USAR AND GDC-17 ITEMS ON OFFSITE POWER REQUINEMENTS AND DESIGN. NOTEABLE AREAS ARE FLAGGE

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8.2 OFFSITE POWER SYSTEM

8.2.1 DESCRIPTION

The offsite power system consists of six physically independent circuits from the Arizona-New Mexico-California-Southern Nevada power grid to the PVNGS switchyard. Offsite power from the switchyard through three startup transformers and six intermediate buses is provided to supply two physically independent preferred power circuits to the ac power distribution system of each unit. The offsite power system is described in this section and is depicted in figures 8.1-1 and 8.2-1.

8.2.1.1 <u>Transmission Network</u>

The transmission system associated with PVNGS supplies offsite ac power at 525 kV for startup, normal operation, and safe shutdown of Units 1, 2, and 3. The six 525 kV lines of this system, PVNGS to RUDD, PVNGS to Westwing I, PVNGS to Westwing II, PVNGS to Kyrene, PVNGS to North Gila, and PVNGS to Devers, cover distances of approximately 37, 44, 44, 74, 114, and 235 miles, respectively.

All six transmission lines associated with PVNGS traverse relatively flat terrain and their design meets grade B requirements specified by the National Electrical Safety Code, sixth edition.

The Code specifies loading areas, wind loads for towers and conductors, and safety factors to be used. The conductors and the overhead ground wires are dampened to maintain acceptable levels of vibration. None of the 525 kV lines associated with PVNGS cross one another. There is a crossing of the Westwing I and Westwing II lines by 525 kV line not associated with PVNGS, approximately 43 miles from PVNGS.

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Revision 12 LDCR 02-F023 The six transmission lines associated with the PVNGS switchyard, and their rights-of-way, are designed so as to minimize line proximities that could result in simultaneous failure of more than one circuit. Based on historical transmission system data, the frequency of occurrence for breakage of the span of line that crosses the two Westwing and Westwing lines is 1.1×10^{-5} per year. In the highly unlikely event of grid instability resulting from simultaneous short-circuiting of both Westwing lines, a loss of all nonemergency AC power event could result. This design basis event is evaluated in chapter 15.

8.2.1.2 <u>Switchyard and Connections to the Onsite Power</u> <u>System</u>

Prior to the construction of PVNGS there were no transmission lines to, or transmission switchyards in the vicinity of, the site.

Construction of PVNGS includes construction of a 525 kV switchyard of the breaker-and-a-half design in which three breakers are provided for every two terminations, either line or transformers. The switchyard is connected to the six 525 kV transmission lines associated with PVNGS, the 525/24 kV turbine-generator main transformers, and the 525/13.8 kV startup transformers, as shown in figure 8.2-2. These figures reflect the development of the switchyard as each unit is added.

Each turbine-generator connects to the switchyard through a main transformer, a 525 kV tie line, and two 525 kV switchyard breakers, as shown in figure 8.2-2. Physical connections between the units and the 525 kV switchyard are shown in figure 8.2-1.

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The three startup transformers connect to the switchyard through two 525 kV switchyard breakers each, and feed six 13.8 kV intermediate buses. These buses are arranged in three pairs, each pair feeding only one unit.

The intermediate buses for Units 1, 2, and 3 are interconnected to the startup transformers so that each unit's buses can access all three startup transformers when all startup transformers are connected to the switchyard.

The intermediate buses are connected to the onsite power system by one 13.8 kV transmission line per bus (two per unit). These lines are physically separated to minimize the possibility of simultaneous failure of the lines.

8.2.1.2.1 Switchyard and Offsite Power System Development Figure 8.2-2 depicts the switchyard and 13.8 kV bus arrangements.

Necessary 525 kV breaker installation is accomplished during refueling, if possible, or during operation. All operating 525 kV positions are transferred to the opposite bus: thus, continuity of offsite power is maintained.

