UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

January 19, 1995

NRC INFORMATION NOTICE 95-04: EXCESSIVE COOLDOWN AND DEPRESSURIZATION OF THE REACTOR COOLANT SYSTEM FOLLOWING A LOSS OF OFFSITE POWER

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to an excessive cooldown and depressurization of the reactor coolant system (RCS) and the main steam system following a loss of offsite power at the McGuire Nuclear Station Unit 2. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On December 27, 1993, while McGuire Unit 2 was operating at 100-percent power, 525-kV bus line 2B was lost because of a failed insulator (this was the event initiator). Because the expected turbine runback failed to initiate, breakers for bus line 2A opened on overcurrent protection, resulting in a loss of offsite power to the unit. Reactor coolant pumps tripped when offsite power was lost, resulting in core cooling by natural circulation. Emergency diesel generators successfully started and provided power to the vital buses. The reactor tripped on "Power Range High Flux Rate" 36 seconds into the event, and the turbine immediately tripped because of the reactor trip. After the reactor trip, the RCS rapidly cooled down and depressurized because of a reduction of energy input and an increase in energy removal, by full unthrottled auxiliary feedwater (AFW) flow and several steam release paths. The steam paths included the AFW pump, open steam line relief and safety valves, open steam dumps, and open drain lines. A safety injection signal was received on low pressurizer pressure 7 minutes and 32 seconds into the event, followed by another safety injection signal on low steam line pressure and a main steam isolation signal 1 second later. The main steam isolation valve (MSIV) for steam generators A and B failed to close fully. The continuing steam loads, including the open MSIV, caused secondary system pressure to drop rapidly, and unthrottled AFW flow continued to lower steam pressure and temperature. Continued secondary cooling caused a continuous drop in the RCS temperature. In addition, because forced circulation was lost with the loss of the reactor coolant pumps, a large temperature differential existed across

the reactor core, indicated by a rapid reduction in the RCS cold-leg temperature. Sixteen minutes and 48 seconds into the event, operators throttled AFW flow to zero for all four steam generators, allowing the stabilization of pressure in steam generators A, C, and D. Pressure in steam generator B recovered temporarily but continued to drop because of the open MSIV. In addition, water level in steam generator B was decreasing. Approximately 1.5 hours into the event, the indicated wide-range water level in steam generator B reached zero. Concurrently, operators were cycling pressurizer power-operated relief valves to reduce the primary pressure and thereby reduce the differential pressure across the tubes of steam generator B to less than 11.03 MPa [1600 psi] (as suggested by McGuire emergency operating procedures for a dry steam generator). Differential pressure across the tubes of steam generator B reached approximately 13.65 MPa [1980 psi]. Cycling the power-operated relief valves caused the pressure and water level to increase in the pressurizer relief tank, rupturing the rupture disk. Ice condenser doors opened in response to the rupture of the rupture disk. Offsite power was restored approximately 1.5 hours into the event, and the vital buses were realigned to offsite power approximately 2.5 hours into the event.

Discussion

In its followup evaluation, Duke Power Company (the licensee) concluded that steam loads and AFW flow caused the rapid secondary side depressurization and cooldown before the main steam isolation. The licensee performed detailed modeling of the relative contributions to the cooldown of the unthrottled AFW flow, the AFW pump turbine steam load, and the open steam line drains, and determined that the open steam line drains were the primary contributor. At McGuire, AFW actuation logic for a loss of offsite power automatically starts the turbine-driven AFW pump. A loss of offsite power causes a loss of control power for both main feedwater pumps, which trips the pumps and causes an automatic start of the motor-driven AFW pumps. AFW injects at the maximum rate when started automatically. At the time the safety injection actuated, the operators had not reached a point in the emergency operating procedures where throttling of the AFW was allowed. In addition, no specific guidance was given to the operators for monitoring the RCS cold-leg temperature or throttling the AFW to slow a cooldown indicated by the cold-leg temperature. In natural circulation, reactor coolant cooling is best tracked by monitoring the cold-leg temperature. Emergency operating procedures (EOPs) have been changed to instruct operators when checking for an uncontrolled cooldown that the cold-leg temperature will be used if reactor coolant pumps are off to ensure that operators control AFW earlier in this type of event. A training package was issued to all reactor operators on the use of the EOP foldout page. This information should reduce the time required to complete EOPs and to arrive at the steps for manual main steam isolation and throttling of the AFW. The licensee has also modified steam line drains upstream and downstream of the MSIVs to fail closed on a loss of power. The modifications will slow the secondary side depressurization rate and the RCS cooldown rate. The change of the EOP is consistent with Revision 1B of the Westinghouse Emergency Response Guidelines. These changes were discussed by the operations support manager in a lecture during requalification training of the licensed operators. The changes will ensure more effective AFW control during an excess cooldown process following a reactor and turbine trip.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian K. Grimes, Director
Division of Project Support
Office of Nuclear Reactor Regulation

