UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
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December 6, 2006

EA-06-296

James M. Levine, Executive
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SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, and 3 - NRC SPECIAL INSPECTION REPORT 05000528/2006012; 05000529/2006012; 05000530/2006012

Dear Mr. Levine:

On November 30, 2006, the U.S. Nuclear Regulatory Commission (NRC) completed a special inspection at your Palo Verde Nuclear Generating Station, Units 1, 2, and 3. This inspection examined activities associated with the Unit 3 Train A emergency diesel generator (EDG) failures that occurred on July 25 and September 22, 2006. On both occasions the EDG failed to produce an output voltage during testing. The NRC's initial evaluation satisfied the criteria in NRC Management Directive 8.3, "NRC Incident Investigation Program," for conducting a special inspection. The basis for initiating this special inspection is further discussed in the Charter, which is included as Attachment 2 to this report. The determination that the inspection would be conducted was made by the NRC on September 29, 2006, and the inspection started on October 2, 2006.

The enclosed special inspection report documents the inspection findings which were discussed on November 9, 2006, with you, and other members of your staff, and on November 30, 2006, with Mr. David Mauldin, Vice President, Engineering, and other members of your staff. The inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. The inspectors reviewed selected procedures and records, observed activities, and interviewed personnel.

The attached report discusses two findings that appear to have low to moderate safety significance (White). As described in Section 3.0 of this report, the NRC concluded that the failure to establish appropriate instructions for performing corrective maintenance activities on a K-1 relay resulted in the Unit 3 Train A EDG being inoperable between September 4 and 22, 2006. Additionally, the failure to identify and correct the cause of the erratic EDG K-1 relay operation prior to installation of the relay on July 26, 2006, was identified as another performance deficiency that contributed to the Unit 3 Train A EDG being inoperable for a period

greater than the Technical Specification completion time. The safety significance of these findings was assessed on the basis of the best available information, including influential assumptions, using the applicable Significance Determination Process and were preliminarily determined to be White (i.e., low to moderate safety significance) findings. Preliminarily, these findings have a low to moderate safety significance when assuming a loss of offsite power initiating event and the Unit 3 Train A EDG being in an unreliable condition for approximately 40 days and a nonfunctional condition for approximately 18 days. Attachment 3 of this report provides a detailed description of the preliminary risk assessment. In accordance with NRC Inspection Manual Chapter (IMC) 0609, "Significance Determination Process," we intend to complete our evaluation using the best available information and issue our final determination of safety significance within 90 days of this letter.

These findings do not represent an immediate safety concern because of the corrective actions you have taken. These actions involved inspecting, cleaning, and implementing mechanical adjustments, as appropriate, to the operating mechanism of the EDG K-1 relays.

Also, these findings constitute apparent violations of NRC requirements and are being considered for escalated enforcement action in accordance with the NRC Enforcement Policy. The current Enforcement Policy is included on the NRC's web site at http://www.nrc.gov/reading-rm/adams.html.

Before we make a final decision on this matter, we are providing you an opportunity to present to the NRC your perspectives on the facts and assumptions, used by the NRC to arrive at the findings and their significance, at a Regulatory Conference or in writing. As discussed during a telephone call with Mr. Scott Bauer, Department Leader, Regulatory Affairs, we understand that it is your intent to discuss your perspectives during a Regulatory Conference. Accordingly, a Regulatory Conference is scheduled to be conducted in the NRC Region IV office in Arlington, Texas, on January 16, 2007. We encourage you to submit supporting documentation at least one week prior to the conference in an effort to make the conference more efficient and effective. This Regulatory Conference will be open to public observation.

Since the NRC has not made a final determination in this matter, no Notice of Violation is being issued for these inspection findings at this time. In addition, please be advised that the number and characterization of apparent violations described in the enclosed inspection report may change as a result of further NRC review.

The report also documents one finding with two examples involving inadequate implementation of the operability determination process. This finding was determined to be a violation of very low safety significance. Because of the very low safety significance and because it was entered into your corrective action program, the NRC is treating this finding as a noncited violation consistent with Section VI.A.1 of the NRC Enforcement Policy. If you contest the noncited violation in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN.: Document Control Desk, Washington, DC 20555-0001; and the NRC Resident Inspector at the Palo Verde Nuclear Generating Station.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's

document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Arthur T. Howell III, Director
Division of Reactor Projects

Dockets: 50-528
50-529
50-530
Licenses: NPF-41
NPF-51
NPF-74

Enclosure:
Inspection Report 05000528/2006012; 05000529/2006012; 05000530/2006012
w/Attachment 1: Supplemental Information
Attachment 2: Special Inspection Charter
Attachment 3: Significance Determination Evaluation

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SUNSI Review Completed: __TWP_ ADAMS: √ Yes ☐ No Initials: __TWP____
√ Publicly Available ☐ Non-Publicly Available ☐ Sensitive √ Non-Sensitive

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U.S. NUCLEAR REGULATORY COMMISSION

REGION IV

Dockets:	50-528; 50-529; 50-530
Licenses:	NPF-41; NPF-51; NPF-74
Report No.:	05000528/2006012; 05000529/2006012; 05000530/2006012
Licensee:	Arizona Public Service Company
Facility:	Palo Verde Nuclear Generating Station, Units 1, 2, and 3
Location:	5951 S. Wintersburg Road Tonopah, Arizona
Dates:	October 2 through November 30, 2006
Inspectors:	M. Hay, Senior Project Engineer, Team Leader Dr. S. Rutenkroger, Reactor Inspector, Engineering Branch 1 M. Runyan, Senior Reactor Analyst
Accompanied:	M. Bloodgood, Reactor Engineer, Nuclear Safety Professional Development Program
Approved By:	Arthur T. Howell III, Director Division of Reactor Projects

SUMMARY OF FINDINGS

IR 05000528/2006012; 05000529/2006012; 05000530/2006012; 10/02/2006 - 11/09/2006; Palo Verde Nuclear Generating Station, Units 1, 2, and 3: Special Inspection in response to Unit 3 Train A EDG failures on July 25 and September 22, 2006.

The report covered a 5-day period (October 2-6, 2006) of onsite inspection, with in-office review through November 30, 2006, by a special inspection team consisting of one senior project engineer, one reactor inspector, one reactor engineer, and one senior reactor analyst. Three findings were identified. The significance of most findings is indicated by its color (Green, White, Yellow, Red) using Inspection Manual Chapter 0609, "Significance Determination Process." Findings for which the significance determination process does not apply may be Green or be assigned a severity level after NRC management review. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 3, dated July 2000.

Summary of Event

The NRC conducted a special inspection to better understand the circumstances surrounding two failures of the Unit 3 Train A emergency diesel generator that occurred on July 25 and September 22, 2006. Both failures involved the emergency diesel generator failing to obtain an output voltage during surveillance testing because of faulty K-1 relay operation. In accordance with NRC Management Directive 8.3, "NRC Incident Investigation Program," it was determined that this event involved repetitive failures of safety related equipment having potential adverse generic implications and had sufficient risk significance to warrant a special inspection.

A. NRC-Identified and Self Revealing Findings

Cornerstone: Mitigating Systems

- TBD. The team identified an apparent violation of 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," for the failure to establish appropriate instructions for performing corrective maintenance activities on an emergency diesel generator K-1 relay. As a result, following identification that a replacement emergency diesel generator K-1 relay was unreliable, the licensee performed ineffective corrective maintenance activities on this relay. This performance deficiency contributed to the Unit 3 Train A emergency diesel generator being inoperable between September 4 and 22, 2006, and a failure on September 22, 2006. Immediate corrective actions included inspection, cleaning, and/or performing mechanical adjustments on all emergency diesel generator K-1 relays. This issue was entered into the licensee's corrective action program as Condition Report/Disposition Request 2926830.

