50-313

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 15 1980

MEMORANDUM FOR: Carlyle Michelson, Director
Office for Analysis & Evaluation
of Operational Data

FROM: Faust Rosa, Chief
Power Systems Branch
Division of Systems Integration, NRR

SUBJECT: AEOD REPORT ON THE LOSS OF OFFSITE POWER EVENT AT ARKANSAS NUCLEAR ONE, APRIL 7, 1980 (REPORT DATED OCTOBER 15, 1980)

REFERENCE: Memorandum from C. Michelson to H. R. Denton dated December 5, 1980, Loss of Offsite Power Event at Arkansas Nuclear One, Units 1 and 2 on April 17 (sic), 1980

I have reviewed the subject report which was transmitted to H. R. Denton by your memorandum dated Nov. 5, 1980. My review was limited to those portions of the report which address the offsite power aspects of the event. I found the report to be in error in its analysis of the event, its interpretation of GDC 17, and consequently in its conclusions. As the responsible Branch Chief in the electrical power area, and (coincidently) as the staff member that evaluated the ANO design for conformance to GDC 17 following the loss of offsite power event at ANO on September 16, 1978, I feel that it is necessary to correct the unwarranted negative impression conveyed by this report with regard to the adequacy of GDC 17 and the competence of the staff in its application. I have also reviewed your memorandum (reference) which provides some clarification in regard to the offsite power aspects of the subject report. I find that these clarifications do not correct any of what I consider to be the major deficiencies in the report. I recommend that this report be retracted, and reissued after a proper evaluation of the offsite power aspects of the subject event has been performed.

Enclosure 1 provides the interpretation of the requirements of General Design Criterion 17 (GDC 17), Electric Power Systems, and GDC 5, Sharing of Structures Systems and Components, which are used by the Power Systems Branch (PSB) in licensing reviews. Enclosure 2 is the station single line diagram from the ANO Unit 2 FSAR. These enclosures are intended to provide the background for the following specific comments.

1. In general, any evaluation of a loss-of-electric-power event at a nuclear plant must be based on a clear understanding of the requirements of GDC 17.

The evaluation should then determine (1) whether these requirements had been met, (2) whether the requirements are adequate (or would have been if implemented) for assuring plant safety, (3) what other factors (if any) not directly related to GDC 17 requirements played a significant part in the course of the event, and (4) whether the GDC 17 (or other) requirements need to be revised and how in order to assure safety. However, any evaluation findings of design or other deficiency should be supported by reference to specific non-conformance with existing regulations, or by inclusion in the evaluation of fully developed supporting bases; anything less than this can only have a negative impact on both nuclear safety and the nuclear regulatory process. In my opinion, the subject report reflects a lack of clear understanding of the requirements of GDC 17, and it does not address explicitly and unambiguously any of the points cited above.

2. I was unable to determine from the following statements in the report, and from the related discussion in the report and in the reference memorandum, whether the finding of deficiency was attributed to non-conformance of the design to the requirements of GDC 17 and GDC 5, to the misinterpretation and consequent misapplication of these requirements by the staff, or to the inadequacy of the requirements themselves:

   Pg. ii - "The most important findings include: the lack of regulatory requirements for the station switchyard to function following a single failure;..."

   Pg. 7 - "<u>Finding</u>

   The finding concerning the offsite power system is that a single failure (loss of autotransformer) results in a loss of offsite power event for both units at Arkansas Nuclear One. Since the implementation of GDC 17 has not required the offsite power system to meet the requirements of the single failure criterion, this deficiency may be generic to all operating plants. It is undesirable that a single failure should result in a loss of offsite power transient for both units and the actuation of safety-related equipment."

The staff interpretation of the requirements of these GDCs, and a description of how they are applied, are provided in Enclosure 1. I would be pleased to discuss any differing interpretation of these requirements that may be held by AEOD staff.

If the finding was attributed to non-conformance to these GDCs (as interpreted in Enclosure 1), then the finding is in error for the reasons discussed in comment (3) below. If the finding was attributed to the inadequacy of the

requirements of GDCs 5 and 17, then there is an obvious failure to recognize that such a finding cannot possibly be supported by the simple qualitative evaluation of the subject event that was performed; such a finding can only be supported by a comprehensive quantitative probabilistic assessment of overall AC power availability such as that presently underway in generic Task A-44, Station Blackout. Completion of this task is scheduled for 1982 (G. Edison or P. Baranowsky, PAS, can provide further details).

