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MEMORANDUM FOR: Victor Stello, Jr., Director, Division of Operating Reactors, NRR

FROM: Robert E. Heineman, Director, Division of Systems Safety, NRR

SUBJECT: RESPONSE TO OPERATING EXPERIENCE MEMORANDUM NO. 7- FLOODING OF TURBINE BUILDING AT OCONEE

50-269

Summary of Occurrence

The subject memorandum addresses a potential safety problem that could result from flooding the turbine building by a failure of the circulating water system. The specific conditions producing such an event were: (a) the source of circulating water, Lake Keowee, was located at a higher elevation than the condenser water box, (b) a manway was opened to inspect the condenser, (c) a 78-inch pneumatic-piston operated isolation valve on the discharge side of the condenser was closed with a jackscrew in place, (d) the inadvertent operation of the pneumatic piston of the discharger isolation valve caused the attendant jackscrew to fail and the valve to open, and (e) the static head of the water on the lake caused circulating water to back-flow through the open valve and manway flooding the turbine building floor. A safety related electric oil pump for one of the three auxiliary feedwater turbine pumps was inundated. Other non-safety related components were also rendered inoperable. In addition, a potential existed for flooding the safety related components in the auxiliary building which is separated from the turbine building by a 21-inch curb. Approximately one and one-half million gallons of water back-flowed into the turbine building in 32 minutes.

Present Review Process

Standard Review Plan Sections 10.4.1, Main Condenser, and 10.4.5, Circulating Water System, of NUREG 75-087, outline our review procedure and acceptance criteria for assuring that flooding the turbine building will not cause unacceptable flooding of areas housing safety related

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systems or components. Section 10.4.1, Paragraph I Areas of Review, item 2c of the SRP deals with "the means provided to deal with flooding from a complete failure of the main condenser and to preclude damage to safety related equipment from the flooding." The circulating water systems, Section 10.4.5, Paragraph I Areas of Review, item 2 of the SRP covers "a malfunction, failure of a component, or failure of a circulating water pipe do not have unacceptable adverse effects on the functional performance capabilities of safety related systems located in the immediate area." This is the upper bound. In both sections of the SRP, the acceptance criterion is that a failure of piping or of a component should not cause unacceptable flooding of areas housing safety related equipment so that their functional performance capabilities will not be precluded. Plant layouts and drawings are used to assure that access opening to safety related areas are at an elevation well above the conservatively estimated flooding elevation.

Planned Action

Sections 10.4.1 and 10.4.5 of the Standard Review Plan contain the necessary criteria and review procedures to bound the problem in such a way that any flooding of the turbine building will not prevent safety related components from performing their safety function. Therefore, in response to Operating Experience Memorandum No. 7, we see no basis upon which to propose additional changes in our standard review procedures nor any changes in the Standard Review Plan. Our position is based on the following:

1. Oconee and other operating reactor plants received their operating licenses prior to the issuance of the Standard Review Plan and thus could have safety related components located in the turbine building. Nuclear Plants reviewed in accordance with Sections 10.4.1 and 10.4.5 of the SRP should not have safety related components located in their turbine building.

2. As presently stated, our analysis assumes the worst break such that the building is continually being flooded at the maximum flow rate. Under these conditions, we require that all safety related equipment should be protected. The type of protection is in most cases plant dependent. We recommend that OR plants be afforded similar protection after a case-by-case review is completed especially in view of the fact that the circulating water and condenser are non-seismic systems.

3. In our review process we assume that the turbine building is flooded and the flood level is determined by conservatively estimating the circulating water system flow rate. Access openings to safety related areas must be located above the maximum attainable flood level in the turbine building. In addition, we consider the potential for flood paths such as passageways, pipe chases, and/or cableways which join the flooded space to other areas that contain safety components necessary for safe shutdown.

4. The flooding that occurred, as outlined in Operating Experience Memorandum No. 7, dumped 1.5 $X10^6$ gallons in 30 minutes which corresponds to a flow rate of 50,000 gal/min. Plants under review for a CP or OL meet one of the following:

   a. Nuclear Plants that use cooling towers for a heat sink to cool the circulating water have a water inventory of about 7 to 8 $X\ 10^6$ gallons. The entire inventory of the cooling tower is then assumed to be dumped into the turbine building in 10-15 minutes.

   b. Nuclear plants that use a heat sink with an unlimited supply of cooling water assume that the turbine building is flooded until there is flow out the turbine building and over the plant grade. These assumptions represent a "worst case" review process and therefore, are more conservative than the flooding that occurred in Operating Experience Memorandum No. 7.

5. The following assumption, e.g. failure of condenser or expansion joints, is considered since the circulating water system is a non-safety related system and it cannot be relied upon to function or maintain its integrity in the event of an earthquake. Accordingly, any attempt to prevent flooding in the event of an earthquake should rely on a safety grade system.

Original signed by
Robert E. Heineman

Robert E. Heineman, Director
Division of Systems Safety
Office of Nuclear Reactor Regulation

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Division of Operating Reactors

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Division of Systems Safety

ORIG: X | CC: | OTHER:

ACTION NECESSARY: X | CONCURRENCE: ☐ | DATE ANSWERED:
NO ACTION NECESSARY: ☐ | COMMENT: ☐ | BY:

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DESCRIPTION (Must Be Unclassified)
OEM #7 - Flooding of Turbine Bldg. at Oconee

ENCLOSURES:

REFERRED TO	DATE	RECEIVED BY	DATE
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Action			
Interim Response by 3/21			
D. Fischer			

REMARKS: Return original yellow ticket with a copy of the incoming and reply to Ann Haikalis.

