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May 26, 1982

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Station Units 1 and 2
Braidwood Station Units 1 and 2
Reactor Vessel Head Temperature
NRC Docket Nos. 50-454, 50-455,
50-456, and 50-457

Dear Mr. Denton:

This is to provide additional information regarding the temperature of the fluid in the reactor vessel head region at Byron and Braidwood. Review of this information should close Confirmatory Issue 22 of the Byron SER.

In the Byron SER the staff indicated that experimental confirmation of the reactor vessel head fluid temperature would be required. We have reviewed the analytical and experimental bases for the T cold assumption and conclude that no further experimental work is justifiable. Attachment A to this letter summarizes our reasoning.

It is requested that the staff review this document and withdraw this requirement for Byron. If confirmatory measurements are to be required eventually for a plant of the Byron class, they should be pursued on a generic basis with all of the applicants involved.

Please address any further questions regarding this matter to this office

One signed original and fifteen copies of this letter and the attachment are provided for your review.

Very truly yours,

T. R. Tramm
Nuclear Licensing Administrator

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Attachment A
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ATTACHMENT A

Basis for Upper Head Fluid Temperature in the
Byron/Braidwood Reactor Vessels

4205N

BACKGROUND INFORMATION

In order to achieve upper head temperatures equal to the vessel cold leg temperature (T_{cold}), bypass flow is diverted into the head region from the downcomer region (which is at T_{cold}). This bypass flow enters the head region via head cooling spray nozzles in the upper core barrel flange, and exits the region through the control rod guide tubes (and also the support columns for plants with upper head safety injection [UHSI]). These flow paths are illustrated in Figure 2-1 of Reference 1.

Due to a radial pressure variation, or skew, in the upper plenum (the region through which coolant exits the core), it is possible for the pressure in the upper head region to be lower than the pressure at some of the flow paths between the head region and the plenum. This permits flow from the upper plenum (which is at a temperature equal to the core outlet temperature) to enter the head region, mixing with the T_{cold} fluid and raising the average head fluid temperature above T_{cold} . A typical pressure distribution is illustrated in Figure 2-3 of Reference 1.

Core outlet flow can be prevented from entering the head region by effectively increasing the pressure in the head, so that it exceeds the pressures at all flow paths between the head region and upper plenum. This is done by increasing the size of the flow paths (cooling nozzles) between the downcomer region and the head region.

An analytical model was developed to accurately predict the upper head temperature in all types of plants. This model is described in Section 2 of Reference 1.

To provide experimental verification of the model, a 1/5 - scale model upper head temperature test was developed as described in Section 3 of Reference 1.

Further confirmation of the analytical model was obtained by an in-plant head fluid temperature measurement program as described in Section 4 of Reference 1.

In the text below, the analytical model is summarized, along with evidence supporting the conclusion that the model has been adequately verified to predict the upper head temperature in all types of Westinghouse plants, and specifically in plants of the Byron class of Commonwealth Edison.

ANALYTICAL MODEL

Assumptions

The solution of the model is based on the following verified assumptions:

- The horizontal pressure variation in the upper head region is negligible, and the vertical pressure variation is due only to gravity.
- Thermal stratification in the upper head region is negligible.

The text on pages 3 - 24 through 3 - 25 of Reference 1 describes the three flow patterns which were postulated for the upper head region: density gradient controlled, form/viscous drag controlled, and momentum controlled. Based on the results of the 1/5-scale model test which included temperature measurements as well as high speed movies of the flow patterns, it was concluded (page 3-61 of Reference 1) that the flow field is momentum controlled at plant operating conditions. If the flow pattern was drag controlled, pressure gradients would be significant. This is not the case. Currents set up by the cooling nozzle jets serve to maintain adequate mixing in the region.

Figure 4-18 of Reference 1 graphically illustrates the absence of significant thermal stratification as verified by operating plant and scale model data.

