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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
AUDIT OF THE OCONEE-1/-2/-3 DESIGN FOR THE
RESOLUTION OF IE BULLETIN 79-27 CONCERNS
DUKE POWER COMPANY
OCONEE NUCLEAR STATION, UNITS 1, 2 AND 3
DOCKET NOS. 50-269, 50-270 AND 50-287

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 or 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 the 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 responses 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 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, 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 Oconee-1/-2/-3 audit consisted of two parts: 1) a pre-audit documentation review comprised of (a) examining plant electric distribution system single line diagrams, 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 as needed to bring the plant from an operating state with a reactor trip to a safe shutdown and cooldown condition; 2) an on-site audit chartered with determining 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 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 potentially 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 plant 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 by 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 a 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 (and the subsequent restoration of power to those cascaded power buses), 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 the operator capability for achieving a safe shutdown using the applicable procedures in each case. The selected buses were power panelboards KU, DIB, and KVIB (each normally has a unit designator [1, 2, or 3] before the equipment designation). Panelboards KU and DIB have loss of power annunciation in the control room. Loss of power to panelboard KVIB, however, would have to be deduced from the loss of power to specific loads such as the reactor coolant pump channel B power monitor.

3.1 Non-Class 1E 120-Vac Computer Power Panelboards KU

The Oconee Station has essentially identical 120-Vac computer power panelboards; 1KU in Unit 1, 2KU in Unit 2, and 3KU in Unit 3 (Diagram 1). Panelboard KU supplies a significant number of loads that are required to be operable by shutdown and cooldown procedures. Major loads supplied by the KU panelboards are two annunciator panels called 'Statalarm', the plant computer (including input/output and display devices), and nuclear instrumentation (source, intermediate, and power range) recorders. The KU panelboards are also a source of backup power to the ICS.

The KU panelboard normally receives power from the KU inverter. 125-Vdc power is supplied to the KU inverter through two isolating transfer diode assemblies. The diode assemblies consist of a fuse-protected series/parallel network of diodes. The assemblies are so connected to isolate the two dc power sources from each other. The diodes and fuses are continuously monitored; an alarm occurs if a component fails. Other alarms monitor the input and output circuit breakers, and control power for the monitor and indicating circuits. Should the KU inverter fail, an alternate, regulated AC power source is accessed by either a built-in automatic static transfer switch (not shown in Diagram 1), an external ASCO transfer switch, or a manual transfer.

The loss of power to KU panelboard is annunciated on its unit 'Statalarm'. The 'Statalarm' power source is independent of the KU panelboard, and will not be affected by the loss of the KU panelboard power. An undervoltage relay on the KU panelboard operates the annunciator module. The response procedure for this alarm lists the manual actions to be performed by the operator (Appendix A).

The KU panelboards supply power for the computer logging of parameters such as steam generator tube-to-shell temperature difference, startup transformer temperatures, pressurizer surge line temperature, and electrohydraulic control system emergency trip. The licensee stated that all these parameters can be manually logged by the operator.

The KU panelboards supply power to display groups 04 and 16 of the operator aide computer in their respective units. These display groups are transferred to panelboard OAC on the loss of the panelboard KU power source, thus assuring the availability of these displays. The nuclear instrument recorders will also be lost due to the loss of KU panelboard. However, the operator will have indications from individual channels to help him follow the plant shutdown procedure.

As the KU panelboards only provide an alternate source of power to the ICS, a unit's ICS will not be affected by the loss of its KU panelboard.

Reactor building temperature instruments that are powered by the KU panelboards are not needed for normal plant shutdown except for recovery from a loss of coolant accident and for the operation of the hydrogen recombiners. Thus, the loss of this instrumentation will not affect the operator's ability to achieve a safe shutdown upon the loss of the KU panelboard.

Indication of the 1B (2B or 3B) core flood tank outlet valve position is lost with the loss of KU panelboard. This valve is locked in the open position while the unit is operating. Power is still available to close the valve in the normal manner.

