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

October 11, 1996

NRC INFORMATION NOTICE 95-04, Supplement 1: EXCESSIVE COOLDOWN AND DEPRESSURIZATION OF THE REACTOR COOLANT SYSTEM FOLLOWING LOSS OF OFFSITE POWER

Addressees

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

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice supplement to alert addressees to an excessive cooldown and depressurization of the reactor coolant system and the main steam system following a loss of offsite power at Catawba Nuclear Station, Unit 2. It is expected that recipients will review their programs to determine if similar conditions exist at their facilities. However, no specific action or written response is required.

Background

The main generator at Catawba Unit 2 normally supplies power to the onsite electrical distribution system through auxiliary transformers. Power to the offsite electrical grid is supplied by way of two half-size stepup transformers (designated 2A and 2B) using a dual-output circuit-breaker design (Figure 1). When the main generator is shut down, the two output circuit breakers are opened and offsite power is supplied (backfed) to onsite loads by means of two separate circuits via the two stepup transformers. An isolated-phase bus system connects the generator and transformers.

In Information Notice 95-04, the staff described a December 27, 1993, loss of offsite power event at McGuire Unit 2. The event was initiated by the failure of a 525-kV insulator. Reactor coolant pumps tripped on the loss of offsite power, resulting in core cooling by natural circulation. Emergency diesel generators (EDGs) started and provided power to vital buses. After the reactor trip, the reactor coolant system rapidly cooled down and depressurized because of a reduction in energy input and an increase in energy removal by full, unthrottled auxiliary feedwater (AFW) flow and several steam flow paths. The steam flow paths included the AFW pump turbine and open steamline drainlines.

The continuing steam flow caused secondary system pressure to drop rapidly, and unthrottled AFW flow continued to lower steam pressure and temperature. Continued secondary cooling caused the reactor coolant system temperature to drop. A safety injection signal on low pressurizer pressure occurred 7 minutes and 32 seconds into the event. In Licensee Event Report No. 93-008-00 (Accession No. 9402080199), the licensee stated that the McGuire event was bounded by events described in Chapter 15 of the McGuire Final Safety Analysis Report. Specifically it was bounded by the complete loss of reactor coolant flow and the steam line break events. The licensee also stated that overall response of the plant, from a safety point of view, was satisfactory.

In an evaluation of the McGuire event, Duke Power Company, the licensee for the McGuire and Catawba plants, 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. The licensee modified the McGuire steamline drain valves upstream and downstream of the main steam safety valves to fail closed on a loss of power. The modification was made to help slow the secondary side depressurization rate and the reactor coolant system cooldown rate during a loss of offsite power event, giving operators increased time to address the event. At the time of the event described below, the licensee had not yet made the design modification to the Catawba units that had been implemented at McGuire.

Description of Circumstances

A loss of offsite power and safety injection occurred at Catawba Unit 2 on February 6, 1996, when two potential transformer resistor bushings in the 22-kV isolated-phase bus system simultaneously shorted to ground. This caused a phase-to-phase fault that resulted in a generator lockout followed by a turbine trip and reactor trip. The lockout interrupted power supply to the 22-kV isolated-phase buses 2A and 2B and led to the loss of offsite power.

Reactor coolant pumps tripped when offsite power was lost. Core cooling was maintained by natural circulation with heat removal via AFW and steam generator relief valves steaming to the atmosphere. EDG 2A started and energized essential bus 2ETA. However, before the event occurred, EDG 2B had been taken out of service for unplanned maintenance on its associated battery charger. Consequently, power to essential bus 2ETB was initially unavailable. Within 3 hours, EDG 2B was restored to service and essential bus 2ETB was reenergized. EDG 2B was secured approximately 5.5 hours into the event when offsite power was made available to essential bus 2ETB via a crosstie from the operating Catawba Unit 1. An additional crosstie from Unit 1 was established to power the redundant essential bus 2ETA, allowing EDG 2A to be secured about 7.5 hours into the event.

A low steam pressure safety injection signal initiated approximately 8 minutes after the start of the Catawba event. Similar to the McGuire event, the low reactor coolant system pressure condition resulted from high steam loads and unthrottled AFW injection. The steam loads included the turbine-driven AFW pump and steaming through main steamline drains. As stated above, at Catawba, the licensee had not implemented the design modification to have the steamline drain valves fail closed on loss of power.

