Review of the Submittal in Response to U.S. NRC Generic Letter 88-20, Supplement 4: "Individual Plant Examination-External Events"

Fire Submittal Screening Review Technical Evaluation Report: Palo Verde Revision 5: September 9, 1998

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1.0 INTRODUCTION

This Technical Evaluation Report (TER) presents the results of the Step 0 review of the fire assessment reported in the Palo Verde Nuclear Generating Station "Individual Plant Examination of External Events (IPEEE)" [1], requests for additional information (RAI) based on questions raised during the initial review [2], and the licensee responses to those questions [3].

1.1 Plant Description

The Palo Verde Nuclear Generating Station consists of three virtually identical units of Combustion Engineering System 80™ Pressurized Water Reactor Nuclear Steam Supply System Pressurized Water Reactor, each rated at 3817 MW_t. The three units began commercial operation between January 1986, and January 1988. Each unit consists of a Reactor Containment, Turbine, Auxiliary, Fuel, Radwaste, Control/Corridor, Diesel Generator, Main Steam and Support Structure, and Operations Support buildings. The Main Control Room is located in the 140-foot elevation of the Control Building. Palo Verde is a two-train plant with regard to safety-related equipment. Redundant trains of 100% capacity are provided to mitigate Design Basis Accidents and Anticipated Operational Occurrences with redundancy of all functions. A third-of-a-kind pump, not meeting Appendix-R separation standards, is also available and was of significance in both the internal events PRA and IPEEE. No other unique features of the plant design were noted in the submittal.

1.2 Review Objectives

The performance of an IPEEE was requested of all commercial U.S. nuclear power plants by the U.S. Nuclear Regulatory Commission (USNRC) in Supplement 4 of Generic Letter 88-20. [4] Additional guidance on the intent and scope of the IPEEE process was provided in NUREG-1407. [5] The objective of this Step 0 screening review is to help the USNRC determine if the Palo Verde submittal has met the intent of the generic letter and to also determine the extent to which the fire assessment addresses certain other specific issues and ongoing programs.

1.3 Scope and Limitations

The Step 0 review was limited to the material presented in the Palo Verde IPEEE submittal and responses to requests for additional information (RAI). RAIs were submitted to the licensee based on an initial review of the submittal alone. The scope of the review was limited to verifying that the critical elements of an acceptable fire analysis have been presented. An in-depth evaluation of the various inputs, assumptions, and calculations was not performed. The review was performed according to the guidance presented in Reference 6. The results of the review against the guidance in the reference document are presented in Section 2.0. Conclusions and a recommendation as to the adequacy of the Palo Verde IPEEE submittal with regard to the fire assessment and its use in supporting the resolution of other issues are presented in Section 3.0.

2.0 FIRE ASSESSMENT EVALUATION

The following subsections provide the results of the review of the Palo Verde fire assessment. The review compares the fire assessment against the requirements for performing the IPEEE and its use in addressing other issues. Both areas of weakness and strengths of the fire assessment are highlighted.

2.1 Compliance with USNRC IPEEE Guidelines

The USNRC guidelines for performance of the IPEEE fire analysis derive from two major documents. The first is NUREG-1407, [5] and the second is Supplement 4 to USNRC Generic Letter 88-20. [4] In the current screening assessments, the adequacy of the utility treatment in comparison to these guidelines has been made as outlined in "Guidance for the Performance of Screening Review of Submittals in Response to U. S. NRC Generic Letter 88-20, Supplement 4: Individual Plant Examinations - External Events," Draft Revision 3, March 21, 1997. [6] The following sections discuss the utility document in the context of the specific review objectives set forth in this Screening Review Guidance Document and assess the extent to which the utility submittal has achieved the stated objectives.

2.1.1 Documentation

Palo Verde was the PWR pilot demonstration plant for the FIVE Methodology. The first FIVE analysis was completed in 1991. The analysis was updated in 1993 to include the results of the internal events PRA, Appendix-R reconstitution effort, requested NRC enhancements to the FIVE Methodology, the improved EPRI fire event data that was available, and plant modifications resulting from these efforts. Modifications of significance in the IPEEE fire study impact control room fire scenarios and include 1) installation of a remote disconnect capability for cooling of the Train B DC Equipment Room; 2) separation of control of fire dampers for Trains A and B switchgear rooms; and 3) separation of common fuse protection for safe shutdown and non-safe shutdown control circuits to eliminate the loss of control of both trains in the event of a fire. The results of the 1993 analysis are documented in the IPEEE submittal and take credit for the modifications noted. At the time of the submittal (1995), procedural guidance was in place for failures affecting these systems, since the modifications were not scheduled to be completed until 1997.

The submittal includes the qualitative steps of a FIVE Phase I assessment, including fire area/compartment identification, safe shutdown equipment location, qualitative screening, and a Fire Compartment Interaction Analysis (FCIA). For the quantitative steps of a FIVE analysis (Phase II), Palo Verde has substituted results from its internal events PRA and other assumptions in order to produce an estimate of the CDF upper bound from fires. Drawing from FIVE, a numerical screening criterion of CDF < 1.E-6/yr is used. The final step of the FIVE analysis, a confirmatory walkdown, was not discussed. The study assumed generic FIVE data in most cases.

The IPEEE fire submittal cites supporting second tier documentation as the source for much of the result. These supporting documents and the analyses documented in them have not been examined in this review of the IPEEE submittal. For example, in the quantitative fire compartment screening steps, both FIVE worksheets and COMPBRN III were used. Core damage sequence results were calculated. Only the results of these calculations are presented, however. Input data, geometry, and other assumptions used in these calculations could not be examined. In general, numerical results cannot be validated, based on the information provided in the submittal.

Other assumptions beyond those explicit in the FIVE methodology and included in the submittal are

- A third-of-a-kind start-up auxiliary feedwater pump and its associated cabling, not meeting Appendix R separation requirements, were located during walkdown and were credited.

- Several types of equipment were eliminated in determining potential ignition sources since there are no recorded fire events involving them in the fire events database. These included small batteries, small pumps, and junction boxes containing qualified cables.

- Manual fire suppression was not credited in the analysis. The FRSS issue of collateral damage from manual fire suppression was not discussed.

- Thermo-Lag was assumed to be an adequate fire barrier in the original submittal. Responses to requests for additional information (RAI) indicate that Thermo-Lag was included in combustible loading estimates in some compartments.

2.1.2 Plant Walkdown

Several walkdowns were performed by a large team consisting of identified personnel from the plant and supporting contractors, all with fire and safety experience and responsibilities. Short resumés of the walkdown team and other experts consulted in the fire study were included in the submittal.

