U. S.NUCLEAR REGULATORY COMMISSION

REGION III

Reports No. 50-456/90026(DRP); 50-457/90027(DRP)

Docket Nos. 50-456; 50-457 Licenses No. NPF-72; NPF-77

Licensee: Commonwealth Edison Company
Opus West III
1400 Opus Place
Downers Grove, IL 60515

Facility Name: Braidwood Station, Units 1 and 2

Inspection At: Braidwood Site, Braidwood, Illinois 60407

Inspection Conducted: December 17, 1990 through January 26, 1991

Inspectors: S. G. Du Pont
R. A. Kopriva

Approved By: B. Burgess, Chief
Reactor Projects Section 1A

2/15/91
Date

Inspection Summary

Inspection from December 17, 1990 through January 26, 1991 (Reports No. 50-456/90026(DRP); 50-457/90026(DRP))

Areas Inspected: Routine, unannounced safety inspection by the resident inspectors of licensee action on previously identified items, licensee event reports, operational safety verification, monthly maintenance observations, monthly surveillance observations, report review and meetings.

Results: Of the 7 areas inspected, no violations were identified in 5 of these areas. Two non-cited violations were identified. One in the area of Licensee Event Reports (LERs) and one in the area of operational safety.

- Review of management's involvement to ensure quality of safety related activities for November 1990 indicated minimal involvement. Review of December 1990 and January 1991 involvement indicated improvements to an adequate level of involvement.

- A non-cited violation of technical specification was identified with LER 456/90014. The licensee entered Mode 3 without ensuring that the main steam isolation valves were operable.

- A non-cited violation of technical specifications was identified by the licensee pertaining to an inoperable channel of the Loose Parts Monitoring system. The licensee had failed to make a special report within the required 10 days.

- Operations, in general, appear to be adequate. However, one reactor scram occurred due to the failure of the Unit 1 main generator (five scrams for Unit 1 in 1990). Management's involvement, as noted above, improved during this inspection period.

- Maintenance/Surveillance appears to remain constant with slight improvement by reducing the backlog of work requests to below 800 during this inspection period. There were no missed surveillances during this inspection period.

DETAILS

1. Persons Contacted

   Commonwealth Edison Company (CECo)

   *K. L. Kofron, Station Manager
   *G. E. Groth, Production Superintendent
   *D. E. O'Brien, Technical Superintendent
   *G. R. Masters, Assistant Superintendent, Operations
   R. J. Legner, Services Director
   *R. D. Kyrouac, Nuclear Quality Program Superintendent
   *D. E. Cooper, Technical Staff Supervisor
   *D. J. Miller, Regulatory Assurance Supervisor
   J. Graham, Braidwood Project Manager, PWR Projects Department
   M. E. Lohman, Assistant Superintendent, Maintenance
   A. D'Antonio, Quality Control Supervisor
   S. Roth, Security Administrator
   R. L. Byers, Assistant Superintendent, Work Planning and Startup
   L. W. Raney, Nuclear Safety Supervisor
   C. Vanderheyden, Training Supervisor
   P. Maher, Assistant Technical Staff Supervisor
   E. W. Carroll, Regulatory Assurance
   P. Holland, Regulatory Assurance
   J. Smith, Master, Electrical Maintenance

   *Denotes those attending the exit interview conducted on January 24, 1991 and at other times throughout the inspection period.

   The inspectors also talked with and interviewed several other licensee employees, including members of the technical and engineering staffs, reactor and auxiliary operators, shift engineers and foremen, and electrical, mechanical and instrument maintenance personnel, and contract security personnel.

2. Licensee Action on Previously Identified Items (92701, 92702)

   a. Open Items

      (Closed) 456/88029-01; 457/88029-01: The ventilation room doors to the emergency diesel generator rooms had received damage due to high differential pressure existing across the doors resulting in slamming. The licensee had made temporary repairs and had not completed final repairs prior to the completion of NRC inspection (Inspection Reports 456/88029; 457/88029). Subsequently, final corrections were completed and appears to have prevented recurrence. This item is considered to be closed.

      (Closed) 456/89026-02; 457/89026-03: The licensee's procedure for sampling fuel oil did not reflect actual practices being performed onsite. This issue was addressed as a concern by the inspector since both the procedure and actual practices were adequate to ensure quality of received fuel oil. The licensee revised the actual practices to reflect the approved procedure and this item is considered closed.

(Closed) 456/90013-02; 457/90016-02:

The licensee's calculated radial peaking factor (Fxy) indicated values greater than the expected for the lower core fuel region. The licensee increased their monitoring of Fxy until the value returned to the expected values. The inspector reviewed the licensee's calculations and agreed that Fxy values were no longer a concern. These items are considered to be closed.

b. Violations

(Closed) 456/88013-01: Unit 1 operated between May 10 and 27, 1988, without a timely calibration of the power range high neutron flux trip setpoint in violation of technical specification requirements. The licensee immediately reduced the unit power to below the technical specification limits on May 27, 1988. The failure to perform the calibration of the moveable incore detection system within the technical specification required frequency was due to the failure of 19 out of 58 thimbles sticking on May 10, 1988. On June 11, 1988, Westinghouse (vendor) successfully cleared all 58 thimbles, effect[illegible]ly solving the thimble blockage problem. The licensee satisfactorily completed the monthly incore calibration check on June 15, 1988 and the quarterly calibration on June 28, 1988. Since this problem has not recurred and the licensee continued to meet the technical specification requirements, this item is considered to be closed.

(Closed) 456/89022-02: The licensee failed to make a required notification per 10 CFR 50.72 within the required time. The licensee developed and implemented a procedure, BwAP 1250-2T, Checklist for Event Notification Screening Guidelines, which appears to have been effective in preventing recurrence. This item is considered to be closed.

(Closed) 456/89026-01; 457/89026-01: On September 15, 1989, the licensee exceeded the Technical Specification by having the direct current cross tie closed between both units. The licensee immediately opened the cross tie and supplied temporary power to the affected battery upon notification that Technical Specifications were exceeded. Although Technical Specifications were exceeded, the condition that both units were in with the cross tie closed met the design basis contained in the FSAR. The licensee has limited the use of the cross tie until a technical specification change request is approved to resolve the difference between the FSAR and technical specifications. Based upon the administrative limit on the use of the cross tie, these items are considered closed.

(Closed) 456/89028-01: The licensee failed to initiate a 10 CFR 50.59 safety evaluation of the pressurizer safety valve test performed on September 2, 1989. Subsequent to the issuance of the violation, a safety evaluation was conducted and determined that no safety impact resulted due to the performance of the tests. Additionally, the licensee revised administrative procedure BwAP 1600-1, Maintenance Work Request, to require 10 CFR 50.59 evaluations of testing performed as part of nuclear work request packages. The inspector reviewed the procedure change and found the corrective actions to be adequate. This item is considered to be closed.

(Closed) 457/90011-01: The licensee failed to meet technical specification required flow from the spray additive tank to the containment spray (CS) system. The inspector reviewed the corrections to procedure BwAP 330-1, Station Equipment Out of Service and determined that adequate guidance was provided concerning prevention of throttle valves being used as isolation for removing equipment out of service. This item is considered to be closed.

(Closed) 456/90013-01: The licensee failed to perform the required personnel air lock leak rate test within the allowable time. The inspector reviewed the licensee's root cause determination and associated corrective actions and found them to be adequate. Procedure BwAP 1450-1, Access to Containment, was revised to require entries into the containment entry logbook which is being monitored to initiate performance of the required surveillance. This item is considered to be closed.

(Closed) 457/90016-01: The Station Control Room Engineer (SCRE) authorized the 2A Auxiliary Feedwater pump to be placed out of service while the 2B Emergency Diesel Generator was inoperable for maintenance which violated administrative controls contained in procedure BwAP 330-1, Station Equipment Out of Service. The inspector found the licensee's corrective actions appropriate for a personnel error by reviewing and emphasizing the techniques of self checking and verification associated with out of service activities. This item is considered to be closed.

NRC Region III management reviewed the existing open items for the Braidwood station and determined that the following open items will be closed administratively due to their safety significance relative to emerging priority issues and to the age of the item. The licensee is reminded that commitments directly relating to these open items are the responsibility of the licensee and should be met as committed. NRC Region III will review licensee actions by periodically sampling administratively closed items.