In my opinion, the only findings that can be supported by the AEOD evaluation is a recommendation for performance of a task A-44 type assessment; and possibly another recommendation that licensees review the design and coordination of their switchyard protective relaying in view of the ANO experience (see comment (4) below).

3. Conformance of the ANO design to GDC 17 was reviewed by the undersigned immediately following the incident at ANO on September 16, 1978. This incident involved a number of electrical failures including a failure in the offsite power system. The review concluded that the design had not been in conformance with GDC 17 with regard to the independence between the two required offsite power circuits because, under certain conditions, in event of failure of the autotransformer (the common element in the immediate access circuit for both units) the auxiliary loads of both units were automatically transferred to Startup Transformer No. 2 (the common element in the second circuit which had been designed as a second immediate access circuit for both units), thus overloading and failing this circuit. This is a violation of requirement (e) cited in Enclosure 1. This review was fully documented in Enclosure 3 [It is noted that the reference memorandum corrects the statement on Pg. 3 of the report that "a staff position regarding conformance to GDC 17 was not formalized."]

   Enclosure 3 also presented three acceptable methods for attaining conformance to GDC 17. One of these methods, the defeat of all capability for automatic transfer of loads to ST2, i.e., simply making it a delayed access circuit, was implemented prior to restart of both units. During the subject event there was no automatic transfer of loads to ST2; therefore, the design was in conformance with GDC 17.

4. The report (primarily on Pg. 2) describes the isolation of the autotransformer as a failure due to malfunction of "protective relay switches." Characterizing this as a failure is at best questionable. As noted in the report, the licensee was unable to establish that this was a failure. It is of course possible that the coordination of the switchyard protective relaying was not optimized, and this should be checked. However, it is much more likely that the protective relaying and associated breakers functioned in accordance with

design in response to the power transient associated with the failure from offsite causes of the third of three 500 kv transmission lines and one of the two 161 kv lines, and the trip of the two units. In the absence of data explicitly defining the prior and post event switchyard breaker configuration and the timing and sequence of the breaker operations that occurred, it is virtually impossible to characterize the autotransformer isolation as a failure.

5. The AEOD evaluation lacks perspective in that it does not place any emphasis on the remaining capability of the offsite/onsite electric power system immediately following the event. The event was not a total loss of offsite power, only the 500 kv immediate access offsite power capability was lost. The delayed access circuit from the 161 kv switchyard through transformer ST2 to both units was available throughout and could have been used (as noted in the report) by means of manual operator action from the control room. However, operator action to effect this immediately was neither necessary from a safety standpoint or desirable from a human factors standpoint, since the two diesel generators in both units had automatically started and energized all the emergency buses. Additionally, since the 500 kv immediate access circuit suffered no equipment damage, it could have been used as a second delayed access circuit. Thus, on a per unit basis immediately following the event, the onsite system was capable of supplying power for the minimum required accident loads assuming a single failure; and the offsite/onsite system was capable of supplying minimum required safe shutdown loads assuming a triple failure.

6. The subject event involved the failure from offsite causes of four of the five transmission lines emanating from the switchyard. This would be a severe challenge to the offsite system of any multi-unit nuclear plant site, regardless of the specific switchyard/unit circuit configuration. In my opinion, the performance of the ANO offsite/onsite electric power system during the subject event represents an affirmation of the adequacy of GDC 17, not a basis for questioning its adequacy.

I would be pleased to meet with AEOD staff for a further discussion of the above comments.

Faust Rosa

Faust Rosa, Chief
Power Systems Branch
Division of Systems Integration, NRR

Enclosure:
As stated

cc: See page 5

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ENCLOSURE 1

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 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.

