NRC FORM 366 (6-1998) U.S. NUCLEAR REGULATORY COMMISSION

# LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)



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TITLE (4)

Reactor Trip Resulting From a Failure a Vital Inverter and a Subsequent Inverter failure.

| EVENT DATE (5) | | | LER NUMBER (6) | | | REPORT DATE (7) | | | OTHER FACILITIES INVOLVED (8) | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | DAY | YEAR | YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | MONTH | DAY | YEAR | FACILITY NAME | DOCKET NUMBER |
| 11 | 09 | 1998 | 1998 | -- 003 -- | 01 | 05 | 27 | 1999 | SQN UNIT 2 | 05000328 |
| | | | | | | | | | FACILITY NAME: NA | DOCKET NUMBER: 05000 |

| OPERATING MODE (9) | 1 | THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (Check one or more) (11) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| POWER LEVEL (10) | 100 | | 20.2201(b) | | 20.2203(a)(2)(v) | X | 50.73(a)(2)(i) | | 50.73(a)(2)(viii) |
| | | | 20.2203(a)(1) | | 20.2203(a)(3)(i) | | 50.73(a)(2)(ii) | | 50.73(a)(2)(x) |
| | | | 20.2203(a)(2)(i) | | 20.2203(a)(3)(ii) | | 50.73(a)(2)(iii) | | 73.71 |
| | | | 20.2203(a)(2)(ii) | | 20.2203(a)(4) | X | 50.73(a)(2)(iv) | | OTHER |
| | | | 20.2203(a)(2)(iii) | | 50.36(c)(1) | | 50.73(a)(2)(v) | | Specify in Abstract below or in NRC Form 366A |
| | | | 20.2203(a)(2)(iv) | | 50.36(c)(2) | | 50.73(a)(2)(vii) | | |

LICENSEE CONTACT FOR THIS LER (12)

| NAME | TELEPHONE NUMBER (Include Area Code) |
|---|---|
| J. W. Proffitt, Licensing Engineer | (423) 843-6651 |

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

| CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO EPIX | | CAUSE | SYSTEM | COMPONENT | MANUFACTURER | REPORTABLE TO EPIX |
|---|---|---|---|---|---|---|---|---|---|---|
| X | EF | INVT | S250 | Y | | | | | | |
| | | | | | | | | | | |

| SUPPLEMENTAL REPORT EXPECTED (14) | | | EXPECTED SUBMISSION DATE (15) | MONTH | DAY | YEAR |
|---|---|---|---|---|---|---|
| | YES (If yes, complete EXPECTED SUBMISSION DATE). | NO | | | | |

**Abstract** (Limit to 1400 paces, i.e., approximately 15 single-spaced typewritten lines) (16)

This LER is being revised to provide an additional condition of an oscillator board with a bad solder joint. On November 9, 1998, at 1139 Eastern standard time (EST), an automatic reactor trip occurred. The reactor trip was initiated by an overpower differential temperature reactor trip caused by the loss of vital power to the power range neutron detectors. The silicon controlled rectifier in the bridge circuit of Vital Inverter 1-IV failed causing the inverter to fail. With a nuclear instrumentation system power range channel out of service for testing, the logic necessary to initiate the reactor trip was completed. Control room operators responded to the unit promptly, diagnosed the condition, and took necessary actions to stabilize and maintain the unit in a safe condition. The inverter bridge circuit was replaced and the inverter was returned to an operable status. On November 25, 1998, at 0924 EST, Vital Inverter 1-IV tripped. The inverter trip was caused by a failed oscillator board with a bad solder joint, attributed to a manufacturer's defect. The component was replaced and the inverter was returned to an operable status. On April 28, 1999, during an extent of condition review, an oscillator board with a bad solder joint was identified on the 2-IV vital inverter. The remaining Units 1 and 2 inverters were verified to be acceptable. The oscillator board was repaired and returned to service.

## I. PLANT CONDITION(S)

Units 1 and 2 were in power operation at approximately 100 percent.

