AUGMENTED INSPECTION TEAM REPORT

U.S. NUCLEAR REGULATORY COMMISSION

CALLAWAY LOSS OF ANNUNCIATORS EVENT

OCTOBER 16 - 19, 1992

INSPECTION REPORT NO. 50-483/92018(DRP)

U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-483/92018(DRP) License No. NPF-30

Docket No. 50-483

Licensee: Union Electric Company
Post Office Box 149 - Mail Code 400
St. Louis, MO 63166

Facility Name: Callaway Nuclear Power Station

Inspection Conducted: October 19 through 25, 1992

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Inspection Summary:

Inspection on October 19-25, 1992 (Report No. 50-483/92018(DRP))

Areas Inspected: Special Augmented Inspection Team (AIT) inspection conducted in response to the loss of control room annunciators at the Callaway Nuclear Power Station on October 16, 1992. The review included validation of the sequence of events, determination of the root cause for the annunciator loss and equipment failures during the event, evaluation of licensee response to the event, and evaluation of the licensee's event classification and reporting.

Results: No operational safety parameters were approached or exceeded. The AIT concluded that the root cause of the initial power supply failure was random failure of its power transformer; the root cause of the subsequent blown fuses was personnel error; and the overall root causes for the event were poor communications/teamwork, lack of a questioning attitude/complacency, inadequate knowledge of annunciator system, and a less than adequate work performance.

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1.0 Introduction

1.1 Event Summary

On October 19, 1992 at approximately 12:40 p.m., Callaway engineers reviewing operational data from October 16 and 17 discovered that at 1:00 a.m. on October 17, all main control room annunciators had been inoperable and the operators had been unaware of this condition.

1.2 AIT Formation

On October 19, 1992, senior NRC managers determined that an AIT was warranted to gather information on the loss of annunciators, partial loss of annunciators, and failure to recognize the operational effects which occurred during the event. An AIT was formed consisting of the following personnel:

Team Leader: R. A. Westberg, Team Leader, Division of Reactor Safety (DRS)

Team Members: B. L. Bartlett, Senior Resident Inspector Callaway Site, Division of Reactor Projects

R. A. Spence, Reactor Systems Engineer, AEOD

T. D. Reidinger, License Examiner, DRS

L. R. Wharton, Licensee Project Manager Callaway Site, NRR

F. P. Paulitz, I&C Engineer, NRR

One member of the AIT, the Senior Resident, was on site on October 19, 1992. The full AIT arrived on site October 20, 1992. In parallel with formation of the AIT, RIII issued a Confirmatory Action Letter (CAL) (Enclosure 2) on October 20, 1992, which confirmed certain licensee actions in support of the team inspection.

1.3 AIT Charter

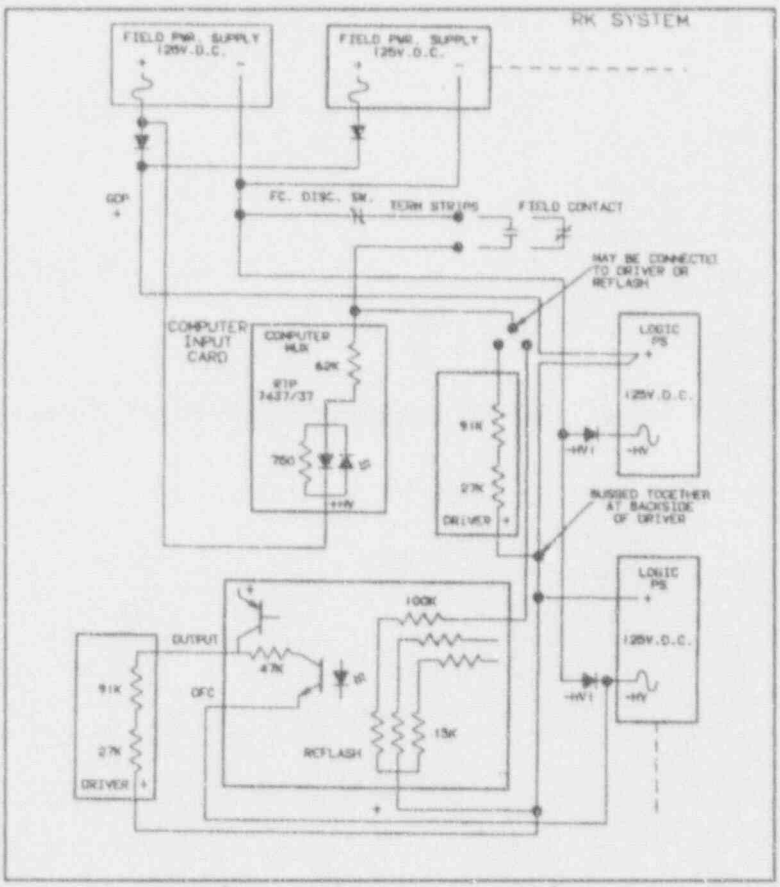
A charter was formulated for the AIT and transmitted from W. L. Forney to R. A. Westberg on October 20, 1992, (Enclosure 3) with copies to appropriate EDO, NRR, AEOD, and RIII personnel. The AIT's objectives were to: (1) conduct a timely, thorough, and systematic inspection related to the event, (2) assess the safety significance of the event and communicate to Regional and Headquarters management the facts and safety concerns related to the event such that appropriate followup actions are taken, and (3) collect, analyze, and document factual information and evidence sufficient to determine the cause(s), conditions, and circumstances pertaining to the event.

The AIT completed its charter and was terminated on Saturday, October 24, 1992.

2.0 Background Information

2.1 System Description

The annunciator system was designed by the Riley Corporation. The system is designed to monitor 1400 alarm points using field contacts which either open or close, to alert operators in the control room by illuminating an annunciator window and sounding an audible alarm. Individual alarm points that are grouped on a system basis also feed the plant computer for display on the cathode-ray tube and the alarm printer.



Annunciator Power Supplies

The system has four power supplies connected to a 125Vdc station battery to power the 1400 field alarm contacts. These power supplies have common

(parallel connected) inputs and outputs, and each power supply input and output is protected by a one ampere "slow blow" (delayed opening) fuse. There are also 14 logic power supplies that receive their input power from one of two 125Vdc station battery systems, one of which is common to the field contact power supplies discussed above. The logic power supplies provide five different voltages to the system and each has a protective fuse associated with its voltage. None of the fuses (78 total) have local indication or indicating lights to monitor their operability.

