UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

August 28, 1995

NRC INFORMATION NOTICE 95-35: DEGRADED ABILITY OF STEAM GENERATORS TO REMOVE DECAY HEAT BY NATURAL CIRCULATION

Addressees

All holders of operating licenses or construction permits for pressurized-water reactors (PWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to conditions that may degrade the ability of the steam generators (SGs) to remove decay heat by natural circulation of the reactor coolant in Mode 5, cold shutdown. 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

During a refueling outage in September 1994 on Vogtle Unit 1, the licensee found that the ability to remove decay heat by natural circulation through the steam generators was degraded. On September 11, 1994, Vogtle Unit 1 entered a refueling outage. On September 16, 1994, the unit was in Mode 5 with the reactor coolant system (RCS) being drained down. The reactor coolant pumps were tagged out of service and residual heat removal (RHR) system Train B was in service removing decay heat. RHR Train A was operating intermittently but had been administratively removed from service to adjust the suction valve limit switch and allow stroking of local valves. During this period, the SGs were relied upon to meet the technical specification requirement for a second source of decay heat removal. While taking credit for the steam generators as a heat sink, the RCS was vented to the containment atmosphere when the pressurizer code safety valves were removed and a conoseal on the reactor vessel head was disassembled. The licensee later determined that the heat removal capability by natural circulation through the SGs was degraded. When the RCS was vented, the inability to pressurize the RCS reduced the natural circulation cooling capacity.

On February 13, 1995, the licensee for Turkey Point Units 3 and 4 reported that during previous refueling outages it had relied upon the SGs for decay heat removal when the SGs may not have been able to perform that function. Specifically, the licensee relied upon the SGs as one of the means of decay heat removal while testing one of the RHR loops with the RCS vented. The

licensee later concluded that the RCS cannot support subcooled natural circulation decay heat removal through the SGs while the RCS is vented.

Discussion

These two examples illustrate plant conditions that were not adequate to fully support natural circulation through the SGs as a method of decay heat removal during operation in Mode 5 with loops filled and the reactor coolant pumps out of service.

Technical specifications generally require two methods of decay heat removal in Mode 5 with loops filled. When this is the case, they generally go on to indicate that this requirement can be satisfied by two loops of RHR or one loop of RHR and a minimum water level in the SGs. Decay heat can be removed either through the RHR system or through the SGs by natural circulation after the reactor coolant pumps are secured. The heat removal mechanism with residual heat removal is through forced circulation through the RHR heat exchanger. Heat removal with natural circulation of reactor coolant through the SGs occurs because of the differential pressure created between the heated water in the reactor core and the cooler water in the SG tubes. This differential pressure is created through temperature differences that in turn create fluid density differences between these two locations.

When the RCS is being depressurized and cooled down, the reactor coolant pumps are stopped, the RCS is depressurized and vented, and level is decreased in preparation for Mode 6 (refueling) entry. In Mode 6, both RHR trains must be operable. During the transition from Mode 5, with no reactor coolant pumps running, to Mode 6, plant conditions may exist that are not adequate to support natural circulation. The second train of RHR may need to be operable before proceeding with plant cooldown and depressurization to provide a second method for RCS cooling.

During natural circulation, the SG secondary side water boils and steams off through the atmospheric relief valves or other openings that may exist during shutdown conditions. The minimum temperature at which boiling will begin in the SG is 100° C [212° F]. A minimum temperature differential of 28° C [50° F] between the RCS and the SG secondary water is routinely used for evaluating conditions that would ensure sufficient natural circulation flow to prevent boiling in the core. The heat transfer rate across the steam generator tubes is less for lower RCS-to-SG secondary temperature differentials but still may be adequate to promote sufficient natural circulation and prevent core boiling. Adding the differential temperature of 28° C [50° F] to 100° C [212° F] results in a minimum RCS temperature of 128° C [262° F] to maintain sufficient natural circulation flow. The lowest pressure point in the RCS, at the top of the SG tubes, should therefore be maintained above the saturation pressure for 128° C [262° F]. If the RCS pressure at the top of the SG tubes is allowed to fall below the primary fluid saturation temperature, flashing and steam voiding may occur, interrupting or degrading the natural circulation flow path. Additionally, when system pressure is dropped with elevated water temperatures, gases may come out of solution.

