10 CFR 50.90

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102-07345-MLL/MDD
October 26, 2016

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

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Units 1, 2, and 3
Docket Nos. STN 50-528, 50-529, and 50-530
Renewed Operating License Nos. NPF-41, NPF-51, NPF-74
Response to NRC Electrical Engineering Branch Staff Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications Related to Degraded and Loss of Voltage Relay Modifications

By letter dated April 1, 2016 [Agencywide Documents Access and Management System (ADAMS) Accession No. ML16096A337], Arizona Public Service Company (APS) submitted a license amendment request (LAR) pursuant to the provisions of Section 50.90 of Title 10 of the *Code of Federal Regulations* (10 CFR), for Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3, requesting approval of proposed changes to the PVNGS Technical Specifications (TS). The proposed LAR would revise TS requirements related to the degraded and loss of voltage relays that are planned to be modified to be more aligned with designs generally implemented in the industry. Specifically, the licensing basis for degraded voltage protection will be changed from reliance on a TS initial condition that ensures adequate post-trip voltage support of accident mitigation equipment to crediting automatic actuation of the degraded and loss of voltage relays to ensure proper equipment performance.

By letter dated July 21, 2016 (ADAMS Accession No. ML16203A381), APS supplemented the LAR in response to U.S. Nuclear Regulatory Commission (NRC) Probabilistic Risk Assessment Operations and Human Factors Branch (APHB) staff request for additional information (RAI) (ADAMS Accession No. ML16181A334), dated June 29, 2016.

By letter dated September 9, 2016 (ADAMS Accession No. ML16257A544), APS supplemented the LAR in response to NRC Instrumentation and Controls Branch (EICB) RAIs provided by document, dated August 17, 2016 (ADAMS Accession No. ML16230A231). This RAI response followed an audit performed by the NRC staff on August 26, 2016, as documented in NRC letter dated September 9, 2016, (ADAMS Accession number ML16251A245).

The Electrical Engineering Branch (EEEB) of the NRC staff provided RAIs by NRC document dated September 13, 2016 (ADAMS Accession No. ML16257A330). The Enclosure to this letter provides the APS response to the EEEB RAIs.

The RAI responses do not affect the conclusions of the no significant hazards consideration determination [10 CFR 50.91(a)] provided in the original LAR

No new commitments are being made in this submittal. Should you need further information regarding this response, please contact Michael D. Dilorenzo, Licensing Section Leader, at (623) 393-3495.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: October 26, 2016
(Date)

Sincerely,

Lacal, Maria L(Z06149)

Digitally signed by Lacal, Maria L(Z06149)
DN: cn=Lacal, Maria L(Z06149)
Date: 2016.10.26 05:58:16 -07'00'

MLL/MDD/CJS/af

Enclosure: Response to NRC Electrical Engineering Branch (EEEB) Requests for Additional Information (RAIs) Regarding License Amendment Request (LAR) to Revise Technical Specifications Related to Degraded and Loss of Voltage Relay Modifications

cc:

K. M. Kennedy	NRC Region IV Regional Administrator
S. P. Lingam	NRC NRR Project Manager for PVNGS
M. M. Watford	NRC NRR Project Manager
C. A. Peabody	NRC Senior Resident Inspector for PVNGS
T. Morales	Arizona Radiation Regulatory Agency (ARRA)

Enclosure

Response to NRC Electrical Engineering Branch (EEEB) Requests for Additional Information(RAIs) Regarding License Amendment Request (LAR) to Revise Technical Specifications Related to Degraded and Loss of Voltage Relay Modifications

Introduction

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The Electrical Engineering Branch (EEEB) of the NRC staff provided RAIs by NRC document dated September 13, 2016 (ADAMS Accession No. ML16257A330). This enclosure provides the APS response to the EEEB RAIs. The NRC staff RAIs are provided first, followed by the APS response. The NRC staff summary of regulatory requirements is restated below to establish the context for the EEEB RAIs.

Regulatory Requirements and Guidance:

Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 10 CFR 50.36(c), "Technical Specifications" requires that TS include, among other criteria, (1) process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier, and (2) surveillance requirements, which are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met.