Item No.	Type
Unit 1	
456/79001-1B	BUL
456/79001-4B	BUL

Item No.	Type
456/79001-5B	BUL
456/79001-BB	BUL
456/87038-01	DEV
456/87038-02a	V
456/87038-03a,b,c	OPN
456/87038-05	V
456/87038-06	OPN
456/87038-07	UNR
456/87038-08	OPN

Unit 2

457/79001-1B	BUL
457/79001-4B	BUL
457/79001-5B	BUL
457/79001-BB	BUL
457/87036-01	DEV
457/87036-02a,b	V
457/87036-03a,b,c	OPN
457/87036-04a,b,c,d	V
457/87036-05	V
457/87036-06	OPN
457/87036-07	UNR
457/87036-08	OPN

No violations or deviations were identified.

3. Licensee Event Report (LER) Review (92700)

The inspector reviewed the following LERs for completeness and accuracy:

Unit 1	Unit 2
90018	90010
90014	90009
90013	90008
90012	90007
90011	90006
90010	90005
90007	90004
90005	90003
90004	90001
90003	

All of the above LERs met the notification requirement of thirty days per 10 CFR 73.

The review of Unit 1 LER 90014 indicated either concerns or interest in the conditions that required 10 CFR 50.73 notification. The following addresses the specific details of the events, corrective actions and causes associated with this LER:

Entry into operating Mode 3 prior to performing the 1B Main Steamline Isolation Valve (MSIV) operability test due to management deficiency. On August 12, 1990, the Station Control Room Engineer (SCRE) inadequately reviewed the MSIV full stroke test, BwVS 7.1.5-1, and incorrectly indicated specific steps as not applicable. The test was being performed as post-maintenance operability verification of the 1B MSIV after corrective maintenance had been performed on the standby accumulator. These repairs were performed to resolve a previous unsuccessful valve stroke test and identified erratic behavior associated with the 1B MSIV. However, the work package was rejected and the post-maintenance testing was to be used to verify the operability of the MSIVs. BwVS 7.1.5-1 was identified in the work package as a required post-maintenance test and the work package was identified in the Mode 4 to Mode 3 checklist (BwGP 100-1T3) as a prerequisite for mode change to Mode 3.

The SCRE had reviewed the work package and the valve stroke test procedure. The test procedure listed, as a prerequisite, that the Technical Staff should be contacted to determine the applicability of performing response time testing. It was determined that the response time testing was not required. BwVS 7.1.5-1 also stated that several of the test steps (1.5 through 1.8, 2.5 through 2.8, 3.5 through 3.8, and 4.5 through 4.8) were not applicable if response timing was not required. The SCRE indicated in the test procedures those affected steps as not applicable. However, the SCRE failed to evaluate the actual steps contained in the procedure and by doing so, failed to observe the note contained in the procedure prior to steps 1.5, 2.5, 3.5, and 4.5. This note identified these sections of the procedure as testing the MSIVs for stroke time using the standby solenoid and as such verifying the operation of the affected standby accumulator.

The marked up test procedure was issued to the Unit 1 NSO for performance and subsequently completed. Prior to the actual mode change, the Shift Engineer (SE) verified with the SCRE that BwVS 7.1.5-1 had been completed. The SE then completed the mode checklist and Mode 3 was entered. Approximately one hour after entering Mode 3, a Shift Foreman reviewed the completed BwVS 7.1.5-1 and identified that the operability of the 1B MSIV had not been verified since the standby accumulator had not been tested. The 1B MSIV was immediately declared inoperable and the action statement for Technical Specification 3.7.1.5 was entered. The appropriate testing was subsequently completed and the MSIV declared operable. The Technical Specification action statement was verified not to have been exceeded.

The licensee determined that the root cause or cause of the event was a management deficiency in that the program for restoration of components or systems to operable status following maintenance did not provide a method to facilitate restoration without completion of the work package. The inspector's review of the procedures for mode change (BwGP 100-1), Mode 4 to Mode 3 checklist (BwGP 100-1T3) and the test procedure (BwVS 7.1.5-1) did not completely support the licensee's conclusion and cause classification. The inspector's evaluation is based upon the following:

The MSIV full stroke test procedure, BwVS 7.1.5-1, did contain within the details of the procedure, adequate identification in that steps 2.5 through 2.9 would have tested the affected MSIV standby accumulator. However, the SCRE had marked these steps as not applicable based upon the prerequisite C.6 without evaluating the actual steps in the procedure for applicability to the maintenance performed as documented in the work package. In this case, the cause classification is personnel error.

The work package was listed on the mode checklist (BwGP 100-1T3) as a prerequisite for entering Mode 3. The valve full stroke test (BwVS 7.1.5-1) was also identified by the work package as a required post-maintenance test. The SE failed to review the completed test to verify that the post-maintenance requirements were met, but only discussed the completion of the test with the SCRE. BwGP 100-1 requires that the SE verifies the completion of mode change prerequisites prior to entering the next mode. Administrative procedure BwAP 1600-1, "Maintenance Work Request," requires the SE (or Designee) to review the completed package, including a review of the post-maintenance checklist (BwAP 1600-1T1) for completion. Additionally, the SE is responsible for ensuring that operability testing is satisfactorily completed prior to declaring the system operable. Also, in this case, the cause classification is personnel error.

Both of the above discussions do not support a cause classification of a management deficiency due to programs not providing methods for restoring systems to operable status. In both cases, programs were in place but not followed. The inspector found that the appropriate cause classification to be personnel error.

The licensee's corrective actions included the future development and implementation of a formal methodology to facilitate restoration of components to operable status after maintenance and providing training to appropriate operating personnel on the work package completion process and post-maintenance testing review responsibilities.

A recent finding by the NRC during initial license examination indicated that operating personnel had difficulties in locating requirements in administrative procedures. Based upon this and the examples contained in the above event cause classification, the inspector determined that the licensee's corrective actions did not fully address the failures associated with implementing the existing formal methodologies contained in BwAP 1600-1 and BwGP 100-1. The licensee agreed with the inspector, in general, but stated that a clear formal methodology was still needed for similar situations.

Additionally, the inspector reviewed procedures BwGP 100-1 (Plant Heat Up) and BwGP 100-1T3 (Mode 4 to Mode 3 checklist) in detail and identified that both were mute on the requirements of Technical Specifications 3/4.7.1.5 for operability of MSIVs. Although this did not have any affect upon the event, the licensee's evaluation of the event did not provide a review of the applicability of Technical Specifications to the procedures intended to satisfy Technical Specification requirements for plant heatups and mode changes into operating Mode 3.

This is of interest since Technical Specification 3.7.1.5 is required in Modes 3 through 1 and entering into Mode 3 activates the requirement. The licensee agreed with the inspector's conclusion on the mode change checklist and initiated a review to revise the procedure.

Summary

The event described in Unit 1 LER 90014 was a violation of technical specification in that an operational mode change was made to Mode 3 without verifying that the MSIVs were operational as required by Technical Specification 3.7.1.5. Since the licensee identified the violation and corrective actions were effective in preventing recurrence during several subsequent mode changes, this is considered to be a non-cited violation (456/90026-01(DRP)) in accordance with 10 CFR 2, Appendix C, V.G.1 and, as such, a notice of violation will not be issued.

4. Operational Safety Verification (71707)

During the inspection period, the inspectors verified that the facility was being operated in conformance with the licenses and regulatory requirements and that the licensee's management control system was effectively carrying out its responsibilities for safe operation. This was done on a sampling basis through routine direct observation of activities and equipment, tours of the facility, interviews and discussions with licensee personnel, independent verification of safety system status and limiting conditions for operation action requirements (LCOARs), corrective action, and review of facility records.

On a sampling basis the inspectors daily verified proper control room staffing and access, operator behavior, and coordination of plant activities with ongoing control room operations; verified operator adherence with the latest revisions of procedures for ongoing activities; verified operation as required by Technical Specifications (TS); including compliance with LCOARs, with emphasis on engineered safety features (ESF) and ESF electrical alignment and valve positions; monitored instrumentation recorder traces and duplicate channels for abnormalities; verified status of various lit annunciators for operator understanding, off-normal condition, and corrective actions being taken; examined nuclear instrumentation (NI) and other protection channels for proper operability; reviewed radiation monitors and stack monitors for abnormal conditions; verified that onsite and offsite power was available as required; observed the frequency of plant/control room visits by the station manager, superintendents, assistant operations superintendent, and other managers; and observed the Safety Parameter Display System (SPDS) for operability.

