Omaha Public Power District

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November 13, 1981

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. Darrell G. Eisenhut, Director
U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Licensing
Washington, D.C. 20555

Reference: Docket No. 50-285

Dear Mr. Eisenhut:

The Commission's letter dated May 5, 1981 requested Omaha Public Power District provide an assessment of present procedures and operator training to enable the avoidance, recognition, and proper reaction to reactor vessel voiding during natural circulation cooldown. The District's response is attached.

Sincerely,

W. C. Jones
Division Manager
Production Operations

WCJ/KJM/TLP:jmm

Attachment

cc: LeBoeuf, Lamb, Leiby & MacRae
1333 New Hampshire Avenue, N.W.
Washington, D.C. 20036

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RESPONSE TO COMMISSION'S LETTER DATED MAY 5, 1981
REGARDING NATURAL CIRCULATION COOLDOWN

The Commission's letter identified two areas of concern regarding possible core voiding during natural circulation cooldown of PWR's. As part of the Commission's discussion on these concerns, procedural considerations were identified which the Commission believes should be factored into specific plant procedures and training. Specifically, the Commission asked the District to assess the Fort Calhoun Station's procedures and training with respect to their identified concerns. This assessment was to include three specific requests for information to be provided. Responses to the three specific requests are provided below.

Request 1

Provide a demonstration (e.g., analysis and/or test) that controlled natural circulation cooldown from operating conditions to cold shutdown conditions, conducted in accordance with your procedure, should not result in reactor vessel voiding.

Response

To properly address the District's position for precluding reactor vessel voiding, background information on the factors that affect the thermal behavior of the reactor vessel (RV) upper head region during a typical two-loop natural circulation cooldown is necessary. Specifically, the following points are addressed:

1. Operator actions which increase the cooling rate of the RV upper head region during a natural circulation cooldown.

2. A plant cooldown procedure or strategy which minimizes the probability of a void forming in the RV head.

3. Time requirements between the commencement of plant cooldown and the depressurization of the reactor coolant system (RCS) to the shutdown cooling system entry pressure, to avert the formation of a RV head steam void.

During a plant cooldown when the reactor coolant pumps are unavailable, the core is cooled by transferring heat to the secondary system which induces RCS natural circulation flow as a result of the thermal driving force that results from the temperature difference between the core and steam generator. However, without forced flow in the RCS, the primary coolant flowrate in the RV head region can be negligible, leading to a relatively stagnant region of hot metal and coolant. A steam void can be created in this hot RV head region by the flashing of primary coolant during system depressurization because the RCS pressure is reduced below the saturation pressure corresponding to the temperature of the hot coolant in the localized RV head region. Thus, the key to averting a steam void is to remove the excessive heat in the RV head prior to depressurization of the RCS.

The transfer of heat from the RV head region during a natural circulation cooldown is accomplished by two processes. The first involves the transfer of heat through the RV head into the containment atmosphere, which occurs at a slow and relatively fixed rate. The second involves heat transfer down through the coolant and core metal mass to the RV hot leg nozzle region, which is continuously being cooled by the natural circulation flow. Consequently, heat conduction has the significant role in the RV head cooling process under natural circulation conditions.

Increasing the temperature differential between the stagnant RV head region and the flowing coolant region will increase the transfer of heat from the hot upper head region. Thus, conducting the RCS cooldown at a high rate (prior to depressurization) will increase the temperature gradient and facilitate greater RV head cooling. Moreover, the RCS cooldown should not be stopped when the loop temperatures have decreased to the maximum permissible temperature for the commencement of cooling with the shutdown cooling system. RCS cooldown should continue to as low a temperature as practical to maximize the temperature differential between the RV upper head and circulating coolant.