  The finding is greater than minor because it is associated with the equipment performance cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Using NRC Inspection Manual Chapter 0609, "Significance Determination Process," Phase 1 Worksheet, a Phase 2 evaluation was required

because the finding resulted in the loss of the safety function of the Unit 3 Train A emergency diesel generator for greater than the Technical Specification completion time. The Phase 2 evaluation concluded that the finding was of low to moderate safety significance. A Phase 3 preliminary significance determination analysis also determined the finding was of low to moderate safety significance. The cause of this finding is related to the crosscutting element of human performance associated with resources in that the licensee failed to develop and implement appropriate work instructions prior to performing corrective maintenance activities on an emergency diesel generator K-1 relay (Section 3.0).

- TBD. The team identified an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Actions," for the failure to identify and correct the cause of erratic emergency diesel generator K-1 relay operation prior to installation of the relay on July 26, 2006. This performance deficiency contributed to the Unit 3 Train A emergency diesel generator being inoperable between September 4 and 22, 2006, and a failure on September 22, 2006. Immediate corrective actions included inspection, cleaning, and performing mechanical adjustments, as appropriate, on all emergency diesel generator K-1 relays. This issue was entered into the licensee's corrective action program as Condition Report/Disposition Request 2926830.

  The finding is greater than minor because it is associated with the equipment performance cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Using NRC Inspection Manual Chapter 0609, "Significance Determination Process," Phase 1 Worksheet, a Phase 2 evaluation was required because the finding resulted in the loss of the safety function of the Unit 3 Train A emergency diesel generator for greater than the Technical Specification allowed outage time. The Phase 2 evaluation concluded that the finding was of low to moderate safety significance. A Phase 3 preliminary significance determination analysis also determined the finding was of low to moderate safety significance. The cause of this finding is related to the crosscutting element of problem identification and resolution in that the failure to fully evaluate and implement adequate corrective maintenance actions for the Unit 3 Train A emergency diesel generator resulted in the emergency diesel generator being inoperable for 18 days (Section 3.0).

- The team identified two examples of a noncited violation of 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," for the failure to perform operabilty determinations. In both examples, the licensee failed to perform an operability determination following identification of a degraded condition that had the potential to adversely affect the safety function of all emergency diesel generators. Specifically, an operability determination was not performed after identifying the failure of the Unit 3 Train A emergency diesel generator on July 25, 2006, was potentially the result of plastic debris affecting proper auxiliary contact operation of a K-1 relay. The licensee determined the debris most likely originated from a modification performed on all emergency diesel generator K-1 relays during initial plant startup. Following another failure

of the Unit 3 Train A emergency diesel generator on September 22, 2006, an operability determination was not performed after identifying the failure was the result of the K-1 relay actuating arm not providing adequate compression of the auxiliary contacts. The licensee determined this degraded condition most likely originated during implementation a modification done to all emergency diesel generator K-1 relays during initial plant startup.

This finding is greater than minor because the failure to follow the operability determination process, if left uncorrected, would become a more significant safety concern in that degraded or nonconforming conditions would not be properly evaluated. Using the Phase 1 worksheet in NRC Inspection Manual Chapter 0609, "Significance Determination Process," the finding was determined to have very low safety significance because unreliable K-1 relay operation resulted in no actual loss of safety function of the other five emergency diesel generators prior to corrective actions being implemented, and the finding did not represent a potential risk significant condition because of a seismic, flooding, or severe weather event. This issue is documented in the licensee's corrective action program as Condition Report/Disposition Requests 2928389 and 2940558. The cause of this finding is related to the crosscutting element of problem identification and resolution in that engineering personnel failed to properly evaluate and perform operability determinations for identified degraded conditions affecting the emergency diesel generators (Section 4.0).

B. Licensee-Identified Findings

None.

REPORT DETAILS

1.0 SPECIAL INSPECTION SCOPE

The NRC conducted this special inspection to better understand the circumstances surrounding two failures of the Unit 3 Train A emergency diesel generator (EDG) that occurred on July 25 and September 22, 2006. Both failures involved the EDG failing to obtain an output voltage during surveillance testing because of a faulty K-1 relay operation. In accordance with NRC Management Directive 8.3, "NRC Incident Investigation Program," it was determined that this event met several deterministic criteria and had sufficient risk significance to warrant a special inspection.

The team used NRC Inspection Procedure 93812, "Special Inspection Procedure," to conduct the inspection. The special inspection team reviewed procedures, corrective action documents, and design and maintenance records for the equipment of concern. The team interviewed key station personnel regarding the event, reviewed the root cause analysis, and assessed the adequacy of corrective actions. A list of specific documents reviewed is provided in Attachment 1. The charter for the special inspection effort is provided as Attachment 2.

2.0 EVENT DESCRIPTION

Each unit at Palo Verde contains two safety-related 5500 Kw EDGs that provide standby power for safe plant shutdown in the event the normal supply of power is lost. On July 25, 2006, at 12:53 p.m., the Unit 3 Train A EDG failed to develop an output voltage during a routine surveillance test. When the EDG's are secured a field shorting K-1 relay actuates to electrically short the generator field causing the generator output voltage to collapse. A relay latching mechanism maintains the field shorted until the EDG is started at which time the latch disengages allowing the relay to actuate and un-short the EDG field. With the field no longer shorted the voltage regulator establishes and controls the EDG output voltage. The licensee identified that a faulty set of auxiliary contacts on a K-1 relay prevented the latch from disengaging that resulted in the generator field being shorted during the start of the EDG. The licensee determined the root cause of the auxiliary contact failure could be attributed to either plastic debris or oxide film buildup preventing continuity across the contacts when closed. Following the failure on July 25, 2006, the licensee replaced the failed K-1 relay with a new relay obtained from the warehouse. During continuity checks of the new relay, the same auxiliary contacts were identified to operate unreliably. The last available relay from the warehouse was obtained and it also operated unreliably and it had a warped cover. Based on no other replacement K-1 relays being available, the licensee performed corrective maintenance activities on the first relay obtained from the warehouse in an attempt to resolve the problem. Following these corrective maintenance activities, the relay was successfully tested several times and the Unit 3 Train A EDG was declared operable at 10:35 a.m. on July 26, 2006.

On September 22, 2006, the Unit 3 Train A EDG failed to develop an output voltage following a postmaintenance surveillance test. The licensee identified that the same set

of auxiliary contacts that previously exhibited erratic behavior during continuity checks had failed. The licensee identified that the K-1 relay actuating arm for the affected auxiliary contact module was not providing adequate compression of the auxiliary contacts. Corrective actions involved mechanical adjustments to the actuating arm to provide proper auxiliary contact compression. Additional corrective actions included inspecting, cleaning, and making mechanical adjustments, as necessary, to all other affected EDG K-1 relays.

3.0 PERFORMANCE DEFICIENCIES RESULTING IN EDG FAILURE

a. Inspection Scope

On July 25 and September 22, 2006, the Unit 3 Train A EDG failed to produce output voltage during surveillance testing. The team reviewed the licensee's corrective actions following failure of the Unit 3 Train A EDG on July 25, 2006, to assess their effectiveness with respect to preventing the subsequent failure that occurred on September 22, 2006.

b. Observations and Findings

Introduction: The team identified two apparent violations of NRC requirements. The team identified an apparent violation of 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," for the failure to establish appropriate instructions for performing corrective maintenance activities on an EDG K-1 relay. As a result, following identification that a replacement EDG K-1 relay was unreliable, the licensee performed ineffective corrective maintenance activities on this relay. Additionally, the team identified an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," involving the failure to identify the cause of a significant condition adverse to quality and take corrective actions to preclude repetition. Specifically, following identification that a replacement EDG K-1 relay was unreliable, the licensee failed to identify the cause of this condition and implement adequate corrective actions. These performance deficiencies resulted in the Unit 3 Train A EDG being inoperable between September 4 and 22, 2006, and a failure on September 22, 2006. These issues have potential low to moderate safety significance (White).