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Requirements of GDC 17

This criterion presents the minimum requirements for the offsite and onsite electric power systems deterministically, i.e., in terms of specific system and circuit configurations and functional requirements. The only requirement in GDC 17 for explicitly meeting the single failure criterion is with regard to the onsite power system. In applying GDC 17, it has been useful for the staff to also interpret the deterministic requirements for the offsite power system in terms of required conformance to the single failure criterion. The text of GDC 17 at the left is keyed to the staff interpretation of its deterministic requirements, and the corresponding staff interpretations regarding conformance to single failure:

a. An offsite power system and an onsite power system shall be provided, each independent of the other and capable of providing power for all safety functions. [The offsite and onsite power systems considered together must meet the single failure criterion on a system basis without loss of capability to provide power for all safety functions; additionally, in view of requirement (b) below, the two systems considered together must be capable of sustaining a double failure, one of which is complete loss of offsite power, without loss capability to provide power for the minimum required safety functions.]

b. The complete onsite electric power system (Class 1E) must be capable of sustaining a single failure without loss of capability to provide power for the minimum required safety functions.

c. The offsite system shall be comprised of two physically independent circuits connecting the transmission network (grid) to the onsite distribution system (safety buses). [Separate transmission line towers are required but common switchyard structures are acceptable. No requirement for meeting single failure, and in the absolute sense single failure cannot be met because there is only one power source, the grid.]

d. One of these circuits shall be designed to be available within a few seconds following a loss-of-coolant accident. [The staff has designated this circuit as the "immediate access circuit." Since only one such circuit is required, the offsite power system need not meet the single failure criterion with respect to its immediate access function.]

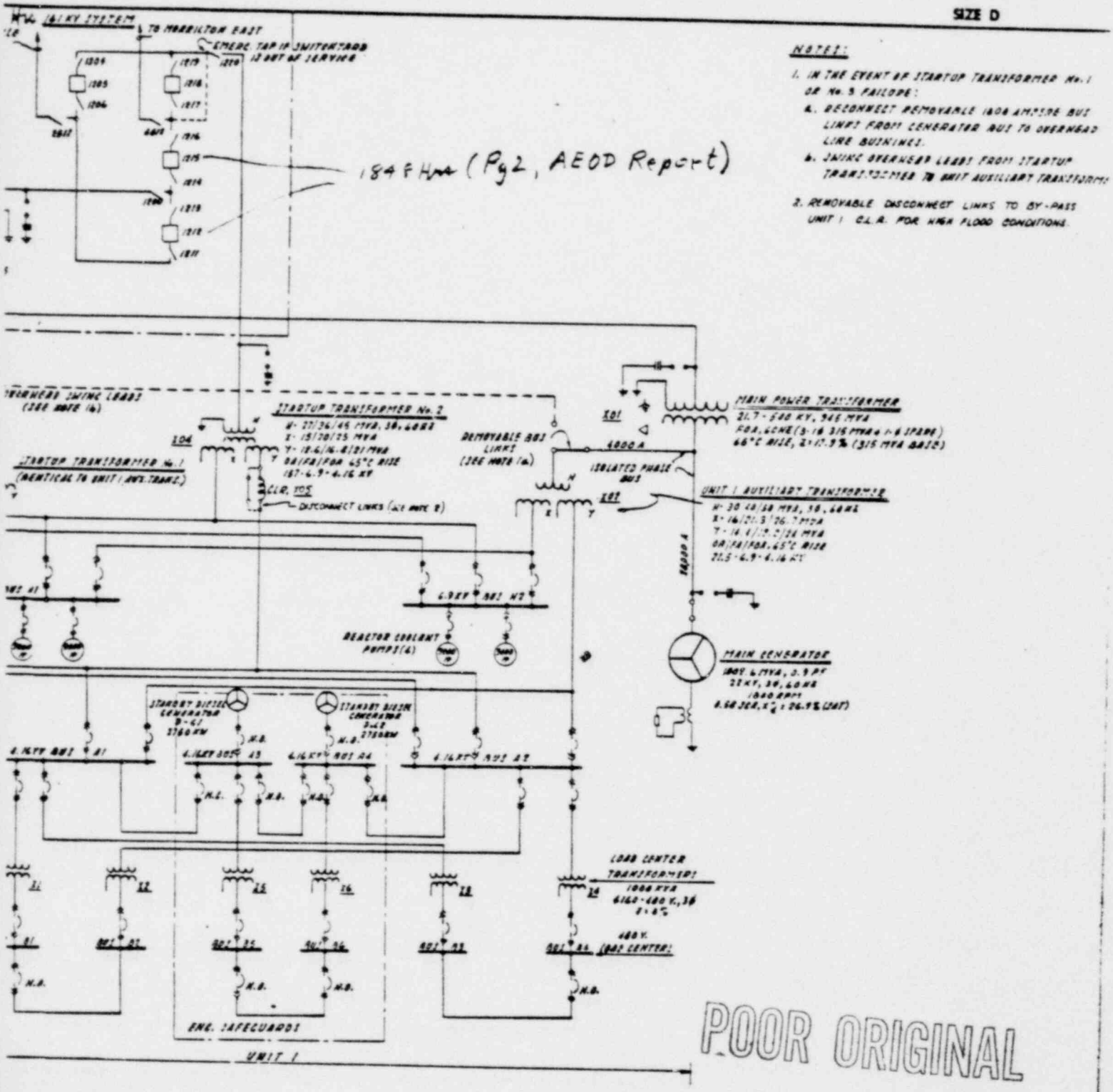
e. Each of the two required offsite power circuits shall be designed to be available in sufficient time to effect safe shutdown in event of loss of all onsite power and the loss of the other offsite circuit. [The second circuit has been designated by the staff as the "delayed access circuit." The offsite power system, i.e., the two circuits considered together, must meet the single failure criterion, but only with respect to the delayed access circuit function.]