General Design Criteria (GDC) 17, states that provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

NRC Standard Review Plan (SRP), NUREG-0800, Branch Technical Position (BTP) 8-6, Revision 3, "Adequacy of Station Electric Distribution System Voltages," dated March 2007 (ADAMS Accession No. ML070710478), outlines the purpose of the degraded voltage relays to protect Class 1E safety-related buses from sustained degraded voltage conditions on the offsite power system under accident and non-accident conditions. Specifically, SRP BTP 8-6, Section B.1, and subparagraphs (a) and (b), states that the second level of undervoltage protection should include two separate time delays:

1) the first time delay should be long enough to establish the existence of a sustained degraded voltage condition (i.e., something longer than a motor starting transient). Following this delay, an alarm in the control room should alert the operator to the degraded condition. The subsequent occurrence of a safety injection actuation signal (SIAS) should immediately separate the Class 1E distribution system from the offsite power system. In addition, the degraded voltage relay logic should appropriately function during the occurrence of an SIAS followed by a degraded voltage condition, and,

2) the second time delay should be limited to prevent damage to the permanently connected Class 1E loads. Following this delay, if the operator has failed to restore adequate voltages, the Class 1E distribution system should be automatically separated from the offsite power system. The bases and justification for such an action must be provided in support of the actual delay chosen.

NRC EEEB RAI-1:

Section 2 of the submittal dated April 1, 2016, states that the Surveillance Requirement (SR) 3.3.7.3 would add a note indicating that the SR would only be applicable to Class 1E bus(es) that have not been modified to include a two stage time delay for the DVR, (and therefore its DVR have a single stage time delay) and an inverse time delay for the LVRs. The NRC staff understands that degraded voltage protection for accident and non-accident conditions is provided by the two stage DVRs and the existing single stage relays are still used at PVNGS. Please provide the following:

a. A tabulated summary of the DVR setpoints (single stage and two stage) and the protective function performed by each relay for the postulated degraded conditions.
b. A tabulated summary of the LVR setpoints and the protective function performed by each relay for the postulated degraded conditions.
c. A diagram depicting the transitional, "in-progress," and final configuration of the safety-related buses in light of the DVR modifications discussed in this LAR.

APS Response RAI-1:

In the LAR cover letter, dated April 1, 2016 (ADAMS Accession No. ML16096A337), APS indicated installation of the modification requires a refueling outage, as the Class 1E bus must be de-energized in order for the modification to be safely performed. The schedule for the installation of the modifications is planned to include one Class 1E bus in each succeeding outage following NRC approval and implementation of the license amendment. PVNGS typically has a refueling outage twice a year, so it is expected that the modifications would be completed approximately 3 years after implementation of the approved license amendment.

The modification involves replacing both the DVR and LVR relays associated with a Class 1E bus at the same time, such that the configuration is either the existing design or the modified design on a given Class 1E bus.

APS letter number 102-07305, dated July 21, 2016 (ADAMS Accession No. ML16203A381), in response to Probabilistic Risk Assessment Operations and Human Factors Branch (APHB) provided an overview of the modifications with regard to operator actions. Specifically, the APS response to NRC Staff Request 1 provided the following overview:

> The change to the degraded voltage scheme adds a short stage timer (less than 10 seconds) to respond to a degraded voltage condition concurrent with a safety injection actuation signal (SIAS). The existing degraded voltage relay (DVR) time delay (approximately 35 seconds) remains essentially unchanged for degraded voltage conditions without a SIAS present. The loss of voltage relay (LVR) time delay design is changed from an inverse time delay relay to a fixed time delay. The time delays and relay actuations are automatic and do not require operator manual actions.
>
> Operator actions to respond to the automatic actuations of the DVRs and LVRs, including actions to assure correct configuration for the plant status, are also unchanged by the LAR.

In summary, the modifications will be installed on a Class 1E bus basis in successive refueling outages. The existing and modified designs are not significantly different from the perspective of operator actions related to the performance of the relay designs. The response to each element of NRC EEEB RAI-1 is provided next.

APS Response RAI-1, Subpart a:

The tabulated summary of the DVR setpoints and their functions is as follows:

Existing Single Stage DVR	
Protective Function	Allowable Value
4160 Volt Essential System Bus Undervoltage - Degraded Voltage	3697V $\leq$ Voltage $\leq$ 3786V 28.6 sec $\leq$ time $\leq$ 35 sec
Proposed Two Stage DVR	
Protective Function	Allowable Value
4160 Volt Essential System Bus Undervoltage - Degraded Voltage (concurrent with SIAS)	3712V $\leq$ Voltage $\leq$ 3767V 5.5 sec $\leq$ time $\leq$ 8.5 sec
4160 Volt Essential System Bus Undervoltage - Degraded Voltage (no SIAS)	3712V $\leq$ Voltage $\leq$ 3767V 31 sec $\leq$ time $\leq$ 40 sec