The IPEEE submittal provides a list of activities performed during the walkdowns. The walkdowns focused on areas identified in the Appendix R Reconstitution effort that designated several "analysis areas" for fire studies. It was not clear from the submittal whether walkdowns were conducted for all locations or just these analysis areas. The walkdowns 1) verified locations of equipment; 2) checked the condition of fire barriers and seals; 3) verified locations of circuits of non-Appendix R components of interest; 4) confirmed assumed unit-to-unit differences between the circuitry of Appendix R systems; and 5) checked for the existence of fixed and transient combustibles. The locations of non-Appendix-R equipment and cabling credited in the fire analysis were also verified during walkdown.

Fire zone maps were provided in a series of figures showing floor plans, locations of Safe Shutdown Equipment (SSE) and cable runs, fire barriers, and fire suppression system elements. The result of the walkdown was a subset of these plant areas to be treated according to the FIVE methodology (Submittal Table 4-1).

According to the submittal, regular fire walkdowns are responsible for the fact that transient combustible loadings were observed to be low in the IPEEE walkdowns. Of note, a final confirmatory walkdown, especially of the areas not subject to detailed analysis, was not discussed. With this exception, the scope of the walkdowns discussed and the expertise of the walkdown team appear to conform to the FIVE methodology and the intent of the IPEEE.

2.1.3 Fire Area Screening

Two levels of qualitative screening were performed as outlined in the FIVE methodology: 1) screening of Fire Areas (i.e., groups of fire compartments) and 2) individual screening of fire compartments in unscreened fire areas. The criteria for qualitatively screening fire areas are clearly identified in the Palo Verde IPEEE submittal and are stated as following the criteria in the FIVE methodology.

Generally a fire area can be screened if the area does not contain Appendix R SSE and if a fire does not result in a demand for a plant shutdown. Fire areas containing SSE components can still be screened (FIVE Phase 1, Step 5) if an additional condition is satisfied: Assuming the equipment is not needed for a normal shutdown, and assuming the loss of both the equipment in the area and any equipment in any normal alternate shutdown path, if this state would not result in a near-term shutdown demand, the area may be screened. (According to FIVE, a near-term shutdown is a shutdown required within eight hours of the fire.) An example would be an ECCS pump solely occupying a fire area. Technical Specifications may also establish a "shutdown demand" as the result of a fire.

Appendix R-compliant barriers were used to define Fire Areas. By definition, fire propagation between main fire areas is not addressed. Within a given Fire Area, fire compartments were defined with less stringent barrier requirements, the barriers being themselves subject to further analysis. Fire zones were defined as convenient, according to the presence of combustibles or target equipment. From a given zone, a fire can be modeled at the locations of the ignition source to assess propagation and damage.

Palo Verde started with twenty-two fire areas (Submittal Table 4-1). Thirteen were eliminated in the initial FIVE screening (Submittal Table 4-2), based on the absence of SSE or near-term shutdown demand resulting from a fire in the area. Of note, the two diesel generator rooms and two ECCS pump rooms were screened early in the analysis. In accordance with FIVE, this equipment is not needed for a normal shutdown and a fire in any of these rooms would not initiate a shutdown demand.

The next level of screening addresses fire propagation between adjacent compartments, the Fire Compartment Interaction Analysis (FCIA) discussed further below. The question addressed at this stage is whether the combination of barriers, suppression, and combustible loads is sufficient to dismiss scenarios involving fires that propagate from adjacent compartments. If so, the screening criteria may be applied to the individual compartments, and possibly result in screening them, that is, based on either the absence of SSE or trip initiators. Seventeen additional analysis areas were screened in this step (Submittal Table 4-3).

At this point in the screening, Palo Verde had 45 remaining fire zones (Submittal Table 4-5). Further screening was accomplished by more detailed analyses of the remaining fire compartments. This required the introduction of the conditional core damage probability (CCDP) following the postulated loss of systems. (Further screening according to FIVE would include combustible loadings, ignition frequencies, and the *unavailability* of alternate shutdown systems.) Submittal Table 4-5 presents bounding estimates of core damage frequencies (CDF) for these remaining zones. Fifteen of the set have bounding CDF estimates exceeding 1.E-6/yr. At this point in the analysis, several pump areas were noted as screened. Both the Train A and Train B cable spreading rooms and the Remote Shutdown Panels were also screened. Details of these results were not provided in the submittal.

For the remaining fifteen zones, limited fire and damage modeling were performed using COMPBRN.III and FIVE worksheets to refine damage estimates. A first pass in this screening assumed failure of postulated targets within a zone and the CCDP following that failure. This allowed fire frequency, including the effectiveness of the plant Transient Combustibles Control Program, to determine a bound on the CDF. This treatment was sufficient to remove a few more fire compartments from consideration. Typically important fire areas in the auxiliary, control, and turbine buildings were retained in the final nine-compartment set.

Automatic fire suppression systems were discussed only in general terms in the original submittal. The maps provided identified the types of suppression equipment present. Operational characteristics were not provided, however. FIVE generic data were presumed to have been used for reliability. Several references to 2nd-tier documentation were made throughout the submittal, which may provide more detail. The impacts of fire suppression systems were considered only in the FCIA and in the screening of a single fire compartment (42D).

The credit taken for fire barriers with open doorways was questioned in the review of the screening of three particular compartments, all charging pump rooms. This resulted in an RAI submitted to the licensee. The response resolved the issue by noting a misstatement in the original submittal, citing the FIVE FCIA Criterion #2 (" . . . based on barrier effectiveness . . . "), when the FCIA Criterion #6 (" . . . presence of suppression over combustibles.") should have been applied.

Screening methods applied in the course of the Palo Verde IPEEE fire study appears to have been performed according to the guidance of the FIVE methodology.

2.1.4 Fire Occurrence Frequency

In the Palo Verde fire assessment, quantitative screening was performed based on a 1E-6/yr core damage criteria. The FIVE approach addresses combustible loadings, ignition frequencies, and the unavailability of alternate shutdown systems, as did the Palo Verde submittal. A first-pass simplification was made by assuming that critical combustion loads were always present and that any equipment present failed. Thus, only overall compartment frequencies needed to be addressed in several cases. Of note, the plant Transient Combustible Control Program was credited in several scenarios with limiting the fire frequency from transient combustibles to 3.8E-3 per reactor year. Submittal Table 4-4 contains fire frequency data presumed to have been used (there is no reference to this table in the text). With two exceptions, it appears to contain generic FIVE frequency data.

The tabulated cable spreading room fire frequency for Palo Verde is approximately 5E-5/yr which is two orders of magnitude below the values in the standard references (FIVE/SNL). The frequency of fires in battery rooms is 2E-4/yr which is an order of magnitude below the values in the references. Details of how they were determined were not presented. These low fire frequencies may be reasonable for a modern plant.

2.1.5 Fire Propagation and Suppression Analysis

In the analysis of intercompartmental fires, the presence of specified barriers, fire suppression, and low combustible loads allows the compartment to be dropped from consideration, following FIVE Phase 1, Step 6. In the FCIA, FIVE allows screening of compartments with fire suppression installed over combustibles to limit fire spread to and from adjacent compartments. In this manner, postulated fires in seventeen analysis areas were also screened (Submittal Table 4-3). Fire damage thresholds were not used in this part of the screening.

