CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NOS. 1 AND 2

INDIVIDUAL PLANT EXAMINATION

STAFF EVALUATION REPORT

Enclosure 1

1.0 INTRODUCTION

On December 30, 1993, Baltimore Gas and Electric Company (BGE) submitted the Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2, Individual Plant Examination (IPE) submittal in response to Generic Letter (GL) 88-20 and associated supplements. On July 11, 1995, the NRC staff sent questions to the licensee requesting additional information. The licensee responded in a letter dated September 12, 1995.

A "Step 1" review of the Calvert Cliffs IPE submittal was performed and involved the efforts of Science & Engineering Associates, Inc., Scientech, Inc./Energy Research, Inc., and Concord Associates in the front-end, back-end, and human reliability analysis (HRA), respectively. The Step 1 review focused on whether the licensee's method was capable of identifying vulnerabilities. Therefore, the review considered: (1) the completeness of the information, and (2) the reasonableness of the results given the Calvert Cliffs design, operation, and history. A more detailed review, a "Step 2" review, was not performed for this IPE submittal. A summary of contractors' findings is provided below. Details of the contractors' findings are in the attached technical evaluation reports (Enclosures A, B, and C) of this staff evaluation report (SER).

In accordance with GL 88-20, BGE proposed to resolve Unresolved Safety Issue (USI) A-45, "Shutdown Decay Heat Removal (DHR) Requirements." No other specific USI or generic safety issues were proposed for resolution as part of the Calvert Cliffs IPE.

The submittal states that the licensee intends to maintain a "living" probabilistic review assessment.

2.0 EVALUATION

The Calvert Cliffs site has two Combustion Engineering pressurized water reactors (PWR) each with a large, dry containment. The Calvert Cliffs IPE has estimated a core damage frequency (CDF) of 2.4E-4 per reactor-year from internally initiated events, including the contribution from internal floods. The Calvert Cliffs CDF compares reasonably but is highest among the Combustion Engineering PWR plants. Accident classes including anticipated transients without scram (ATWS), transients, steam generator tube rupture (SGTR) and internal flooding are all highest among this type of plant. This is attributable to plant-specific aspects such as: the auxiliary feedwater (AFW) valves require air to open; the reactor coolant pumps (RCPs) have one method of seal cooling, and the licensee has assumed a less optimistic seal loss of coolant accident (LOCA) model; there is a swing emergency diesel generator (EDG) that is shared between the two units and requires operator action during certain conditions; DC power is shared between the two units; the station batteries have a 2-hour lifetime with load shedding; both power operated relief valves are required for feed and bleed; and the model for ATWS mitigation is less optimistic, crediting less options than some other IPE models.

Transients, including station blackout, contribute 57 percent to the CDF, LOCAs 24 percent, ATWS 10 percent, internal flooding 6 percent, SGTR 2 percent, and interfacing system LOCAs 1 percent. The important

system/equipment contributors to the estimated CDF that appear in the top sequences are: the RCP seals and power-operated relief valves, AFW, the emergency safeguards features actuation system, the 120 volt AC system, the EDGs, emergency core cooling system injection and salt water cooling. The licensee's Level 1 analysis appears to have examined the significant initiating events and dominant accident sequences.

Based on the licensee's IPE process used to search for decay heat removal (DHR) vulnerabilities, and review of the Calvert Cliffs plant-specific features, the staff finds the licensee's DHR evaluation consistent with the intent of the USI A-45 (DHR Reliability) resolution and is, therefore, acceptable.

The licensee performed a HRA to document and quantify potential failures in human-system interactions and to quantify human-initiated recovery of failure events. The licensee identified the following operator actions as important in the estimate of the CDF. These were associated with: control of the AFW system flow, main feedwater, control and switchgear room cooling, and the component cooling water system, operator tripping of reactor coolant pumps following a loss of seal cooling, and loading the swing EDG during a non-LOCA accident.

The licensee evaluated and quantified the results of the severe accident progression through the use of a containment event tree and considered uncertainties in containment response through the use of sensitivity analyses. The licensee's back-end analysis appeared to have considered important severe accident phenomena. Among the Calvert Cliffs conditional containment failure probabilities: early containment failure is 8.6 percent with isolation failure the primary contributor, late containment failures is 40 percent with containment overpressure being the primary contributor, and bypass is 3.1 percent with SGTR the primary contributor. The containment remains intact 48.6 percent of the time. Early radiological releases are dominated by isolation failure and station blackout sequences. The licensee's response to containment performance improvement program recommendations is consistent with the intent of GL 88-20 and associated Supplement 3.

