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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE AUDIT OF THE RESOLUTION OF IE BULLETIN 79-27 CONCERNS

ARKANSAS POWER AND LIGHT COMPANY

ARKANSAS NUCLEAR ONE, UNIT 1

DOCKET NO. 50-313

1.0 INTRODUCTION

On November 10, 1979, an event occurred at the Oconee Power Station, Unit 3, which is a Babcock & Wilcox (B&W)-designed nuclear power plant. The event started with a loss of power to a Non-class 1E, 120-Vac, single-phase power panel that supplied power to the integrated control system (ICS) and the non-nuclear instrumentation (NNI) system. This loss of power resulted in control system malfunctions and a significant loss of information to the control room operator.

The event at Oconee, Unit 3, occurred as the result of a Non-Class 1E inverter failure and the failure of its automatic bus transfer (ABT) switch to transfer the instrumentation and control loads from the failed inverter to a designated alternate regulated 120-Vac power source. The resulting loss of power to the NNI rendered control room indicators and recorders for the reactor coolant system (except for one wide-range reactor coolant system pressure recorder) and most of the secondary plant systems inoperable. Loss of power also caused the loss of instrumentation associated with the systems used for decay heat removal and coolant addition to the reactor vessel and steam generators. In addition, upon the loss of power, all valves controlled by the ICS assumed their failure positions.

On November 30, 1979, the NRC issued IE Bulletin 79-27, "Loss of Non-Class 1E Instrumentation and Control Power System Bus During Operation" (Reference 1). IE Bulletin 79-27 required licensees to review the effects of loss of power to each Class 1E and Non-Class 1E bus supplying power to plant instrumentation and controls and to determine the resulting effect on the capability to achieve a safe (cold) shutdown condition using plant operating procedures following the power loss. The intent of IE Bulletin 79-27 was to ensure that the loss of power to any bus in the plant electric distribution system would not result in control system actions that would cause a plant upset/transient condition requiring operator action concurrent with the loss of control room information (indications, alarms, etc.) upon which these actions would be based.

On February 26, 1980, an event that involved a loss of NNI system power occurred at the B&W-designed Crystal River, Unit 3, nuclear plant. In this event, failed input signals provided to the ICS from the NNI system caused reactor coolant system (RCS) overpressurization and the subsequent release of reactor coolant into the reactor building. This loss of power also resulted in the failure of most of the instruments needed by the operator to respond to the event, making operator action very difficult. On March 7, 1980, the NRC issued

IE Information Notice 80-10 (Reference 2), which expanded the scope of IE Bulletin 79-27 for B&W-designed reactors to include the implications of the Crystal River event. The NRC review of utility reponses to IE Bulletin 79-27 focused on whether there was reasonable assurance that the concerns of the bulletin had been properly addressed. This assurance was based on an affirmative or clearly implied statement of conformance to all bulletin requirements and a positive indication that all required buses were reviewed.

Following the issuance of IE Bulletin 79-27 and IE Information Notice 80-10, two events occurred at the B&W-designed Rancho Seco nuclear plant involving the loss of ICS/NNI power and loss of control room information. These events, occurring on March 19, 1984 and December 26, 1985 demonstrated that the concerns identified in IE Bulletin 79-27 continued to exist in B&W-designed plants. Additional background information regarding licensee responses to IE Bulletin 79-27 and the NRC evaluation of these responses can be found in Section 7, "Precursors to the December 26, 1985 Incident at Rancho Seco and Related NRC and SMUD Actions," of NUREG-1195 (Reference 3).

In order to resolve the concerns raised in NUREG-1195, the B&W Owners Group submitted a description of the B&W program entitled "Safety and Performance Improvement Program (SPIP)" in their document BAW-1919 on May 15, 1986. The NRC staff reviewed BAW-1919 through Revision 5 and presented its evaluation in NUREG-1231, dated November 1987, and in Supplement No. 1 to NUREG-1231, dated March 1988 (Reference 4).