f. Analyses (performed by the utility) must verify that the grid remains stable in event of loss of the nuclear unit generator, the largest other unit on the grid or the most critical transmission line. [There is no specific requirement for meeting single failure. However, overlapping requirement (a) above requires the offsite/onsite power systems to meet single failure on a system basis.]

Requirements of GDC 5

Sharing of offsite electric power components and systems among nuclear units is permitted in accordance with the clearly stated requirements of GDC 5, and providing all the requirements of GDC 17 are met on a per nuclear unit basis. Sharing of onsite electric power components and systems is no longer permitted, see Regulatory Guide 1.81, Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Plants.

SIZE D



NOTES:

1. IN THE EVENT OF STARTUP TRANSFORMER No. 1 OR No. 3 FAILURE:
   a. DISCONNECT REMOVABLE 1600 AMPERE BUS LINKS FROM GENERATOR BUS TO OVERHEAD LINE BUSHINGS.
   b. SWING OVERHEAD LOADS FROM STARTUP TRANSFORMER TO UNIT AUXILIARY TRANSFORMER
2. REMOVABLE DISCONNECT LINKS TO BY-PASS UNIT 1 C.L.R. FOR HIGH FLOOD CONDITIONS.

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Enclosure 2

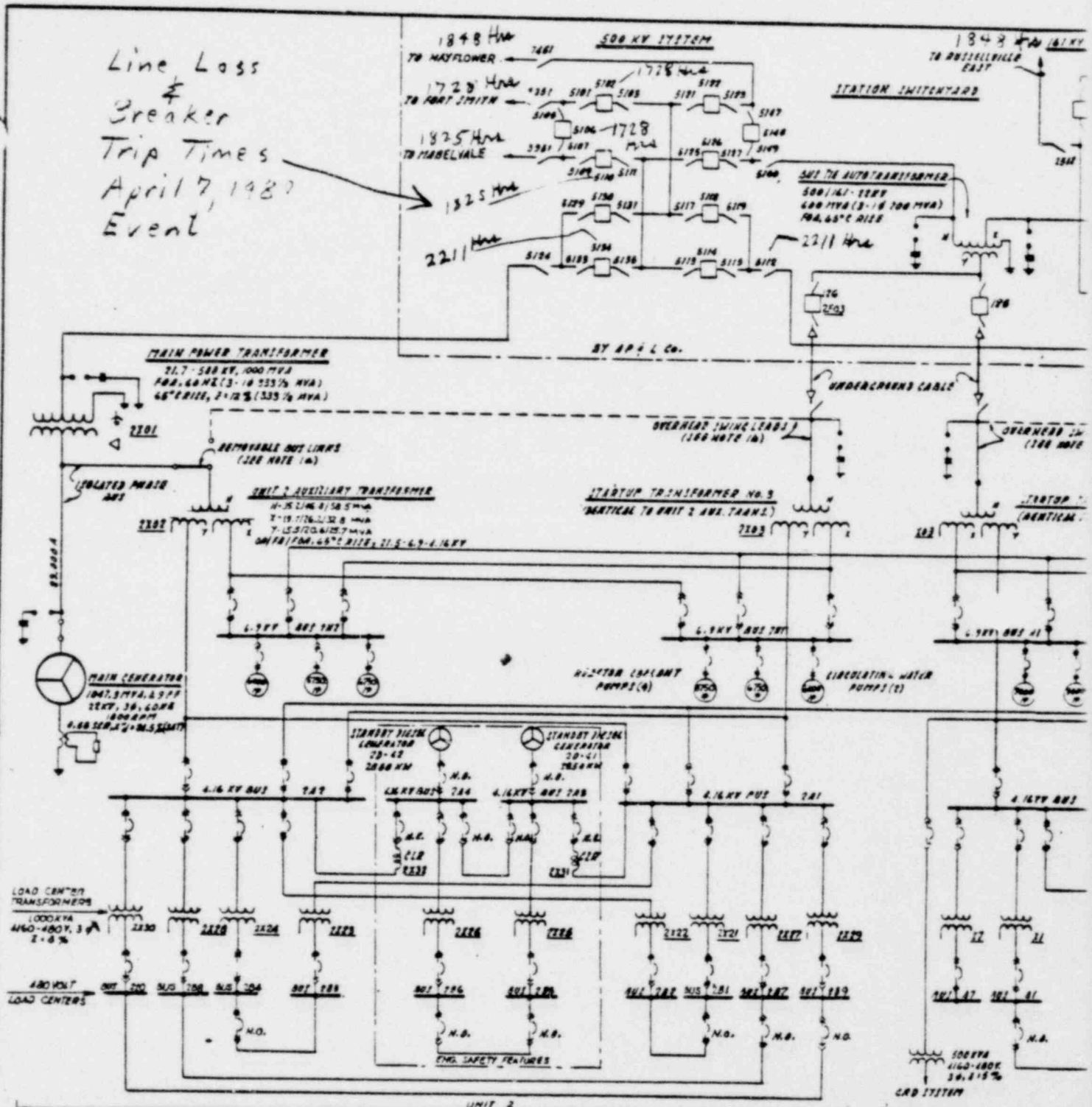
AMENDMENT 49

ARKANSAS POWER & LIGHT COMPANY
