan, Site Vice President, Pilgrim Nuclear Power Station (PNPS)
David Noyes, Director, Recovery, PNPS
Thomas White, Manager, Design and Programs Engineering, PNPS
Grant Flynn, Senior Manager, Operations
Ronald Gaston, Director, Regulatory Compliance, Entergy
Everett Perkins, Manager, Regulatory Assurance, PNPS
Christopher Costanzo, Chief Operating Officer, Northern Fleet, Entergy
Craig Swanner – MPR
John Minderman – MPR
Joe Lavelline – Enercon

ENCLOSURE 2

DESCRIPTION OF NRC FINDING AND REVISED RISK EVALUATION TO SUPPORT FINAL SIGNIFICANCE DETERMINATION

Introduction. The inspectors identified a Green finding with a related, non-cited violation (NCV) of 10 CFR Part 50, Appendix B, Criterion III, "Design Control," associated with Entergy's failure to ensure that design changes were subject to design control measures commensurate with those applied to the original design and were approved by the designated responsible organization. Specifically, Entergy received a new style right angle drive for the 'A' emergency diesel generator (EDG) radiator blower fan from a vendor, but failed to adequately review the differences between the design of the original and replacement drive to identify potential new failure mechanisms for the part or the need for related preventive measures.

Description. On September 28, 2016, while performing prestart checks on EDG X-107A, operations department personnel noted oil on the deck and the oil level in the radiator fan gearbox below the vendor's minimum recommended level (11 pints). Additional checks identified that the pressure setscrew on the oil relief valve for the gearbox had backed out, which created a path for oil to be lost. The inspectors determined that EDG X-107A was likely in this condition since the completion of its last run on August 31, 2016, resulting in 28 days of inoperability. Entergy initiated CR-PNP-2016-07443 and CR-PNP-2016-07443 to capture this issue in the station's corrective action program.

The NRC team identified that in May 2000, while performing planned maintenance activities on the 'A' EDG fan drive gearbox (right angle drive), Entergy identified unsatisfactory backlash readings. This prompted Entergy to replace the fan drive gearbox. While attempting to procure a replacement gearbox, it was discovered that the vendor had upgraded the design and the installed model was no longer available. After determining that the major difference between the models was that the new model incorporated a relief valve in the oil circuit, Entergy concluded that the new model gearbox could be classified as a 'like-for-like' replacement for the old one. The NRC team determined that Entergy's characterization of the change as 'like-for-like' was not appropriate, and that the replacement of the gearbox was, in fact, a design change that should have been subject to a review to determine the differences between the new gearbox design and the old one to determine the suitability of application of the part. As a result of not performing such a review, Entergy did not consider potential new failure mechanisms for the part or the need for related preventive measures.

Analysis. Entergy selected a replacement gearbox for the 'A' EDG in May 2000 without fully reviewing the differences between the new gearbox design and the existing gearbox to determine the suitability of application of the new part. Entergy characterized the change as 'like-for-like,' even though the new model incorporated a relief valve in the oil circuit. As a result, Entergy did not consider potential new failure mechanisms for the part, or the need for related preventive maintenance activities, which was a performance deficiency (PD). The PD was more than minor because it was associated with the design control attribute of the Mitigating Systems cornerstone, and affected the associated cornerstone objective to ensure availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. In accordance with NRC Inspection Manual Chapter (IMC) 0609.04, "Initial Characterization of Findings," and Exhibit 2 of IMC 0609, Appendix A, "The Significance Determination Process for Findings At-Power," the inspectors screened the finding for safety significance and conservatively determined that a detailed risk evaluation was

required based on the 'A' EDG being inoperable for greater than the technical specification allowed outage time, considering the stated mission time of 30 days referenced within Licensee Event Report 2016-008-00.