Because of the loss of offsite power, charging flow and seal injection flow discharge valves failed open, increasing the mass addition to the reactor coolant system. With normal letdown isolated on the safety injection signal, the reactor became water solid. Reactor coolant system pressure increased to the lift setpoint of one of the three pressurizer power-operated relief valves. Over a period of about 6 hours and 15 minutes, the relief valves opened approximately 74 times to control pressure. The pressurizer relief tank rupture disc relieved and reactor coolant system water discharged to the containment.

In Licensee Event Report No. 96-001-00 (Accession No. 9603120449), the licensee stated that this cooldown event was bounded by cooldown events evaluated in Section 15.1 of the Catawba Final Safety Analysis Report. In addition, characteristics that potentially exacerbate overcooling events (i.e., small shutdown margin, highly negative moderator temperature coefficient, and adverse core power distribution due to stuck control rod) were not present during this event.

With respect to the electrical fault initiating the Catawba Unit 2 event, the licensee found evidence of arcing within the failed resistor bushings. Internal degradation of the bushing was postulated to have resulted from moisture ingress. The degraded bushing in the presence of external moisture and other contaminants may have initiated the ground faults. In the one phase of the bus, the heaters were not working because of a failed thermostat. Consequently, moisture buildup and dirt may have occurred, resulting in the X-phase fault. When the degraded bus resistor busing faulted, the current was initially limited to approximately 12 ampères by the high impedance in the generator neutral to ground. Simultaneously, and as a result of the ground fault, voltages in the other two phases increased significantly. This increase in voltage helped to trigger the catastrophic failure of the degraded resistor bushing in another phase. Both failures are considered to have, as a common cause, a degraded bushing in the presence of moisture and other contaminants.

During previous preventive maintenance tests, degraded insulator bushings and moisture contamination were noted as problems at Catawba. Similar failures of resistor bushings were experienced at McGuire, Zion Station, and San Onofre Nuclear Station. The resistor bushings, originally supplied by Westinghouse, were hollow with an internally installed resistor. At Catawba Unit 2, all resistor bushings have been replaced by bushings that use an externally mounted resistor which the vendor believes to be a better design.

Probabilistic risk assessments of this event performed by the NRC staff and the licensee indicate that the potential station blackout sequences dominate the high core damage probability (greater than 1E-4) because the event involved an extended loss of offsite power with one of the two EDGs out of service. Operator actions that reduced the risk of this event included: establishing crossties with Unit 1, restoring EDG 2B within 3 hours, and staffing the safe shutdown facility. The crosstie capability between the two Catawba units is particularly important in assessing the core damage probability of this event because 1.5 days were required to restore the 2B main transformer and 4.5 days to restore the 2A transformer. Without the crossties, the EDGs would have been required to operate for an extended period of time. The conditional core damage probability for this type of event could exceed 1E-3 for plants that do not have crossties available and that do not maintain a safe shutdown facility similar to the one at Catawba.

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 regional office.

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Attachments:
1. Figure 1. Catawba 2 Electric Power Distribution System
2. List of Recently Issued NRC Information Notices