ARKANSAS NUCLEAR ONE - UNIT 2

Station Single Line Diagram

FIGURE 8.3-1

Line Loss & Breaker Trip Times April 7, 1987 Event



UNIT 2 4.16 KV AND 480 VOLT BUS LOADS

4.16 KV SWITCHGEAR			
4.16 KV LOADS	NON-ENGR. SAFETY FEATURES BUS	241	242
	CONDENSATE PUMP	2 - 4000 HP	2 - 4000 HP
	FEEDWATER HEATER DRAIN PUMP	1 - 1500 HP	1 - 1500 HP
	MAIN CHILLER	1 - 950 HP	1 - 950 HP
	ENGR. SAFETY FEATURES BUS	243	244
	EMERGENCY FEEDWATER PUMP	1 - 600 HP	—
	H.P. SAFETY INJECTION PUMP *	2 - 600 HP	1 - 600 HP
	L.P. SAFETY INJECTION PUMP	1 - 500 HP	1 - 500 HP
	SERVICE WATER PUMP *	1 - 800 HP	2 - 800 HP
	CONTAINMENT SPRAY PUMP	1 - 450 HP	1 - 450 HP

480 VOLT LOADS	NON-ENGR. SAFETY FEATURES LOAD CENTERS	ENGR. SAFETY FEATURES LOAD
	281, 282, 283, 284, 287, 288, 289 AND 2810	285 & 286
	COMPONENT COOLING WATER PUMP	CHARGING PUMPS (3-100 HP)
	CONTROL ELEMENT DRIVE MECHANISM	CONTAINMENT COOLING FANS
	WATER TREATMENT AUXILIARIES	ENGINEERED SAFETY FEATURES
	TURBINE AUXILIARIES	PREFERRED EMERGENCY LOAD
	CONTROL ROOM CHILLERS	EMERGENCY LIGHTS
	HEATING AND VENTILATING	EMERGENCY DIESEL GENERATOR
	REACTOR PRESSURIZER BACKUP HEATERS	BATTERY CHARGERS
	RADWASTE AREA AUXILIARIES	MOTOR CONTROL CENTERS
	CONTAINMENT AUXILIARIES	REACTOR PRESSURIZER PROPORTIONAL
	MOTOR CONTROL CENTERS	
	CEDM COOLING FANS	