Submittal Table 4-5 shows CDF bounding estimates of the 45 compartments remaining after the FCIA. Thirty of these were screened by the CDF < 1.E-6/year criterion. The remaining compartments received more detailed treatment to refine the CDF estimate. Both FIVE worksheets and COMPBRN III were used to model fire within the compartments remaining. Data and details of these models were not presented. Additional areas were screened using the resulting CCDPs in combination with fire frequencies. However, in only one fire zone discussed (42D) was fire suppression explicitly credited with reducing the CDF.

The treatment of automatic fire suppression, apart from Zone 42D, credited suppression only in limiting fire spread beyond the compartment containing the ignition source. The maps provided show fire suppression systems installed throughout the plant. However, there was no reference in the submittal to installation according to accepted codes. A regular surveillance program was noted. The impacts of assumed activation and suppression times on fire propagation analysis results are not considered explicitly. The control system was designed to minimize spurious actuation, but the frequency was not quantified. These may be described in other documentation,

but FIVE generic data appear to have been used in most of this analysis. Palo Verde does state that fire suppression systems' unavailabilities, as given by the generic FIVE data, are included in frequency estimates. Also, an array of detectors (smoke, heat, and ultraviolet) and suppression systems (water, CO_2, and Halon) have been employed to match the expected fires.

Manual fire fighting is not credited in the submittal. Fire suppressant damage to equipment was not discussed. The Palo Verde submittal does state that personnel are trained in fire fighting and annually certified in the operation of SCBA gear.

The treatment of electrical cabinets was described only in the Containment Class Electrical Penetration Rooms, 42B and 47A. In these rooms, fire ignition frequencies were reduced by crediting National Electrical Manufacturers Association (NEMA) enclosures with fire propagation-limiting characteristics. This assumption is similar to that assumed in other IPEEE fire submittals, and has been noted as being of generic concern by the NRC. In response to an RAI requesting that the basis for the assumption be identified, the licensee stated that the basis was an in-house assessment by the fire protection staff. Included in the assessment was the fact that the cabinets are not vented and all penetrations are sealed. The response went on to note that dropping the credit taken for these cabinets effects a factor-of-two increase to the compartment's contribution to the fire CDF.

In summary, the FCIA and propagation modeling were generally consistent with the accepted FIVE methodology. The discussion of other issues, such as fire suppression, contained little detail and may have included optimistic assumptions, at least regarding some electrical cabinets.

2.1.6 Fire-induced Initiating Events and Fire Scenarios

The events initiated by equipment loss due to fire include reactor trips, small LOCA's, and loss of offsite power due to fires involving that cabling. ATWS scenarios are dismissed as having small core damage frequencies. For all of the fire zones remaining after the FCIA, the Palo Verde IPEEE calculated a bounding estimate of the CDF. Two event trees (one for a LOSP situation and the other for the non-LOSP situation) were constructed under the premise that maintaining the plant in a hot standby or hot shutdown condition is sufficient for mitigation, i.e., going to a cold shutdown is not required and removes the need to consider operation of the shutdown cooling system. The event trees consider the potential for a pressurizer safety valve sticking open if the steam generator secondary cooling is lost (the plant does not have PORVs). Both Appendix R and non-Appendix R system equipment (the startup auxiliary feedwater pump including cables that were located as part of the analysis) were credited in the event and fault trees.

Operator actions that already existed in the PRA models were retained for the fire analysis but the values were modified to reflect the stress induced by the fire. Details about how the human error probabilities were modified are not provided but reference is made to the EPRI fire PRA methodology and second tier documentation. Human actions directed by the plant Pre-Fire

Strategies Manual and other operating procedures not previously modeled in the PRA were assumed to succeed. This included addressing a spurious Recirculation Actuation Signal, RAS (the transfer of the ECCS pump suction to the containment sumps) which could occur during some fire scenarios. A spurious RAS was modeled in the PRA as resulting in core damage and was reexamined in the fire study.

Operator actions are required in the spurious RAS scenario. Palo Verde states that no more than two of the four signal channels involved in a spurious RAS could be affected by a fire because of a six-foot horizontal separation of cables and the availability of automatic fire suppression. It was assumed, therefore, that either a spurious RAS would not occur or that the operator would successfully diagnose it and respond properly.

Two recovery actions were developed during the fire assessment and IPE, and credited in the fire analysis. A fire in certain compartments in Unit One was identified as resulting in the loss of three out of five connecting transmission lines and a loss of offsite power to all three Palo Verde units. A procedure was developed to disconnect control circuits in the Unit One control room and operate breakers remotely to restore offsite power. The other recovery action involves operating the steam-driven auxiliary feedwater pump locally and manually, a procedure developed and tested during the IPE.

The control room fire modeling assumed that the operators would evacuate the control room and use the Train B systems to perform a safe shutdown (the Train B system control circuits can be disconnected from the control room). The Train A systems are assumed unavailable. Operator training for this scenario was noted. The submittal indicates that the control room analysis did not quantify the potential for failure of the operator to execute a remote shutdown, however. This is a potential shortcoming of the study.

Discussion of the initiating events and scenarios at the February 1997 meeting of the IPEEE Fire Senior Review Board resulted in two RAIs for the licensee. The questions addressed 1) the spurious RAS scenario, the instrumentation available to diagnose it, and operator actions required; and 2) the procedures for recovery from fire-induced LOSP.

The response regarding the spurious RAS scenario provided additional detail to that provided in the original submittal on the subjects of

- cable types and routing,
- control room indications, including additional equipment not previously described,
- the absence of Thermo-Lag barriers in these compartments,
- other barriers and the presence of fire suppression,
- time intervals required for various steps in the postulated accident sequences,
- spurious signals expected from fires in particular compartments important to this scenario.

The licensee response adequately addresses the issues raised in the question on the spurious RAS scenario.

The response regarding the recovery from LOSP provided additional detail on the nature of the scenario, the locations of the components involved in the recovery, and the time required for the recovery actions. The response adequately clarified the ambiguities that led to the question.

The detail given to the development of fire scenarios and their impacts is in general accordance with the intent of the IPEEE process.

2.1.7 Quantification and Uncertainty Analysis

The results of the fire modeling and subsequent requantification of the PRA models show that fires in nine compartments are likely to result in core damage frequencies greater than 1E-6/yr. The nine areas include the control room, the switchgear rooms, the DC equipment rooms, the electrical penetration rooms, and an area in the turbine building. The resulting core damage frequencies for most of these areas are approximately 1E-5/yr. The sum over all nine areas was 8.7E-5 per year. The fire assessments for these areas generally assume that the fire results in the loss of at least one safe shutdown train. Furthermore, fires in compartments containing cabling for the main steam isolation valves were assumed to result in a demand for the pressurizer safety valves to lift, leading to the possibility of an induced LOCA. Thus, the resulting core damage frequencies are believed to be conservative. It is noted that the total core damage frequency for the screened areas does not approach the final core damage frequency calculated for the unscreened areas. Thus, the important fire compartments have probably been identified.