During tours of accessible areas of the plant, the inspectors made note of general plant/equipment conditions, including control of activities in progress (maintenance/surveillance), observation of shift turnovers, general safety items, etc. The specific areas observed were:

a. Engineered Safety Features (ESF) Systems

Accessible portions of ESF systems and components were inspected to verify: valve position for proper flow path; proper alignment of power supply breakers or fuses (if visible) for proper actuation on an initiating signal; proper removal of power from components if required by TS or FSAR; and the operability of support systems essential to system actuation or performance through observation of instrumentation and/or proper valve aligrment. The inspectors also visually inspected components for leakage, proper lubrication, cooling water supply, etc.

b. Radiation Protection Controls

The inspectors verified that workers were following health physics procedures for dosimetry, protective clothing, frisking, posting, etc., and randomly examined radiation protection instrumentation for use, operability, and calibration.

c. Security

During the inspection period, the inspectors monitored the licensee's security program to ensure that observed actions were being implemented according to their approved security plan. The inspector noted that persons within the protected area displayed proper photo-identification badges and those individuals requiring escorts were properly escorted. The inspector also verified that checked vital areas were locked and alarmed. Additionally, the inspector also verified that observed personnel and packages entering the protected area were searched by appropriate equipment or by hand.

d. Housekeeping and Plant Cleanliness

The inspectors monitored the status of housekeeping and plant cleanliness for fire protection, protection of safety-related equipment from intrusion of foreign matter and general protection.

e. Management Involvement

The inspector reviewed the licensee's management and supervisory overview of activities within the control room and auxiliary building from November 1, 1990 through January 18, 1991. The review revealed that senior plant management had minimal involvement in overview of activities during November. Computer timekeeping indicated that senior plant management had made only five entries into the control room. In addition, both the senior plant management and the operating engineers had also made minimal entries into the auxiliary building, indicating minimal overview of activities. The inspector discussed these findings with the licensee and subsequently noted improvements in December 1990 and January 1991. Senior plant management increased their involvement in control room activities as evidenced by 33 entries in December and 16 entries in January (January 1 through 18). Both senior plant management and the operating engineers increased their entries into the auxiliary building to overview activities. Senior plant management tours of the auxiliary building increased from only 7 in November to 25 in December. Although the operating engineers increase their tours of the auxiliary building from only 1 on November to 17 in December, the total amount of actual time in the auxiliary building only increased by 10 minutes. This indicated that the quality of overview by the operating engineers has not increased. The inspector discussed this finding with the licensee. The licensee indicated that the operating engineers had not yet been integrated into a supervisory or overview role to ensure quality of safety related activities. The licensee indicated that a overview role by the operating engineers is being evaluated.

The inspectors also monitored various records, such as tagouts, jumpers, shiftly logs and surveillances, daily orders, maintenance items, various chemistry and radiological sampling and analysis, third party review results, overtime records, QA and/or QC audit results and postings required per 10 CFR 19.11.

On June 13, 1990, the licensee declared Unit 1 loose parts monitoring sensor channel IVE--LM009 inoperable and initiated work request NRW #A41640 to repair the defective sensor. On November 2, 1990, Unit 1 loose parts monitoring sensor channel IVE-LM010 was declared inoperable due to noise generated by the sensor. A preliminary investigation indicated that the noise was due to malfunctioning sensors in the Unit 1 containment. Both of these sensors IVE-LM009 and IVE-LM010 are located on the C Steam Generator inlet/outlet plenum. The failure of both sensors at this collection point, (Steam Generator C inlet/outlet plenum) constitutes an inoperable channel. Technical Specification 3.3.3.8, Loose-Part Detection System states in part: With one or more Loose-Part Detection System Channels inoperable for more than 30 days, prepare and submit a Special Report to the Commission pursuant to Specification 6.9.2 within the next 10 days.

Contrary to the above, the licensee did not submit the special report until December 24, 1990, which is 12 days after the 40 day time period. This is a violation of TS 3.3.3.8 (456/90026-02(DRP)).

Due to the fact that the licensee has met the requirements of 10 CFR 2

Appendix C Section V.G.1, Exercise of Discretion, a Notice of Violation will not be issued as this will be a non-cited violation.

During the next refueling outage, March 1991, the licensee will enter the containment in order to determine the exact cause of the sensor malfunctions. The failed sensor channel will be repaired at that time. Included during the outage will be the 18 month surveillance for the Loose Parts Monitoring system (LPMS) to ensure that the system is functioning properly.

In the interim, the LPMS detectors have been aligned to the following sensors: IVE-LM002 and 003 for the reactor vessel bottom and head; IVELM005, 008 and 012 for the inlet plenums of Steam Generators A, B and D; and IVE-LM018 and 019 for the lower narrow range tops of Steam Generators B and C. The detectors, along with the required day operating surveillances for audible detection of a loose part, will adequately detect any loose part occurrence until sensors IVE-LM009 and 010 can be repaired.

On December 30, 1990, The Unit 1 main generator tripped on a neutral ground overcurrent resulting in a reactor scram from 100 percent power. All safety related equipment responded as designed and the operating crew responded effectively to the event. During the event, one of the power operated relief valves (PORV) automatically opened due to a pressure spike and automatically closed as designed. The inspector reviewed the operating crews response and verified that the appropriate procedures were adhered to during the event and that the reactor was safely placed in hot shutdown. The licensee's investigation revealed that a ground fault existed on the C phase of the generator and that no visual damage existed. Subsequent investigations determined that the fault existed in one of the stator windings. The licensee entered a maintenance outage to repair the stator with expectations of returning the unit to service on February 20, 1990.

No violations or deviations were identified.

5. Monthly Maintenance Observation (62703)

Station maintenance activities affecting the safety-related systems and components listed below were observed/reviewed to ascertain that they were conducted in accordance with approved procedures, regulatory guides and industry codes or standards, and in conformance with Technical Specifications.

The following items were considered during this review: the limiting conditions for operation were met while components or systems were removed from and restored to service; approvals were obtained prior to initiating the work; activities were accomplished using approved procedures and were inspected as applicable; functional testing and/or calibrations were performed prior to returning components or systems to service; quality control records were maintained; activities were accomplished by qualified personnel; parts and materials used were properly certified; radiological controls were implemented; and fire prevention controls were implemented. Work requests were reviewed to determine the status of outstanding jobs and to assure that priority is assigned to safety-related equipment maintenance which may affect system performance.

The following maintenance activities were observed and reviewed:

Unit 1

Main Generator Repair
1B Diesel Generator - 18 month overhaul

The inspectors monitored the licensee's work in progress and verified that it was being performed in accordance with proper procedures, and approved work packages, that 10 CFR 50.59 reviews and applicable drawing updates were made and/or planned, and that operator training was conducted in a reasonable period of time.

No violations or deviations were identified.

6. Monthly Surveillance Observation (61726)

The inspectors observed surveillance testing required by Technical Specifications during the inspection period and verified that testing was performed in accordance with adequate procedures, that test instrumentation was calibrated, that limiting conditions for operation were met, that removal and restoration of the affected components were accomplished, that results conformed with Technical Specifications and procedure requirements and were reviewed by personnel other than the individual directing the test, and that any deficiencies identified during the testing were properly reviewed and resolved by appropriate management personnel.

On December 17, 1990, at 11:24 a.m., the licensee was performing surveillance BwIP 2400-004, "Calibration of Pressure/Differential Pressure Switch." An Instrument Mechanic (IM) preparing to calibrate pressure switch 2PS-FW219 had just started to remove the tubing to the switch when the tubing separated from the nut and Electro-Hydraulic (EH) fluid sprayed out of the tube. This resulted in the EH reservoir low level lockout and EH pump trip occurring. Prompt actions from operating personnel isolated the EH fluid to the 2B Feedwater pump stopping the flow of EH fluid. Several barrels of EH fluid were added to the EH reservoir and the operating personnel, by cycling the EH pumps, were able to maintain adequate EH system pressure to prevent a Unit and main turbine trip and/or a 2C feedwater pump trip that would have been caused by low EH system pressure. The transient had ended when the low EH fluid level alarm cleared at 11:56 a.m. The individuals sprayed with EH fluid were taken off site for medical attention.