8.2.1.2.2 Water Reclamation Facility Load Shedding

The Water Reclamation Facility loads are load shed from the Unit 1 intermediate buses upon a Unit 1 BOP ESFAS Mode 1 signal concurrent with switchyard voltage at or below a value which could result in a trip of offsite power in the event of a safe shutdown or emergency event.

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8.2.1.3 <u>Compliance with Design Criteria and Standards</u> The following analysis demonstrates compliance with General Design Criteria 17 and 18 of 10CFR50, Appendix A, and Regulatory Guide 1.32.

8.2.1.3.1 Criterion 17 -- Electric Power Systems

In addition to the features detailed in paragraphs 8.2.1.1 and 8.2.1.2, compliance with Criterion 17 is further demonstrated by the following:

- A. If one of the two 13.8 kV startup transmission lines per unit is interrupted, the remaining line can supply offsite power to both engineered safety features (ESF) buses, as shown in engineering drawing 01, 02, 03-E-MAA-002.
- B. The two 13.8 kV transmission lines, supported on independent structures, are separated so as to avoid the possibility that the structural collapse of one will cause an outage of the other 13.8 kV line.
- C. The 13.8 kV system is protected from lightning and switching surges by lightning protective equipment and by overhead static lines.
- D. Design of the 125 V-dc system for the switchyards consists of two independent dc systems. Each of the two systems consist of a separate 125 V-dc battery, battery charger, and distribution system. Cable separation is maintained between the two systems. A single failure caused by a malfunction of either of the two 125 V-dc systems does not affect the performance of the other system. The ability of the switchyards to supply offsite power to the plant is not affected by the loss of one of the two 125 V-dc systems.

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- E. Two isolated 13.8 kV supplies from the intermediate 13.8 kV buses are provided to the switchyards. The ac load is divided between two power panels and loss of one feeder from the plant does not jeopardize continued operation of the switchyard equipment.
- F. For reliability and operating flexibility, the switch-. yard design includes a breaker-and-a-half arrangement for each circuit along with breaker failure backup protection. Each breaker has two trip coils on separate, isolated dc control circuits. These provisions permit the following:
 - Any transmission line can be cleared under normal or fault conditions without affecting any other transmission line.
 - 2. Any circuit breaker can be isolated for maintenance without interrupting the power or protection to any circuit (subject to limitations of power system development paragraph 8.2.1.2.1).
 - 3. Short circuits on a section of bus can be isolated without interrupting service to any circuit other than that connected to the faulty bus section.
- G. The offsite sources from the 525 kV switchyards to the startup transformers are separate and independent. The failure or structural collapse of one system or structure does not affect other offsite sources.
- H. The offsite sources from the startup transformers to the 13.8 kV switchgear located at the units are independently and separately routed.
- I. Two physically independent circuits are provided for offsite power to the onsite distribution system for

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each unit. The offsite source normally connected to each ESF bus is immediately available to supply components important to safety following a postulated loss-of-coolant accident. Either of the two offsite sources to each ESF bus, if available, can be connected by control switch operation in the control room. (subject to the limitations of power system development paragraph 8.2.1.2.1).

8.2.1.3.2 Criterion 18 -- Inspection and Testing of Electric Power Systems

The 13.8 kV and 4.16 kV circuit breakers can be inspected, maintained, and tested on a routine basis. This can be accomplished without removing the generators, transformers, or transmission lines from service (subject to limitations of power system development paragraph 8.2.1.2.1).

Transmission line protective relays can be tested on a routine basis. This can be accomplished without removing the transmission lines from service. Generator, main transformer, and service transformer relays are tested on a routine basis when the generator is offline.

Onsite power components will be periodically inspected and maintained as required. This can be accomplished without removing the transmission lines, generators, or transformers from service.

8.2.1.3.3 Regulatory Guide 1.32

As described in paragraph 8.2.1.3.1, listing I, an independent immediate access circuit is provided to each Class 1E bus for each unit.