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(301) 504-1171

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(301 504-2878

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LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
95-03	Loss of Reactor Coolant Inventory and Potential Loss of Emergency Mitigation Functions While in a Shutdown Condition	01/18/95	All holders of Ols or CPs for nuclear power reactors.
95-02	Problems with General Electric CR2940 Contact Blocks in Medium-Voltage Circuit Breakers	01/17/95	All holders of OLs or CPs for nuclear power reactors.
95-01	DOT Safety Advisory: High Pressure Aluminum Seamless and Aluminum Composite Hoop-Wrapped Cylinders	01/04/95	All U.S. Nuclear Regulatory Commission licensees.
94-90	Transient Resulting in a Reactor Trip and Multiple Safety Injection System Actuations at Salem	12/30/94	All holders of OLs or CPs for nuclear power reactors.
94-89	Equipment Failures at Irradiator Facilities	12/28/94	All U.S. Nuclear Regulatory Commission irradiator licensees.
94-88	Inservice Inspection Deficiencies Result in Severely Degraded Steam Generator Tubes	12/23/94	All holders of OLs or CPs for pressurized water reactors.
94-87	Unanticipated Crack in a Particular Heat of Alloy 600 Used for Westinghouse Mechanical Plugs for Steam Generator Tubes	12/22/94	All holders of OLs or CPs for nuclear power reactors.
94-86	Legal Actions Against Thermal Science, Inc., Manufacturer of Thermo-Lag	12/22/94	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Original signed by Brian K. Grimes

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* See previous concurrences

Reviewed by McGuire Senior Resident Inspector (SRI) on 12/29/94 via e-mail. Re-reviewed by Tech Editor on 12/30/94 in response to SRI changes.

OFC	OECB:DOPS	PUB:ADM	SC/OECB:DOPS	SRXB:DSSA
NAME	EBenner	Tech Ed*	EGoodwin*	CLiang*
DATE	12/30/94	11/25/94	11/30/94	12/01/94

OFC	C/SRXB:DSSA	OECB:DOPS	C/OECB:DOPS	D/DOPS
NAME	RJones*	RKiessel*	AChaffee*	BGrimes
DATE	12/12/94	12/13/94	12/15/94	01/12/95

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Discussion

In its followup evaluation, Duke Power Company (the licensee) concluded that excess AFW supply and open drain valves in the steam system were the major causes for the excessive cooldown and depressurization of the RCS during the event. In the McGuire design, both the motor and turbine driven AFW pumps will start and inject maximum flow into each steam generator on an AFW actuation signal. The emergency operating procedures (EOPs) in effect at the time of the event did not provide the operators with early guidance for throttling AFW flow to control the cooldown rate of the RCS. Also, 16 nonsafety-grade steam line drain valves downstream of the MSIVs are designed to fail open on loss of power supplies, resulting in a direct flow path to the condenser from steam line drains downstream of the MSIVs.

The licensee plans to modify all 16 of the steam line drain valves so that they fail closed if offsite power is lost. This system modification will significantly reduce steam loads after a loss of power event.

EOP ES-0.1, "Reactor Trip Response," was changed to specify the use of the RCS cold-leg temperature as a criterion for reducing AFW flow to the steam generators. Cold-leg temperature drops more quickly in a cooldown event when on natural circulation. Thus, operators would throttle AFW flow earlier if excess cooldown of the RCS was occurring. This change of the EOP is consistent with Revision 1B of the Westinghouse Emergency Response Guidelines. Also, the use of the EOP foldout page during event mitigation has been changed to promote increased operator awareness of the items on the foldout page. These changes were discussed by the operations support manager in a lecture during requalification training of the licensed operators. They will ensure more effective AFW control during an excess cooldown process following a reactor and turbine trip.

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