2.2 Precursors to the Event

On the evening of October 16, 1992, the plant was at 100% power, 1224MW electric. No major plant evolutions were in progress and no major pieces of plant equipment were out-of-service. No technical specification action statements were in effect.

The AIT's charter limited the inspection to this one event. However, the AIT noted that previous events of loss of almost all of the annunciators had occurred. There have been 12 previous power supply failures during the last nine years that caused partial losses of operability of the annunciator system.

2.3 Sequence of Events

In order to validate the sequence of events associated with the loss of annunciators, plant computer, related power supplies, and fuse failures, the AIT conducted interviews with licensee management, operations personnel, and instrument and control (I&C) personnel cognizant of the event. Licensee documentation and event review meeting summaries were also reviewed to determine the actual sequence of events.

At 6:40 p.m., approximately 76 annunciators illuminated. The control room operators immediately verified that no plant trip, transient, or other evolution had caused the large number of alarms. This condition was initially diagnosed as either a blown fuse or a power supply problem. The shift supervisor (SS) notified the I&C shift technicians and requested engineering support from the Engineering Duty Officer (EDO). At approximately 7:00 p.m. the plant manager (MCP) was also notified (he was still on-site). At 7:26 p.m., the two I&C technicians replaced one fuse on logic bay power supply No. RK045E1. However, the fuse replacement did not correct the problem or change the status of any of the annunciator windows.

The I&C technicians identified a problem with the Multiplex (MUX) cabinet field power supply No. 2 (RK045D1). The I&C planner reported on site at 8:45 p.m. and began to research previous work requests (WRs) related to annunciator problems. The backup system engineer was contacted and arrived on site at 9:00 p.m.. The I&C technicians obtained a replacement power supply from the warehouse and bench tested it in the I&C shop for about one hour. The planner and system engineer met in the back of the control room at the power supply cabinet to view the degraded power supply, discuss the replacement and any necessary installation precautions. The I&C planner and backup system engineer continued to discuss the power supply installation with the I&C

technicians in the I&C shop. The I&C crew (planner, backup system engineer, and technicians) reviewed drawings and previous WRs to develop an appropriate jumpering configuration.

At approximately 11:00 p.m., the midnight (OWL) shift relieved the 3:00 to 11:00 (PM) shift. The OWL shift I&C technicians were briefed on the WR work instructions by the I&C planner. At 11:15 p.m., the I&C crew entered the control room to obtain SS approval for the WR. The OWL shift SS verified that a specified caution was on the WR and authorized the work. The caution stated if all four power supplies were inoperable that an Alert should be declared. The SS contacted the MCP and informed him of the plans to replace the failed field power supply.

On October 17, 1992 at 12:58 a.m., field power supply No. 2 was replaced and all annunciator window lights cleared. At 1:00 a.m., a short circuit occurred coincident with removal of the output jumpers from the terminal blocks of the power supply. The short circuit caused fuses to blow on all four field power supplies resulting in a loss of the main control room annunciator system. Numerous annunciators (approximately 360) were illuminated. Also affected were numerous plant computer alarms. Fuses for the field power supplies were obtained from the I&C shop and the previously failed power supply. During replacement of the fuses, there was a problem which caused the fuses to blow again at 1:24 a.m.. Additional fuses were obtained from the warehouse, and at 1:56 a.m., the I&C technicians successfully replaced the four blown fuses in the field power supplies and restored power to the main control room annunciator system. Upon restoration of power, the illuminated annunciators cleared and the critical problems with the system were considered corrected. The operations crew performed lamp tests on all the annunciator panels, which they assumed verified operability of the system. The SS signed the WR, indicating completion of work on the annunciator system.

The OWL shift crew continued to observe anomalous annunciator operation at this time. The SS considered the remaining annunciator problems minor, which could wait to be analyzed on the 7:00 a.m. to 3:00 p.m. (AM) and PM shifts.

At approximately 7:00 a.m., the AM shift relieved the OWL shift. Operating crews were told to closely monitor control panels due to continuing annunciator problems. Sometime between 7:00 a.m. and 7:30 a.m. on October 17, 1992, the control room called I&C and indicated that the annunciators were not normal because a demineralizer alarm came in and would not stop flashing when it was acknowledged. At the same time, a reactor coolant system level alarm which is normally defeated during power operations had also come in. At 3:00 a.m., the MCP called the SS concerning the status of the annunciator problem. Discussions were held regarding the need for and authorization to call in additional operations and engineering support to resolve the annunciator problem. The SS contacted the supervising engineer and I&C technicians to again troubleshoot the annunciator system. During the remainder of the shift, troubleshooting of the annunciator system continued.

At 9:32 a.m., operations conducted a lamp test of the annunciator windows and observed a panel with only half bright illumination. At 1:00 p.m., the I&C senior system engineer identified a bad logic power supply which was

subsequently replaced. Operations performed additional local equipment tests to verify the operability of the various trouble annunciators. However, the associated alarms did not activate.

At 4:30 p.m., I&C determined that five additional logic power supply fuses had been blown. These fuses were assumed to have blown at 1:56 a.m. when the four field power supply fuses blew because they were all connected (powered by the same 125Vdc station battery). The fuses were replaced at about 5:00 p.m. and all logic power supplies were verified by a testing scheme developed by the senior system engineer using input relay and driver logic cards. Testing continued until 7:37 p.m. and the event ended when the control room annunciator system, including the plant computer inputs, were verified as completely restored and fully operable.

Based on their review, the AIT determined the time line provided by the licensee associated with the annunciator loss was complete and accurate.

3.0 Event Response

3.1 Operator Response

To determine what actions the operators took in response to the event and the suitability of these actions, the AIT reviewed plant logs, appropriate plant emergency and normal operating procedures, and interviewed the operators involved in the event.

Operator actions during the loss of all annunciators were considered less than adequate. Since the operating crews did not comprehend the assessment capability loss that occurred, they responded to the event in a less than systematic manner, without the use of all available information or procedures to implement compensatory operator actions. As the operators had not been adequately trained in the partial or total loss of the annunciator logic, annunciator power supply systems, or the plant computer system, the operators experienced momentary confusion during the cascading annunciator failures on the various panels. Thus, the reactor operators (ROs) were not aware of the extent of the loss of the annunciators, due to the number of invalid computer alarms that were printed and only a portion of the annunciator windows illuminating. The operators monitored redundant control board instrumentation immediately after the losses of annunciators at 6:40 p.m. on October 16 and at 1:00 a.m. and 1:24 a.m. on October 17, 1992.