Important Parameters

The analytical model of the upper head region is comprised of the following classes of parameters:

- Head Fluid Characteristics
- Head Geometry Hydraulic Characteristics
- Boundary Conditions

These parameters are described below.

Head Fluid Characteristics

As a result of the two assumptions described above, only one (average) pressure and one (average) temperature is associated with the upper head region fluid in the model. These two parameters are the unknowns calculated by the model. For Byron class plants, which will operate with the head temperature at T cold, it is only necessary to calculate a head pressure which is greater than the external pressures at flow paths leading to the plenum. This verifies that the head will be at T cold, and a mixed fluid temperature calculation is not necessary.

Head Geometry Hydraulic Characteristics

The effect of the hydraulic characteristics of the upper head "internals" on the flow within the region is negligible since the flow pattern has been verified to be momentum controlled. Thus, only the boundary hydraulic characteristics where flow enters or leaves the region are important. For non-UHI plants (the category under which the Byron class plants fall) the hydraulic characteristics are: (1) guide tube flow areas and hydraulic resistances; and (2) head cooling nozzle flow areas and hydraulic resistances.

The flow areas are accurately known for each plant. The guide tube hydraulic resistances have been measured in flow tests. In fact, the type of guide tube used in Byron class plants is the same as the type used in the UHI flow distribution test described in Section 2-4 of Reference 1. One phase of that test measured the guide tube hydraulic resistances.

The cooling nozzle hydraulic resistances were determined based on the nozzle geometry.

Boundary Conditions

The boundary conditions are the external temperatures and pressures at each flow path into or out of the head region.

For plants operating at T cold (such as Byron class plants), the fluid temperatures do not affect the results, since no coolant at the core outlet temperature enters the head region.

The boundary pressures are based on 1/7-scale flow model tests. There were two 4-loop 1/7-scale model tests performed that are described in Reference 1. The first model had UHI-type upper plenum hardware. The second model had a non-UHI type upper plenum geometry. The primary differences between the two configurations are that the former had larger support columns and a slightly shorter plenum. This means less available lateral flow area (in effect, a "tighter" plenum). One would expect that if there were a difference in the pressure distribution, the "tighter" plenum would have a more severe skew. This is substantiated by the data presented in Figure 2-8 of Reference 1.

The test data was combined to yield design curves which are shown in Figure 2-11 of Reference 1. These design curves are used in the analytical model for all 4-loop plants. No credit is taken for existence of greater plenum flow areas in other plants.

The upper plenum geometry for the Byron class plants has more available lateral flow area than the geometry used in the 1/7-scale tests. This is due to the use of slotted support columns, and to the fact that the plenum height is greater. Therefore, it is concluded that use of the design curve from the 1/7-scale model tests for the boundary pressure

distribution in the analytical model is conservative for the Byron class plants.

This is further substantiated by agreement between model predictions and in-plant measurements, including a 4-loop plant with slotted support columns.

CONCLUDING REMARKS

Test results were obtained from the 1/5-scale model test at a wide range of upper head cooling bypass flows, up to and exceeding that required to maintain the head temperature at Tcold. Results reported in Section 3 of Reference 1 indicate that the predicted mean head temperature was within 4°F of the measured mean head temperature for all data.

In-plant data taken from six (6) non-UHI plants indicate good agreement between the predicted and measured head temperatures. In addition, recent measurements taken in two (2) plants which were predicted to operate at Tcold by the analytical model are indeed operating at Tcold.

It should also be noted that the cooling nozzles for the Byron class plants are designed for approximately 20% more head cooling bypass flow than the best estimate required value predicted by the analytical model.

It is therefore concluded that there is a sufficient margin of safety in the analytical method used to guarantee that the Byron class plants will operate with the upper head temperature at Tcold.

REFERENCE

- (1) McFetridge, R. H. and Garner, D. C., "Study of Reactor Vessel Upper Head Region Fluid Temperature", WCAP-9404, Revision 1 (Proprietary) and WCAP-9405 (Non-Proprietary), December 1978.