No uncertainty analysis was described in the submittal.

2.1.8 Sensitivity and Importance Ranking Studies

No sensitivity or importance studies were described. However, the submittal states that efforts were made to identify cost-effective modifications that would reduce the potential for core damage due to fires. None were identified.

2.2 Special Issues

As a part of the IPEEE fire submittal, the utilities were asked to address a number of fire-related issues identified in the Fire Risk Scoping Study (FRSS) and USNRC Generic Safety Issues (GSI). Specific review guidance on these issues is taken from Reference 6.

2.2.1 Decay Heat Removal (USI A-45)

As discussed in Generic Letter 88-20 [4] and NUREG 1407 [5], USI A-45 associated with the adequacy of decay heat removal at nuclear power plants is subsumed into the IPE submittals. A

submittal meeting the intent of Generic Letter 88-20, Supplement 4 is assumed to satisfy the requirements of USI A-45. Specifically, the fire assessment presented in the IPEEE submittal should address the adequacy of long-term decay heat removal in the event of fires.

According to the submittal, the issue was addressed through the loss of secondary cooling core-damage sequences. No vulnerabilities from fire were identified. The utility considers the matter closed for IPEEE Fire assessments. Since the assessment did not consider reaching a cold shutdown, it is not clear if the fire assessment covered the full scope of USI A-45.

2.2.2 Effects of Fire Protection System Actuation on Safety-related Equipment (FRSS, GSI-57)

This issue is associated with the concern that traditional fire PRA methods have generally considered only direct thermal damage effects. Other potential damage mechanisms have not been addressed, such as smoke and the potential that the activation of fire suppression systems, either as part of actual fire fighting or spuriously, might result in damage to plant systems and components. In general, this is an area where the database on equipment vulnerability is rather sparse. The analytical results obtained for resolution of the issue, subsumed by GSI-57, identified the dominant risk contributors as: (1) Seismic-induced fire plus seismic-induced suppressant diversion and (2) Seismic-induced actuation of the fire protection system (FPS). The NRC anticipated that the licensee would conduct seismic/fire walkdowns to assess (1) whether an actuated FPS would spray safety-related equipment, and (2) whether some protective measures to prevent the same could be instituted. The results could be documented in the IPEEE submittal.

The Palo Verde submittal responded to the FIVE guidance on the issue of Total Environment Equipment Survival and cited other fire-related studies.

<u>Adverse Effects of Combustion Products</u>: No damage or equipment loss mechanisms from smoke were identified. The submittal noted the paucity of data in this area. It was noted that following any plant fire, an engineering analysis would have to evaluate such concerns and that electrical panel inspections and cleaning would most likely be part of the recovery process. The submittal contained no description of control of smoke in areas occupied by personnel.

<u>Spurious Actuation of the Fire Protection System</u>: The submittal states that the effects of spray and flooding due to inadvertent fire suppression system actuation were included in the flooding assessment reported in the IPE. No damage or equipment loss mechanisms from fire suppressants were discussed in the submittal, either from automatic systems or manual fire fighting.

<u>Operator Effectiveness</u>: The submittal notes that operator actions have been reviewed in establishing strategies and abnormal operating procedures for fire scenarios. These are expressed in the Pre-Fire Strategies Manual and the procedure for remote shutdown following control room evacuation. As part of the Appendix R study, operator actions were reviewed to ensure their credibility in the environment expect. Also, operator SCBA training was noted.

2.2.3 Fire-induced Alternate Shutdown/Control Room Panel Interactions (FRSS, GSI 147)

The issue of control systems interactions is associated primarily with the potential that a fire in the plant, i.e., main control room (MCR), might lead to potential control systems vulnerabilities. Given a fire in the plant, the likely sources of control systems interactions are between the control room, remote shutdown panel, and shutdown systems. Specific areas that should be addressed in the IPEEE fire analysis include 1) Electrical independence of the remote shutdown control systems; 2) Loss of control equipment or power before transfer; 3) Spurious actuation of components leading to component damage, LOCA, or interfacing LOCA; and 4) Total loss of system function. It is anticipated that the licensee's submittal will describe its remote shutdown capability including the nature and location of the shutdown station(s) and the types of control actions that can be taken from the remote panel(s).

In the utility submittal, this issue was briefly addressed, noting the plant modifications underway. The modifications address installation of switches and circuit protection to ensure that the plant Abnormal Operating Procedure (AOP) is effective. According to that procedure, to be executed in the event of a control room fire and evacuation, the reactor will be tripped and control functions resumed from panels in the Train-B cable spreading room. From that location, the control room and Train-A circuitry will all be disabled. Two of the modifications impact the isolation of the safe shutdown panel. Interim contingency actions are prescribed. Palo Verde has taken credit for these modifications in the IPEEE submittal.

2.2.4 Smoke Control and Manual Fire Fighting Effectiveness (FRSS, GSI-148)

Smoke control and manual fire fighting effectiveness is associated with the concern that nuclear power plant ventilation systems are known to be poorly configured for smoke removal in the event of a fire, and hence, a significant potential exists for the buildup of smoke to hamper the efforts of the manual fire brigade to suppress fires promptly and effectively. Sensitivity studies have shown that prolonged fire fighting times can lead to a noticeable increase in fire risk. Smoke, identified as a major contributor to prolonged response times, can also cause misdirected suppression efforts and hamper the operator's ability to shut down the plant safely.

The Palo Verde Pre-Fire Strategies Manual is cited and describes operator actions to achieve a safe shutdown given a fire in any compartment. A specific AOP exists for fires in the control room. Operators are trained on these procedures and are also certified on the use of SCBA. The submittal indicates that operator actions credited in the fire assessment have been reviewed to ensure that the actions have not been taken in a hazardous environment. Access/egress and emergency lighting concerns were considered.

In the utility IPEEE fire analysis, manual fire fighting was not credited for any of the fire scenarios considered. The issues were addressed in second tier documentation and not in the submittal. No conclusion was presented in the submittal.

2.2.5 Seismic/Fire Interactions (FRSS, MSRP)

The issue of Seismic/Fire Interactions primarily involves three concerns. First is the potential that seismic events might result in fires internal to the plant. Such threats might be realized from inadequately secured liquid fuel or oil tanks, through breakage of fuel lines, or through the rocking of unanchored electrical panels (either safety or non-safety grade). The second concern is the potential that seismic events might render fixed fire suppression systems inoperable. This could include detection systems, fixed suppression systems, and fixed manual fire fighting support elements such as the plant fire water distribution system. The third concern is that a seismic event might spuriously actuate fixed fire detection and suppression systems. The spurious operation of detectors might both complicate operator response to the seismic event and/or cause the actuation of automatic fire suppression systems. Actuation of a suppression system may lead to flooding problems, habitability concerns (for CO_2 systems), the diversion of suppressants to non-fire areas rendering them unavailable in the event of a fire elsewhere, the potential over-dumping of gaseous suppressants resulting in an overpressure of a compartment, and spraying of important plant components. It had been anticipated that a typical fire IPEEE submittal would provide for some treatment of these issues through a focused seismic/fire interaction walkdown.

