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SUBJECT: Forwards response to NRC 990614 RAI re util proposed amend to TS 3.8.1, "AC Sources - Operating" & TS 3.3.7, "DG - Loss of Voltage Start," dtd 981216.Commitments to be provided by 990930 included.

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Reference: Letter 102-04224-JML/SAB/RKR, dated December 16, 1998, from J.M. Levine, APS, to NRC, "Request for Amendment to Technical Specification (TS) 3.8.1, AC Sources - Operating and 3.3.7, Diesel Generator (DG) - Loss of Voltage Start (LOVS)"

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN 50-528/529/530
Response to NRC Request for Additional Information Regarding Proposed Amendment to Technical Specifications (TS) 3.8.1, AC Sources - Operating and 3.3.7, Diesel Generator (DG) - Loss of Voltage Start (LOVS)

In a letter to Arizona Public Service Company (APS) dated June 14, 1999, additional information regarding APS's request for an amendment (reference letter) to Technical Specifications 3.8.1, "AC Sources – Operating" and 3.3.7, "Diesel Generator (DG) - Loss of Voltage Start" was requested by the NRC. Enclosed are the responses to the NRC request for additional information.

This letter includes commitments to be provided by September 30, 1999. These commitments include; 1) the results of the voltage criteria review for the spray pond pump house exhaust fans discussed in the response to NRC Request 3, 2) the Bases change discussed in the response to NRC Request 10, and 3) the Technical Specification changes discussed in the responses to NRC Requests 11 and 12.

A001

200030

Please contact Mr. Scott Bauer at (623) 393-5978 if you have any questions or would like additional information regarding this matter.

Sincerely,

Enclosures
WEI/SAB/RKR

cc: E. W. Merschoff
N. Kalyanam
J. H. Moorman
A. V. Godwin

ENCLOSURE 1

Responses to NRC Request for Additional Information Regarding Amendment to Technical Specifications 3.8.1, AC Sources - Operating and 3.3.7, Diesel Generator - Loss of Voltage Start

NRC Request 1

Your December 16, 1998, submittal states that Palo Verde Technical Specification (TS) 3.8.1 Condition G is being revised to ensure that the appropriate actions will be taken to prevent double sequencing of the safety-related loads. Condition G of the revised TS is: "One or more required offsite circuit(s) do not meet required capability." The submittal states that maintaining the "required capability" ensures that post-trip voltage will stay above the degraded voltage relay (DVR) trip setpoint and the event will not cause loss of offsite circuits. The submittal indicates that the operators will use the proposed Bases for TS 3.8.1 Condition G to assess whether the offsite circuits meet the "required capability." The "required capability" of the offsite power circuits is based upon the pretrip switchyard voltage, the number of Palo Verde units on line and capable of regulating switchyard voltage, post-trip startup transformer loading, and number of 525 kV transmission lines in service.

With regard to the switchyard voltage portion of the operator's assessment, the submittal states that the maximum drop in switchyard voltage that would occur as a result of a Palo Verde unit trip has been determined analytically by a bounding grid calculation. Has the accuracy of the grid calculation been determined? How? What is the accuracy, and has it been verified using actual grid experience? If accuracy and grid experience data is not available, describe the conservatism or other techniques used in the analysis to provide confidence that the calculation will bound the actual switchyard voltage. How will the bounding grid calculation be kept current with changing grid conditions over the years? Is a program in place to keep it current?