To prevent inadvertant core lift when starting a reactor coolant pump, the operator normally observes the cold leg temperature. With the loss of this instrumentation caused by the loss of the KU panelboard, the in-core thermocouples are still usable. Operator training is provided for this alternate method of core lift protection.

Based on the above design features, plant operating procedures, and operator training, the audit team concluded that following the loss of power to the KU panelboards (1KU for Unit 1, 2KU for Unit 2, and 3KU for Unit 3), the operator has sufficient instrumentation, indication, and equipment available in the control room to achieve cold shutdown using the approved procedures.

3.2 Class 1E 125-Vdc I&C Power Panelboard DIB

The Oconee Station has essentially identical 125-Vdc instrument and control power panelboards; 1DIB in Unit 1 ; 2DIB in Unit 2, and 3DIB in Unit 3 (Diagram 2). Panelboard DIB supplies a significant number of loads that are required to be operable by shutdown and cooldown procedures. Major loads supplied by this panelboard include the controls for the 'A' emergency feedwater pump, the 'B1' and 'B2' reactor coolant pumps, and the 'B' low pressure injection pump. The licensee stated that the protection scheme of all these loads use a second trip coil with the control power independent of the DIB panelboard. Thus, the operator would be able to trip these loads with no variance from normal procedures. The DIB panelboard also supplies power for the controls of the main turbine, the control rod drive controls, the DIB static inverter (discussed in Section 3.3), and motive power for the letdown isolation valve.

The loss of turbine controls caused by the loss of a DIB panelboard will cause a turbine trip. This, in turn, will cause a reactor trip. The operator is procedurally instructed to manually trip the reactor and the turbine generator as a backup operation for the postulated event. With the turbine trip, the licensee verified that the units power distribution system would successfully transfer from the unit generator to the offsite power. However, two reactor coolant pumps (B1 and B2) will not be operable due to control power loss which is acceptable with a reactor trip as the emergency operating procedure allows operation with one RCP per loop.

The control rod drive controls (diamond control station) receive power from two redundant sources, one of which is the DIB panelboard for that unit. Because of the built-in redundancy, loss of power from a DIB panelboard will not affect operation or indication of the control rods.

Long-term heat removal from the reactor coolant system is provided by one of the three low pressure injection (LPI) pumps. One LPI pump (pump B) will be inoperable due to the loss of control power from panelboard DIB. However, LPI pump "A," backed up by pump "C" will be sufficient to provide long term reactor heat removal during plant shutdown.

The HP-5 letdown isolation valve in each unit is located outside of containment and fails closed on the loss of motive power from panelboard DIB. The licensee stated that there are upstream valves that can be manipulated to regulate letdown flow, however, it will be difficult to match the letdown and makeup flows. The licensee stated that in this case it would be possible and preferable to manually open the failed closed valve.

Based on the above design features, plant operating procedures, and operator training, the audit team concluded that following the loss of power to the 125-Vdc I&C power panelboard DIB, the operator has sufficient instrumentation, indication, and equipment available in the control room to achieve cold shutdown using the approved procedures.

3.3 Class 1E 120-Vac AC Vital Instrumentation Power Panelboards KVIB

The Oconee Station has essentially identical 120-Vac vital instrumentation power panelboards; 1KVIB in Unit 1 , 2KVIB in Unit 2, and 3KVIB in Unit 3 (Diagram 3). Panelboard KVIB is the source of power for the nuclear instrumentation, Reactor Protection System (RPS) channel B, portion of the Engineered Safeguards (ES) instrumentation (channel B), the steam generator level control cabinet, and the Reactor Coolant Pump (RCP) power monitor channel B. The KVIB panelboard is fed from a, a 9.3 KVA static inverter (DIB), that has an integral manual transfer switch. This transfer switch can be used to manually transfer the KVIB panelboard to the alternate power source (regulated power panelboard KRA) if the KVIB panelboard has lost its normal power source from the associated inverter DIB. Loss of power to the KVIB panelboard is not annunciated in the control room, however, annunciation of the trip of the RCP power channel B monitor and the ES instrument system channel B would provide indirect indication of loss of power to this panelboard.