The plant submittal stated only that this issue was addressed in other studies and no new vulnerabilities were identified.

2.2.6 Adequacy of Fire Barriers (FRSS)

The common reliance on fire barriers to separate redundant components needed to achieve a safe shutdown has elevated the risk sensitivity of fire barrier performance. Degraded fire barrier penetration seals and unsealed penetrations in some barriers can contribute to this source of fire risk, since fires in one area might impact other adjacent or connected area through the spread of heat and smoke. In general, it is expected that a utility analysis would provide for some treatment of this by considering that (1) manual fire fighting activities might allow for the spread of heat and smoke through the opening of access doors, and (2) that the failure of active fire barrier elements such as normally open doors, water curtains, and ventilation dampers might compromise barrier integrity.

The plant submittal notes regular surveillance of fire doors, barriers, dampers, and seals. Fire barriers were presumed to function as rated. The current Thermo-Lag controversy is noted, but not discussed in the submittal. Palo Verde notes that the Thermo-Lag impact is limited to some cable trays and conduits. In the response to an RAI, the licensee states that Thermo-Lag was included in the combustible loading estimate for certain compartments.

Under the FIVE methodology, fire barrier concerns are normally addressed in the Fire Compartment Interaction Analysis (FCIA). The utility followed the methodology through this step. The analysis used the FIVE screening criteria (rated barriers, fire suppression, and low combustible loadings) and fire frequency data to eliminate many analysis areas from consideration. Those areas remaining

were modeled with FIVE worksheets or COMPBRN III. The Palo Verde IPEEE submittal has included only the results of the FCIA analysis.

2.2.7 Effects of Hydrogen Line Ruptures (MSRP)

The use of flammable gases in the plant, including hydrogen, introduces the potential that a rupture of the gas flow lines might lead to the introduction of a serious fire hazard into plant safety areas. It had been anticipated that a typical fire IPEEE analysis would include the consideration of such sources in the analysis.

The fire section of the Palo Verde submittal contained no information on this issue.

2.2.8 Common Cause Failures Related to Human Errors (MSRP)

Common cause failures resulting from human errors include operator acts of omission or commission that could be initiating events or could affect redundant safety-related trains needed to mitigate other initiating events. It had been anticipated that a typical fire IPEEE analysis would include the consideration of such failures in the submittal.

This issue was not explicitly discussed. Operator actions were noted above as having been reviewed and adjusted as needed for the fire environment and stress.

2.2.9 Non-safety Related Control System/Safety Related Protection System Dependencies (MSRP)

Multiple failures in non-safety-related control systems may have an adverse impact on safety-related protection systems as a result of potential unrecognized dependencies between control and protection systems. The licensee's IPE process should provide a framework for systematic evaluation of interdependence between safety-related and non-safety related systems and identify potential sources of vulnerabilities. It had been anticipated that the fire IPEEE analysis would include the consideration of such dependencies in the submittal.

This issue was not explicitly discussed. However, one plant improvement credited in the fire study was the planned separation of common fuse protection for safe shutdown and non-safe shutdown control circuits to eliminate the loss of control of both trains in the event of a fire

2.2.10 Effects of Flooding and/or Moisture Intrusion on Non-Safety- and Safety-Related Equipment (MSRP)

Flooding and water intrusion events can affect safety-related equipment either directly or indirectly through flooding or moisture intrusion of multiple trains of non-safety-related equipment. This type of event can result from external flooding events, tank and pipe ruptures, actuations of the fire suppression system, or backflow through part of the plant drainage system. It had been anticipated

that the fire IPEEE analysis would include the consideration of such events in the submittal.

This issue was not explicitly discussed. Noted above was the flooding assessment reported in the IPE.

2.2.11 Shutdown Systems and Electrical Instrumentation and Control Features (SEP)

The issue of shutdown systems addresses the capacity of plants to ensure reliable shutdown using safety-grade equipment. The issue of electrical instrumentation and control addresses the functional capabilities of electrical instrumentation and control features of systems required for a safe shutdown, including support systems. These systems should be designed, fabricated, installed, and tested to quality standards and remain functional following external events. It had been anticipated that the fire IPEEE analysis would include the consideration of this issue in the submittal.

Palo Verde is not an SEP plant. The submittal did not explicitly address this issue. Section 2.2.3 of this review addresses some measures to be implemented at Palo Verde to minimize interactions between control systems.

2.3 Containment Performance Issues Unique to Fire Scenarios

Fires in unscreened fire areas resulted in sequences leading to Plant Damage State event trees identified in the internal events PRA. No new containment failure modes were identified in the submittal.

2.4 Plant Vulnerabilities and Improvements

The submittal noted that no new failure modes were identified in the study. No known failure modes with frequencies greatly exceeding those identified in the internal events IPE were identified. Therefore, the licensee concludes that no vulnerabilities to fire-initiated events exist at Palo Verde. No administrative control or design changes resulted from the study.

According to the submittal, three modifications were underway that impact the plant response to postulated fires. These resulted from Appendix R-related studies at Palo Verde. The modifications were to be completed in 1997, but their current status is unknown. Credit was taken for these improvements in the fire submittal. The three improvements were,

- A remote disconnect switch was to be installed between the control room and the Essential Air Cooling Unit for the Train B DC Equipment Room.
- Control circuitry for dampers controlling the flow of cooling air to the Train A and Train B Essential Switchgear Rooms was to be redesigned for train separation.
- Certain safe shutdown and non-safe shutdown circuits have common fuse protection with the non-safe shutdown circuitry of both Trains A and B routed through a common area. A design change was to be implemented to ensure train independence.

Also noted was a procedure implemented and tested in the IPE to restore offsite power following a fire in certain cable areas of Unit 1.

Palo Verde finds three postulated plant improvements not to be cost-effective:

- The plant has implemented an effective Transient Combustibles Control Program, credited in this analysis with the resulting low vulnerability to fires. Further improvement would not produce significant improvements in the FIVE results.
- In-place automatic fire suppression has a principal function of limiting the growth of fires. The "compartmentalized design" of the plant further contributes to the low vulnerability of the plant to fire by limiting fire growth beyond rated barriers. Improvements in fire suppression would not significantly improve the results of the FIVE analysis.
- Relocation of equipment is ineffective since ignition sources and targets are typically the same.

3.0 Conclusions and Recommendations

Palo Verde was the PWR pilot demonstration plant for the FIVE Methodology. The original 1991 analysis led to several improvements and was updated in 1993 to include the results of the internal events PRA, Appendix-R reconstitution, requested NRC enhancements to the FIVE Methodology, and the improved EPRI data available. The submittal responds to Generic Letter 88-20, including responses relevant to FRSS issues, and portions of the Unresolved Safety Issues, Generic Issues, and Multiple Systems Response Program issues.

