DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

April 30, 1985

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

By letters dated February 22, June 18, July 25, August 29 and October 17, 1984 and March 28, 1985, Duke Power Company documented the deviations between the Catawba Nuclear Station Emergency Procedure Guidelines and the Westinghouse Owners' Group Emergency Response Guidelines. The last outstanding item from the review of these deviations was a commitment to provide additional justification for the additions to guideline ECA-1.2, "LOCA Outside Containment". The attachment provides a description of LOCA's outside containment and the proposed Duke Power Company approach for dealing with them in emergency procedures. This attachment includes a discussion of the use of feed and bleed cooling, as requested in Section 13.5.2 of Supplement 4 of the Catawba Safety Evaluation Report.

Very truly yours,

H.B. Tucker /lbb

Hal B. Tucker

ROS:slb

Attachment

cc: Dr. J. Nelson Grace, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Robert Guild, Esq.
P. O. Box 12097
Charleston, South Carolina 29412

Palmetto Alliance
2135½ Devine Street
Columbia, South Carolina 29205

Mr. Jesse L. Riley
Carolina Environmental Study Group
854 Henley Place
Charlotte, North Carolina 28207

NRC Resident Inspector
Catawba Nuclear Station

B021
1/1

Treatment of LOCAs Outside Containment in the Catawba Emergency Procedure Guidelines

This document discusses unisolable loss-of-coolant accidents (LOCAs) outside containment as they apply to the Catawba Nuclear Station and the guidance for mitigation of those LOCAs in the Catawba Emergency Procedure Guidelines (EPGs). Section I describes the special problems associated with LOCAs outside containment and the criteria that must be met in successfully dealing with them procedurally. Section II divides LOCAs outside containment into categories based on size and on other parameters which influence the stable plant condition finally achieved. Section III summarizes the current Catawba EPG guidance on LOCAs outside containment and proposes new specific actions for the operator to take in mitigating the various accident scenarios. Section IV summarizes the information presented and the conclusions of the evaluation.

I. Unique Problems of LOCAs Outside Containment

In the normal spectrum of LOCAs analyzed in plant Safety Analysis Reports, the injection of borated water from the refueling water storage tank (RWST), to replace reactor coolant lost through the break, eventually depletes the RWST. When RWST level reaches a certain setpoint the safety injection pumps are realigned to take suction from the containment sump which has collected the reactor coolant lost out the break. This process can then continue indefinitely with the liquid inventory being cooled by heat exchangers in the recirculation path. In contrast, for a LOCA outside containment the lost inventory cannot be collected for recirculation. Thus a continuous supply of borated water must be made available to keep the reactor core covered while

removing decay heat and thus preventing inadequate core cooling. The RWST inventory is quite large (~ 350,000 gallons) and the accident must, to present a problem, involve a prolonged loss of inventory. The Catawba plant is designed to minimize the possibility of LOCAs outside containment since the piping systems penetrating containment are equipped with redundant isolation valves. The Catawba EPGs contain specific instructions on which valves to close to stop break flow for isolable LOCAs outside containment. It will therefore be presumed for the remainder of this discussion that the LOCA outside containment is unisolable, i.e., that the loss of inventory cannot be stopped by closing a valve in the flowpath.

Although the preceding paragraph is applicable to PWRs in general, two particular facets of the Catawba Nuclear Station containment design are pertinent to a discussion of LOCAs outside containment. First, Catawba is an ice condenser plant -- any increase in containment pressure above approximately 1 lbf/ft^2 will cause doors to open, admitting the hot air and steam in the lower containment atmosphere into annular compartments containing baskets of borated ice. The total ice inventory is over 2 million pounds which, when melted, is a water volume of ~ 300,000 gallons. The natural convection of air and steam upward through the ice beds can be supplemented, at containment pressures above 0.25 psig, by forced circulation from containment air return fans which have a total flow rate of ~ 80,000 cfm. Thus the ice represents, when melted or while melting at any appreciable rate, a significant water source available for any accident which releases high energy inventory into containment.

Second, the Catawba containment sump is designed such that, to provide low-head safety injection pump suction without the possibility of

entraining air in the piping, the sump must be filled with some minimum amount of water. Specifically, providing flow to both low-head safety injection or residual heat removal (RHR) pumps requires approximately 15,000 ft^3 of accumulated sump inventory. This volume will be referred to in the subsequent discussion as the minimum recirculation volume. An evaluation of unisolable LOCA outside containment transients has shown that initiating a feed and bleed cooling mode by opening the pressurizer PORVs early, to accumulate sump volume and melt ice, will not ensure over the full range of break sizes that the minimum sump volume can be achieved and maintained.