RPS channel B and ES channel B will be tripped by the loss of power to KVIB panelboard. However, RPS or ES initiation will not occur as each system requires 2 channels to trip for actuation.

Loss of power to this panelboard does not affect the ability of the operators to achieve cold shutdown. Although many of the instruments and controls that receive power from this panelboard are procedurally needed for a safe unit shutdown, procedures and operator training are provided to assist in bypassing inoperable controls, manually controlling a normally automatic function, or relying on redundant instrumentation.

Based on the above design features, plant operating procedures, and operator training, the audit team concluded that following the loss of power to the KVIB 120-Vac AC vital instrumentation power panelboards (1KVIB for Unit 1, 2KVIB for Unit 2, and 3KVIB for Unit 3), the operator has sufficient instrumentation, indication, and equipment available in the control room to achieve cold shutdown using the approved procedures.

3.4 Automatic Bus Transfer Switches

Continued power availability on panelboard KU relies on the operation of automatic bus transfer (ABT) by means of ASCO transfer switch and static transfer switch.

Preventative maintenance procedure for the inverter associated with these switches requires the test of the operation of the switches by manually opening the inverter output and input source circuit breakers. The annunciators that monitor position of the ASCO and the static transfer switches are observed to verify the operation of the ABT. The licensee verified that this testing is current for each of the inverters.

4.0 CONCLUSIONS

Based on the sample audit for the loss of three individual buses, the audit team was reasonably assured that a loss of power to any of the three buses will not result in a plant condition that requires operator action and the simultaneous loss of the control room indication on which the required action to bring the plant to a safe shutdown using approved operating procedures is based. The audit results provided sufficient evidence that by using the existing procedures, a safe (cold) shutdown can be achieved at any Oconee Unit following the loss of power to any single Class IE or Non-Class IE bus that supplies power to plant instrumentation and control circuits. It is, therefore, concluded that IE Bulletin 79-27 concerns are adequately resolved for the Oconee design and procedures.

The audit team also concludes that the licensee assures reliable operation of the devices that perform automatic switching of bus power sources from one source to another by periodic testing for their safety function. A preventive maintenance and periodic test program for these devices has been developed and implemented to assure their reliability.

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Dated: December 7, 1989

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 Nonnuclear Instrumentation System Power Supply During Operation," March 7, 1980.