Based on a revised risk evaluation by a Region I Senior Reactor Analyst (SRA), the NRC determined that the finding is of very low safety significance (i.e., Green). External fire risk was the dominant contributor to the risk increase in core damage frequency (CDF). Namely, the risk increase was driven by the impact of a postulated fire in the 'B' 4 kV Switchgear room with the 'A' EDG out of service for maintenance to evaluate and correct the low oil condition (i.e., the unavailability time). The SRA determined that the 'A' EDG fuel rack was tripped at 08:15 on September 28, 2016, and the gearbox maintenance work was completed and the EDG clearance removed for the ready-start position by 22:08 on September 28, 2016. This resulted in an exposure time of a nominal 14 hours of unavailability time for the 'A' EDG. Accordingly, the SRA estimated the increase in CDF by taking the 7.4E-5/yr fire ignition frequency for the 'B' 4kV Switchgear room and multiplying by the exposure time (14 hours/8750 hours in a year) with the assumption of a conditional core damage probability (CCDP) of 1.0, which resulted in an increase in CDF due to external fire events of 1.2E-7/yr. Regarding internal events, the SRA used the 'Limited Use Pilgrim SPAR Model Version 8.24, SAPHIRE 8.1.4, Pilgrim SPAR Model with logic for extended EDG-A operation," with an exposure time of 14 hours, and obtained an increase in CDF of mid E-9/yr. The total risk increase from external and internal events was calculated to be 1.25 E-7/yr, resulting in a Green risk significance characterization.

The dominant fire sequence discussed above assumes the failure of high pressure coolant injection (HPCI) and reactor core isolation cooling (RCIC) to run due to battery depletion in 8 to 11 hours. This would result in considerable time before postulated core damage and potential containment breach. In the absence of early core damage sequences for this event, large early release frequency (LERF) is not a significant risk contributor and the safety significance of this PD is defined by the estimated increase in CDF. Enclosure 3 includes details of the quantitative criteria considered in this final risk determination.

The NRC team did not assign a cross-cutting aspect to this finding because the PD occurred in May 2000. Entergy's program has undergone changes since May 2000, and the NRC team did not identify any recent examples of this PD.

Enforcement. 10 CFR Part 50, Appendix B, Criterion III, "Design Control," requires that measures shall be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety- related functions of structures, systems, and components to which Appendix B applies (i.e., that prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public).

Technical Specification 3.5.F.1 requires that during any period when one emergency diesel generator (EDG) is inoperable, continued reactor operation is permissible only during the succeeding 72 hours unless such EDG is sooner made operable, provided that all of the low pressure core and containment cooling systems shall be operable, and the remaining EDG shall be operable. If this requirement cannot be met, an orderly shutdown shall be initiated and the reactor shall be placed in the cold shutdown condition within 24 hours. The 72-hour limiting condition for operation can be extended to 14 days provided, in addition to the above requirements, the station blackout diesel generator is verified operable.

Contrary to the above, in May 2000, Entergy selected a part that was essential to the safety-related function of a component to which Appendix B applies, and did not review the part for suitability of application. Specifically, when Entergy replaced the 'A' EDG radiator blower fan gearbox and discovered that the installed model was no longer available, Entergy concluded that the new model could be classified as a 'like-for-like' replacement for the old one. However, the new model incorporated a relief valve in the oil circuit that was not part of the installed model and Entergy did not review this additional component for potential failure mechanisms. Consequently, Entergy did not identify that the gearbox had been losing oil until September 28, 2016, by which time the gearbox contained an amount that was well below the minimum recommended level. This condition also resulted in the 'A' EDG being inoperable for a period greater than the technical specification allowed outage time.

