10 CFR 50.90

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April 1, 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
License Amendment Request to Revise Technical Specifications Regarding Degraded and Loss of Voltage Relay Modifications

In accordance with the provisions of Section 50.90 of Title 10 of the *Code of Federal Regulations* (10 CFR), Arizona Public Service Company (APS) is submitting a license amendment request (LAR) to revise the Technical Specifications (TS) for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3. The LAR would revise TS requirements regarding 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.

The proposed amendment satisfies the commitment made to the NRC in APS letter number 102-06948, dated September 26, 2014 [Agency Document Access and Management System (ADAMS) accession number ML14276A032], as modified by letter number 102-07144, dated November 25, 2015 (ADAMS accession number ML15329A228).

The enclosure to this letter provides a description and assessment of the proposed changes including a summary of the technical evaluation, a regulatory evaluation, a significant hazards consideration, and an environmental consideration. The enclosure also contains four attachments. Attachment 1 provides the marked-up existing TS pages. Attachment 2 provides the revised (clean) TS pages. Attachment 3 provides the marked-up TS Bases pages to show the conforming changes. Attachment 4 provides a detailed technical description of the planned modification of the degraded and loss of voltage relays and the underlying technical basis for the scheme changes, including the electrical distribution requirements for the supported accident mitigation equipment and the allowable values established for the relays.

A001
NRR

No new commitments are being made in this submittal. A public pre-submittal meeting was held with the NRC on September 22, 2015 (ADAMS accession number ML15306A235), to discuss the technical and administrative elements of the LAR.

In accordance with the PVNGS Quality Assurance Program, the Plant Review Board and the Offsite Safety Review Committee have reviewed and approved the LAR. By copy of this letter, this LAR is being forwarded to the Arizona Radiation Regulatory Agency in accordance with 10 CFR 50.91(b)(1).

APS requests approval of the LAR within 18 months and will implement the TS amendment within 120 days following NRC approval. 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.

Should you have any questions concerning the content of this letter, please contact Thomas Weber, Department Leader, Nuclear Regulatory Affairs, at (623) 393-5764.

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

Executed on : April 1, 2016
(Date)

Sincerely,

FOR MARIA LACAL

MLL/TNW/CJS/af

Enclosure: Description and Assessment of Proposed License Amendment

cc:	M. L. Dapas	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
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Enclosure

Description and Assessment of Proposed License Amendment

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LIST OF ACRONYMS

ac or AC	Alternating Current
AFAS	Auxiliary Feedwater Actuation Signal
AFP	Auxiliary Feedwater Pump
APS	Arizona Public Service Company
BOP-ESFAS	Balance of Plant Engineered Safety Features Actuation System
BTP	Branch Technical Position
CFR	Code of Federal Regulations
DC	Direct Current
DVR	Degraded Voltage Relay
DG	Diesel Generator
EDG	Emergency Diesel Generator
ESF	Engineered Safety Feature
ESFAS	Engineered Safety Features Actuation System
ETAP	Electrical Transient Analysis Program
GDC	General Design Criterion
GSI	Generic Safety Issue
hp	Horsepower
HPSI	High Pressure Safety Injection
kV	kilovolts (1,000 volts)
LAR	License Amendment Request
LCO	Limiting Condition for Operation
LER	Licensee Event Report
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
LOV	Loss of Voltage
LOVS	Loss of Voltage Start
LPSI	Low Pressure Safety Injection
LVR	Loss of Voltage Relay
MCC	Motor Control Center
MOV	Motor Operated Valve
PVNGS	Palo Verde Nuclear Generating Station
RCP	Reactor Coolant Pump
SIAS	Safety Injection Actuation Signal
SR	Surveillance Requirement
TLU	Total Loop Uncertainties
TS	Technical Specification
UFSAR	Updated Final Safety Analysis Report
URI	Unresolved Item

1.0 SUMMARY DESCRIPTION

The license amendment request (LAR) would revise Palo Verde Nuclear Generating Station (PVNGS) Renewed Operating License Nos. NPF-41, NPF-51, and NPF-74 to revise the Technical Specifications (TS) regarding 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 reliance on automatic actuation of the degraded and loss of voltage relays to ensure proper equipment performance. The proposed amendment satisfies the Arizona Public Service Company (APS) commitment made to the NRC in APS letter number 102-06948, dated September 26, 2014 (Reference 6.1), as modified by letter number 102-07144, dated November 25, 2015 (Reference 6.2).

This enclosure provides a description and assessment of the proposed changes including a summary of the technical evaluation, a regulatory evaluation, a significant hazards consideration, and an environmental consideration. This enclosure also contains four attachments. Attachment 1 provides the marked-up existing TS pages. Attachment 2 provides the revised (clean copy) TS pages. Attachment 3 provides the marked-up TS Bases pages to show the conforming changes. Attachment 4 provides a detailed technical description of the planned modification of the degraded and loss of voltage relays and the underlying technical basis for the scheme changes, including the electrical distribution requirements for the supported accident mitigation equipment and the allowable values established for the relays.

2.0 DETAILED DESCRIPTION

2.1 Proposed Changes to the Technical Specifications

The following specific TS changes are proposed to reflect the planned modifications to the degraded voltage relays (DVRs) and loss of voltage relays (LVRs).

- TS 3.3.7, *Diesel Generator (DG) – Loss of Voltage Start (LOVS)*
    - Revise Surveillance Requirement (SR) 3.3.7.3 for the unmodified Class 1E bus(es):
        - Add a new NOTE indicating the SR is only applicable to Class 1E bus(es) with a single stage time delay for the DVRs and an inverse time delay for the LVRs
    - Add a NOTE to new SR 3.3.7.4 indicating the SR is only applicable to Class 1E bus(es) that have been modified to include a two stage time delay for the DVRs and a fixed time delay for the LVRs
    - Add new SR 3.3.7.4.a for the modified bus(es) to:
        - Provide new TS allowable values for the degraded voltage function
        - Provide a short stage time delay for the DVRs when a safety injection actuation signal (SIAS) is present
        - Provide a long stage time delay for the DVRs when a SIAS is not present

- Add new SR 3.3.7.4.b for the modified bus(es) to:
  - Provide new TS allowable values for the loss of voltage function
  - Provide a fixed time delay relay for the LVRs

- TS 3.8.1, *Electrical Power Systems*
  - Add a new NOTE to the ACTIONS table for Condition G indicating Condition G is not applicable for Class 1E bus(es) provided with a two stage time delay for the DVRs and a fixed time delay for the LVRs

Marked-up TS pages are provided in Attachment 1 and revised TS pages (clean copy) are provided in Attachment 2. The TS Bases will also be revised for consistency with the proposed TS changes. A markup of the TS Bases pages reflecting these conforming changes is provided in Attachment 3 for information. The proposed TS Bases changes will be implemented in accordance with TS 5.5.14, *Technical Specifications (TS) Bases Control Program*, at the same time that the TS changes in the approved license amendment are implemented.

2.2 Need for Proposed Changes

In References 6.1 and 6.2, APS committed to submit an LAR to be more aligned with designs generally implemented in the industry regarding degraded voltage protection. 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 reliance on automatic actuation of the degraded and loss of voltage relays to ensure proper equipment performance.

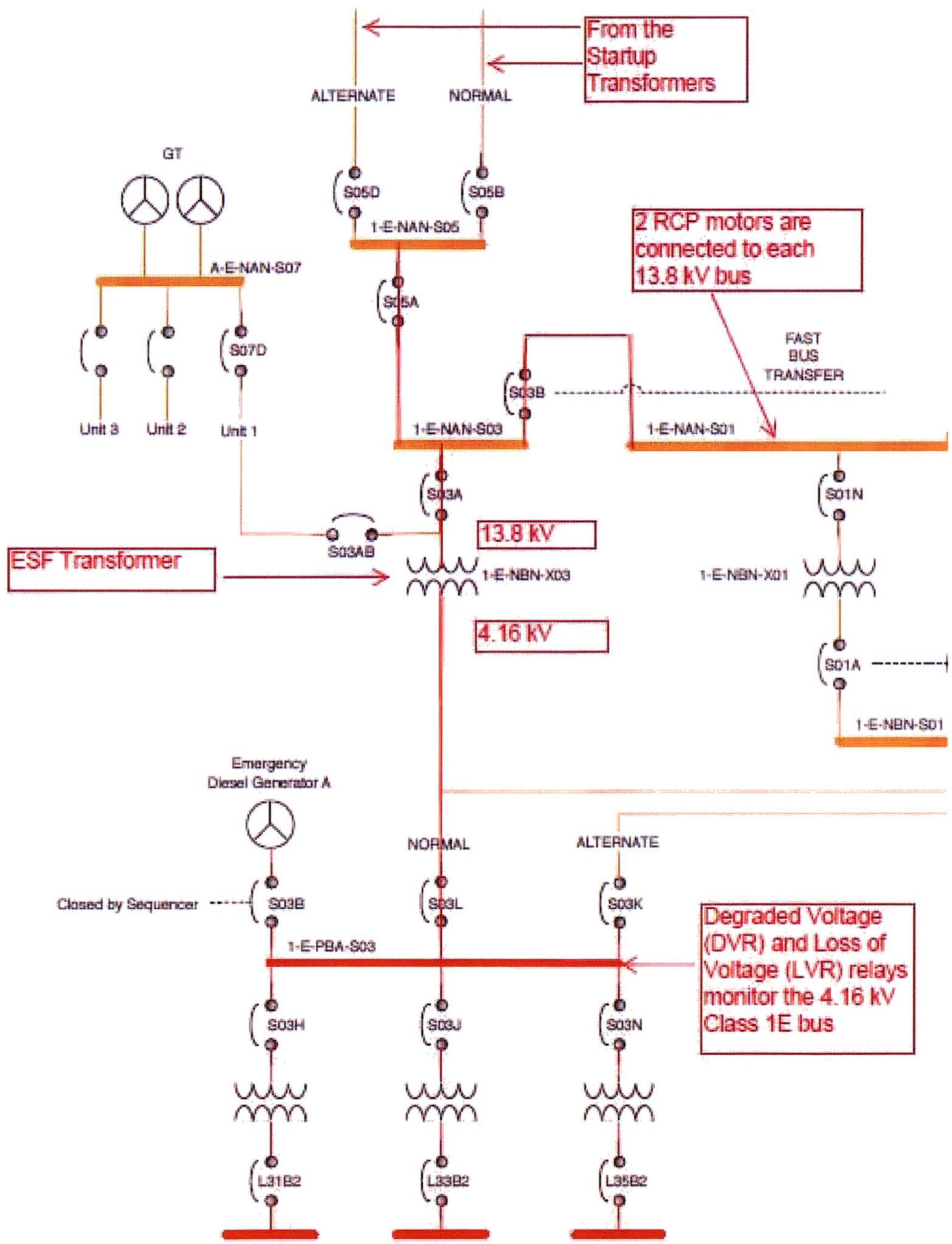
An unresolved item (URI) was originally documented in Reference 6.3 and closed in Reference 6.4. In November 2009, the NRC initially identified the URI with two aspects related to the degraded voltage protection scheme. The first aspect involved the time delay for the degraded voltage protection scheme. Specifically, the existing time delay of up to 35 seconds for transfer of safety buses to the onsite emergency power supplies. APS had submitted a license amendment request, dated December 16, 1998, that proposed TS changes involving administrative controls aimed at preventing the spurious separation of safety buses during an accident, which was approved as license amendment 123, dated December 29, 1999 (Reference 6.5). The inspection report (Reference 6.3) questioned the approved license amendment approach with regard to the DVR time delay.

The second aspect of the URI involved the voltage value used in design calculations to support the DVR voltage setpoint. The second aspect of the URI was closed in Reference 6.4 following APS performance of design calculations that demonstrated adequate equipment performance at the DVR dropout voltage, as compared to the previous calculations that were performed at the DVR reset voltage.

In order to effectively address the first aspect of the URI, modifications to the DVRs have been identified to establish a two stage time delay scheme: one short stage time delay for when an accident (i.e., SIAS) signal is present and a second long stage time delay when no SIAS signal is present. The long stage time delay permits reactor coolant pump (RCP) motor starts, without a concern that the Class 1E buses would be inappropriately separated from the preferred offsite power sources.

The RCPs are provided with large 13.8 kV motors and the start of an RCP motor momentarily lowers bus voltage (for approximately 18 seconds) such that the planned short stage time delay of approximately 7 seconds could cause inappropriate separation of the Class 1E bus from the preferred offsite power sources. While the RCP motors are not powered from the Class 1E buses, the momentary voltage depression resulting from an RCP motor start is on the high (i.e., 13.8 kV non-Class 1E) side of the engineered safety features (ESF) transformers that provide the preferred offsite power to the 4.16 kV Class 1E buses. This relationship is illustrated in the following figure.

13.8 kV to Train "A" Class 1E 4.16 kV Electrical Distribution System



During the development of the modification for the DVRs, it was determined that it would be advantageous to also replace the existing mechanical inverse time delay LVRs with solid state fixed time delay relays.

This LAR proposes to change the PVNGS design and licensing basis such that the design will rely upon the actuation of the degraded voltage protection scheme (DVRs and LVRs) on a deterministic basis, without crediting the preventive administrative controls implemented for TS 3.8.1, Condition G, once the modifications are completed. The current 1-hour required action completion time of LCO 3.8.1, Condition G, would no longer be applicable once the modification is complete on Class 1E bus(es) for the PVNGS units, since the design will rely on the automatic actuation of the relays without crediting administrative controls. Following the completion of the modifications an administrative LAR will be submitted to remove 3.8.1, Condition G and the old relay information from SR 3.3.7.3.

The administrative controls will remain as a defense-in-depth preventive strategy, as compared to being the licensed success path for degraded voltage protection. The administrative controls are documented in the TS Bases and support the operability of the preferred offsite sources. Reliance upon the DVRs and LVRs in the degraded voltage protection scheme is more aligned with designs generally implemented in the industry and the Standard Technical Specifications (NUREG-1432).

The proposed modification and SR changes update the allowable values for the DVRs and LVRs and their respective time delays to be consistent with current setpoint methodologies, as compared to simple operational bands about a nominal setpoint. These changes are also aligned with designs and TS generally implemented in the industry.

3.0 TECHNICAL EVALUATION

A summary of the technical basis for the change is provided in Sections 3.1, 3.2 and 3.3 of this Enclosure. The detailed technical descriptions of the planned modification of the DVRs and LVRs and the underlying technical basis for the scheme change are provided in Attachment 4 of this Enclosure. Included in Attachment 4 is a description of the electrical distribution requirements for the supported accident mitigation equipment and the allowable values established for the relays.

3.1 Degraded Voltage Relay

If the preferred offsite power source is available to the Class 1E buses following an engineered safety features actuation system (ESFAS) signal (i.e., SIAS), the Class 1E loads will be started through a solid-state load sequencer. However, in the event that preferred offsite power source is degraded or lost, as indicated by actuation of the DVRs or LVRs, the Class 1E loads are shed, with a one second load shed pulse, and the standby power source [i.e., emergency diesel generator (EDG)] is connected to the applicable Class 1E buses. The load sequencer then functions to start the required Class 1E loads in programmed time increments. Sequencing of the accident mitigation loads following initial DVR or LVR actuation will be within the timing assumptions of the accident analysis after the modifications are completed. The LAR does not alter the basic voltage setting of the DVRs. The nominal setting of the DVRs is 90 percent of the nominal bus voltage.

The proposed modification to the DVRs and LVRs will address the first aspect of the URI identified in Reference 6.3 by applying a shorter DVR time delay in the event of a SIAS coincident with degraded voltage. This shorter time delay will ensure the DVRs provide the second level of undervoltage protection in a manner aligned with designs generally implemented in the industry.

The design of the modifications are supported by several analyses that ensure the resulting plant design meets the relevant guidelines of NRC Standard Review Plan (NUREG-0800), Branch Technical Position (BTP) 8-6, *Adequacy of Station Electric Distribution System Voltages* (Reference 6.6).

Specifically, BTP 8-6, Section B.1, and subparagraphs (a) and (b) are the relevant sections for the modification. The subparagraphs read as follows:

> *In addition to the undervoltage scheme provided to detect LOOP at the Class 1E buses, a second level of undervoltage protection with time delay should be provided to protect the Class 1E equipment. This second level of undervoltage protection should satisfy the following criteria:*
>
> a. *The selection of undervoltage and time delay setpoints should be determined from an analysis of the voltage requirements of the Class 1E loads at all onsite system distribution levels.*
>
> b. *Two separate time delays should be selected for the second level of undervoltage protection based on the following conditions:*
>
>   i. *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.*
>
>   ii. *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.*

As noted in Section 2.2 of this Enclosure, APS produced an analysis demonstrating the safety-related electrical equipment can perform their design basis functions at the DVR dropout analytical limit, which was the second aspect of the URI closed in Reference 6.4. The analysis demonstrated that the DVR undervoltage settings meet the objectives of BTP 8-6, Section B.1, subparagraph (a). Neither the alarm function in the control room nor the coincidence logic for the actuation of the DVRs and LVRs are affected by the proposed modification.

The existing DVR design provides a separate relay to support the degraded voltage alarm function in the control room. The setpoints for the alarm function (voltage and time delay) are not proposed to be altered by this modification. This is because the nominal voltage setpoint of the relay is not being altered by the modification and the time delay value of the relay is about the same as the SIAS short-stage time delay.

A detailed technical summary of the supporting analyses is provided in Attachment 4 of this Enclosure.

3.1.1 Degraded Voltage Relay Short Stage Time Delay

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 short stage time delay upper limit is based on ensuring the DVR trip will result in actuation of the balance of plant engineered safety features actuation system (BOP-ESFAS) sequencer loss of offsite power (LOOP) response within the time evaluated in safety analyses for LOOP-SIAS events. Safety analyses assume the EDG is ready to receive loads in 10 seconds or less after a SIAS signal, as required by TS SR 3.8.1.7. Allowing for an intentional 1 second delay from the BOP-ESFAS sequencer load shed pulse, results in an analytical limit of 9.0 seconds. The corresponding allowable value is 8.5 seconds. Therefore, the subsequent connection of the EDG to the safety related buses and initiation of load steps will be in accordance with the safety analyses.

While the DVR is timing out, there is a need to ensure that equipment required to operate for an accident response will not be damaged and the protective relays will not trip so that the equipment would still be available to automatically start when sequenced following separation from the offsite source by the DVRs. As described in greater detail in Attachment 4 of this enclosure, calculations were performed that evaluated conditions relevant for SIAS, which is the time period while the DVR timer is running. The results were then used to determine the limits needed for the LVR to ensure equipment required to operate for an accident response will not be damaged and the protective relays will not trip. The LVR limits are discussed in Section 3.2, of this Enclosure.

The short stage timer scenario assumes a degraded voltage coincident with the SIAS. During the short stage time delay, the first two steps of the SIAS load sequence occur, which include start of the high pressure safety injection (HPSI) pump motors at time 0, start of the low pressure safety injection (LPSI) pump motors at time 5 seconds, and start of associated motor operated valves (MOVs) and auxiliary motors at each of those times. The calculation evaluates whether motors would stall, reach motor thermal limits, or whether overcurrent trips would occur.

