UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATING TO NATURAL CIRCULATION COOLDOWN MILLSTONE UNIT 3 NORTHEAST UTILITIES DOCKET NO. 50-423

1.0 INTRODUCTION

Branch Technical Position (BTP) RSB 5-1, "Design Requirements of the Residual Heat Removal (RHR) System," requires that test programs for pressurized water reactors (PWRs) include tests with supporting analysis to (1) confirm that adequate mixing of borated water added prior to or during cooldown can be achieved under natural circulation conditions and permit estimation of the times required to achieve such mixing, and (2) confirm that the cooldown under natural circulation conditions can be achieved within the limits specified in the emergency operating procedures. In addition, the plant is to be designed so that the reactor can be taken from normal operating conditions to cold shutdown using only safety-grade systems. A comparison of performance to that of previously tested plants of similar design may be substituted for these tests.

Millstone Unit 3 is classified as a Class 2 plant with regard to the implementation of the above BTP.

A natural circulation/boron mixing/cooldown test was performed at Diablo Canyon Unit 1 on March 28-29, 1985. On the basis of the Diablo Canyon tests and submittals and the Brookhaven National Laboratory (BNL) technical evaluation report (TER) dated December 1986, the staff has concluded that the Diablo Canyon Unit 1 systems meet the intent of BTP RSB 5-1 for a class 2 plant. By letter dated November 6, 1987, the licensee for Millstone Unit 3 submitted a

Westinghouse analysis to show the applicability of the Diablo Canyon cooldown test results to Millstone Unit 3 rather than conduct such a test at the plant.

The licensee provided the analysis entitled "Millstone Unit 3, Natural Circulation System Comparison," B-12983, which evaluates the capability of Millstone Unit 3 to successfully achieve cold shutdown conditions under the requirements of BTP RSB 5-1. The report includes the following:

1) A comparison of the Diablo Canyon plant and Millstone Unit 3 to demonstrate their similarity.
2) An evaluation of the applicability of the Diablo Canyon test results to Millstone Unit 3.

By letter dated August 3, 1988, in response to NRC staff questions, the licensee provided a revised analysis.

The staff safety evaluation for Diablo Canyon Unit 1, with the attached BNL TER entitled "Technical Evaluation Report for Diablo Canyon Natural Circulation, Boron Mixing, and Cooldown Test," identified the plant parameters that may affect application of the test results to other plants. These parameters are the basis for our evaluation and are discussed in the following sections.

2.0 EVALUATION

Natural Circulation

Diablo Canyon Unit 1 is rated at 3338 Mwt and has four loops in its reactor coolant system (RCS). Millstone Unit 3 is rated at 3411 Mwt and also has a four-loop RCS. The licensee has stated that the general configuration of the piping and components in each reactor coolant loop is the same in both Millstone Unit 3 and Diablo Canyon Unit 1. Significant parameters governing natural circulation are hydraulic flow resistance and thermal driving head.

To demonstrate similarity in design for natural circulation, these two parameters were compared.

Data from the Westinghouse report showed that the Millstone Unit 3 hydraulic resistance coefficients at normal flow conditions was slightly lower than Diablo Canyon's. Thermal driving head, however, because of a difference in steam generator tube lengths, was 5-10% higher for Diablo Canyon. The report showed that the lower natural circulation driving head and the lower overall piping flow resistance for Millstone Unit 3 would decrease the natural circulation flow ratio to approximately 0.99 times that observed for Diablo Canyon. Therefore, the licensee concluded that the natural circulation loop flow rate for either plant would be nearly the same. Differences in reactor power and decay heat levels between the two plants are not expected to alter this conclusion.

The staff questioned the applicability of flow resistance at normal flow conditions when significantly lower flows would exist during natural circulation. The revised report stated that the hydraulic resistance coefficient would slightly increase at lower flows but the expected flow ratio is expected to be valid for both normal and natural circulation. The staff finds this explanation acceptable.

RCS Cooldown

The plant's ability to cool the RCS at a specified cooldown rate, assuming a sufficient supply of auxiliary feedwater, is determined by the capacity of the atmospheric steam dump valves (ADVs). Steam flow through these valves removes the sensible heat and decay heat throughout the cooldown period. The end of the cooldown period, when the steam generator pressure is low, provides the most limiting conditions for valve capacity. The energy to be removed is determined by the water inventory and the amount of structural material in the RCS, and the level of decay heat.

Millstone Unit 3 has four ADVs, one for each steam generator. These ADVs, because of a non-safety grade air supply, cannot be given credit for plant shutdown per BTP RSB 5-1. Four motor operated, safety grade main steam pressure relieving bypass valves (MSPRVs), each of ADV capacity, ensure a steam release path in the event any ADV is unavailable. The MSPRVs are powered from Class 1E buses.

In the event of a single failure, three steam generators would be available for cooldown. In response to FSAR Question 440.24, the licensee stated that two steam generators are sufficient to to cool down the RCS to the RHR initiation temperature. Therefore we find that there is reasonable assurance that the MSPRVs have sufficient capacity to perform an RCS cooldown to the RHR initiation temperature in a reasonable time and the MSPRV capacity is therefore acceptable. In addition, the ADVs have handwheels for manual operation and thus are potentially operable in the event of an insufficient air supply.

