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MEMORANDUM FOR: Chairman Zech
Commissioner Roberts
Commissioner Bernthal
Commissioner Carr
Commissioner Rogers

FROM: Victor Stello, Jr.
Executive Director for Operations

SUBJECT: RESPONSE TO INFORMATION REQUESTED DURING NOVEMBER 9, 1987 BRIEFING OF COMMISSION ON NORTH ANNA STEAM GENERATOR TUBE RUPTURE - PRIMARY-TO-SECONDARY LEAKAGE (M871109)

On November 9, 1987, the NRC staff briefed the Commission on the July 15, 1987 steam generator tube rupture event at North Anna Unit 1. During the briefing, the Commission requested additional information on the procedures that direct the operator to decrease reactor power as primary-to-secondary leakage increases. The Commission also asked the staff to address the permissible period of continued plant operation at degraded conditions and the associated safety significance.

This memorandum encloses the information you asked for. Enclosure 1 focuses on existing requirements which are intended to ensure that plants with increasing primary-to-secondary leakage are shut down before a gross rupture of the leaking tube occurs. The staff has also concluded its assessment of the implications of the North Anna event with respect to the effectiveness of these requirements.

Enclosure 2 assesses the operator actions taken during the North Anna event. The staff has concluded that the actions taken by the North Anna operators before they manually tripped the reactor were appropriate and have no generic implications with respect to plant operating procedures or the Westinghouse Emergency Response Guidelines (ERGs).

Original signed by
Victor Stello

Victor Stello, Jr.
Executive Director
for Operations

Enclosures:
1. Implications
2. Operation Actions

cc w/enclosures:
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OGC

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ENCLOSURE 1

IMPLICATIONS OF NORTH ANNA EVENT WITH RESPECT TO PRIMARY-TO-SECONDARY LEAKAGE LIMITS

Plant Technical Specifications for pressurized water reactors (PWRs) include limits on allowable primary-to-secondary leakage. The purpose of these limits is twofold. First, these limits ensure that primary-to-secondary leakage will be within that assumed in the plant Final Safety Analysis Report (FSAR) safety analyses for design-basis accidents to demonstrate compliance with 10 CFR Part 100 requirements concerning site boundary doses. Second, these limits are intended to ensure that the plant will be shut down before a leaking through-wall flaw becomes sufficiently large to cause a tube rupture. Plant Technical Specification limits for Westinghouse plants such as North Anna are typically 500 gallons per day (i.e., about 0.35 gallon per minute (gpm)) from any one steam generator and 1.0 gpm total leakage from all steam generators. These limits are very small compared to the leak rates associated with a gross tube rupture such as occurred at North Anna Unit 1 and which involved a maximum primary-to-secondary leak rate of approximately 600 gpm.

In general, plant Technical Specifications require that if the leak rate limits are exceeded the leakage must be reduced to be within the Technical Specification limits within 4 hours or the plant must be brought to at least hot standby within the next 6 hours and to cold shutdown within the following 30 hours. Operating experience, which has included hundreds of instances of primary-to-secondary leakage, clearly demonstrates that this approach has been effective in ensuring timely plant shutdown before a small leak leads to a gross tube rupture. However, this approach may not be sufficient when dealing with rapidly propagating fatigue cracks such as the one that led to the North Anna steam generator tube rupture (SGTR) event. The time necessary to propagate this kind of crack from the point of initiation to complete rupture may vary from several hours to a few days. By the time this kind of crack has propagated sufficiently to produce a primary-to-secondary leak equal to the leak rate limits in the plant Technical Specifications, very few hours may remain before the crack propagates to rupture.