In the upper portion of the evaluated degraded voltage range, motors take longer to accelerate but do not stall. In the lower portion of the evaluated degraded voltage range, motors may stall, but draw less current, resulting in a longer time until overcurrent protective relay trips. To evaluate motor performance, the calculation uses motor and load torque characteristics to determine the motor acceleration time as well as current draw with reduced voltage. These are compared with overcurrent relay trip characteristics and manufacturer motor thermal limits as well as the time from start signal to DVR trip.

For motors that may stall or take significantly longer than normal to accelerate, in the lower portion of the evaluated degraded voltage range, their overcurrent relays will not trip and the motor safe stall times are not exceeded for time delays of 9.0 seconds, or shorter. The HPSI pump motor is the limiting component for this evaluation. The bus voltage that allows the HPSI pump motor to stall is one of the inputs to the analytical limit for the replacement LVRs. As described in Section 3.2 of this Enclosure, the LVRs will actuate and de-energize the bus in time to prevent overcurrent relay operation or damage. Some 480 volt motors may stall, but the analysis shows that they will not be damaged and no breakers or relays will be actuated. Motor operated valve motors have a safe stall time of 10 seconds, thus are not evaluated in detail in the calculation since the DVR or LVR actuation will occur prior to that time, since the upper analytical limit is 9.0 seconds.

For motor starters, no fuses will blow due to drawing inrush current for the duration of the short stage DVR time delay. Necessary equipment will, therefore, be available when transferred to the EDG and the conditions of BTP 8-6 subparagraph B.1(b)(i) are met (i.e., DVR/LVR trip only on sustained degraded voltage, DVR logic functions during occurrence of SIAS followed by DVR, and damage to permanently connected Class 1E loads is prevented).

3.1.2 Degraded Voltage Relay Long Stage Time Delay

An analysis of the operation of electrical equipment loads with degraded voltage below the DVR dropout with no SIAS present was performed, as described in greater detail in Attachment 4 of this Enclosure. The analysis was used to determine the upper and lower analytical limits for the voltage setpoint of the LVRs. The limits ensure that the DVR and LVR settings will avoid unnecessary trips while protecting equipment from damage and also ensuring the plant equipment can carry out automatic actions other than a SIAS, when a degraded voltage is present.

The long stage time delay for the DVRs has been analyzed to provide appropriate protection for time analytical limits of 27.4 and 44 seconds. The corresponding allowable values are 31.0 seconds and 40 seconds. The lower limit is based on ensuring the DVR will not trip due to voltage dips during RCP motor starts at the lower end of the switchyard voltage normal operating band. The upper limit is based on not exposing equipment to degraded voltage for longer than manufacturer recommended times and also ensuring no overcurrent trip lockouts occur on running equipment. The analysis shows that equipment running with voltages below the DVR dropout but just above the LVR dropout will not have an overcurrent trip before the maximum long stage time delay limit of 44 seconds.

More specifically, the long stage timer calculation evaluates equipment powered by Class 1E buses subject to a degraded voltage during the non-SIAS delay time. The calculation shows that permanently connected Class 1E loads are not damaged and are available when sequenced to onsite power in accordance with BTP 8-6, Section B.1, subparagraph (b)(ii).

Additionally, the auxiliary feedwater actuation signal (AFAS), which starts the train 'B' auxiliary feedwater pump (AFP-B) with its 1250 horsepower (hp) motor, was selected as the most significant non-SIAS defense-in-depth scenario and is addressed in the calculation.

The train 'A' AFP is steam driven and the associated MOVs are DC powered. The 'N' train (non-essential) motor driven AFP can be powered from the train 'A' Class 1E bus. Each of the AFPs are included in PVNGS Technical Specification 3.7.5, *Auxiliary Feedwater (AFW) System,* but the 'N' train AFP does not receive an AFAS signal. The 'N' train motor driven AFP is important from a risk perspective, but is not credited in the accident analysis. Operation of the 'N' train AFP is an operator manual action and, therefore, is not subject to automatic initiation during a postulated degraded voltage scenario.

The defense-in-depth analysis demonstrates that equipment required to respond to an AFAS will not be damaged and will be available to automatically start when sequenced, following separation from the offsite source by the DVRs.

In a manner similar to the short stage timer analysis, there is a need to ensure that while the DVR long stage timer is running, that equipment is not damaged nor does its protective relay trip. The long stage timer analysis evaluates voltages below DVR dropout. The results of this calculation were then used to determine the limits needed for the LVR. The LVR limits are discussed in Section 3.2 of this Enclosure.

In the upper portion of the evaluated degraded voltage range, motors take longer to accelerate but do not stall. In the lower portion of the evaluated degraded voltage range, motors may stall, but draw less current, resulting in a longer time until overcurrent protective relay trips. To evaluate motor performance, the calculation uses motor and load torque characteristics to determine the motor acceleration time as well as current draw with reduced voltage. These are compared with overcurrent relay trip characteristics and manufacturer motor thermal limits as well as the time from start signal to DVR trip.

The calculation for the long stage timer analyzes two scenarios with degraded voltage. The first scenario involves permanently connected equipment while the unit is either operating or shutdown. The second scenario involves an AFAS with power operation equipment running. The first scenario is to demonstrate compliance with the BTP, Section B.1, subparagraph (b)(ii). The second scenario is a defense-in depth assessment, beyond the regulatory guidance of the BTP.

The long stage timer first scenario analysis shows that no permanently connected motors will stall, no contactors will drop out, and no overcurrent trips will occur during the long stage delay time period of up to the analyzed limit of 44 seconds. Necessary equipment will be available when sequenced to the EDG and the conditions of BTP 8-6, Section B.1, subparagraph (b)(ii) are met for the long stage time delay (i.e., permanently connected Class 1E loads are not damaged and are available when sequenced to onsite power).

For the defense-in-depth long stage timer scenario (AFAS 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 signal and initiating the applicable BOP-ESFAS sequence onto the EDG.

With regard to related MOVs, the analysis shows that for a successful AFP-B motor start, the MOVs that are required to open at the time the AFP-B motor is started may stall until the AFP-B motor has completed accelerating and bus voltage recovers. The AFP-B motor acceleration time is less than 6.3 seconds and the MOV motor safe stall time is 10 seconds, so voltage will recover and the MOVs will open. With degraded bus voltages prior to an attempted AFP-B motor start lower than the voltage where the MOVs could stroke, the AFP-B start will be unsuccessful. The attempt to start the AFP-B will cause LVR actuation prior to any damage to the MOVs and the MOVs would be loaded onto the EDG with sufficient voltage to perform their safety functions.

As mentioned previously, the 'N' train AFP is unaffected by a coincident degraded voltage and AFAS signal. It would be available for manual operation after the bus is transferred to the EDG and, therefore, serves as additional defense-in-depth protection for the auxiliary feedwater heat removal safety function.

For motor starters that would be actuated by an AFAS, no fuses will blow due to drawing inrush current if actuated during the DVR long stage time delay with degraded voltages, such that the AFAS sequence will be successful.

3.2 Loss of Voltage Relay

The proposed new replacement LVRs, with a fixed time delay, will have limits and corresponding allowable values based on the following criteria:

1. The time delay must be long enough to not separate from offsite power during fast recovering grid disturbances such as a lightning strike. The analyzed limit for this criterion is 1.2 seconds and the corresponding allowable value is 1.4 seconds.

2. The time delay must be short enough to respond to a total loss of voltage without exposing the equipment to a very low voltage. It must also be less than the minimum safe times determined for the various equipment analyzed in the supporting calculations. The analyzed limit for this criterion is 2.5 seconds and the corresponding allowable value is 2.3 seconds.

3. The voltage must be below the minimum related to a RCP motor start, to ensure that the LVR does not cause an inappropriate separation from offsite power during that motor start. The analyzed limit is 3314 volts with a corresponding allowable value of 3300 volts.

4. The voltage must be above the minimum safe voltages determined for the various equipment analyzed in the supporting calculations. The analyzed limit for this criterion is 3220 volts and the corresponding allowable value is 3240 volts.

The new replacement LVRs are definite-time devices, so they will respond within fixed times regardless of the actual voltage level, so long as it is below the dropout value. As stated in the discussion of the DVR long-time delay analysis the supporting calculations determined limits to ensure that:

1. The capability of the equipment required to respond to a SIAS to automatically restart after the DVR short stage time delay with a bus voltage below the DVR lower voltage analytical limit, and

2. The capability of permanently connected Class 1E equipment to operate with voltage just above the upper LVR dropout limit for the DVR long stage time delay.

The calculations provide the limits needed to ensure the adequacy of the LVR dropout setpoint to protect equipment from damage and to ensure equipment does not lock out requiring a manual reset of overcurrent devices. The time delay of the LVR dropout is long enough to allow for switchyard voltage transients caused by lightning strikes, clearance of grounds or other faults, while being short enough to minimize time equipment is off-line due to the loss of voltage.

The upper limit on the LVR dropout setpoint is coordinated with the minimum voltage expected during operation by ensuring it would not actuate due to the voltage dip caused by a RCP motor start in the lower end of the switchyard voltage normal operating band. A more detailed description of the calculations is provided in Attachment 4 to this Enclosure.

3.3 Relay Setpoint Determination

The proposed modifications and TS SR changes provide new allowable values for the modified relays and their respective time delays that are consistent with current setpoint methodologies. These changes are aligned with designs and TS generally implemented in the industry.

The method for determining the setpoints and the TS allowable values is consistent with current practices at PVNGS. The PVNGS design guide on this topic is consistent with current industry standards as described in greater detail in Attachment 4 of this Enclosure. The analytical limits are from various electrical analyses, accident analysis requirements, and from plant hardware characteristics.

The coordination of requirements for relay voltage and time delays and the determination of instrument inaccuracies and calibration acceptance criteria are provided in the supporting calculation described in greater detail in Attachment 4 of this Enclosure. The calculation addresses the bases for upper and lower bounds on the dropout voltages and time delays for the DVRs and LVRs as discussed in sections 3.1 and 3.2 of this Enclosure. It also provides the values required to be demonstrated during testing for actual in-service relay performance to meet the analytical limits for times and voltages. The setpoint calculation uses the conclusions of the supporting calculations, inputs from the transmission operator, as well as historical operating performance for the PVNGS relays.

Various potential factors affecting instrument uncertainty were considered. Vendor information for those factors was used or engineering judgments developed for any factors lacking specific vendor information. The various factors were then combined for an overall device uncertainty. The device uncertainties were combined to obtain total loop uncertainties (TLU) for appropriate environmental conditions. The uncertainty for the various devices was compared to work order history and found that instrument performance was within results expected from the determined uncertainty. The historical performance data supports the vendor information and the device uncertainties determined in the calculation. The uncertainties were applied to the analytical limits and the setpoints and allowable values obtained. The allowable values will be used to demonstrate operability of the DVRs and LVRs during periodic surveillance testing. A more detailed description of the setpoint and allowable value derivation calculation is provided in Attachment 4 to this Enclosure.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements

Relevant elements of NRC requirements, as well as a brief overview of PVNGS design features related to those requirements, are described below, with the NRC requirement identified first, followed by the related PVNGS design features in italics.

The regulations in 10 CFR 50.36(c)(2)(ii)(B), *Limiting conditions for operation*, state:

> Criterion 2. A 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.
>
> *Technical Specification (TS) 3.3.7 and 3.8.1 currently meet this requirement and will continue to meet this requirement after the proposed changes are approved and implemented.*

GDC 17, *Electric Power Systems*, requires the onsite and offsite power system (assuming the other system is not functioning) to have sufficient capacity and capability to assure:

1. Specified fuel design limits and design conditions of reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences, and the
2. Core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

Key relevant elements of GDC 17 requirements, as well as a brief overview of PVNGS design features related to those requirements, are described below, with the NRC requirement identified first, followed by the related PVNGS design features in italics:

Electric power from the transmission system to onsite distribution system to be supplied by "two physically independent offsite circuits."

> *Seven 525 kV transmission lines connect the PVNGS 525 kV switchyard with the RUDD, Colorado River, Westwing and Hassayampa switchyards. Seven physically independent circuits on four separate rights-of-way provide electric power from the transmission network to the PVNGS 525 kV switchyard which, in turn, supplies offsite (preferred) power to the onsite power system. Design of the offsite power system minimizes the*

possibility that failure of any one circuit will cause the failure of any other circuit. For each nuclear power unit, two physically independent, full-capacity electric power circuits supply offsite (preferred) power to the onsite power system. Each circuit is available following a postulated LOCA to ensure that core cooling, containment integrity, and other vital safety functions are maintained.

The last paragraph of 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."

Provisions are included to minimize the probability of losing electric power from any of the remaining sources 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 diesel generator. Electric system stability studies indicate that major disturbances on one circuit of the transmission network will not cause loss of the transmission network circuits supplying offsite electric power to the units.

In addition to its two offsite (preferred) electric power supplies, each redundant load group is supplied by an EDG. The EDG is capable of providing the total load requirements for a safe shutdown of the unit, or for the ESF equipment, following a LOCA or other postulated accidents. The inherent design of the onsite power system prevents automatic paralleling of the two redundant load groups for each unit, the paralleling of the two diesel generators for each unit, or the automatic paralleling of any diesel generator with any of the offsite (preferred) power supplies.

With respect to GDC 17, the regulatory position of Regulatory Guide 1.32, *Use of IEEE STD 308-1971, "Criteria for Class 1E Electrical Systems for Nuclear Power Generating Stations"* (Revision 0, August 11, 1972), states "Criterion 17 delineates the design requirements regarding availability of power from the transmission network. Accordingly, a preferred design would include two immediate access circuits from the transmission network. An acceptable design would substitute a delayed access circuit for one of the immediate access circuits provided that availability of the delayed access circuit conforms to Criterion 17."

The PVNGS design provides a minimum of two immediate access offsite to onsite circuits from the transmission network.

GDC 17 defines design requirements. It does not specify operating requirements or stipulate operational restrictions on the loss of offsite power sources. The operating requirements are described in Regulatory Guide 1.93, *Availability of Electric Power Sources* (Revision 0, December 1974) and are based upon the design of the plant ac power systems. One of the underlying purposes of GDC 17 is that a failure of the offsite source (including degraded voltage) should not cause a failure of the onsite source to perform its safety function.

The PVNGS design complies with this purpose. During an actual loss of voltage or degraded voltage condition, the loss of voltage and/or degraded voltage time delay will isolate the Class 1E 4.16 kV distribution system from offsite power before the diesel is ready to assume the emergency loads.

NRC Standard Review Plan (NUREG-0800), Branch Technical Position (BTP) 8-6, *Adequacy of Station Electric Distribution System Voltages,* Revision 3, March 2007, describes the various elements of an acceptable design to address industry events with regard to degraded voltage protection schemes.

> *The proposed modification to the DVRs and LVRs and related design analyses document the PVNGS design meets these requirements. More detailed descriptions of how these requirements are addressed are provided in Attachment 4 of this Enclosure.*

Regulatory Guide (RG) 1.105, *Setpoints for Safety-Related Instrumentation*, Revision 1, November 1976, describes a method that the NRC staff finds acceptable for use in complying with the NRC regulations for ensuring that setpoints for safety-related instrumentation are initially within, and will remain within, the TS limits.

> *APS used this guide to establish the setpoint calculation methodologies and the planned changes to the related plant surveillance procedures.*

4.2 Precedent

The proposed license amendment was developed using relevant information from recently approved changes to degraded voltage protection schemes (References 6.7 through 6.12) at other nuclear stations.

4.3 Significant Hazards Consideration

As required by 10 CFR 50.91(a), *Notice for Public Comment*, an analysis of the issue of no significant hazards consideration using the standards in 10 CFR 50.92, *Issuance of Amendment*, is presented below:

1. Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No.

   The proposed change would revise the allowable values of the Palo Verde Nuclear Generating Station (PVNGS) Engineered Safety Features Actuation System (ESFAS) Class 1E 4.16 kV bus degraded voltage and loss of voltage relays. Specifically, the proposed change includes a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays with corresponding voltage settings. The proposed change is supported by design calculations and analyses to ensure that the Class 1E buses will be isolated from the normal off-site power source at the appropriate voltage level and time delay under either accident or non-accident sustained degraded voltage conditions. The normally operating safety-related motors will continue to operate without sustaining damage or tripping during the worst-case, accident (i.e., safety injection actuation signal, SIAS) or non-accident degraded voltage condition for the maximum possible time-delay. Thus, the safety-related loads will be available to perform their safety function if a loss-of-coolant accident (LOCA) coincident with a loss-of-offsite power (LOOP) occurs following a degraded voltage condition.

The proposed change implements a new design for a reduced (short stage) time delay to isolate safety buses from offsite power if a LOCA were to occur coincident with a sustained degraded voltage condition. This ensures that emergency core cooling system pumps inject water into the reactor vessel within the time assumed and evaluated in the accident analysis, consistent with current NRC requirements and 10 CFR Part 50, Appendix A, General Design Criterion 17, *Electric Power Systems.*

The proposed changes do not adversely affect accident initiators or precursors. The diesel generator start, due to a LOCA signal, and loading sequence are not affected by this change. During an actual loss of voltage or degraded voltage condition, the loss of voltage and/or degraded voltage time delay will isolate the Class 1E 4.16 kV distribution system from offsite power before the diesel is ready to assume the emergency loads, which is the limiting time basis for mitigating system responses to the accident. For this reason, the existing LOCA with coincident LOOP analysis continues to be valid.

Therefore, the proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

   Response: No.

   The proposed change would revise the allowable values of the PVNGS ESFAS Class 1E 4.16 kV bus degraded voltage and loss of voltage relays. Specifically, the proposed change includes a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays with corresponding voltage settings.

   The proposed change does not introduce any changes or mechanisms that create the possibility of a new or different kind of accident. While the proposed change does install new relays, with new settings and time delays, the relays are not new to the industry and are not being operated in a unique or different manner. No new effects on existing equipment are created nor are any new malfunctions introduced.

   The accidents and events previously analyzed remain bounding. Therefore, the proposed amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

   Response: No.

   The proposed change would revise the allowable values of the PVNGS ESFAS Class 1E 4.16 kV bus degraded voltage and loss of voltage relays. Specifically, the proposed change includes a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays with corresponding voltage settings. The proposed change implements a new design for a reduced time delay to isolate safety buses from offsite power if a LOCA were to occur coincident with a sustained degraded voltage condition. This ensures that emergency core cooling system pumps inject water into the reactor vessel within the time assumed and evaluated in the accident analysis, consistent with current NRC requirements and 10 CFR Part 50, Appendix A, General Design Criterion 17, *Electric Power Systems.* The proposed TS change to the maximum and minimum allowable voltages for the Class 1E 4.16 kV buses will allow all safety loads to have sufficient voltage to perform their intended safety functions while ensuring spurious trips are avoided. Thus, the results of the accident analyses will not be affected as the input assumptions are protected.