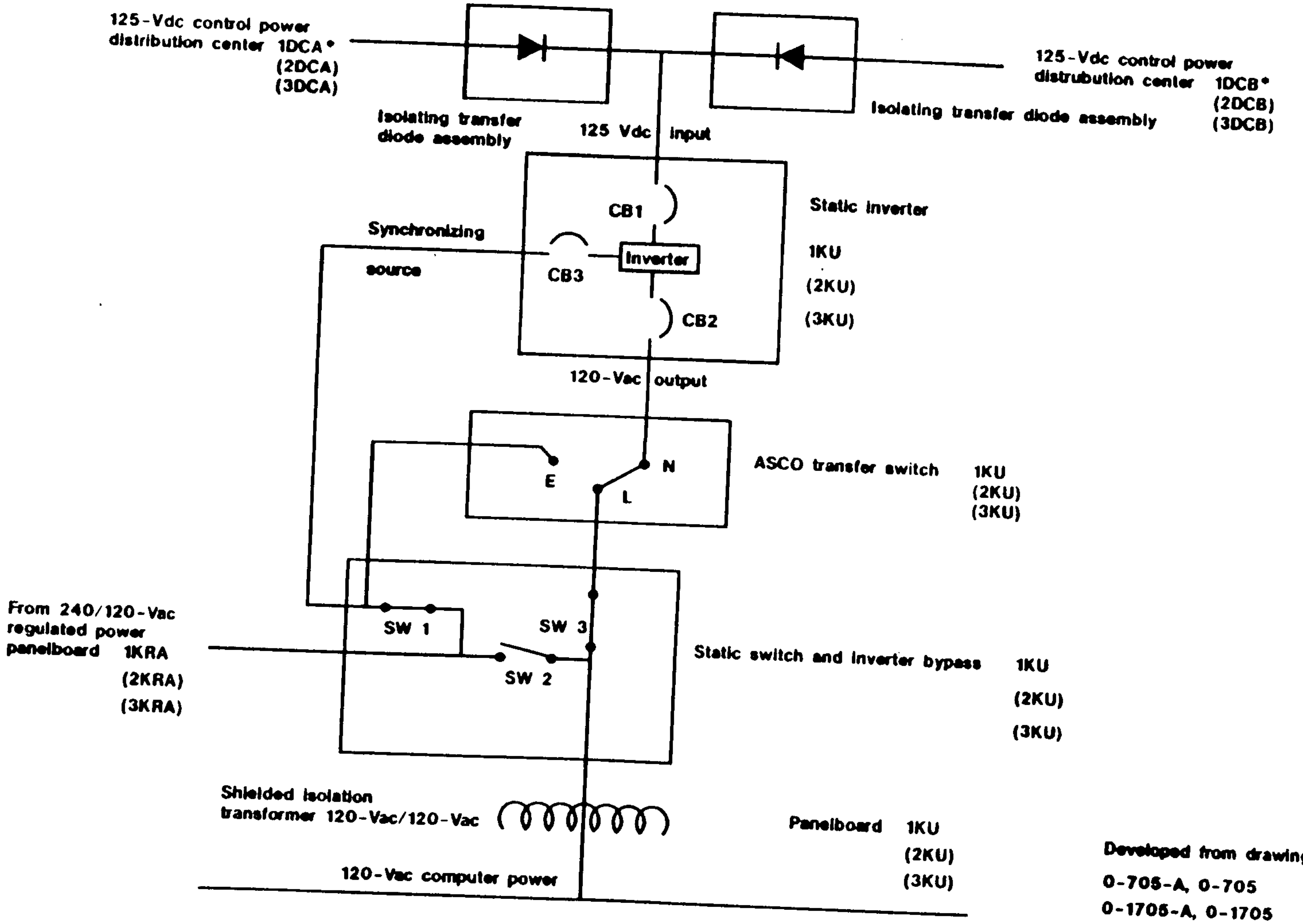
3. NUREG-1195, "Loss of Integrated Control System Power and Overcooling Transient at Rancho Seco on December 26, 1985," February 1986.

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. Non-Class 1E 120-Vac Computer Power Panelboards KU