APS Response RAI-1, Subpart b:

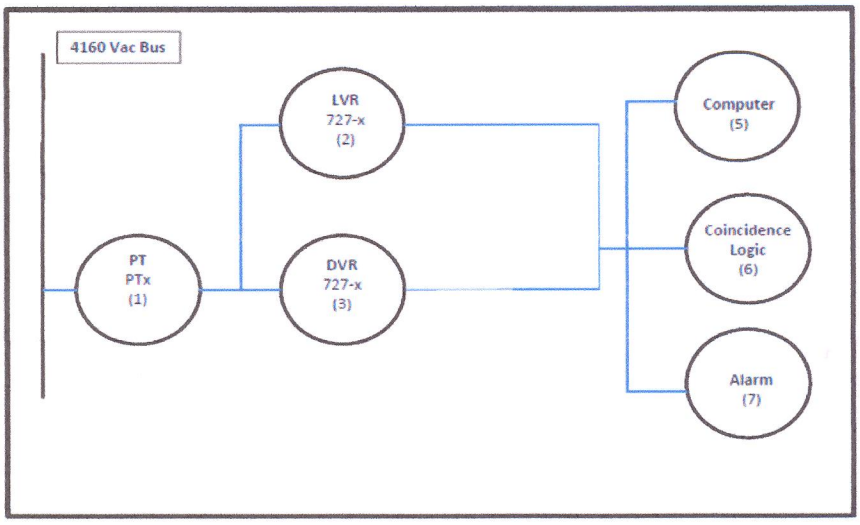
The tabulated summary of the LVR setpoints and their functions is as follows:

Existing Inverse Time Delay LVR	
Protective Function	Allowable Value
4160 Volt Essential System Bus Undervoltage - Loss of Voltage	2929.5 V 10.3 sec $\leq$ time $\leq$ 12.6 sec 0 Volts 2.0 sec $\leq$ time $\leq$ 2.4 sec
Proposed Fixed Time Delay LVR	
Protective Function	Allowable Value
4160 Volt Essential System Bus Undervoltage - Loss of Voltage	3240V $\leq$ Voltage $\leq$ 3300V 1.4 sec $\leq$ time $\leq$ 2.3 sec

APS Response RAI-1, Subpart c:

The modification will be implemented on one Class 1E bus (train) in each refueling outage. Each PVNGS Unit will, therefore, operate one full fuel cycle with one modified Class 1E train and one Class 1E train with the existing configuration as an interim configuration. The interim configuration will exist until the modification is completed on both Class 1E busses (trains) on that PVNGS Unit.

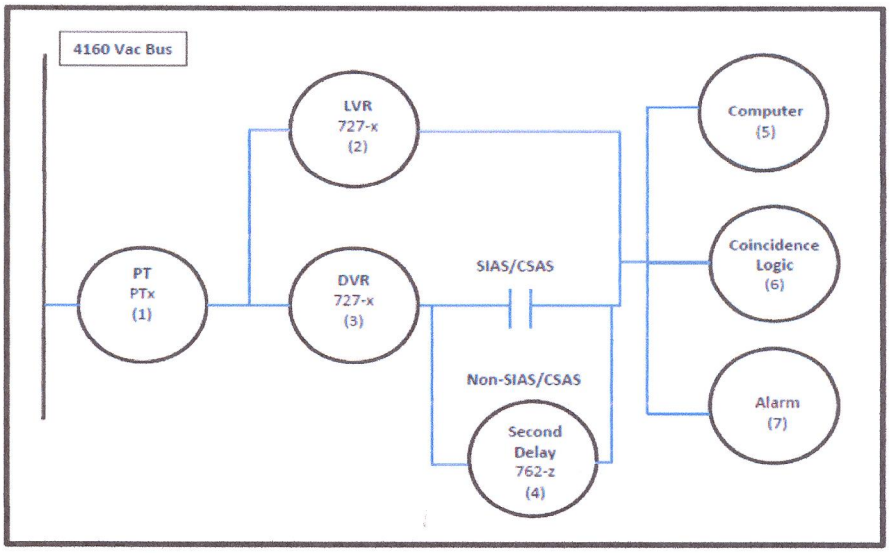
The following simplified diagram (one of 4 channels) depicts the configuration for a single Class 1E bus before the modification is installed:



Both LVR and DVR have voltage sensing and timer elements. The DVR is an ABB Type 27N relay. When voltage drops to the dropout (setpoint) the timer starts. If voltage rises above the pickup (reset) the timer stops. If voltage does not rise above the pickup (reset) before

the predetermined timer setpoint then the DVR trips and sends the signal onward, as shown. The LVR is a GE inverse time delay relay, in that the lower the voltage, the shorter the time before the LVR trips and sends the signal onward.