The diesel generator start, due to a LOCA signal, is not affected by this change. During an actual loss of voltage or degraded voltage condition, the loss of voltage and/or degraded voltage relay voltage settings and time delays will continue to isolate the Class 1E 4.16 kV distribution system from offsite power before the emergency diesel generator is ready to assume the emergency loads. Therefore, the proposed amendment does not involve a significant reduction in the margin of safety.

4.4 Conclusion

APS concludes that operation of the facility in accordance with the proposed amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified. Based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, *Standards for Protection Against Radiation.* However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or a significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

6.1 Arizona Public Service Company (APS) letter number 102-06948, *Degraded Voltage License Amendment Request Commitment*, dated September 26, 2014 (ADAMS accession number ML14276A032)

6.2 APS letter number 102-07144, Change to Degraded Voltage License Amendment Request Submittal Commitment Date, dated November 25, 2015 (ADAMS accession number ML15329A228)

6.3 Nuclear Regulatory Commission (NRC) letter, Palo Verde Nuclear Generating Station – NRC Component Design Bases Inspection Report 05000528; 05000529; 05000530/2009008, which transmitted Inspection Report 2009-008, dated November 19, 2009 (ADAMS accession number ML093240524)

6.4 NRC letter, Palo Verde Nuclear Generating Station – NRC Integrated Inspection Report 05000528/2014004,05000529/2014004,and 05000530/2014004, which transmitted Inspection Report 2014-004, dated November 12, 2014 (ADAMS accession number ML14317A308)

6.5 NRC letter, Palo Verde Nuclear Generating Station Units 1, 2, and 3 – Issuance of Amendments Re: Changes Related to Double Sequencing and Degraded Voltage Instrumentation, License Amendment 123, dated December 29, 1999 (ADAMS accession numbers ML003670582, ML003670584, and ML003670587)

6.6 NRC Standard Review Plan (NUREG-0800), Branch Technical Position (BTP) 8-6, *Adequacy of Station Electric Distribution System Voltages,* Revision 3, March 2007 (ADAMS accession numbers ML070710478)

6.7 NRC letter, Catawba Nuclear Station, Units 1 and 2, Issuance of Amendments Regarding Non-Conservative Technical Specification Allowable Value, dated January 12, 2016 (ADAMS accession numbers ML15320A333 ML16007A176)

6.8 NRC letter, Fermi 2 - Issuance of Amendment to Revise Degraded Voltage Function to Reflect Modification, dated October 20, 2010 (ADAMS accession number ML102770382)

6.9 NRC letter, Grand Gulf Nuclear Station, Unit 1 – Issuance of Amendment Re: Request for Changing Five Technical Specifications Allowable Values, dated August 31, 2015 (ADAMS accession number ML15195A355)

6.10 NRC letter, LaSalle County Station, Units 1 and 2, Issuance of Amendments Revision Loss of Voltage Relay Setting, dated September 29, 2014 (ADAMS accession number ML 14252A913)

6.11 NRC letter, Braidwood Station, Units 1 and 2, and Byron Station, Unit Nos. 1 and 2 - Issuance of Amendments Regarding Installation of New Low Degraded Voltage Relays and Timers on the 4.16 kV Engineered Safety Features (ESF) Buses, dated December 21, 2015 (ADAMS accession number ML15307A776)

6.12 NRC letter, Shearon Harris Nuclear Power Plant (HNP), Unit 1 – Issuance of Amendment to Revise Technical Specifications Table 3.3-4, Engineered Safety Features Actuation System Instrumentation, dated June 30, 2015 (ADAMS accession number ML15163A056)

ATTACHMENT 1

Marked-up Technical Specifications Pages

3.3.7-3
3.3.7-4
3.8.1-5

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.7.1	Perform CHANNEL CHECK.	In accordance with the Surveillance Frequency Control Program
SR 3.3.7.2	Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program
SR 3.3.7.3	-------------------NOTE------------------- Only applicable for Class 1E bus(es) provided with a single stage time delay for the degraded voltage relays and an inverse time delay for the loss of voltage relays. -- Perform CHANNEL CALIBRATION with setpoint Allowable Values as follows: a. Degraded voltage function ≥ 3697 V and ≤ 3786 V Time delay: ≥ 28.6 seconds and ≤ 35 seconds; and b. Loss of voltage function Time delay: ≥ 10.3 seconds and ≤ 12.6 seconds at 2929.5 V, and ≥ 2.0 seconds and ≤ 2.4 seconds at 0 V.	In accordance with the Surveillance Frequency Control Program

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.7.4	-------------------NOTE------------------ Only applicable for Class 1E bus(es) provided with a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays. --- Perform CHANNEL CALIBRATION with setpoint Allowable Values as follows: a. Degraded voltage function ≥ 3712 V and ≤ 3767 V with a two stage time delay Short stage time delay: ≥ 5.5 seconds and ≤ 8.5 seconds; and Long stage time delay: ≥ 31.0.seconds and ≤ 40.0 seconds; and b. Loss of voltage function ≥ 3240 V and ≤ 3300 V Time delay: ≥ 1.4 seconds and ≤ 2.3 seconds	In accordance with the Surveillance Frequency Control Program

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
-------------NOTE--------- Condition G is not applicable for Class 1E bus(es) provided with a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays. -------------------------- G. One or more required offsite circuit(s) do not meet required capability.	G.1 Restore required capability of the offsite circuit(s). OR -------------NOTE------------ Enter LCO 3.8.1 Condition A or C for required offsite circuit(s) inoperable. ----------------------------- G.2 Transfer the ESF bus(es) from the offsite circuit(s) to the EDG(s).	1 hour 1 hour
H. Required Action and Associated Completion Time of Condition A, B, C, D, E, F, or G not met.	H.1 Be in MODE 3. AND H.2 Be in MODE 5.	6 hours 36 hours
I. Three or more required AC sources inoperable.	I.1 Enter LCO 3.0.3.	Immediately

ATTACHMENT 2

Revised Technical Specifications Pages (Clean Copy)

3.3.7-3
3.3.7-4
3.8.1-5

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.7.1	Perform CHANNEL CHECK.	In accordance with the Surveillance Frequency Control Program
SR 3.3.7.2	Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program
SR 3.3.7.3	-------------------NOTE------------------- Only applicable for Class 1E bus(es) provided with a single stage time delay for the degraded voltage relays and an inverse time delay for the loss of voltage relays. -- Perform CHANNEL CALIBRATION with setpoint Allowable Values as follows: a. Degraded voltage function ≥ 3697 V and ≤ 3786 V Time delay: ≥ 28.6 seconds and ≤ 35 seconds; and b. Loss of voltage function Time delay: ≥ 10.3 seconds and ≤ 12.6 seconds at 2929.5 V, and ≥ 2.0 seconds and ≤ 2.4 seconds at 0 V.	In accordance with the Surveillance Frequency Control Program

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.7.4	-------------------NOTE------------------- Only applicable for Class 1E bus(es) provided with a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays. -- Perform CHANNEL CALIBRATION with setpoint Allowable Values as follows: a. Degraded voltage function ≥ 3712 V and ≤ 3767 V with a two stage time delay Short stage time delay: ≥ 5.5 seconds and ≤ 8.5 seconds; and Long stage time delay: ≥ 31.0.seconds and ≤ 40.0 seconds; and b. Loss of voltage function ≥ 3240 V and ≤ 3300 V Time delay: ≥ 1.4 seconds and ≤ 2.3 seconds	In accordance with the Surveillance Frequency Control Program

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
-------------NOTE--------- Condition G is not applicable for Class 1E bus(es) provided with a two stage time delay for the degraded voltage relays and a fixed time delay for the loss of voltage relays. -------------------------- G. One or more required offsite circuit(s) do not meet required capability.	G.1 Restore required capability of the offsite circuit(s). OR -------------NOTE------------ Enter LCO 3.8.1 Condition A or C for required offsite circuit(s) inoperable. ----------------------------- G.2 Transfer the ESF bus(es) from the offsite circuit(s) to the EDG(s).	1 hour 1 hour
H. Required Action and Associated Completion Time of Condition A, B, C, D, E, F, or G not met.	H.1 Be in MODE 3. AND H.2 Be in MODE 5.	6 hours 36 hours
I. Three or more required AC sources inoperable.	I.1 Enter LCO 3.0.3.	Immediately

ATTACHMENT 3

Marked-up Technical Specification Bases Pages

B 3.3.7-1
B 3.3.7-2
B 3.3.7-3
B 3.3.7-4
B 3.3.7-5
B 3.3.7-6
B 3.3.7-7
B 3.3.7-8
B 3.3.7-9
B 3.8.1-7
B 3.8.1-16
B 3.8.1-18
B 3.8.1-21

B 3.3 INSTRUMENTATION

B 3.3.7 Diesel Generator (DG) - Loss of Voltage Start (LOVS)

BASES

BACKGROUND

The DGs provide a source of emergency power when offsite power is either unavailable or insufficiently stable to allow safe unit operation. Undervoltage protection will generate a LOVS in the event a Loss of Voltage (LOV) or Degraded Voltage (DV) condition occurs.

Four solid state degraded voltage and four solid state under voltage relays [four solid-state relays and four induction disk relays][1] are provided on each 4.16 kV Class 1E bus for the purpose of detecting a sustained degraded voltage or a loss of bus voltage condition, respectively. The protective function of the Degraded Voltage Relays is maintained by assuring that they always actuate when voltage is ≤3712 [3697][1] V. To prevent spurious actuations, ~~the~~ time delays are provided; one for when a SIAS[2] is present (i.e., short stage time delay) and a second when no SIAS is present (i.e., long stage time delay). The Degraded Voltage Relays will not actuate when voltage is >~~3786~~3767 [3786][1] V. The time delay for the Degraded Voltage Relays is a maximum of ~~35~~ 40 [35][1] seconds when no SIAS[2] is present to permit Reactor Coolant Pump starts, without creating the potential for inappropriate loss of offsite power, and is not affected by the voltage level at which they are actuated. The time delay when a SIAS[2] is present (i.e., short stage time delay) is less than 8.5 seconds to coordinate with the design bases accident analysis.

The Loss of Voltage Relays actuate at a lower voltage. Their time delay varies depending on the voltage level, the lower the voltage, the shorter the time delay for Class 1E bus(es) that have not replaced the inverse time delay relay with a fixed time delay relay. The ~~primary~~ function of the Loss of Voltage Relays is to trip in 2.3 [2.4][1] seconds or less for a ~~complete~~ loss of voltage condition [and trip within 12.6 seconds if voltage drops to 2929.5 volts][1].

The Balance of Plant Engineered Safety Features Activation System (BOP ESFAS) Loss of Power/Load Shed (LOP/LS) module receives inputs from the LOV and DV relays. The LOP/LS module has four channels, each of the channels has one LOV input and one DV input. If either a LOV or DV signal is received in that channel, the channel trips. If any 2 of the 4 channels trip, a signal is sent to the BOP ESFAS Diesel Generator Start Signal (DGSS) module starting the diesel. The LOVS initiated actions are described in "Onsite Power Systems" (Ref. 1).

Footnote 1: Information in brackets [] relate to Class 1E buses that have not implemented the Degraded Voltage Relay two stage timer modifications and replaced the inverse time delay Loss of Voltage Relay.

Footnote 2: Discussion of two stage timer (i.e., SIAS signal time delay) applies only to Class 1E buses with the two stage timer DVR and fixed time delay LVR modification installed.

(continued)

BACKGROUND (continued)

Trip Setpoints and Allowable Values

~~Based on the trip setpoint, Calculation 13-EC-PB-202 (Ref. 5)~~ The trip setpoints and Allowable Values are based on the analytical limits presented in References 5, 6 and 7. Reference 8 establishes allowable minimum dropout and maximum reset values for the Degraded Voltage Relays, taking into account calibration tolerances, instrumentation uncertainties, and instrument drift. Maintaining the minimum dropout voltage (≥3712 [3697][1] V and ≤3767 [3786][1] V) ensures protection during ~~sustained~~ degraded voltage conditions.

~~Maintaining the maximum reset voltage (approximately 3805 V, Ref. 6) prevents spurious actuation during analyzed conditions. Calculations 01, 02, 03-EC-MA-221 (Ref. 6) verify that the voltage will recover above the maximum reset value following the most adverse accident loading scenario, and that the relays will not actuate during the transient period of automatic load sequencing.~~

The actual nominal trip setpoint is more conservative than that required by the plant specific setpoint calculations. If the measured setpoint does not exceed the Allowable Values, the relays are considered OPERABLE.

Setpoints in accordance with the Allowable Values will ensure that the consequences of accidents will be acceptable, providing the plant is operated from within the LCOs at the onset of the accident and the equipment functions as designed.

The undervoltage protection scheme has been designed to protect the plant from spurious trips caused by the offsite power source. A complete loss of offsite power will result in approximately a 2 second delay in LOVS actuation. The DG starts and is available to accept loads within a 10 second time interval on the Engineered Safety Features Actuation System (ESFAS) or LOVS. Emergency power is established within the maximum time delay assumed for each event analyzed in the accident analysis (Ref. 2).

(continued)

BACKGROUND

Trip Setpoints and Allowable Values (continued)

Since there are four protective channels in a two-out-of-four trip logic for each division of the 4.16 kV power supply, no single sensor failure will cause or prevent protective system actuation.

APPLICABLE SAFETY ANALYSES

The DG – LOVS is required for Engineered Safety Features (ESF) systems to function in any accident with a loss of offsite power. Its design basis is that of the ESFAS.APPLICABLE Accident analyses credit the loading of the DG based on a loss of offsite power during a loss of coolant accident. The actual DG start has historically been associated with the ESFAS actuation. The diesel loading has been included in the delay time associated with each safety system component requiring DG supplied power following a loss of offsite power. The analysis assumes a nonmechanistic DG loading, which does not explicitly account for each individual component of the loss of power detection and subsequent actions. This delay time includes contributions from the DG start, DG loading, and Safety Injection System component actuation. The response of the DG to a loss of power must be demonstrated to fall within this analysis response time when including the contributions of all portions of the delay.
The required channels of LOVS, in conjunction with the ESF systems powered from the DGs, provide plant protection in the event of any of the analyzed accidents discussed in Reference 2, in which a loss of offsite power is assumed. LOVS channels are required to meet the redundancy and testability requirements of GDC 21 in 10 CFR 50, Appendix A (Ref. 4).

The delay times assumed in the safety analysis for the ESF equipment include the 10 second DG start delay and the appropriate sequencing delay, if applicable. The response times for ESFAS actuated equipment in LCO 3.3.5, "Engineered Safety Features Actuation System (ESFAS) Instrumentation," include the appropriate DG loading and sequencing delay.

The DG – LOVS channels satisfy Criterion 3 of 10 CFR 50.36(C)(2)(ii).

(continued)

LCO

The LCO for the LOVS requires that four channels per bus of LOVS instrumentation be OPERABLE in MODES 1, 2, 3, and 4 and when the associated DG is required to be OPERABLE by LCO 3.8.2, "AC Sources – Shutdown." The LOVS supports safety systems associated with the ESFAS. In MODES 5 and 6, the four channels must be OPERABLE whenever the associated DG is required to be OPERABLE to ensure that the automatic start of the DG is available when needed.

Actions allow maintenance (trip channel) bypass of individual channels.

Loss of LOVS Function could result in the delay of safety system initiation when required. This could lead to unacceptable consequences during accidents. During the loss of offsite power, which is an anticipated operational occurrence, the DG powers the motor driven auxiliary feedwater pumps. Failure of these pumps to start would leave only the one turbine driven pump as well as an increased potential for a loss of decay heat removal through the secondary system.

Only Allowable Values are specified for each Function in the LCO. Nominal trip setpoints are specified in the plant specific setpoint calculations. The nominal setpoints are selected to ensure that the setpoint measured by CHANNEL FUNCTIONAL TESTS does not exceed the Allowable Value if the bistable is performing as required. Operation with a trip setpoint less conservative than the nominal trip setpoint, but within the Allowable Value, is acceptable, provided that operation and testing is consistent with the assumptions of the plant specific setpoint calculation. A channel is inoperable if its actual trip setpoint is not within its required Allowable Value.

APPLICABILITY

The DG – LOVS actuation Function is required in MODES 1, 2, 3, and 4 because ESF Functions are designed to provide protection in these MODES. Actuation in MODE 5 or 6 is required whenever the required DG must be OPERABLE, so that it can perform its function on a loss of power or degraded power to the vital bus.

(continued)

ACTIONS

A LOVS channel is inoperable when it does not satisfy the OPERABILITY criteria for the channel's function. The most common cause of channel inoperability is outright failure or drift of the bistable or process module sufficient to exceed the tolerance allowed by the plant specific setpoint analysis. Typically, the drift is found to be small and results in a delay of actuation rather than a total loss of function. Determination of setpoint drift is generally made during the performance of a CHANNEL FUNCTIONAL TEST when the instrument is set up for adjustment to bring it within specification. If the actual trip setpoint is not within the Allowable Value, the channel is inoperable and the appropriate Conditions must be entered.

In the event a channel's trip setpoint is found nonconservative with respect to the Allowable Value, or the channel is found inoperable, then all affected Functions provided by that channel must be declared inoperable and the LCO Condition entered. The required channels are specified on a per DG basis.

A.1 and A.2

Condition A applies if one channel per DG bus is inoperable.

If the channel cannot be restored to OPERABLE status, the affected channel should either be bypassed or tripped within 1 hour (Required Action A.1).

Placing this channel in either Condition ensures that logic is in a known configuration. In trip, the LOVS Logic is one-out-of-three. In bypass, the LOVS Logic is two-out-of-three. The 1 hour Completion Time is sufficient to perform these Required Actions.

Once Required Action A.1 has been complied with, Required Action A.2 allows prior to entering MODE 2 following the next MODE 5 entry to repair the inoperable channel. If the channel cannot be restored to OPERABLE status, the plant cannot enter MODE 2 following the next MODE 5 entry. The time allowed to repair or trip the channel is reasonable to repair the affected channel while ensuring that the risk involved in operating with the inoperable channel is acceptable. The prior to entering MODE 2 following the next MODE 5 entry Completion Time is based on adequate channel independence, which allows a two-out-of-three channel operation since no single failure will cause or prevent a system actuation.

(continued)

ACTIONS

B.1 and B.2

Condition B applies if two channels per DG bus are inoperable.

If the channel cannot be placed in bypass or trip within 1 hour, the Conditions and Required Actions for the associated DG made inoperable by DG – LOVS instrumentation are required to be entered. Alternatively, one affected channel is required to be bypassed and the other is tripped, in accordance with Required Action B.2. This places the Function in one-out-of-two logic. The 1 hour Completion Time is sufficient to perform the Required Actions.

One of the two inoperable channels will need to be restored to OPERABLE status prior to the next required CHANNEL FUNCTIONAL TEST because channel surveillance testing on an OPERABLE channel requires that the OPERABLE channel be placed in bypass. However, it is not permitted to bypass more than one DG-LOVS channel, and placing a second channel in trip will result in a loss of voltage diesel start signal.