Although no procedural guidance existed, the OWL shift SS appropriately directed that no power level changes be initiated after the loss of annunciators because they were concerned about being able to monitor plant equipment status. The two ROs, on their own initiative, increased the frequency of their respective main control board panel walkdowns after the initial annunciator loss. However, this was not performed continuously, nor were additional ROs assigned to augment the on-shift ROs.

The operators' inadequate understanding of the annunciator system resulted in the following:

- not declaring an alert when all annunciators were lost
- devoting insufficient manpower to corrective actions
- not implementing available abnormal procedures on the loss of the plant computer when plant computer was partially lost
- continuing a liquid radwaste release during the event
- Signing the WR as completed while 163 annunciators still remained inoperable
- devoting shift management resources to a 345kV line tag out
- performing turbine stop valve surveillance testing during the event
- ignoring some plant computer alarms
- not taking adequate control room or plant compensatory measures
- devising unapproved, informal, and ad hoc annunciator functional testing which resulted in a false impression of the operability of the annunciator system, when in fact, 163 annunciators were inoperable.

3.2 Managerial Performance

3.2.1 Initial Shift Supervision Involvement

When it was concluded that there was a problem with the annunciator system, the SS called I&C and the MCP. Normally, the SS would call the EDO but since he had seen the MCP in the control room about an hour before he thought he might still be on site. Thus, when he called the MCP and informed him that approximately 76 annunciators were inoperable, the MCP came to the control room. The SS then called the EDO at home and informed him of the situation. During this time frame, the SS called the engineering duty supervisor and requested that an I&C engineer be sent to the site to assist the I&C technicians.

When the I&C technicians determined that the 125Vdc field contact power supply had failed, the SS requested that an I&C planner be sent to the site to help plan any WRs needed to replace the power supply. The I&C planner arrived on site and began to research previous WRs. As part of a documentation review on the computer, the I&C planner found a previous WR for replacing the power supply. It was still on the computer when the PM shift SS walked by and read it. At about this time, the next shift operating crew was arriving to take the OWL shift. The SS informed the OWL shift SS of a caution in the previous WR which stated that if all four power supplies were inoperable that an Alert should be declared. The OWL shift SS informed the I&C planner that when the new WR was written that he wanted a similar caution placed in it.

When the power supply fuses blew at 1:00 a.m., the SS went to the back of the control room to find out what had occurred. He was informed that they had "blown some fuses." No one informed the SS which fuses had been blown or what the effects of this would be; however, the SS did not ask for this information.

When the EDO and the MCP had talked with the PM shift SS, they had requested that they be notified of any change in status. However, this request was not recorded in the turnover log. This information was passed on to the OWL shift SS during the shift turnover. The OWL shift SS failed to notify either of these individuals of the additional annunciators that had become inoperable.

During the shift turnover briefing, the OWL shift SS had directed his ROs to pay additional attention to the control boards and delayed performance of a scheduled surveillance. However, when the additional annunciators became inoperable at 1:00 a.m., no additional personnel were brought in to observe the control room boards, no plant announcement was made to alert plant personnel to pay additional attention to plant status, and the equipment operators were not directed to increase monitoring of their assigned equipment status.

The SS and the crew did evaluate plant conditions in an effort to determine whether they met the conditions for an alert status. Due to the misconception that only one half of the annunciators were inoperable since only half were illuminated, the SS decided that they were not in an alert. The OWL shift STA also joined the discussion of emergency action level (EAL) conditions and agreed with the SS that an alert level was not reached. However, the STA accepted the hypothesis that only one half of the annunciators were inoperable without additional independent verification. The STA also did not discuss what equipment was affected with I&C, review the annunciator system, or question which annunciators were affected.

The licensee's internal problem identification and resolution system is known as the SOS (Suggestion, Occurrence, Solution) program. The SOS program is utilized by the licensee to identify opportunities for improvement, employee safety concerns, and issues of regulatory significance. The SS should have generated a SOS following the failure of the initial power supply and for the annunciator problems.

3.2.1.1 Conclusions

a. The SS did not understand the operation of the annunciator system, and that unilluminated annunciators could be inoperable (except for one RO on the PM shift, none of the individuals involved in this event were knowledgeable in the failure mode of the annunciators). Both the SS and the STA were convinced that since some annunciators were illuminated, some power was still available to the annunciator system.

b. The SS lacked a questioning attitude. He did not fully pursue the question of which fuses had blown when he talked to the I&C technicians.

c. The OWL shift SS failed to notify either the EDO or the MCP of the additional annunciators that were inoperable after the shift change.

d. The inclusion of the caution in the power supply replacement WR was a positive initiative; however, the misconception on how the annunciator system worked and the lack of a questioning attitude negated this action.

e. The SSs should have directed that SOSs be written documenting the night's events.

f. The shift logs did not identify the need to notify the EDO and the MCP of changing plant conditions

3.2.2 Subsequent Plant Management Involvement

Following the initial power supply failure at 6:40 p.m. on October 16, 1992, the SS called the MCP who was still on the site. The MCP went to the control room and received a briefing. The MCP was informed that a field contact power supply failure had occurred but that only about 76 annunciators were affected. The SS and MCP concurred that the indication for an emergency classification of alert was not satisfied. The MCP discussed the situation with the SS and briefly observed the I&C technicians performing troubleshooting activities. The MCP then left the control room and eventually left the site. The SS called the EDO at his residence and informed him of the current plant status. The decision was again reached that the emergency action level for an alert was not satisfied. Both the EDO and the MCP specifically requested that they be informed of any change in plant status. This information was passed on verbally from the PM SS to the OWL shift SS.

At approximately 11:30 p.m., the MCP called the SS and was given a status on the replacement of the failed power supply. The MCP informed the SS that if any additional assistance was required that he should go ahead and call them in.

Between 8:00 and 8:30 a.m., on October 17, 1992, the MCP called the SS to get an update. The MCP was informed that the power supply was replaced and that during the replacement approximately 360 annunciators had come in. When the MCP learned that the EDO had not been informed of the night's events he directed that the EDO be informed of the annunciator status. The MCP then offered additional help to the on-shift staff but since the annunciators had been "repaired," the SS did not perceive a need for any additional help. When the SS called the EDO, he informed him of the current plant status but neglected to inform him of the approximately 360 annunciators that had been lost, since he thought the EDO had previously been informed. There was no additional discussion with the MCP or the EDO concerning whether an alert should have been declared.