The licensee's immediate corrective actions on September 28, 2016, to restore compliance included draining the oil and inspecting the gearbox internals for damage (none was identified); reassembling, bench-testing, and setting the relief valve; and refilling the gearbox with new oil and then performing the monthly surveillance test. Entergy also performed two root cause evaluations pertaining to this issue which have resulted in additional corrective actions, including: revising the pre-start check procedure to include guidance on how to validate gearbox oil level and training non-licensed operators on the process; establishing a method to monitor equipment inside the EDG radiator fan rooms and revising applicable procedures; reviewing the gearbox design in accordance with 10 CFR 50.59 requirements; and conducting an extent of condition review. Because this violation is of very low safety significance (Green), is non-willful, and because Entergy entered this issue into its corrective action program as CR-PNP-2016-9706 and CR-PNP-2016-07443, this violation is being treated as a non-cited violation (NCV) consistent with Section 2.3.2.a of the NRC Enforcement Policy. **(NCV 05000293/2017008-01, Design Change Not Appropriately Reviewed by Entergy)**

ENCLOSURE 3

NRC INDEPENDENT REVIEW OF ENTERGY'S ENDURANCE TEST AND ASSESSMENT

Entergy, in order to determine the effects of the 'A' emergency diesel generator (EDG) fan gearbox loss of oil condition, contracted with a 3rd party vendor to perform a simulated mock-up 24 hour endurance test of the degraded condition with the actual impacted gearbox. The vendor performed testing on June 5 and 6, 2017, at an off-site test facility.

A team of three NRC inspectors were present at the vendor facility on June 5 and 6, 2017, to observe Entergy's test setup and performance. The intent of the NRC team was to perform an independent assessment in order to provide technical input to the final risk significance determination of the 'A' EDG fan gearbox loss of oil inspection finding. The team's objective was to assess the fidelity between the actual plant as-found gearbox condition and design, and the mock-up test performance and configuration established in the facility. This observation was intended to evaluate the conduct of this endurance test in order to determine the functionality of the gearbox with the significantly reduced oil level condition.

Based on the following facts surrounding the 24 hour test endurance run, including an assessment of the test results presented by Entergy at the Regulatory Conference, the NRC determined that the test performed at the vendor facility to simulate the fan gearbox was valid and believed that the gearbox would have been functional for at least 24 hours in the low oil condition. Therefore, the NRC Senior Reactor Analyst (SRA) determined that an increase to the nominal failure rate probability of the 'A' EDG to run, over its baseline value, was not technically justified for the non-conforming gearbox condition. The team did not identify any design or operational issues with the fidelity between the mock-up and the plant configuration that would invalidated the above assumption. Also, the team did not observe any test results that would indicate degradation of the gearbox, in a reduced oil level, that would challenge a 24 hour mission time. The oil analysis performed after the endurance run revealed some small iron particles indicative of bearing and/or gear wear. These particles did not impact the ability of the gearbox to operate for 24 hours.

The NRC team which observed the test noted the following additional observations/facts in support of this conclusion:

- The original gearbox, oil pump, tubing, and relief valve were used;
- The input shaft coupling was new and a different design, and the output shaft coupling was a new spare, however the team determined this was not a factor which would invalidate test results for two reasons: (1) bearing damage would be the primary response while coupling damage is a secondary response (i.e., bearing damage would occur first, which would then challenge the couplings;
- The type of gear oil was the same as that used in the plant;
- The relief valve cap was forced in the offset position, (appeared to be more offset than the degraded condition in the field) to match the worst case "as-found" condition. The cap was gagged with a strap to ensure that it remained offset during the 24 hour endurance run with the largest gap opening available to ensure a conservative outcome with the least resistance to leakage out of the normally closed system;
- Fan flowrate and room temperature simulated worst case conditions. The measured fan flow was lower than the established maximum test controls, which provided conservatism, and data was available to ensure the fan flowrate remained within the test

range. The room temperature within the enclosure of the gearbox simulated summer conditions, the worst case temperature from August to September 2016, and ignored diurnal effects (i.e. cooling down during the night). The SRA also noted the large break loss-of-coolant-accident (LOCA) loading conditions for the EDG had been calculated to establish a lower band of allowable temperature in the gearbox room. The SRA noted this was likely a very conservative assumption because the postulated events driving the risk of the issue were fire events, resulting in main steam isolation valve closures without LOCA conditions. Therefore, with the Reactor Core Isolation Cooling (RCIC) system in service controlling level, the Core Spray pump would not be in service and thus present a much lower kilowatt load on the engine during an actual event than in the test configuration. This is noted as a conservatism because convective cooling was shown to have a notable effect on heat transfer for the non-conforming gearbox;