APS Response

Palo Verde conservatively used the grid model developed by the Western Systems Coordinating Council (WSCC) to determine the voltage effect of a Palo Verde unit trip. The analyses that were used to develop the proposed Bases for TS 3.8.1 Condition G modeled the following adverse conditions:

- Heavy grid loading
- A major transmission line to the Palo Verde Switchyard out of service
- Generation in the Phoenix Metro area at the minimum amount needed to ensure adequate pre-trip voltages
- A single Palo Verde unit on line
- That unit is boosting switchyard voltage to the maximum credible extent prior to its trip
- That unit trips as a result of a LOCA

This scenario is quite extreme, and nothing comparable to it has ever occurred at Palo Verde. In recent years, the most extreme electrical event occurred on August 10, 1996 as a result of the partial collapse of the Western transmission grid. Palo Verde Units 1

and 3 tripped, and Unit 2 remained on line. Therefore, Unit 2 was still available to regulate the switchyard voltage. Immediately following the trip of Units 1 and 3, the switchyard voltage rose slightly, and the voltage stayed well within the administrative limits during the disturbance. When a Palo Verde unit trips with one or both of the other units on line, those units automatically compensate for most of the lost voltage support. In the scenario that was modeled (as discussed above), there is no local voltage support following the LOCA-initiated trip of the Palo Verde unit.

The variable which most determines the effect of a unit trip on switchyard voltage is the change in the flow of VARs (volt-amperes reactive) as a result of the trip. Based on both analysis and empirical data, the effect of a VAR change on switchyard voltage is limited and predictable. Data from manual VAR changes conducted during day-to-day plant operation confirms the analytical result that a change of approximately 30 MVAR is required to effect a one kV change in switchyard voltage. Therefore, if a single Palo Verde unit was on line and supplying, for example, 300 MVAR to the switchyard, tripping of that unit would cause an approximately 10 kV decrease in switchyard voltage. Although there are other secondary factors that affect this result (which are included in the model), there are no known phenomena that would cause a substantially greater voltage effect.

In the above example, a pre-trip voltage of 535 kV would result in a post-trip voltage of approximately 525 kV, which would not be of concern. On the other hand, if the pre-trip voltage were, for example, 525 kV, the post-trip voltage would be approximately 515 kV, which may be of concern in certain conditions. Thus, both pre-trip Palo Verde MVAR output and pre-trip switchyard voltage must be considered together. Furthermore, these variables are not independent. Raising the MVAR output, for example, causes the pre-trip switchyard voltage to rise.

The condition of concern, then, is the combination of high Palo Verde MVAR output and low pre-trip switchyard voltage. Switchyard voltage tends downward when loading is high in the Phoenix area. In such cases, Palo Verde and other facilities are used to provide voltage support. However, due to the inherent characteristics of grid components and various operating considerations such as voltage requirements at other locations, the proportion of voltage support provided by Palo Verde is limited. The analyses described above conservatively quantify the voltage effect in the event that that support is lost, and the proposed LCO and Bases ensure that the offsite circuits remain viable.

Palo Verde is continuing to perform grid analyses in-house with full cognizance of 10CFR requirements. Modifications to the grid that could affect the TS or its Bases are subject to screening and evaluation by Palo Verde personnel in accordance with 10CFR50.59.

NRC Request 2

The submittal states that with one or the other Palo Verde units on line and available to regulate switchyard voltage, the switchyard voltage will not change significantly following a unit trip. In this condition, the post-trip switchyard voltage is assumed to be equal to the measured steady-state pre-trip switchyard voltage. Have you considered how the switchyard voltage would be affected if the remaining Palo Verde unit(s) were operating at their maximum megavolt-amperes reactive (MVAR) capability prior to the unit trip? For example, if two Palo Verde units were on line generating their maximum MVARs supporting the switchyard voltage, how would the switchyard voltage be affected if one of the units tripped? Has this been considered in developing the operators' assessment for the "required capability" of the offsite circuits?

APS Response

Palo Verde units are operated well below their maximum capability of 710 MVAR (normally is less than 400 MVAR). Due to the settings of the main transformer taps, operation of the units at their MVAR limit would result in overvoltage conditions at the Palo Verde switchyard and elsewhere on the grid, even during heavy grid loading conditions. Therefore, Palo Verde has always operated with ample MVAR capability margin. It should also be noted that, at high MVAR levels, the pre-trip switchyard voltage is also high, so, even if the other unit(s) were unable to pick up all of the lost MVARs, voltage margin would exist ensuring adequate post-trip voltage.