The following simplified diagram (one of 4 channels) depicts the configuration for a single Class 1E bus after the modification is installed:



Both LVR and DVR have voltage sensing and timer elements. The modified DVR is a slightly different model than before the modification. Before the modification, the DVR was ABB Type 27N, model 411T7375-HF-L-DP. After the modification, the DVR is ABB Type 27N, model 411T4375-HF-L-DP. The only difference is the "4" after the "T" in the model number, which indicates that the timer range is 1-10 seconds instead of the existing 10-100 seconds. The signal from each PT (device 1) is sent to both the LVR (device 2) and DVR (device 3). The output from a given pair of both DVR and the LVR (devices 3 and 2) go to a single computer point (device 5) and to a single alarm point (device 7). Either DVR or LVR, or both of the pair can send the trip signal related to a given PT to the coincidence logic (device 6). For a given train, if two of the four inputs to the coincidence logic are tripped a loss of power signal is sent.

The LVR senses voltage and when it drops below the setpoint it starts the timer. After the modification, the LVR model number will be ABB Type 27N model 411T4375-HF-L-DP, the same as the DVR. If it times out before being reset by voltage rising above the reset value, the signal is sent onward.

The DVR also senses voltage in the same manner as the LVR but with different voltage and timer setpoints. When the DVR trips, a signal is sent to both the relay labeled as SIAS/CSAS (Containment Spray Actuation Signal) and to the second delay timer. If a SIAS/CSAS is present, the relay is closed and the signal passes directly on to the coincidence logic, etc. The time delay is the timer part of the DVR. If a SIAS/CSAS is not present, the signal is controlled by the second delay timer (device 4). It is a simple timer (no voltage sensing) that starts timing when it receives the signal from the DVR and trips when it times out. The total time delay for the non-SIAS/CSAS condition is the sum of the DVR timer and the second delay timer.

NRC EEEB RAI-2:

Section 3.1.1 of LAR "Degraded Voltage Relay Short Stage Time Delay" states the following:

> "The new short stage time delay for the DVRs, that is in effect when a SIAS also occurs, has analytical limits of 5.0 and 9.0 seconds. The corresponding allowable values are 5.5 and 8.5 seconds. The time delay is long enough to establish the existence of a sustained degraded voltage condition (i.e., something longer than a motor-starting transient), as described in BTP 8-6, Section B.1, subparagraph (b)(i). The lower analytical limit is based on ensuring the DVR will not trip due to voltage dips during SIAS load starts, which are 5 seconds apart. For an offsite source that is degraded but still allows loads to start, motors will accelerate and voltage will recover above DVR dropout prior to the next sequence step. The corresponding allowable value for the lower analytical limit is 5.5 seconds."

The NRC Staff understands that the motor start, motor stall and motor withstand capability for all safety related motors was evaluated at the analytical limits for DVR dropout voltage of 3690 volts (V). The DVR will dropout during a motor start as the bus voltage will drop below 3690V. The assumption is that grid voltage may recover and allow the 4160V safety bus voltage to improve to a value above the DVR 'reset' (and not 'dropout' as stated above) voltage (3805V) to reset the relay prior to the next load sequencing. However, from an analytical perspective, the grid voltage should be maintained at degraded conditions to demonstrate the capability of large motors to successfully start and run under degraded voltage conditions at the safety busses. Page 9 of the LAR states, "For the defense-in-depth long stage timer scenario (AFAS [auxiliary feedwater actuation signal] actuation case), the largest motor at each load step was evaluated and shown to be able to start for voltages below the DVR dropout but above a point where the AFAS actuation would cause LVR actuation. If the degraded voltage is below a value where AFAS initiated equipment would successfully operate, the voltage dip from starting the AFP-B motor will cause an LVR actuation, resulting in a LOOP [loss of offsite power] signal and initiating the applicable BOP-ESFAS [balance of plant engineered safety features actuation system] sequence onto the EDG [emergency diesel generator]." The NRC staff understands that motor start and operation between the DVR dropout setpoint and LVR actuation point was analyzed. Please confirm that this methodology was used for the PVNGS DVR analyses.