Description: On July 25, 2006, at 12:53 p.m., the Unit 3 Train A EDG failed to develop an output voltage during a routine surveillance test. The licensee identified that a faulty set of auxiliary contacts on a K-1 relay resulted in the generator field being shorted during the start of the EDG. A new K-1 relay assembly was acquired from the warehouse and during functional testing the same auxiliary contacts exhibited erratic operation. The team noted that Work Order 2913004 stated, in part, that the "K-1 relay failed at first. Checked and re-attempted satisfactory. Performed several times satisfactory. System engineering showed up and after discussing the problem they wanted to verify repeatability. Checking contact resistance was found to be erratic. Unable to clean the contacts to get consistent readings. Determined not reliable and ordered last K-1 relay from the warehouse."

Initial attempts, by electrical maintenance personnel, to clean the auxiliary contacts of the first relay obtained from the warehouse consisted of using a 9-volt battery connected across the contacts. By cycling the contacts, the licensee stated that an electrical arc could potentially clean any oxidation affecting the contact's ability to pass current. The licensee stated this practice was utilized because engineering would not allow intrusive actions, such as taking the relay apart, to clean the auxiliary contacts because of concerns with maintaining critical dimensions. The team noted the licensee had no maintenance instructions applicable to disassembly of the relay and no detailed vendor specifications describing the critical attributes of the device. The licensee stated that obtaining this type of information was not possible because the equipment was obsolete, it was commercially dedicated by a vendor, and the vendor and manufacturer of the component were no longer in business. Based on these reasons, the licensee stated that no maintenance activities were performed on the auxiliary contacts and that when problems were encountered the K-1 relay was replaced as a whole unit.

After initial attempts to clean the K-1 relay auxiliary contacts using the 9-volt battery failed, the licensee obtained the last replacement K-1 relay available onsite. Again, they found that the same set of auxiliary contacts on this relay exhibited erratic operation when cycled. Additionally, the cover to this relay was found in a warped condition. At this point the licensee decided to perform intrusive cleaning of the auxiliary contacts on the first device that they determined was unreliable following non-intrusive cleaning efforts. The team noted that no detailed work instructions were established to perform this activity to improve its reliable operation. As previously stated, the licensee did not possess any detailed vendor information specifically related to performing maintenance activities on this device. After disassembling the auxiliary contacts, cleaning, and reassembly, the relay was tested several times and the erratic behavior was not observed during subsequent functional tests of the relay. A postmaintenance surveillance test of the EDG was performed satisfactorily and the equipment was declared operable at 10:35 a.m. on July 26, 2006.

On September 22, 2006, the Unit 3 Train A EDG failed to develop an output voltage following a postmaintenance surveillance test. The licensee identified that the same set of auxiliary contacts that exhibited erratic behavior on the K-1 relay had failed, resulting in the generator field being shorted during the start of the EDG. The licensee identified that the auxiliary contacts were not held closed when the K-1 relay was energized because of an actuating arm that was not adequately depressing the auxiliary contact switch. The team noted that this condition most likely existed during the initial testing on July 25, 2006, and would have contributed to the erratic operation of this contact switch assembly. Additionally, the team determined that this condition was not identified and corrected because instructions for performing corrective maintenance activities on the unreliable K-1 relay were inadequate. The team noted that the last successful start of the Unit 3 Train A EDG was on September 4, 2006.

As previously stated, the licensee initially believed the erratic behavior resulted from oxidation of the contact surfaces which required an intrusive maintenance activity to clean the contact surfaces. The licensee stated that contact oxidation is a common occurrence requiring cleaning. The team reviewed all work orders associated with replacement of the K-1 relay dating back to 1984 and noted that none of the work orders documented erratic auxiliary contact operation because of oxidation. During the review

of work orders, the team noted that Work Order 00067739, dated December 11, 1984, discussed troubleshooting and repair activities for a faulty auxiliary contact on the K-1 relay affecting the Unit 1 Train B EDG. This work order contained instructions to inspect the auxiliary contact arm on the K-1 relay and make adjustments as needed for proper contact operation per Technical Manual MO18-390. The maintenance technician performing the work documented, "Adjusted the actuation arm for the auxiliary contacts on the left side of the K-1 contactor as required." Based on this work order, the team determined that on this occasion the licensee had worked on the auxiliary contact operating mechanism to ensure reliable operation. A technician involved in this maintenance activity did not recall the specifics of the work performed on the relay nor the use of technical information contained in the technical manual. The team reviewed the technical manual and found that no pertinent maintenance information for the K-1 relay existed.

Although no pertinent maintenance information for the K-1 relay was identified during review of Technical Manual MO18-390, the team noted that detailed instructions were provided to maintenance personnel for ensuring that critical tolerances of other relays were maintained. The team noted that the voltage controlled overcurrent relay, reverse power relay, frequency relay, and negative-phase sequence time overcurrent relay, all associated with the EDG voltage regulating system, contained specific installation, operation, and maintenance instructions. The team noted that these instructions provided detailed information for activities involving contact cleaning, contact adjustments, operational checks, and mechanical adjustments for each particular type of relay to ensure reliable operation.

The licensee stated that the EDG K-1 relays had a history of operating reliably. Data collected since 1990 indicated that the EDG K-1 relays had not failed because of auxiliary contact problems similar to the failures identified in July and September of 2006. The team determined that this reliability data further demonstrated that, when the erratic relay operation was identified, the licensee should have recognized that corrective measures were needed that would require appropriate instructions to ensure future reliable operation.

The team determined that the licensee's problem analysis efforts were narrowly focused, which led them to conclude that the cause of the erratic relay operation was oxidized contacts. The erratic operation of the K-1 relay provided an indication that sufficient auxiliary contact continuity existed, at least intermittently, which indicated that another failure mechanism was contributing to the unreliable K-1 relay operation. If the licensee performed an adequate cause analysis of this significant condition adverse to quality, then they may have identified the failure mechanism associated with the actuating arm not providing adequate contact compression prior to installation of the new relay on July 26, 2006.

Analysis: NRC Inspection Manual Chapter 0612, "Power Reactor Inspection Reports," defines a performance deficiency as an issue that is the result of a licensee not meeting a requirement or standard where the cause was reasonably within the licensee's ability to foresee and correct and that should have been prevented. The licensee determined that the K-1 relay that failed in September of 2006 was unreliable prior to placing it in service and would require corrective maintenance. The licensee stated that

disassembly of the relay to implement intrusive corrective actions had never been performed because of concerns with maintaining critical dimensions for reliable relay operation. The licensee did not obtain, nor did they develop, detailed information specific to performing corrective or preventive maintenance activities for this specific relay. On the basis of these considerations, the team concluded that the licensee's failure to establish and implement adequate maintenance instructions to resolve the unreliable K-1 relay condition was a performance deficiency resulting in the Unit 3 Train A EDG being inoperable between September 4 and 22, 2006. The team determined that the EDG was inoperable for an 18-day period on the basis that when the EDG was shut down on September 4, 2006, the K-1 relay auxiliary contacts would have been positioned and maintained in a state that would have resulted in a subsequent failure of the relay to operate properly following an EDG start signal. Additionally, the team determined that the failure to perform an adequate cause assessment of the erratic relay operation contributed to the inoperability of the Unit 3 Train A EDG.

These findings are greater than minor because they are associated with the equipment performance cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Using NRC Inspection Manual Chapter 0609, "Significance Determination Process," Phase 1 Worksheet, a Phase 2 analysis was required because the findings resulted in the loss of the safety function of the Unit 3 Train A EDG for greater than the Technical Specification completion time. The Phase 2 and 3 evaluations preliminarily concluded that the findings were of low to moderate safety significance. (See Attachment 3 for Phase 2 and Phase 3 details.) The cause of the Criterion XVI finding is related to the crosscutting element of problem identification and resolution in that the failure to fully evaluate and implement adequate corrective maintenance actions for the Unit 3 Train A EDG contributed to the EDG being inoperable for 18 days. Additionally, the cause of the Criterion V finding is related to the crosscutting element of human performance associated with resources in that the licensee failed to develop and implement appropriate work instructions prior to performing corrective maintenance activities on the subject EDG K-1 relay, which contributed to the EDG being inoperable for 18 days.