After one channel is restored to OPERABLE status, the provisions of Condition A still apply to the remaining inoperable channel.

C.1

Condition C.1 applies when more than two channels on a single bus are inoperable.

Required Action C.1 requires all but two channels to be restored to OPERABLE status within 1 hour. With more than two channels inoperable, the logic is not capable of providing the DG – LOVS signal for valid Loss of Voltage or degraded voltage condition. The 1 hour Completion Time is reasonable to evaluate and take action to correct the degraded condition in an orderly manner and takes into account the low probability of an event requiring LOVS occurring during this interval.

D.1

Condition D.1 applies if the Required Actions and associated Completion Times are not met.

Required Action D.1 ensures that Required Actions for the affected DG inoperabilities are initiated. Depending upon plant MODE, the ACTIONS specified in LCO 3.8.1, "AC Sources – Operating," or LCO 3.8.2 are required immediately.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS

The following SRs apply to each DG – LOVS Function.

SR 3.3.7.1

Performance of the CHANNEL CHECK ensures that a gross failure of instrumentation has not occurred. A CHANNEL CHECK is normally a qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and status to other indications or status derived from independent instrument channels measuring the same parameter. A CHANNEL CHECK consists of verifying all relay status lights on the control board are lit. CHANNEL CHECK will detect gross channel failure; thus, it is key to verifying that the instrumentation continues to operate properly between each CHANNEL CALIBRATION.

Agreement criteria are determined by the plant staff. If the channels are within the criteria, it is an indication that the channels are OPERABLE. For clarification, a CHANNEL CHECK is a qualitative assessment of an instrument's behavior. Where possible, a numerical comparison between like instrument channels should be included but is not required for an acceptable CHANNEL CHECK performance.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

SR 3.3.7.2

A CHANNEL FUNCTIONAL TEST is performed to ensure that the entire channel will perform its intended function when needed.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

The as found and as left values must also be recorded and reviewed for consistency.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.3.7.3 and SR 3.3.7.4

SR 3.3.7.3 and SR 3.3.7.4 are the performance of a CHANNEL CALIBRATION. The CHANNEL CALIBRATION verifies the accuracy of each component within the instrument channel. This includes calibration of the Loss of Voltage and Degraded Voltage relays and demonstrates that the equipment falls within the specified operating characteristics defined by the manufacturer. The Surveillance verifies that the channel responds to a measured parameter within the necessary range and accuracy. CHANNEL CALIBRATION leaves the channel adjusted to account for instrument drift between successive surveillances to ensure the instrument channel remains operational. CHANNEL CALIBRATIONS must be performed consistent with the plant specific setpoint analysis. Any setpoint adjustment shall be consistent with the assumptions of the current plant specific setpoint analysis.

The as found and as left values must also be recorded and reviewed for consistency.

The setpoints, as well as the response to a Loss of Voltage and Degraded Voltage test, shall include a single point verification that the trip occurs within the required delay time, as shown in Reference 1. The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

SR 3.3.7.3 is modified by a Note. The Note indicates that the SR is only applicable to Class 1E buses that are provided with a single stage time delay Degraded Voltage Relays and an inverse time delay for the Loss of Voltage Relays. The Allowable Values of SR 3.3.7.3 reflect an allowable range about a nominal setpoint.

SR 3.3.7.4 is modified by a Note. The Note indicates the SR is only applicable to Class 1E bus(es) that are provided with a two stage time delay for the Degraded Voltage Relays and a fixed time delay for the Loss of Voltage Relays. The Allowable Values protect analytical limits as described in References 5, 6 and 7. The short stage (i.e., SIAS) time delay and the long stage (i.e., non-SIAS) time delay is applicable only to Class 1E buses that have implemented the two stage time delay modification on the Degraded Voltage Relays.

REFERENCES

1. UFSAR, Section 8.3

2. UFSAR, Chapter 15.

BASES

3. Controlled Dwg. Relay Setpoint Sheets.
4. 10 CFR 50, Appendix A, GDC 21.
5. ~~Calculation 13-EC-PB-202~~
5. Calculation 13-EC-MA-0643, "Degraded Voltage Results/Component Review"
6. ~~Calculations 01, 02, 03-EC-MA-221~~
6. Calculation 13-EC-PB-0205, "Degraded Voltage Relay Short Stage Timer Analysis"
7. Calculation 13-EC-PB-0206, "Degraded Voltage Relay Long Stage Timer Analysis"
8. Calculation 13-EC-PB-0202, "4160 V Degraded Voltage Relay (DVR) and Loss of Voltage Relay (LoVR) Setpoint & Calibration Calculation"

BASES

APPLICABILITY (continued)

The AC power requirements for MODES 5 and 6, and during movement of irradiated fuel assemblies are covered in LCO 3.8.2, "AC Sources – Shutdown."

ACTIONS

Condition A applies only when the offsite circuit is unavailable to commence automatic load sequencing in the event of a design basis accident (DBA). In cases where the offsite circuit is available for sequencing, but a DBA could cause actuation of the Degraded Voltage Relays, Condition G applies for Class 1E bus(es) with single stage time delay DVRs and inverse time delay LVRs.

A note prohibits the application of LCO 3.4.0.b to an inoperable DG. There is an increased risk associated with entering a MODE or other specified condition in the Applicability with an inoperable DG and the provisions of LCO 3.0.4.b which allows entry into a MODE or other specified condition in the Applicability with the LCO not met after performance of a risk assessment addressing inoperable systems and components, should not be applied in this circumstance.

A.1

To ensure a highly reliable power source remains with the one offsite circuit inoperable, it is necessary to verify the OPERABILITY of the remaining required offsite circuit on a more frequent basis. Since the Required Action only specifies "perform," a failure of SR 3.8.1.1 acceptance criteria does not result in a Required Action not met. However, if a second required circuit fails SR 3.8.1.1, the second offsite circuit is inoperable, and Condition C, for two offsite circuits inoperable, is entered.

A.2

Required Action A.2, which only applies if the train (i.e., ESF bus) cannot be powered from an offsite source, is intended to provide assurance that an event coincident with a single failure of the associated DG will not result in a complete loss of safety function of critical redundant required features. These features require Class 1E power from PBA-S03 or PBB-S04 ESF buses to be OPERABLE, and include: charging pumps; radiation monitors Train A RU-29 and Train B RU-30 (TS 3.3.9), Train A RU-31 and Train B RU-145; pressurizer heaters (TS 3.4.9); ECCS (TS 3.5.3 and TS 3.5.4); containment spray (TS 3.6.6); containment isolation valves NCA-UV-402, NCB-UV-403, WCA-UV-62, and WCB-UV-61 (TS

(continued)

ACTIONS

C.1 and C.2 (continued)

Condition C applies only when the offsite circuits are unavailable to commence automatic load sequencing in the event of a design basis accident (DBA). In cases where the offsite circuits are available for sequencing, but a DBA could cause actuation of the Degraded Voltage Relays, Condition G applies for Class 1E bus(es) with single stage time delay DVRs and inverse time delay LVRs.

D.1 and D.2

Pursuant to LCO 3.0.6, the Distribution System ACTIONS would not be entered even if all AC sources to it were inoperable resulting in de-energization. Therefore, the Required Actions of Condition D are modified by a Note to indicate that when Condition D is entered with no AC source to a train, the Conditions and Required Actions for LCO 3.8.9, "Distribution Systems – Operating," must be immediately entered. This allows Condition D to provide requirements for the loss of one offsite circuit and one DG without regard to whether a train is de-energized. LCO 3.8.9 provides the appropriate restrictions for a de-energized train.

According to Regulatory Guide 1.93 (Ref. 6), operation may continue in Condition D for a period that should not exceed 12 hours.

In Condition D, individual redundancy is lost in both the offsite electrical power system and the onsite AC electrical power system. Since power system redundancy is provided by two diverse sources of power, however, the reliability of the power systems in this Condition may appear higher than that in Condition C (loss of both required offsite circuits). This difference in reliability is offset by the susceptibility of this power system configuration to a single bus or switching failure. The 12 hour Completion Time takes into account the capacity and capability of the remaining AC sources, a reasonable time for repairs, and the low probability of a DBA occurring during this period.

(continued)

ACTIONS (continued)

G.1 and G.2

A Note indicates that Condition G is not applicable for Class 1E bus(es) provided with a two stage time delay for the Degraded Voltage Relays (DVR) and a fixed time delay Loss of Voltage Relays (LVR). The DVRs are being modified to install a two stage time delay design: one short stage time delay for when a SIAS is present and a second long stage time delay when no SIAS is present. The LVRs are being modified to replace the existing mechanical inverse time delay relays with fixed time delay relays. Condition G is not applicable to Class 1E bus DVRs and LVRs that have been modified. The installation of the two stage time delays ensures automatic actuation of the DVRs within the assumptions of the accident analysis should the offsite source post-trip voltage be degraded. Conditions A and C remain applicable to Class 1E buses that have been modified. The more restrictive requirements of Condition G reflect the single stage time delay DVR design not being consistent with the time delay assumptions of the accident analysis.

To ensure offsite circuits will not be lost as a consequence of a DBE, certain conditions must be maintained. Failure to maintain these conditions may result in double sequencing should an accident requiring sequencer operation occur.

An offsite circuit meets its required capability by maintaining either of the following conditions:

1. Steady-state switchyard voltage at or above the minimum level needed to support the offsite circuit's functions. The minimum allowable voltage is the value calculated as follows or 528.5 kV, whichever is less:

Base minimum voltage (provides for emergency loads on PBA-S03 or PBB-S04 and house loads on NAN-S01 or NAN-S02)		518 kV
If the offsite circuit is connected to 1-E-NAN-S05 or 1-E-NAN-S06	add	6.5 kV
If the house load group associated with the offsite circuit is connected to both NBN-S01 and NBN-S02 (tie breaker NBN-S01C closed)	add	4 kV
If the offsite circuit is connected to another unit's PBA-S03 or PBB-S04	add	1.5 kV

(continued)

ACTIONS

G.1 and G.2 (continued)

winding, this condition must be achieved in both units. Although Palo Verde has no formal restrictions on the amount of time that fast bus transfer can be out of service, this option should be used judiciously in order to maintain forced circulation capability.

3. Transfer the safety bus(es) to the diesel generator(s). 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).

Options 1 and 2 satisfy Required Action G.1, and Option 3 satisfies Required Action G.2. With more than one offsite circuit that does not meet the required capability, Condition G could be satisfied for each offsite circuit by the use of Required Action G.1 or G.2. The Completion Time for both Required Action G.1 and G.2 is one hour. The one hour time limit is appropriate and consistent with the need to remove the unit from this condition, because it supports an initial condition for the degraded voltage prevention strategy. ~~the~~ . ~~level of degradation exceeds that described in Regulatory Guide 1.93 (Ref. 6) for two offsite circuits inoperable. The regulatory guide assumes that an adequate onsite power source is still available to both safety trains, but in~~ In a scenario involving automatic load sequencing and low voltage to the ESF buses with a single stage time delay DVR design, adequate voltage is not assured from any of the power sources for the following systems immediately after the accident signal has been generated (i.e., while the degraded voltage relay is timing out): radiation monitors Train A RU-29 or Train B RU-30 (TS 3.3.9), Train B RU-145; ECCS (TS 3.5.3); containment spray (TS 3.6.6); containment isolation valves (TS 3.6.3); auxiliary feedwater system (TS 3.7.5); essential cooling water system (TS 3.7.7); essential spray pond system (TS 3.7.8); essential chilled water system (TS 3.7.10); control room essential filtration system (TS 3.7.11); ESF pump room air exhaust cleanup system (TS 3.7.13); and fuel building ventilation.

Required Action G.2 is modified by a Note. The reason for the Note is to ensure that the offsite circuit is not inoperable for a time greater than the Completion Time allowed by LCO 3.8.1 Condition A or C. Therefore, if Conditions A or C are entered, the Completion Time clock for

(continued)

ATTACHMENT 4

Technical Description of Modification of the Degraded and Loss of Voltage Relays

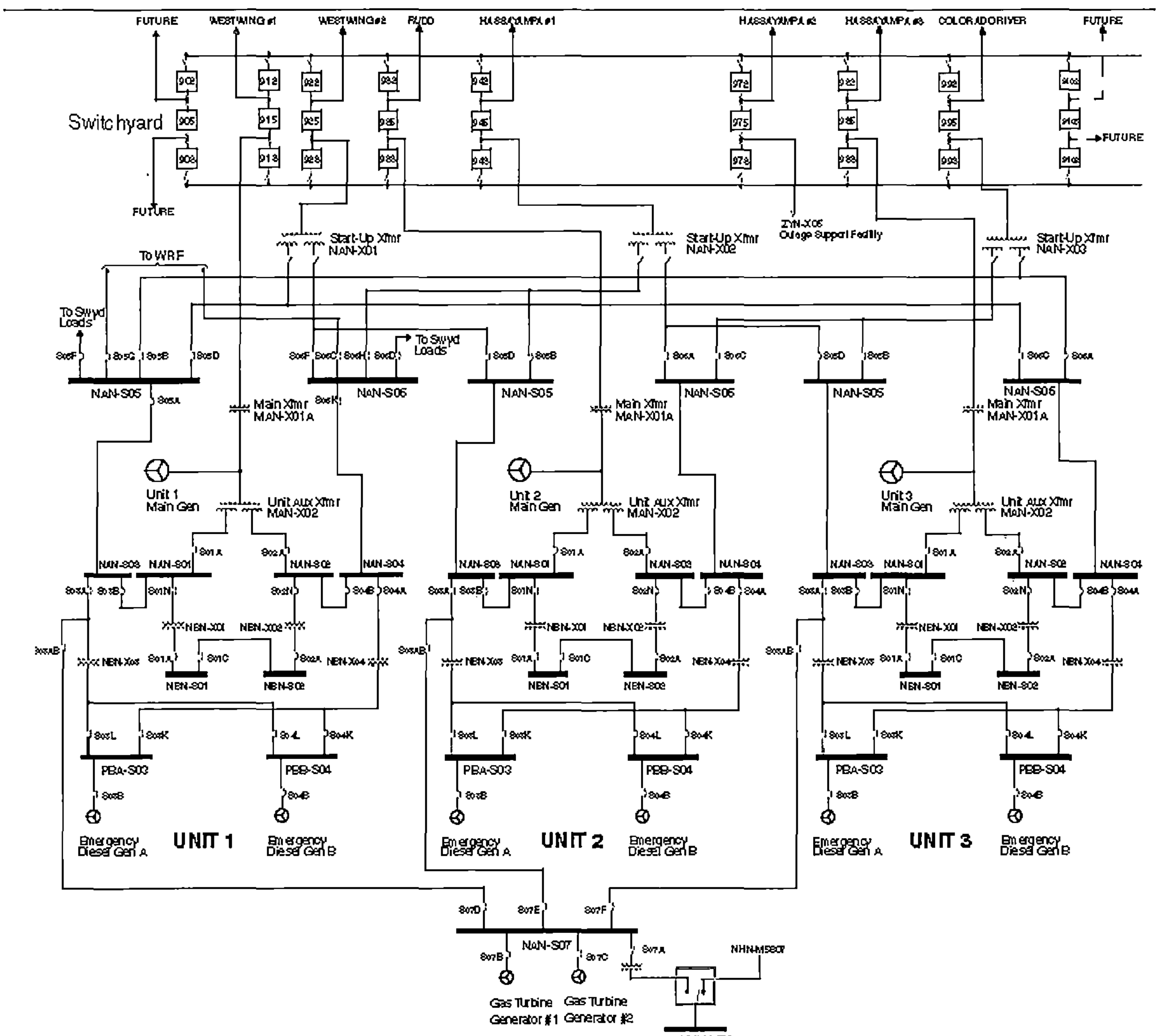
Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

1. Purpose

The purpose of Attachment 4 to the license amendment request (LAR) Enclosure is to provide additional technical summaries of the various calculations which support the modification discussed in the LAR.

2. System Description

Seven physically independent 525 kilovolt (kV) transmission lines of the Western Interconnection are connected to the Palo Verde Nuclear Generating Station (PVNGS) 525 kV switchyard, as shown in the figure below. Three 525 kV tie lines supply power from the switchyard to three startup transformers, which supply power to six 13.8 kV intermediate buses. Two physically independent circuits supply offsite (preferred) power to the onsite power system of each PVNGS unit.



Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

The PVNGS 525 kV switchyard utilizes a breaker-and-a-half design in which three breakers are provided for every two terminations, either line or transformers. Each turbine-generator connects to the PVNGS 525 kV switchyard through a main transformer, a 525 kV tie line, and two 525 kV switchyard breakers.

The three startup transformers connect to the PVNGS 525 kV switchyard through two 525 kV switchyard breakers each, and feed six 13.8 kV intermediate buses (two per unit). These buses are arranged in three pairs, each pair feeding only one unit. The intermediate buses for PVNGS Units 1, 2, and 3 are interconnected to the startup transformers so that each unit's buses can access a primary and backup startup transformer winding when all startup transformers are connected to the switchyard. The intermediate buses are connected to the onsite power system by one 13.8 kV transmission line per bus (two per unit).

The Class 1E alternating current (ac) power system distributes power at 4.16 kV, 480 volt, and 120 volt to all Class 1E loads. Also, the Class 1E ac power system supplies power to certain selected loads that are not directly safety-related but are important to the plant. The Class 1E ac power system contains standby power sources (emergency diesel generators) that automatically provide the power required for safe shutdown in the event of loss of the offsite source providing 4.16 kV Class 1E bus voltage. In addition, two station blackout generators (i.e., gas turbine generators) are provided that serve as the alternate ac source for compliance with the station blackout rule (10 CFR 50.63).

The safety-related equipment is divided into two load groups per unit. For each unit, either one of the associated load groups is capable of providing power for safely shutting down the unit. Each ac load group consists of one 4.16 kV bus, three 480 volt load centers, and four 480 volt motor control centers (MCCs). Two non-Class 1E MCCs are connected to each load group and are tripped on a safety injection actuation signal (SIAS).

Each redundant ESF load sequencer system performs logic functions to generate the loss of offsite power (LOOP) signal/load shed signal, the diesel generator start signal (DGSS), and the load sequencer start and permissive signals. The LOOP 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, a LOOP signal and load shed pulse are generated. The LOOP signal is sent to the DGSS logic. The load shed pulse (1 second) sheds 4.16 kV and selected 480 volt 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.

Each 4.16 kV switchgear bus is equipped with undervoltage relays for load shedding, diesel generator starting, and undervoltage annunciation in the control room. The existing PVNGS design has four, 4.16 kV safety-related bus induction disc loss of voltage relays (LVRs), and four solid-state degraded voltage (DVRs) relays with built-in time delays. The LVRs have a drop out voltage that varies with time, so that they will commence time out if the voltage falls below 78 percent for a long time or below 70 percent for a short time (12.6 seconds or less). The DVRs will commence a maximum 35 second time-out when the bus voltage drops to less than 90 percent (nominal) of design voltage.

Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

The purpose of this LAR is to modify the DVR and LVR design and licensing basis. The modifications and the supporting analysis are described in the following sections.

3. Summary of Calculations Not Affected by the Licensing Amendment

There are several calculations supporting the DVR and LVR setpoints. This section will provide an overall hierarchy of the calculations and subsequent sections summarize the various design aspects of the DVRs and LVRs in more detail.

The LAR does not alter the basic voltage setting of the DVRs. The nominal setting of the DVRs is 90 percent of the nominal bus voltage. The ac distribution calculation for each unit, Reference 6.1 of this Attachment, establishes the minimum switchyard voltage based on the degraded voltage relay setting. The minimum switchyard voltage ensures that after the required safety-related loads are sequenced onto the safety bus following an accident, the safety related bus voltage is above the reset value of the degraded voltage relay and safety related loads remain on offsite power. This approach has not changed since license amendment 123 was approved in 1999, Reference 6.5 of this Attachment.

As noted in section 2.2 of the LAR Enclosure, one aspect of the URI involved the voltage value used in design calculations to support the DVR voltage setpoint. Calculation 13-EC-MA-0643, *Degraded Voltage*, Reference 6.2 of this Attachment, was completed to ensure that analysis is provided to support the analytical limits for DVR pickup voltage of 3805 volts and the DVR dropout voltage of 3690 volts.

Reference 6.2 of this Attachment addresses the following design aspects:

- All 480 volt and above Class1E distribution circuits having minimum requirements are evaluated with sustained degraded voltage on 4.16 kV bus at the drop-out analytical limit
- Motor Operated Valve (MOV) torque and thrust calculations were run using the analytical limit for dropout of the DVR in the MOV MIDAS calculation software
- All 120 volt distribution panel circuits having minimum voltage requirements are evaluated with sustained degraded voltage on 4.16 kV bus at the drop-out analytical limit
- All 120 volt control circuits having minimum voltage requirements are evaluated with sustained degraded voltage on 4.16 kV bus at the drop-out analytical limit
- All 480 volt and above Class 1E motor circuits having starting requirements are evaluated both starting individually and with the corresponding sequenced load group with sustained degraded voltage on 4.16 kV bus at the drop-out analytical limit
- All 120 volt control circuits having minimum voltage requirements were also evaluated with the transient voltage dip from sequenced load groups starting from sustained degraded voltage on 4.16 kV bus at the drop-out analytical limit
- Overcurrent protection review of 4.16 kV and 480 volt Class 1E switchgear motors was completed. The review concluded the following:
    - All 4.16 kV motors will accelerate without tripping. Overcurrent alarms may occur, however, the increase in running currents due to substantially lower

calculated terminal voltage caused by degraded voltage levels at the Class 1E bus will not cause the motors to trip
  - All 480 volt load center Class 1E motors accelerate and remain running without tripping solid-state trip device at the terminal voltages caused by degraded voltage levels at the Class 1E bus

The aspect of the URI regarding voltage adequacy was closed in Reference 6.6 of this Attachment. The conclusions reached in the above analysis are not affected by the modification described in this LAR, therefore, no further detail for this analysis is provided in this technical summary.

The undervoltage protection for the safety related Class 1E buses is proposed to be performed by a combination of the DVRs and LVRs. The initial conditions (i.e., prevention strategy) will no longer be credited as the licensing basis for degraded voltage protection. However, if the offsite source voltage is below the minimum operable voltage, then the offsite source is inoperable and the appropriate LCO entered. The calculations that form the basis for the ac distribution system are itemized in Reference 6.1 of this Attachment.

In a condition when a Class 1E bus(es) is inoperable because of degraded voltage, the electrical distribution system voltage response may or may not be beyond that predicted by the offsite power analysis, depending on the actual motor starting scenario (number/size of motors started, actual system loading, grid voltage capability, etc.). Nonetheless, there are only three possible outcomes for the Class 1E bus voltage response:

- The voltage decreases to a voltage above the DVR dropout setting (DVR does not actuate). This outcome is bounded by the analyses discussed in Reference 6.2 of this Attachment.
- The voltage decreases below the DVR/LVR dropout setting and subsequently recovers above DVR/LVR reset setting prior to the DVR/LVR time delay limit being exceeded (DVR/LVR starts timing but does not time out). This outcome is covered by the analyses discussed in References 6.1 and 6.2 of this Attachment.
- 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). This outcome is covered by the analysis discussed in References 6.3 and 6.4 of this Attachment.

4. Summary of Calculations Supporting License Amendment Request

This section provides a summary of the new calculations created or existing calculations revised to support for the LAR.

Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

4.1 Degraded Voltage Relay Short Stage Timer

Calculation 13-EC-PB-0205, *Degraded Voltage Relay Short Stage Timer*, Reference 6.3 of this Attachment, was created to ensure that all equipment needed for a safety injection actuation signal (SIAS) were protected from either damage or the tripping of the protective lockout relays while the DVR is timing. The purpose of the short stage timer is to implement automatic controls that actuate within the timing assumptions of the accident analysis. Given a SIAS coincident with insufficient voltage from the grid such that it causes safety bus voltages to be below the DVR or LVR setpoint, this calculation determines the analytical limits to ensure that the LVR or DVR will transfer the SIAS loads to the emergency diesel generator (EDG) in sufficient time that the SIAS loads can perform their safety functions. This calculation demonstrates that the short stage time delay of the DVR is acceptable, when coordinated with appropriate limits for the LVR to ensure loads perform their design basis functions. The analytical limits related to the short stage timer are 5 seconds based on the load sequencer interval and 9 seconds based on the EDG start time of 10 seconds minus the load shed pulse of 1 second.

Calculation 13-EC-PB-0205 uses the following criteria:

- The time delay values need to ensure the actuation times are consistent with the accident analysis

  The accident analysis assumes a 10 second delay before starting SIAS loads to allow 10 seconds for the EDG to start and be ready to accept loads. The EDG receives a start signal directly from the SIAS actuation regardless of the status of offsite power. For a coincident degraded voltage and SIAS event, the selected time delay needs to accommodate detection, load shedding (1 second pulse), and subsequent sequencing of accident loads. Keeping the maximum delay time less than or equal to 9 seconds ensures that none of the assumed accident analysis times will be exceeded.

- The time delay needs to be long enough 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

  The target of 5 seconds is based on the sequencer adding loads in 5 second increments. Setting the minimum time delay to 5 seconds will allow sufficient time for bus voltage recovery after each load sequence.

- To ensure that these settings are acceptable, it must be verified that no equipment will be damaged and no protective devices would lock out during this time frame

  Calculation 13-EC-PB-0205 determined the undervoltage relaying, either the LVR or the DVR, needs to trip in 6 seconds or less and at a voltage of 2918 volts or higher on the safety bus (since the DVR time setpoint is based on the limits of 5 seconds and 9 seconds described above, then this voltage and time combination becomes a criterion for the limits of the LVR). This will ensure the high pressure safety injection

Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

(HPSI) pump is available when transferred to the EDG, and will ensure the above criterion is met. The analysis that led to this conclusion is summarized as follows:

The following table from section 6.2.2.2 of Reference 6.3 of this Attachment shows the breaker trip time compared to the motor start time at various motor terminal voltages for the HPSI pump.

Table 4-1
HPSI Motor Breaker Compared to the Anticipated Motor Start Time

PB Bus Voltage	Motor Terminal Voltage	Locked Rotor Current (amps)	HPSI A-train Breaker Trip Time (sec)	HPSI B-train Breaker Trip Time (sec)	Anticipated motor start time (sec)
3018.27	3000	510	7.19	6.37	5.42
2917.66	2900	493	7.37	6.54	6.50
2817.05	2800	476	7.60	6.71	8.40
2716.44	2700	459	8.03	6.89	14.21
2615.83	2600	442	8.45	7.07	15.96

Note that the "B" train breaker is set to trip faster than the "A" train breaker and is the limiting case. As long as the motor start time is less than the breaker trip time at a particular voltage, the motor will not be locked out by the breaker. The above table shows at 2900 volts the breaker trip time and the motor start time are essentially the same.

The bus voltage was determined using the cable impedance based on 90 °C and 390 feet for the longest cable length among all three units noted in the plant cable data base and the locked rotor current at each voltage. The anticipated motor start times are calculated using the motor speed torque curve, the load brake horsepower and generally recognized formulas for motor acceleration. The program assumes a constant motor terminal voltage, which is conservative, since as the motor accelerates, the current and corresponding voltage drop will decrease, and the voltage will increase.

To ensure that the protective relay does not trip and prevent the motor from being available when transferred to onsite power, the undervoltage relaying needs to actuate first. The replacement LVR nominal voltage setpoint is higher than 2900 volts and has a nominal time delay setpoint of 2 seconds which will ensure that the loads are transferred to onsite power well before the breaker protecting the HPSI pump motor would trip. The calculation shows for the low pressure safety injection (LPSI) pump, over the same span of voltages, the breaker trip times exceed 9 seconds. Therefore, the HPSI pump is the limiting component for this analysis. The HPSI and LPSI pumps are the only two 4160 volt motors that get demand signals in the first 10 seconds of a SIAS actuation.

Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

For the 480 volt motors, the instantaneous trip is set to twice the locked rotor current and the safe stall times were verified to be longer than 9 seconds. Thermal overload protection is bypassed by a SIAS signal. Specific stall analysis for the motors was not performed. It was assumed that the motors may stall, and the analysis shows that they will not be damaged and no breakers or relays will be actuated so the necessary equipment will be available when transferred to the EDG.

4.2 Degraded Voltage Relay Long Stage Timer

The purpose of the long stage timer is to protect equipment from a sustained degraded voltage condition under non-SIAS conditions. Calculation 13-EC-PB-0206, *Degraded Voltage Relay Long Stage Timer Analysis*, (Reference 6.4 of this Attachment) was developed to evaluate equipment powered by Class 1E buses subject to a degraded voltage during the non-SIAS delay time. The calculation shows that permanently connected Class 1E loads are not damaged and are available when transferred to onsite power in accordance with BTP 8-6, Section B.1, subparagraph (b)(ii).

The analytical limits related to the long stage timer are:

- DVR Long Timer Lo Limit – 27.4 seconds to prevent spurious trips during reactor coolant pump (RCP) motor starts
- DVR Long Timer Hi Limit – 44 seconds to limit the exposure of equipment to a sustained degraded voltage
- LVR Voltage Lo Limit – 3220 volts ensures that an auxiliary feedwater actuation signal (AFAS) can be successfully completed during the long stage time delay or transfers to onsite power
- LVR Voltage Hi Limit – 3314 volts to prevent spurious trips during RCP starts

For defense-in-depth, the calculation addresses the effect of degraded voltage on the equipment started by an AFAS, during the longer non-SIAS delay time. The short stage timer evaluation addresses a degraded voltage coincident with a SIAS. For other ESFAS actuations not covered by the short stage timer (i.e., non-SIAS events), an AFAS starts the B-train auxiliary feedwater pump which is a 1250 hp motor. Because of this, the AFAS actuation was selected as the most significant non-SIAS event and was reviewed for its impact during the long stage timer delay. The A-train auxiliary feedwater pump (AFP-A) is steam driven. The AFP-A related MOVs are direct current (DC) operated and, therefore, are not affected by the degraded voltage scenario.

The calculation established the following criteria:

- To prevent spurious trips, the limiting case for the LVR upper voltage setting is to ensure interference does not occur during the RCP start transient. The value is 3314 volts at the 4.16 kV bus level.

- The LVR is also used to protect any running safety related permanently connected motors from stalling during the non-SIAS event DVR time delay. This calculation determined for all three units, the permanently connected loads will not stall down to a voltage of 3020 volts at the 4.16 kV level. The 3020 volts at the 4.16 kV bus level will not cause motor control center (MCC) starters to drop-out permanently connected loads that would normally be running during full power and shutdown operation.

- For additional defense in depth, the calculation evaluates the response to an AFAS during the non-SIAS event DVR delay time. This was selected because the AFAS starts a 1250 hp motor and has the largest impact to the safety related bus voltage for non-SIAS actuations. For voltages where the voltage during AFP motor start remains above 3220 volts (pre-start voltage above 3405 volts) the AFAS actuation will be completed on offsite power including MOV operation, and for voltages where the AFP motor start causes a voltage drop below 3220 volts, an AFAS actuation will cause the LVR to transfer the safety bus to onsite power and all required equipment will be available to function following the transfer.

4.2.1 Spurious Trip Review

As stated in the previous section, to prevent spurious trips, the limiting case for the LVR upper voltage setting is to ensure interference does not occur during the RCP start transient. The upper limit for LVR dropout is determined to be 3314 volts on the 4.16 kV bus.

The RCPs are used in the start-up evolution to achieve plant heat-up conditions. Although not directly connected to the safety related bus, the RCPs are connected to the start-up transformers and the loading on the transformer during an RCP motor start does have an impact on the voltage of the safety related bus. A review of the last 19 RCP motor starts was performed to quantify available margin with data from actual plant conditions. The maximum Class 1E bus voltage drop experienced was 593 volts with the lowest bus voltage dropping to 3600 volts. These starts are typically done with the bus voltage above 4200 volts.

The bounding results for RCP starts modeled in the existing calculations of record, 01-EC-MA-0221, 02-EC-MA-0221, and 03-EC-MA-0221, *AC Distribution* (Reference 6.1 of this Attachment), show that the minimum voltage drop at the Class 1E 4160 volt bus level could be as low as 3290 volts, if the switchyard is at its minimum level and the applicable startup transformer is heavily loaded.

Electrical Transient Analysis Program (ETAP) was used to remove some overly conservative assumptions. The new RCP motor starting analysis was re-performed at 524.5 kV for all three units and the calculated minimum voltage for any unit was 3321 volts for Unit 1. The loss of voltage upper limit will be placed at 3314 volts based on Unit 1 results that bound the other two units. This value has over 250 volts of margin below the minimum actual observed voltage during an RCP motor start. This ensures that the LVR will not spuriously trip during normal RCP motor starts.

4.2.2 Protection of Permanently Connected Loads

As stated previously in section 4.2 of this Attachment, calculation 13-EC-PB-0206 shows that permanently connected Class 1E loads are not damaged and are available when

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transferred to onsite power in accordance with BTP 8-6, Section B.1, subparagraph (b)(ii). To demonstrate this, the calculation determines the LVR voltage value necessary to protect any running safety related permanently connected motors from stalling during degraded voltage conditions below DVR setting.

This calculation determined for all three units, the permanently connected loads will not stall at a voltage of 3020 at the 4160 volt level. The 3020 volts at the 4160 volt bus level will not cause MCC starters to drop-out permanently connected loads that would normally be running during full power and shutdown operation.

For induction motors the following equation is used:

$$V_{stall} = \sqrt{\frac{Tload}{Tbd}} \times Vrated$$

Where:
V_{stall} = stall voltage of the motor
Tload = motor load torque
Tbd = motor breakdown torque
V_{rated} = rated voltage of the motor

In most cases the manufacturer has supplied the breakdown torque as a percentage of the full load torque so the stall voltage can be calculated as follows:

$$V_{stall} = \sqrt{\frac{100\%}{Tbd\%}} \times Vrated$$

Note: Vrated = 4000 volts for motors on the 4160 volt bus
= 460 volts for motors on the 480 volt bus

The following tables show the results of calculated voltage at the terminal of each motor identified as operating during either full power or shutdown using the ETAP distribution model. The minimum voltage required for each induction motor to not stall was determined as discussed above. The maximum torque the motor can develop is used to determine a voltage limit that would reduce the torque to the full load torque causing the motor to stall. The results show terminal voltages calculated at each of the motor components is above the calculated stall voltage with 3020 volts at the 4160 volt bus level. Only the Unit 1 results are shown for this summary, which are representative for the three units.

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Table 4-2
Unit 1 Motor Results

Load	Breakdown Torque (% of full load torque)	Vmin (Volts)	A-Train Full Power steady-state at LOV setting (Volts)	A-Train Shutdown steady-state at LOV setting (Volts)	B-Train Shutdown steady-state at LOV setting (Volts)	B-Train Full Power steady-state at LOV setting (Volts)
1EWCNJ01A Normal Chilled Water Instrument Panel	287	271.5	326.2	325.8	[redacted]	[redacted]
1JSQARU29 Control Room Intake Air Radiation Monitor	365	240. 8	334.1	333.1	[redacted]	[redacted]
1JSQBRE145 Fuel Bldg Vent Exhaust Radiation Transmitter	365	240. 8	[redacted]	[redacted]	338.6	338.2
1JSQBRE146 Fuel Bldg Vent Exhaust Radiation Transmitter	365	240. 8	[redacted]	[redacted]	331.6	335.1
1JSQBRU01 Containment Bldg Atmos. Radiation Monitor	365	240.8	[redacted]	[redacted]	335.2	338.7
1JSQBRU30 Control Room Intake Air Radiation Monitor	365	240.8	[redacted]	[redacted]	332.7	336.2
1JSQBRU34 Containment Bldg Exhaust Radiation Monitor	365	240.8	[redacted]	[redacted]	334.6	338
1MAFNP01 N-Train Aux Feed Pump	272.8	2421.8	[redacted]	3005.6	[redacted]	[redacted]
1MCHAP01 Charging Pump	227.3	305.1	334.4	333.6	[redacted]	[redacted]
1MCHBP01 Charging Pump	227.3	305.1	[redacted]	[redacted]	340.9	340.3
1MCHEP01 Charging Pump	227.3	305.1	340.5	340	335	335
1MDFAP01 EDG Fuel Oil Transfer Pump	213.9	314.5	333.2	332.2	[redacted]	[redacted]
1MDFBP01 EDG Fuel Oil Transfer Pump	213.9	314.5	[redacted]	[redacted]	338	337.5
1MDGAP01 EDG Jacket Water Pump	287.2	271.4	330	330.9	[redacted]	[redacted]
1MDGAP04 EDG Pre-Lube Pump	267.9	281	332.1	333	[redacted]	[redacted]
1MDGBP01 EDG Jacket Water Pump	287.2	271.4	[redacted]	[redacted]	330.9	334.4