8.2.1.3.4 Industry Standards

The design complies with applicable standards and recommendations of:

- Institute of Electrical and Electronics Engineers, Inc.
 (IEEE) National Electrical Manufacturer's Association
 (NEMA)
- National Electrical Code (NEC)
- American Society of Civil Engineers (ASCE)
- Underwriters' Laboratory, Inc. (UL)
- American Iron and Steel Institute (AISI)

8.2.2 ANALYSIS

The transmission system associated with PVNGS is planned so that the loss of a single transmission element (i.e., line or transformer) does not result in loss of load, transmission overload, undervoltage condition, or loss of system stability to the Arizona-New Mexico-California-Southern Nevada extra high voltage (EHV) grid. Offsite power supply reliability is determined by the performance of the six 525 kV supply circuits associated with PVNGS. The source stations for these circuits (RUDD Westwing, Kyrene, Miguel, and Devers) all have three or more connected circuits of 230 kV and above, which provide the appropriate reliability.

Power flow studies conducted for the described system indicate that the system can reliably deliver power to all project participants using the above planning criteria. Dynamic stability studies have shown that the system can withstand the following disturbances without loss of system stability or loss of load:

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- A. A permanent 3-phase fault on the switchyard 525 kV bus with subsequent loss of the critical 525 kV line.
- B. A sudden loss of one of the three PVNGS units with no underfrequency load shedding measures in effect.
- C. The sudden loss of the largest single load on the Arizona-New Mexico-California-Southern Nevada system.

In withstanding these disturbances, which are used as design criteria, the system exhibits a very stable response, with significant positive damping achieved and with system frequency deviation held within acceptable limits. (Salt River Project letter to APS # SALT RIVER PROJECT 20020206, "Final Report for the 2002 Palo Verde / Hassayampa Operating Study", 2/6/2002). These results represent the response of the system associated with PVNGS with 7% generation stability margin.

Although these studies conclude that a PVNGS unit trip would not cause grid instability, certain chapter 15 accident analyses conservatively assume that offsite power is lost as a consequence of a PVNGS turbine trip. Refer to section 8.3.4 and table 15.0-0.

Grid availability data on EHV systems in the area indicate an outage rate of 2.08 total outages per year per 100 line miles. Of these, 1.08 are due to planned outages and 1.00 are due to forced outages. Due to all causes, the outage ratio for 500 kV lines in the area is 0.00180.

On 230 kV systems in the area, similar data indicate outage rates of 6.59 total outages per year per 100 line miles. Of these, 2.97 are due to planned outages and 3.61 are due to forced outages. Due to all causes, the outage ratio for 230 kV lines in the area is 0.0394.

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These outages are most commonly attributable to lightning. Other causes are fog, contamination, flooding, other aspects of weather, falling objects, equipment failure, emergency maintenance, employee error, and, hypothetically, dust contamination. The chief constituents of dust storms are nonconducting clay dust (usually quartz) and conducting gypsum (calcium sulphate) which can contaminate the insulators. This contamination increases the probability of flashover, especially with fog or dew, by disclosing the salts to form an electrolyte.

However, dust buildup is reduced by the self-clearing action of the "V" string insulator configuration used in EHV line construction and by the abrasive action of the dust and sand. Also, any adverse conditions resulting from insulator contamination within the switchyard can be corrected by washing the insulators.

APS has never experienced a flashover in any of its EHV switchyards due strictly to dust on insulators and has found that dust storms contribute little to the outage frequency of EHV transmission lines.

Likewise, APS has not experienced any known dust-caused insulation failures at the 15 kV or 4 kV voltage levels in "either open substation facilities or enclosed switchgear.

Therefore, it is felt that dust loading on the 13.8 kV system will not be a problem. The system is designed such that, with rare exceptions, forced outages do not result in loss of load. Other forms of contamination that increase the probability of flashover in certain areas, especially near the Pacific coast, are sea-salt deposits and industrial contaminations. The insulators can become contaminated by the salt deposits and

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when fogging conditions exist, flashovers are more likely to occur.