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

FEB 25 1977

MEMORANDUM FOR: R. E. Heineman, Director, Division of Systems Safety

FROM: V. Stello, Jr., Director, Division of Operating Reactors

SUBJECT: OPERATING EXPERIENCE MEMORANDUM NO. 7
FLOODING OF TURBINE BUILDING AT OCONEE

PROBLEM

With Oconee Units 1 and 2 at full power operation and Unit 3 shutdown for refueling, partial flooding of the turbine building occurred; a common turbine building serves the three Oconee nuclear units.

The gravity flow of circulating water from Lake Keowee continued for about 30 minutes through opened manways in the Unit 3 condenser. The full water level in Lake Keowee provides about a 25 foot head referenced to the basement floor of the turbine building. The back flow of water from the lake through one of six condenser outlet valves was stopped after an accumulation of 16 to 24 inches of water in the basement of the turbine building. Oconee Units 1 and 2 remained at power operation.

PRESUMED CAUSE

The Unit 3 main condenser was isolated for inspection; manways were open. The six 78 inch manually operated inlet valves and the six 78 inch pneumatic-piston operated outlet valves were closed. As a backup measure a jackscrew was installed on each outlet valve to preclude inadvertent opening. Solenoids to each outlet valve were energized to provide closure air to the pneumatic driven outlet valves.

Loss of AC power to the solenoids occurred. Air "to open" was introduced to each of the six pneumatic pistons of the outlet valves. The driving force of one piston was sufficient to fail the attendant jackscrew and one valve opened. This resulted in backflow of water from Lake Keowee through opened condenser manways to the turbine building. AC power was restored after about 30 minutes reenergizing the solenoids, and properly securing each of the six outlet valves.

An isolated air supply to the pneumatically operated valves would have precluded this event. These outlet valves are designed to fail open upon loss of power to the solenoid control valve.

SAFETY SIGNIFICANCE

Twenty one inch curbs between the auxiliary and turbine buildings at the Oconee Station prevented water flowing to the auxiliary building. Water accumulated to a depth of about 16 inches along the curbs.

Within the turbine building, an electrically driven oil pump for one of the three steam-driven emergency feedwater pumps, and a hotwell pump became inoperable as a result of the flooding. The oil pump was the only affected safety equipment.

All hotwell, booster, and main feedwater pumps, which are located on the floor of the turbine-building basement, could have become inoperative if the flooding had not been stopped.

If flooding of the auxiliary building had occurred the pumps of the LPCI and the HPCI systems, and all sources of water to the secondary side of all steam generators, could have become inoperable.

The Oconee flooding incident occurred as a result of the inadvertent opening of a main condenser isolation valve in the circulating water system while the condenser was open for maintenance. The fact that flooding of the turbine building continued until the valve could be repositioned raised concerns regarding the consequences of an unisolable break in the circulating water system piping inside the turbine building. It should be noted that, if a facility's circulating water system piping is located at an elevation higher than that of the source of water, the adverse consequences of an unisolable break in the circulating water piping would be minimized.

REPAIR

To preclude recurrence of this incident, the licensee, Duke Power Company, will take the following steps:

1. Dual-coil, mechanically latched solenoids will be used to replace the present ones on the condenser outlet valves. The latched solenoids to not change state with loss of power.

2. The power for the controls of the condenser circulating water system (CWS) will be changed to provide automatic, uninterrupted, transfer to a backup power source.

3. Position indicating lights for the condenser outlet valves will be placed in the control room.

4. Procedures for opening the CWS inside the turbine building will be revised as necessary to require,

   a) vented inlet and outlet pipes if all pumps are shutdown;

   b) manually operated valves at the condenser inlet to be closed and mechanically locked;

   c) air to pneumatic-piston valves be blocked and the pistons vented;

   d) screw jacks be placed at condenser outlet valves; and,

   e) lock in closed position the condenser emergency discharge valve to the gravity drain system when the condenser is isolated for inspection.

Additionally, the licensee is reviewing other potential flooding modes to determine necessary facility modifications to preclude, regardless of the source, unacceptable flooding levels. Consideration is being given to a gravity drain system from the basement of the turbine building.

DOR ACTION

DOR is reviewing the circulating water system for all operating facilities.

Determinations will be made whether a positive differential head exists between the water source and the CWS; and if so, whether design provisions prevent flooding of safety-related equipment.

Also, evaluations will be made to determine whether or not adequate design features exist to preclude damage of safety equipment from postulated leaks in the CWS.

RECOMMENDATIONS

Section 10.4.5 Circulating Water System (CWS), of the Standard Review Plan contains the bases for acceptance of the CWS. However, there are no explicit requirements related to the type of flooding event that occurred at Oconee. We recommend that consideration be given to the development of an NRR position to preclude such flooding events that could damage safety-related equipment.

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We also recommend that facilities now under review be evaluated to assure that design and operational methods are appropriate to preclude the occurrence of similar events. This applies to those facilities where elevation differences between the source of circulating water and the circulating system could potentially jeopardize the operation of safety-related equipment.

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