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Load	Breakdown Torque (% of full load torque)	Vmin (Volts)	A-Train Full Power steady-state at LOV setting (Volts)	A-Train Shutdown steady-state at LOV setting (Volts)	B-Train Shutdown steady-state at LOV setting (Volts)	B-Train Full Power steady-state at LOV setting (Volts)
1MDGBP04 EDG Pre-Lube Pump	267.9	281			332.8	336.3
1MECAE01 Essential Chiller Compressor	211.2	2752.4		3018.6		
1MECAP01 Essential Chilled Water Circ Pump	227.2	305.2		332.6		
1MECAP10 Essential Chiller Oil Pump	295	267.8		332.3		
1MECBE01 Essential Chiller Compressor	211.2	2752.4			3018.6	
1MECBP01 Essential Chilled Water Circ Pump	227.2	305.2			338.8	
1MECBP10 Essential Chiller Oil Pump	295	267.8			339.9	
1MEWAP01 Essential Cooling Water Pump	210	2760.3		3015.3		
1MEWBP01 Essential Cooling Water Pump	210	2760.3			3013.8	
1MHAAZ02 LPSI Pump Rm Air Control Unit	240	296.9		336.4		
1MHAAZ03 Containment Spray Pump Rm Air Control Unit	315	259.2		335.8		
1MHAAZ05 Essential Chilled Water Pump Rm Air Control Unit	315	259.2		335.7		
1MHABZ02 LPSI Pump Rm Air Control Unit	240	296.9			341	
1MHABZ05 Essential Chilled Water Pump Rm Air Control Unit	367	240.1			340.7	
1MHCNA01A Containment Bldg Normal Air Control Unit	258	286.4	324.3	323.4		
1MHCNA01B Containment Bldg Normal Air Control Unit	258	286.4			325.7	325.7
1MHCNA01C Containment Bldg Normal Air Control Unit	258	286.4	326.3	326.6		
1MHCNA01D Containment Bldg Normal Air Control Unit	258	286.4			331.2	332.9

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Load	Breakdown Torque (% of full load torque)	Vmin (Volts)	A-Train Full Power steady-state at LOV setting (Volts)	A-Train Shutdown steady-state at LOV setting (Volts)	B-Train Shutdown steady-state at LOV setting (Volts)	B-Train Full Power steady-state at LOV setting (Volts)
1MHCNA02A Containment Bldg CEDM Normal Air Control Unit	255	288.1	315.9	315	[redacted]	[redacted]
1MHCNA02B Containment Bldg CEDM Normal Air Control Unit	255	288.1	[redacted]	[redacted]	329.7	329
1MHCNA02C Containment Bldg Normal Air Control Unit	255	288.1	321.1	321.5	[redacted]	[redacted]
1MHCNA02D Containment Bldg Normal Air Control Unit	255	288.1	[redacted]	[redacted]	327.1	328.8
1MHCNA03A Containment Bldg Reactor Cavity Normal Air Control Unit	238	298.2	324.8	324.4	[redacted]	[redacted]
1MHCNA03B Containment Bldg Reactor Cavity Normal Air Control Unit	238	298.2	[redacted]	[redacted]	328.5	328.5
1MHCNA03C Containment Bldg Reactor Cavity Normal Air Control Unit	238	298.2	326.7	326.3	[redacted]	[redacted]
1MHCNA03D Containment Bldg Reactor Cavity Normal Air Control Unit	238	298.2	[redacted]	[redacted]	322.9	322.9
1MHCNA06A Containment Bldg Pressurizer Normal Air Control Unit	253	289.2	328.9	329.2	[redacted]	[redacted]
1MHCNA06B Containment Bldg Pressurizer Normal Air Control Unit	253	289.2	[redacted]	[redacted]	325.5	327.2
1MHFAJ01 Fuel & Aux Bldg Essential Air Filter Fan	341	249.1	[redacted]	331.8	[redacted]	[redacted]
1MHFBJ01 Fuel & Aux Bldg Essential Air Filter Fan	341	249.1	[redacted]	[redacted]	327.6	[redacted]
1MHSAJ01 Spray Pond Pumphouse Exhaust Fan	253	265.5	275	[redacted]	[redacted]	[redacted]
1MHSBJ01 Spray Pond Pumphouse Exhaust Fan	253	265.5	[redacted]	[redacted]	[redacted]	287.2
1MPCAP01 Fuel Pool Cooling Pump	207.4	319.4	327.5	326.6	[redacted]	[redacted]

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Load	Breakdown Torque (% of full load torque)	Vmin (Volts)	A-Train Full Power steady-state at LOV setting (Volts)	A-Train Shutdown steady-state at LOV setting (Volts)	B-Train Shutdown steady-state at LOV setting (Volts)	B-Train Full Power steady-state at LOV setting (Volts)
1MPCBP01 Fuel Pool Cooling Pump	207.4	319.4			328.5	328.5
1MSCNP24A Sample Cooling Water Pump	240	296.9	326.9			
1MSIAP01 Low Pressure Safety Injection Pump	202.6	2810.2		3015.9		
1MSIAP02 High Pressure Safety Injection Pump	241.1	2576.1		3012.5		
1MSIAP03 Containment Spray Pump	210.6	2756.3		3014.7		
1MSIBP01 Low Pressure Safety Injection Pump	210.6	2756.3			3015.4	
1MSIBP02 High Pressure Safety Injection Pump	241.1	2576.1			3011.9	
1MSIBP03 Containment Spray Pump	210.6	2756.3			3014.1	
1MSPAP01 Essential Spray Pond Pump	199.4	2832.7	3003.3	3003.2		
1MSPBP01 Essential Spray Pond Pump	199.4	2832.7			3003.8	3003.9
1MWCNE01A Normal Chiller	252	2519.8	3009.1	3009		
1MWCNP01A Normal Chilled Water Circ Pump	237	298.8	326.2	325.8		
1MWCNP10A Chilled Water Oil Pump	295	267.8	326.3	326		

Table 4-2 Notes:

1. Specific ETAP scenario names are:
   a. A train Full Power: AENANX03Z->1EPBAS03, 1ENANS01 FP steady-state at LOV setting
   b. A train Shutdown: AENANX03Z->1EPBAS03, 1ENANS01 SD steady-state at LOV setting
   c. B train Full Power: AENANX02Y->1EPBBS04, 1ENANS02 SD steady-state at LOV setting
   d. B train Shutdown: AENANX02Y->1EPBBS04, 1ENANS02 FP steady-state at LOV setting
   e. The naming convention is to describe the Start-Up transformer secondary winding ->13.8 kv bus -> 4160 V bus for the A and B trains

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2. Blank cells indicate the equipment is not used in that scenario.
3. 1MHAAZ03 bounds 1MHABZ03, which is not specifically itemized in the Table.

Some non-motor components may have a terminal voltage below the voltage that is required for continuous operation. Since the non-motor type equipment is protected from damage via overcurrent protection, this calculation verifies that the maximum non-SIAS time delay of the DVR will actuate prior to any individual overcurrent device actuation such that these loads will be available once transfer to the EDG occurs.

For example, some non-motor type loads are protected by a fuse and the analysis ensures that the fuse will not blow during the maximum non-SIAS delay time. The following table shows the expected running loads in amps and verifies no overcurrent trips for the permanently connected loads will be actuated during the delay time. Only the Unit 1 results are shown which are representative for the three units.

Table 4-3
Unit 1 Non-Motor Overcurrent Protection (@ 3020V on the Class 1E Safety Related Bus)

Load	Max Running Current (amps)	Overcurrent Type	Trip Time (sec)
1ENHND19 120V Distribution Panel	56.7	Breaker - THFK 70 Amp	n/a
1ENHND20 120V Distribution Panel	56.8	Breaker - THFK 70 Amp	n/a
1ENNAV13 480/120V Class Voltage Regulator	82.8	Breaker - THFK 80 Amp (Trip > 100)	n/a
1ENNBV14 480/120V Class Voltage Regulator	79	Breaker - THFK 80 Amp (Trip > 100)	n/a
1ENNNV17 480/120V Non-class Voltage Regulator	78.6	Breaker - THFK 80 Amp (Trip > 100)	n/a
1ENNNV18 480/120V Non-class Voltage Regulator	60.1	Breaker - THFK 80 Amp (Trip > 100)	n/a
1EPHAD31 240/120V Distribution Panel	51.7	Fuse Gould TRS 60R	n/a
1EPHAD33 240/120V Distribution Panel	26.1	Breaker - THFK 70 Amp	n/a
1EPHAD37 240/120V Distribution Panel	26.4	Breaker - THFK 70 Amp	n/a
1EPHBD32 240/120V Distribution Panel	46.8	Fuse Gould TRS 60R	n/a
1EPHBD36	28.8	Breaker - THFK 70 Amp	n/a

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Load	Max Running Current (amps)	Overcurrent Type	Trip Time (sec)
240/120V Distribution Panel			
1EPHBD38 240/120V Distribution Panel	26.6	Breaker - THFK 70 Amp	n/a
1EPKAH11 Battery Charger "A"	97.9	Breaker - THFK 125 Amp	n/a
1EPKAH15 Battery Charger "AC"	98.3	Breaker - THFK 125 Amp	n/a
1EPKBH12 Battery Charger "B"	81.5	Breaker - THFK 125 Amp	n/a
1EPKBH16 Battery Charger "BD"	81.2	Breaker - THFK 125 Amp	n/a
1EPKCH13 Battery Charger "C"	49.2	Breaker - THFK 125 Amp	n/a
1EPKDH14 Battery Charger "D"	41	Breaker - THFK 125 Amp	n/a
1EPNAV25 Voltage Regulator for Distribution Panel D25	52.7	Breaker - THFK 80 Amp	n/a
1EPNBV26 Voltage Regulator for Distribution Panel D26	59.4	Breaker - THFK 80 Amp	n/a
1EPNCV27 Voltage Regulator for Distribution Panel D27	33.5	Breaker - THFK 80 Amp	n/a
1EPNDV28 Voltage Regulator for Distribution Panel D28	32.5	Breaker - THFK 80 Amp	n/a
1EQBAV01 Essential Lighting Isolation Transformer	77.6	Breaker - THFK 80 Amp	n/a
1EQBBV02 Essential Lighting Isolation Transformer	77	Breaker - THFK 80 Amp	n/a
1EQBND90 Essential Lighting Panel	93.8	Breaker – Solid State Trip > 400 Amps	n/a
1EQBND91 Essential Lighting Panel	89.8	Breaker – Solid State Trip > 400 Amps	n/a
1EQFNH13 Battery Charger for Plant Communications Panel	27.84	Breaker - SQD QO 25 Amp (Trip > 25 amp)	~120 sec
1EQFNN01 Plant Communication UPS	75.7	Breaker - SQD QO 60 Amp (Trip > 60 amp)	~120 sec
1EQFNN02 Plant Communication UPS	28.7	Breaker - THED 60 Amp	n/a
1EQJNX05 Heat Trace Transformer	24.5	Breaker - THED 50 Amp	n/a
1EQMAV31 Voltage Regulator for	8.86	Breaker - THFK 80 Amp	n/a

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Load	Max Running Current (amps)	Overcurrent Type	Trip Time (sec)
Heat Trace Panel			
1EQMBV30 Voltage Regulator for Heat Trace Panel	8.9	Breaker - THFK 80 Amp	n/a
1EQMNC06A Heat Trace Cabinet	16.8 @ 240, ~8.4 @ 480	Breaker - 15A at 480 volts	n/a
1EQMNX04B3 Heat Trace Transformer	8.5	Breaker - THED 70 Amp	n/a
1EQMNX08A Heat Trace Transformer	24.8	Breaker - THFK 70 Amp	n/a
1EQMNX08B Heat Trace Transformer	20.7	Breaker - THFK 70 Amp	n/a
1ESQND03 Radiation Monitor Power Distribution Panel	14.2 @ 240, 7.1 @ 480	Breaker - 30A at 480 volts	n/a
1ESQND09 Radiation Monitor Power Distribution Panel	14.2 @ 240, 7.1 @ 480	Breaker - 30A at 480 volts	n/a
1JSQNRU02 Essential Cooling Water Rad Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU03 Essential Cooling Water Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU04 SG Blowdown Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU05 SG Blowdown Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU07A Aux Steam Condensate Receiver Tank Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU08 Aux Bldg Exhaust Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU09 Aux Bldg Lower Level Exhaust Rad Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU10 Aux Bldg Upper Level Exhaust Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU23 Lab Area Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1JSQNRU26 Sample Room Radiation Monitor	2.2	15 amp fuse, Bussman LPN-RK-SP	n/a
1MDGAM01 EDG Jacket Water	33.4	Breaker - THED 70 Amp	n/a

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Load	Max Running Current (amps)	Overcurrent Type	Trip Time (sec)
Warmup Heater			
1MDGAM02 EDG Lube Oil Heater	15.9	Breaker - THED 50 Amp	n/a
1MDGAM03 EDG Lube Oil Heater	3.3		
1MDGBM01 EDG Jacket Water Warmup Heater	34	Breaker - THED 70 Amp	n/a
1MDGBM02 EDG Lube Oil Heater	16.1	Breaker - THED 50 Amp	n/a
1MDGBM03 EDG Lube Oil Heater	3.4		
1MHFAE01 Fuel and Aux Bldg Essential Duct Heater	21.7	Thermal Overload (Trip > 42 amp)	n/a
1MHFBE01 Fuel and Aux Bldg Essential Duct Heater	21.5	Thermal Overload (Trip > 42 amp)	n/a
1MRCEA05 Pressurizer Backup Heater	139.2	Breaker Solid State Trip > 440 amp	n/a
1MRCEB10 Pressurizer Backup Heater	139.2		
1MRCEA16 Pressurizer Backup Heater	139.2		
1MRCEA14 Pressurizer Backup Heater	138.9	Breaker Solid State Trip > 440 amp	n/a
1MRCEB01 Pressurizer Backup Heater	138.9		
1MRCEB09 Pressurizer Backup Heater	138.9		

Table 4-3 Notes:

1. 'n/a' in the trip time column means that the running current would not trip the overcurrent device.

Two components in the above table do have running loads that exceed the overcurrent trip value but will not trip the device in less than 120 seconds for the calculated running current. This includes non-safety related equipment 1EQFNH13, the battery charger for the in-plant communication system and 1EQFNN01 uninterruptable power supply, which receives power from the same distribution panel.

The communication system has a four hour battery backup with 1EQFNF13 battery, which is charged by 1EQFNH13 charger. The system was designed such that failure of a single component within the system would not cause a failure of in-plant

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communications. The 1EQFNN01 uninterruptable power supply has a battery so its loads will also continue to run during the DVR until power is restored from the EDG. Regardless, no damage or operational issues would be expected for this equipment over the 44 second time delay.

Since it was previously shown that the motors do not stall down to this voltage, the following table shows the expected running loads in amps for the permanently connected motors and verifies no overcurrent trips for the permanently connected loads will be actuated during the delay time. Only the Unit 1 results are shown, which are representative for the three units.

Table 4-4
Unit 1 Motor Overcurrent Trip Protection Time (@ 3020 volts on the Safety Related Bus)

Load	Max Running Current (amps)	Overcurrent Type and Setting	Trip Time (sec)
1EWCNJ01A Normal Chilled Water Instrument Panel	5.4	Breaker - THED 30 amp	n/a
1JWCNE01 Normal Chiller	4.6		
1MWCNP10A Chilled Water Oil Pump	3.1		
1JSQARU29 Control Room Intake Air Radiation Monitor	3.5	Breaker - THED 15 amp	n/a
1JSQBRE145 Fuel Bldg Vent Exhaust Radiation Transmitter	3.4	Breaker - THED 15 amp	n/a
1JSQBRE146 Fuel Bldg Vent Exhaust Radiation Transmitter	3.5	Breaker - THED 15 amp	n/a
1JSQBRU01 Containment Bldg Atmos. Radiation Monitor	3.4	Breaker - THED 15 amp	n/a
1JSQBRU30 Control Room Intake Air Radiation Monitor	3.5	Breaker - THED 15 amp	n/a
1JSQBRU34 Containment Bldg Exhaust Radiation Monitor	3.4	Breaker - THED 15 amp	n/a
1JECAE01 Essential Chiller Compressor	4.3	Breaker - THED 30 amp	n/a
1MECAP10 Essential Chiller Oil Pump	3.1		
1JECBE01 Essential Chiller Compressor	4.4	Breaker - THED 30 amp	n/a
1MECBP10 Essential Chiller Oil Pump	3		

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Load	Max Running Current (amps)	Overcurrent Type and Setting	Trip Time (sec)
1MAFNP01 N-Train Aux Feed Pump	150.7	Breaker - ALARM > 160 amp, Trip > 240 amp	n/a
1MCHAP01 Charging Pump	129.5	Breaker - Alarm > 148 amp, Solid State Trip > 247.5 amp	n/a
1MCHBP01 Charging Pump	127	Breaker - Alarm > 148 amp, Solid State Trip > 247.5 amp	n/a
1MCHEP01 Charging Pump	129	Breaker - Alarm > 148 amp, Solid State Trip > 247.5 amp	n/a
1MDFAP01 EDG Fuel Oil Transfer Pump	3.5	Breaker – TEC Thermal Overload Trip > 4.6 amp	n/a
1MDFBP01 EDG Fuel Oil Transfer Pump	3.5	Breaker – TEC Thermal Overload Trip > 4.6 amp	n/a
1MDGAP01 EDG Jacket Water Pump	7.2	Breaker – TEC Thermal Overload Trip > 8.1 amp	n/a
1MDGAP04 EDG Pre-Lube Pump	16	Breaker – TEC Thermal Overload Trip > 25.6 amp	n/a
1MDGBP01 EDG Jacket Water Pump	7.2	Breaker – TEC Thermal Overload Trip > 8.1 amp	n/a
1MDGBP04 EDG Pre-Lube Pump	16	Breaker – TEC Thermal Overload Trip > 25.6 amp	n/a
1MECAE01 Essential Chiller Compressor	86.8	Breaker - ALARM > 67.5 amp, Trip > 105 amp	Alarm
1MECAP01 Essential Chilled Water Circ Pump	27.6	Breaker – TEC Thermal Overload Trip > 31 amp	n/a
1MECBE01 Essential Chiller Compressor	86.8	Breaker - ALARM > 67.5 amp, Trip >105 amp	Alarm
1MECBP01 Essential Chilled Water Circ Pump	26.8	Breaker – TEC Thermal Overload Trip > 31 amp	n/a
1MEWAP01 Essential Cooling Water Pump	111	Breaker - ALARM > 135 amp, Trip > 210 amp	n/a
1MEWBP01 Essential Cooling Water Pump	113.3	Breaker - ALARM > 135 amp, Trip > 210 amp	n/a
1MHAAZ02 LPSI Pump Rm Air Control Unit	4.1	Breaker – TEC Thermal Overload Trip > 5.6 amp	n/a
1MHAAZ03 Containment Spray Pump Rm Air Control Unit	4.8	Breaker – TEC Thermal Overload Trip > 5.1 amp	n/a