The licensee is still investigating several aspects of this occurrence. This is the first time the licensee had preformed this surveillance. The last time this surveillance was performed it had been completed; 1) prior to the startup of the unit, and 2) performed by contractor personnel. The licensee is reviewing and revising the procedure, drawings and any other instructions that may be associated with this occurrence. They are also inspecting the tubing where the coupling broke off. The resident inspectors are following the licensee's actions.

No violations or deviations were identified.

7. Report Review

During the inspection period, the inspector reviewed the licensee's Monthly Performance Report for December 1990. The inspector confirmed that the information provided met the requirements of Technical Specification 6.9.1.8 and Regulatory Guide 1.16.

The inspector also reviewed the licensee's Monthly Plant Status Report for December 1990.

No violations or deviations were identified.

8. Meetings and Other Activities (30702)

On January 25, 1991, the Branch Chief for the Division of Reactor Projects (DRP) Branch 1, and the NRR Licensing Project Manager for the Braidwood Station visited the site. The resident inspectors provided a site tour.

9. Management/Plant Status Meeting

A meeting was held on January 25, 1991, between the Station Manager and Chief, Branch 1, Division of Reactor Projects and members of each of their staffs. The purpose of the meeting was for the licensee to provide an update on the status of Units 1 and 2, and the licensee's update of their actions as the result of the Enforcement Conference which was held on December 11, 1990.

No violations or deviations were identified.

10. Exit Interview (30703)

The inspectors met with the licensee representatives denoted in Paragraph 1 during the inspection period and at the conclusion of the inspection on January 25, 1991. The inspectors summarized the scope and results of the inspection and discussed the likely content of this inspection report. The licensee acknowledged the information and did not indicate that any of the information disclosed during the inspection could be considered proprietary in nature.

Attachment A

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

JAN 2 ° 1991

MEMORANDUM FOR: Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation of Operational Data

FROM: Jack E. Rosenthal, Chief
Reactor Operations Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation of Operational Data

SUBJECT: HUMAN FACTORS STUDY REPORT - BRAIDWOOD 1 (10/04/90)

On October 4, 1990, at 1:24 a.m., Braidwood Unit 1 experienced a loss of approximately 600 gallons of water from the reactor coolant system (RCS) while in cold shutdown. Braidwood 1 technical staff was conducting two residual heat removal (RHR) system surveillances concurrently, an isolation valve leakage test and valve stroke test. After completing a leakage measurement per one surveillance procedure, a technical staff engineer (TSE) in the control room directed an equipment attendant to close an RHR system vent valve. However, before those instructions could be carried out, another TSE in the control room directed that an RHR isolation valve be opened per another surveillance procedure. While the equipment attendant was still closing the vent valve, RCS coolant at 360 psig and 180 °F exited the vent valve, ruptured a tygon tube line and sprayed two engineers and the equipment attendant in the vicinity of the vent valve. This loss of coolant was reported to the control room and control room personnel quickly identified the cause of and isolated the leak.

Later on October 4, 1990, Region III formed an NRC Augmented Inspection Team (AIT) to perform an onsite special review of this event. The AIT team leader was Mr. W. D. Shafer of Region III. Other team members included S. Diab, NRR/PRAB, S. G. Du Pont, Region III/Dresden SRI, W. J. Kropp, Region III/Byron SRI, S. D. Sands, NRR/PD32, E. A. Trager, AEOD/ROAB, and J. L. Harbour, Idaho National Engineering Laboratory (INEL). INEL provided assistance as part of an AEOD program to study the human factors aspects of events. The team was at the site October 4 through 6 and gathered data from discussions, plant logs, strip chart recordings, and interviews of plant operators.

Enclosed is the report prepared by INEL of the results of the human factors study. Specific human performance aspects of this event are addressed in this memorandum.

JAN 2 8 1991

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Task Awareness

Braidwood operational and technical personnel were at three levels of task involvement and awareness: low, medium, and high. This was a major factor contributing to this event.

The shift engineer (SE), shift control room engineer (SCRE), Unit NSO and SA did not participate in the execution of the two surveillances and are considered to have had a low level of involvement and awareness. In addition, these personnel were unaware that the stroke test was being conducted.

Technical staff engineer (#3) and the auxiliary NSO had a moderate level of task involvement and awareness. Although they directly participated in some of the activities associated with the two procedures, both individuals appeared to lack an overall understanding of the systems configuration at all times. The auxiliary NSO did not involve himself in monitoring the state of the system while executing the valve manipulations and, thus did not serve to provide redundancy to the activities of technical staff engineers 1 and 2.

Technical staff engineers 1 and 2 had a high level of task involvement and awareness and were directly involved in all aspects of conducting and coordinating the two procedures. As a result success in this activity depended to a large extent on the performance of TSEs 1 and 2. However, their performance was affected because they were trying to conduct a difficult coordination task (perform two different surveillance procedures simultaneously on the same system) while fatigued (having been on the job for more than 17 hours). Furthermore, there were no redundancies or checks on their performance by operations personnel, which would be expected in a normal command, control, and communications structure in the control room.

Task Coordination

The task of coordinating two procedures in parallel without any written guidance is fairly complex and dynamic and requires knowledge-based behavior as opposed to rule-based behavior, and the probability of making an error is relatively high in such situations. This probability can be increased if the person involved in the activity is in a state of physical or mental fatigue, as might be the case after working for more than 17 hours. In executing dynamic tasks, it is critical that system redundancies or checks be in place to catch and prevent such errors. No such checks or redundancies were in place at Braidwood Unit 1 immediately preceding the event at 1:20 a.m. on October 4, 1990.

Command, Control, and Communications

A normal command, control, and communications structure was not present during the execution of these two surveillances. The SE, SCRE, and Unit 1 NSO were not sufficiently in the command, control and communication loop to offer oversight of the technical staff engineering activities, nor be aware of changes in the RCS configuration.

This event emphasizes the need for the operations shift organization to be thoroughly aware and in control of activities that may have an effect on the reactor plant.

This report is being sent to Region III for appropriate distribution within the region.

Original signed by

Jack E. Rosenthal, Chief
Reactor Operations Analysis Branch
Division of Safety Programs
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of Operational Data

Enclosure: As stated

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TRIP REPORT

Jerry L. Harbour

On-Site Investigation and Analysis of
the Human Factors of an Event
at Braidwood Unit 1
on October 4, 1990

(Reactor Coolant System Loss)

Investigative Team

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Stevie Dupont, Region III, Dresden SRI
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*Team Leader

October, 1990
INEL/EG&G Idaho, Inc.

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ACKNOWLEDGMENTS

Appreciation is expressed for the cooperation of the Braidwood Station staff, in particular the Unit 1 Control Room operators and technical staff engineering personnel who were on duty during Shift 3 on October 4 and who freely provided information concerning their observations, thinking, and actions. Thanks also to Orville Meyer, EG&G, Idaho, for his valuable input and editorial comments.

OUTLINE

EXECUTIVE SUMMARY

On October 4, 1990, at approximately 1:24 a.m., Braidwood Station Unit 1 experienced a loss of approximately 600 gallons of water from the Reactor Coolant System (RCS) while in cold shutdown. Later that day, NRC Region 3 formed an Augmented Inspection Team (ATI) to investigate the event. The AIT team leader was Wayne Shafer of Region III, NRC. Other team members included Sammy Diab, NRR/PRAB, Stevie Dupont, Region III, Dresden SRI, Wayne Kropp, Region III, Byron SRI, Stephen Sands, NRR/PD32, Eugene Trager, AEOD/ROAB, and Dr. Jerry Harbour, Idaho National Engineering Laboratory (INEL). INEL provided assistance as part of an AEOD program to study the human factors aspects of events. The team spent October 4 through 6 at the site and gathered data from discussions, plant logs, and extensive interviews with control room operators, technical staff engineering personnel, work planning personnel, and other station staff. This trip report provides a review of the details of the event, an analysis of the human factors that were relevant to the event, and a summary of the findings from the analysis.

