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Subject: Arkansas Nuclear One - Units 1 and 2
Docket Nos. 50-313 & 50-368
License Nos. DPR-51 & NPF-6
Offsite Power Source

Gentlemen:

On October 5, 1991, an Arkansas Nuclear One (ANO) engineering evaluation identified specific conditions which could jeopardize the capability of an offsite power source to meet the requirements of 10CFR50, Appendix A General Design Criteria 17 (GDC 17) for ANO 1 & 2. It was determined that during peak summertime load conditions the 161 kV offsite power source might not be able to maintain adequate voltage to ANO loads during accident conditions with both units off line and the 500 kV power source unavailable. The impact of increased 161 kV grid loading with time was not identified due to the failure to incorporate Millstone Degraded Grid Voltage requirements into the Entergy transmission system review criteria. ANO informed the NRC of this condition in a Licensee Event Report (LER) dated November 5, 1991 (1CAN119105).

This LER was supplemented on March 27, 1992 (1CAN039206). The supplement included a discussion of the root cause of the condition and long term plans for corrective actions related to operation during summer loading conditions. The purpose of this submittal is to provide a complete discussion of these areas along with a detailed discussion on compliance with GDCs 17 and 5 and the appropriate Technical Specifications.

If you have any additional questions or require further information concerning this issue, please contact my office.

Very truly yours,

James J. Fisicaro

James J. Fisicaro
Director, Licensing

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INTRODUCTION

On October 5, 1991, an Arkansas Nuclear One (ANO) engineering evaluation identified specific conditions which could jeopardize the capability of an offsite power source to meet the requirements of 10CFR50, Appendix A General Design Criteria 17 (GDC-17) for ANO 1 & 2. It was determined that during peak summertime load conditions the 161 kV offsite power source might not be able to maintain adequate voltage to ANO loads during accident conditions with both units off line and the 500 kV power source (autotransformer) unavailable. The impact of increased 161 kV grid loading with time was not identified due to the failure to incorporate Millstone Degraded Grid Voltage requirements into the Entergy transmission system review criteria. ANO informed the NRC of this condition in a Licensee Event Report dated November 5, 1991 (1CAN119105).

CONDITION DESCRIPTION

Description of the Electrical Distribution Network

Electric power is supplied [illegible] ANO switchyard by five separate transmission lines. The [illegible] provides a single line diagram of the ANO offsite power [illegible], one from the Mabelvale substation, one from the [illegible], and one from the Mayflower substation, feed [illegible] ring bus. The remaining two lines, one from the Russellville East substation and the other from the Morrilton East substation, feed the 161 kV ring bus. Two physically independent circuits with startup transformers sized to carry full plant essential loads are provided from the station switchyard to the onsite electrical distribution system. Startup Transformer 1 (S/U-1) and Startup Transformer 3 (S/U-3) are supplied from the 22 kV tertiary winding of the 500/161 kV autotransformer. Startup Transformer 2 (S/U-2), which is supplied by the 161 kV ring bus, serves as a second source of offsite power for both units.

During normal plant operation, onsite power is supplied by each unit's main generator via its respective auxiliary transformer. If a plant trip occurs, the unit's loads are "fast transferred" to its respective startup transformer (S/U-1 for ANO-1 and S/U-3 for ANO-2). If the autotransformer or 500 kV transmission lines were to become unavailable, offsite power could still be supplied by S/U-2 either automatically, if auto transfer is selected, or manually.

Computer Model Used

The computer software program that was used in the initial in-plant Millstone Study was the General Electric "LFLOA*" Program. This program was verified against Becthel Corporation's "Voltanal" program and the verification report was maintained in Becthel's Chief Engineer's Office.

The computer software program that is currently being used to perform ANO in-plant studies is the SKM "DAPPER" computer load flow package. At ANO, benchmark testing against an IEEE standard 40 bus load flow case and an IEEE four bus motor starting case indicated that ANO's DAPPER load flow software package gives the correct results.

The transmission load flow computer models that were used in both the initial 1978 Millstone analysis and the present analysis, were obtained from the Southwest Power Pool (SPP). The SPP is one of nine members of the North American Electric Reliability Council (NERC). This Council was established after the 1968 New York City blackout to institute reliability criteria and coordinate area-wide power system studies to assure that the United States has an adequate and reliable electrical bulk power system. Annually, the utilities from the eight SPP southwestern states prepare transmission and generation computer models which accurately represent the expected transmission system for this region of the United States. These models are prepared and validated annually. After validation, the SPP forwards these models to the member companies and the other reliability councils so that both long term planning studies and short term operational studies can be performed. Both the SPP and Entergy Corporation use the Power Technologies Power System Software (PSSE) Package to perform the transmission studies. This package is widely used in the utility industry for transmission system studies.