NRC Request 3

The submittal states that maintaining the "required capability" ensures that post-trip voltage will stay above the DVR trip setpoint and the event will not cause loss of offsite circuits. Have you established that the safety equipment will start and operate properly if the offsite source voltage is at a value just above the point at which the DVRs would actuate? That is, have you performed both a dynamic and steady state analysis to verify that safety equipment would safely start and continue to operate if the switchyard voltage is at a point just above a value that would result in actuation of the relays? What technique was used to perform the analysis, hand calculation or software program? Has the technique been validated, by a test or otherwise?

APS Response

Palo Verde has performed calculations which assume that the post-trip switchyard voltage is at a level that would result in recovery of the voltage at the 4160 V busses just to the maximum DVR reset voltage (considering loop uncertainties) following automatic load sequencing. The transient voltages during sequencing and the steady-state voltages following sequencing are calculated at load equipment terminals and elsewhere throughout the network. A qualified software program (ECALC) is used. These calculations verify that the load equipment would receive adequate voltage in this scenario, and take into account the effects of sustained motor inrush conditions on other equipment. Palo Verde has also performed motor starting calculations to determine their starting time under the most adverse conditions. These calculations verify that the motors will not overheat during starting and that protective devices will not actuate as a result of long starting time. All Class 1E equipment has been verified to meet its voltage criteria in this scenario with the exception of the spray pond pump house exhaust fans that are still under review. The results of this review will be included with the technical specification and Bases changes expected (see responses to NRC requests 10 and 11) to be submitted by September 1999.

The ECALC software was qualified using hand calculations to verify that the output was valid. Voltage measurements have also been recorded in the plant to verify that the impedances of system elements, such as distribution cables and transformers, are accurately modeled.

NRC Request 4

a. In the submittal you state that APS has not been able to identify a practical automatic device that would prevent double sequencing. Reference 19 contained in a 1997 IEEE paper, "A Discussion of Degraded Voltage Relaying for Nuclear Generating Stations," identifies a potential method for accomplishing this. This reference (S. Z. Haddad, J. B. Wisniewski, and S. G. H. Ashrafi, "Degraded Voltage Protection for Nuclear Plant Safety-Related Loads," *Transactions of the American Nuclear Society*, vol. 66, 1992, pp. 442-443) recommends a supervisory instantaneous undervoltage relay whose function would be to decide at the instant of a loss-of-coolant accident (LOCA) signal whether LOCA mitigation should be from the offsite power supply or from the diesel generator. Have you considered such protection at Palo Verde? If so, why was it ruled out?

b. An additional option that is available is to reduce the time delay of the DVR and utilize a loss of power relay with a definite time delay characteristic and higher setpoint (around 80 percent). This would provide a smaller window of vulnerability that equipment is exposed to before it is separated from the degraded offsite system. The tripping of the main generator could also be delayed until after all automatic load sequencing has taken place in order to maintain the higher pretrip switchyard voltage during the electrically demanding load sequencing period, and utilize the DVR protection during steady-state operation for which it is better suited. While these options would not preclude double sequencing, they would provide better assurance that the electrical equipment could tolerate it. Have these options been considered? If so, why were they ruled out? Have other options been considered? What are they and why were they ruled out?

APS Response

a. Palo Verde was involved in the authorship of the 1997 IEEE paper and had previously reviewed the approach proposed by Haddad, Wisniewski, and Ashrafi in their 1992 paper. Palo Verde's design is based on requirements outlined in a December 12, 1977 letter from the NRC that specifies a single voltage setpoint, with a time delay, for degraded voltage protection. The scheme proposed in the 1992 paper uses multiple voltage settings. Modification of the design to implement the suggestions in the 1992 paper was ruled out because the voltage at the 4160 V bus at the instant of a LOCA signal is not an accurate indicator of the voltage later in the event. There are a number of relevant variables that would not be monitored by the proposed scheme, including pending changes in the grid voltage, status of the fast bus transfer circuitry, and the magnitude of voltage change that would occur as a result of automatic switching operations subsequent to the LOCA signal. Therefore, such a scheme would not necessarily prevent double sequencing. It could allow sequencing to commence

onto the offsite circuits even when ongoing voltage changes could cause subsequent tripping.