At the time of the incident, Braidwood Unit 1 was in cold shutdown with the RCS at ≈ 180 degrees F and 360 psig. Two procedures were being executed in parallel by technical staff engineering, BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance and BwVS 0.5-2.RH.2-1, Residual Heat Removal Valve Stroke Test. The two surveillances had begun on Shift 3 (3 to 11 p.m.) and were still ongoing at shift changeover from Shift 3 to Shift 1 (11 p.m. to 7 a.m.). At approximately 1:20 a.m., two Technical Staff Engineers (TSEs 1/2) stationed in the control room, instructed another technical staff engineer (TSE 3) stationed in the 364 Elevation of the Auxiliary Building Unit 1 penetration area, to have the Equipment Attendant (EA) close vent valve 1RH028B, which was being used to collect leakage from the closed valve 1RH8702B, per BwVS 4.6.2.2-1. At approximately 1:24 a.m. TSE 1, without receiving confirmation from TSE 3 that the 1RH028B valve had closed, instructed the Auxiliary Nuclear Station Operator (Auxiliary NSO) to open valve 1RH8702B, per BwVS 0.5-2.RH.2-1.

Opening valve 1RH8702B aligned the RCS to the inlet of the still open vent valve 1RH028B. During the time that the 1RH8702B was open and the 1RH028B was being closed by the EA, flow through the vent suddenly surged and burst the tygon tubing attached to the valve, resulting in personnel in the Auxiliary Building being sprayed with hot water. Total indicated loss of pressurizer level was 5%, from 40 to 35%, which represents an approximate loss of 600 gallons.

TSE 3, another TSE present in training with TSE 3, and the EA, were all decontaminated following the incident. The EA received a second-degree-burn approximately 2 in. in diameter, on his left forearm when he shielded his face from the spraying water. After being decontaminated, he was taken to a local hospital for treatment of the burn.

The human factor issues were the controlling factors for this event and included:

> Task Characterization - - TSEs 1/2's task of coordinating two procedures in parallel without any written guidance represents a fairly complex, dynamic task which requires knowledge-based behavior as opposed to rule-based behavior. The probability of making an error or mental slip (e.g., momentarily forgetting a step,) is quite high in such situations. This probability may be increased if the person involved in such activities is in a possible state of physical/mental fatigue, suggested by the fact that TSEs 1/2 had been working some 17 to 19 hours. In executing dynamic tasks, it is critical that system redundancies or checks be in place to catch and/or prevent such errors. No such redundancies, however, were in place at Braidwood Unit 1 immediately preceding the incident at 1:20 a.m. on March 4th.

> Task Involvement/Awareness - - Three levels of task involvement and awareness by operational and technical staff engineering personnel were identified. The Shift Control Room Engineer (SCRE), Unit 1 NSO, Shift Engineer (SE), and Shift Adviser (SA) had a low level of task involvement/awareness and, in fact, were not cognizant that two procedures were being conducted. This lack of knowledge is

attributed to insufficient information being transferred during the shift turnover/briefing, and the SCRE and Unit 1 NSO not monitoring the types of activities being conducted in the Unit 1 control room. TSE 3 and the Auxiliary NSO had a moderate level of task involvement and awareness. Although they directly participated in executing some of the activities associated with the two procedures, both individuals appeared to lack an overall understanding of the system's configuration at all times. The Auxiliary NSO did not involve himself in monitoring the state of the system while executing the valve manipulations and, thus did not serve to provide redundancy to the activities of TSEs 1/2. TSEs 1/2 had a high state of task involvement/awareness and were directly involved in all aspects of conducting and coordinating the two procedures.

This task involvement/awareness configuration points out that overall task success was essentially a function of TSEs 1/2's performance. As noted earlier, however, their performance was affected by conducting a difficult coordination task under a possible state of physical/mental fatigue. Without any redundancies or checks on their performance by other operational personnel, which would be expected in a normal command, control, and communication structure, the likelihood of committing some type of error (e.g., slip) was quite high.

Bypassing Normal Command, Control, and Communication Structure

A normal command, control, and communication structure was not present during the execution of these two surveillances. The SE, SCRE, and Unit 1 NSO were not sufficiently in the command, control, and communication loop to offer oversight of the technical staff engineering activities, nor were they aware of changes in the RCS configuration.

1.0 INTRODUCTION

1.1 Purpose

NRC Region III formed an Augmented Inspection Team (AIT) to investigate the October 4, 1990 loss of approximately 600 gallons of water from the Reactor Coolant System (RCS) at Braidwood Unit 1 while in cold shutdown. The RCS loss resulted from the inadvertent opening at approximately 1:20 a.m. on October 4th of valve 1RH8702B per Procedure BwVS 0.5-2.RH.2-1 Residual Heat Removal Valve Stroke Test, prior to completing the closure of valve 1RH028B per Procedure BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance.

1.2 Scope

INEL provided assistance to the AIT as part of the AEOD program to study the human factors aspects of events. This report describes the results of analyses of the human factors aspects of the October 4, 1990 Braidwood I loss of reactor coolant event. These analyses focused on operational staff configuration, operational staff shift changeover briefings concerning the two ongoing procedures, communication channels among key personnel, characterization of the tasks being performed, the degree of involvement/awareness of personnel pertaining to the execution of the two surveillance procedures, the adequacy of the procedures, the adequacy of the human-machine interface, administrative controls on overtime, and operator recovery from the event.

1.3 Team Composition

The inspection team was lead by Wayne Shafer, Region III, NRC. Other team members included Sammy Diab, NRR/PRAB, Stevie Dupont, Region III, Dresden SRI, Wayne Kropp, Region III, Byron SRI, Stephen Sands, NRR/PD32, Eugene Trager, AEOD/ROAB, and Dr. Jerry Harbour, Idaho National Engineering Laboratory.

2.0 DESCRIPTION OF INVESTIGATION

2.1 Background

The Braidwood Nuclear Station is located in Illinois, approximately 60 miles southwest of Chicago, and consists of two Westinghouse, four-loop PWR's, each of 1120 MWe net capacity. The plant entered commercial operation in 1988. Both units are operated from a common control room. At the time of the incident, Unit 1 was in cold shutdown with the RCS at ≈ 180 degrees F and 360 psig.

Control room personnel are under the direction of the SE, with a SCRE responsible for oversight of both Units 1 and 2. A licensed NSO is directly charged with the operation of each unit. A SA is also present to assist personnel in the control room. At the time of the incident, another licensed NSO, termed the Auxiliary NSO, was working in the Unit 1 control room and was directly involved in conducting the two surveillances with technical staff engineering personnel. All operational personnel at the time of the incident, which occurred at approximately 1:20 a.m., had reported on shift at approximately 11:00 p.m., October 3. This shift is designated Shift 1, and runs from 11:00 p.m. to 7:00 a.m. The SCRE, Unit 1 NSO, Auxiliary NSO, SA, and SE were interviewed during the on-site investigation. The SCRE and SE are licensed SROs; the NSOs are licensed ROs.

Three technical staff engineers (TSEs 1, 2, and 3), a technical staff engineer in training who was with TSE 3 and one Equipment Attendant (EA) were directly involved in conducting the two procedures (BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance and BwVS 0.5-2.RH.2-1, Residual Heat Removal Valve Stroke Test) at the time of the incident. TSE 3 and the EA were positioned in the 364 Elevation of the Auxiliary Building, Unit 1 penetration area. A second technical staff engineer was with TSE 3 in the Auxiliary Building and was observing the surveillances. This individual, however, appeared to play no role in the ongoing events. TSEs 1/2 were positioned in the Unit 1 control room, working directly with the Auxiliary NSO. TSE 2 served primarily as a communications interface between the control room and the Auxiliary Building. TSE 1 signed off on all procedural steps and primarily directed and coordinated all activities relating to the execution of the two procedures. This task division, however, was not rigid. TSE 1 for example, did communicate at times directly with TSE 3 in the Auxiliary Building. Technical staff engineering personnel had reported on shift the previous morning, October 3. TSE 1 had been working approximately 19 hours at the time of the incident, and TSE 2 approximately 17 hours. TSEs 1, 2, 3, the observer, and the EA were interviewed during the on-site investigation.