No further plant management involvement occurred until October 19, 1992. Discussions were held in the regular morning status meeting at 6:45 a.m.. As a result of those discussions the licensee decided to meet with some of the

individuals involved and gather more information. This meeting was held at 10:00 a.m. and was attended by the MCP and the EDO. During this meeting it was determined that it was very likely that all control room annunciators had been inoperable from 1:00 a.m. to 1:56 a.m. on October 17, 1992. Subsequently the licensee made a final determination that the annunciators had indeed been inoperable and made an Emergency Notification System phone call to the NRC.

3.2.2.1 Conclusions

a. The lack of knowledge on the annunciator system which existed in the shift crews also existed in plant management.

b. The shift crew's failure to keep the EDO and to a lesser extent the MCP fully informed of the status of the annunciators contributed to management's failure to realize the extent of the situation.

c. The MCP and the EDO repeatedly offered additional assistance to the on-shift crews. In addition, management authorized the SSs involved to call out any needed assistance without additional management approval. The SSs involved repeatedly declined the offer.

d. Even though the licensee believed that 50 percent of the annunciators were inoperable, additional operators were not assigned to verify plant conditions. When the SSs failed to request additional personnel to perform this verification, plant management should have directed that it be performed.

3.2.3 Onsite Review Committee

There was no Onsite Review Committee (ORC) involvement. This event never got to ORC because an alert was never declared; therefore, ORC never got a chance to review this incident, immediately prior to, during, or immediately following the event.

3.3 Human Performance Issues

The were a number of latent factors identified during the event. A discussion of these factors follows

3.3.1 Teamwork and Communications

The licensee had developed a teamwork training program, T61.TEAM.8, with the National Academy for Nuclear Training, in May 1990 to help operators recognize their individual and team strengths. All operators had received this training to enhance control room teamwork, nurture the control room team culture, and to strengthen control room team performance. However, the teamwork among the operators and between the operators and the I&C personnel during this event was less than adequate.

Dissenting RO concerns regarding the decision not to declare an alert were not dealt with appropriately by two SSs. The PM shift SS reportedly told an RO that they were not in an alert, but would not provide a rationale or discuss it further. The OWL shift SS repeatedly convinced his ROs that declaring an alert was not necessary. The two ROs who were concerned that the intent of the EAL regarding the declaration of an alert on the partial loss of annunciators did not forcefully present or pursue their concerns with the SS, when more than half of the annunciators were out-of-service.

There was less than adequate communication between control room operators and the I&C technicians and systems engineer, control room operators and equipment operators, and the SSs and plant management. For example, the I&C technicians and backup system engineer did not clearly inform any of the operating crew that their actions resulted in the blowing of all the output fuses, which then rendered all four field power supplies inoperable. Thus, the ROs were not aware of the extent of the loss of the annunciators. The ROs were not always informed of when I&C was going to perform work that affected the control board annunciator responses.

The control room operators did not communicate the extent or significance of the loss of control room annunciators to the equipment operators. The equipment operators were rarely used to verify the validity of annunciator and computer alarms and were not directed to increase the monitoring frequency of plant equipment.

The SS's failure to recognize the complete loss of annunciators at 1:00 a.m. October 17, 1992, resulted in an alert not being declared and licensee management, the NRC, and other government agencies not being notified. This failure also resulted in a lack of managerial and technical expertise available to adequately address the loss of annunciators.

There was a less than adequate job pre-briefing on the annunciator WR by the backup system engineer, the I&C planner, or the SS. For example, the I&C technicians and the backup system engineer had not read the WR. However, the caution, relative to the loss of all power supplies requiring an alert, was discussed.

During the day shift annunciator light testing on October 17, 1992, a RO determined that four annunciator panel sections illuminated at only half intensity. Although the RO informed the control room supervisor, this information was not communicated to the I&C personnel or SS for approximately three hours, during which time the operators thought that only five annunciator windows were out-of-service.

3.3.2 Command and Control

The SS on the October 17, 1992 OWL shift did not exhibit a sufficiently questioning attitude. He did not adequately question or take charge of the I&C personnel to determine which power supplies had been shorted out. He did not direct continuous monitoring of main control board indications. He did not direct equipment operators to continuously monitor the plant equipment. He did not inform the plant management or the NRC of the annunciator failures.

The OWL shift SS did not use the dual role STA as an STA on the annunciator problem. Instead the STA performed as a field supervisor on an unrelated turbine surveillance procedure.

There were also problems on the October 17th AM shift. For example, the ROs independently developed an unapproved ad hoc annunciator functional test without management oversight. However, the control room supervisor with the SS's approval did re-initiate I&C repair efforts after learning that five annunciator windows showed invalid alarms.

The I&C group on the OWL shift was composed of two technicians, an I&C engineer, and an I&C planner. There was no management direction as to the single point of accountability or contact for the operators. The technicians had different opinions of who was in charge (system engineer or senior I&C technician); consequently, no one informed the operators of the loss of all four field power supplies, despite the caution discussed at the beginning of the work. Contributing to the failure was the misconception in the operation of the annunciator system; I&C personnel convinced themselves that since some annunciators were illuminated some power was still available to the annunciator system. Therefore, they did not adequately question whether the unilluminated annunciators were receiving power.

3.3.3 Procedures

All the operators interviewed indicated that they did not use any procedures to respond to the loss of annunciators.

Plant procedures did not address the symptoms for a partial or total loss of the RK system (alarm annunciators) or partial loss of the plant computer. There was no abnormal procedure that provided appropriate actions to respond to this type of event. There was no guidance on the maintenance of a steady state reactor power level after a loss of annunciators.

Even though the plant computer was responding with numerous false data points, e.g. "Safety Injection pump A in lockout," abnormal procedure, No. OTO-RJ-00001, "Loss of Plant Computer," was not used. However, this procedure did not sensitize the operator for the need to take compensatory measures or identify the parameters, indications, or equipment for increased operator monitoring. Although the ROs lost confidence in the validity of the plant computer alarm indication, they were not aware of the extent of the loss of the annunciators and did not adequately use the alarm response procedures effectively to verify the proper plant actions. There was no procedural guidance on the need to verify plant computer alarms against annunciator window alarms during partial system failures.