b. Palo Verde's position is that double sequencing, even under normal voltage conditions, is not a desirable scenario and must be avoided. The effect of starting, stopping, and restarting emergency equipment can result in unpredictable consequences. For example, pumps may be designed to start with their associated motor operated valves in particular positions. During the initial sequencing, the valves could change state and remain in a different position than analyzed when the pump receives its second start signal, resulting in abnormal mechanical stresses. We have been unable to identify an optimal time at which double sequencing could be allowed to occur which would make these risks acceptable. Additionally, a change in the timing would not resolve our concern with the interruption of the core cooling capabilities assumed in the accident analyses as a consequence of double sequencing.

Delay of the generator tripping until the initial sequencing is completed would result in motoring of the generator for approximately 30 seconds which is not a desirable option from a generator protection standpoint.

In general, automatic systems were ruled out due to their inability to prevent double sequencing. An ideal system would:

- Avoid double sequencing by commencing sequencing onto the diesel generators when conditions were such that the offsite circuits were unable to support the accident loads, and

- Provide annunciation during normal plant operation when the offsite circuits are inoperable due to potential low post-trip voltage.

As discussed, we have not found a system that would accomplish these functions.

The other alternative considered was removal of the DVR trip function to eliminate the risk of double sequencing. Palo Verde believes that the proposed administrative controls adequately preclude degraded voltage vulnerabilities without having to rely on the relays. This option has not been pursued because it is contrary to the requirements stipulated in the December 12, 1977 NRC letter to APS.

NRC Request 5

Your submittal implies that double sequencing must be avoided for an accident scenario to be safely mitigated. What brings you to this conclusion? Are your conclusions the same for a double-sequencing scenario that is initiated by a nondegraded voltage delayed loss of offsite power as for the double sequencing that is initiated by a degraded voltage? We understand that the double sequencing of safety equipment has been previously demonstrated by a test at Palo Verde. If there is concern for double sequencing that is the result of a nondegraded voltage delayed loss of offsite power, what did the test fail to capture that is the cause for the concern?

APS Response

As discussed above, the concerns with double sequencing are not alleviated even when the initial sequencing occurs at acceptable voltages. We have tested our automatic load sequencer to verify that it will respond to a resequencing scenario. We have not simulated such an event by actually starting, stopping, and restarting the emergency equipment under the conditions that would exist during an accident.

Palo Verde does not have any analyses or testing that would provide adequate assurance that all accident scenarios will be safely mitigated in the event of double sequencing, although in an actual event mitigation may be adequate. Therefore, Palo Verde proposes the additional controls specified in the proposed technical specification change to minimize the possibility of double sequencing occurring during an accident.

NRC Request 6

In your April 7, 1999, meeting with the NRC staff in Rockville, Maryland, you provided an estimate of the frequency of a low switchyard voltage occurring with an accident at Palo Verde. This frequency was 7.5E-8/year. The probability that the switchyard voltage would be low was obtained by taking the total amount of time (12.5 minutes) that the Palo Verde switchyard voltage was less than 525 kV, over the period of time (4.25 years) that the procedural controls were in effect at Palo Verde. Ideally, the estimate of the probability that the switchyard voltage would be low following an accident would be obtained by collecting data on the number of times a plant trip resulted in a low switchyard voltage. This would capture any failures of grid voltage correction equipment (generator voltage regulators, capacitors, static VAR compensators, etc.) following a trip, and also any analytical inaccuracies. Is this kind of data available over the period of time the procedural controls were in effect? If so, what has it shown? The information should include plant trips when multiple Palo Verde units are on line and also plant trips when only a single Palo Verde unit is operating. If operation of a single Palo Verde unit has been rare, provide data on how frequently single Palo Verde operation has occurred in the past and an estimate of frequency expected in the future. In addition, please submit the frequency estimates provided in the April 7, 1999, meeting and identify how the results were obtained.