During performance of Procedure BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance on March 4, valve 1RH0288, RH Hot Leg Suction Vent Valve, was opened to collect leakage past the RH Hot Leg Suction Valves, 1RH8702A and 1RH8702B, and past the RH Hot Leg Suction Line Pressure Relief Check Valve, 1RH8705B. Procedure BwVS 0.5-2.RH.2-1, Residual Heat Removal Valve Stroke Test, which times the opening stroke of the Hot Leg Suction Valves 1RH8702A&B, was also being performed in parallel with BwVS 4.6.2.2-1. The 1RH8720A valve had been timed when it was opened via BwVS 4.6.2.2-1 to change lineups to check leakage past the 1RH8702B and 1RH8705B valves. Figure 1 depicts schematically the various valve configurations and lineups.

After the leakage check on the valves was completed, the EA, via TSE 3 stationed in the Auxiliary Building, was directed by way of radio communication at approximately 1:20 a.m., to close vent valve 1RH028B, which was being used to collect leakage from the closed valve 1RH8702B per Procedure BwVS 4.6.2.2-1, Step F.2.21, by TSEs 1/2 in the Unit 1 control room. After approximately 4 minutes elapsed, TSE 1 directed the Auxiliary NSO to stroke open valve 1RH8702B per Procedure BwVS 0.5-2.RH.2-1, Step F.4.3. This directive by TSE 1 to the Auxiliary NSO was not heard by TSE 2, who was awaiting confirmation of the closure of valve 1RH028B from TSE 3. Further, TSE 1 had not received confirmation that valve 1RH028B had been closed before issuing the directive to open valve 1RH8702B.

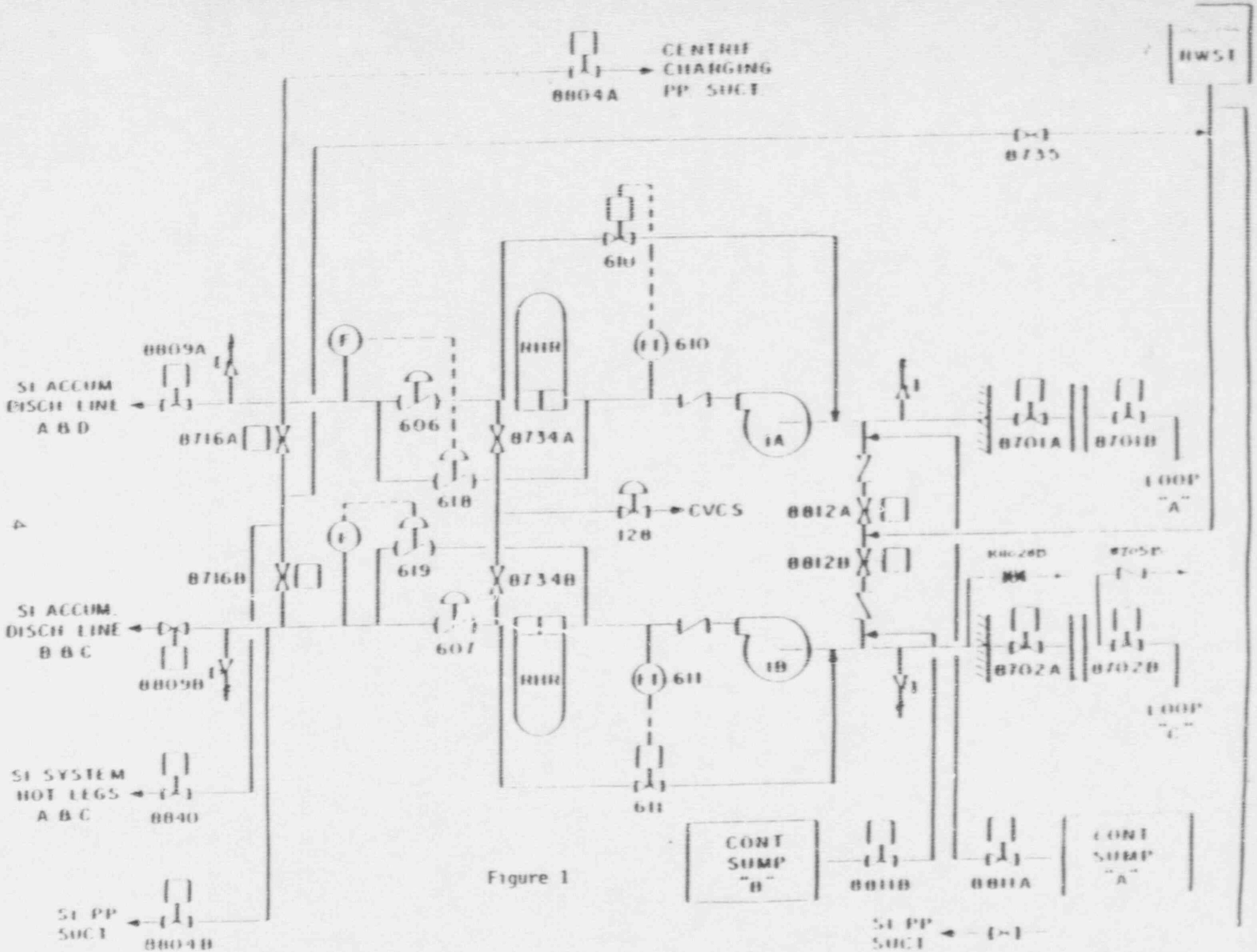

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Figure 1

Opening valve 1RH8702B aligned the RCS to the inlet of the still open vent valve 1RH028B. During the time that the 1RH8702A valve was open and the 1RH028B valve was closing, leakage through the vent increased and burst the tygon tubing attached to the valve, resulting in personnel in the Auxiliary Building being sprayed with hot water. Total indicated loss of pressurizer level was 5%, from 40 to 35%, which represents an approximate loss of 600 gallons.

TSE 3 in the Auxiliary Building upon being sprayed, immediately called the control room and reported the leak. The Unit 1 NSO noted a decrease in pressurizer level and immediately closed the 1RH8702B valve to stop the RCS inventory loss. He further closed the 1RH8702A valve to ensure the leak was isolated.

TSE 3, the TSE observing the procedure with TSE 3, and the EA, were all decontaminated following the incident. The EA received an second degree burn approximately 2 in. in diameter, on his left forearm when he shielded his face from the spraying water. After being decontaminated, he was taken to a local hospital for treatment of the burn.

2.2 Event Time Line

The following event-time-line sequence was constructed based upon interviews with the control room operators, technical staff engineering personnel, work planning personnel, and various log and briefing sheets:

<u>10/3/90</u>

- 0700 Operating engineer determined that BwVS 4.6.2.2-1, "Reactor Coolant System Pressure Isolation Valve Leakage Surveillance" would be conducted on A and B trains in a continuous manner.

- 0900 Technical staff engineering personnel decide to perform stroke surveillance test Procedure BwVS 0.5-2RH.2-1, "Residual Heat Removal Valve Stroke Test."

- 1500 Procedure 4.6.2.2-1 determined to be critical path and Technical Staff Engineering personnel instructed to provide 24-hour coverage.

- 1515 No records indicate that the two surveillances were discussed during Shift 2 to Shift 3 turnover.

- 1645 BwVS 4.6.2.2-1 and BwVS 0.5-2RH.2-1 surveillance testing started on Train A.

- 2100 Tech staff engineering personnel decide engineering personnel relief crew is not necessary, since surveillances will be completed in a few hours.

- 2200 Relief Tech Staff engineering crew notified not to come in.

- 2300 1A RH surveillances completed (partial).

- 2342 B-RH surveillance started

10/4/90 B-RH leak test surveillance in progress.

- 0120 TSE 2 in control room instructs TSE 3 in Auxiliary Building to close 1RH028B vent valve. TSE 1 further instructs TSE 3 to hang OOS tag.

  TSE 3 in Auxiliary Building acknowledge instructions to TSE 2 in control room and begin task of closing valve.

- 0124 TSE 1 directs Auxiliary NSO to open valve 1RH8702B.

  Auxiliary NSO opens valve 1RH8702B.

5% PZR level drop.

Tygon tube ruptures spraying personnel in Auxiliary Building. TSE 3 in Auxiliary Building calls the control room on telephone to report problem.

1RH8702B valve closed by Unit 1 NSO - - event terminated. All testing secured and measures initiated to decontaminate individuals in Auxiliary Building and provide medical treatment for EA.

(Possible precursor: Tech staff engineering determined they had failed to stroke-test one isolation valve in Train A during the leak test surveillance, and had to repeat step.)