From time to time, Entergy Planning Engineers have verified (from actual transmission system measurements) that these computer models accurately reflect the conditions on the transmission system. Entergy recently took the autotransformer out of service for maintenance and obtained actual measured voltages in the 161 kV switchyard. These measured values will be compared to the voltages predicted by the computer model, to again confirm the accuracy of the computer's transmission model for the ANO area. This appears to meet the guidelines of Branch Technical Position PSB-1 for the initial Millstone Analysis, which states that analytical techniques and assumptions used in the voltage analyses must be verified by actual measurements. However, it should be noted that the root cause of the ANO 161 kV offsite power concern is in no way related to the accuracy of the ANO or transmission system load flow models.

Event Description

While investigating the implications of NRC Information Notice 89-83, ANO identified that the offsite grid loading on the Arkansas Power & Light (AP&L) 161 kV system had increased to the point that reanalysis of the ability of the system to carry ANO loads on S/U-2 was necessary. Early indications of the analysis were that, with the ANO 500 kV autotransformer out of service and minimal or no credit taken for support from local hydro generation, unacceptable low voltages could result at the primary connection to S/U-2.

As part of this investigation, ANO was informed by the Entergy System Operations Center that following loss of the 500 kV autotransformer with both units off-line during load conditions on the system at or below those expected to occur prior to the summer of 1992, the dispatcher could respond as necessary to maintain the 161 kV system voltage at acceptable levels until the autotransformer was returned to service or both ANO units were safely shutdown. Subsequent to this information, the System Operations Center informed ANO that expected summertime peak loads would render them unable to maintain the required 161 kV at the S/U-2 primary windings if the 500/161 kV autotransformer were to become unavailable while both ANO units were off-line and no generation support was available from the Dardanelle Dam.

The anticipated 1992 summer peak load for the four state Entergy System is projected to be 11955 MW. The projected annual load growth for the Entergy System for the next ten (10) years is approximately 1.5% per year. The 1992 summer peak load level represents an increase of approximately 20% over the 1978 peak load level. It is noteworthy that the ANO area peak load has increased at a much higher rate (more than 60%). The 1978 load level model was used in the initial Millstone Analysis to determine the adequacy of the offsite transmission system.

ROOT CAUSE EVALUATION

On June 3, 1977, the NRC issued a generic letter to all operating nuclear power plants concerning undervoltage protection for the emergency power systems (Millstone event). In correspondence with the NRC during the time frame of January 1978 to August 1979, ANO submitted the Millstone Degraded Voltage Analysis and planned modifications to prevent sustained undervoltage conditions.

The ANO Millstone Analysis indicated that for the 1978 transmission system conditions, all safety related loads would perform their required safety functions with the stated minimum grid offsite voltages and grid system capacity. The minimum voltages would be experienced during summer peak conditions whenever the 500/161 kV autotransformer at ANO is out of service and the largest generating unit on the system is in an outage.

ANO stated that the grid offsite voltage could degrade to 150 kV (93% of 161 kV) during summer peak conditions for the autotransformer outage condition if additionally all the local hydrogenerators were coincidentally out of service. This condition was deemed unlikely and not considered credible. ANO also stated that there was no credible condition that would cause the grid voltages to degrade to unacceptable levels that would actuate the Millstone undervoltage relays. In letter dated December 17, 1979, the NRC found the ANO Millstone Analysis and proposed modifications to be acceptable.

A recent review of the analysis and the associated correspondence indicated that no action was taken to quantify how many years into the future the required minimum offsite voltages levels could be maintained before additional improvements to the system would be necessary to maintain the minimum voltage. Additionally, following the initial Millstone Analysis, no formal procedure between ANO and the Entergy transmission system was established to perform a periodic review of the network.

As the transmission system loads increased over the years, AP&L performed annual studies and recommended necessary improvements to assure that adequate voltage levels as defined by the Entergy transmission criteria were maintained on the system. However, the Millstone offsite voltage requirements for ANO are considerably more restrictive than the Entergy or the regional transmission criteria. Therefore, the annual studies were not performed with the more stringent criteria, and consequently, the more restrictive Millstone minimum voltages were not maintained.

A recent investigation of the transmission system indicated that the offsite ANO transmission voltages could have degraded to unacceptable levels during approximately the 1980 summer peak. This investigation used present day transmission models and historical transmission loads.