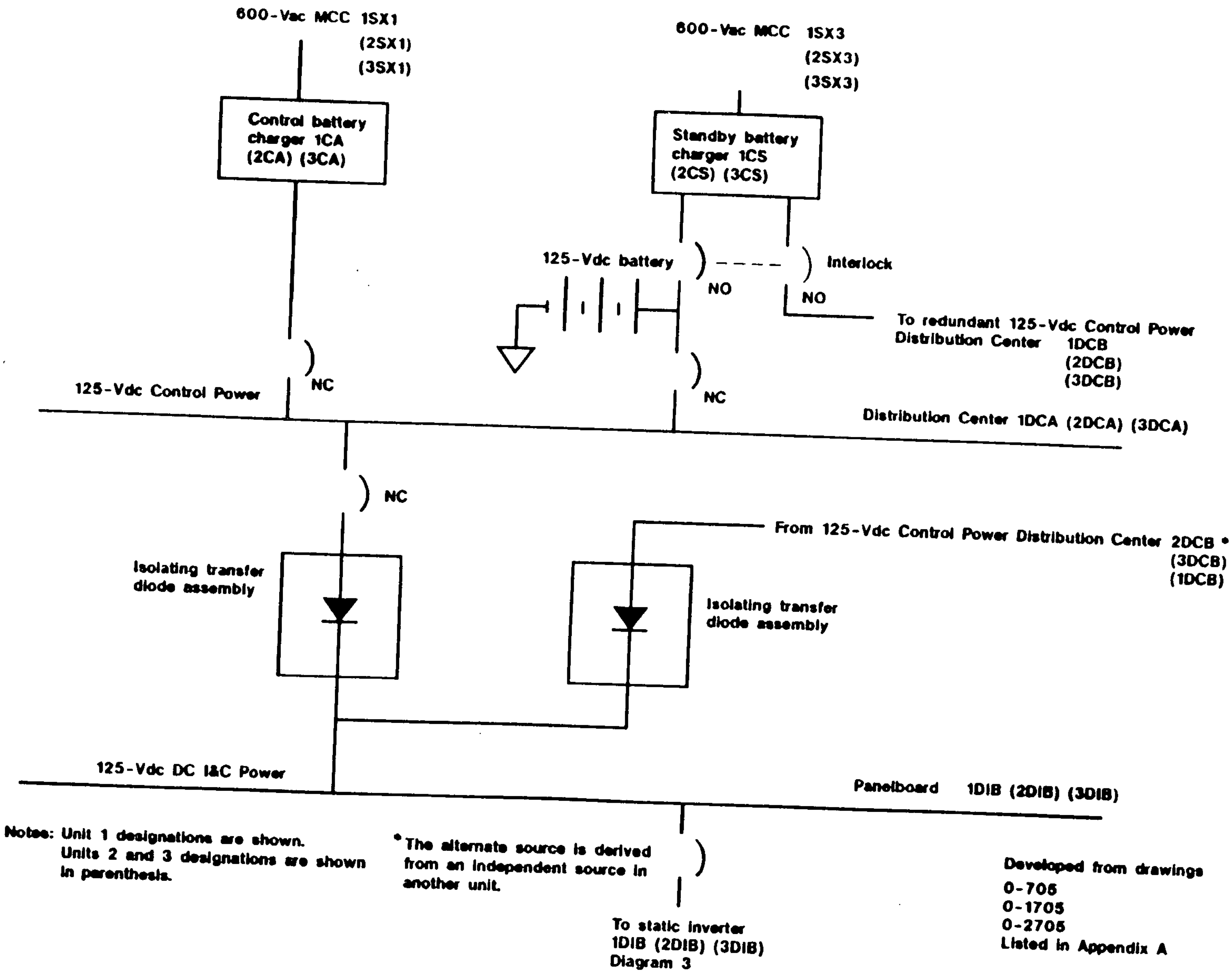


Developed from drawings
0-705-A, 0-705
0-1705-A, 0-1705
0-2705-A, 0-2705
Listed in Appendix A

Note: Unit 1 designations are shown
Units 2 and 3 designations are shown in peretheais

*125-Vdc distribution center 1DCA is redundant to 125-Vdc distribution center 1DCB. Units 2 and 3 have the same redundancy.