Enforcement: 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," states, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Contrary to this, the licensee failed to develop appropriate instructions or procedures for corrective maintenance activities on the Unit 3 Train A EDG K-1 relay. This failure resulted in the Unit 3 Train A EDG being inoperable between September 4 and 22, 2006. This item has been entered into the licensee's corrective action program as Condition Report/Disposition Request (CRDR) 2926830. Pending determination of safety significance, this finding is identified as an apparent violation (AV) 05000530/2006012-01, "Failure to Establish Appropriate Instructions."

10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," states, in part, that measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected and for significant conditions adverse to quality, measures shall assure that the cause of the condition is determined

and corrective action taken to preclude repetition. Contrary to this, the licensee failed to identify and correct the cause of the erratic EDG K-1 relay operation prior to installation of the relay on July 26, 2006. This failure resulted in the Unit 3 Train A EDG being inoperable between September 4 and 22, 2006. This item has been entered into the licensee's corrective action program as CRDR 2926830. Pending determination of safety significance, this finding is identified as AV 05000530/2006012-02, "Failure to Identify and Correct a Condition Adverse to Quality."

4.0 Failure to Implement the Operability Determination Process

a. Inspection Scope

The team assessed the engineering and operations departments' implementation of the operability determination (OD) process after identifying potential adverse conditions involving reliable K-1 relay operation of the EDGs. This assessment was performed through interviews and a review of precisely logs, ODs, and related documents. In addition, the team conducted an independent assessment of system operability.

b. Observations and Findings

Introduction: The team identified two examples of a Green noncited violation of 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," involving the failure to follow the OD procedure.

Description:

Example One

Administrative Procedure 40DP-9OP26, "Operability Determination and Functional Assessment," Revision 17, Section 1.3, stated, in part, that the OD process is entered when the ability of a Technical Specification system or component to perform its specified safety function is called into question by the discovery of a degraded condition.

As previously discussed, on July 25, 2006, the Unit 3 Train A EDG failed to produce output voltage during surveillance testing. The licensee identified that a faulty set of auxiliary contacts on a K-1 relay resulted in the generator field being shorted during the start of the EDG. The team noted that an engineering team was assigned to perform a root cause analysis for the K-1 relay auxiliary contact failure. This root cause evaluation was documented in CRDR 2913003. The root cause team determined the most probable cause was due to contamination on the contact surface either from oxidation or from pieces of plastic filings found in the contact area. The plastic pieces were believed to have resulted from a modification of the contact block actuator implemented by Design Change Package DCP X-PE-007. This design change added auxiliary contacts, latching mechanisms, and spacers to all EDG K-1 relays at the facility to address seismic concerns identified during testing of the K-1 relay during the initial plant construction phase.

The NRC inspection team noted that the licensee's root cause assessment team concluded that only the Unit 3 Train A EDG was potentially degraded by this condition. The evaluation stated, in part, that:

> The same model/type field shorting contactor is used on all six Class 1E EDGs. In addition, two spare K-1 relays removed from the warehouse exhibited the same symptoms with varying resistance across the auxiliary contacts. An inspection/test of the auxiliary contacts for all other EDGs was performed, with no other auxiliary contact resistance problems identified.

The NRC team was informed that the licensee's inspection consisted of a functional check of the relay and did not involve visually inspecting the auxiliary contact internals to identify the presence of plastic filings. Based on this, the team determined that the inspection and contact resistance testing alone failed to demonstrate why only the Unit 3 Train A EDG K-1 relay was affected since the relay had operated properly since being placed in service on August 1, 2001. Therefore, the licensee inadequately assessed the extent of condition of the unreliable relay operation relative to the other EDGs at the facility.

The NRC team noted that the root cause assessment identified a degraded condition, plastic filings in the contact module that likely affected all the facility EDGs. However, the licensee failed to enter the OD process after identifying this potentially degraded condition.

Example Two

As previously discussed, on September 22, 2006, at 1:18 a.m., the Unit 3 Train A EDG failed to produce output voltage during surveillance testing. The licensee identified that a faulty set of auxiliary contacts on a K-1 relay resulted in the generator field being shorted during the start of the EDG. The licensee identified that the K-1 relay actuating arm for the affected auxiliary contact module was not providing adequate compression of the auxiliary contacts. The licensee noted that part of the actuating arm consisted of a metal tab that was bent in a configuration that would result in less contact compression. The licensee decided to straighten the metal tab, thereby, providing additional contact compression. Five functional tests of the relay were performed and the EDG was declared operable following a postmaintenance surveillance test on September 22, 2006, at 5:48 p.m.

The team noted that CRDR 2926830 documented the licensee's evaluation of this failure. The CRDR stated, in part:

> The auxiliary contacts that had failed were added to the K-1 relay by Design Change Package DCP X-PE-007 during plant startup in response to electrical seismic latch failures. Engineering believes that the actuator arm mounted metal tab was initially bent because originally there were no auxiliary contacts on that side of the K-1 relay. Following completion of the design change, the auxiliary contacts appeared to be working properly so the actuator arms were left bent down. Inspection of some of the K-1

relays removed from EDGs in the past found at least one that had the actuator arm straight; however, in most cases, the actuator arm metal tab for the auxiliary contacts were found bent down. This is a repeat failure of Unit 3 Train A EDG to produce output voltage. Recent verification of acceptable K-1 relay auxiliary contact continuity on the other five EDGs provides the basis that this condition is not present on those relays.

The NRC team was informed that the licensee's inspection consisted of a functional check of the relay and did not involve visually inspecting the auxiliary contact actuating arms to identify a bent configuration. Based on this, the team determined that the inspection and contact resistance testing alone failed to demonstrate why only the Unit 3 Train A EDG K-1 relay was affected, since the relay had operated properly since being placed in service on July 26, 2006. Therefore, the licensee inadequately assessed the extent of condition of the unreliable relay operation relative to the other EDGs at the facility.

The team noted that the engineering assessment identified a degraded condition, a bent K-1 relay actuating arm resulting in unreliable operation, that likely affected all the facility EDGs. The licensee failed to enter the OD process after identifying this potentially degraded condition. Following discussions with the licensee, an OD was performed on September 27, 2006.

In both of these examples the team determined that engineering failed to recognize that the identified degraded conditions had the potential to adversely affect the other EDGs. On both occasions engineering relied on continuity checks of the auxiliary contacts to inappropriately conclude that the other EDGs were not affected. The team noted that the testing results were pertinent to an OD assessment; however, the information did not provide adequate justification for not implementing the OD process ensuring reasonable assurance existed supporting operability of the other EDGs.

Analysis: The performance deficiency was associated with engineering personnel not adequately implementing the provisions of the OD procedure following the identification of a degraded condition. This finding was more than minor because the failure to follow the operability determination process, if left uncorrected, would become a more significant safety concern in that degraded or nonconforming conditions would not be properly evaluated. Using the Phase 1 worksheet in Manual Chapter 0609, "Significance Determination Process," the finding was determined to have very low safety significance because, although these conditions resulted in unreliable K-1 relay operation, no actual loss of safety function occurred (with respect to the other 5 EDGs) prior to corrective actions being implemented, and the finding did not represent a potential risk significant condition due to a seismic, flooding, or severe weather event. This finding involved problem identification and resolution crosscutting aspects associated with engineering personnel failing to properly evaluate and perform operability determinations for identified degraded conditions.

Enforcement: 10 CFR Part 50, Criterion V, "Instructions, Procedures, and Drawings," states, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings.

