Tennessee Valley Authority, Sequoyah Nuclear Plant, P.O. Box 2000, Soddy Daisy, Tennessee 37384

May 7, 2024

U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. Louis McKown
Branch Chief – Division of Reactor Projects
Marquis One Tower
245 Peachtree Center Avenue, NE., Suite 1200
Atlanta, GA 30303-1257

Sequoyah Nuclear Plant, Units 1 and 2
Renewed Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Subject: Apparent Violation Supplemental Information (Tennessee Valley Authority - Sequoyah Nuclear Plant)

Reference: EA-24-008, "Sequoyah, Units 1 and 2 – NRC Inspection Report 05000327/2024090 and 05000328/2024090 and Preliminary Greater-Than-Green Finding And Apparent Violation, letter dated March 19, 2024

In the referenced letter, the Nuclear Regulatory Commission (NRC) documented a finding and associated apparent violation that has been preliminarily determined to be of greater than very low safety significance (greater-than-Green, or GTG) regarding a failure of the 1B Diesel Generator. The Tennessee Valley Authority (TVA) was provided with the opportunity to request a Regulatory Conference or to submit a position on the proposed GTG finding in writing.

TVA and NRC participated in a Regulatory Conference on May 2, 2024, in which TVA presented information regarding the apparent violation.

The purpose of this letter is to provide additional Information in support of TVA's position. Documents provide correspondence between TVA and the 1B Diesel Generator vendor, Engine Systems, Inc. (ESI), regarding further investigation of the September 2023 failure. The documents were not available prior to the NRC Significance and Enforcement Review Panel (SERP) conducted in February 2024.

There are no new regulatory commitments in this letter. If you have any questions, please contact Mr. Rick Medina, Site Licensing Manager, at (423) 843-8129 or rmedina4@tva.gov.

Sincerely,

Marshall, Thomas B. Digitally signed by Marshall, Thomas B.
Date: 2024.05.07 08:12:20 -04'00'

Thomas B. Marshall

Site Vice President
Sequoyah Nuclear Plant

Enclosures:

1. ESI Response – TVA Lash Adjuster Potential Part 21, dated April 19, 2024
2. TVA Response to ESI Response, dated April 24, 2024
3. ESI Response – Plausibility of Lash Adjuster Failure Scenario, dated April 29, 2024

cc: NRC Regional Administrator – Region II
NRC Region II Branch Chief
NRC Senior Resident Inspector – Sequoyah Nuclear Plant
NRC Document Control Desk

Enclosure 1

ESI Response – TVA Lash Adjuster Potential Part 21

ENGINE SYSTEMS, INC.
175 Freight Rd., Rocky Mount, NC 27804
Telephone: 252/977-2720
Fax: 252/446-1134

To: Tennessee Valley Authority
James Edmonds

Ref: Lash Adjuster P/N 40118613 (D/C 05D)
TVA PO# 00001690, release 00403
ESI SO# 3001209

Date: April 19, 2024

The root cause evaluation associated with TVA report SQN CR 1900849 indicates the lash adjuster assembly internal spring had a pre-existing crack formation and failed due to fatigue. This was screened as a potential Part 21 reportable issue and ESI was asked to review the root cause and provide a formal, written response with ESI's position, including any counter arguments. The purpose of this letter is to provide ESI's response to the root cause.

ESI acknowledges the comprehensive analysis performed within SQN CR 1900849 and in general agrees with many of the conclusions. However, there are several key items that, in ESI's opinion, disagree with the final conclusion and call into question the deduction of the lash adjuster as the cause. These items are discussed below:

- Thread damage to rear valve bridge adjustment screw

  The upper 13 threads of the adjustment screw were undamaged and damage occurred only to the lower 13 threads. This indicates the adjustment screw was in the fully retracted position before the event occurred since 13 exposed threads coincides with a fully retracted adjustment screw position. For a typical installation approximately 6 threads are exposed above the valve bridge.

- Rapid loosening of the locknut

  ESI believes the likelihood for the adjustment screw locknut to loosen due to a failed lash adjuster is low (ESI is not aware of an instance). The probability is even lower for the locknut to rapidly loosen in the timeframe required of the TVA technical report. The report indicates locknut loosening occurred after the failed lash adjuster caused the spring seat to fracture which led to the dropped exhaust valve. The dropped exhaust valve would have caused near immediate catastrophic engine damage that resulted in an engine shutdown. In this scenario, the loosening would have taken place over the relatively brief time from dropping the valve until engine shutdown. For a typical installation, the adjustment screw must rotate approximately 7 turns to reach fully retracted position. ESI finds it unlikely for the locknut to loosen and for the adjustment screw to turn 7 revolutions in this timeframe.

With regard to the lash adjuster spring, ESI has not reached the conclusion of a reportable defect with the lash adjuster supplied on TVA PO# 00001690, release 00403. While the TVA report indicates there may have been a preexisting fatigue crack in the lash adjuster spring, it is not conclusive to ESI this condition existed. There are no known lash adjuster failures due to an internal spring fracture nor is ESI aware of any other failures of lash adjusters from this specific batch, of which qty 527 were supplied.