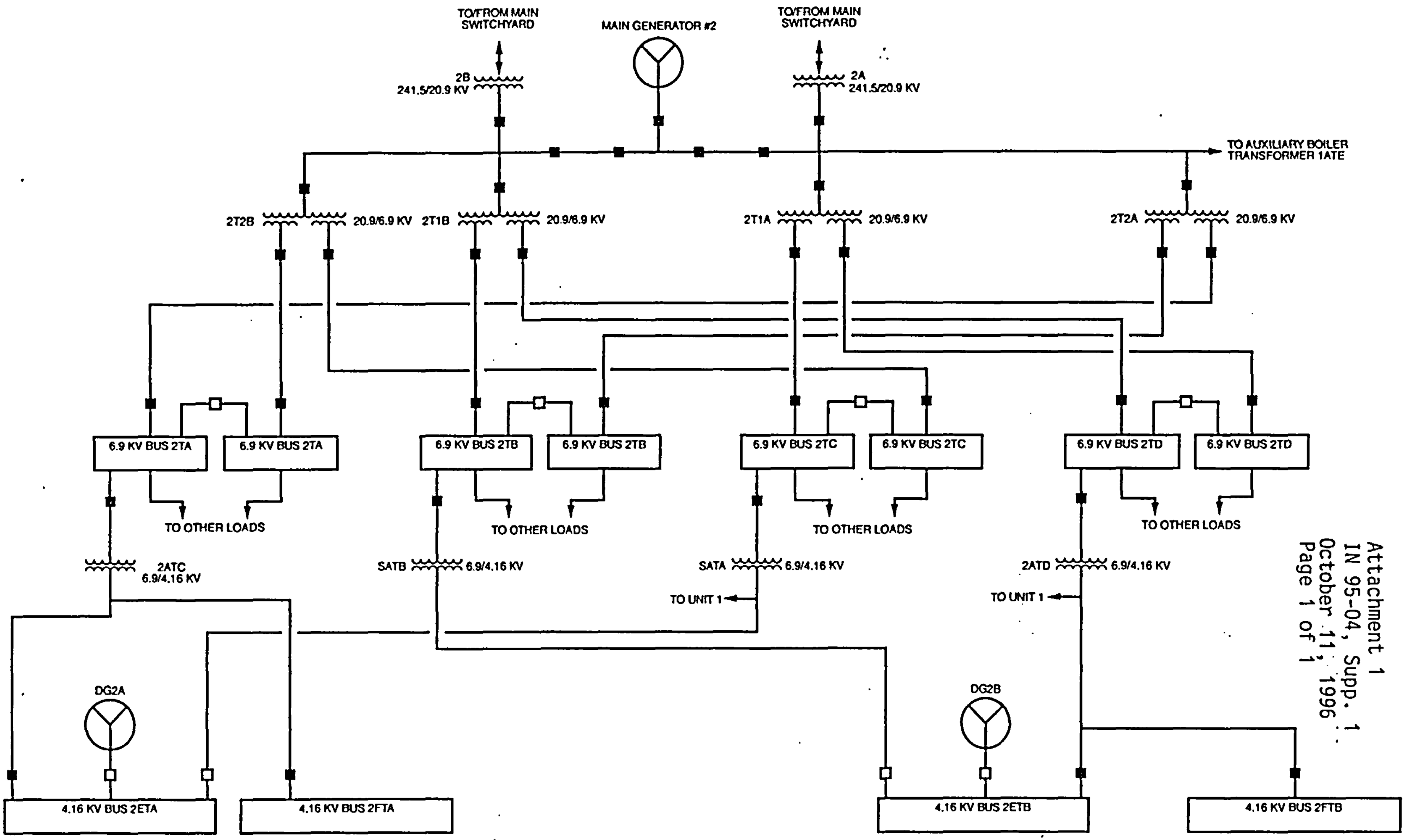

Figure 1. Catawba 2 Electric Power Distribution System

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
96-40, Supp. 1	Deficiencies in Material Dedication and Procurement Practices and in Audits of Vendors	10/07/96	All holders of OLs or CPs for nuclear power reactors
96-52	Cracked Insertion Rods on Troxler Model 3400 Series Portable Moisture Density Gauges	09/26/96	All U.S. Nuclear Regulatory Commission portable gauge licensees and vendors
92-68, Supp. 1	Potentially Sub-standard Slip-On, Welding Neck, and Blind Flanges	09/16/96	All holders of OLs or CPs for nuclear power reactors
96-51	Residual Contamination Remaining in Krypton-85 Handling System After Venting	09/11/96	All material licensees
96-50	Problems with Levering-In Devices in Westinghouse Circuit Breakers	09/04/96	All holders of OLs and CPs for nuclear power plants
96-49	Thermally Induced pressurization of of Nuclear Power facility Piping	08/20/96	All holders of OLs or CPs for nuclear power reactors
96-48	Motor-Operated Valve Performance Issues	08/21/96	All holders of OLs or CPs for nuclear power reactors

OL = Operating License
CP = Construction Permit