APS Response RAI-2:

APS confirms that the described methodology was used for the PVNGS DVR analyses. Motor starting evaluations were performed with the safety bus artificially set at the DVR dropout value of 3690V. This analysis is documented in calculation 13-EC-MA-0643, *Degraded Voltage Result / Component Review.* This calculation is Reference 5 of the proposed TS Bases for LCO 3.3.7, and was reviewed during the closeout of the NRC unresolved item described in Section 2.2 of the LAR and documented in NRC inspection report dated November 12, 2014 (Reference 6.4 of the LAR enclosure).

For the evaluation, motors were started in their load groups according to sequencer timing steps of 0, 5, 10, 15, 20, 25, and 30 seconds at DVR dropout voltage. In addition, individual motor starts, using the static model, were also performed as this would capture motors that

are not sequenced. This analysis verified that the motors did not stall, which ensures that protective breakers do not trip, and the motors would be available when the bus transfers to the onsite source.

Using this conservative analysis method shows that if voltage were to recover to only the dropout voltage, motors would start. For the DVR short stage timer, however, it would be more precise for the cited LAR Section 3.1.1 statement to read:

> "voltage will recover above DVR **reset** prior to the next sequence step."

The reason it is more precise to use the term 'reset' as compared to the term 'dropout' is that the electrical design philosophy assumes that if the Class 1E bus voltage does not recover above the reset voltage before the start of each load group, the offsite source may not be sufficiently capable, therefore, automatic transfer to the onsite source is appropriate.

More information regarding how motor starts and operation between the DVR setpoint and the LVR actuation point were assessed in the analyses is provided in the response to NRC EEEB RAI-3.

NRC EEEB RAI-3:

For the scenarios where the voltage decreases below the DVR/LVR dropout setting but does not recover above the DVR/LVR reset setting prior to the DVR/LVR time delay limit being exceeded (DVR/LVR actuates and times out causing automatic disconnection of offsite power and automatic transfer to the onsite power supply), please address the following:

a. Confirm if a range of initial bus voltages above the DVR dropout voltage was considered to envelope the limiting cases, and explain the methodology used to address this issue.
b. Confirm whether the safety-related buses are protected in the operating band between the lower limit of the DVR and the upper limit of the LOV, and explain the methodology used to address this issue.

APS Response RAI-3, Subpart a:

APS confirms that a range of initial bus voltages above the DVR dropout voltage were considered. The PVNGS electrical distribution analyses address the full load and minimum load conditions which are expected, and consider the anticipated range of voltage variations for the offsite power sources. The analyses of the offsite power system demonstrate that the safety-related electrical distribution system will perform its intended design functions under accident conditions with the offsite power supply at the minimum allowable (operable) voltage and capacity. These analyses factor in the effects of plant post-trip voltage dips, fast-bus transfers and load sequencing. Based on the analysis results, the minimum switchyard voltages are selected conservatively, with sufficient margin to account for analytical uncertainties and to provide assurance that the degraded voltage relays will not inappropriately actuate as a result of an accident.

The design of the DVR or LVR relays is to separate the offsite source should it become incapable of being the preferred power source for safety-related equipment. There is ample margin between the minimum allowable (operable) voltage and the DVR and LVR setpoints.

The switchyard voltage is continuously monitored and alarmed in the Unit 1 control room. The first stage trouble alarms are set at a voltage well above the minimum switchyard voltage to allow operators to respond before the minimum switchyard voltage is reached. Should operator intervention be ineffective and voltage continue to degrade, the DVR and LVR relays would provide automatic protection by separating the offsite source, so that the onsite emergency diesel generators would provide power to the safety-related equipment.

The degraded voltage coordination analyses looked at conditions where the safety bus voltage was at or below the DVR dropout. This ensured that the DVR and LVR are coordinated and protect the Class 1E 4160V bus and equipment appropriately, regardless of the initial plant conditions or configurations. These analyses are separate from the analysis described in the response to NRC EEEB RAI-2 that was performed at the DVR dropout voltage, and are described in greater detail in the response to Subpart b of this RAI.

APS Response RAI-3, Subpart b:

APS confirms the safety-related buses are protected in the operating band between the lower limit of the DVR and the upper limit of the LVR. As shown in the table for the response to NRC EEEB RAI-1, the lower allowable value for the DVR is 3712V and the upper allowable value of the LVR is 3300V. The protection and coordination is confirmed by the analyses in calculations 13-EC-PB-0205, Revision 0, *Degraded Voltage Relay Short Stage Timer Analysis,* and 13-EC-PB-0206, Revision 0, *Degraded Voltage Relay Long Stage Timer Analysis*.