Bypass Flow and Upper-Head Cooling

A potential exists for void formation in the upper-head of the reactor vessel during the cooldown/depressurization of the RCS under natural circulation conditions if the upper head is relatively isolated from the rest of the RCS and its fluid temperature remains higher than the coolant temperature in the main flow paths of the RCS. Upper-head cooling under natural circulation conditions is influenced by core bypass flow and mixing in the upper head.

Westinghouse plants may be divided into two groups according to the magnitude of the bypass flow: Thot and Tcold plants. For the Tcold plants, such as Millstone Unit 3, sufficient bypass flow exists to make the temperature of the upper head fluid [illegible] ally equal to the cold-leg temperature. On the other hand, for the Tho[illegible]ts, whi[illegible]des Diablo Canyon, the bypass flow is much smaller. F[illegible] rcumstance results in upper head temperature rang[illegible]eg and the hot-leg temperatures and raises a possibilit[illegible]ion in the upper-head region.

The licensee stated that the reactor vessel spray nozzle between the downcomer and the upper-head region for Millstone Unit 3 has a significantly larger flow area than that of Diablo Canyon. This circumstance allows better flow communication and mixing in the upper head during natural circulation. The upper head volume for Millstone Unit 3 is larger than that of Diablo Canyon. The NRC staff considers the upper head volume effect on cooling of the upper head to be small compared to the contribution of flow through the spray nozzles. We would therefore expect a shorter cooling time for a Tcold plant compared with that of a Thot plant of the same size.

Boron Mixing

The Diablo Canyon boron mixing test evaluation demonstrated adequate boron mixing under natural circulation conditions when highly borated water was injected into the RCS. Contributing to the diffusion of the boron is the mixing effect created as the flow passes through the reactor coolant pumps and the steam generator tubes. The plant's ability to achieve the proper shutdown margin, however, depends mainly on the injection rate of boron relative to the total inventory of water in the RCS. The required concentration change of about 300 ppm for the test was achieved in less than 1 hour.

Under normal operation at Millstone Unit 3, the boric acid solution is injected into the RCS via the charging and reactor coolant pump seal injection lines. Upon loss of instrument air, charging flow control is possible by use of a safety-related throttling flow path that bypasses the air operated charging flow control valve. A different throttling valve, powered from a Class 1E bus can be used to throttle seal injection line flow.

In the event that both the normal and excess letdown lines are unavailable for the RCS inventory control, a safety grade reactor head vent letdown flow path to the pressurizer relief tank is available.

The source of boron for Millstone Unit 3 is the boric acid tanks (BATs) which have a boron concentration significantly less than that of Diablo Canyon. Thus, addition of a larger quantity of borated water over a longer time will be required to reach the desired concentration change. The licensee calculated that for Millstone Unit 3, approximately one hour is needed to achieve the same concentration change demonstrated in the test. On the basis of this calculation the staff finds that there is reasonable assurance that sufficient time exists for boron injection and mixing to achieve the required shutdown margin.

Depressurization

The Diablo Canyon test demonstrated that the RCS could be depressurized from cooldown conditions to the RHR initiation pressure under natural circulation conditions using the pressurizer auxiliary spray and/or pressurizer power operated relief valves (PORVs).

At Millstone Unit 3 depressurization may be accomplished through the use of the pressurizer PORVs or the pressurizer auxiliary spray. However, the pressurizer auxiliary spray is not safety grade, and thus is not available for the RCS depressurization per BTP RSB 5-1.

The licensee stated that either of the two PORVs is capable of providing the depressurization function. Each PORV has a safety-grade Class 1E solenoid operated valve. In the event that a PORV fails open, the PORV block valves, which are safety-grade, may be used to block the affected PORV flow path. At the end of the depressurization, the RCS is approximately at 400 psig. The RHR system may now be placed in service and the cooldown to cold shutdown condition continued.

Cooling Water

The primary auxiliary feedwater supply to the steam generators is provided by the condensate storage tank (CST) at Diablo Canyon, while Millstone Unit 3 uses the seismic category I demineralized water storage tank (DWST). Alternate sources of auxiliary feedwater at Millstone Unit 3 include the CST, service water system, and the domestic water system. Spoolpieces, maintained on site, must be added to connect the service water and domestic water systems to the auxiliary feedwater system.

The BNL TER estimated a 360,000-gallon auxiliary feed water requirement for Diablo Canyon on the basis of a 43-hour cooling time for the upper head. This calculation was based on assumptions of no heat loss from the upper head to the containment and a limited amount of bypass fluid mixing with fluid in the bottom of the upper head. We would further conclude that had Diablo Canyon been a Tcold plant, and with heat transfer from the upper head to containment considered, the cooling requirement would have been significantly less than 360,000 gallons.

The Millstone Unit 3 DWST has a capacity of 340,000 gallons with a technical specification (TS) minimum capacity of 334,000 gallons. In addition, the alternate or backup supply provides an essentially unlimited auxiliary feedwater supply. Since Millstone Unit 3 is a Tcold plant, we conclude that there is reasonable assurance that sufficient cooling water inventory exists to meet the proposed plant cooldown method .

3.0 CONCLUSION

The staff assessed the capability of Millstone Unit 3 to meet the requirements of RSB BTP 5-1. We have identified and evaluated the plant parameters that may affect application of the Diablo Canyon natural circulation test results to Millstone Unit 3.

On the basis of the licensee's submittals, and our evaluation as previously discussed, we conclude that the licensee has demonstrated that the Diablo Canyon natural circulation tests are applicable to Millstone Unit 3 and that they comply with the requirements of BTP RSB 5-1.