2.3 Analysis

2.3.1 Crew Briefings

Following shift changeover from Shift 3 (3 to 11 p.m.) to Shift 1 (11 p.m. to 7 a.m.), the SCRE, the unit NSO, the SE, and the SA were advised that Procedure BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance, was in progress and being conducted by Technical Staff Engineering. They were not informed, however, that Procedure BwVS 0.5-2RH.2-1, Residual Heat Removal Valve Stroke Test, was also being conducted in parallel with the leakage test. The only member of the control room operational staff who was aware that both procedures were being conducted was the Auxiliary NSO, who did not pass this information on to other operational staff personnel.

2.3.2 Communication Channels

As illustrated in Figure 2, communication patterns at the time of the incident included direct communication between TSEs 1/2 and TSE 3 in the Auxiliary Building, between TSE 3 and the EA in the Auxiliary Building, and between TSEs 1/2 and the Auxiliary NSO in the Unit 1 Control Room. The Auxiliary NSO was not in direct or continuous communication concerning the execution of the two surveillances with any other operating staff personnel (e.g., NSO, SCRE, SA, and SE). This observation is substantiated by the fact that the NSO, SCRE, SA, and SE were unaware that two surveillances were being conducted in parallel. Also, it is important to note that the Auxiliary NSO and TSE 3 were not in direct communication with each other, but rather interfaced through TSEs 1/2. Figure 2 further illustrates that the standard command, control, and communication structure was bypassed, with the NSO, SCRE, and SE completely out of the command/control loop. As will be noted, this absence resulted in a lack of system redundancy or checks on the activities being performed by technical staff engineering personnel.

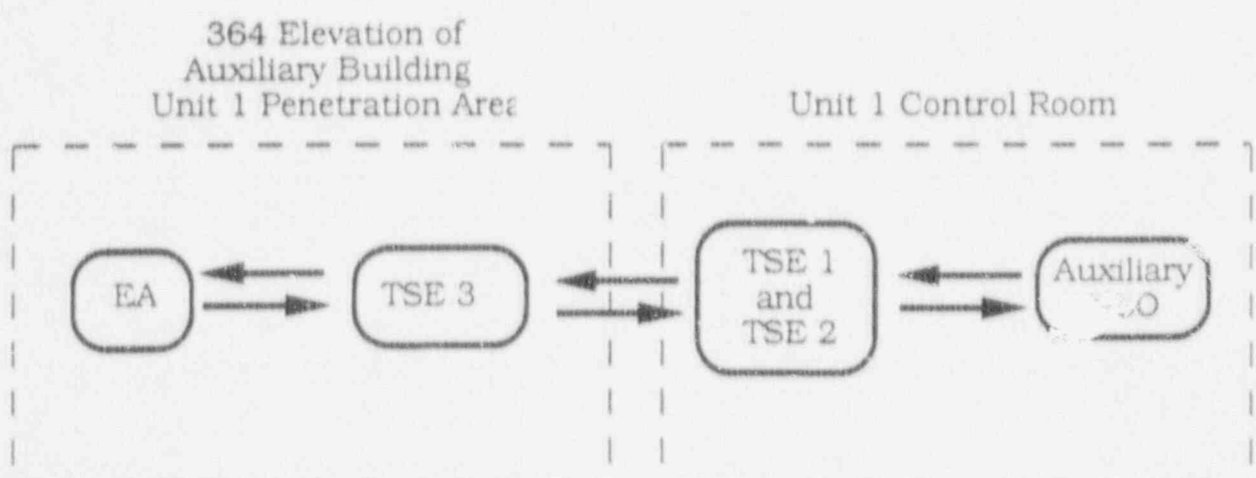

Figure 2. Communication patterns.

2.3.3 Task Characterization

At the time of the incident, two procedures, BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance, and BwVS 0.5-2RH.2-1, Residual Heat Removal Valve Stroke Test, were being conducted in parallel by technical staff engineering personnel. It should be noted that the two procedures are compatible and can be executed in parallel. However, there are no written guidelines on how to coordinate the two separate surveillances. Further, when questioned, most personnel could not remember conducting the two surveillances in parallel prior to October 3 and 4, 1990. Although the execution of each procedure, separately, is fairly straightforward and falls under what is termed rule-based behavior (e.g., behavior in which a person follows written rules; a step-by-step task), the coordination and execution of both procedures in parallel is a knowledge-based behavior (e.g., a behavior that requires an individual to plan his actions based on an analysis of the functional and physical properties of a system), and is more difficult to execute successfully. This type of coordination effort is referred to as a dynamic task, which requires a higher degree of man-machine interaction than is required for routine, procedurally guided tasks. Dynamic tasks may involve decision making, keeping track of several functions simultaneously, controlling several functions simultaneously, or any combination of these.

The increased complexity of performing both procedures in parallel was substantiated by the Auxiliary NSO who noted that they had become "lost" in attempting to coordinate the two separate surveillances at various times during Shift '. It should be further noted that while conducting the same two surveillances on the A train during Shift 3 (3 to 11 p.m.), a step involving the stroking of a valve was omitted. Also, at the time of the incident, TSE 1 had been on the job for approximately 19 hours, and TSE 2 for some 17 hours. Thus, the probability of committing an error on a dynamic task that is rarely performed in a potential state of high fatigue is quite high. For example, Swain and Guttman, 1983 (NUREG-1278, Table 20-16) place the probability of committing such an error at between 0.25 and 0.5.

2.3.4 Task Involvement/Awareness

A determination of task involvement/awareness among various operational personnel was also attempted. Task involvement refers to the degree in which an individual directly participated in executing the various steps of the two procedures. System awareness refers to the extent those same individuals were aware of changes in system configuration based on executing those steps (e.g., aware that by opening a valve, a change in the configuration of the system had occurred, and being able to mentally "picture" and understand that change). Three levels of involvement/awareness were identified: high, medium, and low. Based on this categorization, personnel were assigned to each level, as illustrated in Figure 3.

As depicted in the figure, the SCRE, Unit 1 NSO, SA, and SE had a low level of task involvement/awareness and in fact, were not even cognizant that both a leakage and a stroke surveillance were being conducted in parallel. This low task involvement/awareness appears to have been caused by an inadequate shift turnover, inadequate shift briefings, failure of the Auxiliary NSO to appraise the NSO of the extent of testing taking place, failure of the NSO to appraise himself of the exact nature of the tasks being conducted within the Unit 1 control room, and bypassing of the normal command, control, and communication structure.

TSE 3 and the Auxiliary NSO had a moderate level of task involvement/awareness. Although they were directly involved in executing some of the tasks required per the two procedures, they did not execute all of them. For example, the Auxiliary NSO was not always aware of instructions being given to TSE 3 by TSEs 1/2, nor was TSE 3 aware of instructions given to the Auxiliary NSO. As a result of this incomplete involvement and not communicating directly, neither individual was totally aware of the overall configuration of the system at all times - TSE 3, because he was not informed of all procedural steps being conducted by TSEs 1/2 in the Unit 1 control room, and the Auxiliary NSO, because he was not cognitively monitoring changes in system configuration as a result of executing the various procedural steps (e.g., he appeared to be only following instructions from TSEs 1/2). If a greater integration of TSE 3 and the Auxiliary NSO had occurred, the two individuals could have served as redundancies, serving as checks on the actions and directives of TSEs 1/2.

TSEs 1/2 had a high involvement/awareness of the two surveillances. They were involved in monitoring all facets of the two procedures, issuing all procedural directives, performing all required calculations, signing off all completed procedural steps, acting as the critical communications interface between themselves and TSE 3 and the Auxiliary NSO, and continuously monitoring all changes in system configuration.

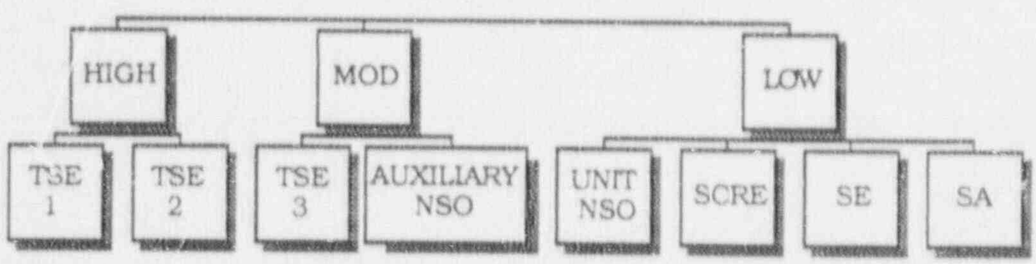

Figure 3. Personnel task awareness/involvement.