Administrative Procedure 40DP-9OP26, "Operability Determination and Functional Assessment," Revision 17, Section 1.3, stated, in part, that the OD process is entered when the ability of a Technical Specification system or component to perform its specified safety function is called into question by the discovery of a degraded condition. Contrary to the above, on two occasions the licensee failed to enter the OD process when the ability of a Technical Specification system or component safety function was called into question. On July 25, 2006, following failure of the Unit 3 Train A EDG, an OD was not performed after identifying the failure was likely because of plastic filings affecting proper auxiliary contact operation of a K-1 relay. The filings were believed to be from a modification that was performed on all EDG K-1 relays during initial plant startup. On September 22, 2006, following another failure of the Unit 3 Train A EDG, an OD was not performed after identifying the failure was the result of the K-1 relay actuating arm not providing adequate compression of the auxiliary contacts. The licensee determined this condition most likely resulted from a modification performed on all EDG K-1 relays during initial plant startup. Because the finding is of very low safety significance and has been entered into the licensee's corrective action program as CRDR's 2928389 and 2940558, this violation is being treated as a noncited violation consistent with Section VI.A of the Enforcement Policy: Noncited Violation 05000528;05000529;05000530/2006012-03, "Failure to Implement the Operability Determination Process."

5.0 CORRECTIVE ACTIONS FOLLOWING EDG FAILURES

a. Inspection Scope

The team assessed the licensee's immediate and long-term planned corrective actions associated with the Unit 3 Train A EDG failures that occurred on July 25 and September 22, 2006. This assessment was performed through interviews, review of operator logs, corrective action documents, work orders, and related documents.

b. Observations and Findings

Following the Unit 3 Train A EDG failure on July 25, 2006, the licensee identified that plastic filings inside the auxiliary contact module may have resulted in the failure. The licensee concluded this material most likely was introduced during a design change performed on all the K-1 relays and subsequently established a schedule to inspect all the EDG auxiliary contact modules. The team noted these inspections were scheduled to be performed November 2006 through March 2007. NRC Inspection Manual, Part 9900, Technical Guidance, "Operability Determination and Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety," Section 4.2, states, "When a potential degraded or nonconforming condition is identified, the licensee should take action without delay to confirm if a system, structure, or component is degraded or nonconforming." The team concluded that waiting approximately 8 months to identify whether other EDGs were affected by this potential adverse condition was not commensurate with the safety consequences of having a degraded EDG.

Following the September 22, 2006, Unit 3 Train A EDG failure, the licensee identified that a bent K-1 relay actuating arm resulted in unreliable auxiliary contact operation. Immediate corrective actions involved straightening the arm to provide additional contact compression for the Unit 3 Train A EDG. The team noted that the licensee implemented timely corrective actions to inspect and implement mechanical adjustments, as needed, to all the EDG relays to ensure adequate contact compression during operation. These actions were implemented September 27-30, 2006, and incorporated the inspections resulting from the July failure that were originally not scheduled to be completed until March 2007. The licensee straightened bent K-1 relay contactor arms for the Unit 2 Trains A and B EDGs, and the Unit 1 Train B EDG. The team determined that these actions were timely and they included the inspections identified following the July failure. Therefore, there were no regulatory findings associated with timeliness of these corrective actions.

The team noted that long-term planned corrective actions consisted of replacing all of the EDG automatic voltage regulators, including replacement of the K-1 relays, with a different design. The licensee stated that they plan to have these replacement activities accomplished during the next refueling outage for each unit.

6.0 Generic Implications

The team reviewed various NRC generic communications and operating experience from other licensees relevant to the EDG relay failures identified at the Palo Verde Nuclear Generating Station. No relevant similar relay failures were identified. Both the NRC and the licensee concluded that the relay problems pertaining to ensuring adequate contact compression is provided by the actuator arm was potentially of generic concern. On October 21, 2006, the licensee submitted voluntary Licensee Event Report (LER) 50-530/2006-006-00 to report this concern.

4OA3 Event Follow-up (71153)

.1 (Closed) LER 05000530/2006-006-00, Voluntary LER for Failure of Emergency Diesel Generator to Attain Required Voltage Due to Relay Contactor

On September 22, 2006, at 1:18 a.m., the Unit 3 Train A EDG failed to produce output voltage during surveillance testing. The licensee identified that a faulty set of auxiliary contacts on a K-1 relay resulted in the generator field being shorted during the start of the EDG. The licensee identified that the K-1 relay actuating arm for the affected auxiliary contact module was not providing adequate compression of the auxiliary contacts. The licensee noted that part of the actuating arm consisted of a metal tab that was bent in a configuration that would result in less contact compression. Immediate corrective actions involved mechanical adjustments made to the actuating arm providing additional contact compression for the Unit 3 Train A EDG. Additionally, the licensee implemented corrective actions to inspect and make adjustments as needed to all the EDG relays. As discussed in section 3.0 of this report, the Unit 3 Train A EDG failure on September 22, 2006, resulted from and inadequate cause assessment and the failure to establish appropriate corrective maintenance instructions which

resulted in a violation of Technical specification 3.8.1.B since the inoperable EDG exceeded the completion time of 72 hours. The team determined that the licensee failed to identify that 10 CFR 50.73(a)(2)(B) requires the licensee to report any operation or condition which was prohibited by the plant's Technical Specifications. Based on the licensee having performed a voluntary LER addressing both Unit 3 Train A EDG failures that occurred on July 25, 2006, and September 22, 2006, the failure to make a required report in accordance with 10 CFR 50.73 constitutes a violation of minor significance that is not subject to enforcement action in accordance with Section IV of the NRC's Enforcement. This LER is closed.

4OA6 Meetings, Including Exit

On November 30, 2006, the inspection results were discussed with Mr. David Mauldin, Vice President, Engineering, and other members of the plant staff. The inspectors asked the licensee whether any of the material examined during the inspection should be considered proprietary. No proprietary information was identified.

ATTACHMENT 1: SUPPLEMENTAL INFORMATION
ATTACHMENT 2: SPECIAL INSPECTION CHARTER
ATTACHMENT 3: SIGNIFICANCE DETERMINATION EVALUATION

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel

S. Bauer, Department Leader, Regulatory Affairs
P. Borchert, Director, Operations
L. Bullington, Probabilistic Risk Analysis
C. Churchman, Director, Engineering
C. Cooper, Acting Electrical Maintenance Engineering Section Leader
E. Dutton, Nuclear Assurance Department
C. Eubanks, Vice President, Nuclear Operations
M. Green, LAN Department
J. Holmes, Section Leader
R. Henry, Site Representative
D. Leech, Department Leader, Corrective Action Program
J. Levine, Executive Vice President, Generation
C. Marschall, Consultant
D. Mauldin, Vice President, Engineering
L. Nguyen, LA Power and Water
S. Peace, Owner Services Consultant
M. Perito, Plant Manager
J. Proctor, Section Leader, Regulatory Affairs - Compliance
C. Seaman, General Manager, Regulatory Affairs and Performance Improvement
D. Steen, Senior Engineer
T. Radtke, General Manager
B. Ramey, Maintenance Engineering Department Leader
R, Schwartsbeck, Enercon Services
E. Shouse, Site Representative
G. Sowers, Section Leader, Probabilistic Risk Analysis
D. Straka, Senior Consultant, Regulatory Affairs
D. Vogt, Section Leader, Operations/Shift Technical Advisor
D. Withers, Maintenance Engineering

NRC Personnel

T. Vegel, Deputy Director, Division of Reactor Projects
G. Warnick, Senior Resident Inspector, Palo Verde Nuclear Generating Station

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

05000530/2006012-01	AV	Failure to Establish Appropriate Instructions
05000530/2006012-02	AV	Failure to Identify and Correct aCondition Adverse to Quality
05000528;05000529; 05000530/2006012-03	NCV	Failure to Implement the Operability Determination Process

Closed

05000528; 05000529; 05000530/2006012-03	NCV	Failure to Implement the Operability Determination Process
05000530/2006-006-00	LER	Voluntary LER for Failure of Emergency Diesel Generator to Attain Required Voltage Due to Relay Contactor