Only a limited number of STAs were trained to use OTS-RJ-00001, "Restoration of Plant Computer Failures." This procedure refers to OTO-RJ-00001, "Loss of Plant Computer," for actions if plant computer failures occur during restoration. STAs indicated that this could be used for the determination of operability of the plant computer.

The Emergency Plan Implementing Procedure, EIP-ZZ-00101, "Classification of Emergencies," does not include the loss of the plant computer as a specific criteria for the declaration of any emergency classification. Yet, the plant computer provides more alarm information than the annunciators do.

The operators questioned had many different views as to what a "plant transient" meant as used as a criterion in the "Indications" section for a Site Area Emergency due to a loss of annunciators. For example, some thought a power level change was sufficient to increase the emergency classification while others did not.

The work request did not contain a systematic troubleshooting plan to determine the cause of annunciator system failure or a post maintenance testing method with acceptance criteria.

The operators did not have a list to determine which annunciator windows were inoperable on loss of specific power supplies.

The plant's technical specifications contained references to certain annunciator alarms. These included: $T_{avg} - T_{ref}$ deviation (TS 4.1.1.4.b), rod position deviation monitor (TS 4.1.3.2), axial flux difference monitor (TS 4.2.1.1.b), and quadrant power tilt ratio (TS 4.2.4.1). The plant procedures consider these alarms inoperable when the plant computer or the appropriate MUX power supply is inoperable. The operators began tracking these technical specification related alarms at the 1:00 a.m. October 17 loss of annunciators and verified the operational data.

The procedural deficiencies were considered to be contributors to the root causes of the event. For example, had there been procedures, the lines of communication would have been established, the questions to ask would have been provided, and the required knowledge of the annunciator system would have been provided or referenced.

3.3.4 Training

Discussions with the licensee regarding classroom and simulator training courses regarding a total or partial loss of plant annunciators or partial loss of the plant computer indicated the following:

3.3.4.1 Classroom Training

No specific training on a partial or total loss of annunciators or partial loss of the plant computer has been conducted.

There was no training specifically addressing the operation of the annunciator system. Training on specific annunciation windows was included with the training on the system affected by the alarm.

There was no specific operator, engineering, or management classroom training on the annunciator system. This resulted in the operators being unaware that open and closed logic or field contacts cause either illuminated or unilluminated failed annunciator windows.

Operators were not trained that individual annunciator panel lamp tests are sufficient only for testing the lamps and determining the partial loss of a PK bus, but inadequate as an annunciator system functional test. The operators were not trained that individual alarm logic or driver cards, or logic power supply failures would not manifest self-revealing symptoms.

The operators were not trained that a specific field or logic power supply energized annunciator windows in multiple alarm panels, despite several previous power supply failures. The operators had no training or technical information on which annunciator windows were inoperable on loss of a specific field or logic power supply.

The simulator was not modeled to simulate the partial or total loss of all main control board annunciators or the plant computer, or to enable effective training on the abnormal or diagnostic loss of plant computer procedures, OTO-RJ-00001 and OTS-RJ-00001.

The I&C technicians had been trained on the operational characteristics of the annunciator system including the loss of the annunciator system upon loss of the power supplies. They had also been specifically instructed on the caution relative to declaring an alert if all four power supplies were lost. During the event, this knowledge was not used.

While training was not specified as a root cause of the event, it was a contributor to the lack of knowledge of the annunciator system.

3.3.4.2 Simulator Scenario

One dynamic simulator scenario (DS-28) was developed in response to an event at Nine Mile Point, Unit 2, and administered to all operating crews during the 91-5 cycle of operator requalification. This was initiated by the partial loss of the PK01 bus which resulted in the loss of horn and window lights in four balance of plant annunciator panel sections. The simulator scenario subsequently cascaded through multiple primary and secondary system malfunctions compounding the loss of annunciators.

There were no abnormal procedures that addressed the partial loss of the PK system. The annunciator response procedure, OTA-RLRK017, for window 17B, "PK01/02/03/04 TROUBLE," immediate action did not direct a response to the loss of the annunciators affected. It only describes actions to be taken to determine which PK bus was lost. In the scenario, the operators have to deduce that the annunciators were lost based on observing changes in control board indications. While this challenged the operators' knowledge-based reasoning capability in a training scenario, the lack of guidance can delay operator response in an actual loss of annunciators caused by a PK bus failure.

The annunciator system failure response from this scenario was different from that in the October 17, 1992 event. The simulator scenario training conducted on the crews was ineffective in properly responding to this event because of its lack of similarity.

3.3.5 Human Performance Investigation

The licensee conducted an investigation and questioned the operators, but did not have all the operators prepare individual statements after the event; therefore, it did not appear to constitute a rigorous human performance investigation.

3.3.6 Operating Crew Stress Level

The event occurred at 1:00 a.m. during the second day of an OWI shift. The operators stated that they had no unusual fatigue at the time.

3.3.7 Man-Machine Interface

The main control board has no annunciator or indication of a failed annunciator field or logic power supply to alert the operators. The operators had to deduce the failure.

The space available to the I&C technicians to perform the replacement of the field power supply was confined.

4.0 Equipment Failures

Between 7:30 p.m. and 11:00 p.m. on October 16, I&C technicians made voltage measurements on the 14 logic and four field power supplies. As a result, one 0.5A fuse was replaced on a logic power supply and the voltage of one field power supply was determined to be unacceptable (low).

Between 11:00 p.m. on October 16 and 7:00 a.m. on October 17, 1992, a replacement field power supply was obtained from the warehouse and bench tested. The WR indicated that the power supply was to be replaced and to repair the fuses. During the replacement, it was necessary to jumper both the input and output field supplies between two of the power supplies that were physically between the one that was being replaced. While setting up to remove the jumpers, the I&C technicians reported that an electrical arc was observed and additional annunciator windows illuminated. The four field power supplies had blown input fuses. These fuses are rated one ampere and are the slow blow type.

Additional fuses for the field power supplies were obtained from the I&C shop and the previously failed power supply. During replacement of the fuses, there was a problem with one of the fuses holders. This caused a delay in the fuse placement which caused the fuses to blow again. (It is necessary to replace them all in a short time so that the load is shared.) Additional fuses were obtained from the warehouse, inserted without a delay, and the system was thought to be restored at 1:56 a.m..

A logic power supply was replaced between 1:30 p.m. and 2:00 p.m. and between 3:00 p.m. and 5:00 p.m. five logic power supply fuses were replaced. The voltage was measured on the 14 logic power supplies and the four field power supplies. Subsequently, all measurements indicated normal voltages. Further functional testing indicated that the annunciator system was operable.