When relying on the ability of the SGs to remove decay heat by natural circulation of reactor coolant in Mode 5, the following factors are worthy of consideration: (1) the ability to pressurize and control pressure in the RCS, (2) secondary side water level in the SGs relied upon for decay heat removal, (3) availability of a supply of feedwater, and (4) availability of an auxiliary feedwater pump capable of injecting into the relied-upon SGs. Consideration should also be given to avoiding the potential for pressurization of the SG secondary side. It is also important to note that during the decay heat removal scenario for the natural circulation process, a mode change (Mode 5 to Mode 4) could occur due to heat up of the RCS.

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Dennis M. Crutchfield

Dennis M. Crutchfield, Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contact: Brian R. Bonser, RII
(706) 554-9901

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93-83, Supp. 1	Potential Loss of Spent Fuel Pool Cooling After a Loss-of-Coolant Accident or a Loss of Offsite Power	08/24/95	All holders of OLs or CPs for nuclear power reactors.
95-33	Switchgear Fire and Partial Loss of Offsite Power at Waterford Generating Station, Unit 3	08/23/95	All holders of OLs or CPs for nuclear power reactors.
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OL = Operating License
CP = Construction Permit

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therefore be maintained above the saturation pressure for 128°C [262° F]. If the RCS pressure at the top of the SG tubes is allowed to fall below the primary fluid saturation temperature, flashing and steam voiding may occur, interrupting or degrading the natural circulation flow path. Additionally, when system pressure is dropped with elevated water temperatures, gases may come out of solution.

When relying on the ability of the SGs to remove decay heat by natural circulation of reactor coolant in Mode 5, the following factors are worthy of consideration: (1) the ability to pressurize and control pressure in the RCS, (2) secondary side water level in the SGs relied upon for decay heat removal, (3) availability of a supply of feedwater, and (4) availability of an auxiliary feedwater pump capable of injecting into the relied-upon SGs. Consideration should also be given to avoiding the potential for pressurization of the SG secondary side. It is also important to note that during the decay heat removal scenario for the natural circulation process a mode change (Mode 5 to Mode 4) could occur due to heat up of the RCS.

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When relying on the ability of the SGs to remove decay heat by natural circulation of reactor coolant in Mode 5, the folowing factors are worthy of consideration: (1) the ability to pressurize and control pressure in the RCS, (2) secondary side water level, at or above the top of the tubes in the SGs relied upon for decay heat removal, (3) availability of a supply of feedwater, and (4) availability of an auxiliary feedwater pump capable of taking suction from the feedwater source and injecting into the relied-upon SGs. Consideration should also be given to avoiding the potential for pressurization of the SG secondary side. It is also important to note that a mode change (Mode 5 to Mode 4) could occur during the decay heat removal scenario for the natural circulation process.

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maintained above the saturation pressure for 262° F [128° C]. Flashing and steam voiding may occur interrupting or degrading the natural circulation flow path if the RCS pressure at the top of the SG tubes is allowed to fall below the primary fluid saturation temperature. An added complication of gasses coming out of solution can occur when system pressure is dropped with elevated water temperatures.

When relying on the decay heat removal capability of the SGs via natural circulation of reactor coolant in mode 5 certain criteria should be considered. These criteria include: 1) the ability to pressurize and control pressure in the RCS; 2) the SGs relied upon for decay heat removal have secondary side water level at or above the top of the tubes; 3) a supply of feedwater is available; and 4) an auxiliary feedwater pump is available capable of taking suction from the feedwater source and injecting into the relied upon SGs. Consideration should also be given to avoiding the potential for pressurization of the SG secondary side. It is also important to note that a mode change (mode 5 to mode 4) will occur during the decay heat removal scenario for the natural circulation process.

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