Included in the SPIP program are specific tasks to be completed by each utility; however, the SPIP tasks do not include a review to determine whether the specific concerns of IE Bulletin 79-27 have been properly addressed and resolved. The NRC staff believes that proper resolution of IE Bulletin 79-27 concerns, in conjunction with implementation of SPIP recommendations, should significantly reduce the frequency and severity of loss of power transients at B&W-designed plants, including those transients resulting from loss of power to the ICS/NNI. As part of the staff audit of the SPIP program, the Instrumentation and Control Systems Branch (ICSB) is conducting an audit of each B&W facility to verify the resolution of IE Bulletin 79-27 concerns.

2.0 AUDIT METHODOLOGY

The Arkansas Nuclear One-1 (ANO-1) audit consisted of two parts: 1) a pre-audit documentation review comprised of (a) examining plant electric distribution system single line diagrams along with other drawings from the Final Safety Analysis Report (FSAR), system descriptions, and reactor trip and shutdown procedures (Reference 5), and (b) preparing a list of the equipment, instruments, controls, and indications identified in the procedures and needed to bring the plant from an operating state with a reactor trip to a safe shutdown and cooldown condition; 2) on-site audit to determine if a safe shutdown can be achieved in the event of a postulated worst case bus failure using established operating procedures. The audit team met with the licensee's representatives (Reference 6) to determine the sources of power to each of the instruments and equipment in the list prepared during the pre-audit documentation review. Three buses were selected for review by the audit team based upon the majority of the components identified on the list and supplied from these buses, and their downstream connections, which failed due to the cascading power loss. The failure of the three selected buses appeared to represent the worst case scenarios due to the consequential loss of a substantial number of instruments and equipment that could increase the complexity of the operator actions required to stabilize the plant and to achieve a safe shutdown following a reactor trip.

The applicable sections of the reactor trip, plant shutdown, and cooldown procedures were examined by the audit team and the utility representatives to determine how each step would be performed while failing the selected buses one at a time. For those steps that were affected by the bus failure, the licensee described how the step would be performed (for example, by using a redundant instrument, switching to another power source, or performing manual actions to achieve a safe shutdown). The audit team also examined annunciator response procedures to determine if specific directions were provided to the operator for dealing with the loss of power to the plant distribution system.

3.0 EVALUATION

The audit team evaluated the effects of the loss of power to each selected bus by analyzing the combined effects of the loss of power to the bus loads (instruments, controls, pumps, valves, etc.) and the resulting effect on the ability to proceed to cold shutdown using approved procedures. The review included an evaluation of the indication and annunciation provided to alert the operator in the control room to the loss of bus power. Equipment and component losses that result from the failure of the selected buses were evaluated along with the cumulative effects of loss of power to loads due to cascading power losses, to determine the overall effect on the plant during operation.

The audit team selected three specific cases of bus failure and performed a detailed evaluation to determine operator capability for achieving a safe shutdown using the applicable procedures in each case. These three cases are described below.

3.1 Loss of Class 1E 480-Vac Motor Control Center (MCC) B61

MCC B61 has only one source of power (no provisions for an alternate power source) and many components and equipment powered from this MCC are not essential for the safe shutdown. However, for those that are needed for safe shutdown, there were alternate or redundant components and equipment available or alternate methods were identified to achieve a safe shutdown (For example, the steam generator B main feedwater isolation valve cannot change position electrically when MCC B61 is failed; however, when procedurally required to terminate main feedwater, the operator will be able to trip the main feedwater pumps to accomplish this step of the procedure). The major loads on MCC B61 are 120-Vac Non-Class 1E instrument and control Bus Y02, inverters Y22 and Y24, and battery charger D04. All of the loads on MCC B61 are listed in Attachment C of Procedure 1107.02, "ES Electical System Operation."(Reference 5).