4.1 Analysis of Root Cause Determination

The AIT determined the root cause of the equipment failures as follows:

a. The failure mode of the field power supply was low voltage. The intermediate cause of the low voltage was failure of the primary field windings of the power transformer. The root cause of this failure will be determined by the licensee and reported as part of the CAL response.

b. The most probable intermediate cause of the blown fuses in the field power supply was grounding of a temporary jumper clip during replacement of the failed power supply. The root cause appeared to be personnel error.

c. The most probable root cause of the blown fuses in the logic power supplies was a current surge generated when the field power supplies were lost.

About 25 hours passed from the initial identification of the event until the system was fully operable. The difficulty in determining the extent of the failures and in restoring the system operability were as follows:

- the field contact power supplies are wired in parallel
- the instruction manual was inadequate
- the system drawings did not completely identify the inter-relation between the effect of field power supply failure and the logic power supplies
- e ground detector also ties the system together
- the I&C engineers who had the greatest knowledge of the system were not available when the event occurred

4.2 Corrective Actions

The licensee tried to reproduce the electrical fault that occurred during the field contact power supply failure but was unable to identify how it occurred.

Because of previous problems with the annunciator system, in 1991, a request for resolution was proposed to modify the annunciator system to separate the system so that three groups of 400 alarms and one group of 200 alarms are independent from each other. The modification would prevent system interaction so that failures would be confined to one group, therefore they would be easier to analyze and repair. Construction Modification Package No. 91-1037 has been issued to address the above problem and is proposed to be implemented after the 1993 refueling outage.

Implementation of this modification and the identification of which annunciators are on which power supply should prevent a similar event from happening in the future.

5.0 Event Classification and Reporting

Emergency Implementing Procedure, EIP-22-00101, Attachment 1, addresses loss of annunciators as follows:

Initiating Condition	Indication(s)	Emergency Classification
Most or All Alarms(Annunciators) Lost	Annunciator Panels RK014 through RK026 are not operable	ALERT

The operators have been trained at Callaway to use only the criteria listed in the "Indications" section as the trigger for the declaration of the emergency specified. Additional consideration of the intent of the initiating condition listed is discouraged. In this case, while the "Initiating Condition" accurately reflects the guidance in NUREG 0654 that an alert should be declared if most annunciators are lost, the "Indications Section" lists loss of all annunciator panels on the main control board as the only criteria. This created a dichotomy and effectively narrowed the initiating condition to all annunciators lost since the indications column did not accurately reflect the intent of the initiating condition.

The operators interviewed had different opinions of the need for declaring an emergency classification and on the percentage of annunciators necessary to be inoperable before the declaration must be made. This ranged from 51% to 75%. An opinion was also expressed that a smaller loss of the safety system annunciators instead of a certain percentage of the total annunciators would have more safety significance. Several of those interviewed originally had the opinion that an alert was not necessary, but after the fact concluded that the extra expertise and manpower that the declaration of alert would have brought to bear on the problem would have been worthwhile.

At 6:40 p.m. on October 16, 1992, 193 annunciators were lost (approximately 76 illuminated, the rest dark). The RO explained to his SS that he saw half of the annunciators flash then go dark except for the 76 that stayed illuminated. He had experienced previous annunciator power supply failures, recognized this as such, and expected that some of the unilluminated annunciators had also failed. He noted that many of the plant computer alarms were unreliable. Although the RO had little confidence in the annunciators or the plant computer systems, he did not enter the "Loss of Plant Computer" abnormal procedure. He asked his SS why they should not be in an alert. The SS reportedly responded that they were not in an alert, but offered no explanation.

At 1:00 a.m. on October 17, 1992, all annunciators were lost. Another RO was concerned that an alert was not declared based on counting 360 of the 683

annunciators being illuminated. This operating crew was unaware that the unilluminated annunciator panels were also out-of-service. The plant computer again provided obviously unreliable alarms. Several discussions between the ROs and SS regarding the proper emergency declaration occurred, but an alert was not declared. At 1:56 a.m. on October 17, 1992, all but 163 annunciators were returned to service, although the operators were aware of only five annunciator windows with problems at this time. If an alert had been declared in recognition of the 1:00 a.m. loss of annunciators, it would have remained in effect until adequate post-maintenance testing proved the satisfactory operation of the annunciators. However, no emergency declaration of any kind was made.

As a result, the operating crew did not summon management or sufficiently knowledgeable technical experts to expeditiously resolve the loss of the annunciator problems. The operators did not adequately inform plant management of the extent of the loss of annunciators during the event. The licensee also did not take many of the compensatory measures that may have been expected as a result of this type of event. The licensee did not staff the Technical Support Center during the event. Additional licensed operators were not called upon to continuously monitor plant instrumentation. Equipment operators were not directed to increase monitoring status of equipment parameters in the plant. The number of annunciator windows illuminated was not included in operator logs, despite the fact that window counts were made and photographs taken The WR did not include a systematic troubleshooting plan and did not clearly indicate the power supplies that had blown fuses. An unrelated turbine stop valve surveillance test was performed while 163 annunciators were unknowingly out-of-service. Repair of the a nunciator system was halted prematurely for most of the morning of October 17, 1992, as a result of less than adequate post-maintenance testing.

The licensee faxed a statement to the NRC Operations Center at 12:47 a.m. CDT and made an official Emergency Notification System event notification at 2:14 p.m. EDT on October 19 1992, which was taken as ENS Report No. 24453. The report was submitted pursuant to 10 CFR 50.72.b.1.v., which requires the reporting of a major loss of emergency assessment capability. 10 CFR 50.72.a specifies that the NRC Operations Center be informed immediately after the notification of state and local governments of the declaration of an alert, and not later than one hour after the time the licensee declares an emergency. 10 CFR 50.72.a specifies that the NRC Operations Center be informed as soon as practical and in all cases within an hour of the event. Thus, while the contents of this report were adequate, it was about 60 hours late.

The Missouri State Emergency Management Agency Director was informed of the event at 3:30 p.m. on October 19, 1992. The presiding Commissioners for Callaway, Osage, Gasconade, and Montgomery, Missouri counties were informed of the event between 3:35 p.m. and 4:10 p.m. on October 19, 1992. The Mayor of Fulton, Missouri was informed of the event at 10:00 a.m. on October 20, 1992.