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Load	Max Running Current (amps)	Overcurrent Type and Setting	Trip Time (sec)
1MHAAZ05 Essential Chilled Water Pump Rm Air Control Unit	4.8	Breaker – TEC Thermal Overload Trip > 5.1 amp	n/a
1MHABZ02 LPSI Pump Rm Air Control Unit	4	Breaker – TEC Thermal Overload Trip > 5.6 amp	n/a
1MHABZ05 Essential Chilled Water Pump Rm Air Control Unit	4.4	Breaker – TEC Thermal Overload Trip > 5.1 amp	n/a
1MHCNA01A Containment Bldg Normal Air Control Unit	224.7	Breaker – Solid State Trip > 280 amp	n/a
1MHCNA01B Containment Bldg Normal Air Control Unit	223.1	Breaker – Solid State Trip > 280 amp	n/a
1MHCNA01C Containment Bldg Normal Air Control Unit	222.7	Breaker – Solid State Trip > 280 amp	n/a
1MHCNA01D Containment Bldg Normal Air Control Unit	219.4	Breaker – Solid State Trip > 280 amp	n/a
1MHCNA02A Containment Bldg CEDM Normal Air Control Unit	311.1	Breaker – Solid State Trip > 420 amp	n/a
1MHCNA02B Containment BldgCEDM Normal Air Control Unit	297.9	Breaker – Solid State Trip > 420 amp	n/a
1MHCNA02C Containment Bldg Normal Air Control Unit	305.2	Breaker – Solid State Trip > 420 amp	n/a
1MHCNA02D Containment Bldg Normal Air Control Unit	299.7	Breaker – Solid State Trip > 420 amp	n/a
1MHCNA03A Containment Bldg Reactor Cavity Normal Air Control Unit	71.4	Breaker – Solid State Trip > 67.1 amp	~320 sec
1MHCNA03B Containment Bldg Reactor Cavity Normal Air Control Unit	70.5	Breaker – Solid State Trip > 67.1 amp	~320 sec
1MHCNA03C Containment Bldg Reactor Cavity Normal Air Control Unit	70.9	Breaker – Solid State Trip > 67.1 amp	~320 sec
1MHCNA03D Containment Bldg Reactor Cavity Normal Air Control Unit	71.7	Breaker – Solid State Trip > 67.1 amp	~320 sec
1MHCNA06A Containment Bldg Pressurizer Normal Air Control Unit	18.2	Breaker – Solid State Trip > 13.9 amp	~120 sec

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Load	Max Running Current (amps)	Overcurrent Type and Setting	Trip Time (sec)
1MHCNA06B Containment Bldg Pressurizer Normal Air Control Unit	18.4	Breaker – Solid State Trip > 13.9 amp	~120 sec
1MHFAJ01 Fuel & Aux Bldg Essential Air Filter Fan	53.3	Breaker – TEC Thermal Overload Trip > 52.9 amp	~390 sec
1MHFBJ01 Fuel & Aux Bldg Essential Air Filter Fan	54	Breaker – TEC Thermal Overload Trip > 52.9 amp	~390 sec
1MHSAJ01 Spray Pond Pumphouse Exhaust Fan	21.7	Breaker – TEC Thermal Overload Trip > 16.7 amp	~135 sec
1MHSBJ01 Spray Pond Pumphouse Exhaust Fan	20.7	Breaker – TEC Thermal Overload Trip > 16.7 amp	~135 sec
1MPCAP01 Fuel Pool Cooling Pump	111.9	Breaker - ALARM > 144 amp, Trip > 225 amp	n/a
1MPCBP01 Fuel Pool Cooling Pump	112.6	Breaker - ALARM > 144 amp, Trip > 225 amp	n/a
1MSCNP24A Sample Cooling Water Pump	3.6	Breaker – TEC Thermal Overload Trip > 3.1 amp	~200 sec
1MSIAP01 Low Pressure Safety Injection Pump	84	Breaker - ALARM > 120 amp, Trip > 189 amp	n/a
1MSIAP02 High Pressure Safety Injection Pump	161.1	Breaker - ALARM > 160 amp, Trip > 240 amp	Alarm
1MSIAP03 Containment Spray Pump	119.7	Breaker - ALARM > 120 amp, Trip > 195 amp	n/a
1MSIBP01 Low Pressure Safety Injection Pump	83.6	Breaker - ALARM > 120 amp, Trip > 189 amp	n/a
1MSIBP02 High Pressure Safety Injection Pump	157.2	Breaker - ALARM > 140 amp, Trip > 240 amp	Alarm
1MSIBP03 Containment Spray Pump	118.3	Breaker - ALARM > 120 amp, Trip > 195 amp	n/a
1MSPAP01 Essential Spray Pond Pump	102.5	Breaker - ALARM > 100 amp, Trip > 160 amp	Alarm
1MSPBP01 Essential Spray Pond Pump	100	Breaker - ALARM > 100 amp, Trip > 160 amp	Alarm
1MWCNE01A Normal Chiller	175.5	Breaker - ALARM > 160 amp, Trip > 280 amp	Alarm
1MWCNP01A Normal Chilled Water Circ Pump	66.5	Breaker – TEC Thermal Overload Trip > 67.1 amp	n/a

Table 4-4 Notes:

1. 'n/a' in the trip time column means that the running current would not trip the overcurrent device.
2. 1MHAAZ03 bounds 1MHABZ03, which is not specifically itemized in the Table.

The running current values were compared to the trip device curve and it was confirmed that no devices are tripped during the 44 second long stage time delay. The calculation also verifies no 120 volt MCC starters drop-out permanently connected loads that would normally be running during full power and shutdown operation for 3020 volts at the 4160 volt bus level.

4.2.3 Additional AFAS Evaluation

For additional defense in depth, the calculation does evaluate the response to an AFAS during the non-SIAS event DVR delay time. This was selected because the AFAS starts the 1250 hp B train auxiliary feedwater pump motor (AFP-B) and has the largest impact to the safety related bus voltage for non-SIAS actuations. To ensure an AFAS would be successful or successfully transferred to onsite power during this delay time, the limiting case for the LVR lower voltage setting is 3220 volts at the 4160 volt bus level. As explained in more detail below, because of the voltage drop that occurs when the "B" train auxiliary feedwater (AF) pump starts, any voltage above 3400 volts will ensure a successful AFAS actuation. For any voltage below 3400 volts, the start of the "B" AF pump will cause the LVR to actuate, with its nominal time delay setpoint of 2 seconds, to transfer the functions to onsite power, and all required equipment will be available to function following the transfer.

The AFAS automatically initiates starting of the following loads and timing:

- 0 seconds, EDG start
- 0 seconds, diesel fuel transfer pump motor
- 0 seconds, AF pump B motor and B train valves JAFBHV0030, JAFBHV0031, JAFBUV0034 and JAFBUV0035
- 20 seconds, essential cooling water motor
- 25 seconds, essential spray pond motor and pump house exhaust fan
- 25 seconds, diesel room essential exhaust fan
- 25 seconds, diesel generator control room essential exhaust fan
- 30 seconds, essential chilled water pump motor
- 30 seconds, essential chiller motor

The A-train auxiliary feedwater pump (AFP-A) is steam driven. The AFP-A related MOVs are direct current (DC) operated and, therefore, are not affected by the degraded voltage scenario.

The following table shows the AF "B" pump breaker trip times at various voltages. The breaker trip values were determined from the minimum setting from the calibration procedure 32MT-9ZZ13, *Testing and Calibration of the GE 12IFC66K1A and 12IFC66KD1A Time Overcurrent Relays* (Reference 6.8 of this Attachment), and completed work orders to get the absolute fastest time the breaker could trip. The tripping times were also based on a spare AF pump "B" motor since it has the highest locked rotor current as recorded during the factory test.

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Table 4-5
AF "B" Pump Breaker Trip Times at Various Voltages

PB Bus Voltage	Motor Terminal Voltage	Locked Rotor Current (amps)	AFB Pump Breaker Trip Time (sec)	Anticipated motor start time (sec)
3237.13	3200	784.40	6.62	6.29
3196.67	3160	774.59	6.68	6.64
3135.97	3100	759.88	6.76	7.26
3034.81	3000	735.37	6.92	8.67
2933.65	2900	710.86	7.17	11.01
2832.49	2800	686.35	7.42	16.81

The bus voltage was calculated using the locked rotor current at each voltage level and the cable impedance. The anticipated motor start times are calculated using a PVNGS created program which uses the motor speed torque curve, the load brake horsepower and generally recognized formulas for motor acceleration. The program assumes a constant motor terminal voltage, which is conservative, since as the motor accelerates, the current and corresponding voltage drop will decrease, and the voltage will increase.

The other motors started by an AFAS signal have longer trip times at lower voltages so the AF pump "B" is the bounding case. Since actuation of AFAS includes the starting of the AF pump "B" motor (AFP-B) simultaneously with the motor operated valves, the limiting case was determined to be the AFP-B motor and not the motor operated valves. It was determined that an AFAS actuation with 3405 volts at the 4160 volt bus level would result in tripping of the LVR at the proposed lower analytical limit to ensure that lock out of the AF pump "B" motor (MAFBP01) does not occur. The motor start would result in a bus voltage drop to 3215 volts due to inrush of the motor while the motor would see 3182 volts at its terminals due to the voltage drop in the cable from the bus to the motor.

The calculation determined that the lower analytical limit for the LVR voltage setting should be 3220 volts, which will ensure any initiation of the AFAS sequence at 3405 volts or below would result in tripping the LVR and thus assuring that all components remain available when the transfer to the EDG occurs. Initiation of the AFAS sequence just above 3405 volts will result in the MOVs stalling while the MAFBP01 motor starts, but the valves will function once the AFP-B motor has accelerated and voltage recovers above 3400 volts. Since the AFP-B acceleration time at 3200 volt terminal voltage is 6.29 seconds, the MOVs will be in a stall condition for less than 10 seconds which is less than the safe stall time for the MOVs.

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5. Allowable Values

This section of Attachment 4 of the LAR Enclosure includes the following topic areas:

- Overall method for uncertainty
- Setpoint and allowable value determinations
- Definition of acronyms for the section
- Analytical limits, factors considered in determination of instrument uncertainty
- Combination of uncertainties
- The method for determining limiting setpoints and allowable values
- Instrument performance monitoring and tolerance actions
- Results and conclusions from the calculation
- Comparison of as-found values to Technical Specification allowable values
- Vendor information about instrument uncertainties
- Work order history

5.1 Overall Method for Uncertainty, Setpoint, and Allowable Value Determination

The general PVNGS method for determining uncertainties is described in document 81TD-0DC88, *Design Guide for Instrument Uncertainty and Setpoint Determination* (Reference 6.9 of this Attachment. It is generally consistent with ISA-RP67.04.02-2000, *Methodologies for Determination of Setpoints for Nuclear Safety-Related Instrumentation*. Note that while the calculation uses the concepts and principles of the ISA recommended practice, PVNGS is committed to Regulatory Guide 1.105, *Instrument Setpoints*, Revision 1 (November 1976).

5.2 Definition of Acronyms

1. AL = Analytical Limit, the limiting value of the parameter of concern as determined by analysis and/or testing.
2. AFT = as-found tolerance
3. AFV = as-found value
4. ALT = as-left tolerance, same as the calibration tolerance (CT)
5. ALV = as-left value
6. DSp = Design Setpoint (nominal, plant installed setting)
7. IV = Input Value, used with % IV for a statement of uncertainty. The nominal setpoint is used as the Input Value and uncertainties around that determined. The process may involve iteration.
8. LSp = Limiting Setpoint, least conservative nominal setpoint that still protects the AL. Explicit margin is not included in the LSp.
9. SRSS = square root sum of squares
10. TLU = Total Loop Uncertainty
11. U_A = Instrument channel uncertainty for accident or abnormal conditions. These are the conditions that likely will exist when the instrument function is needed. For some environments this may be the same as normal operation. This is the TLU for accident conditions.
12. U_T = Instrument channel uncertainties that exist during testing or calibration conditions. There may be different parts of testing uncertainty to align with the groups of instrument

tested together, or individually. For 13-EC-PB-202, *4160 V Degraded Voltage Relay (DVR) and Loss of Voltage Relay (LoVR) Setpoint & Calibration Calculation*, all instruments are tested individually. However the DVR and the Secondary Timer work together for a total time delay. A testing uncertainty is determined for the combination for the purpose of developing the TS Allowable Values.

5.3 Analytical Limits

The following analytical limits provide the basis for the setpoints and Allowable Values. References that are also summarized as part of this LAR are noted. Otherwise, only the value and a brief description are provided.

1. DVR Dropout Voltage Lo Limit - 3690 volts - Defined in 13-EC-MA-643, developed from 01, 02, 03-EC-MA-221
2. DVR Pickup Voltage Hi Limit - 3805 volts - Defined in 13-EC-MA-643
3. DVR Short Timer Lo Limit - 5 seconds - Load sequencer interval
4. DVR Short Timer Hi Limit - 9 seconds - Diesel start and load time (10 seconds) minus load shed pulse (delay) (1 second)
5. DVR Long Timer Lo Limit - 27.4 seconds - Defined in 13-EC-PB-206 (RCP start time)
6. DVR Long Timer Hi Limit - 44.0 seconds - Defined in 13-EC-PB-206
7. LVR Voltage Lo Limit - 3220 volts - Defined in 13-EC-PB-206
8. LVR Voltage Hi Limit - 3314 volts - Defined in 13-EC-PB-206
9. LVR Time Lo Limit - 1.2 seconds - Minimum time to prevent interference with fast recovering grid disturbances
10. LCR Time Hi Limit - 2.5 seconds - Short enough to respond to a total loss of voltage without exposing the equipment to a very low voltage. Chosen to be similar to previous range. This bounds other values determined in 13-EC-PB-205 and 13-EC-PB-206

5.4 Factors Considered in Determination of Instrument Uncertainty

Consistent with the PVNGS document 81TD-0DC88, *Design Guide for Instrument Uncertainty and Setpoint Determination*, the following factors that might affect instrument uncertainty are considered:

1. Accuracy - same as vendor accuracy
2. Drift, time dependent
3. Humidity effect
4. Insulation resistance losses or current leakage - considered, but not needed since all instruments and cables are in a mild environment
5. Measurement & Test Equipment (M&TE)
6. Power supply variations
7. Process corrections and uncertainties
8. Radiation - considered, but not needed since all instruments are in a mild environment
9. Seismic acceleration
10. Temperature effect

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The following factors are part of the normal process of determining instrument and total loop uncertainty, but are not relevant for this particular set of instruments.

1. Atmospheric pressure
2. Head correction due to temperature variations of fluid in tubing and piping
3. Process pressure

Note that for Calculation 13-EC-PB-0202, the relevant vendors do not provide extensive information about the various factors. Therefore, engineering judgments were made about the magnitude of those factors. The device uncertainty was validated for calibration conditions by the work order history presented later in this section.

5.5 Combination of Uncertainties

Bias uncertainties are combined algebraically. In general, bias uncertainties of different signs do not cancel each other. Positive bias terms are added together and negative bias terms are added together.

Random uncertainties are combined using square-root-sum-of-squares (SRSS).

This ensures that the total uncertainty is neither non-conservative (by using SRSS for all uncertainties) nor overly conservative (by combining all algebraically).

5.6 Method for Determining Limiting Setpoints and Allowable Values

For discussion purposes only one side of AL and TS AV will be shown. For calculation 13-EC-PB-0202, there are both upper and lower ALs and TS AVs. The lower AL and TS AV are mirrors in concept of what is presented below and in Figure 5-1.

The starting point is the AL. The total loop uncertainties (TLU) for accident or abnormal conditions (U_A) are determined. The uncertainties for testing conditions (U_T) are also determined.

Note that for 13- EC-PB-0202, all of the instruments are calibrated individually. Therefore, all instruments have a testing uncertainty (as-found tolerance, AFT) for monitoring expected performance. However, only the testing uncertainty for the relay or timer is relevant for determination of the TS Allowable Value.

In the case of the secondary timer (long-stage timer), both the DVR and the secondary timer are calibrated separately, but the results are combined to provide an effective group calibration. Therefore, the testing uncertainty of the DVR and the secondary timer together (but not the potential transformer) is relevant for determining the TS Allowable Value. The comparison for this TS AV is discussed in section 5.9.

The LSp is based directly on the AL with the inclusion of TLU for abnormal or accident conditions. This is shown by the vertical line between AL and LSp on the figure. The LSp is the least conservative nominal setpoint that still protects the AL. The margin between the LSp and the final Design Setpoint (DSp, nominal setpoint) is shown as M_1.

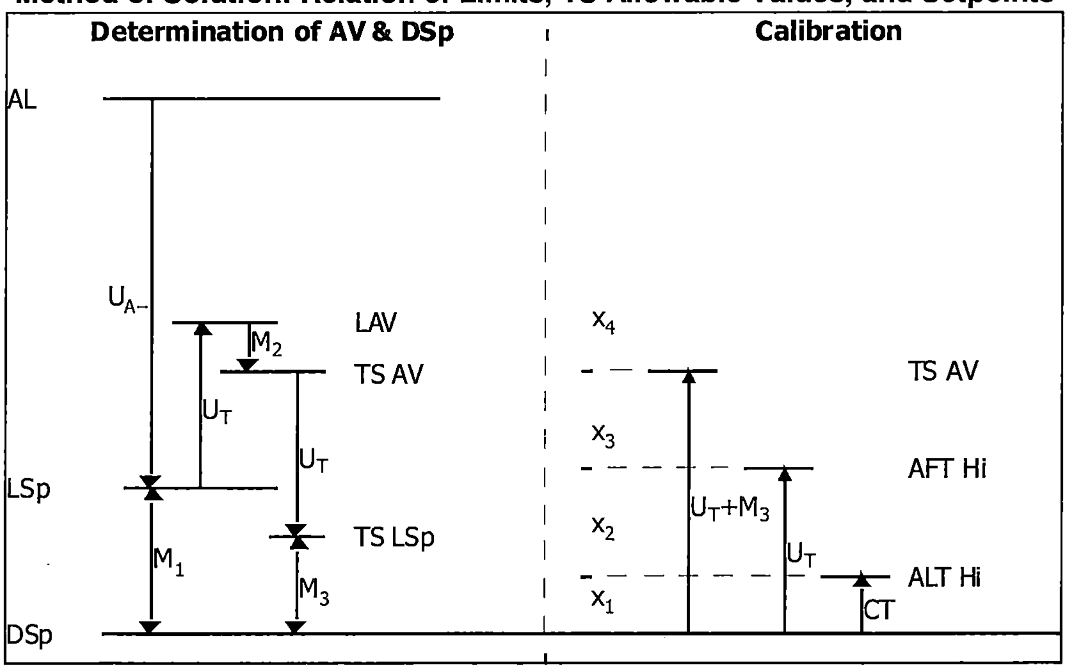
Next the Limiting Allowable Value (LAV) is determined based on the LSp and testing uncertainty of the relay. The LAV is the least conservative as-found value that still protects the AL. Margin (M_2) is commonly added to the LAV to provide a "round number" to be published in the Technical Specifications. It also moves the TS Allowable Value further from the AL.

To ensure that the final DSp does not encroach on the TS Allowable Value, a limiting setpoint based on the TS AV is determined. This is simply the testing uncertainty subtracted from the TS AV. This is called the TS LSp. As can be seen this is the same as the LSp moved away from the AL by the margin M_2.

The margin between the TS LSp and the DSp is shown as M_3 and is simply the difference between M_1 and M_2.

The final DSp must be below the TS LSp, which is below the LSp.

Figure 5-1
Method of Solution: Relation of Limits, TS Allowable Values, and Setpoints



5.7 Instrument Performance Monitoring and Tolerance Actions

Figure 5-1 also shows the relation with the various testing tolerances. During a calibration, the technicians may find the instrument as-found value (AFV) in different possible ranges. These ranges are discussed and the general actions taken for each range.