Some insights and unique plant safety features identified by the licensee at Calvert Cliffs Nuclear Power Plant are:

- An air source is required to open AFW valves; this tends to increase the CDF for transients involving loss of main feedwater.

- There is no seal injection for RCPs; a loss of component cooling water thermal barrier cooling alone results in loss of seal cooling. This tends to increase the CDF from seal LOCAs.

- The plant has a swing EDG; this tends to raise the CDF compared to plants with more than one EDG dedicated to each plant. It must be dedicated to the unit for which the preferred EDG has failed, thereby possibly rendering it unavailable to the unit with an accident. Also, the swing

EDG does not automatically load following a loss of offsite power, and operator action is required to prevent it from tripping on high jacket water temperature within 10 minutes.

- DC power is shared between the two units; this tends to increase the CDF due to loss of offsite power, because if the EDG normally dedicated to one unit fails, the swing EDG must power that unit resulting in loss of charging power to selected batteries at the other unit.

- The batteries have a 2-hour lifetime; this is relatively short and tends to increase the CDF from station blackout since it restricts the time available to recover offsite power. Load shedding was considered for station blackout events.

- Both power operated relief valves are required to feed and bleed; this tends to increase the CDF compared to plants where only one valve is required.

- The ability to crosstie AFW and plant air between the two units lowers the CDF due to transients by providing extra redundancy.

- The configuration of the reactor vessel and containment cavity allows water to flow freely into the cavity, and also provides a path for molten debris to spread over the containment floor. There are no penetrations through the biological shield. The containment floor configuration helps ensure smooth flow and even spreading of core debris.

- The containment emergency sump is protected from entrained debris by a 16 inch high curb, the normal sump has no curb.

The licensee used the NUMARC Severe Accident Closure Guidelines, NUMARC 91-04, to identify potential vulnerabilities and to determine if corrective actions were warranted. Vulnerabilities identified by the Calvert Cliffs IPE include:

- Loss of electrical switchgear room cooling.

- Loss of main feedwater following a plant trip.

- Loss of AFW availability if valves are inoperable.

- Loss of pressurizer spray during a SGTR because of proceduralized trip of RCPs.

- Significant challenges to operators following an inadvertent engineered safeguards features, reactor protection system and AFW system actuation resulting from failure of two 120 volt AC buses.

- RCP seal LOCA resulting from loss of component cooling water seal cooling (the dominant CDF sequence).

- Common cause or maintenance failure of both turbine driven AFW pumps.

Corrective actions have been implemented which address these vulnerabilities except for the RCP seal LOCA for which the licensee determined actions are not required. These include:

- Fans were staged near each of the four switchgear rooms to provide backup cooling, procedures were issued, and surveillance is being performed.

- The feedwater control system has been modified to prevent loss of main feedwater after a plant trip by rapidly reducing pump speed.

- Enhanced surveillance has been implemented for normally closed manual valves that support AFW pump operation.

- Emergency operation procedures have been revised to allow the use of pressurizer vent valves for depressurization.

- Training, including simulator training has been implemented that addresses an inadvertent engineered safeguards features, reactor protection system and AFW system actuation resulting from failure of two 120 volt AC buses.

- Isolation valves have been added to isolate a turbine driven AFW pump for maintenance.

The reported CDF of 2.4E-04 included the effects of those reported modifications which were expected to affect CDF. However, it did not include the beneficial effect of the addition of two emergency diesel generators, and other committed modifications, as a result of the station blackout rule which were scheduled for completion after the IPE freeze date of March 19, 1992. (The licensee estimates that the additional diesel generators will lower CDF approximately 17 percent.)

3.0 CONCLUSION

Based on the above findings, the NRC staff notes that: (1) the licensee's IPE is complete with regards to the information requested by GL 88-20 (and associated guidance NUREG-1335), and (2) the IPE results are reasonable given the Calvert Cliffs Nuclear Power Plant design, operation, and history. As a result, the staff concludes that the licensee's IPE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the Calvert Cliffs IPE has met the intent of GL 88-20.

It should be noted, that the staff's review primarily focused on the licensee's ability to examine Calvert Cliffs for severe accident vulnerabilities. Although certain aspects of the IPE were explored in more detail than others, the review is not intended to validate the accuracy of the licensee's detailed findings (or quantification estimates) that stemmed from

the examination. Therefore, this SER does not constitute NRC approval or endorsement of any IPE material for purposes other than those associated with meeting the intent of GL 88-20.

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