The short stage timer works concurrently with a Safety Injection Actuation Signal (SIAS) and the analysis confirms the following criteria, as stated in the short stage timer analysis:

- The analytical limits for short stage timer were determined to be five seconds to nine seconds.

- The upper limit of the time delay value was chosen to ensure the actuation times would begin within 10 seconds to maintain consistency with the accident analysis.

- The five second lower limit of the time delay value was chosen to prevent unintended actuation of the protective relays during momentary voltage dips below the pick-up setpoint associated with motor starts during normal or accident conditions.

After the appropriate setpoint methodology was applied, the actual time delay value of seven seconds was chosen.

To ensure that these settings are acceptable, it was verified that equipment will not be damaged and protective devices would not lock out during the short stage time frame. This calculation verified coordination down to 3000V, which is lower than the LVR upper allowable value of 3300V.

The long stage timer analysis established the basis for the LVR settings using the following criteria:

- The LVR lower analytical limit protects permanently connected running safety related motors from stalling.

- Safety related loads that are automatically started during a coincident AFAS and degraded voltage condition are not locked out or damaged during the DVR time out interval.

- Undervoltage relays do not spuriously operate during normal running and transient conditions such as motor starting. Exceptions are alarm-only relays that may be susceptible to occasional actuation during extreme motor starting conditions as a compromise in order to provide an appropriate level of sensitivity during steady-state conditions.

- Undervoltage relays that initiate equipment tripping do not actuate as a result of transient voltage dips caused by transmission grid disturbances.

The combination of these analyses demonstrate that the Class 1E buses are adequately protected and the functions of the DVR and LVR are adequately coordinated.

NRC EEEB RAI-4:

BTP 8-6, Section B, Item 2, states that the Class 1E bus load shedding scheme should automatically prevent shedding during sequencing of the emergency loads to the bus. Please confirm if the DVRs and LVRs are bypassed during load sequencing on the onsite emergency diesel generators.

APS Response RAI-4:

The DVRs and LVRs are bypassed in the way the load sequencer responds to a loss of power (LOP) signal as described in UFSAR 8.3.1.1.3.10.1, reprinted below. It should be noted that the undervoltage relays in the description below could be either the DVR or LVR relays or both, depending on the specific voltage transient. The 60-second 'off delay' described below ensures the engineered safety features (ESF) loads are allowed to sequence on to the bus such that a near-term subsequent LOP signal will not prevent sequencing. The sequence steps are completed within approximately 30 seconds. The proposed modifications described in the LAR do not affect this design feature.

> 8.3.1.1.3.10.1 Load Sequencer Design and Testing
>
> Each redundant ESF load sequencer system performs logic functions to generate the loss of offsite power (LOP) signal/load shed signal, the diesel generator start signal (DGSS), and the load sequencer start and permissive signals.
>
> Each redundant ESF load sequencer system is supplied from a separate 120V vital ac distribution bus and a separate Class 1E 125V dc distribution bus. The LOP signal/load shed signal logic continuously monitors the Class 1E 4.16 kV bus for an undervoltage condition using four undervoltage relays. If an undervoltage trip occurs, annunciation and indication is provided to the operator. On a two-out-of-four coincidence of undervoltage relay trips or upon manual actuation, an LOP signal and load shed pulse are generated. The LOP signal is sent to the DGSS logic. The LOP signal (maintained through a 60-second off delay) also actuates forced shutdown system loads by deenergizing actuation relays.

The load shed pulse (1 second) sheds 4.16 kV and selected 480V loads from the Class 1E 4.16 kV bus and trips the 4.16 kV Class 1E bus preferred (offsite) power supply breakers by energizing actuation relays.

NRC EEEB RAI-5:

Information Notice 95-05, "Undervoltage Protection Relay Settings Out of Tolerance Due to Test Equipment Harmonics," dated January 20, 1995 (ADAMS Accession No. ML031060397), discusses the effect of test equipment harmonics on offsetting relay operating points. Please confirm if the proposed new relays have harmonic filters to preclude spurious actuations due to bus harmonics.

APS Response RAI-5:

APS confirms that the proposed DVRs and LVRs have harmonic filters to preclude spurious actuations due to bus harmonics. The modification will use ABB undervoltage relay model number 411T4375-HF-L-DP. The letters 'HF' in the model number indicates "Harmonic Filter." The existing DVRs are also provided with harmonic filters.