* THIRD PUMP CAN BE STARTED FROM EITHER BUS

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Enclosure 3

NOV 01 1978

MEMORANDUM FOR: J. F. Stolz, Chief, Light Water Reactors Branch 1, DPM

FROM: Faust Rosa, Chief, Power Systems Branch, DSS
Rod Satterfield, Chief, Instrumentation and Control Systems Branch, DSS

SUBJECT: ARKANSAS NUCLEAR ONE; INCIDENT ON SEPTEMBER 16, 1978; AUTO TRANSFER OF AUXILIARY LOADS ON BOTH UNITS TO STARTUP TRANSFORMER NO. 2 WITH CONSEQUENT OVERLOAD; CONFORMANCE TO GDC-17

The incident at Arkansas Nuclear One (ANO) on September 16, 1978 brought into question the conformance to GDC-17 of the offsite power system design of this station. We have reviewed the ANO design in light of this incident; this review was conducted in close coordination and consultation with cognizant personnel of I&E, DOR, DPM and the Licensee (Arkansas Power and Light Company) and its AE. As a result of this review we conclude that the present offsite power system design is not in conformance with GDC-17 with regard to the independence between the two required offsite power circuits. Our rationale and recommendations are as follows:

A description of the pertinent features of the ANO offsite power system design is provided in the Enclosure. It is clear from this description that under certain conditions Startup Transformer No. 2 (ST2), which is in the "delayed access" offsite power circuit* (for both units) required by GDC-17, will be automatically overloaded due to a failure in the autotransformer which is the common element in the immediate access offsite power circuit which is also required by GDC-17. More specifically, the automatic overload, i.e., disabling, of ST2 will result when a failure of the autotransformer circuit occurs concurrently with any of the following station conditions and events:

a) both units in either startup or shutdown mode,

b) trip of one unit while the other is in either the startup of shutdown mode, and

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*The design feature of automatic load transfer to ST2 which is provided actually makes this a second immediate access circuit, thus exceeding GDC-17 requirements with regard to access capability; however, the resulting overload of ST2 violates the independence requirements of GDC-17.

Contact:
F. Rosa
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c) simultaneous trip of both units.

GDC-17 requires, in part, that "Electric power from the transmission network to the onsite electric distribution system 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." Since in the ANO design a failure in the immediate access offsite power circuit results in failure of the delayed access circuit, we conclude that the ANO offsite power system design is not in conformance with GDC-17; however, the Unit 1 situation is being handled by DOR and Unit 2 is presently shutdown. Prior to Mode 2 licensing of Unit 2, this matter will need to be resolved.

We recommend that the licensee be advised of the above cited non-conformance with GDC-17 and requested to modify his design to bring it into conformance before Unit 2 goes into Mode 2 operation. In our opinion, acceptable methods for attaining conformance with GDC-17 include:

1) Replacement of Startup Transformer No. 2 with one capable of carrying the worst case combination of automatically transferred loads.

2) Defeat of all capability for automatic transfer of loads to Startup Transformer No. 2.

3) Defeat of capability for automatic transfer of selected loads such that Startup Transformer No. 2 will never experience an overload condition (including excess voltage drop resulting in unacceptable voltage at the safety buses) due to the worst case combination of the retained automatic load transfer capability.

Development is underway of a PSB Technical Position addressing the detailed application of GDC-17 to offsite power system designs involving similar automatic switching schemes. Pending completion of this position (and its approval by the R^3C if required), acceptable means of implementing option 3 above include: (1) defeat of automatic load transfer in one unit while retaining it in the other, or (2) partial defeat of automatic load transfer in either or both units.

Also, procedural implementation of option 2 or 3 utilizing existing switching capabilities (as opposed to a design change) would be acceptable pending completion of the above cited PSB position. Such procedural implementation should include written procedures for (1) defeat of the required automatic switching capability, (2) manual load shedding and switching including manual loading required to make use of ST2 as the delayed access offsite power circuit for either or both units, and (3) daily logging of the status of automatic load switching. Unrestricted operation of Unit 2 (and Unit 1 insofar as automatic load transfer to ST2 is concerned) would be permissable provided the above procedural requirements are approved by I&E and incorporated in the Technical Specifications.