Strengths of the submittal include 1) a strong fire and safety walkdown team; 2) other documented fire safety work cited in references (but not examined in this review); 3) the development of specific accident sequences from fire initiating events; 4) the extension of the analysis to a final estimate of CDF's for significant fire events; and 5) the inclusion of operator actions required in some scenarios.

Several topics were introduced, but incompletely discussed in the submittal and could not be assessed in this review. These may be discussed in supporting documents. Among these are the following:

- Input and details of the FCIA could not be examined. The COMPBRN III work was performed by a subcontractor (SAIC) and details were not presented.

- Automatic fire detection and suppression systems were important to results, but little description was given of how they were used in modeling. (FIVE gives fire-suppression systems credit for limiting propagation, within a simple caveat on the reliability of the system.) Operational details, such as detection and activation time, were not included and may be important in accident sequences. The effects of inadvertent or spurious activation of fire-suppression systems were not discussed.

- The effects of fire suppressants on safety-related equipment, either from automatic or manual fire fighting, were not discussed.

- The in-progress effort to isolate the remote shutdown panels from the control room and Train-A addresses an issue of interest, but the effectiveness of the implementation remains to be demonstrated. The control room fire scenario credited these changes but did not address the time required for evacuation and reassembly, and the details of resumption of control.

- The fire review noted no discussion of hydrogen and flammable gases stored as potential sources of ignition and combustibles following a seismic event.

Several issues were raised in the review of the original submittal, resolution of which was needed before making a recommendation regarding acceptance of the submittal as meeting the IPEEE intent. These issues were the subject of requests for additional information (RAI) which were submitted to the licensee.

- The spurious recirculation actuation signal (RAS) scenario discussed in the submittal identified a scenario with a high probability of core damage, but insufficiently described the details of the scenario, and the basis for assuming operator recovery.

- The discussion of loss of offsite power scenarios identified two recovery actions involving transit of personnel and apparent coordination with an off-site agency, the Salt River Project. The recovery actions, particularly the one-hour recovery, appeared optimistic but was not described in detail.

- Fire zones 46A, 46B, and 46E were treated as having three-hour barriers, despite open doorways in each compartment.

- In the discussion of compartments 42B and 47A, CDF's were reduced by crediting a NEMA-4 enclosure with fire propagation-limiting properties. The enclosure cited is not rated for fire containment.

The responses to these questions were discussed in this review and were generally found to address the issues raised adequately.

In summary, the information presented in the IPEEE fire submittal and the responses to several follow-up questions, appear to address adequately the issues needed in the IPEEE fire assessment. The reviewers find that a sufficient level of documentation and appropriate bases for analysis have been established to recommend that the subject licensee submittal has substantially met the intent of the IPEEE process.

4.0 References:

1) Palo Verde Nuclear Generating Station "Individual Plant Examination of External Events," Rev.0, Arizona Public Service, 1 June 1995.

2) Letter from Mark Cunningham to William H. Bateman, "Request for Additional Information on Palo Verde IPEEE Submittal," 10 October 1997.

3) Letter from William E. Ilde to U. S. Nuclear Regulatory Commission, "Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 Docket Nos. STN 50-528/529/530 Response to Request for Additional Information Regarding Individual Plant Examination of External Events Submittal for the Palo Verde Nuclear Generating Station," 27 February 1998.

4) USNRC, "Individual Plant Examination of External Events for Severe Accident Vulnerabilities - 10 CFR §50.54(f)," Generic Letter 88-20, Supplement 4, April 1991.

5) USNRC, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities", NUREG-1407, May 1991.

6) S. Nowlen, M. Bohn, J. Chen, "Guidance for the Performance of Screening Reviews of Submittals in Response to U.S. NRC Generic Letter 88-20, Supplement 4: 'Individual Plant Examination - External Events,'" Rev. 3, 21 Mar 1997.

TECHNICAL EVALUATION REPORT ON THE REVIEW OF THE PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 INDIVIDUAL PLANT EXAMINATION FOR EXTERNAL EVENTS (IPEEE) SUBMITTAL ON HIGH WINDS, FLOODS, AND OTHER EXTERNAL EVENTS (HFO)

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PRAB/DRAA/RES/USNRC

April 1999

Appendix C

TECHNICAL EVALUATION REPORT ON THE REVIEW OF THE PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 INDIVIDUAL PLANT EXAMINATION FOR EXTERNAL EVENTS (IPEEE) SUBMITTAL ON HIGH WINDS, FLOODS, AND OTHER EXTERNAL EVENTS (HFO)

1. Background

The Palo Verde Nuclear Generating Station (PVNGS) is a Combustion Engineering (CE)-designed System 80 pressurized water reactor (PWR) plant located on the delta banks of the Gila River and the Hassayampa River in northern Arizona. Buckeye is the closest town, located about 15 miles east of the plant, and the nearest boundary of Phoenix is approximately 34 miles east of the plant. The U.S. Nuclear Regulatory Commission issued an operating license (OL) to Units 1, 2, and 3 of the PVNGS facility in 6/1/1985, 4/24/1986, and 11/25/1987 respectively. Units 1, 2, and 3 began commercial operation in 1/28/1986, 9/19/1986, and 1/8/1988 respectively. The facility was designed to applicable design criteria of the 1975 Standard Review Plan (SRP). The licensee's HFO IPEEE process made use of the requirements of staff-issued Generic Letter (GL) 88-20, Supplement 4, along with the procedural guidance of NUREG-1407, in developing its response to information on high winds, external floods, and other external events (HFO)-related severe accidents. The licensee's IPEEE used the progressive screening approach described in NUREG-1407 and focused on identifying design and operational vulnerabilities due to postulated HFO events. The licensee's evaluation of HFO events also considered current plant design (Final Safety Analysis Report (FSAR), Amendment 8) and the updated HFO-related historical databases that were developed since the OLs of the PVNGS facility.

2. High Winds and Tornados

The licensee evaluated the current plant design and operation against high winds and tornados in the vicinity of the PVNGS site and determined that the current design was in conformance with the current FSAR design criteria. The high winds and tornado evaluation included:

1. a review of historical high winds and tornado data for the period 1950 thru 1994,
2. an analysis of tornado data characterization by L. A. Twisdale (documented in Reference 5.5.3 of Section 5.5 of the IPEEE),
3. an assessment of tornado missiles (a range of missile spectrum) on safety-related structures, and
4. an evaluation of external plant walk-down findings of tornado-exposed structures and components.