Thus, the licensee's immediate and subsequent actions related to an emergency classification were less than adequate.

6.0 Safety Significance

The AIT concluded that no operational parameters were approached or exceeded and that there were no radiological consequences to this event. However, the AIT had concerns with the following:

1. The delay in detecting and responding to this the event.

2. The potential for delay in detecting and responding to a plant transient or other events while annunciators are out-of-service.

3. The potential for equipment that is damaged or out-of-service not being readily identified.

4. Callaway's operators were trained to use annunciators during transients and did not thoroughly understand or pursue the significance of the event.

5. The proper declarations and reports had not been made as required.

7.0 Overall Conclusions

7.1 Cause of Equipment Failures

The AIT determined that the causes of the equipment failures were as follows:

a. The intermediate cause of the power supply failure appeared to be failure of its power supply transformer.

b. The failure of the fuses in the field power supplies and the logic power supplies was due to personnel error.

7.2 Root Causes for the Event

The AIT used an events and causal factors charting technique to develop the root causes of the event. The event was considered to be the initial loss of all annunciators, the partial loss of annunciators until Saturday at 7:37 p.m., and the failure to recognize the operational effects of the annunciator loss.

The team identified four root causes for the event. Absent any one of these causes, the event would have been significantly mitigated. The root causes were as follows:

7.2.1 Poor Communications/Teamwork.

This existed between the SS and the EDO, the SS and the plant manager, the SS and the I&C technicians, and the SS and the shift crew. It also existed in the control room logs. For example:

- The I&C technicians, I&C engineer, and I&C planner did not inform the SS what fuses blew and what the effects were.

- The OWL shift SS did not call the EDO or the MCP after the 1:00 a.m. event. This occurred despite the fact that both the EDO and MCP had asked to be called if there were any changes.

- The AM shift SS did not inform the EDO of the 1:00 a.m. event.

- The RO turnover sheets (Fri PM to OWL) did not mention that dark annunciators could also possibly be inoperable.

- The SRO turnover sheet did not inform the OWL shift SS of the above comment.

- The SSs did not adequately brief the ROs or the equipment operators on I&C actions or changing conditions.

7.2.2 Lack of a Questioning Attitude/Complacency.

There were numerous times during this event that a more questioning attitude could have prevented the event or its consequences. For example:

- Less than adequate questioning by the SS/Operating Supervisor to the I&C technicians in regard to which power supplies and fuses were inoperable.

- Less than adequate questioning by the SS/Operating Supervisor with regard to generic comments made by the I&C technician on what the extent of the problems was.

- RO logs did not address the significance or number of annunciators that were illuminated.

- Several ROs questioned the decision that an alert was not required several times but allowed themselves to be convinced otherwise.

- The operators, the I&C technicians, the engineer, and the work planner all thought that the annunciator system was still receiving power from someplace since some annunciators were illuminated; however, no effort was made to verify this assumption.

7.2.3 Inadequate Knowledge of Annunciator System.

There were numerous individuals involved with the event that lacked adequate knowledge of the annunciator system which hampered their ability to make appropriate decisions. For Example:

- The operators, engineers and management involved received less than adequate training on the annunciator system to permit an understanding of the symptoms of its failure. One RO who had experienced power supply failures previously learned through that experience, but did not pass on his knowledge during shift turnover.

- I&C personnel had received training on the annunciator system, but did not use that knowledge to conclude that all annunciators had been lost.

- There was a lack of available procedures on the partial or total loss of the annunciator system, or the partial loss of the plant computer.

- Neither the operators nor the I&C personnel had correlations between the annunciator windows and the power supplies to aid in the determination of which annunciator windows were inoperable.

7.2.4 Less than Adequate Work Performance.

There were numerous instances where work performance contributed to an inability to appropriately diagnose and respond to the annunciator problem. Further, since the WR was non-safety related, it did not receive the same level of attention as a safety related WR would have received. For Example:

- Loss of all four field power supplies was apparently a result of the jumpering operation during replacement of power supply No. 2.

- There was a less than adequate pre-job briefing. Only the caution about the potential of an alert was noted to the I&C group by the SS.

- There was inadequate post-maintenance testing after the four field power supply fuses were replaced, which resulted in the operators' belief that only five annunciator windows were still out-of-service.

- The WR did not contain a systematic troubleshooting plan and it was completed without clearly identifying which fuses and power supplies were replaced or affected.

- The I&C technicians and the engineer did not read the WR which contained the caution about the declaration of an alert if all four power supplies were lost.

8.0 Exit Interview

The team met with licensee representatives (denoted in enclosure 4) on October 24, 1992, and summarized the purpose, AIT charter items, and findings of the inspection. The team discussed the likely informational content of the inspection report with regard to documents or processes reviewed by the team during the inspection. The licensee did not identify any such documents or processes as proprietary.

ENCLOSURE 2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

CONFIRMATORY ACTION LETTER

OCT 2 0 1992

Union Electric Company
ATTN: Mr. Donald F. Schnell
Senior Vice President - Nuclear
Post Office Box 149 - Mail Code 400
St. Louis, MO 63166

CAL-RIII-92-012

Dear Mr. Schnell:

This confirms the conversation on October 19, 1992, between Messrs. William Forney and Robert Greger of my staff and you and Mr. Gary Randolph of your staff related to the loss of annunciators which occurred on October 16 - 17, 1992. With respect to the Callaway plant matters discussed, we understand that you will perform the following actions:

1. Conduct an investigation to determine the causes of the annunciator failures and the failure of shift personnel to recognize the extent of these failures, and to evaluate the decision making and communications associated with the event.

2. Place the power supply which failed in quarantine until released by the NRC's Augmented Inspection Team (AIT).

3. Maintain documentary evidence of your investigation effort and make this available to the AIT.

4. Evaluate these most recent equipment failures and staff actions in light of past equipment failures and staff performance to determine if additional actions are necessary.

5. Provide within 30 days to NRC Region III a documented evaluation of the above issues including corrective actions you have taken or plan to take.

None of the actions specified herein should be construed to take precedence over actions which you feel necessary to ensure plant and personnel safety.

If your understanding differs from that set forth above, please call me immediately. Issuance of this Confirmatory Action Letter does not preclude issuance of an Order formalizing the above commitments or requiring other actions on the part of Union Electric Company. Nor does it preclude NRC from

OCT 2 0 1992

taking enforcement action for violations of NRC requirements that may have prompted the issuance of this letter.