LIST OF DOCUMENTS REVIEWED

Drawings
13-M018-00159
C72-15000-100
D72 12200 750 Rev. E
D72-12200-710 Rev. E
D72-12200-100 Rev. B

Miscellaneous
1986 Document Specification 13-MM-0018
CES 0391-45C Seismic Test Program on Unit and Diesel Generator Control Panel
Emergency Diesel Generator Pre-operational Test

Surveillance Logs
IEEE 387 (1972 Version)
Design Change Package DCP 2SE-PE-007
Design Change Package DCP 10E-PE-007
M018-00425 Seismic Qualification Report on Triaxial Shake Table Tests of Two K-1 Relays
M018-00367 Report of Witness Tests of KSV-20-T Engine-Generator Set
Miscellaneous Documents Containing Pre-operational Test Data
Miscellaneous Control Room Log Entries for K-1 Relay Failures
Plant Change Request 86-13-PE-002
Purchasing Order 10470-13-MM-018 Documentation
Purchasing Order 33501265 Documentation

Purchasing Order 44930161 Documentation
Purchasing Order 60113782 Documentation
Portec Inc. Instruction Manual for the Static Voltage Regulator System
SFR 1PE-018
TN-E-3489

Startup Work Authorizations
SWA 15805, 1 SWA 15532, 1 SWA 15795, 1 SWA 17469, 1 SWA 16047, 2 SWA 15532, 2 SWA 15795, 2 SWA 16047, 3 SWA 15532, 3 SWA 15795, U1-SWA 15188, and U1-SWA 19219

Engineering Evaluation Requests
EER 85-PE-007
EER 85-PE-008
EER 84-PE-002

Procedures
93PE-1PE01

CRAIs
2829958, 2829959, 2829960, 2829961, 2829964, 2829965, 2829967, 2829971, 2829973, and 2829974

CRDRs
43930, 51630, 51743, 53295, 53788, 55546, 58135, 59433, 90278, 115952, 160332, 2361791, 2405054, 2410347, 2432009, 2532225, 2570582, 2579229, 2582956, 2641676, 2645588, 2650009, 2660221, 2752631, 2759704, 2784750, 2847506, 2872154, 2906158, 2913003, 2926830, and 2927262

Work Orders
00003495, 67521, 67550, 119715, 360726, 360944, 412917, 1040142, 1071966, 1329487, 2361781, 2410350, 2750447, 2794362, 2902642, 2913004, 2913286, 2913287, 2913295, 2913306, 2913753, 2919666, 2919670, 2919671, 2919672, 2919673, 2919747, and 2926829

SPECIAL INSPECTION CHARTER

September 29, 2006

MEMORANDUM TO: Michael Hay, Senior Project Engineer,
Project Branch D, Division of Reactor Projects (DRP)

Dr. Scott Rutenkroger, Reactor Inspector,
Engineering Branch 1, Division of Reactor Safety

Michael Bloodgood, Reactor Engineer, Nuclear Safety Professional Development Program, Project Branch D, DRP

FROM: Arthur T. Howell III, Director, DRP **/RA/ AVegel for**

SUBJECT: SPECIAL INSPECTION CHARTER TO EVALUATE THE PALO VERDE NUCLEAR GENERATING STATION UNIT 3 EMERGENCY DIESEL GENERATOR FAILURE

A Special Inspection Team is being chartered in response to the Palo Verde Nuclear Generating Station Unit 3 Emergency Diesel Generator (EDG) failure. The diesel failed to develop an output voltage when started for a surveillance test. The licensee determined that a modification to the field flashing relay caused the failure. You are hereby designated as the Special Inspection Team members. Mr. Hay is designated as the team leader. The assigned SRA to support the team is Mike Runyan.

A. Basis

On July 25, 2006, Unit 3, Train A, EDG failed to develop output voltage during a surveillance test. The licensee's root cause determined plastic debris potentially prevented auxiliary contacts from properly functioning resulting in shorting out of the generator field during startup preventing a proper field flash. Two replacement relays obtained from the licensee warehouse exhibited the same unreliable condition. After performing corrective maintenance activities on one of the relays, the diesel was subsequently tested and declared operable on July 26, 2006.

On September 22, 2006, Unit 3, Train A, EDG failed to develop output voltage during a surveillance test. The licensee determined that the same auxiliary contact which failed in July 2006 was faulty. The licensee identified that this failure was attributed to a bent metal actuator arm that is used to actuate the auxiliary contacts associated with the field shorting circuit. Additionally, the licensee determined this bent metal actuator arm potentially exits in all six EDG's at the facility. Based on previous failures it appears this bent arm is the underlying root cause for the field shorting auxiliary contacts' failure to operate reliably, and this condition may affect all operating EDG's at the facility.

This Special Inspection Team is chartered to review the generic impact of the relay's bent arms on the other Palo Verde Emergency Diesel Generators as well as any potential impact on other nuclear plants. The team is also to review the design change method and reviews that the licensee used when making the relay modifications. The team will also review the licensee's operability determination and corrective action program for determining the root cause and correction of the diesel's failure.

B. Scope

The team is expected to address the following:

1. Develop a complete scope of the failures of all Palo Verde Emergency Diesel Generators to develop an output voltage.

2. Review the extent of condition determination for this condition (current and prior K1 relay failures) and whether the licensee's actions are comprehensive. This should include potential for other diesel failures.

3. Review the licensee's determination of the cause of any design deficiencies. Independently verify key assumptions and facts. If available, determine if the licensee's current and prior root cause analyses and corrective actions have addressed the extent of condition for problems with the emergency diesel generators K1 relays.

4. Determine if the Technical Specifications were met when the diesel failed.

5. Review and assess the corrective actions for current and past similar failures.

6. Review the licensee's EDG operability determination to evaluate the emergency diesel generator's operability.

7. Collect data as necessary to support a risk analysis.

8. Determine if this issue has generic implications to other nuclear facilities.

C. Guidance

Inspection Procedure 93812, "Special Inspection," provides additional guidance to be used by the Special Inspection Team. Your duties will be as described in Inspection Procedure 93812. The inspection should emphasize fact-finding in its review of the circumstances surrounding the event. It is not the responsibility of the team to examine the regulatory process. Safety concerns identified that are not directly related to the event should be reported to the Region IV office for appropriate action.

The Team will report to the site, conduct an entrance, and begin inspection no later than October 4, 2006. While on site, you will provide daily status briefings to Region IV management, who will coordinate with the Office of Nuclear Reactor Regulation, to ensure that all other parties are kept informed. A report documenting the results of the inspection should be issued within 30 days of the completion of the inspection.

This Charter may be modified should the team develop significant new information that warrants review. Should you have any questions concerning this Charter, contact me at (817) 860-8248.

SIGNIFICANCE DETERMINATION EVALUATION

Significance determination process Phase 1:

In accordance with NRC Inspection Manual Chapter 0609, Appendix A, "Significance Determination of Reactor Inspection Findings for At-Power Situations," the inspectors conducted a significance determination Phase 1 screening and determined that the finding resulted in loss of the safety function of the Train A emergency diesel generator for greater than the Technical Specification allowed outage time. Therefore, a Significance Determination Process Phase 2 evaluation was required.

Significance determination process Phase 2:

The Risk-Informed Inspection Notebook for Palo Verde Nuclear Generating Station, Unit 3, Revision 1, September 2, 2003, was utilized for the Phase 2 evaluation of the inoperable Train A emergency diesel generator. The following steps and the associated findings are listed below:

- Select or define the applicable initiating event scenarios:

  Table 2, "Initiators and System Dependency for Palo Verde Nuclear Generating Station, Units 1, 2, and 3," was reviewed to determine that the loss of offsite power (LOOP) initiating event scenario was the only scenario that needed to be analyzed due to the failure of the Train A EDG.