The design basis tornado for the PVNGS facility is 300 miles per hour (MPH). The design basis high wind speed is 105 MPH. The IPEEE noted that the essential spray ponds (ESPs) which are located outside the power block house, were not designed to extreme tornado missile loads. There are a total of six ESPs (two ESPs per unit). All other safety-related components are located inside the power block house which was designed against tornado wind loads and tornado missile loads. The licensee performed a simplified tornado missile hazard frequency analysis of the ESP nozzles (a total of four nozzles per unit) for all three units, using the revised tornado missile hazard data and revised modeling assumptions. The failure of the ESP nozzles was assumed to result in failure of the ultimate heat sink (UHS). The UHS failure frequency estimates were found to be about 1.9E-7, 4.0E-7, and 2.9E-9 per year, for units 1, 2, and 3 respectively. The licensee did not characterize any tornado-related vulnerabilities to the UHS. The staff finds that the licensee's high winds and tornado evaluation is consistent with the guidance provided in Section 5.2 of NUREG-1407.

3. External Floods

The licensee evaluated the current plant design and operation against floods of Winters Wash and East Wash, and the probable maximum precipitation (PMP) flood, and determined that the current design was in conformance with the current FSAR design criteria. The external flood evaluation included:

1. a review of offsite developments since the OL (e.g., identification and modification of two upstream dams),
2. a review of historical flood levels in the Gila river and the Hassayampa river (including recent river flood data for the period 1986 thru 1994),
3. a Hershfield statistical analysis using the new hydro meteorological report (HMR)-49 data on rainfall to evaluate the impact of high intensity rainfall, and
4. an evaluation of potential failures of upstream dams (a total of 8 dams), including seismically induced dam failures.

Design basis flood levels for the PVNGS facility are elevations 957.5 feet, 960.5 feet, and 963.5 feet for units 1, 2 and 3 respectively. The essential spray ponds, which are part of the ultimate heat sink for the PVNGS facility, are equipped with adequate protection against the floods of Winters Wash and East Wash. All other safety-related components are located in the power block house which is provided with a flood protection against site flooding due to Winters Wash, East wash, and the PMP. The licensee concluded that the results of the existing FSAR (Amendment 8) flood design calculations bound the results of the new flood design calculations which made use of the recent PMP data. The licensee did not find any flood-related design vulnerabilities. The staff finds that the licensee's external flood evaluation is consistent with the guidance provided in Section 5.2 of NUREG-1407.

4. Transportation Accidents and Nearby Facility Events

4.1 Chemical Release Events

Offsite chemical release- The licensee evaluated the main control room (MCR) design and operation against postulated chemical release events within five miles of the site boundary. The chemical release evaluation included a review of the data on safety problems associated with offsite chemical releases (primarily railroad-related chemical spills documented by the Department of Transportation and the safety management reports developed by the Southern Pacific Transportation Company (SPTC)). The original MCR

design basis for chemical release protection was based on criteria documented in regulatory guides (RGs) 1.78, 1.91 and 1.95. As part of the PVNGS IPEEE, the licensee identified applicable chemical sources (flammable compressed gases, chlorine, and other poisonous liquids) shipped in freight trains which are operated by the SPTC through its Phoenix - Yuma line in the vicinity of the site. The IPEEE did not find any new railroads built in the vicinity of the PVNGS site since the OL. The licensee evaluated the potential for chemical spill events in the vicinity of the site and concluded that the frequency of chemical shipments in freight trains decreased from the level that was estimated at the time of the OL. The licensee concluded that the current facility design meets the 1975 SRP criteria (Section 2.2.3.1.3 of the PVNGS FSAR). The staff finds that the licensee's offsite chemical release events evaluation is consistent with the guidance provided in Section 5.2 of NUREG-1407.

Onsite chemical release- The IPEEE did not find any new onsite storage devices (e.g., tanks and pressurized canisters) containing a significant amount of chemicals (e.g., chlorine, propane, and hydrogen) which would have significant impact on plant safety.

4.2 Air Transportation Accidents

The licensee evaluated the current building design features (e.g., power block house and ESPs) against postulated aircraft crashes (both civilian and military aircraft crashes) within 11 miles of the site boundary. The air transportation hazard evaluation included:

1. a detailed evaluation of historical data on airway-specific aircraft crash rates (documented by the telephone conversations by Nuclear Fuel Management with the officials of Buckeye Municipal Airport and Luke Air Force Base (LAFB) in August 1993),
2. a review of general aviation data (documented by the Federal Aviation Administration) on total number of flights, and
3. an update of the aircraft crash rates and air aviation data to reflect the additional seven years of data from 1986 thru 1993.

The original building design basis for postulated aircraft impact was based on safety evaluations conducted using RGs 1.27 and 1.91 for the PVNGS facility. As part of the IPEEE, the licensee identified applicable airways and associated commercial air traffic and general aviation, and estimated an aircraft impact frequency for applicable airways, using updated airways data and updated general aviation data. The total aircraft impact frequency estimate for all airways was found to be about 3.0E-8 per year. The total aircraft impact frequency was dominated by the air carriers of the J-4 airway. The licensee concluded that the total aircraft impact frequency estimate for the PVNGS facility was lower than the corresponding frequency that was estimated when the OLs were issued. The licensee did not identify any design vulnerability to ESPs due to postulated aircraft impact events. The staff finds that the licensee's aircraft crash events evaluation is consistent with the guidance provided in Section 5.2 of NUREG-1407.

4.3 Highway Transportation Accidents

The licensee identified changes in traffic patterns and offsite developments with respect to new roads and highways within five to ten miles of the site boundary that were built since the OL. The licensee also assessed potential highway and transportation events involving hazardous materials release. No new county roads, highways, or highway extensions (additional lanes and bridge extensions) were built within 5 miles of the site boundary since the OL. The licensee concluded that the existing Buckeye-Salome road, which is located 2 miles away from the plant structures, has experienced a slight increase in average daily traffic. However, this county road may not be used in shipment of significant amounts of hazardous chemicals. Interstate highway I-10, which is located 6.5 miles away from the plant structures, may be used in shipment of hazardous chemicals. Because of the long distance of this highway from the facility, the licensee concluded that postulated chemical spills and release of credible missiles due to abnormal highway events, will not have a significant impact on safety-related structures at the PVNGS facility. The licensee concluded that the current facility design meets the 1975 SRP criteria (Section 2.2.3.1.2 of the PVNGS FSAR). The staff finds that the licensee's highway events evaluation is consistent with the guidance provided in Section 5.2 of NUREG-1407.

4.4 Other Transportation Events

The licensee indicated that no river barges that carry a significant quantity of explosives were found within five miles of the site boundary. Two rivers, the Gila river and the Hassayampa river, are considered to be too shallow for transportation of medium to large barges.

5. Other External Events

5.1 Postulated Rupture of Pipelines Carrying Combustible Gas and/or Flammable Liquids

Neither new pipelines (buried or above ground) nor changes to existing pipelines within five miles of the site boundary were identified by the licensee. The licensee indicated that one 12-inch pipeline (referred to as the Santa Fe pipeline) carrying high pressure petroleum products is located at a distance of about 11 miles. The licensee noted one actual rupture of this pipeline since the OL. The licensee judged that the safety assessment of this event was found to have an insignificant impact on safety-related structures at the PVNGS facility. The staff finds that the licensee's pipeline rupture events evaluation is consistent with the guidance provided in Section 5.2 of NUREG-1407.