Sincerely,

Carl J Paperiello for

A. Bert Davis
Regional Administrator

Distribution

cc:
G. L. Randolph, Vice President,
Nuclear Operations
J. V. Laux, Manager Quality
Assurance
Tom P. Sharkey, Supervising
Engineer, Site Licensing
DCD/DCB (RIDS)
OC/LFDCB
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L. R. Greger, RIII
R. A. Westberg, RIII

ENCLOSURE 3

SCS

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

OCT 2 0 1992

MEMORANDUM FOR: R. A. Westberg, Team Leader, Callaway Augmented Inspection Team (AIT)

FROM: W. L. Forney, Deputy Director, Division of Reactor Projects

SUBJECT: AIT CHARTER-CALLAWAY LOSS OF ANNUNCIATOR EVENT

An Augmented Inspection Team (AIT) is being dispatched to the Callaway plant in accordance with NRC Manual Chapter 0325. The AIT is being sent due to the significance of the loss of all control room annunciators and the apparent failure of the licensee to make appropriate notifications and emergency declarations on October 17, 1992.

Enclosed for your implementation is the final Charter to evaluate the events associated with the October 16 - 17, 1992 Callaway loss of annunciator events. This Charter was prepared in accordance with the NRC Incident Investigation Manual and the April 18, 1991 Manual Chapter 0325 AIT implementing procedure.

The AITs objectives are to:

1) Conduct a timely, thorough, and systematic inspection related to this event.

2) Assess the safety significance of the event and communicate to Regional and Headquarters management the facts and safety concerns related to the event such that appropriate followup actions are taken.

3) Collect, analyze, and document factual information and evidence sufficient to determine the cause(s), conditions, and circumstances pertaining to the event.

If you have any questions regarding these objectives or the enclosed Charter, please do not hesitate to contact either Robert Greger or myself.

William L. Forney

William L. Forney, Deputy Director
Division of Reactor Projects

Enclosure: AIT Charter

See Attached Distribution

Distribution
cc w/enclosure:
A. B. Davis, RIII
C. J. Paperiello, RIII
E. G. Greenman, RIII
F. J. Miraglia, NRR
J. G. Partlow, NRR
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D. F. Ross, AEOD
J. A. Zwolinski, NRR
G. E. Grant, EDO
B. L. Bartlett, SRI
L. R. Wharton, NRR

Callaway Loss of Annunciators Augmented Inspection Team (AIT) Charter

You are to perform an inspection of the October 16 - 17, 1992 annunciator events to include the following:

1. Determine that all immediate safety concerns associated with the loss of annunciator events have been addressed by the licensee.

2. Determine and validate the sequence of events associated with the loss of annunciators and plant computer, and the related power supply and fuse failures. (Pay particular attention to time durations of annunciator losses.)

3. Determine the root cause for the failures, including:

   a. Annunciator power supply
   b. Annunciator output power supply fuses
   c. Annunciator logic power supply fuses

   In evaluating the root cause consider the relationship of the failures to possible troubleshooting or design weaknesses for both the safety-related and balance-of-plant (BOP) equipment.

4. Review the adequacy of the licensee's investigation of these specific events and the licensee's program for event analysis. Oversee troubleshooting, testing, and analysis of affected equipment.

5. Interview plant operators, I & C personnel, and other plant staff directly involved in the events and troubleshooting, to evaluate:

   a. Operator actions, procedural guidance, and training
   b. Training and procedural guidance for other plant staff involved in the events or troubleshooting
   c. Notifications to plant management and NRC
   d. Recognition by the operators and plant staff of the extent of annunciators which were lost

6. Evaluate licensee managerial performance related to this event, including:

   a Initial shift supervision involvement (SRO, Shift Supv., STA, etc.)
   b. Subsequent plant management involvement (Plant Manager, EP Manager, etc.)
   c. Onsite Review Committee involvement

7. Evaluate completeness of licensee's 10 CFR 50.72 report.

8. Determine whether appropriate work controls were implemented for the troubleshooting and repair activities.

9. Review the licensee's immediate and subsequent actions related to emergency classification for these events.

ENCLOSURE 4

PERSONS CONTACTED

Union Electric Company

D. F. Schnell, Senior Vice President, Nuclear
G. L. Randolph, Vice President, Nuclear Operations
W. R. Campbell, Manager, Callaway Plant
R. J. Baker, Supervising Engineer, Computers
H. A. Bauer, Planning and Scheduling
L. S. Beaty, I&C Engineer
H. D. Bono, Supervisor, Engineering
M. B. Cleary, Supervisor, Corporate Communications
M. L. DeYoung, I&C Technician
M. S. Evans, Superintendent, Training
J. M. Gloe, Supervising Engineer - Performance/Test (Engineering Duty Supervisor - week of 10-15-92 to 10-23-92)
M. E. Heinzer, SS (PM Shift Friday and Saturday)
E. W. Henson Jr., I&C Technician
G. A. Hughes, Supervisor, Independent Safety Engineer Group
W. O. Jessop, SS, Operator Training
J. L. Keyes, RO (OWL shift)
J. V. Laux, Manager, Quality Assurance
A. G. Lord, I&C Engineer
S. A. Maglio, Operating Supervisor
M. L. McKee, I&C Technician
P. W. Mory, SS (Day Shift)
P. S. Myers, Engineer, Design Control
C. D. Naslund, Manager, Nuclear Engineering
R. J. Neil, SS (OWL shift)
C. L. Norris, I&C Technician
G. W. Olmstead, STA (OWL shift)
W. C. O'Neil, I&C Technician
A. C. Passwater, Manager, Licensing and Fuels
J. R. Peevy, Manager, Operations Support
L. E. Petty, I&C Technician
C. S. Petzel, Quality Assurance Engineer
M. A. Reidmeyer, Quality Assurance Engineer
D. R. Smallwood, Senior Nuclear Clerk
M. A. Stiller, Manager, Nuclear Safety and Emergency Preparedness
W. A. Witt, Operating Supervisor SRO (OWL Shift)
A. E. White, Supervisor, Emergency Preparedness
D. E. Young, Superintendent Operations (Emergency Duty Officer EDO)
J. Vice, RO, AM shift
W. Gruer, RO, OWL shift
R. Greathouse, RO, PM shift
M. Jennings, STA/CRS, PM shift
E. Stewart, CRS, AM shift
S. Aldrich, RO, PM shift
T. P. Sharkey, Supervising Engineer - Site Licensing