The licensee for North Anna has implemented corrective actions that are expected to minimize the potential for future fatigue cracks. In addition, the licensee has implemented an enhanced leak rate monitoring program that goes beyond minimum plant Technical Specification requirements. This program ensures that if the plant is in a degraded condition as a result of a rapidly propagating fatigue crack, the operator will be quickly alerted to this situation and the plant will be shut down before the tube ruptures. The program sets administrative limits on primary-to-secondary leakage (e.g., 100 gallons per day (gpd) per steam generator) that are substantially more restrictive than the Technical Specification limits. If the administrative limits are exceeded, the procedures require that plant power level be reduced to $\leq$ 50% within 90 minutes. Analysis performed by Westinghouse indicates that operation at $\leq$ 50% power will reduce flow-induced vibration sufficiently to arrest further crack propagation and subsequent tube rupture. In addition, analysis has shown that the 90-minute criterion for reducing power to $\leq$ 50%

ensures that the power will be reduced before rupture occurs; this conclusion is based on consideration of a leak-rate-versus-time curve that the staff finds conservative for rapidly propagating fatigue cracks. In addition to reducing power to ≤ 50% in 90 minutes, the improved program also calls for the plant to shut down to hot standby within 6 hours of exceeding the 100-gpd administrative leak rate limit.

As a generic followup to the North Anna event, the staff issued Bulletin 88-02, dated February 5, 1988, requesting that all licensees and applicants who have specified steam generator models check for the presence of off-nominal conditions which could render these steam generators vulnerable to rapidly propagating fatigue cracks. The bulletin also requests that corrective actions be implemented, if found to be necessary.

Regarding safety significance, the mechanism that caused the SGTR event at North Anna is not likely to produce multiple tube ruptures because the rapid rate of crack propagation associated with this mechanism results in a high likelihood that the crack will lead to plant shutdown (as a result of rupture or leakage exceeding the administrative and/or Technical Specification limits) before another tube becomes similarly degraded. Single-tube SGTR events, such as occurred at North Anna, are analyzed in the FSAR as design-basis events. Nevertheless, like other design-basis accidents (e.g., loss-of-coolant accident, main steam line break), SGTRs are complex transients that represent a significant challenge to safety systems and reactor operators. Thus, it is desirable that the frequency of such events be minimized.

ENCLOSURE 2

ASSESSMENT OF OPERATOR ACTIONS DURING
NORTH ANNA STEAM GENERATOR TUBE RUPTURE EVENT

The North Anna Emergency Operating Procedures (EOPs) were developed from the Westinghouse Owner's Group (WOG) Emergency Response Guidelines (ERGs) Rev. 1. The ERGs for the SGTR event address actions to be taken following reactor trip

Before manually tripping the plant during the July 15, 1987 steam generator tube rupture (SGTR) event, the North Anna Unit 1 operators were not in a situation requiring use of the EOPs. The control room operator, during the first 5 minutes of the transient, had not yet positively identified that there was an SGTR in progress. The increase in charging flow, isolation of the letdown line, and runback of the turbine performed during the initial 5-minute period were intended to contribute to an orderly shutdown of the plant after the abnormal plant conditions were noticed. The staff believes that these operator actions were prudent from a safety standpoint for the following reasons: (1) during an orderly shutdown, the condenser remains available as a heat sink and thus the contaminated secondary system fluid is contained rather than released to the atmosphere and (2) a possible challenge to the plant protection systems may be prevented. In addition, the staff finds that these actions were consistent with the WOG ERGs.

For most SGTR events, an automatic reactor trip will occur when the trip setpoints are reached. The safety analysis of the SGTR event results in an automatic reactor trip early in the sequence of events. During the North Anna event, the operator manually tripped the reactor before the automatic trip setpoint was reached. The staff believes this action is bounded by the design-basis scenario.

For an SGTR with a lower break flow rate than the design-basis break flow rate, the time delay for a reactor trip does not cause a safety concern because the condenser will remain available as a heat sink and contain the contaminated fluid, thereby minimizing offsite dose. Therefore, the staff believes that, on indication of primary-to-secondary leakage, a power run-back and orderly shutdown of the plant is preferable to forcing an immediate shutdown.

On this basis, the staff finds that the actions taken by the North Anna operators before they manually tripped the reactor were appropriate and have no generic implications with respect to plant operating procedures or the Westinghouse ERGs.