5.2 Sand Storms

The licensee evaluated the current plant design and operation against anticipated dust storms in the vicinity of the PVNGS site. As part of the IPEEE, the licensee conducted a special study to collect dust storm-related data for a longer time period and evaluated the dust impact on the PVNGS safety-related equipment. This evaluation included:

1. a collection and an evaluation of historical dust storm data for the period 1956 thru 1990,
2. an evaluation of the external plant walk-down findings of the dust-exposed structures, buildings inlets, and exhaust components, and
3. a dust-induced vulnerability evaluation (e.g., plant trip, and dust impact on filters and the essential ventilation system).

The plant areas for which the dust impact evaluation was conducted included the EHV switchgears of the offsite power system, diesel generator (DG) room components, DG inlets and exhaust system, the UHS, the engineered safety feature (ESF) switchgear room, the ESF Equipment room, battery rooms, and the main control rooms. The licensee concluded that the current design was in conformance with the current FSAR design criteria (Section 2.3.1.2.6 of the PVNGS FSAR). The licensee did not identify any dust-induced vulnerabilities for the above areas of the PVNGS facility. The staff finds that the licensee's dust storm evaluation is consistent with the guidance provided in Section 2.8 of NUREG-1407.

5.3. Lightning

As part of their evaluation of lightning strikes , the licensee evaluated the original design basis (general design criteria (GDC)-2, GDC-17, and GDC-18) for the electrical equipment located indoors and outdoors of the PVNGS buildings, using the 1975 SRP review guidance. This evaluation included:

1. a collection and an evaluation of site-specific data on actual lightning events,
2. a qualitative evaluation of lightning-induced impact on plant response and onsite equipment and instrumentation, and
3. a quantitative evaluation of lightning strike initiating events on the overall CDF at PVNGS.

The licensee collected PVNGS-specific lightning events data for the period between 1986 thru 1994 from the PVNGS site database and grid operating databases. Four lightning strike-related events were identified and evaluated for overall plant safety significance. Three of these four events involved a reactor trip, and one event involved only power reduction without a reactor trip. None of these events resulted in loss of offsite power events and failure of the mitigating systems and equipment located in the power block house. The licensee evaluated qualitatively all four lightning strike events for the overall core damage frequency. The licensee concluded that the impact of the lightning strikes was bounded by that of the loss of offsite power events and other reactor trip events which were evaluated in the licensee's Individual Plant Examination (IPE) submittals. The quantitative impact of the loss of offsite power event and the reactor trip event on overall plant safety was previously evaluated by the licensee as part of the PVNGS IPE submittal and accepted by the staff. Neither unusual plant conditions nor abnormal plant responses due to lightning-induced failures were identified. The licensee also judged and concluded that the PVNGS facility existing design meets 1975 SRP criteria for lightning strike-induced impact (Section 2.3.1.2.4 of the PVNGS FSAR). The staff finds that the licensee's evaluation of lightning strikes is consistent with the guidance provided in Section 2.8 and Appendix D of NUREG-1407.

6. Other Plant-Unique External Events

NUREG-1407, in Section 2.12, notes that all licensees should confirm that no plant-unique external events known to the licensee at the time of their IPEEE submittal with potential severe accident vulnerability are being excluded from their IPEEE. The licensee made an attempt to identify site-specific unique hazards, such as the lightning strikes and the sand storms, and evaluated them for the overall plant safety significance.

7. Resolution of Generic Safety Issues (GSIs)

7.1 GSI-103, "Design for Probable Maximum Precipitation (PMP)"

The licensee evaluated potential safety problems to be addressed as part of GL 89-22, dated October 19, 1989. These problems involve the adequacy of building roofs to withstand the loads imposed during postulated local high intensity rainfall in very short time intervals, and the adequacy of the plant site drainage system during local high intensity rainfall. The licensee's evaluation and assessment of the GL 89-22-requested response and actions are documented in the PVNGS calculations file system which is currently maintained at the PVNGS technical center. It is the staff's understanding that the updated PMP calculations made use of the rainfall data documented in site-specific HMR reports (e.g., updated HMR-49 by the NOAA/Department of Commerce). The IPEEE states that the new PMP calculations resulted in levels of roof ponding loads and site drainage flow discharge rates that were found to be bounded by the results of the original FSAR calculations (Section 2.4.3.1 of the FSAR). Thus, the licensee concluded that the new PMP data was not a concern for PVNGS. The staff finds that the licensee's GSI-103 evaluation is consistent with the guidance provided in Section 6.2.2.3 of NUREG-1407.

7.2 GSI-156, "Systematic Evaluation Program (SEP)"

The PVNGS facility does not belong to the SEP group of plants. Therefore, GSI-156 is not applicable to PVNGS.

7.3 GSI-172, "Multiple System Responses Program (MSRP)"

There is one MSRP issue related to the HFO area which is titled, "Effects of Flooding and/or Moisture Intrusion on Non-safety Related and Safety Related Equipment." The effects of flooding on safety related equipment and non-safety-related equipment were addressed in the licensee's IPEEE submittal (Section 5.2). The IPEEE also evaluated external flood-related design vulnerabilities for this issue. No design-related vulnerabilities due to this issue were found. The staff finds that the licensee's evaluation of this issue is consistent with the intent of the IPEEE program.

8. Unique Plant Features, Potential Vulnerabilities, and Improvements

The PVNGS facility is designed with ESPs that were built outside the power block house of the plant. All portions of the power block house, except the ESP structures and components, were designed against tornado wind loads and tornado missile loads. The tornado missile evaluation of the IPEEE included an update of the site-specific tornado data and the tornado missile impact assessments for the ESP structures and the ESP spray nozzles. The PVNGS IPEEE also evaluated the impact of site-specific data on sand storms and its impact on plant safety. Based on the verification that the original plant design is in conformance with the 1975 SRP, the HFO portion of the PVNGS IPEEE did not identify any plant vulnerabilities. HFO-related plant improvements also were not identified by the IPEEE.

9. Conclusions

Noteworthy strengths in the PVNGS IPEEE submittal include detailed probabilistic modeling of tornado wind loads and tornado missile loads and qualitative assessment of site-specific sand storm events by the licensee. Other features of the IPEEE include the overall clarity and completeness of the IPEEE submittal. No weaknesses in HFO examination methods or associated documentation were found.

The IPEEE provided plant-specific safety information which could be used as part of the resolution of GSI-103. The IPEEE submittal also documented information that addresses the one HFO-related GSI-172 (Multiple System Response Program) issue. Neither plant vulnerabilities nor plant improvements were identified for HFO events that were evaluated in the IPEEE.

It is concluded that the licensee's PVNGS IPEEE submittal for the HFO events meets the intent of GL 88-20, Supplement 4, including the procedural requirements of NUREG-1407.