Battery charger D04 supplies the 125-Vdc Bus D02 loads including inverters Y22 and Y24 and charges the associated battery bank. Should the loss of MCC B61 cause disabling of battery charger D04, the battery bank will resume supplying power to the 125-Vdc bus D02. Alternate battery charger D05 can also be connected manually to Bus D02. Non-Class 1E 120-Vac Bus Y02 is powered from MCC B61 through a stepdown transformer, and supplies a variety of instruments and controls that are listed in Procedure 1107.01. The audit team reviewed Bus Y02 loads and determined that the loss of most of the instruments and controls powered by this bus has no effect on achieving a safe shutdown condition. For those instruments and controls whose loss could impact the shutdown procedures, either alternate power sources or completely redundant channels are provided, or alternate procedures are used (For example, the operating procedures require a manual local trip of the main feedwater pumps when the loss of Y02 causes loss of pump control power, or the proportional pressurizer heater controls lost with the loss of bus Y02 will not affect plant operation as the redundant pressurizer heater bank will still be available). The loss of power to bus Y02 is annunciated in the control room and the required operator responses are provided in procedure 1203.12A. In addition to various guidelines, this procedure directs the operator to manually connect bus Y02 through bus tie breakers to redundant bus Y01. This manual action is performed only when there is no fault on bus Y02.

Based on the above design features, plant operating procedures, and operator training, the audit team concluded that following the loss of power to 480-Vac MCC B61, the operator has sufficient instrumentation, indication, and equipment available to achieve cold shutdown using approved procedures.

3.2 Loss of 125-Vdc Bus D01

The audit team chose to examine 125-Vdc bus D01 (Diagram 2) because it is the dc source of electrical power to instrument inverters Y11, Y13, and Y25. Inverters Y11 and Y13 provide vital instrument power for the reactor protection system, while Y25 provides power to the plant computer. Bus D01 also supplies the engineered safety actuation system (ESAS) control bus RA1 and the station switchyard controls along with 125-Vdc distribution panel D11 to power control circuits such as the turbine trip circuitry, the generator lockout circuitry, the main feedwater pump turbine auxiliaries, and ac switchgear controls. Bus D01 is powered by battery charger D03 and has a backup supply from a 1350 ampere-hour, 125-Vdc battery bank. A spare battery charger, D05, can be manually connected to bus D01 when battery charger D03 is inoperable.

Annunciator response procedure 1203.12A (Reference 5) deals specifically with the loss of bus D01 and provides procedures for its recovery. This procedure also lists the the affected dc buses and distribution panels, and the ac switchgear that lose control power as a consequence of the failure of bus D01.

In the ANO-1 design, the loss of dc power to an inverter causes trip of both the normal ac and dc sources to that inverter. However, the bus loads including NNI and ICS, will not be affected by the loss of power to the inverter because the inverter supplied instrument buses have an alternate source of 120-Vac regulated power available within the inverter cabinet. An automatic power seeking bus transfer (ABT) switch selects this alternate source on the loss of dc power to the inverter. Thus, the loss of inverters Y11 and Y13 will not affect their associated instrument buses. Similarly the loss of inverter Y25 will not affect computer power supply. Additionally, the loss of power to the computer bus RC1 has no affect on the ability of the operators to bring the plant to a cold shutdown condition. Computer indication is not referenced in the shutdown procedures and the computer has no control function. It is used for data logging and as a backup indicator to the primary instrument readouts.

The loss of ESAS control bus RA1 will cause a reactor trip if the reactor is operating at greater than 50 percent power. Loss of distribution panel D11 will not cause an automatic turbine trip or open the generator output breakers following the reactor trip. Thus, the generator will remain connected to the switchyard. Manual operator action is required to either re-energize D11 from redundant power source D02 per Section 9 of procedure 1107.01 or to use alternate methods to trip the turbine and open the generator output breakers per EOP 1202.01 (Reference 5). The main feedwater pumps will continue operating as distribution panel D11 provides one of two power sources for the main feedwater pump controls. The turbine-driven emergency feedwater (EFW) pump control power is independent from bus D01 and will be available to start and feed both steam generators when the manual trip of the main feedwater pumps is procedurally required. The needed valves to establish flow are powered by the redundant dc distribution system.

Bus D01 is a backup source of power to switchyard controls that normally receive power from an independent switchyard battery and battery charger. Loss of power to the switchyard controls due to the loss of bus D01 will not occur with the normal distribution system alignment. Should bus D01 be supplying this power when bus D01 is lost, manual operation of the switchyard by the operator is still possible.