The Entergy System peak load information for the years 1980 until 1991 is provided below.

Year	Historical Peaks (Megawatts)
1980	11769
1981	11394
1982	10382
1983	10870
1984	10456
1985	10870
1986	11697
1987	11270
1988	11442
1989	11483
1990	12189
1991	11852

These peak loads do not include approximately 1400 MW of imbedded loads that reside in the Entergy System Control Area boundaries but which represent electrical users that are not Entergy customers.

CORRECTIVE ACTIONS

Modifications

A joint study by ANO and Entergy System Transmission Planning was performed to develop a corrective action plan to allow continued operation for the peak 1992 summer load season. The results of this study indicate that several recommended actions should be performed before the 1992 summer peak load season.

The transmission system actions include the installation of a 161 kV transmission capacitor bank at the ANO switchyard. In addition, the transformer taps at the Mayflower autotransformer will be changed as necessary. Because of these tap changes potentially causing overvoltage problems, AP&L will ensure that a planned reactor bank at the Mayflower substation is installed concurrent with these other actions. These actions will be performed by May 1, 1992.

The ANO plant system actions include the change of voltage taps on the ANO-1 & 2 4160/480 volt load center transformers serving the Class 1E safety loads. The taps for the ANO-1 load center transformer were changed during the current refueling outage (1R10). The ANO-2 transformer taps were changed during the current forced outage.

ANO has implemented procedural and operational guidance changes to prevent unacceptable voltages when the auxiliary loads are transferred to S/U-2. These changes require the control switches for the feeder breakers from S/U-2 to both units to be maintained in the "Pull to Lock" position except under carefully analyzed conditions. This position disables the auto transfer of the auxiliary loads to S/U-2 and allows selective manual loading of the transformer. The auto transfer function is not a design requirement and is not required to be operable by either unit's Technical Specifications. Procedural guidance was also implemented to restrict the loading of S/U-2 when the autotransformer is unavailable to ensure its capability to supply safety loads.

At the Entergy Dispatching Center, operating procedures (use of hydro unit generation, transmission system changes, load shedding, etc.) have been established which provide the necessary steps for restoration of the 161 kV offsite voltage levels at ANO. These actions, along with the committed physical improvements will ensure the capability of providing adequate voltage levels at ANO, even under the most severe contingency evaluated.

<u>Verification of General Design Criteria and Technical Specification Compliance</u>

IEEE Standard 308 defines that the preferred power supply shall consist of two or more circuits from the transmission network or equivalent source of energy to the Class 1E distribution system input terminals. For ANO these sources are defined as follows:

Preferred Power Source	Source From
• ANO-1	
S/U-1	22 kV Tertiary Winding of 500/161 kV Autotransformer
S/U-2	161 kV Switchyard
• ANO-2	
S/U-3	22 kV Tertiary Winding of 500/161 kV Autotransformer
S/U-2	161 kV Switchyard

- General Design Criteria (GDC) 17

GDC 17 provides the requirements for the preferred power supplies. In part the GDC states, "Electric power from the transmission network to the onsite electric distribution system shall be supplied from two independent circuits designed and located so as to minimize the likelihood of their simultaneous failure."

The preferred power sources listed above meet these requirements since each unit's preferred power sources have one circuit connected to the autotransformer and the other circuit connected to the 161 kV switchyard. These are independent circuits and have been designed to prevent their simultaneous failure.

The independence required by GDC 17 among the onsite and offsite power sources is addressed in the last paragraph of the GDC. "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 generation by the nuclear unit, the loss of power from the transmission network, or the loss of power from the onsite electric supplies."

Whether the nuclear units' auxiliaries are operating on their unit auxiliary transformers or their 22 kv-fed startup transformer (S/U-1 and 3), the trip of one or both nuclear units would not cause the 500 kV or 161 kV transmission system or the autotransformer to fail. Neither will it affect the diesel generators. Thus, the offsite power supplies will remain intact to function as required.

The loss of power from the transmission network would indicate a complete system-wide blackout. This would cause the operating units to trip, due to no outlet for the power, and result in the loss of the preferred offsite power supplies in the ANO transmission switchyard. However, the onsite power supplies (emergency diesel generators) will be unaffected by the loss of offsite and generating unit power by virtue of the design of the loss of voltage and degraded voltage relaying and the separation of the safety busses from the offsite power supplies. This capability is assured by the analyzed response of the units to previously evaluated loss of offsite power events.