APS Response

We have had no events in which a plant trip caused a significant decrease in switchyard voltage. As discussed, the limiting event is one in which only one Palo Verde unit is on line, and it then trips. In the five year period from July 1, 1994 to July 1, 1999, Palo Verde has operated with only one unit on line for a total of 23.8 days, the last such occurrence on August 11, 1996. In all of these cases the single unit remained on line. Simultaneous outages are not planned at Palo Verde. Based on the shorter duration of refueling outages, the elimination of mid-cycle outages, and the record of the past three years, it is expected that such conditions would be rare in the future.

The primary means of voltage control at the Palo Verde switchyard is the Palo Verde generators. If one or both of the other units is on line following a trip, the voltage changes very little due to the regulating effect of the other unit(s). We have found no instances in which the regulators were called upon to automatically control the voltage, but failed to do so. The offsite circuits do not rely on any other local voltage regulating equipment such as static VAR compensators. Voltage is regulated elsewhere on the grid by a large number of other generators and regulating equipment.

The Palo Verde generator voltage regulators were originally set up to maintain the voltage at the generator terminals to the desired level, but, to further limit the voltage variation in the switchyard, line drop compensation circuitry on the Palo Verde generators was later put into service. During the past several years that this equipment

has been in service, the switchyard has been successfully operated within a very narrow voltage band (525 to 535.5 kV) with very few and brief deviations.

The frequency values discussed at the April 7, 1999 meeting were based on the following:

- The total time that the switchyard voltage was lower than 525 kV during the 4.25-year period was 12.5 minutes. Thus, the probability of this condition is 12.5 minutes divided by 4.25 years which is approximately 5E-6.

- The accident frequency (approximately 1.5E-2/year) was obtained by summing the frequencies for all accidents that can result in actuation of the automatic load sequencers.

These two values were multiplied together to obtain the probability of an accident during a low switchyard voltage condition: 5E-6 times 1.5E-2/year equals 7.5E-8/year.

NRC Request 7

In the April 7, 1999, meeting with the NRC staff, you showed a slide entitled "Actions Taken" that identified a list of things that had been done at Palo Verde relative to the undervoltage problem. Please provide that list, including any other measures taken, along with a discussion of each item and what it has accomplished. Identify those measures that are used to control the switchyard voltage level and that provide the operator with information that the voltage level is approaching or may be in an unsatisfactory range. Identify the setpoints of any low voltage alarms or trips.

APS Response

The following measure was implemented to control switchyard voltage:

- **Restricted switchyard normal operating range.** Our energy control center was instructed to maintain the Palo Verde switchyard voltage at least 525 kV. This was implemented in early 1993 and has been successfully accomplished since that time. The energy control center has an alarm that operates at approximately 526 kV.

The following measures were implemented to provide the operator with information that the voltage level is approaching or may be in an unsatisfactory range:

- **Upgraded Unit 1 switchyard voltage meter.** A digital meter was installed and its loop uncertainty quantified in a calculation.
- **Added Unit 1 control room low voltage alarm.** The Unit 1 control room alarm is set at 524 kV when three startup transformers are in service and 525 kV when two transformers are in service.

The following measures were implemented to improve the performance of the Palo Verde onsite distribution system:

- **Implemented LCO/Administrative Controls.** An interim Technical Specification condition was created (LCO 3.8.1G) that specifies minimum switchyard voltage limits for each of the units.
- **Replaced DVRs with more accurate relays.** The old electro-mechanical relays were replaced with solid state units, which significantly reduced the operating tolerances.
- **Revised Class 1E transformer tap settings.** The 4160 to 480 volt load center transformer taps were adjusted to provide 2-1/2% boost. This improved the voltage of 480 and 120 volt equipment during postulated accident conditions.
- **Added trip of WRF load on SIAS and low voltage.** Low voltage contact closes when the alarm described above is actuated.