Based on the above design features, plant operating procedures, and operator training, the audit team concluded that following the loss of 125-Vdc bus D01, the operator has sufficient instrumentation, indication, and equipment available to achieve cold shutdown using approved procedures.

3.3 Loss of ±24-Vdc NNI Power

The audit team chose to examine ±24-Vdc NNI-X and ±24-Vdc NNI-Y buses (Diagram 3). Power indicators have been provided in the control room in response to IE Bulletin 79-27 for both NNI-X and NNI-Y buses.

Each of the two NNI-X buses (+24-Vdc bus and -24-Vdc bus) receive auctioneered power from their respective set of two power supply modules. Each of the two modules in a set are supplied by independent and redundant sources of Class 1E 120-Vac power. One power source is a division 1 inverter output bus while the other power source is a division 2 regulated instrument bus. The inverter has a primary ac power source, a backup dc power source, and an alternate ac power source. These design features ensure that a single failure of these power sour es will not degrade the ±24-Vdc NNI-X instrument power buses.

The two NNI-Y buses (+24-Vdc bus and -24-Vdc bus) are each supplied by a single power supply module (non-auctioneered supply) being fed by a single source of 120-Vac power. However, the design includes an automatic bus transfer (ABT) switch to automatically transfer the 120-Vac input to both modules from inverter supplied power (preferred division 1 power source) to a regulated power source (from redundant division 2). The audit team identified that reactor controls are not supplied by the NNI-Y ±24-Vdc buses and thus, a failure of the NNI-Y ±24-Vdc buses will not affect reactor controls.

The audit team also examined the licensee's calculation number 87E-0084-01, "Known Safe State Evaluation for ANO-1 ICS/NNI" (Reference 5). This document evaluates partial and total loss of ICS/NNI power, and is divided into the following sections:

1. Loss of ICS power (total)
2. Loss of ICS power (ac only)
3. Loss of NNI-Y power (dc, ac, or total)
4. Loss of NNI-X power (all)
5. Loss of NNI-X power (ac)
6. Loss of NNI-X power (dc)
7. Loss of NNI and ICS power (all)
8. Loss of NNI-X and -Y power (all)

In these sections, the licensee assumed (1) that there are no component failures beyond the equipment lost due to the failed bus; (2) that the power distribution system is in a worst-case alignment, namely, buses were assumed to be loaded so that they become a cascading failure; (3) that safety systems were operable; (4) that the plant was operating at full power; and (5) that no operator action occured for ten minutes. This last assumption goes beyond the assumptions of the audit team in that the audit team assumed operator action. Thus, the licensee's evaluation is more conservative than the audit reported here.

In each of the above analyzed events, the known safe state (hot shutdown) was attained. The licensee stated that cold shutdown is possible once hot shutdown is achieved because the decay heat removal system is available.

Based on the above design features, plant operating procedures, and operator training, the audit team concluded that following a loss of power to ±24Vdc NNI-X or NNI-Y buses, the operator has sufficient instrumentation, indication, and equipment available to achieve cold shutdown using approved procedures.

3.4 Automatic Bus Transfer Switches

The continued power availability on certain buses, such as the vital instrument buses (Diagram 2) and the NNI-X and NNI-Y 120-Vac instrument buses (Diagram 3), relies on the operation of ABT switches. These buses are normally supplied with inverter-derived power with automatic bus transfer (ABT) switch operation to connect to a regulated power supply on a low inverter output voltage (Section 3.2).

Although the licensee had cleaning and housekeeping procedures for these switches, they had no requirement or procedure to periodically test the capability of the switches to perform their design function. Since the ABTs are installed to transfer the power from one source to another and are assumed to operate, that capability should be demonstrated periodically. It is the staff's position that the licensee should institute a surveillance program that periodically tests the operability of these devices to demonstrate their reliability. This position is consistent with the B&W Owners Group SPIP recommendations, which include preventive maintenance and periodic testing of ABT switches used for maintaining ICS power supplies (TR-183-ICS).