Diagram 2. Class 1E 125-Vdc I&C Power Panelboards DIB

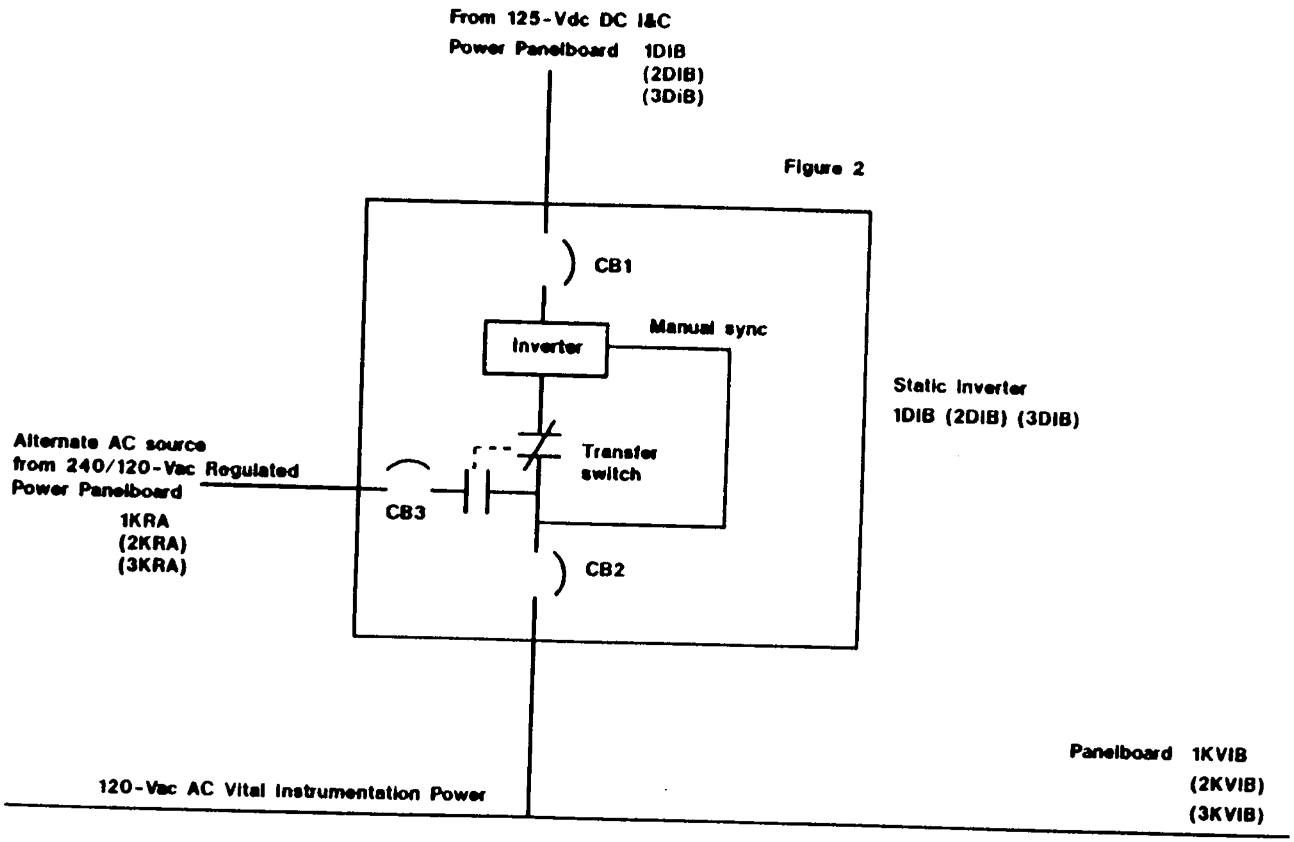


Notes: Unit 1 designations are shown.
Units 2 and 3 designations are shown in parenthesis.

* The alternate source is derived from an independent source in another unit.

Developed from drawings
0-705
0-1705
0-2705
Listed in Appendix A

Diagram 3. Class 1E 120-Vac AC Vital Instrumentation Power Panelboards KVIB



Note: Unit 1 designations are shown
Units 2 and 3 designations are
shown in parenthisis

Developed from drawings
0-705
0-1705
0-2705
Listed in Appendix A

APPENDIX A
DOCUMENTS EXAMINED

The following documentation was examined as part of this audit.

Drawings

Drawing Number	Unit	Revision	Title
D8038873E	--	DE	Integrated and Aux Control Power Distribution Part 1
D8038873E	--	DF	Integrated and Aux Control Power Distribution Part 1
D8041442D	--	DG	Integrated and Aux Control Power Distribution Part 1
D8032306D	--	DE	Integrated and Aux Control Power Distribution Part 1
D8041443B	--	DC	Integrated and Aux Control Power Distribution Part 2
D8038874C	--	DD	Integrated and Aux Control Power Distribution Part 2
OEE-118-33	--	2	Elementary Diagram PWR. PNL. BDS. Under Voltage Alarms
F4059	--	--	Electrical Load List
0-700	1	15	One Line Diagram Relays and Meters 19kV
0-702	1	17	One Line Diagram 6900V and 4160V Station Auxiliary System
0-702A	1	16	One Line Diagram 6900V and 4160V Station Auxiliary System
0-702-A2	1	3	One Line Diagram 6900V and 4160V Station Auxiliary System