To minimize the effect of both salt and industrial contamination, the insulators are washed with demineralized water. The frequency of washing depends on the area. Some areas near the Pacific Coast require washing once a month while areas farther inland require washing every 90 days. The use of semi-conducting glazed insulators also reduces the flashover rates in areas of high contamination. No washing of insulators is anticipated in the desert regions.

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Anticipated operational occurrences. Ante ated operational occurrences mean the onditions of normal operation which are ected to occur one or more times during, fe of the nuclear power unit and include b re not limited to loss of power to all real ilation pumps, tripping of the turbine ge ator set, isolation of the main condense id loss of all offsite power.

CRITERIA

I. Overall Requirements

Criterion 1-Quality standards and recordi ructures, systems, and components import at to safety shall be designed, fabricated scted, and tested to quality standards coninsurate with the importance of the safety ictions to be performed. Where generally cognized codes and standards are used, ly shall be identified and evaluated to demine their applicability, adequacy, and flictency and shall be supplemented or dified as necessary to assure a quality duct in keeping with the required safety ction. A quality assurance program shall established and implemented in order to vide adequate assurance that these struces, systems, and components will satisfacly perform their safety functions. Approite records of the design, fabrication, ition, and testing of structures, systems, components important to safety shall be ntained by or under the control of the lear power unit licensee throughout the of the unit.

iterion 2-Design bases for protection nst natural phenomena. Structures, sys-3. and components important to safety I be designed to withstand the effects of ral phenomena such as earthquakes, tores, hurricanes, floods, tsunami, and ies without loss of capability to perform safety functions. The design bases for) structures, systems, and components reflect: (1) Appropriate consideration of nost severe of the natural phenomena have been historically reported for the and surrounding area, with sufficient in for the limited accuracy, quantity, period of time in which the historical have been accumulated, (2) appropriate inations of the effects of normal and act conditions with the effects of the natphenomena and (3) the importance of fety functions to be performed.

erion 3-Fire protection. Structures, sysand components important to safety be designed and located to minimize, tent with other safety requirements. obability and effect of fires and explo-Noncombustible and heat resistant lals shall be used wherever practical

ered in designing the system against a failure are under development.

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shout the unit, particularly in locasuch as the containment and control Fire detection and fighting systems of priate capacity and capability shall be ded and designed to minimize the adeffects of fires on structures, systems. bromponents important to safety. Firehing systems shall be designed to assure bitheir rupture or inadvertent operation degnot significantly impair the safety caphility of these structures, systems, and pomponents.

Oriterion 4-Environmental and dynamic efkets design bases. Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation. point associated with hormal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.

Criterion 5-Sharing of structures, systems, and components. Structures, systems, and components important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

II. Protection by Multiple Fission Product Barriers

Criterion 10-Reactor design. The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

Criterion 11-Reactor inherent protection. The reactor core and associated coolant systems shall be designed so that in the power operating range the net effect of the prompt inherent nuclear feedback characteristics tends to compensate for a rapid increase in reactivity.

Criterion 12-Suppression of reactor power oscillations. The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed.

Criterion 13-Instrumentation and control. Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

Criterion 14-Reactor coolant pressure boundary. The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

Criterion 15-Reactor coolant system design. The reactor coolant system and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.

Criterion 16-Containment design. Reactor containment and associated systems shall be provided to establish an essentially leaktight barrier against the uncontrolled re-lease of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

Criterion 17-Electric power systems. An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

The onsite electric power supplies, including the batteries, and the onsite electric distribution system, shall have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure.

Pt. 50, App. A

Pl. 50, App. A

Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. A switchvard common to both circuits is acceptable. Each of these circuits shall be designed to be available in sufficient time following a loss of all onsite alternating current power supplies and the other offsite electric power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. One of these circuits shall be designed to be available within a few seconds following a loss-ofcoolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained.

Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

Criterion 18-Inspection and testing of electric power systems. Electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of Important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components. The systems shall be designed with a capability to test periodically (1) the operability and func-tional performance of the components of the systems, such as onsite power sources, relays, switches, and buses, and (2) the operability of the systems as a whole and, under conditions as close to design as practical, the full operation sequence that brings the systems into operation, including operation of applicable portions of the protection system, and the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system.

Criterion 19-Control room. A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration of the accident. Equipment at appropriate locations outside the control room shall be provided (1) with a design capability for prompt hot shutdown of the reactor, in-

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cluding necessary instrumentation and controls to maintain the unit in a safe condition during hot shutdown, and (2) with a potential capability for subsequent cold shutdownics the reactor through the use of suitable pite cedures.

Applicants for and holders of construction permits and operating licenses under this part. who apply on or after January 10, 197 applicants for design certifications units part 52 of this chapter who apply on or after January 10, 1997, applicants for and holder of combined licenses under part 52 of this chapter who do not reference a standard de sign certification, or holders of operating H. censes using an alternative source telin under § 50.67, shall meet the requirements of this criterion, except that with regarded control room access and occupancy, lide quate radiation protection shall be provided to ensure that radiation exposures shall not exceed 0.05 Sv (5 rem) total effective dose equivalent (TEDE) as defined in \$50.2 for the duration of the accident.

111. Protection and Reactivity Control Systems;

Criterion 20-Protection system function?. The protection system shall be designed (1) to initiate automatically the operation of appropriate systems including the reactivity control systems, to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences and (2) to sense accident conditions and to initiate the operation of systems and components important to safety. Criterion 21-Protection system reliability and

testability. The protection system shall b signed for high functional reliability and In service testability commensurate with safety functions to be performed. Redancy and independence designed into protection system shall be sufficient f sure that (1) no single failure results in to of the protection function and (2) remov from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable rel ability of operation of the protection system can be otherwise demonstrated. The profile tion system shall be designed to permit bits odic testing of its functioning when the out testing of its functioning when the first tor is in operation, including a capability is test channels independently to detah failures and losses of redundancy that int have occurred.

Criterion 22—Protection system independent The protection system shall be designed assure that the effects of natural pronomena, and of normal operating, which is nance, testing, and postulated accident that ditions on redundant channels do not shall in loss of the protection function, or shall be demonstrated to be acceptable on some that defined basis. Design techniques, stitfunctional diversity or diversity in bompo functional diversity or diversity in bompo nent design and principles of operation for

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ie used to the extent prac iss of the protection functic *Criterion 23—Protection syst* The protection system shall full into a safe state or in onstrated to be acceptable of fined basis if conditions sur tion of the system, loss of et tric power, instrument air), to press environments (e.g., e cold, fire, pressure, steam, istion) are experienced.

Criterion 24-Separation of control systems. The protecti be separated from control sy tent that failure of any sin tem component or channel, moval from service of any s system component or channy mon to the control and pro leaves intact a system sat ability, redundancy, and in quirements of the protection connection of the protection tems shall be limited so as isafety is not significantly im Criterion 25-Protection sys for reactivity control malfuncti tion system shall be designe specified acceptable fuel de not exceeded for any single the reactivity control syster dental withdrawal (not ejec) iof control rods.

Criterion 26-Reactivity cont dancy and capability. Two in tivity control systems of . principles shall be provided. tems shall use control rods cluding a positive means for rods, and shall be capable of : ling reactivity changes to as conditions of normal opera inticipated operational oc with appropriate margin fo mch as stuck rods, specified design limits are not exceed mactivity control system sh: reliably controlling the rat shanges resulting from p power changes (including ze. assure acceptable fuel design preceded. One of the system ple of holding the reactor nder cold conditions.

Criterion 27—Combined react ims capability. The reactivi ens shall be designed to h capability, in conjunction w fon by the emergency core of reliably controlling reacti issue that under postulated. Hons and with appropriate n or the capability to cool the bined.

Criterion 28-Reactivity lin

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