Based on this task involvement/awareness configuration, successful task performance was essentially dependent on the successful performance of TSEs 1/2. However, TSEs 1/2 performance was affected by attempting to coordinate a fairly complex dynamic task, as described in section 2.3.3, and in a possible state of physical and mental fatigue, suggested by the number of hours worked (approximately 19 and 17 hours, respectively). Also, this configuration highlights the lack of any redundancies or checks on TSEs 1/2's performance.

2.3.5 Administrative Controls on Overtime

Presently, no administrative controls exist for limiting the amount of allowable overtime of technical staff engineering personnel.

2.3.6 Procedures

As previously described, two procedures, BwVS 4.6.2.2-1, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance, and BwVS 0.5-2RH.2-1, Residual Heat Removal Valve Stroke Test, were used. Upon review, no discrepancies or irregularities in either procedure were noted. Further, no procedure was used, or even exists, for conducting the Leakage and Stroke surveillances in parallel.

2.3.7 Human-Machine Interface

No deficiencies were identified in the human-machine interface.

2.3.8 Operator Recovery from the Event

The event was quickly terminated by the actions of the Unit 1 NSO. He noted a decrease in pressurizer level and closed valve 1RH8702B to stop the RCS inventory loss. He further closed the 1RH8702A valve to ensure the leak was isolated. TSE 2, who received the call from TSE 3, did not immediately understand the source of the leakage. This lack of understanding is most likely attributed to his not knowing that the directive to open the 1RH8702B valve by TSE 1 had been given. Also, the Auxiliary NSO did not immediately diagnose the problem, presumably as a result of being under the impression that the

1RH028B valve had been closed. TSE 1 realized the source of the leakage, but by that time, the NSO had already taken steps to terminate the incident.

2.4 Synthesis

As previously stated, the initiating event that resulted in the incident at the Braidwood Unit 1 on March 4th, was the premature opening at approximately 1:20 a.m. of the 1RH8702B valve per Procedure BwVS 0.5-2RH.2-1, Step F.4.3, Residual Heat Removal Valve Stroke Test, before completing the closure of the 1RH028B valve per Procedure BwVS 4.6.2.2-1, Step F.2.21, Reactor Coolant System Pressure Isolation Valve Leakage Surveillance. According to the investigation and developed time line, the Auxiliary NSO was directed by TSE 1 in the Unit 1 control room to open the 1RH8702B valve before receiving confirmation from TSE #3 stationed in the Auxiliary Building that the 1RH028B valve had actually been closed. Both TSEs 1/2 stationed in the control room were aware that the EA had been directed to close valve 1RH028B. However, only TSE 1 was aware of the second directive given to the Auxiliary NSO to open valve 1RH8702B.

The primary cause of this incident is the failure ("forgetting") of TSE 1 to receive confirmation of the closure of valve 1RH028B before issuing the directive to open valve 1RH8702B. However, a number of factors contributed to this error of omission and the fact that checks built into the system to detect and avert such errors were not implemented.

As noted earlier, the performance of TSE 1 was adversely affected by performing a fairly complex "dynamic task" requiring knowledge-base behavior and involving the coordination of two separate procedures. Further, these procedures are not routinely conducted in this manner, thus experience level was also a factor. Also, task complexity may have been further compounded by the fact that TSE 1 had been working for approximately 19 hours at the time of the incident. Fatigue may have affected his mental capacities, which in turn would have made a complex task even more difficult. Given these circumstances, the probability of making an error in such situations by a single individual is quite high, as demonstrated Swain and Guttman, 1983 (NUREG-1278, Table 20-16), who placed a probability of committing such an error at between 0.25 and 0.5.

Given this high error potential, it is extremely important that redundancies or checks built into the system are utilized. This, however, was not the case in the Unit 1 control room. Because of an inadequate shift turnover/briefing, the SCRE, Unit 1 NSO, SE, and SA were unaware that both tests were being performed in parallel. It is possible that had they been aware of the extent of testing, they would have implemented some types of redundancies. It is also noteworthy that the Unit 1 NSO was unaware of the scope of testing being performed, even after some 2 hours on shift. These observations point out that the normal command, control, and communication structure that one would expect to find was not in place.

The Auxiliary NSO, who was assigned to assist the technical staff engineers in conducting the tests, was not cognizant of the configuration of the system he was operating. It appears that he was simply following instructions without thinking of the consequences/changes in the system's configuration. This lack of system awareness was partly a result of the way the test was being performed (e.g., directed only by TSEs 1/2), not communicating directly with TSE 3, not monitoring all instructions given to TSE 3 and TSE 3's responses, and overrelying on TSEs 1/2 to maintain a mental model of the system's state.

TSE 3, stationed in the 364 Auxiliary Building, only received instructions from TSEs 1/2 pertaining to actions required in the Auxiliary Building (e.g., to physically close a valve). Had he been informed of all procedural actions, as well as all directions given to the Auxiliary NSO, he may have been able to avert the situation that occurred. For example, if TSEs 1/2 had informed him to close valve 1RH028B as well as informing him that they were going to instruct the Auxiliary NSO to open valve 1RH8702B, he may have immediately replied that valve 1RH028B had not been closed yet. Also, if he would have communicated directly with the Auxiliary NSO, both he and the Auxiliary NSO would have been more integrated into the overall task configuration and would have served as redundancies or checks on TSEs 1/2.

It is suggested that given the requirement of performing a dynamic task in a possible fatigued state, it is not unlikely that an error will be committed. This observation is reaffirmed by the fact that a step was omitted earlier while conducting the same two procedures on Train A. Given this high error probability, it is essential that the task be configured in such a way that redundancies or checks are present. These redundancies were lacking, however, at the time of the incident, and the expected command, control, and communication structure was not in place.

3.0 SUMMARY OF FINDINGS

The findings from the analysis of this event may be summarized under two topics.

1. Task Characterization

   The task of coordinating two procedures in parallel without any written guidance represents a fairly complex, dynamic task which requires knowledge-based behavior as opposed to rule-based behavior. The probability of making an error or mental slip (momentarily forgetting a step, etc.) is quite high in such situations. This probability can be increased if the person involved in such activities is in a possible state of physical/mental fatigue, suggested by the fact that the persons in question had been working some 17 to 19 hours. In executing dynamic tasks, it is critical that system redundancies or checks be in place to catch and/or prevent such errors. No such redundancies, however, were in place at Braidwood Unit 1 immediately preceding the incident at 1:20 a.m. on March 4th.

2. Task Involvement/Awareness

Three levels of task involvement/awareness by operational and technical staff engineering personnel were identified. The SCRE, Unit 1 NSO, SE, and SA had a low level of task involvement/awareness and, in fact, were not even cognizant that two procedures were being conducted. This ignorance is attributed to insufficient information being transferred during the shift turnover/briefing, and the SCRE and Unit 1 NSO not monitoring the types of activities being conducted in the Unit 1 control room. TSE 3 and the Auxiliary NSO had a moderate level of task involvement/awareness. Although they directly participated in executing some of the activities associated with the two procedures, both individuals appeared to lack an overall understanding of the system's configuration at all times. The licensed Auxiliary NSO did not involve himself in monitoring the state of the system while executing the valve manipulations and, thus did not serve to provide redundancy to the activities of TSEs 1/2. TSEs 1/2 had a high state of task involvement/awareness and were directly involved in all aspects of conducting and coordinating the two procedures.

This task involvement/awareness configuration points out that overall task success was essentially a function of TSEs 1/2's performance. As noted earlier, however, their performance was affected by conducting a difficult coordination task under a possible state of high physical/mental fatigue. Without any redundancies or checks on their performance by other operational personnel, which would be expected in a normal command, control, and communication structure, the likelihood of committing some type of error (e.g., slip) was quite high.

3. Bypassing Normal Command, Control, and Communication Structure

A normal command, control, and communication structure was not present during the execution of these two surveillances. The SE, SCRE, and Unit 1 NSO were not sufficiently in the command, control, and communication loop to offer oversight of the technical staff engineering activities, nor be aware of changes in the RCS configuration.