II. Evolution of LOCA Outside Containment Scenarios

The primary characteristic determining the operator and procedural response to a LOCA outside containment is break size. For relatively small leaks the lost inventory can be made up from an external source on a continuous basis. For larger leaks this makeup cannot compensate for break flow and another long term cooling mode, as described below, can be reached. The chief factor in determining the eventual alignment of safety injection systems, and the usefulness of the ice condenser and sump inventory as an intermediate water source, is the presence or absence, during the transient, of the minimum recirculation volume. The following paragraphs will describe the different characteristics of larger versus smaller breaks and the effect of the existence of the minimum recirculation volume.

Large Break Scenarios

Through intentional operator action or due to the eventual loss of a suction source fo. the safety injection pumps, the reactor coolant system (RCS) pressure

will decrease to the saturation value for LOCAs outside containment above a certain size. Due to energy removal via the break flow and possibly the steam generators, the RCS temperature is likely to be low enough that the saturation pressure is at or near atmospheric. Depressurization to atmospheric pressure with the pressurizer PORVs will decrease the driving head for the break flow to its lowest possible, or residual, value. For the purpose of this discussion it will be assumed that the broken pipe connects to the RCS at the most limiting, i.e. lowest, piping location, the bottom of a hot leg of one of the main coolant loops. Even if the RCS pressure is assumed to be 0 psig, there will be some positive pressure at the external break location due to the static head of the liquid over the break. Thus, there will always be some pressure difference to drive the residual flow, even when the RCS is at atmospheric pressure. By draining the RCS liquid inventory down to just below the bottom of the hot leg, the residual flow can be reduced to only steam and the pressure difference virtually eliminated. At this level the reactor core will remain covered but will not be cooled by a circulating flow. Decay heat will boil the inventory remaining in the vessel below the hot leg nozzles. Additional inventory must be continuously supplied to the vessel through the cold leg safety injection connections in order to offset the boiloff. With the break uncovered the maximum amount of flow necessary is only that which, when heated to saturation in the core and boiled, will remove an amount of energy equal to the decay heat. Reflux boiling, i.e. condensation in the steam generator U-tubes of the steam generated in the core and backflow of this condensate into the reactor vessel, is expected to occur in this situation. This condensate contributes makeup flow for core cooling, thus reducing the amount of water which must be supplied from an external source. In order to further conserve

inventory the operator can, assuming a break in the RHR pump suction line, determine which coolant loop is connected to the ruptured line and keep the steam generator temperature in that loop at or above the RCS temperature. This will prevent heat transfer, and therefore condensation, in that loop and minimize condensate lost out the break. This mode of core cooling can be continued indefinitely as long as there is a source of water for injection. The amount of water needed will slowly decrease as decay heat decreases with time. The amount of water remaining in the vessel can be monitored with the Reactor Vessel Level Indication System (RVLIS) lower range channels. These instruments indicate liquid level by sensing the static pressure drop between the inside bottom of the reactor vessel and the lower part of the hot leg. If safety injection were used to maintain RCS liquid level above the bottom of the hot leg (liquid continues to be lost out the break), a stable long term cooling mode could be reached as described in the next section.

Small Break Scenarios

As discussed in the previous section the RCS liquid level may be able to be maintained above the break location. For this to be done on a continuous basis the injected flow must make up for the residual flow lost through the break. This flow must be supplied indefinitely, through makeup to the RWST or by charging from the Chemical and Volume Control System (CVCS). If the break is very small the available makeup flow is greater than residual flow and can compensate for additional, higher pressure break flow above the residual amount. However, this condition only results in increased external inventory loss without contributing to better core cooling. Therefore, the operator should depressurize the RCS to atmospheric conditions as quickly as possible

while maintaining a subcooled margin. This depressurization rate will be controlled by the decrease in coolant temperature, and therefore saturation temperature. If energy removal via break flow is not enough to achieve the maximum permissible cooldown rate, the operator should supplement the temperature reduction by steaming the steam generators. The RCS will, for this size range of breaks, ultimately reach a state approximately resembling a normal shutdown condition with decay heat being removed by the RHR heat exchangers and inventory loss being made up by injection flow.

Combined Accident Scenarios

It is possible that an unisolable LOCA outside containment can occur in combination with a high energy line break inside containment. If the high energy line break (LOCA, steam line break or feed line break) provides sufficient water volume by itself, or in combination with melted ice from the ice condenser, to deposit the minimum recirculation volume in the containment sump, the safety injection pumps can be transferred to the cold leg recirculation mode upon RWST depletion. This is an advantage since, even if the recirculation cannot be sustained due to a loss of minimum recirculation volume, some of the lost inventory can be used in the interim. Further, in an ice condenser plant such as Catawba an additional and, depending on the magnitude of the energy release into containment, potentially large borated water source is gained. Such an additional source may greatly contribute to maintaining adequate inventory during the time prior to the decay heat flow decreasing to the capacity of the continuous external makeup.