## II. DESCRIPTION OF EVENT

### A. Event:

On November 9, 1998, at 1139 Eastern standard time (EST), an automatic reactor trip occurred. The reactor trip was initiated by an overpower differential temperature reactor trip caused by the loss of vital power to a power range neutron detector. The silicon controlled rectifier (SCR) in the bridge circuit of Vital Inverter 1-IV [EIIS Code EF] failed causing the inverter to fail. This was likely initiated by a voltage transient that followed starting the "CS" component cooling system pump [EIIS Code CC] during performance of an American Society of Mechanical Engineers Section XI test. The failure of the vital inverter resulted in a loss of power to 120-Volt alternating current (VAC) Vital Instrument Power Board 1-IV. With the nuclear instrumentation system power range Channel II out of service, the loss of the 120-VAC Vital Instrument Power Board completed the logic necessary to initiate the reactor trip. The inverter was repaired and returned to service on November 10, 1998.

On November 25, 1998, at 0924 EST, Vital Inverter 1-IV tripped and Operations declared the inverter inoperable. It was determined that the inverter trip was caused by a oscillator board with a bad solder joint. The solder problem is attributed to a manufacturer's defect. The component had been replaced as part of the repair activities for the event described above. After review of the failure mechanism, it was determined that the component did not comply with the inverter seismic requirements. Although the inverter met the postmaintenance testing requirements when it was returned to service on November 10, 1998, it was determined that the inverter had been inoperable since that time and this condition is considered

an operation prohibited by technical specifications.

On April 28, 1999, during an extent of condition review, an oscillator board with a bad solder joint was identified on the 2-IV Vital Inverter. The oscillator board was installed as part of a vendor recommended preventive maintenance activity on October 2, 1997. The oscillator board did not comply with the inverter seismic requirements. Although the inverter met the postmaintenance testing requirements when it was placed in service following installation of the oscillator board, it was determined that the inverter had been inoperable since that time. The remaining Units 1 and 2 inverters were verified to be acceptable.

B. **Inoperable Structures, Components, or Systems that Contributed to the Event:**

On November 9, 1998, nuclear instrumentation system power range Channel II was out of service for performance of functional testing.

There were no components out of service on November 25, 1998, that contributed to the second inverter failure.

C. **Dates and Approximate Times of Major Occurrences:**

| | |
|---|---|
| November 9, 1998, at 1139 EST | A reactor trip occurred with a subsequent turbine trip. The main control room operators stabilized the reactor in Mode 3 (hot standby). |
| November 9, 1998, at 1139 EST | Operations entered the applicable limiting condition for operations (LCOs) associated with the failure of the vital inverter and loss of power to 120-VAC Vital Instrument Power Board 1-IV. |
| November 9, 1998 | Operations exited the applicable LCOs following power restoration to 120-VAC Vital Instrument Power Board 1-IV. |

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| November 10, 1998, at 1025 EST | To allow adequate time to complete the troubleshooting activities and the repair of the 1-IV Vital Inverter, TVA requested and was granted discretionary enforcement for an additional 48 hours. |
| November 10, 1998, at 1156 EST | The repairs and testing were completed and did not require the use of the discretionary enforcement granted by NRC. The vital inverter was declared operable and LCO 3.8.2.1.b was exited. |
| November 25, 1998, at 0924 EST | Vital Inverter 1-IV tripped and Operations declared the inverter inoperable. LCO 3.8.2.1 was entered. |
| November 25, 1998, at 1620 EST | The repairs and testing for operability were completed on Vital Inverter 1-IV. Operations declared the inverter operable and exited LCO 3.8.2.1. |
| April 28, 1999, at 0858 Eastern Daylight Time (EDT) | Vital Inverter 2-IV was removed from service for performance of testing, maintenance activities, and an extent of condition review. Operations entered LCO 3.8.2.1 Action (b) on Unit 1. |
| April 28, 1999 | During performance of the activities, it was identified that an oscillator board contained a bad solder joint. The oscillator board with the bad solder joint was repaired and reinstalled. |
| April 28, 1999, at 1438 EDT | Testing of the 2-IV Vital Inverter was completed and the inverter was returned to service. Operations exited LCO 3.8.2.1 on Unit 1. |

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D. **Other Systems or Secondary Functions Affected:**

The loss of power to 120-VAC Vital Instrument Power Board 1-IV resulted in the steam dumps not being available.