ENGINE SYSTEMS, INC.
175 Freight Rd., Rocky Mount, NC 27804
Telephone: 252/977-2720
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Based on a review of the information obtained throughout this evaluation process, ESI has been unable to conclude the issues identified are reportable per 10CFR part 21. ESI will continue to assist in any further analysis pursuant to the power assembly failure.

Regards,

John Kriesel
Engine Systems Inc.
Engineering Manager

Enclosure 2

TVA Response to ESI Response

To: Engine Systems INC
John Kriesel

Ref: ESI Response – TVA lash adjuster potential Part 21 (April 19, 2024)
MPR letter (0047-0059-LTR-001, Rev. 0)
MPR calculation (0047-0059-CALC-001, Rev 0)

Date: April 24, 2024

The ESI review of the TVA lash adjuster potential Part 21 associated with root cause evaluation report SQN CR 1900849 determined that it can not be concluded the issues identified are reportable per 10CFR Part 21. This was based on findings that the Lash Adjuster failure due to a cracked internal spring is the only reported failure for the batch of 527 provided under PO 00001690 and inconclusive evidence of when the crack was initiated. In addition, the ESI report provided counter arguments to consider regarding TVA's conclusion that the lash adjuster failure was the root cause for the EDG 1B2 Engine Failure. The purpose of this letter is to provide ESI additional information and solicit ESI's input on plausibility of a Lash Adjuster failure being a possible initiator of the EDG 1B2 Engine failure.

Part 21 Disposition:

TVA agrees that the Lash Adjuster failure does not meet the requirements to report per 10CFR Part 21. First, with ESI's findings that the Lash Adjuster failure due to a cracked internal spring is the only reported failure for the batch of 527 provided under PO 00001690, it is evident this is an isolated event. Second, there is no conclusive evidence that a manufacturing-related defect existed in the spring when ESI provided the affected lash adjuster to TVA. Instead, a fatigue crack initiated and propagated in the spring due to specific EDG service conditions over time, most likely as a result of stresses experienced during numerous EDG starts, including fast starts. The term "pre-existing" used to describe the fatigue crack in the TVA root cause report was intended to convey the conclusion that the crack was present, but with the spring not yet completely fractured, when the EDG was started the day of the failure in September, 2023. The crack continued to propagate and the spring ultimately fractured at some point during the failure run and initiated all of the valvetrain component damage experienced during the failed run. The Lash Adjuster was installed in 2005. If a manufacturing defect was present at the time of installation, the EDG would have failed much sooner than the event in 2023. The EDG 1B-B had approximately 2,000 hours of operation with multiple idle and fast starts in that time frame. It is acknowledged that the published Lash Adjuster service life is 16,000 hours based on EMD testing of locomotive engines, which are operated differently than Nuclear applications. The TVA Diesel Program Manager will present the information from the evaluation findings to the EMD/ESI Diesel Users Group for consideration to evaluate lash adjuster life cycle for nuclear specific operation.

ESI Counter Arguments for Lash Adjuster Root Cause:

TVA is providing the below responses for consideration to elicit ESI's feedback on plausibility of the lash Adjuster failure being the cause of the EDG 1B2 Engine failure. Since the completion of the Root Cause, MPR Associates has provided a calculation and summary letter which provide further insights on how the adjusting screw lock nut may loosen as a consequence of the lash adjuster failure and allow the adjustment screw to back off. The MPR letter and calculation are provided as reference attachments. To

aide in the discussion, the rapid loosening of the lock nut will be addressed first, as it will better explain the thread damage to the rear valve bridge adjustment screw.

(1) Rapid loosening of the lock nut:

Based on further information provided by the MPR calculation and ESI response, it is acknowledged by TVA that the Root Cause scenario sequence process map requires revision. The process map showed the lock nut loosening after the exhaust valve dropped into the cylinder, but evaluations demonstrate that loosening of the lock nut likely initiated soon after the lash Adjuster failure occurred, and the loosening progressed over minutes, if not hours, during the EDG run in September (The EDG 1B-B was approximately 4 hours into a 24-hour Surveillance run when shutdown was initiated because of the damage caused by the dropped exhaust valve).

Loosening of the lock nut most likely initiated well before the exhaust valve dropping. When the lash adjuster fails and a significant local lash is introduced, the loading of the adjustment screw and lock nut change dramatically and immediately. The excessive lash results in impact forces that are much larger than the forces on the screw during normal operation without a failed lash adjuster (as high as 1,900 lbf for a fully collapsed lash adjuster). The failure of a single lash adjuster also results in unbalanced loading of the valve bridge, which creates a bending moment on the bridge. This bending moment is cyclical with each rocker arm actuation. The bending moment results in additional lateral loading of the adjustment screw as opposed to purely axial loading of the screw during normal operation. The magnitude of the lateral load is significant, on the order of 600 lbf for a fully collapsed lash adjuster based on the MPR calculation. The additional impact loads due to the failed lash adjuster occur at the engine speed of 900 rpm, which is a frequency of 15 Hz. Overall, the failed lash adjuster results in significant vibrational loading of the adjustment screw and lock nut in both axial and lateral orientations.