GDC 17 further states that "one of these two independent 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."

This requirement is met by S/U-1 for ANO-1 and S/U-3 for ANO-2. A fast transfer from the normal alternating current supply (unit auxiliary transformer) to these sources typically takes place within a few cycles following a plant trip. Additionally, a dead bus transfer capability is present that can be accomplished within approximately two seconds should the fast transfer fail. These sources for each unit are sufficiently sized to provide the required electrical capacity following a loss-of-coolant accident.

GDC 17 defines requirements for the second independent circuit. Each of these (both independent offsite sources) circuits "shall be designed to be available in sufficient time following a loss of all onsite alternating current power supplies and the other electrical power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded."

The GDC 17 second source of offsite power for both units is S/U-2, which is sized to carry the combined safety loads of both units following the loss of onsite alternating current power supplies. S/U-2 has been additionally sized to carry the safety related accident loads of one unit while supplying the safety related emergency auxiliary loads of the other unit following the loss of all onsite alternating current power supplies. This has been stated in Section 8.2 of the original ANO-2 Safety Evaluation Report (SER).

In order to assure that S/U-2 had sufficient capacity to comply with GDC 17, it was necessary to prevent automatic fast transfer of the auxiliary loads of both units to S/U-2. Since the offsite transmission system cannot support the fast transfer loads on S/U-2 (if the autotransformer is out-of-service), except under very limited conditions, it has become necessary to require each unit to manually access S/U-2. With appropriate procedures in place at ANO, the loading of S/U-2 can be maintained at a level which can be supported by the transmission system at all times of the year. Therefore, ANO is in compliance with GDC 17 for this second offsite power source (S/U-2).

GDC 17 also requires that S/U-2 be available in "sufficient time following a loss of all onsite alternating current and the other offsite source to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded". ANO has reviewed the station blackout coping capability of both units. This work established that both ANO units have sufficient capability to cope with a loss of all alternating current power for at least one hour. Therefore, it was concluded that a delay of 30 minutes or less in establishing delayed manual access to S/U-2 is an appropriate time for consideration of the ability of this source to satisfy the requirement of GDC 17. ANO will currently maintain manual delayed access of auxiliary loads of each unit to S/U-2. As stated above, the necessary procedures are in place to accomplish this function.

When the proposed improvements to the transmission system are completed and its capacity to support ANO auxiliary loads have been increased, the fast transfer feature to S/U-2 may be reactivated under certain analyzed conditions. This would be highly desirable when periodic maintenance of the 500/161/22 kV autotransformer is being performed and the normal fast transfer offsite sources (S/U-1 and 3) for both units are unavailable.

- GDC 5

GDC 5 requires that systems important to safety cannot be shared if such sharing would "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." Both IEEE Standard 308 and NUREG-0800 recognize the applicability of GDC 5 to the requirements for the preferred power supply.

As stated previously, the preferred power supply is defined as the "offsite power". By GDC 17 requirements, this offsite power must consist of two independent circuits. One of these (first GDC 17 offsite source) must be immediately available for loss-of-coolant-accident mitigation. The second offsite circuit (second GDC 17 offsite source) is allowed to be a delayed access source. Its availability is restricted only to a time frame consistent with that necessary to ensure successful coping with a loss of alternating current power.

The first GDC 17 preferred power sources at ANO are in compliance with the GDC 5 sharing requirements. The preferred power system for ANO-1 has the capacity in S/U-1 (first GDC 17 source) to supply necessary loads to mitigate an accident in that unit. Likewise, the preferred power system for ANO-2 has the capacity in S/U-3 (first GDC 17 source) to supply necessary loads to mitigate an accident in that unit. The only component of offsite equipment that supplies power to both of these transformers is the 500/161/22 kV autotransformer in the ANO switchyard. These two transformers (S/U-1 and 3) are powered from the 22 kV tertiary winding of this autotransformer. Therefore, to assure that the preferred power system is in compliance with GDC 5, ANO would have to require that the autotransformer was sufficiently sized to carry accident loads in one unit and orderly shutdown loads of the other unit. Since the autotransformer 22 kV tertiary winding that supplies S/U-1 and 3 has more capacity (approximately 160 MVA total) than the combined capacities of S/U-1 and 3 (and many times greater than that required for GDC 5), Entergy Operations has determined that ANO is in compliance with GDC 5 as it relates to the primary, immediately available circuit of the preferred power supply (first GDC 17 offsite source).