A simulation of the RV upper head cooling process was conducted for natural circulation conditions. This simulation used a procedure which is similar to the one presently being developed for the Fort Calhoun Station. The cooling processes included heat conduction, localized natural circulation induced flow, and shrinkage induced flow into the RV head region. The simulation assumed a reactor trip at full power at time zero, followed by the onset of natural circulation in the RCS. After two hours of hot shutdown, a 75^{o}F/hr RV cooldown was initiated. Three final RCS temperatures (330^{o}F, 300^{o}F, and 270^{o}F) were utilized to determine if varying the coolant temperature had any effect on the cooling of the RV head. The attached figure provides the results of the cooldown simulation for a plant with hydraulic design features typical of the RV upper head at the Fort Calhoun Station. It should be noted that, due to heatup and cooldown curve limitations, this specific procedure cannot be used by the Fort Calhoun Station. However, a procedure will be developed based upon similar considerations and techniques.

The maximum shutdown cooling system entry pressure at the Fort Calhoun Station is 250 psig, corresponding to a saturation temperature of 406^{o}F. Therefore, to avert the formation of a RV steam void, the RCS cannot be completely depressurized to allow initiation of the shutdown cooling system until the coolant in the RV head is less than 406^{o}F. This can be accomplished by delaying final RCS depressurization until the RV head coolant temperature is known to be less than 406^{o}F. The simulation and resultant figure provided the required hold times (e.g., approximately 20 hours for a RCS temperature of 300^{o}F) for the three final RCS hot leg temperatures. The figure demonstrates that the establishment of a lower RCS temperature results in shorter hold times, permitting earlier initiation of the shutdown cooling system.

Request 2

Provide verification that supplies of condensate-grade auxiliary feedwater are sufficient to support your cooldown method.

Response

The feedwater requirements for conducting a natural circulation cooldown at the Fort Calhoun Station is estimated to be 180,000 gallons for shutdown cooling entry temperatures between 250°F and 300°F. This assumes the cooldown is conducted in a manner similar to that described in the response to Request 1. The auxiliary feedwater storage tank has a minimum capacity of 55,000 gallons which is in accordance with its FSAR design to provide sufficient water to maintain the reactor in hot shutdown for eight hours. A nominal inventory of 145,000 gallons is normally maintained in other sources at the Fort Calhoun Station. Utilization of these sources requires offsite power be available. If offsite power or sufficient condensate-grade feedwater was not available, river water could be supplied to the auxiliary feedwater system by the diesel driven fire pump.

Request 3

Provide a description of your training program and the provisions of your procedures (e.g., limited cooldown rate, response to rapid change in pressurizer level) that deal with prevention or mitigation of reactor vessel voiding.

Response

Operator training in the prevention of RV voiding during natural circulation cooldown has been conducted and will continue as part of the reactor operator's hot license and requalification training program. The training includes a thorough evaluation of the St. Lucie Unit No. 1 RV voiding incident, review of expected instrument behavior and system parameters during RV void formation, and discussion of RCS cooldown methods which will minimize the probability of a void forming. Upon implementation of the natural circulation cooldown procedure described below, training will be provided on this procedure.

A specific procedure for conducting a natural circulation cooldown will be implemented by April 1, 1982. The procedure will be based upon the technique of rapidly cooling down the RCS and then holding pressure for a period of time before initiating shutdown cooling. The procedure will consider the following:

1) Availability of offsite power.

2) Available inventory of condensate-grade feedwater.

3) Availability of the water plant.

4) RCS pressure and temperature limits due to RT_{NDT}.

5) Use of reactor coolant pump(s) to circulate water to the RV head region.

The procedure will also address the possibility of forming a void in the RV head region if it is shown that the RCS flow can be maintained on shutdown cooling with a void in the RV head and insufficient condensate-grade feedwater does not exist to conduct a natural circulation cooldown without forming a void in the RV head region.

The District recognizes that restraints imposed by availability of condensate-grade feedwater, RV head void, and RT_{NDT} considerations make a natural circulation cooldown undesirable at the Fort Calhoun Station. Therefore, the natural circulation cooldown procedure will only be used in a situation where forced circulation of the RCS cannot be re-established for an extended period of time and there is a critical need to be in cold shutdown.

FIGURE

REACTOR VESSEL UPPER HEAD COOLING VIA NATURAL CIRCULATION