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

FROM: Jack E. Rosenthal, Chief
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Office for Analysis and Evaluation
of Operational Data

SUBJECT: HUMAN PERFORMANCE STUDY REPORT – FORT CALHOUN STATION (7/3/92)

On July 3, 1992, Fort Calhoun experienced a partially stuck-open relief valve, depressurization, and safety injection. Prior to the event, Fort Calhoun was operating at 100 percent power. At 11:36 p.m., the operating crew transferred a nonsafety-related inverter from bypass to normal following maintenance on the inverter. Immediately following the transfer, a control room operator observed voltage oscillations on the associated bus. The voltage oscillations caused an electrical supply breaker to electrical panel AI-50 to trip open on high current.

A number of pressure transmitters that provide input to the control circuitry for the main turbine (supplied by panel AI-50) lost power, causing the main turbine control valves to shut while the main turbine stop valves remained open (loss of load without a turbine trip). The steam bypass valves to the condenser remained closed because a turbine trip signal is needed for them to automatically operate. With the condenser lost as a heat sink, reactor coolant system temperature and pressure increased. The main steam safety valves opened. An automatic reactor scram and turbine trip occurred at approximately 2400 psia, and the pressurizer power-operated relief valves (PORVs) opened.

Reactor pressure continued to rise and a pressurizer code safety valve opened to reduce reactor coolant system pressure. Reactor coolant pressure subsequently decreased to 1745 psia and then began to increase. Operators implemented their emergency operating procedures (EOPs) for standard post trip actions. When pressure reached 1925 psia, quench tank alarms were received and reactor pressure began to rapidly decrease. Operators shut the PORV block valves, but reactor pressure continued to decrease. Safety injection, and containment and ventilation isolation signals were received. Operators diagnosed that pressurizer code safety valve RC-142 had opened and remained partially open. Later investigation found that the initial pressure increase, which had caused the valve to actuate, also resulted in a lowering of RC-142's lift and reseat setpoints.

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The partially open safety valve created an unisolable loss of coolant from the pressurizer to the quench tank. The quench tank rupture disc blew as designed allowing the reactor coolant to spill into the containment sump.

Operators transitioned to procedure EOP-20, "Functional Recovery," based on multiple problems (inverter failure and unisolable loss of coolant). The event was classified as an Alert at 11:52 p.m. on July 3. The licensee activated the emergency response organization and notified offsite agencies. Several key personnel were already onsite due to involvement in the inverter maintenance activities and were immediately available to assist the shift supervisor with emergency plan activities.

As directed by EOP-20, the operations crew secured reactor coolant pumps, verified natural circulation, and initiated a plant cooldown and depressurization to shutdown cooling entry conditions. Reactor coolant system leakage was minimized during the cooldown by stopping or throttling safety injection flow.

The emergency classification was downgraded to a Notification of Unusual Event (NOUE) at 06:30 a.m. on July 4 with the reactor coolant system at 290 °F and 360 psia. The NOUE was terminated at 6:40 p.m. that evening with the plant depressurized and on shutdown cooling at about 120 °F.

On July 4, 1992, Region IV formed an NRC Augmented Inspection Team (AIT) to perform an onsite special review of this event. The onsite AIT team leader was Mr. P. Harrell of Region IV. Other onsite team members included P. Wagner, Region IV, C. Paulk, Jr., Region IV, T. Reis, Region IV, C. Liang, NRR/RSB, J. Kauffman, AEOD/ROAB, and W. Steinke, Idaho National Engineering Laboratory (INEL). INEL provided assistance as part of an AEOD program to study human performance. The human performance specialists were onsite July 4 through 9, 1992, and gathered data from discussions, plant logs, strip chart recordings, and interviews of plant staff.

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

Shift Organization and Staffing

The shift organization and staffing contributed to the crew's effective response. The reactor operators had clearly defined areas of chief responsibility. The primary licensed operator was responsible for the reactor plant, while the secondary licensed operator was responsible for balance of plant (BOP). Similarly, the senior reactor operator responsibilities were split. The shift supervisor was responsible for site and emergency response, while the licensed senior operator directed the operators in responding to the event. A dedicated communicator was used for event notifications. The "single role" shift technical advisor monitored safety functions and otherwise assisted the crew. In addition, circumstances were fortunate in that the operations manager and the maintenance supervisor were in the plant and available to assist the shift supervisor early in the event. The prompt activation of the emergency response organization also contributed to timely support of the operating crew.

Task Awareness

The operating crew exhibited a high level of task awareness during the event. Proactive monitoring and actions were taken. Future actions were anticipated to preempt undesirable plant conditions. A number of factors probably contributed to the high level of task awareness. The event occurred at the beginning of shift when awareness is typically high. The event was a "classical" loss of coolant from the pressurizer. Operators are frequently trained and examined for such events. Two of the crew members had experienced a similar loss-of-inverter event in 1986. Operators accurately diagnosed the event, and understood the observed and expected plant response.

Maintenance

Several latent factors contributed to the failure of the inverter that initiated the event. Post-maintenance testing could not be performed without placing the inverter in service, and information was not available from the vendor regarding correct circuit board configuration. Similarly, the torque required for the setpoint locking nut of the safety-relief valve was not available, which may have contributed to the safety-relief valve failing partially open.

Training and Procedures

Operators made specific comments that training on the plant-specific simulator had improved their ability to respond to events compared to (previous) training on a nonplant-specific simulator. The operators felt that it was more beneficial to observe one's own plant response (Fort Calhoun indications, controls and locations) rather than that of a generic plant. Another advantage of a site-specific simulator was that during training sessions, procedures were used and "validated," (i.e., procedure weaknesses were identified and corrected). Despite this, several weaknesses in the EOPs became apparent during the event. These weaknesses involved the electrical lineup for start of reactor coolant pumps, guidance for placing low-temperature overpressure protection in service, and guidance for condensate pump control. A strength was noted in that practical emergency plan response was routinely practiced and discussed during simulator training.

Human-Machine Interface

Several human-machine interface weaknesses were identified. The valve controls and indications for stopping and throttling high-pressure safety injection (HPSI) were located about 10 feet apart. The HPSI valves were not designed as throttle valves, and therefore, did not have consistent linear control characteristics throughout their range of control. The sonic flow indications for the PORV and safety relief valves were remotely located from associated indications.

Because some of the computer displays were malfunctioning, operators obtained information using alternative means. Some operators reported difficulty doing this, suggesting that routine training could be improved by including actions for degradation or failure of computer systems.

Equipment Performance

All safety-related equipment functioned as designed during the event, except for the partially-open pressurizer safety relief valve. Operators experienced a variety of problems in balance of plant (BOP) systems during the early stages of the event that required additional operator time and attention.

Overall

The response to the event was a success. Many strengths were identified in: control room organization and staffing; crew response, including task awareness; procedures; and training. As could be expected with any very infrequent event, specific potential improvements were identified in the areas of maintenance, human-machine interface, training, and procedures.

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

Original signed by

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Enclosure: As stated

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