- **Replaced Class 1E control power transformers.** In each unit, three control power transformers were upgraded from 200 or 250 VA to 500 VA to improve the voltage performance of the control circuit.
- **Relocated control element drive mechanism (CEDM) fan sequence step.** The non-Class 1E control element drive mechanism CEDM cooling fans were automatically started at the 5-second sequencer step. The voltage dip as a result of the inrush current of this and other equipment was excessive, so we delayed the automatic starting of these fans until after all other sequencing was completed.

NRC Request 8

Your submittal states that the "required capability" of each offsite circuit must be reviewed if either of the following conditions exist:

> The steady-state switchyard voltage is below 525 kV or
>
> Only one Palo Verde unit is on line and capable of regulating switchyard voltage (generator synchronized to the grid and automatic VAR control equipment in service).

What is the "automatic VAR control equipment" referred to in the second bullet? Does this equipment automatically compensate for the lost VARs provided by a Palo Verde generator that has tripped? What mechanism will provide the lost VARs that were being provided by a Palo Verde generator that has tripped?

APS Response

The "automatic VAR control equipment" is the exciter of the Palo Verde unit that is on line. The rationale is that the unit, if regulating switchyard voltage, could cause a change in switchyard voltage if it trips. The VARs that would be lost by tripping of a Palo Verde generator are only a small percentage of the VARs available on the grid. We do not credit replacement of the lost VARs by any particular device. Even if the tripping results in a net reduction in total VARs, the change in Palo Verde switchyard voltage is limited and quantifiable as discussed above.

NRC Request 9

Following an accident, what is the sequence of events and approximate times of accident signal initiation, reactor trip, safety load initiation (start of load sequencing), turbine trip, generator trip, nonsafety load fast bus transfer, and water reclamation facility trip? What signals initiate each of these?

APS Response

Within the first second of an accident signal, the following would occur, as initiated by the BOP-ESFAS system:

- Reactor Trip
- Turbine trip
- Start of load sequencing
- Diesel generator start signal
- WRF trip (initiated by low voltage and SIAS)

Approximately 4-5 seconds later, the following would occur, as initiated by the main generator reverse power relay:

- Generator trip
- Non-safety load fast bus transfer

NRC Request 10

We note that there are a number of options available to the operator to exit revised Condition G. One of those would be to block fast bus transfer which, depending on the number of offsite circuits affected and transfers blocked, could leave the plant reliant on natural circulation when the plant trips. There is however no time limit with the plant in this condition that we are aware of. Because of this, this might be the operator's preferred choice since Required Action G.2 (Transfer the engineered safety feature bus(es) from the offsite circuit(s) to the emergency diesel generator(s)) would still leave the plant in a 72-hour or 24-hour Action statement. We recognize that there are often competing safety and regulatory demands between the choices the operator must make and believe that these considerations and some guidance should be provided to the operators in the TS Bases to help him make the correct choice. For example, a discussion of the relationship between natural circulation events and blocking fast bus transfer for extended periods might be helpful. Please provide a discussion of the options available to the operator to exit Condition G and identify the safety and regulatory consequences of those. Add some guidance of this nature to the TS Bases or explain why it is not needed.

APS Response

Options in their order of preference are as follows:

1. Improve post-trip switchyard voltage. In most cases raising the VAR output of the Palo Verde units would be done quickly and simply. If only one Palo Verde unit was on line, that unit's VAR output would be lost if it were to trip, so other changes to the grid operation would normally be implemented to improve the post-trip voltage. There are a number of methods that the grid operators could implement at other locations, including increasing the grid VAR supply and changing transformer taps.

2. Reduce post-trip loading. The probability that we would need to use this approach is very low. One way it could be accomplished is by disabling fast bus transfer. Palo Verde has no formal restrictions on the amount of time that fast bus transfer can be out of service, and the safety analyses do not credit fast bus transfer. However, Operations is very cognizant of the importance of maintaining forced circulation capability and has expressed reluctance to exercise the blocking option in the past. In the rare cases where it would be considered, there is a good chance that it would need to be performed on only one train (two out of four pumps). Besides blocking fast bus transfer, there may be other options to reduce the loading, such as removing loads or realigning equipment power sources.