4.0 CONCLUSIONS

The audit team was reasonably assured that a loss of power to any of the three buses considered would not result in a loss of the control room indication necessary to bring the plant to a safe shutdown using approved operating procedures. The audit results provided sufficient evidence that the operators, using the existing procedures, can achieve a safe (cold) shutdown condition at ANO-1 following the loss of power to any single Class 1E or Non-Class 1E bus that supplies power to plant instrument and control circuits. It is therefore concluded that IE Bulletin 79-27 concerns have been adequately resolved for ANO-1.

The audit team believes that to ensure reliable operation of the devices that perform automatic switching of bus power sources from one power source to another, the devices should be periodically tested for their safety function. A periodic test program for these devices is recommended to be developed by the licensee.

Dated: July 7, 1989

Principle Contributor: I. Ahmed

5.0 REFERENCES

1. NRC IE Bulletin No. 79-27, "Loss of Non-Class 1-E Instrumentation and Control Power System Bus During Operation," November 30, 1979.

2. NRC Information Notice No. 80-10, "Partial Loss of Non-Nuclear Instrument System Power Supply During Operation," March 7, 1980.

3. NUREG-1195, "Loss of Integrated Control System Power and Overcooling Transient at Rancho Seco on December 26, 1985," February, 1986.

4. NUREG-1231, "Safety Evaluation Report Related to Babcock & Wilcox Owners Group Plant Reassessment Program," November 1987 and Supplement 1 to the NUREG, March 1988.