The loss of power to 120-VAC Vital Instrument Power Board 1-IV resulted in deenergizing a relay for the Unit 2 steam generator (S/G) blowdown flow to the cooling tower blowdown flow isolation valve, isolating the flow.

No other systems were affected by the oscillator board that included the bad solder joint.

E. **Method of Discovery:**

The reactor and turbine trips were annunciated on the main control room panels.

The November 25, 1998, inverter trip was annunciated on the main control room panels.

On April 28, 1999, during performance of maintenance activities, testing, and an extent of condition review, it was identified that an oscillator board on the 2-IV Vital Inverter contained a bad solder joint.

F. **Operator Actions:**

Control room operators responded to the reactor and turbine trips as prescribed by emergency procedures. They promptly diagnosed the condition and took necessary actions to stabilize and maintain the unit in a safe condition. Operations entered the applicable LCOs associated with the failure of the vital inverter and loss of power to the vital board.

Following the November 25, 1998 inverter trip, Operations responded to the failure of the vital inverter as prescribed by abnormal operating procedures. They promptly diagnosed the condition and took necessary actions to stabilize and maintain the unit. When the main feedwater

regulator valves began to close, operators quickly diagnosed the problem and placed the valves in manual. Operations entered the applicable LCOs associated with the failure of the vital inverter and loss of power to the vital board.

No operator action was required for the April 28, 1999 identification of the oscillator board containing the bad solder joint since the associated inverter had been removed from service for performance of maintenance activities.

**G. Safety System Responses:**

The reactor protection systems, including feedwater isolation and auxiliary feedwater start, responded to the trip as expected with the loss of an inverter and 120-VAC Vital Instrument Power Board 1-IV.

Following the reactor trip, steam pressure increased to approximately 1065 psig at which point one or more of the first bank of main steam safety valves opened.

As a result of the November 25, 1998 event, the safety systems responded as expected with the loss of an inverter and 120-VAC Vital Instrument Power Board 1-IV.

No safety system response was required for the identification of the oscillator board containing a bad solder joint.

## III. CAUSE OF THE EVENT

**A. Immediate Cause:**

The immediate cause of the unit trip was the initiation of a reactor trip signal when Channel IV of the nuclear instrumentation system power range was lost in conjunction with the power range Channel II instrumentation previously being removed from service.

The immediate cause of the November 25, 1998, inverter trip was a loose connection in the inverter circuit.

The immediate cause of the bad oscillator board identified on April 28, 1999, was a bad solder joint.

B. **Root Cause:**

The root cause of the unit trip was the failure of an SCR in the inverter bridge circuit of Vital Inverter 1-IV. This was likely initiated by a voltage transient that followed starting the CS component cooling system pump.

The root cause of the November 25, 1998 inverter trip, was a bad solder joint on a oscillator board, attributed to a manufacturer's defect.

The root cause of the bad solder joint on the oscillator board identified on April 28, 1999, is attributed to a manufacturer's defect.

C. **Contributing Factors:**

None.

## IV. ANALYSIS OF THE EVENT

When the reactor trip occurred, the pressurizer pressure decreased to approximately 2065 psig as expected, then increased until a pressurizer PORV automatically actuated. The increase in pressurizer pressure was primarily the result of the loss of the pressurizer spray capabilities because of the loss of power to 120-VAC Vital Instrument Power Board 1-IV. Additionally, the S/G atmosphere relief valves on Loops 2 and 3 were manually closed as required by procedures. The pressurizer PORV maintained the reactor coolant system (RCS) pressure to approximately 2340 psig. There was no indication of an RCS safety valve lifting and the RCS pressure limits were not exceeded. The results of this trip are below RCS pressures evaluated in the Final Safety Analysis Report (FSAR) for the limiting transient.

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When the reactor trip occurred, normal letdown isolated as a result of the loss of power to 120-VAC Vital Instrument Power Board 1-IV. Operations placed excess letdown in service.

