AEOD ENGINEERING EVALUATION REPORT*

UNIT: Calvert Cliffs, Unit 2
DOCKET NO.: 50-318
LICENSEE: Baltimore Gas & Electric Company
NSS/AE: Combustion Engineering, Inc./ Bechtel Corp.

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DATE: May 25, 1984
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SUBJECT: ADVERSE SYSTEM INTERACTION WITH DOMESTIC WATER SYSTEMS

EVENT DATE: October 19, 1983 (LER 83-60)

SUMMARY

Electrical equipment necessary for reactor operation and safe shutdown may be vulnerable to unanticipated interactions with the domestic water system because of their mutual proximity at various locations in the reactor building. Actual events of faulted safety-related electrical equipment from domestic water systems are infrequent and the potential consequences of their interaction was not considered in the licensing process, the Standard Review Plan, or as a Generic Issue. In our opinion, this interaction does not significantly affect public risk, but NRR should consider including this topic in USI A-17 "System Interaction in Nuclear Power Plants."

*This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

	Plant	NSSS	Architect/Engineer (A/E)
1.	St. Lucie-1	Combustion Engineering	EBASCO
2.	Arkansas-2	Combustion Engineering	Bechtel
3.	North Anna	Westinghouse	Stone & Webster

These designs are typical of most of the PWR support buildings.

We found at each site that the cable spreading room (also identified as the electrical equipment room or emergency switchgear room) is directly beneath the control room. Therefore, an interaction of electrical or control systems due to water incursion similar to the event at Calvert Cliffs could occur at each plant in the survey. The complex of electrical equipment in the cable spreading room in the plants of this survey would include:

CEA Drive Electrical Power Cabinets
4160V Switchgear Panels
480V Switchgear Panels
125V AC Instrument Busses
125V DC Control Centers
Batteries and Battery Chargers
15 or 20 KVA Inverters

Some of the electrical equipment in the cable speading room is safety-related with other equipment necessary for support functions. Potential sources of domestic water leakage into the control room or at locations directly above other electrical equipment at each plant in the survey were:

1. Calvert Cliffs

   As previously noted, the men's restroom, kitchen and janitorial area is next to the control room. Directly above is the women's restroom and laundry facilities.

2. St. Lucie-1

   Adjacent to the control room are two restrooms separated by the kitchen. Directly below this area is the site evacuation alarm and the hot shutdown panels.

3. Arkansas-2

   The toilet, laundry, and janitorial areas are separated by walls from the control area and are located a safe distance from the control room. However, directly beneath these sources of potential domestic water leakage are the two safety-related 4160V switchgear panels and the 125V DC control power. This equipment is essential after loss of normal and preferred power because the emergency diesel generators power the 4160V busses and their 4160V circuit breakers are cycled with 125V DC control power.

DISCUSSION

A shutdown control element assembly (CEA) inadvertently inserted into the reactor core because of an overflowing toilet at the Calvert Cliffs Nuclear Power Plant. The chain of events began on October 19, 1983 with Unit 2 at 70% power. On this day, a woman's restroom on the uppermost level (69'-0") of the auxiliary building was opened for use following its conversion from a men's restroom, and the main toilet waste line clogged with nondissolving material somewhere below the 45'0" level. It is believed that another obstruction, perhaps a crowbar, had been left in the drain line during initial construction and contributed to the drain line blockage. The clogged drain line affected the control room toilet at the next lower elevation (45'-0"). At an indeterminate time, from presumed intermittent flushing of the toilet on the 69'0" level, the control room toilet overflowed and water spread into the control room where the slope of the control room floor directed the toilet overflow toward the old (out-of-service) security control cabinets. There it seeped between the control cabinet and the control room floor, through the fire barrier cable penetration seal and onto a conduit that leads through the ceiling of the cable spreading room. The water followed the conduit to Section 6 of the Shutdown Group Coil Power Programmer cabinets and dripped onto the multiple breakers for 3 of the 4 CEA's within the cabinet (CEA's 46, 48, and 49). CEA 46's main circuit breaker tripped, and its associated shutdown element fully inserted into the core. Further investigation revealed that moisture was present in the plug-in CEA modules that control the timer, upper gripper, lower gripper, load transfer and pull-down coils. The temporary fire protection cable penetration seal through the control room floor (Kaowool - a ceramic fiber material) was inspected and found intact and functional. The licensee sealed the Kaowool with Flamastic, a more water-resistant fire barrier. Curbing was subsequently installed around the control room restroom to contain and redirect any future overflows from this area.

