UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

June 12, 1996

NRC INFORMATION NOTICE 96-36: DEGRADATION OF COOLING WATER SYSTEMS DUE TO ICING

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 potential degradation of facility water intake systems (circulating, service, and fire water) due to icing conditions. 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

Wolf Creek

Between 1:45 a.m. and 2:45 a.m. (all times central standard time) on January 30, 1996, operators at Wolf Creek received alarms indicating that the circulating water system traveling screens were becoming blocked. A visual inspection showed that the traveling screens for bays 1 and 3 were frozen and that water levels in these bays were approximately 2.5 m [8 ft] below normal. The emergency service water system was started with the intent to separate this system from the service water system. However, the emergency service water system was incorrectly aligned; flow was directed to the service water system and warming flow to the emergency service water system suction bays was restricted. Operators also shifted to circulating water pump B. At approximately 3:30 a.m., operators received a service water pressure alarm and an electric fire pump started on low service water pressure. The shift supervisor then directed a manual reactor/turbine trip. Circulating water system bays were subsequently determined to be at 3.5 m [12 feet] below normal. The level loss was caused by water from the spray wash system freezing and blocking the traveling screens.

The Train A emergency service water system pump was tripped and declared inoperable at 7:47 a.m. because of low discharge pressure and high strainer differential pressure. At about 8:00 a.m., the supervising operator coming on shift noted the incorrect alignment of the emergency service water system and took action to correct it. At about 5:45 p.m., the operators declared Train A operable on the basis of an engineering evaluation and placed it in service. However, the pump was again stopped 1-1/2 hours later at approximately 7:30 p.m. when the pump exhibited further oscillations in flow and pressure. At approximately 8:00 p.m., operators noted that emergency service water system Train B suction bay level was 4.5 m [15 ft] below normal and decreasing slowly. Operators placed additional heat loads on Train B and the suction bay levels subsequently recovered. At 10:14 p.m., the operators again started Train A emergency service water system and secured it at 10:27 p.m. due to decreasing flow and pressure.

At about 10:00 a.m. on January 31, divers inspected the suction bay of Train A and noted complete blockage of the trash racks by frazil ice. Train B was not inspected because the pump was running. The ice blockage was cleared by 4:00 p.m. by sparging the trash racks with air. The emergency service water system was designed to have warming flow injected in front of trash racks to increase bulk water temperature and prevent the formation of frazil ice. Due to calculational errors by the architect-engineer and the as-built system configuration, the emergency service water system warming flow was insufficient to prevent frazil ice from forming at the Train A trash racks.

FitzPatrick

On February 25, 1993, at 1:25 a.m., the electric fire pump started on low fire header pressure. After verifying normal fire header pressure, operators secured the electric fire pump, and the diesel fire pumps subsequently started on low header pressure. It was later determined that the fire jockey pump had lost suction because of the decreasing screenwell level.

Over the next several minutes, operators noted an increase in circulating water system motor amperage (which is consistent with decreased suction pressure). Reactor power was also reduced and one circulating water pump was secured. At 1:40 a.m., an operator reported that the screenwell level was approximately 3 m [10 ft] below normal and the reactor was manually scrammed. After a second circulating water pump was subsequently secured, the screenwell water level quickly recovered. The licensee concluded that the reduced screenwell level had been caused by ice partially blocking the lake intake structure. Either frazil ice formed around or in front of the heated intake bar racks, or slush ice was present in front of the bar racks.

Fermi

On February 5, 1996, at approximately 2:30 p.m., diesel generator service water pump C failed to develop normal discharge pressure, flow, and motor current during a surveillance. This made Division I emergency diesel generator (EDG) 12 inoperable. After several unsuccessful attempts to start the pump, an air purge of the pump column on the discharge of the pump was initiated in an attempt to clear any obstruction in the column or the pump inlet. The licensee detected blockage when it tried to blow air through the pipe. At 8:21 p.m., the pump was started and after 3 to 5 seconds an erratic discharge pressure was noted. In a short time, pump flow, discharge pressure, and motor amps were normal. The following day, on February 6, diesel generator service water pump B was started. The pump, which cools Division II

EDG 13, showed no flow, no pressure, and low amperage for the first 30 seconds. After approximately 90 seconds, normal flow discharge pressure and motor current were achieved. The remaining safety-related pumps were tested satisfactorily.

The diesel generator service water pumps are all deep-draft pumps and take suction from the ultimate heat sink reservoir which is a segregated pool. The licensee evaluation concluded that although the reservoir temperatures are maintained above 5 °C [41 °F], part of the pump column and two of the linear guide bearings are located above the water level and are exposed to ambient air temperature conditions. The failure of the diesel generator service water pump C was attributed to ice buildup around the shaft and spider bearing from leakage past the discharge check valve and the cold weather. The licensee also concluded that under some credible meteorological conditions, the functions of both divisions could have been affected.

Discussion

Frazil icing is a phenomenon that affects the operation of intake structures in regions that experience cold weather. The accumulation of frazil ice on intake trash racks can completely block the flow of water into the intake. The process starts when the water flowing into the intake is supercooled (a condition where the water is below the freezing point). The supercooling may be very small, on the order of a few hundredths of a degree.

The supercooling occurs with a loss of heat from a large surface area such as a lake with open water and clear nights. High winds contribute to the problem by providing mixing of the supercooled water to depths as great as 6 to 9 m [20 to 30 ft]. The frazil ice, which is composed of very small crystals (1-15 mm) with little buoyancy because of their size, is carried along in the water and mixed all through the supercooled water.

The suction of the supercooled water and the suspended frazil ice crystals through an intake structure brings the frazil ice crystals in contact with the trash rack bars. Frazil ice crystals easily adhere to any object with which they collide. The ice collects first on the upstream side of the trash racks, then steadily grows until the space between the trash racks is bridged. This bridging rapidly blocks the trash racks. The accumulation of ice can withstand high differential pressures; effectively damming the intake suction.

Facility vulnerability to icing events is a function of plant design. Frazil and other ice formation is dependent on specific environmental conditions and represents a potential common-mode failure that can cause the loss or degradation of multiple cooling water systems, including the potential loss of the ultimate heat sink.

Related Information

NUREG/CR-0548, "Ice Blockage of Water Intakes."

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 project manager.

Brian Grimes

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96-33	Erroneous Data From Defective Thermocouple Results in a Fire	05/24/96	All material and fuel cycle licensees that monitor temperature with thermocouples
96-32	Implementation of 10 CFR 50.55a(g)(6)(ii)(A), "Augmented Examination of Reactor Vessel"	06/05/96	All holders of OLs or CPs for nuclear power reactors
96-31	Cross-Tied Safety Injection Accumulators	05/22/96	All holders of OLs or CPs for pressurized water reactors
96-30	Inaccuracy of Diagnostic Equipment for Motor-Operated Butterfly Valves	05/21/96	All holders of OLs or CPs for nuclear power reactors
96-29	Requirements in 10 CFR Part 21 for Reporting and Evaluating Software Errors	05/20/96	All holders of OLs or CPs for nuclear power reactors
96-28	Suggested Guidance Relating to Development and Implementation of Corrective Action	05/01/96	All material and fuel cycle licensees
96-27	Potential Clogging of High Pressure Safety Injection Throttle Valves During Recirculation	05/01/96	All holders of OLs or CPs for pressurized water reactors

OL = Operating License
CP = Construction Permit

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Original signed by Brian K. Grimes

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