Bolted connections are susceptible to self-loosening due to vibrational loading, in particular due to lateral loads. This is especially true for situations where fastener preload is marginal. The lock nut is used to establish preload in the adjustment screw; this preload creates an elastic clamping force that keeps the lock nut from loosening during operation. The calculated preload for the adjustment screw with the lock nut torqued to 80 ft-lb is approximately 6000 lbf, which is relatively low for a 5/8” nominal diameter bolt. Fasteners are typically preloaded to 2/3 to 90% of their material yield strength, with higher values used in applications that are susceptible to vibration. Based on this, typical preload values for a similarly sized bolt of the same alloy and hardness (AISI 8620 low-alloy steel, 95 HRBW core hardness) would be approximately 10,000-14,000 lbf (assuming a yield strength of 60 ksi). The design of the rocker arm, adjustment screw, and locknut also results in the screw engagement length (the effective distance over which preload is developed) being relatively short. The overall impact is that there is only 0.7 mil (0.0007”) of elastic elongation in the adjustment screw because of the 6,000 lbf preload. The small elongation makes the adjustment screw sensitive to loss of preload due to lock nut counter-rotation. A counter-rotation of the lock nut of only 4.6 degrees will result in complete loss of preload in the adjustment screw. The valvetrain design has sufficient margin to mitigate lock nut loosening during normal operation because loads are purely axial and relatively small (approximately 300-700 lbf) compared to the screw preload. However, a lash adjuster failure results in additional impact loads of significant magnitude that are subjected to the adjustment screw and lock nut (and other valvetrain components) at relatively high frequency. In general, the lash adjuster failure creates vibrational loading

conditions that are well-documented in technical literature to initiate and drive the self-loosening of bolted connections.

Overall, the loosening of the lock nut and adjustment screw likely began early in the failure sequence (as soon as the lash adjuster failed) and took some time to reach the as-found condition with the lock nut fully off and the adjustment screw backed out. The loosening continued as the other valvetrain components became damaged and failed, and the loosening potentially accelerated with each component failure due to higher loads.

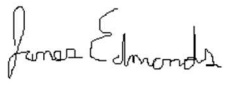
(2) Thread damage to rear valve bridge adjustment screw:

Determination of the adjusting screw lock nut loosening earlier in the failure scenario (just after Lash Adjuster failure versus after the exhaust valve dropping) aides in explaining the observed differences in thread damage to the rear valve bridge adjustment screw. The ESI conclusions on the lower thread damage would be correct assuming that the lock nut loosened and the adjustment screw backed out at the very end of the failure sequence after everything had already failed. This is however not the case with determination that the lock nut would have loosened much sooner in the failure scenario. The operating loads become more abnormal, both in magnitude and orientation, as lash increases and the resulting impact loads also increase and cause additional components to fail. The adjustment screw was close to or fully backed out at the end of the failure when all components had already failed. The loads on the threads should have been greatest at this point compared to earlier in the failure sequence when lash and the resulting impact loads were much smaller. The forces exerted on the adjusting screw would have been less when the lock nut first loosened after lash adjuster failure versus the more significant forces as the lash became greater, components began to fail, and the exhaust valve dropped (Note: The EDG continued to run for 2 minutes after the crank case over-pressure alarm came in). This explains why the damage to the lower threads on the adjustment screw were more severe until the adjusting screw fully backed out against the rocker arm.

<u>Response Requested:</u>

TVA request ESI provide feedback on the technical merits of the above positions and the plausibility of the Lash Adjuster failure scenario.

Regards,



James Edmonds
TVA Nuclear
Senior Program Manager Emergency Diesel Generators

Enclosure 3

ESI Response – Plausibility of Lash Adjuster Failure Scenario

ENGINE SYSTEMS, INC.
175 Freight Rd., Rocky Mount, NC 27804
Telephone: 252/977-2720
Fax: 252/446-1134

To: Tennessee Valley Authority
James Edmonds

Ref: ESI Response – TVA lash adjuster potential Part 21 (April 19, 2024)
TVA Response to ESI on SQN EDG 1B2 Failure (rev 00)
MPR letter (0047-0059-LTR-001, Rev.0)
MPR calculation (0047-0059-CALC-001, Rev.0)

Date: April 29, 2024

A conference call took place with teams from TVA, MPR, and ESI on April 25, 2024 to discuss the letters and calculations referenced above. As an outcome to the call, ESI agreed to review the information and provide feedback to the failure scenario presented. ESI has completed our review and agrees with the technical merit of the reports prepared by TVA and MPR and concedes the lash adjuster failure scenario presented is plausible.

Regards,

John Kriesel
Engine Systems Inc.
Engineering Manager