- Estimate the likelihood of scenario initiating events and conditions:

  The performance deficiency was assumed to exist for 58 days. The Phase 2 analysis assumed the EDG was nonfunctional for an 18-day period, representing the period from its last successful start on September 4, 2006, to its failed surveillance on September 22, 2006. Using Table 1, "Categories of Initiating Events for Palo Verde Nuclear Generating Station Unit 3," the initiating event likelihood for loss of offsite power was determined to be valued at 3. Additional risk was accrued during the first 40 days of exposure because of a higher likelihood of failure of the K-1 relay.

- Estimate the remaining mitigation capability:

  Using the SDP worksheet for a LOOP (Table 3.7, SDP Worksheet for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 - Loss of Offsite Power (LOOP)), Sequences 1, 2, 3, 4, and 5, the following results were assigned for each:

  Sequence 1: LOOP-AFW - 6
  Sequence 2: LOOP-EAC-REC3 - 8
  Sequence 3: LOOP-EAC-TDAFW-REC1 - 8
  Sequence 4: LOOP-EAC-SEAL-HPSI - 12
  Sequence 5: LOOP-EAC-SEAL-REC1 - 10

- Estimate the risk significance of the inspection finding:

  NRC Inspection Manual Chapter 0609, "Significance Determination Process," Appendix A, Attachment 1, "Counting Rule Worksheet," was utilized using one sequence that resulted in a value of 6. Since step 10 was greater than zero, the risk significance of the inspection finding was determined to be at low to moderate safety significance (White).

Phase 3 Analysis

Description of Performance Deficiencies

On July 25, 2006, the Unit 3 Train A EDG failed to start because of a failed K1 relay. The last two spare relays obtained from the warehouse were identified to operate unreliabley. The licensee performed corrective maintenance on one of the relays and following installation it failed on September 22, 2006. Two performance deficiencies were identified that contributed to the September 22, 2006, failure. The first performance deficiency involved the failure to establish appropriate instructions for performing corrective maintenance activities on an emergency diesel generator K-1 relay. The second performance deficiency involved the failure to identify and correct the cause of the erratic EDG K-1 relay operation prior to installation of the relay on July 26, 2006.

Assumptions

1. The Unit 3 Train A EDG demand record is shown in the following table. (A failed bench test of the new K1 relay was not credited because it may have been due to debris buildup resulting from a long period of warehousing.)

Date	Demand Result	K-1 Relay
7/25/06	Fail to Start	Old
7/26/06	Successful Start	New
8/07/06	Successful Start	New
8/24/06	Successful Start	New
9/04/06	Successful Start	New
9/22/06	Fail to Start	New

The data was analyzed using three alternate assumptions as follows:

Deterministic Assumption

It is assumed that the as-left condition of the EDG following a run either predisposes it to a guaranteed success or failure on the next demand. This assumes that the success or failure on the next attempt is a function of the as-left condition of the relay following a load run.

Based on this assumption, the Train A EDG was guaranteed to fail to start on any demand subsequent to the last successful run on September 4, 2006, but was likewise guaranteed to succeed on any demand prior to this date. Therefore, the EDG is assumed to be a failed state for 18 days.

Stochastic Assumption

It is assumed that the EDG success or failure is a probabilistic event on any given demand. This assumes that the relay is more or less in the same state following each run, but that the as-left tolerances are so close to critical that the chance of success or failure on the next demand is purely a probabilistic event.

Using this assumption, the Train A EDG was vulnerable to failure on any demand following the installation of the new K1 relay on July 26, 2006. The successful start on July 26, 2006, and prior bench/installed test successes and failures were excluded from the data set because of possible preconditioning effects. Therefore, three demands and one failure were left. The resulting assumption is that the Train A EDG would have a 0.25 chance of failing to start from a K1 relay failure in response to any demand during the 58-day period between July 26, 2006, and September 22, 2006.

Combination Assumption

It is assumed that a stochastic mechanism existed for the first 40 days, but after the final successful start on September 4, 2006, the EDG was guaranteed to fail on its next demand and, therefore, was in a failed state for the final 18 days of the exposure period.

Using this assumption, the Train A EDG had a 0.25 probability of failing to start because of a failed K1 relay for the first 40 days and a 1.0 probability of failure for the final 18 days of the exposure period.

2. The analyst discarded any risk that may have accrued from September 22, 2005, to July 25, 2006, (the balance of a one-year period) because of a lack of failure history during this period (as confirmed by a review of surveillance test results).

3. The analyst modified the current Palo Verde SPAR model (Revision 3.21, October 28, 2005) to reflect the plant-specific LOOP frequencies listed in NUREG/CR-6890, “Reevaluation of Station Blackout Risk at Nuclear Power Plants,” Volume 1, Table D-1. This study comprised an update based on an analysis of offsite power events during 1986-2004. This change to the Palo Verde SPAR model for this specific analysis was

endorsed by a representative of the Idaho National Laboratory (INL), the NRC's contractor for SPAR model development.

Category of LOOP	Current SPAR Value	Revised Value Based on NUREG/CR-6890
Plant Centered	2.07E-3/yr.	2.01E-3/yr.
Switchyard Centered	1.04E-2/yr.	9.01E-3/yr.
Grid Related	1.86E-2/yr.	4.40E-2/yr.
Weather Related	4.83E-3/yr.	3.83E-3/yr.

4. It is assumed that the Unit 3 Train B EDG was not vulnerable to fail from the same cause as the Train A EDG failure for the entire 58-day exposure period. This is based on the fact that the relay actuator arm in the K1 relay for this diesel generator was confirmed to be in a field-straightened configuration during this period. Therefore, common cause was not invoked in the analysis and a failure probability of 1.0 was used in lieu of TRUE. This is a key assumption with respect to the risk estimate because common cause, if presumed, would result in a large increase in the value of the fail-to-start common cause basic event.

5. No specific recovery of the Train A EDG was assumed, and no changes were made to the EDG recovery values in the SPAR model. That is, for this analysis, the analyst assumed that the recovery probability of the EDGs was nominal.

6. The SPAR model includes cross-connection capabilities from the other units' diesel generators. However, the cutsets that include these basic events are very insignificant in the analysis. Therefore, the analyst did not adjust Unit 1 and 2 EDG common cause probabilities from the base case.

Internal Events Analysis

The Palo Verde SPAR model (Revision 3.21, October 28, 2005), modified as described above, was used at a truncation of E-12.

Deterministic Assumption

Based on this assumption, the Train A EDG was guaranteed to fail to start on any demand subsequent to the last successful run on September 4, 2006, but was likewise guaranteed to succeed on any demand prior to this date. Therefore, the EDG was assumed to be in a failed state for 18 days. The use of a "T/2" assumption is not valid in this case because the normally open contact is assumed to be open following the previous EDG run. This would cause the K1 unlatch coil to fail to energize for any hypothetical demand during this period and result in failure of the EDG field flash.

In the SPAR model, the following changes were made:

EPS-DGN-FS-DGA was set to 1.0

The result in SAPHIRE is 1.047E-4/yr. A review of the cutsets revealed that several included independent failures of Train A EDG to run as well as the test and maintenance basic event. These cutsets were logically inconsistent:

Cutsets containing:	Value
EPS-DGN-FR-DGA	2.024E-6/yr.
EPS-DGN-TM-DGA	4.084E-7/yr.
Total	2.432E-6/yr.

Extracting these cutsets leaves a result of 1.047E-4 - 2.432E-6 = 1.023E-4/yr. Therefore, for an 18-day exposure period, the delta-CDF of the finding is 1.023E-4yr.(18/365) = 5.0E-6/yr.

Common cause events were retained in the evaluation case in order to retain the entire probability of failure of the Train B EDG.

Stochastic Assumption

Using this assumption, the Train A EDG was vulnerable to failure on any demand following the installation of the new K1 relay on July 26, 2006. As discussed above, the Train A EDG had a 0.25 probability of failing to start from a K1 relay failure in response to any demand during the 58-day period of time between July 26, 2006, and September 22, 2006.

