DWIGHT

USAR AND GDC-17 ITEMS ON OFFSITE POWER REQUIREMENTS AND DESIGN. NOTEABLE AREAS ARE FLAGGED

TROY

B/6

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 Transmission Network

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.

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 Switchyard and Connections to the Onsite Power System

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.

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 inter-connected 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.

8.2.1.3 Compliance with Design Criteria and Standards

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.

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 switchyard 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:

1. 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 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:

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.

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 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.

Anticipated operational occurrences. Antic-
ated operational occurrences mean those
onditions of normal operation which are ex-
ected to occur one or more times during the
fe of the nuclear power unit and include bu
re not limited to loss of power to all recir
ulation pumps, tripping of the turbine gen
ator set, isolation of the main condenser
nd loss of all offsite power.

CRITERIA

I. Overall Requirements

Criterion 1—Quality standards and records.
ructures, systems, and components impor-
nt to safety shall be designed, fabricated,
ected, and tested to quality standards com-
ensurate with the importance of the safety
nctions to be performed. Where generally
cognized codes and standards are used,
ey shall be identified and evaluated to de-
rmine their applicability, adequacy, and
ficiency 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 struc-
es, systems, and components will satisfac-
ly perform their safety functions. Appro-
ate records of the design, fabrication,
tion, 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-
s, and components important to safety
l be designed to withstand the effects of
ral phenomena such as earthquakes, tor-
es, hurricanes, floods, tsunami, and
es without loss of capability to perform
safety functions. The design bases for
structures, systems, and components
reflect: (1) Appropriate consideration of
most 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 ac-
t conditions with the effects of the nat-
phenomena and (3) the importance of
fety functions to be performed.

erion 3—Fire protection. Structures, sys-
and 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
ials shall be used wherever practical

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

throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

Criterion 4—Environmental and dynamic effects 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, 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 leak-tight barrier against the uncontrolled release 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.

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 switchyard 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-of-coolant 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 functional 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, including necessary instrumentation and controls to maintain the unit in a safe condition during hot shutdown, and (2) with a potential capability for subsequent cold shutdown of the reactor through the use of suitable procedures.

Applicants for and holders of construction permits and operating licenses under this part who apply on or after January 10, 1997, applicants for design certifications under part 52 of this chapter who apply on or after January 10, 1997, applicants for and holders of combined licenses under part 52 of this chapter who do not reference a standard design certification, or holders of operating licenses using an alternative source term under § 50.67, shall meet the requirements of this criterion, except that with regard to control room access and occupancy, adequate 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.

III. Protection and Reactivity Control Systems

Criterion 20—Protection system functions. 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 be designed for high functional reliability and inservice testability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (1) no single failure results in loss of the protection function and (2) removal from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred.

Criterion 22—Protection system independence. The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function, or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, shall

be used to the extent prac
loss of the protection functic
Criterion 23—Protection syst
The protection system shal
fail into a safe state or in
onstrated to be acceptable o
fined basis if conditions su
tion of the system, loss of e
tric power, instrument air),
verse environments (e.g., e
cold, fire, pressure, steam,
iation) are experienced.
Criterion 24—Separation o
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 chann
mon to the control and prc
leaves intact a system sat
ability, redundancy, and i
quirements of the protectio
connection of the protection
tems shall be limited so as
safety 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
of 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 fo
rods, and shall be capable of
ling reactivity changes to as
conditions of normal oper
anticipated operational oc
with appropriate margin f
such as stuck rods, specified
design limits are not excee
reactivity control system sh
reliably controlling the rat
changes resulting from p
power changes (including xe
assure acceptable fuel desig
exceeded. One of the system
ble of holding the reactor
under cold conditions.
Criterion 27—Combined react
tems capability. The reactivi
tems shall be designed to h
capability, in conjunction w
tion by the emergency core
of reliably controlling reacti
assure that under postulated
tions and with appropriate m
rods the capability to cool t
tained.
Criterion 28—Reactivity lin
tivity control systems shall b