Drawing Number	Unit	Revision	Title
0-703E	1	29	One Line Diagram Station Auxiliary Circuits 600V
0-703F	1	33	One Line Diagram Station Auxiliary Circuits 600V 2
0-703G	1	28	One Line Diagram Station Auxiliary Circuits 600/208V/480
0-704	1	46	One Line Diagram Station Auxiliary Circuits 208y/120VAC
0-705	1	36	One-Line Diagram 120Vac and 125Vdc Station Auxiliary Circuits Instrumentation Vital Buses
0-705-A	1	--	One-Line Diagram 240/120Vac Station Auxiliary Circuits Comp., ICS & Reg Supply
0-705-B	1	15A	One-Line Diagram 125/250Vdc Station Auxiliary Circuits
0-785-G	1	2	One-Line Elem. Conn. PNL. Cutout ICS Redundant PWR. Source
0-1700	2	13	One Line Diagram Relay and Meters 19kV
0-1702	2	10	One Line Diagram 6900V & 4160V Station Auxiliary System
0-1703-D	2	19	One Line Diagram Station Auxiliary Circuits 600V
0-1703-E	2	19	One Line Diagram Station Auxiliary Circuits 600V
0-1703-G	2	21	One Line Diagram Station Auxiliary Circuits 600V
0-1705	2	26	One Line Diagram 120VAC and 125VDC Station Auxiliary Circuits Instrumentation Vital Buses

Drawing Number	Unit	Revision	Title
0-1705-A	2	26	One Line Diagram 240/120VAC Station Aux. Circuits Comp,. ICS & Reg. Supply
0-2700	3	9	One Line Diagram Relays and Meters 19kV
0-2702	3	13	One Line Diagram 6900V and 4160V Station Auxiliary Sys.
0-2703-D	3	27	One Line Diagram Station Auxiliary Circuits 600/208V
0-2703-E	3	18	One Line Diagram Station Auxiliary Circuits 600/208V
0-2703-G	3	20	One Line Diagram Station Auxiliary Circuits 600V
0-2704	3	39	One Line Diagram Station Auxiliary Circuits 208/120VAC
0-2705	3	33	One Line Diagram 120VAC and 125VDC Station Aux Circuits Instrumentation Vital Buses
0-2705-A	3	28	One Line Diagram 240/120VAC Station Aux. Circuits Comp., ICS & Reg. Supply

Procedures

Number	Changes	Title
OP/1/A/1102/10	83	Controlling Procedure for Unit Shutdown
IP/0/A/3011/1	15	Preventative Maintenance Procedure for Exide Inverters

Number	Changes	Title
IP/0/B/3011/10	00	Preventive Maintenance Procedure for SCI Inverter
1SA-12-E-8	--	Power Panelboard 1DIB Voltage Low
OP/1/A/1106/01	23	Oconee Nuclear Station Turbine Generator
1SA-5/C-12	--	EL Computer Inverter System Trouble
2SA-12/E-9	--	Computer Power Panelboard 2KU Voltage Low
3SA-12/E-9	--	Computer Power Panelboard 3KU Voltage Low
AP/1/A/1700/23	1	Loss of 1KI Bus
EP/1/A/1800/01	2	Emergency Operating Procedure
OP-OC-EL-DCD	1	Operator Training/DC Power Distribution
OP/1/A/1102/04	47	Operation at Power

APPENDIX B

LICENSEE PERSONNEL CONTACTED

C. Boyd*	Design
D. Deatherage*	Operations
W. Foster	Maintenance
G. Edens	Transmission Engineer
T. Glenn*	Maintenance
C. Harlin*	Compliance
E. LeGette	Compliance
B. Millsaps*	Maintenance
W. Rostrom	Maintenance
T. Stevens	Operation Assistant Shift Supervisor
R. Sweigart*	Operations Superintendent
M. Tuckman*	Station Manager

NRC Personnel Participating

I. Ahmed*	NRC/SICB
R. McCormick*	INEL
A. Udy*	INEL
L. Wert*	NRC/RI

* Attended Exit Meeting.