- Bearing temperatures and gearbox vibrations were monitored during the entire 24 hour endurance run and vibrations reached steady state within 1 hour and bearing temperatures in a little over 2 hours. There was one temperature excursion on the upper shaft output bearing which reached a maximum bearing temperature in the nominal 225 to 230 deg. Fahrenheit range. This quickly turned when room temperatures were slightly lowered a few degrees to simulate LOCA loads being removed in accordance with expected operator actions per procedure. The team noted that per the bearing manufacturer, the onset of bearing damage does not occur until a temperature of 300 degrees Fahrenheit is reached. Per the oil manufacturer, any residual oil film on components within the gearbox should not be compromised below this temperature;
- The NRC team noted that information from the vendor suggested the gearbox is rated for 2.5 times the design speed and 3 times the horsepower used in actual service conditions in the plant. Therefore the gearbox was designed to accommodate much greater loading than expected during EDG operation;
- Based on the bearing temperature response during the test, a very small amount of oil was likely being supplied to the upper output shaft bearing, similar to the small-scale vendor hydraulic model performed weeks prior to this actual test;
- Post-test oil analysis found indicators of small wear particles (mostly less than 5 mils) symptomatic of some misalignment of the gears but this did not impact the ability of the gearbox to operate for 24 hours;
- Lastly, the team reviewed post-test pictures of the gearbox internals (gear teeth and a spherical ball bearing) and did not observe signs of damage; however, a small piece of foreign material (potentially inspection port gasket material) was found in the oil bath while draining the oil. The SRA determined that damage would not be expected to occur as a result of this two inch flexible material because migration to the pump suction port would be extremely unlikely. This is because of extremely low flowrates/velocities generated by the oil pump, based on hydraulic modeling by the vendor.

Summary of Risk Insights

Due to the test results and the NRC team input, the SRA determined there was no technical basis to adjust or increase the standardized plant analysis risk (SPAR) model's assumed failure rate of the 'A' EDG to run based on the various facts and observations noted above for its 24 hour mission time. Therefore, the team agreed with Entergy's conclusion that the 'A' EDG was functional for its probabilistic risk assessment (PRA) mission time at any time prior to September 2016 with respect to the as-found degradation of the gearbox. However, the fire ignition frequency for a postulated fire in the 'B' Switchgear room with the 'A' EDG out of service for maintenance to repair the gearbox, would have an effect of increasing the CDF due to this performance deficiency (PD).

Calculated Risk Increase Due to Finding

As noted above, the increase in CDF due to this finding would be limited to the unavailability of the 'A' EDG during the time the degraded condition was discovered and the EDG was taken out of service for repair.

Internal Events Risk Increase

The SRA used the "Limited Use Pilgrim SPAR Model Version 8.24, SAPHIRE 8.1.4, Pilgrim SPAR model with logic for extended EDG A operation", with an exposure time of 14 hours and obtained an increase in core damage frequency of mid E-9/yr. The dominant core damage sequences consisted of postulated loss-of-offsite-power (LOOP) weather related events with failure of the 'B' EDG to run and station blackout EDG to run with failure of power recovery.

External Events Risk Increase

Although the internal events risk was negligible, inspection manual chapter (IMC) 0609 Appendix A, Section 6, specifies any internal events results that are less than 1.0E-7 can be evaluated for external event risk contribution at the discretion of the regional SRA. Due to the insights learned of the risk associated with a fire in the 'B' Switchgear room, the SRA determined that an evaluation of this case was warranted.