5. Schematics, drawings, and procedures listed in Appendix A of this report.

6. Licensee personnel contacted during the audit and listed in Appendix B of this report.

Diagram 1 ES 480-Vac MCC B61

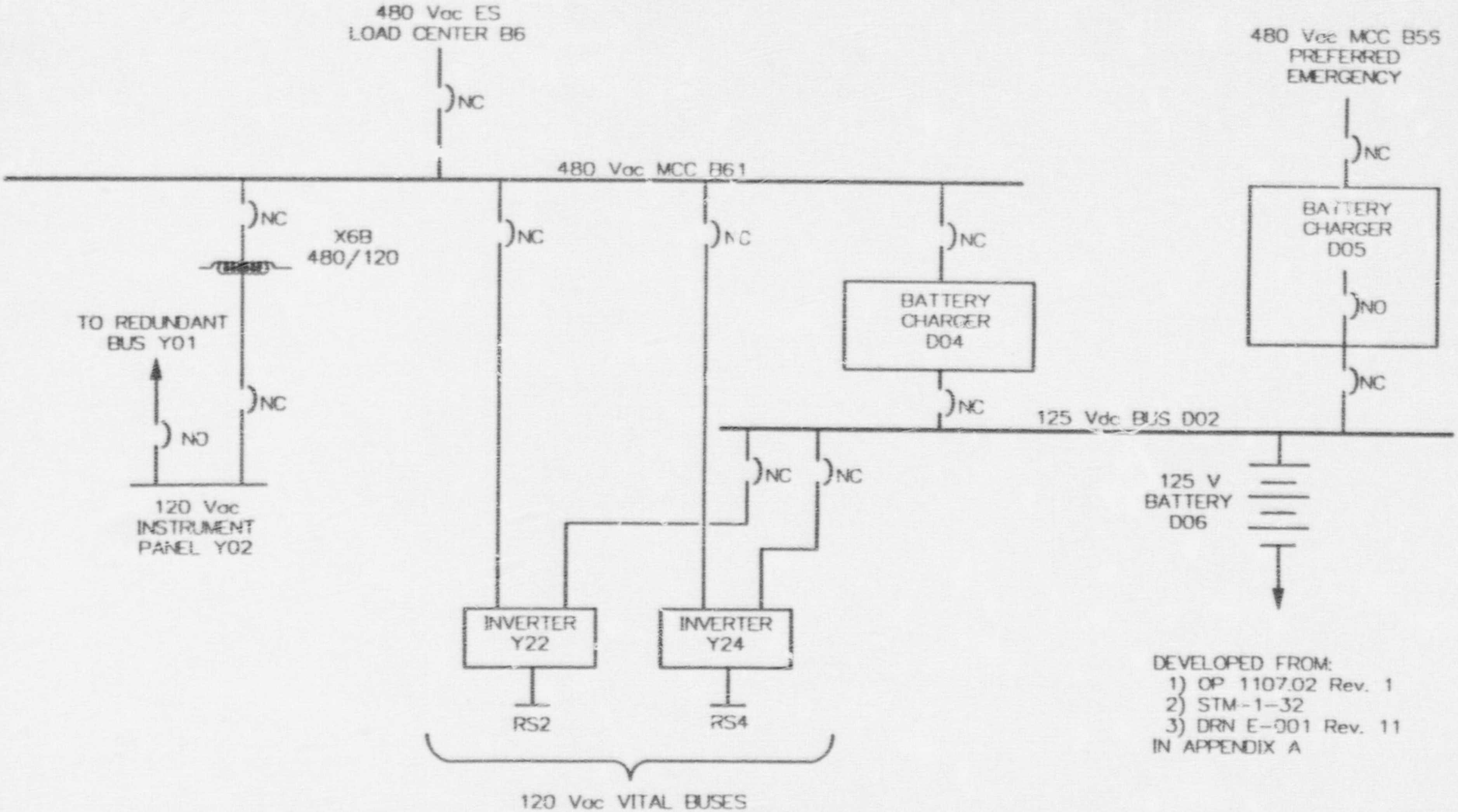
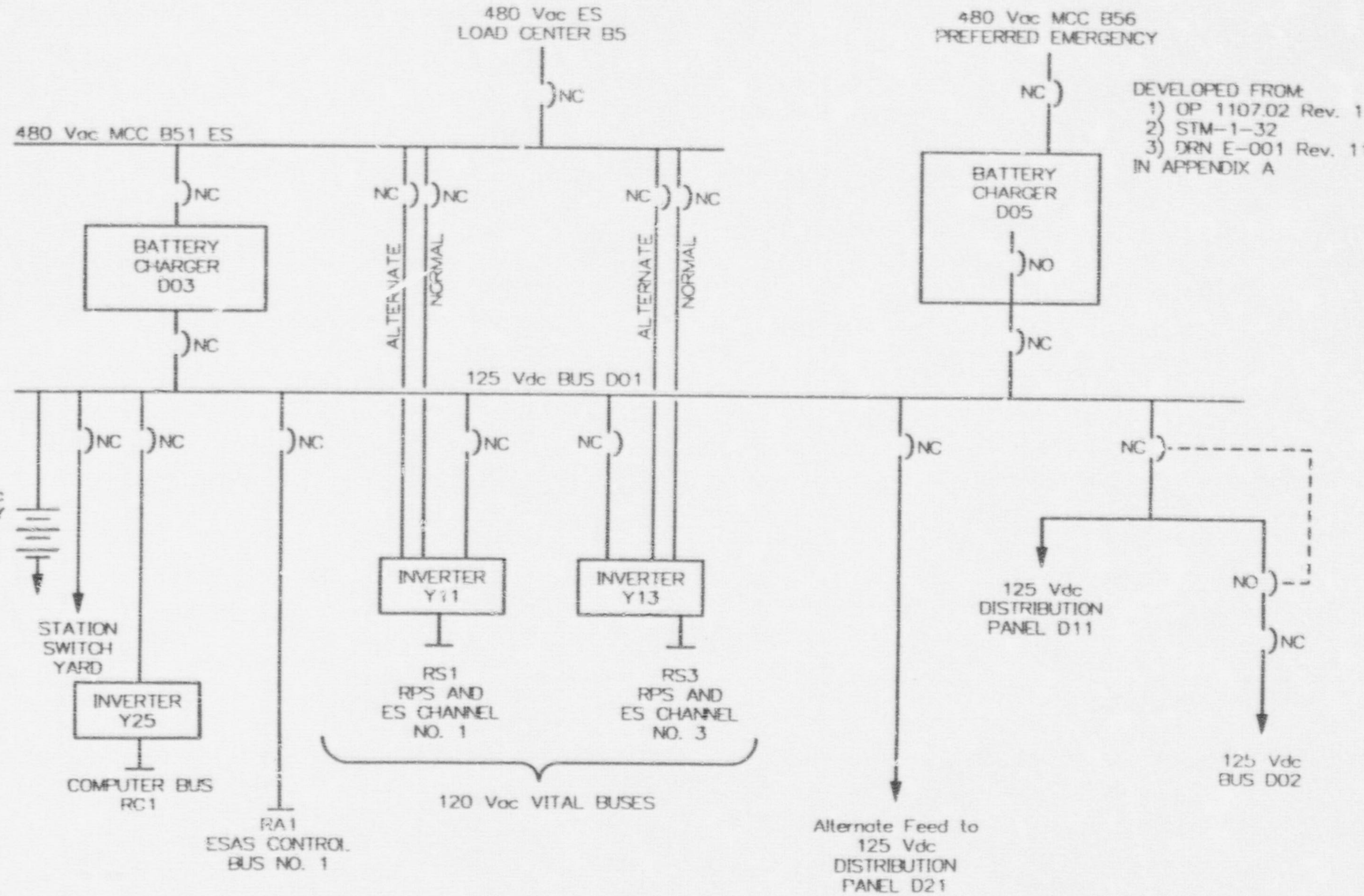
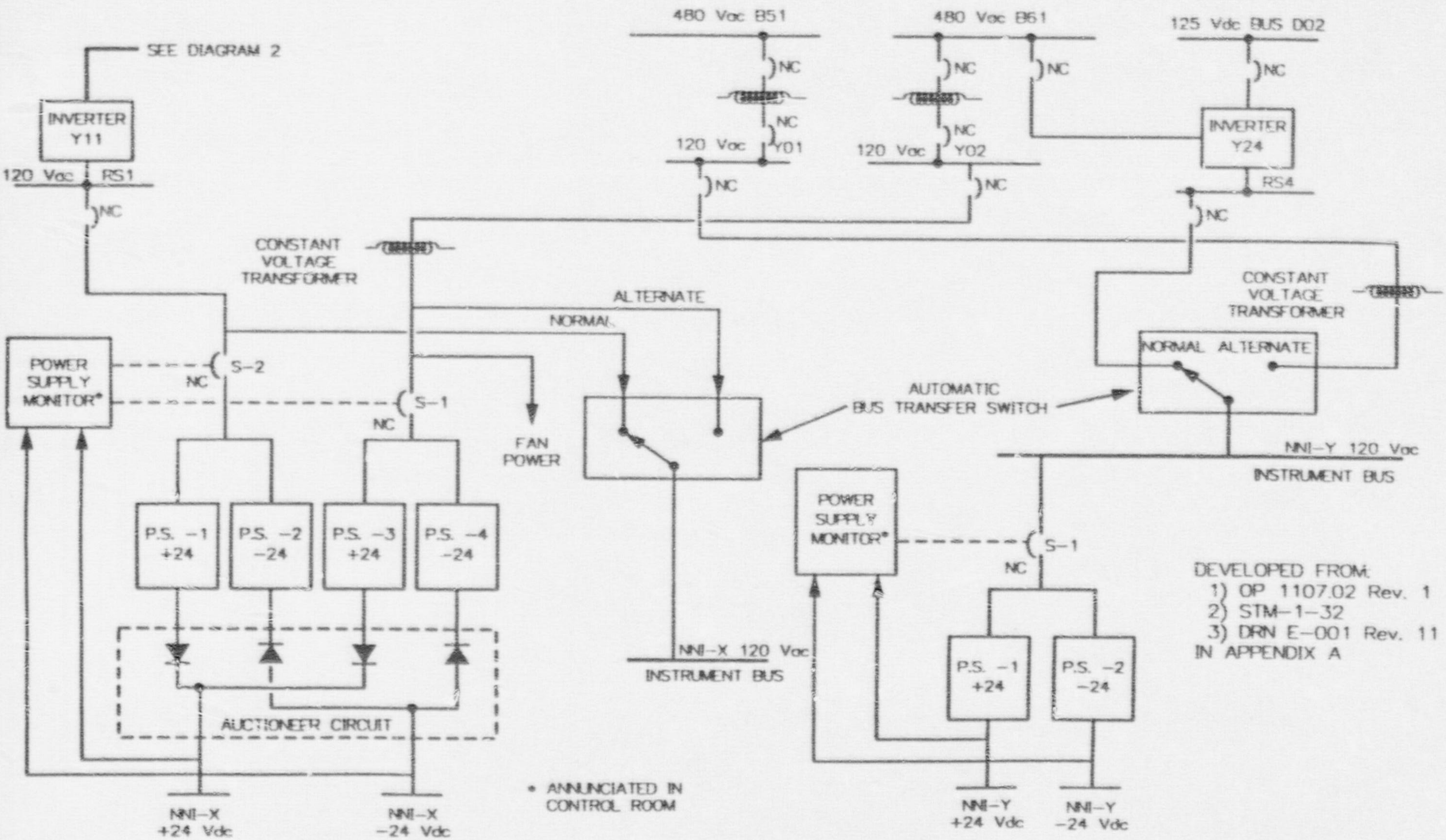