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Note that the as-left (ALT) and as-found tolerances (AFT) are always based on the Design Setpoint (DSp, nominal setpoint). The ALT and AFT extend above and below the DSp. Only one side is illustrated here. The same concepts apply whether the AFV is above or below the DSp.

Each individual instrument has a set of tolerances (ALT & AFT) and its performance is monitored as described below.

1. x1 - When the as-found value (AFV) is within the as-left tolerance (ALT), point x1, then no action is required.
2. x2 - When the AFV is outside the ALT and within the as-found tolerance (AFT), point x2, then the instrument is adjusted so that the as-left value (ALV) is within the ALT. No other action is required.
3. x3 - When the AFV is outside the AFT and within the TS Allowable Values, point x3, then the instrument is Out-of-Tolerance (OoT). The Corrective Action Program is entered and a Condition Report written. The instrument is not performing as expected. If the technician is able to readily adjust the instrument to within the ALT, and he/she observes that, except for the OoT, the instrument is behaving as expected; then the instrument may be returned to service. The OoT condition and the return to service are discussed with the Control Room operators.
4. x4 - When the AFV is outside the AFT and also outside the TS Allowable Values, point x4, then the instrument is Out-of-Tolerance (OoT). There are three actions for this scenario:
   - Similar to x3 above the Corrective Action Program is entered.
   - The Operability Determination process is also entered.
   - Nuclear Regulatory Affairs reviews the issue for reportability.

For any of the scenarios above, if the technician observes that the instrument does not easily calibrate, or has some other anomaly, then it is considered degraded and appropriate measures are taken to adjust, repair, or replace the instrument as needed so that the ALV is reliably inside the ALT.

In all cases the instrument is not returned to service unless the ALV is reliably inside the ALT. This is either via adjustment, repair of the existing instrument, or replacement. Repair or replacement also involves entering the Corrective Action Program.

5.8 Results and Conclusions from the Calculation

The figures below are copied from calculation 13-EC-PB-0202 and provide a summary of the Analytical Limits, the final Design Setpoint, and the resulting TS Allowable Values.

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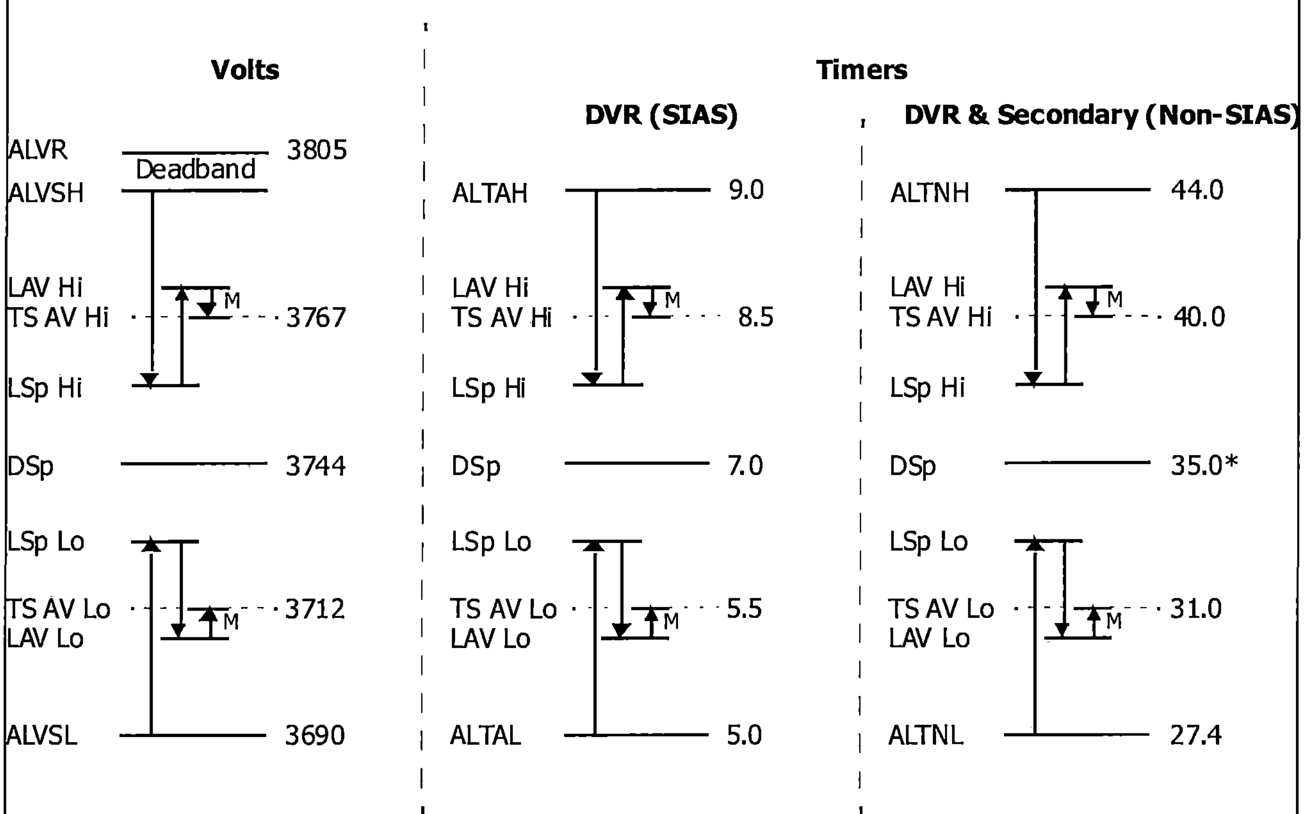
Figure 5-2
DVR: Relation of Analytical Limits, Technical Specifications, and Setpoints

Degraded Voltage Relay



AL = Analytical Limit
ALVR = AL, Voltage Reset
ALVSH = AL, Voltage Setpoint Hi
ALVSL = AL, Voltage Setpoint Lo
ALTAH = AL, Time Accident Hi
ALTAL = AL, Time Accident Lo
ALTNH = AL, Time Normal Hi
ALTNL = AL, Time Normal Lo

DSp = Design Setpoint (nominal, installed)
LAV = Limiting Allowable Value
LSp = Limiting Setpoint
M = Margin
TS AV = Tech Spec Allowable Value
* This is the combined DSp. The DSp of the Secondary Timer individually is the difference between this value and the DSp for the DVR.

The Secondary Timer performance is monitored as described for all instruments.

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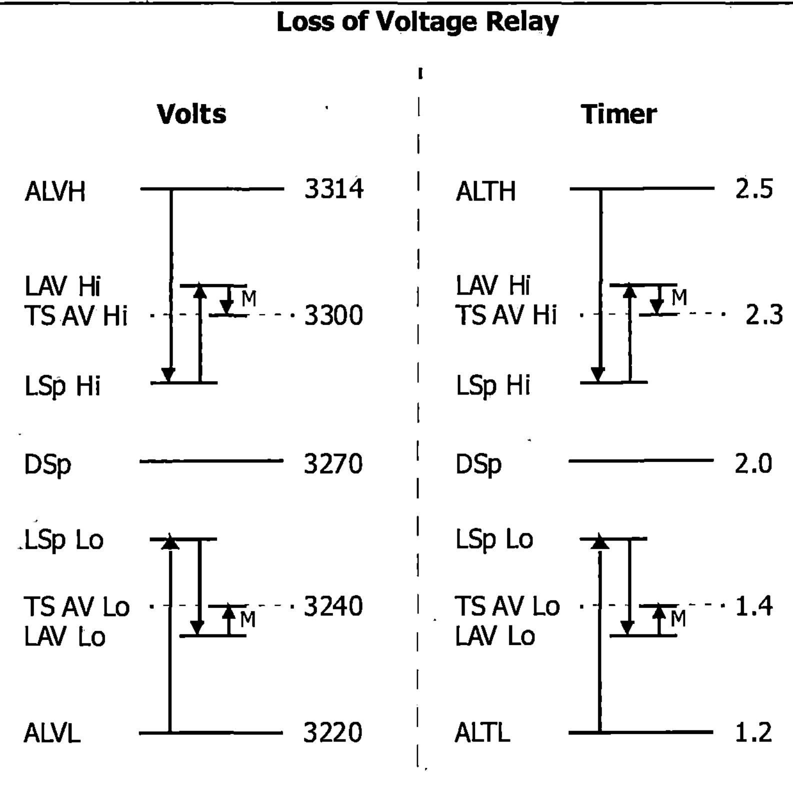
Figure 5-3
LVR: Relation of Analytical Limits, Technical Specifications, and Setpoints



AL = Analytical Limit		DSp =	Design Setpoint (nominal, installed)
ALVH =	AL, Voltage Hi	LAV =	Limiting Allowable Value
ALVL =	AL, Voltage Lo	LSp =	Limiting Setpoint
ALTH =	AL, Time Hi	M =	Margin
ALTL =	AL, Time Lo	TS AV =	Tech Spec Allowable Value

5.9 Comparison of As-Found Values to Technical Specification Allowable Values

There are five (5) sets of TS Allowable Values (see Figure 5-2 and Figure 5-3). Four are the comparison of the as-found value for a single device and parameter to the Allowable Value for that device and parameter.

The TS Allowable Value for the DVR and secondary timer is for a combination of two devices in series. However, the devices are not calibrated together. Therefore, no single as-found value for the series is measured. Instead, the sum of the two individual device as-found values can be added within the Surveillance Test (ST) for an effective combined as-found value. This effective combined as-found value, the sum of the devices AF values, is compared to the TS Allowable Value.

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5.10 Vendor Information about Instrument Uncertainties

5.10.1 Potential Transformer (PT)

The PT is intended to be a relatively fixed transformation of voltage from the 4160 volt bus to the 120 volt circuits used for measurement. However, it can vary based on burden or load. Based on the various curves provided by the vendor a potential uncertainty was determined. The M&TE used to test the PT is required to have a minimum accuracy. No other information is provided by the vendor.

The resulting uncertainty is acceptable, based on the work order history provided below.

5.10.2 Under Voltage Relay (UVR)

The vendor provides specifications for voltage repeatability at constant temperature and control voltage, a temperature effect, and a control voltage variation effect. The vendor provided only a repeatability specification for the time delay. Other effects not provided by the vendor were considered as negligible. The M&TE used to test the UVR for both voltage and time is required to have a minimum accuracy. The resulting uncertainty is acceptable, based on the work order history provided below.

5.10.3 Secondary Timer

The vendor provided a specification for the timer accuracy for "normal" and "adverse" conditions. Other effects not provided by the vendor were considered as negligible. The M&TE used to test the secondary timer is required to have a minimum accuracy. The resulting uncertainty is acceptable, based on the work order history provided below.

5.11 Work Order History

5.11.1 Work Order History for Potential Transformers

The as-left and as-found tolerances for the PT are both ±0.10% IV, ±0.035 turns. These tolerances there have been used for several years. The data summarized below are the results of the transformer turns ratio (TTR) testing from many work orders. The specific result from the work orders have been recorded and compared to the tolerances above. It is summarized to show that the tolerances developed in the calculation are acceptable.

1. There were 144 measurements (over approximately 12 years) of the PT turns ratio. This consisted of 3 units x 2 trains x 4 PTs per train x 6 work orders for each train.
2. The desired turns ratio is 34.916 and the tolerance is ±0.035 (34.881 to 34.951). This tolerance corresponds to the nominal turns ratio and the 0.10 % IV for the M&TE accuracy.
3. There were two that were found outside the as-found tolerance out of the 144 data points. This is above 98 percent passing.

This summary of data shows that the existing tolerance for the PTs is acceptable.

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5.11.2 **Work Order History for ABB Type 27N Relays**

The as-left and as-found voltage tolerances for the DVR work order history are ±0.10 volts ac and ±0.62 volts ac, respectively. These tolerances presented have been used for several years. The data summarized below are the results of the calibrations from many work orders. It is presented to show that tolerances developed in calculation 13-EC-PB-202 are acceptable. As noted below some of the calibration parameters have changed slightly. However, applying the current tolerances helps to show that the relays are performing consistently over the years.

Note that the model of the DVR for this data was ABB Type 27N, model 411**T7**375-HF-L-DP. After implementation of the modification the model will be 411**T4**375-HF-L-DP. The only difference is the possible range of the time delay setpoint. The model T7 has a time delay range of 10 - 100 seconds and the T4 has a time delay range of 1 - 10 seconds.

1. As shown in calculation 13-EC-PB-202, the desired dropout voltage is 107.08 volts and the as-found tolerance is ±0.62 volts (106.46 to 107.70 volts). The as-left tolerance is ±0.10 volts (106.98 to - 107.18 volts).

2. Note that about 2007 there were changes to the calibration value as a result of revision 3 of calculation 13-EC-PB-202. The nominal setpoint (3744 volts, as expressed on the 4160 bus) did not change. However, due to a change in the nominal turns ratio, the nominal setpoint measured on the 120 volt range did change slightly from 106.90 volts to 107.08 volts. The as-found tolerance also changed from ±1.27 volts (105.63 - 108.17 volts) to ±0.62 volts (106.46 - 107.70 volts). The previous as-left tolerance was the same as the previous as-found tolerance.

3. The number of out-of-tolerances is summarized at the end of the table (using current tolerances).

4. Not all of the data included both an as-found value and an as-left value. In many cases before about 2007, the as-found value was within the as-left tolerance and, therefore, no adjustment was made and accordingly no separate as-left value was recorded. About 2007, the procedure was changed to include an inspection of the relay, which then required an as-left adjustment, independent of the as-found value. That is why the number of data points for as-found values is different from as-left values.

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Table 5-1
Work Order History for DVRs

Simple Statistics of Values								
Parameter	Abbrvn	Dropout		Pickup		Timer		
		As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
Number of samples (approximately 12 years of data)	N	208	147	208	147	208	150
Average	Avg	106.98	107.05	107.53	107.51	31.89	31.80
Uncertainty (2*σ)	U	0.36	0.14†	0.34‡	0.29	0.18	0.15
Observed Hi Value	Hi	107.40	107.16	108.00	107.90	32.10	31.98
Observed Lo Value	Lo	106.42	106.60	107.15	107.15	31.61	31.55
Predicted Hi (Avg + 2*σ)	Pred Hi	107.34	107.19	107.88	107.81	32.07	31.95
Predicted Lo (Avg – 2*σ)	Pred Lo	106.62	106.91	107.19	107.22	31.72	31.66
Number out-of-tolerances Tol New/Old ‡‡	—	1/0	7/4	4/2	0/0	0/0	0/0

†This is larger than the as-left tolerance provided in calculation 13-EC-PB-202. This may be affected by previous calibrations which had a larger as-left tolerance.
‡This is smaller than the as-found tolerance provided in calculation 13-EC-PB-202.
‡‡ The two numbers are X/Y where X is the number of out-of-tolerances based on the tolerances of 13-EC-PB-0202 revision 3 and forward. The number Y is the number of out-of-tolerances after subtracting those that were within the tolerance used at the time of the calibration.

Note that the vendor time and voltage uncertainty information from the vendor is the same for both the T7 and T4 models. The time delay specification is 10%. The average or nominal setpoint was around 32 seconds (see average row for Timer columns). Therefore, an expected time variation of around 3.2 seconds appears consistent with vendor information. However, the calculated uncertainty was more than 10 times better than that. The uncertainty of the as-found data was 0.18 seconds and the uncertainty of the as-left data was 0.15 seconds. This data supports that the equipment is capable of a tighter tolerance of even 1% of the setpoint, which would be ~0.32 seconds.

5.11.3 **Work Order History for Agastat ETR Timers**

PVNGS does not have any direct experience or history with Agastat ETR timers. A request for information from other utilities resulted in a set of data from another station. A summary of the data is presented below.

1. The as-found tolerance range was 9 to 11 seconds (10 ±1 second). The as-left tolerance range was 9.5 to 10.5 seconds (10 ±0.5 seconds).

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2. For a nominal setpoint of 10 seconds, the vendor specification data indicates that the tolerance should be 5% or 0.5 seconds. That is consistent with the tolerance used by the other station.
3. In all but one case the as-found value was within the as-left tolerances and, therefore, no adjustment was made and the work orders from the other station did not record a separate as-left value. Therefore "NA" is used to indicate that a statistical parameter cannot be determined from that one case.
4. The simple statistical parameters on the data support the as-left tolerance of ±0.5 seconds. The standard deviation is the sample standard deviation rather than a population deviation since the number of data points is small. The symbol σ, as opposed to s, is used to more clearly indicate a standard deviation.

Table 5-2
Agastat ETR Data From Another Station

Parameter	As-Found	As-Left
Number of samples	22	1
Average	9.98	10.19
Uncertainty (2*σ)	0.48	NA
Uncertainty as %IV	4.81	NA
Observed Hi Value	10.69	NA
Observed Lo Value	9.60	NA
Predicted Hi (Avg + 2*σ)	10.46	NA
Predicted Lo (Avg – 2*σ)	9.50	NA
Number out-of-tolerance	0	0

6. References for Attachment 4

6.1 AC Distribution Calculations

a. PVNGS Unit 1 – Calculation 01-EC-MA-0221, *AC Distribution*, Revision 14
b. PVNGS Unit 2 – Calculation 02-EC-MA-0221, *AC Distribution,* Revision 14
c. PVNGS Unit 3 – Calculation 03-EC-MA-0221, *AC Distribution*, Revision 11

6.2 Calculation 13-EC-MA-0643, *Degraded Voltage Result /Component Review,* Revision 2

6.3 Calculation 13-EC-PB-0205, *Degraded Voltage Relay Short Stage Timer Analysis,* Revision 0

6.4 Calculation 13-EC-PB-0206, *Degraded Voltage Relay Long Stage Timer Analysis,* Revision 0

Attachment 4
Technical Description of Modification of the Degraded and Loss of Voltage Relays

6.5 NRC letter, *Palo Verde Nuclear Generating Station Units 1, 2, and 3 – Issuance of Amendments Re: Changes Related to Double Sequencing and Degraded Voltage Instrumentation,* License Amendment 123, dated December 29, 1999 (ADAMS accession numbers ML003670582, ML003670584, and ML003670587)

6.6 NRC letter, *Palo Verde Nuclear Generating Station – NRC Integrated Inspection Report 05000528/2014004,05000529/2014004,and 05000530/2014004, which* transmitted Inspection Report 2014-004, dated November 12, 2014 (ADAMS accession number ML14317A308)

6.7 Calculation 13-EC-PB-0202, *4160 V Degraded Voltage Relay (DVR) and Loss of Voltage Relay (LoVR) Setpoint & Calibration Calculation*, Revision 5

6.8 32MT-9ZZ13, *Testing and Calibration of the GE 12IFC66K1A and 12IFC66KD1A Time Overcurrent Relays*, Revision 4

6.9 81TD-0DC88, *Design Guide for Instrument Uncertainty and Setpoint Determination,* Revision 1