3. Transfer the safety bus to the diesel generator. This is less desirable than option 2, because it would perturb the plant. It would cause the plant to remain in an LCO 3.8.1 condition (A or C, depending on whether one or two buses are transferred).

The TS Bases will be revised to include additional discussion of these options. The revised TS Bases are expected to be submitted by September 30, 1999.

NRC Request 11

TS 3.3.7 Surveillance Requirement (SR) 3.3.7.3 is being changed by deleting the specific voltage at which the DVR time delay occurs. The time delay however is specified as "35 seconds" with no lower limit. With no lower limit on the time delay the delay could degrade to a very short delay, such that the DVR would separate the offsite system from the safety buses on a short negative voltage transient when it is not necessary to separate. A lower limit should therefore be specified for this time delay.

APS Response

A lower limit will be added to TS 3.3.7 SR 3.3.7.3. The revised SR is expected to be submitted by September 30, 1999.

NRC Request 12

TS 3.3.7 SR 3.3.7.3 is being changed for the loss of voltage relay to verify the time response at 0 volts (≤ 2.4 seconds) rather than 2929.5 volts (≤ 11.4 seconds). The explanation provided is that there is no specific requirement in any analysis that the loss of voltage relays trip in 2.4 seconds or less for a complete loss of voltage function; their explicit function is to trip in 2.4 seconds or less for a complete loss of voltage condition. The loss of voltage setpoint (≥ 3250 volts) is also being deleted. The explanation provided is that although the nominal setpoint of these relays is 3250 volts, they will not necessarily trip at that level; the manufacturer shows only the time/voltage curve for these relays in the range of 0 to 2925 volts because the trip time above 2925 is less predictable.

The relay in question is apparently a time undervoltage relay with inverse time characteristics. While we agree that the primary function of the relay is to detect a loss of voltage, there is also a secondary function provided by this relay. That function is to provide a lower limit for the DVR such that a voltage that falls substantially below the setpoint of the DVR will be detected by the loss of voltage relay and trip the circuit more quickly than the DVR, avoiding the potentially more limiting effects of the lower voltage. The change to only test the relay at 0 volts would not verify this secondary function of the relay. We agree that the nominal setpoint (3250 volts) is not a predictable value at which to check the timing of the relay. Therefore, we believe that the relay timing should be checked at the maximum (2929.5 volts) and minimum (0 volts) points shown on the manufacturer's time/voltage curve for the relay. In addition, the surveillance should specify a lower as well as an upper limit for the time delay to avoid unwanted separations from the offsite power system as explained in question 11 above.

APS Response

A surveillance requirement at 2929.5 volts will be added. Upper and lower limits will be added based on a ±10% uncertainty band. The revised SR is expected to be submitted by September 30, 1999.

NRC Request 13

One of the changes being made to the Palo Verde Updated Final Safety Analysis Report is the deletion of a statement that the time delays of the undervoltage relays are such that: "The allowable time delay, including margin, does not exceed the maximum time delay that is assumed in accident analyses." No explanation for this deletion has been provided. Please explain why this statement is being deleted and the impact on the safety analysis.

APS Response

This statement was based on one of the stipulations of the December 12, 1977 NRC letter which mandates that Palo Verde install DVRs. This stipulation implies that the relays are expected to perform a useful function during the period immediately following an accident signal. However the letter also states that the concern is "sustained degradation of the offsite power system's voltage." A "sustained" condition would not exist during this transient period. The Palo Verde DVRs do protect against sustained degraded voltage conditions, but are not useful during fluctuating voltage conditions such as would occur right after an accident signal.