Diagram 2 125-Vdc Bus D01



DEVELOPED FROM:
1) OP 1107.02 Rev. 1
2) STM-1-32
3) DRN E-001 Rev. 11
IN APPENDIX A

Diagram 3 NNI Power System



* ANNUNCIATED IN CONTROL ROOM

DEVELOPED FROM:
1) OP 1107.02 Rev. 1
2) STM-1-32
3) DRN E-001 Rev. 11
IN APPENDIX A

APPENDIX A

DOCUMENTS EXAMINED

The following documentation was examined as part of this audit.

FSAR

Chapter 8	Rev. 11	Electrical Systems
Section 3.2.6	Rev. 11	Alternate Shutdown Systems and Components
Figure 8-1	Rev. 11	Station Single Line Diagram

Manuals

Sections 1, 3, 4, 6 and 7, "Inverter Installation and Operation," TMS 250.001D/0.0090 (controlled document).

DRAWINGS

Drawing Number	Revision	Title
M-230 Sheet 1	62	P&ID Reactor Coolant System
6600-MIR-189 Sheet 1	14	NNI Power Distribution Schematic
STM-1-32		
Fig. 32.44		480-Vac Distribution
Fig. 32.47		125-Vdc Distribution
Fig. 32.54		Inverters Functional Diagram
Fig. 32.58		NNI-X Power
Fig. 32.59		NNI-Y Power
Fig. 32.60		ICS Power

PROCEDURES

Procedure Number	Procedure Revision	Procedure Title
1102.10	29	Plant Shutdown and Cooldown
1107.01	3.1	Electrical System Operations
1107.02	2	ES Electrical System Operation
1202.01	11	Emergency Operating Procedure
1203.12A	24	Annunciator K01 Corrective Action
1203.12B	19	Annunciator K02 Corrective Action
1203.12L	19	Annunciator K14 Corrective Action
1307.002	1	Vital ac Inverter Test and Inspection

APPENDIX A (con't)

DOCUMENTS EXAMINED

DESIGN REVIEW REPORT

Project calculation No. 87E-0084-01, "Known Safe State Evaluation for ANO-1 ICS/NNI," July 15, 1985.

NUREG

Section 6.1.7, "ICS/NNI Reliability," NUREG 1231, Supplement 1, December 7, 1988.

APPENDIX B
LICENSEE PERSONNEL CONTACTED

R. Barnes	AP&L Design Engr.
K. Camite	AP&L OPSS Training
D. Howard	AP&L Licensing
P. Lomax	AP&L Licensing
S. Quennez	ANO General Manager
G. Sullins	AP&L Design Engr
R. Thorton	AP&L Licensing

NRC PERSONNEL PARTICIPATING

I. Ahmed	SICB/NRR
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R. McCormick	INEL
A. C. Udy	INEL