Implementation of the above position regarding automatic load transfer to Startup Transformer No. 2 involves the offsite power system for both units. The permissable operational status of Unit 1 is being reviewed separately by DOR (see memorandum from G. Lainas to R. Reid dated October 27, 1978, Voltage Degradation At Class 1E 480 Volt Buses). This review will include consideration of the proposed Millstone fix for degraded grid voltage conditions which includes design changes as well as administrative controls. (An approved Millstone fix has already been installed in Unit 2).

Faust Rosa

Faust Rosa, Chief
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R.L. Satterfield

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Enclosure:
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ENCLOSURE

Description of the Offsite Power System
Design for Arkansas Nuclear One
Units 1 and 2

The following design features of the Arkansas Nuclear One (ANO) station are pertinent to the evaluation of the design for conformance to GDC-17, in light of the incident which occurred on September 16, 1978.

1) Each of the two units has a dedicated unit auxiliary transformer (UAT) and a dedicated startup transformer (ST) each of which can supply all a-c power to all the unit auxiliaries, both safety and non-safety. The UAT's are supplied from their respective unit generator; the two ST's are both supplied through a single auto-transformer which also interconnects the 500 KV and 161 KV sections of the station switchyard.

2) A backup startup transformer, Startup Transformer No. 2 (ST2), is provided which can serve both units. This transformer is supplied directly from the 161 KV section of the switchyard. However, it does not have the capacity for carrying the full auxiliary loads of both units.

3) On unit trip, all the unit auxiliary loads will be transferred automatically from its UAT to its ST. This will occur in both units, independently.

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4) When unit auxiliary loads are being carried by the respective ST and this source of power is lost for any reason, all the unit auxiliary loads will be transferred automatically to the backup ST 2. This also will occur in both units, independently.

5) When both units are being supplied by their respective ST's and the common source of power to the ST's (the autotransformer) is lost, then the auxiliary loads of both units will be automatically transferred to ST2. This will overload ST2 (exceed MVA rating) and also produce excess voltage drop resulting in a degraded voltage condition at the buses (safety and non-safety) of both units.

6) With the existing design, the overloading of ST2 will result automatically on failure of the autotransformer circuit feeding the two dedicated startup trasnformers, when the failure occurs concurrently with the following conditions or events:

   a) both units in either the startup or shutdown modes of operation,

   b) trip of one unit while the other is in either the startup or shutdown mode of operation, and

   c) simultaneous trip of both units.

7) The Millstone fix for degraded grid voltage conditions which includes a second level of undervoltage trip (at approximately 92% of nominal) was installed in Unit 2; this fix is scheduled for installation in Unit 1 at the next refueling outage. It should be noted that the Millstone fix is intended to protect the onsite safety related distribution systems from a degraded grid voltage condition not against degraded voltage due to overload of a startup transformer (although it is also effective in this regard). Therefore, the Millstone fix is necessary in order to meet the GDC-17 requirements for independence between the offsite and onsite power systems. However, the Millstone fix is not considered pertinent to the evaluation of the offsite system design for conformance to the GDC-17 requirement for independence between the two required offsite power circuits. In this case, the design feature in question is the automatic overloading of one of the required offsite power circuits to both units on failure of the other offsite circuit.

It is noted that item 6(b) above covers the incident which occurred at ANO on September 16, 1978. Specifically, this incident was

initiated by a spurious trip of Unit 1 while Unit 2 was in the startup mode. This resulted in automatic transfer of the Unit 1 auxiliary loads from its UT to its ST. Since Unit 2 was already on its ST, this transfer loaded the autotransformer with the full auxiliary loads of both units, resulting in trip of an autotransformer overcurrent relay (which had not been adjusted for two unit operation) and consequent opening of the circuit breakers feeding the two ST's. Loss of the ST's automatically transferred the auxiliary loads of both units to ST2 exceeding its MVA rating and producing a degraded voltage at the auxiliary buses (safety and non-safety) of both units. The overcurrent protective relaying for the autotransformer has since been corrected to preclude recurrence of this type of failure.

The above description does not address those aspects of the September 16, 1978 incident or plant design which are not pertinent to the evaluation of the offsite power system for conformance to GDC-17.