The increase in risk for taking out the 'A' EDG to repair the gearbox is dominated by the external event postulated fire conditions within the 'B' 4kV A6 Switchgear room. Entergy contracted fire modeling support from a vendor to model the conditions and fire scenarios in order to analyze the impact from the unavailability of the 'A' EDG. The vendor's fire modeling included a characterization of ignition sources, fire growth and propagation analysis for each ignition source (as necessary), fire suppression and detection analyses (as necessary), and a list of targets (e.g. cables, raceways and components) related to the impact for each scenario with estimated time to damage. The result was a list of fire modeling damage states and frequency of damage. The SRA performed a review of the methodology for the vendor report to ensure it was consistent with the guidance identified in NUREG/CR-6850, and NRC IMC 0609, Appendix F.

The report analysis resulted in a determination of a total 'B' Switchgear room fire ignition frequency of 7.4E-5/yr, with an assumption of a conditional core damage probability (CCDP) of 1.0, due to the assumed loss of all AC power, including the source from Bus A8, 'B' EDG, Unit Power and the Startup Transformer, with the 'A' EDG in repair and unavailable. The SRA noted in some cases credit for short term High Pressure Coolant Injection (HPCI) availability (up to 8 hours to allow some credit for AC power source recovery – manual breaker closures depending on fire location) of 90% was applied with a 0.1 factor. This was applied to that scenario's ignition frequency as long as HPCI was determined to not be affected by the particular scenario. The SRA noted that the same logic could be applied in consideration that the RCIC system should remain functional and unaffected until battery depletion (8 hours) by the postulated 'B' Switchgear room fire and unavailability of the 'A' EDG. The SRA determined that for cases where recovery could be credible, this 0.1 value was determined to be appropriate and reasonable for screening.

Exposure Time – Repair Time

The SRA determined that the 'A' EDG fuel rack was tripped on 08:15 on September 28, 2016 and the gearbox work was completed and EDG clearance removed for the ready start position at 22:08 on September 28, 2016. This resulted in an exposure time of a nominal 14 hours of unavailability time for the 'A' EDG.

The SRA estimated the increase in CDF by taking the 7.4E-5/yr fire ignition frequency and multiplying by the exposure time (14 hours/8760 hours in a year) with the assumption of a CCDP of 1.0 to get a resultant estimate of the increase in CDF due to external fire events of 1.2E-7/yr.

The total increase in risk from both internal and external events was determined to be 1.25E-7/yr for this issue or of very low safety significance (Green).

Potential Risk Contribution from LERF

For issues resulting in an increase in CDF > 1E-7, IMC 0609 requires an evaluation of Large Early Release Frequency (LERF) using the guidance of NUREG-1765, "Basis Document for LERF Significance Determination Process," and IMC 0609, Appendix H, "Containment Integrity SDP." The PD associated with the unavailability of the 'A' EDG would be considered a Type A finding and, as such, the calculated increase in CDF value is used in conjunction with an appropriate LERF factor (multiplier) to determine the estimated increase in LERF associated with the issue. Per Appendix H, Table 5.2, LERF factors of 1.0 or 0.6 are used for high pressure core damage accident sequences with the drywell dry or flooded, respectively. These Appendix H LERF factors are considered conservative bounding values. More recent insights from an NRC Office of Research sponsored study by Energy Research, Inc. (ERI/NRC-03-04, November 2003) and the State of the Art Reactor Consequence Analysis Project at Peach Bottom Nuclear Power Station (NUREG/CR-7110) have identified that improved modeling and analysis of anticipated types and sizes of reactor coolant system ruptures, projected containment heating and fuel-coolant interactions, and operator actions taken in accordance with emergency operating procedures significantly reduce the potential for containment breach and the likelihood of a large early release. Furthermore, the dominant sequence discussed above (i.e. assumed failures of HPCI and RCIC to run due to battery depletion in 8 to 11 hours) would result in considerable time before postulated core damage and potential containment breach. In the absence of early core damage sequences for this event, LERF is not a significance risk contributor and the safety significance of this PD is defined by the estimated increase in CDF.