Following the reactor trip, S/G pressure increased to approximately 1010 psig. The introduction of cold auxiliary feedwater reduced steam pressure to 940 psig. As discussed above, the loss of the vital inverter and 120-VAC Vital Instrument Power Board 1-IV caused a loss of power to the condenser steam dump system. As a result, steam pressure increased to approximately 1065 psig at which point one or more of the first bank of main steam safety valves opened and stabilized steam pressure at 1065 psig. S/G pressure exceeded the normal power atmospheric relief valve setpoint of 1025 psig as a result of a malfunction of two of the atmospheric relief valves. One of the atmospheric relief valves opened at a pressure higher than its setpoint. Subsequent atmospheric relief valve operation, after restoration of power, reduced steam pressure to approximately 1020 psig. This response was well within safety limits. Technical specification and FSAR requirements were not challenged.

The plant safety systems responses during and after the unit trip were bounded by the responses described in the FSAR. Therefore, this event did not adversely affect the health and safety of plant personnel or the general public.

During the time period the 1-IV inverter was considered to have been inoperable (November 10-25, 1998), the Channels I, II, and III inverters and sufficient equipment were available to have shutdown the plant and maintained the plant in a safe condition. Therefore, this condition did not adversely affect the health and safety of plant personnel or the general public.

During the time period the 2-IV inverter was considered to have been inoperable (October 2, 1997 through April 28, 1999), the Channel I, II, and III inverters and sufficient equipment were available to have shutdown the plant and maintained the plant in a safe condition. Therefore, this condition did not adversely affect the health and safety of plant personnel or the general public.

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## V. CORRECTIVE ACTIONS

### A. Immediate Corrective Actions:

Control room operators responded to the reactor and turbine trips as prescribed by emergency procedures. Operators promptly diagnosed the condition and took necessary actions to stabilize and maintain the unit in a safe condition.

Control room operators responded to the 1-IV inverter trip as prescribed by procedures. Operators promptly diagnosed the condition and entered the applicable LCO associated with the failure of the vital inverter. The oscillator board was replaced and the inverter was returned to service.

The defective oscillator board was repaired and reinstalled in the 2-IV inverter. The inverter was tested and returned to service.

### B. Corrective Actions to Prevent Recurrence:

The inverter bridge circuit was replaced. The repairs and testing for operability of the vital inverter were completed. The 120-VAC Vital Instrument Power Board 1-IV was returned to operable status.

An analysis of the bridge circuit determined that there was a random failure of the SCR.

A design change has been initiated to replace the vital inverters with inverters that contain a static switch. The static switch will prevent the loss of power to the boards following a trip of the inverter.

Each of the Units 1 and 2 Vital Inverters have been inspected. No other problems with the circuit boards were identified. The vendor has been notified of the identified condition.

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## VI. ADDITIONAL INFORMATION

### A. Failed Components:

The November 9, 1998 event, involved an inverter (Solid State Controls, Inc., Model No. SV12200/AC34R). Plant personnel examined the inverter and determined the inverter tripped as a result of a failed SCR in the bridge circuit.

The November 25, 1998 event, involved the same inverter. Plant personnel examined the inverter and determined the inverter tripped as a result of a bad solder joint on the oscillator board.

The condition identified on April 28, 1999, involved Vital Inverter 2-IV. The inverters are the same models. The bad solder joint on the oscillator board was the result of a manufacturer's defect.

### B. Previous LERs on Similar Events:

A review of previous events identified two other events (LER 50-327/90021 and LER 50-327/1998001) associated with the failure of a vital inverter. LER 50-327/1998001 was not the result of a failed inverter bridge circuit. LER 50-327/90021 was a random failure of a SCR caused by the prolonged paralleling of the normal and maintenance sources during transfer from one power source to the other. The SCR was replaced and the inverter was returned to service. This event involved a failed SCR in the bridge circuit that was likely initiated by a voltage transient that followed starting of a pump. Therefore, the previous corrective actions could not have prevented this event.

There are no previous similar events associated with a inadequate solder joints on the vital inverters.

### C. Additional Information:

None.

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## VII. COMMITMENTS

None.