From the preceding sections it can be seen that unisolable LOCAs outside con-can reach one of the following long term cooling modes:

Boiling Pot Mode: For LOCAs above a certain size the RCS is depressurized and drained to a level just below the bottom of the hot leg nozzles. The break

location is uncovered and only steam is subsequently released outside containment. Decay heat is removed by injection of borated water through the cold leg connections, which is heated to saturation, boiled, and condensed in the steam generator tubes. The vessel water inventory is monitored via the lower range RVLIS channels. This approach will require comparatively little makeup since the worst case decay heat load at one hour can be removed by 300 gpm, some of which is kept in the system by reflux boiling.

Makeup Injection Mode: For LOCAs below a certain size a continuous external source can supply borated water to make up for that lost outside containment. Decay heat is removed by the RHR system as in a normal shutdown.

Makeup Recirculation Mode: This mode is identical to Makeup Injection Mode except that the RHR pumps take suction from the containment sump rather than the RCS.

III. Catawba EPG Guidance on LOCAs Outside Containment

In terms of specific failures which give rise to unisolable LOCAs outside containment, the Catawba EPGs recognize both an unspecified event, usually postulated as the failure of two series containment isolation valves with a break downstream (Event V sequence), and a steam generator tube rupture (SGTR) with a steam line break outside containment on the same loop. Although these events are dealt with in separate guidelines, this is a descriptive convenience to aid operator diagnosis of the latter event. The preceding discussion applies to either scenario and both guidelines contain similar instructions. Two important differences are that the SGTR scenario is 1) expected to result in much smaller leakage than, for example, a small break in an RHR pump suction line, and 2) the SGTR leak flow can eventually be stopped by depressurizing the RCS to atmospheric pressure and draining the liquid level to below the U-tubes.

Of the possible long term cooling scenarios discussed in the previous section, only the makeup modes are currently treated in the Catawba EPGs. Specifically the operator is told to make up to the RWST and/or to supply borated water to the RCS from any available source. These instructions apply to either makeup mode. Also, for the makeup recirculation mode the operator is given guidance on the operation of containment spray, based on the containment pressure response, so as to conserve RWST inventory while controlling pressure below the design value.

The following specific items are proposed for inclusion into the Catawba EPGs to further guide the operator in responding to an unisolable LOCA outside containment.

1. For the Boiling Pot Mode, the operator will be instructed to depressurize the RCS in a controlled manner to reduce driving pressure for the break and to drain the RCS to uncover the break location and stop the loss of liquid inventory outside containment. These operations will be accomplished with the pressurizer PORVs. When the depressurized, partially drained condition is reached, the operator will be told to monitor vessel inventory with the lower range RVLIS instrument and to provide the necessary makeup flow to maintain vessel level.

2. For the Makeup Injection Mode, the operator will be given instructions on throttling safety injection to more carefully control flow rates and conserve RWST inventory. This can be done in part by shifting the high-head safety injection pump discharge path to the normal charging line which has flow control valves. This guidance is already contained in the EPGs. Further, since the RCS will be depressurized, the operator will be told to restore control to the RHR pump discharge flow control valves (these valves fail full open on a safety injection signal) and use these to

control flow while stopping the intermediate-head safety injection pumps (the flow from these pumps cannot be throttled).

3. For the Makeup Recirculation Mode, in addition to the safety injection throttling described above, the operator will be instructed to manually actuate the containment air return fans to enhance ice melt by providing forced circulation through the ice beds. The operator already has available values for the minimum recirculation volume, as a function of sump outflow rate, which must be maintained to sustain cold leg recirculation.

IV. Summary

The Catawba EPGs already contain some guidance on mitigating LOCAs outside containment. Section III above proposes additional instructions to enable the operator to successfully establish stable, long term core cooling. The general approach begins with isolating the break if possible. If the break is unisolable the operator will cool down and depressurize the RCS in a controlled manner to reduce the inventory lost outside containment. This will minimize flooding and contamination in the external break location, e.g. the Auxiliary Building, and will gain time by decreasing the RWST depletion rate. As explained in Section II the time gained will mean a smaller flow rate required to remove decay heat for the boiling pot mode. A small break flow will also mean a greater likelihood that a continuous external water supply can be used to achieve one of the makeup modes.

The results of our evaluation indicate that it is difficult to ensure for the full range of break sizes that a benefit will be obtained by opening the PORVs and initiating feed and bleed cooling for a LOCA outside containment. This is mainly attributable to the need to establish the minimum sump recirculation volume before the bleed volume and any resulting ice melt volume is available

for core cooling. Therefore, the feed and bleed mode will not be used in the Catawba EPGs.