It should be noted that both units share S/U-2 as their second GDC 17 source. S/U-2 has been sized to carry the safety related accident loads of one unit while additionally supplying the safety related emergency auxiliary loads of the other unit following the loss of all onsite alternating current power supplies to achieve a safe shutdown. This has been stated in Section 8.2 of the original ANO-2 SER.

As previously stated, in order to assure that S/U-2 and the offsite transmission system has sufficient capacity to comply with GDC 5 and GDC 17, it was necessary to prevent automatic transfer of the auxiliary loads from one or both units to S/U-2. With appropriate procedures in place at ANO, the loading of S/U-2 can then be maintained at a level which can be supported by the transmission system at all times of the year.
Therefore, ANO is in compliance with GDC 5 with respect to the second GDC 17 source (S/U-2).

- Technical Specifications

Both ANO units have technical specifications requiring the operability of onsite and offsite power supplies. These specifications have Limiting Condition's for Operation (LCO's) which establish allowable operating times should either or both sources of offsite power becomes inoperable.

ANO-1 Technical Specification 3.7.1.G requires that load shedding circuitry be operable if S/U-2 is selected for auto access (fast transfer). ANO-1 Technical Specification 3.7.1.H stipulates that if Specification 3.7.1.G cannot be met, the feeder breakers from S/U-2 must be placed in "Pull-to-Lock". On October 3, 1991, ANO conservatively declared the load shedding circuitry inoperable and placed the S/U-2 feeder breakers in "Pull-to-Lock". By placing the S/U-2 feeder breakers in "Pull-to-Lock", the auto access by ANO-1 to S/U-2 was defeated and loads were then required to be manually loaded to S/U-2.

By placing the S/U-2 feeder breakers in "Pull-to-Lock", the loading of the required safety loads onto S/U-2 could be accomplished while maintaining acceptable voltages to these busses. An auto access of safety and non-safety loads under certain conditions (i.e., outage of the 500/161 kV autotransformer during peak system load conditions) could have resulted in unacceptable voltages to the safety busses and actuation of the Millstone undervoltage relays. Therefore it was prudent to defeat this auto access feature for S/U-2.

PERIODIC REVIEW/VALIDATION OF LOAD PROFILES

Since the offsite transmission network is a dynamic system, which changes over the years in both configuration and load level, it will be necessary to perform periodical studies of the transmission system to assure that, within analyzed conditions, adequate offsite voltage levels are maintained to ANO. To assure that the transmission area load growth does not again result in inadequate offsite voltage levels, ANO will require an update of the ANO specific offsite power system study by Entergy every two years.

LONG TERM MEASURES BEING REVIEWED

Contingency Should Loads Exceed Projection

The proposed improvements/changes to both the offsite transmission system and ANO will provide adequate voltage to the ANO 161 kV switchyard and engineered safeguard busses under the most severe conditions evaluated (loss of the 500/161 kV autotransformer and the coincident loss of the four local Dardanelle hydro units at the same time that both ANO units are offline during summer peak conditions). As was stated in previous correspondence with the NRC, this condition is highly improbable. For this contingency, after the modifications discussed above are completed in 1992, adequate voltage levels can be maintained through the year 1996 for the transmission system loading levels that are presently projected.

This projection is based on both system and ANO area load growth forecasts. If for any reason the loads exceed this projected level, one or more of the four local hydro units could be used to provide adequate voltage levels to ANO should the autotransformer fail during peak loading conditions. It should be noted that credit for these local hydro units was assumed during the resolution of the Millstone degraded voltage issues in 1976.

At the Entergy Dispatching Center, operating procedures (use of hydro unit generation, transmission system changes, load shedding, etc.) have been established which provide the necessary steps for restoration of 161 kV offsite voltage levels at ANO. These actions, along with the committed physical improvements will ensure the capability of providing adequate voltage levels at ANO, even under the most severe contingency evaluated.

As a further goal, an additional capacitor bank for the Russellville area is under consideration. Assuming the completion of this additional modification, voltage levels should not fall to unacceptable low levels for any predictable event and therefore, use of corrective operating procedures for the system dispatchers would not be expected.

Potential Future Enhancements

Entergy Operations is continuing to investigate longer term modifications which will assure adequate offsite voltage levels beyond 1996. One possible modification includes the installation of voltage regulation on the offsite power sources. These regulators would typically provide a +/- 10% correction in voltage magnitude and would therefore provide a long term assurance that adequate voltage levels would be delivered even if the 500/161 kV autotransformer or any other 161 kV transmission line is out-of-service.

ANO OFFSITE POWER SYSTEM