A typical nuclear facility may be expected to have many outlets of domestic water at various floor elevations to serve necessary plant and human functions, e.g., restrooms, drinking fountains, showers, kitchen facilities, shop wash basins, laundry, janitorial areas, etc. These facilities are grouped together in accordance with accepted centralized plumbing design codes and practices, e.g., American Standard Association's National Plumbing Code, ASA A 40.8. For example, at Calvert Cliffs, the shift supervisor's office, men's restroom, kitchen and janitorial area are next to the control room. Also, for practicality of electrical design, the centralized complex of the cable spreading room and battery room are located near the control area; i.e., directly beneath the control room at Calvert Cliffs. The complex of electrical equipment and cables in the cable spreading room and the control room could be adversely affected by direct water contact. The battery room at Calvert Cliffs receives protection by a separate roof enclosure.

We reviewed three other PWR plant designs to see if domestic water leakage could affect electrical components. The floor plans and equipment locations reviewed were:

4. North Anna

The restroom and drinking fountain are immediately next to the control room in the service building. The incore instrumentation cabinets are the nearest electrical equipment in the control room. The control room interface may be of less potential problem than the other plants in the review. However, at North Anna, the emergency switchgear and relay room contains 480V and 4160V switchgear.

The temporary fire barrier material failed to stop or redirect the seepage of water from entering the floor opening below the old security control cabinets at Calvert Cliffs. However, the permanent fire barrier cable penetrations, although they are composed of layers of different materials (Kaowool, Flamastic, Marinite and Vermiculite), are not required to be watertight either. Appendix R requires only that a water spray stream does not pass unimpeded through the cable fire barrier penetration and does not displace the seal from the penetration. Typically, during a fire endurance test, smoke will flow from the unexposed side of the fire barrier. In addition, if the water spray should enter the cable conduit, it would be transported along the conduit to electrical equipment.

The engineering design of a well-balanced, efficient drainage system is based on assigning a drainage constant for each different plumbing fixture. For example, a tank operated water closet would have a value of six fixture units; a wash sink is assigned two units. A 2-inch diameter building drain at a slope of 1/4-inch per foot is capable of accommodating 21 fixture units. However, in practice, the actual location of the drain may not be in the vicinity of the plumbing fixture. For instance, typically, floor drains are not located in restrooms, janitorial areas, kitchens, etc., because they are likely to clog, and therefore are not an acceptable solution to mitigate events of this nature. The licensee installed curbing around the restroom as his final corrective action. Perhaps, the ultimate solution may be to install all curbing to direct flow toward the stairwell.

The hypothesized interaction of domestic water systems with plant electrical systems or instrumentation was not specifically reviewed as part of the licensing process for Calvert Cliffs. To our knowledge, from our limited review of system interactions of this type, domestic water system interactions were not specifically identified:

- in the floor protection and postulated piping failure section of the Standard Review Plan (SRP), Chapter 3.6.1;
- as a potential water source for other SRP topics;
- as a part of the Systematic Evaluation Program (SEP); and
- as a Generic Issue.

FINDINGS

Domestic water systems can be in close proximity to electrical equipment that is necessary for stable plant operation, accident mitigation and safe shutdown. The floor plan survey of 4 PWRs identified that one interface is in the vicinity of the control room. At each plant, domestic water outlets were near the control room and the electrical equipment room or cable spreading room was directly beneath the control room. Therefore, leakage from the domestic water system has the potential to interact with either electrical equipment in the control room or in the electrical rooms below.

Events of unwanted leakage of a domestic water system may seem to be a familiar occurrence to most homeowners. However, in our opinion, the actual disablement of safety-related equipment at a nuclear power plant is a statistically infrequent event.

The potential consequences of a domestic water system interaction with safety-related plant systems have not been addressed in the licensing or the review process.

CONCLUSIONS

The proximity of electrical equipment and domestic water systems can be identified at the nuclear power reactors. Actual disablement of electrical equipment important to safety is a statistically rare event. In addition, the locations of the domestic water systems within the plant are generally continuously manned spaces which means any leak should be rapidly detected. Further, domestic water supply lines are generally 1" or less so the effects of a postulated moderate energy line crack as defined in SRP 3.6.1 should be minimal due to the small leak flow rate. In our opinion, the adverse interaction of domestic water systems with safety-related equipment is a very small contributor to the core-melt probability.

Although our "engineering judgement" leads us to believe this systems interaction does not significantly impact public risk, it is suggested that NRC might include this topic in USI A-17 "System Interactions in Nuclear Power Plants."