Based on design considerations, the delay was set at ≤ 35 second time delay, which exceeds the 10 seconds between an accident signal and availability of AC power assumed in the accident analyses. The NRC, as discussed in the Safety Evaluation Report, reviewed this design. No attempt was made to correlate the time delay with the accident analysis time, because it is impossible to assure that these relays would initiate transfer to the diesel generators within the assumed 10 seconds if the offsite circuit voltage drops to an inadequate level as a result of the various automatic switching operations that occur during such an event, regardless of their time delay setting.

The UFSAR change has no impact on any safety analyses, because the analyses do not postulate an accident associated with a degraded voltage condition. Palo Verde is analyzed for a LOP (i.e., complete loss of offsite power) as a consequence of a LOCA. Although the load sequencer is designed to respond to a "LOCA that is followed at a later time by a LOP" (UFSAR Section 8.3.1.1.3.10.1), the accident analyses do not postulate that the LOP occurs more than 3 seconds after an accident. UFSAR section 8.3.4 includes timing requirements for reestablishment of core cooling and emergency feedwater flow if a LOP should occur "some time after the standby generators are up to rated voltage and speed, and after the required ESF equipment is running following one or more ESFAS." However, the UFSAR does not discuss a LOP that occurs during the transient period when emergency equipment has not yet reached a stable operating condition.

Even if the accident analyses were modified to take the DVR time delay into account, it could not be assured that core cooling would be established within this period, nor that the equipment would perform satisfactorily following such an event. For example, if sequencing commenced onto the offsite circuits, causing the voltage to fall into the DVR operating range, say 20 seconds into the sequencing, reestablishment of core cooling from the diesel generator supply would not be accomplished until after another approximately 35 seconds, or at total of approximately 55 seconds after the accident signal, plus the additional time from the restart of sequencing. The analyses would be unable to demonstrate that the equipment would perform satisfactorily following the timeout period due to the possibility of equipment damage or misoperation due to low voltage during the timeout period.

Even with a shorter time delay, the DVRs would not perform a useful protective function during the period of automatic switching immediately following an accident signal while the voltage is fluctuating. An LCO that considers the status of relevant electrical parameters is the appropriate means of assuring adequate voltage supply in this period. This conclusion is based on the following:

- During the period immediately following the inception of an accident, the voltage sensed by the DVRs drops and then fluctuates due to various automatic switching operations. These dynamic effects are incompatible with a DVR design that utilizes one voltage setpoint, with a time delay, to attempt to measure the adequacy of the offsite circuits. Although this scheme is suitable for steady-state conditions, it is inadequate as a "start-permissive" design during transient conditions. For example, if the voltage prior to the accident was only slightly above the DVR setpoint, the DVR would permit the starting of the safety-related equipment onto the offsite circuits even when the inevitable effect of the additional loading was a depression of the voltage into the DVR operating range, actuation of the DVRs, deenergization of the equipment, and reenergization onto the DGs.
- The DVRs do not protect against low voltages that could be imposed on the safety equipment during the relay timeout period.
- Starting the emergency equipment on the offsite sources, then immediately tripping them and restarting them on the DGs could cause a delay in core cooling and other possible vulnerabilities such as tripping of protective devices and water hammer (see NRC Information Notice 93-17, Revision 1, "Safety Systems Response to Loss of Coolant and Loss of Offsite Power," 25 March 1994) which would be difficult to analyze. The proposed measures guard against such a scenario.
- Regulatory Guide 1.93 requires that an accident not cause a separation of the safety-related equipment from the offsite circuits. Since the undervoltage relays cannot anticipate the voltage changes that will occur as a consequence of an accident, other measures, such as our analyses and proposed administrative controls, must be credited to ensure the viability of the offsite sources during this period. The NRC has previously notified the industry of the need for these analyses and administrative controls (NRC Information Notice 84-02, "Operating a Nuclear Power Plant at Voltage Levels Lower than Analyzed," 10 January 1984, and NRC

Information Notice 86-100, "Loss of Offsite Power to Vital Buses at Salem 2," 12 December 1986). The administrative controls, i.e., the LCO, limit the period of plant vulnerability in accordance with accepted standards when conditions occur which are more severe than those used in the analyses.