In SPAR, the following changes were made:

EPS-DGN-FS-DGA was set to 0.25 + 5E-3 (base case probability) = 0.255

The result in SAPHIRE is 2.447E-5. For the 58-day exposure period, the resulting delta-CDF is 2.447E-5 (58/365) = 3.9E-6/yr.

Combination Assumption

Using this assumption, the Train A EDG had a 0.25 probability of failing to start because of a failed K1 relay for the first 40 days and a 1.0 probability of the same failure for the final 18 days of the exposure period.

The result from the deterministic assumption is the same in this case. The exposure time for the stochastic portion is set at 40 instead of 58 days. Using the results above, the delta-CDF of the combination assumption is 5.0E-6/yr. + 40/58 (3.9.E-6/yr.) = 7.7E-6/yr.

External Events

Seismic

Palo Verde is located in a relatively stable seismic region for a plant located in the Western USA. The Idaho National Laboratory conducted a study to predict the frequency of a LOOP resulting from a seismic event at all US plants, as documented in "Frequency of Seismically-Induced LOOP events for SPAR models," Revision 1, September 2005. The conclusion of this study was that the mean frequency for a seismically-induced LOOP at Palo Verde is 5.37E-5/yr. The study concluded that the failure of ceramic insulators would be the most likely failure mode inducing a LOOP.

For risk assessment purposes, a seismically-induced LOOP would have a recovery profile similar to a severe weather event-induced LOOP. In SPAR (as modified above for this analysis), the frequency of a weather-related LOOP (used for the internal events assessment) is 3.83E-3/year. Therefore, the increase in LOOP frequency from seismic events is not significant by itself as it relates to the risk of this finding.

The analyst also considered the possibility that an earthquake that results in a LOOP could damage equipment (apart from the diesel generators) that could add non-negligible risk to the finding. To address this issue, INL produced a document entitled, "Seismic Event Modeling and Seismic Risk Assessment Handbook," Revision 1, September 2005. In particular, a LOOP resulting from an earthquake that also involved loss of risk-significant equipment in Train B and/or loss of the gas turbine generators could result in significant risk despite the low frequency of seismically-induced LOOPs. Within this document, Table B-1, "Generic SSC Seismic Fragilities," provides a list of components along with the median g-force required to damage them. The following table lists examples of the equipment of concern and the frequency of earthquakes at Palo Verde that exceed the threshold value:

Component	High Confidence Low Probability of Failure Capacity (g)	Frequency of >g Earthquake at Palo Verde
Electrical Equipment (function during seismic event)	0.34	1.0E-5/yr
Electrical Equipment (function after seismic event)	0.77	1.0E-8/yr.
Battery Chargers/Inverters	0.54	1.0E-6/yr.
Batteries/Battery Racks	1.3	<9.3E-10/yr.
Diesel Generator/Support Systems	1.06	<9.3E-10/yr.
Turbine-driven pumps	0.85	1.0E-9/yr.

Equipment success at g-forces well above the HCLPF value is possible. Based on review of the information provided above and other information in the INL document, the analyst concluded that earthquakes causing LOOPs and loss of other on-site equipment would add risk small in comparison to the internal events result.

The analyst assumed (conservatively) that the gas turbine generators would be lost in a seismic event that also causes a LOOP. To calculate the risk of the finding in light of this assumption, the analyst ran two cases using the revised SPAR model. In both runs, the frequency of LOOPs was set at 5.37E-5/year (frequency of seismic-induced LOOPs), and nonrecoveries of offsite power for all relevant times (3 hours and less as well as 24 hours) were set to TRUE (there are no offsite recovery events within the E-12 truncation greater than 3 hours in the Palo Verde SPAR model except for 24 hours; therefore, this change set is equivalent to assuming that offsite power following an earthquake is not recovered). Both gas turbine generator fail-to-start events were set to TRUE and only LOOP sequences were quantified. In the first case, the EDGs are assumed to be nominally reliable and available. This result was 1.362E-7/yr. In the second case, EDG A is assigned a failure probability of 1.0 for the fail-to-start event. The result was 2.747E-6/yr. The resulting CDF of the finding attributable to a seismic event that debilitates the gas turbine generators is therefore (2.747E-6 - 1.362E-7)(18/365) = 1.3E-7/yr.

Based on disussions, the licensee's PRA assigns a value of approximately 4E-7/yr delta-CDF for seismic events for a 18-day exposure period.

Fire

The analyst reviewed the licensee's "IPEEE for Severe Accident Vulnerabilities," June 30, 1995, to determine the risk attributable to the finding resulting from internal fires.

A fire in Room 5B (Train B ESF switchgear room) was considered to have the largest potential risk to the finding. A fire in this room would possibly cause a loss of offsite power to both ESF buses. In this case, with a failure of EDG A to start, a station blackout situation would exist. In the IPEEE, the CDF result for a fire in the Train B ESF switchgear room was 9.73E-6/yr. The fire ignition frequency for this room was 5.5E-3/yr.

The analyst determined that the IPEEE did not contain sufficient information to quantify the risk attributable to fires pertaining to the performance deficiency. Therefore, the analyst requested that the licensee use its fire PRA model for this purpose. The licensee reported that their fire PRA calculates a delta-CDF of 3.716E-6/yr for EDG A being nonfunctional versus the base case condition. For this case, the EDG failure was assumed to be independent in nature, the same assumption used in the SPAR analysis. For an 18-day exposure, this would result in a delta-CDF of 1.8E-7/yr.

As a comparison, the following table shows the differences in the treatment of Room 5B between the IPEEE and the fire PRA.

Room 5B	IPEEE	Fire PRA
Fire Ignition Frequency	5.5E-3/yr.	4.16E-3/yr.
CDF	9.73E-6/yr.	1.17E-7/yr.

This example shows that the CCDP of a fire in this room decreased from 1.8E-3 in the IPEEE to 2.8E-5 in the fire PRA. This difference is not surprising because the IPEEE was basically a screening tool that assumed worst-case bounding conditions while the fire PRA incorporated realistic, best-estimate approximations.

Internal Flooding/High Velocity Winds/Other External Events

The analyst concluded qualitatively that no other external events would add appreciably to the risk of the finding. The licensee reported that the risk added from internal flooding according to their model was in the E-8 range.

Combined Risk

Using the licensee analysis results for seismic and fire events, the following table indicates the total estimated risk of the finding for each of the assumed failure mechanisms:

Assumption	Internal Events	Seismic	Fire	Total Risk
Deterministic	5.0E-6	4E-7/yr	1.3E-7/yr	5.5E-6/yr
Stochastic	3.9E-6	3E-7/yr[1]	1.0E-7/yr[1]	4.3E-6/yr
Combination	7.7E-6	6E-7/yr[1]	2.1E-7/yr[1]	8.5E-6/yr

1. Seismic and fire CDFs were adjusted for the stochastic and combination assumptions.

Large Early Release Frequency

In accordance with IMC 0609, Appendix H, station blackout sequences, which predominate the risk of the assessed condition, are not considered significant release events for a large, dry containment. Therefore, large early release was considered unimportant in this analysis.

Licensee Analysis

The analyst did not receive a detailed description of the licensee's analysis, but was informed verbally that the delta-CDF of the finding for internal events and fire, assuming an 18-day exposure and no recovery of the Train A EDG, was approximately 1.6E-6/yr.

Adding the licensee's approximate seismic risk, the overall result would be approximately 2.0E-6/yr.

References

Palo Verde SPAR model (Revision 3.21, October 28, 2005)

NUREG/CR-6890, "Reevaluation of Station Blackout Risk at Nuclear Power Plants," Volume 1, Table D-1

"Seismic Event Modeling and Seismic Risk Assessment Handbook," Revision 1, September 2005

"Palo Verde IPEEE for Severe Accident Vulnerabilities," June 30, 1995

Palo Verde Fire PRA Overview and Results, 13-NS-C072