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August 24, 1989
Fort St. Vrain
Unit No. 1
P-89319

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

ATTN: Mr. Seymour H. Weiss, Director
Non-Power Reactor, Decommissioning and
Environmental Project Directorate

Docket No. 50-267

SUBJECT: **FORT ST. VRAIN DEFUELING ANALYSIS - REQUEST FOR ADDITIONAL INFORMATION**

REFERENCE:
(1) NRC Letter, Heitner to R.O. Williams, dated July 25, 1989 (G-89247)
(2) PSC Letter, Crawford to Weiss, dated August 16, 1989 (P-89287)
(3) NRC Letter, Heitner to R.O. Williams, dated August 8, 1989 (G-89261)

Dear Mr. Weiss:

On March 7, 1989, Public Service Company of Colorado (PSC) and General Atomics (GA) representatives met with NRC representatives to present preliminary PSC plans for defueling Fort St. Vrain. Included in this presentation was an overview of major defueling considerations, including core physics analyses and a preliminary evaluation of boronated defueling elements. These defueling elements, containing lumped boron poison pins, are to be inserted in the core to replace spent fuel elements as each fuel region is defueled to ensure reactivity control as well as maintain core thermal-hydraulic characteristics and seismic integrity.

In Reference 1, the NRC identified concerns related to (1) the spread in predicted values of K-effective for various boronation levels of the lumped poison pins which the NRC considered could be indicative of code modeling errors, and (2) the ability of the boronated defueling elements to satisfy Design Criteria 27, "Redundancy of Reactivity Control". PSC's responses to the specific NRC concerns identified in Reference 1 are attached.

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PSC has finalized its evaluation of defueling and concluded that "no unreviewed safety questions exist which would preclude PSC from proceeding with the defueling process". This analysis has been forwarded to the NRC for review in Reference 2. In addition, the NRC requested (Ref. 3) that the interim reactivity control Technical Specifications and the Technical Specification Upgrade Program (TSUP) drafts concerning the Fuel Handling Machine and Fuel Storage be incorporated into the Technical Specifications before defueling operations commence. PSC is expediting the preparation and review of these Technical Specification changes for submittal to the NRC.

Should you have any additional questions related to design or use of the defueling elements following review of this letter or Reference 2, please contact Mr. M.H. Holmes at (303) 480-6960.

Very truly yours,

A. Clegg Crawford

A. Clegg Crawford
Vice President,
Nuclear Operations

ACC:CRB/cb

Attachment

cc: Regional Administrator, Region IV
ATTN: Mr. T.F. Westerman, Chief
Projects Section B

Mr. Robert Farrell
Senior Resident Inspector
Fort St. Vrain

ATTACHMENT 1
PSC RESPONSE TO NRC CONCERNS
RELATED TO DEFUELING ELEMENTS

NRC CONCERN NO. 1:

The NRC Staff has replotted the PSC curves of K-effective vs. boronation (for the defueling elements) presented in the March 7, 1989, NRC/PSC meeting. Simple extrapolation of PSC data approaching the case of "zero" regions defueled shows a wide range of results for K-effective. (Total spread of predicted values is greater than 0.05.) Ideally the model should predict only one value since boronation has no effect before defueling begins.

The Staff is concerned that the spread in K-effective is due to model errors. PSC is requested to provide the following:

(1) Provide a full evaluation of these errors or demonstrate that PSC's calculations are consistent for "zero" regions defueled.

(2) The evaluation should provide a worst case estimate of "K-effective" vs. "number of regions defueled" for the proposed boronation scheme.

PSC RESPONSE:

In January and February of 1989, the various options for defueling the FSV core were evaluated, including options for defueling sequence, reactivity control, thermal-hydraulic and seismic considerations and accident control. Based on the evaluation, graphite defueling elements containing lumped boron poison pins were selected to replace the fuel blocks in each region defueled.

The GAUGE code was used in both the preliminary defueling analysis and subsequent detailed defueling analysis to evaluate core reactivity for the various defueling scenarios evaluated. GAUGE has been used extensively to predict core reactivity for various core conditions, including refueling. GAUGE has been demonstrated to accurately predict core reactivity based on close agreement between estimated critical rod positions and actual critical rod positions during numerous reactor startups.

To commence the defueling analysis and defueling element design, a number of assumptions were required. Included in these assumptions were the preliminary defueling sequence, time in core, and the boron loading (i.e., boron concentration and number of pins per defueling element). To guarantee that an adequate shutdown margin exists at any point in the defueling sequence, calculations using these assumptions for all 37 configurations would have been required for every design consideration (6-pin, 12-pin, 24-pin).

In order to prevent unnecessary calculations during preliminary analyses, three specific points in the defueling sequence (i.e., 2-regions defueled, 11-regions defueled and 17-regions defueled) were selected for analysis using the preliminary defueling sequence. It was recognized in this analysis that the predominant positive contribution to core reactivity would occur when the control rods were withdrawn in regions of high reactivity worth. Using these three probable worst cases, a preliminary parametric study of 6-pin, 12-pin and 24-pin designs was conducted.

The calculations demonstrated that the 12-pin design was well beyond the "saturation point" for reactivity control. The results of this preliminary analysis were presented to the NRC on March 7, 1989, and were the basis for PSC's selection of the 12-pin design at that time.

Since the March PSC/GA/NRC meeting, the defueling element and pin design has been further refined. Pin diameter and stack height were further defined to accommodate manufacture of the defueling elements. The defueling sequence has been further defined to accommodate the defueling time motion study. Analyses were then performed for each of the 37 regions in the defueling sequence order; the results of these analyses are presented in the Defueling SAR and confirm that the 12-pin lumped poison pins provide a very conservative design.

In response to NRC Concern No. 1, it is agreed that the model should ideally predict only one value of K-effective for the "Zero Regions Defueled" case, regardless of the number of pins selected. The input to the code is exactly the same for a "0 ppm Boron" case as it is for a "Zero Regions Defueled" case and the GAUGE code produces the same answer in each analysis.

The spread in values for K-effective that results from simple extrapolation is not the result of model errors, but rather is observed because simple extrapolation is not a valid technique. In general, core reactivity tends to decrease during defueling. However, the data points presented in the March 7th meeting do not represent a smooth function. These data were generated assuming that 2 control rods are withdrawn - the control rod in the region being defueled and the control rod in the subsequent region in the defueling sequence. The calculated K-effective for each point within the defueling sequence may increase or decrease, depending upon the next region to be unrodded. This increase or decrease is dependent on the widely varying spacial reactivity distribution which exists in the core, resulting in significant differences in control rod reactivity worth. Therefore, simple extrapolation back to a "Zero Regions Defueled" condition will produce an incorrect answer. This is especially true since the three cases that were originally chosen were based on the consideration that these cases would represent the worst case reactivity control problems (peak K-effectives) expected to be encountered during defueling.

The Defueling SAR calculates the explicit K-effective for each point in the selected defueling sequence and presents the results of the analyses in Tables 3-2 through 3-5. These analyses identify the worst case estimates of "K-effective" vs. "number of regions defueled" requested in the NRC concern.

NRC CONCERN NO. 2:

During defueling, the boronated defueling elements provide reactivity control in conjunction with the control rods.

Evaluate this proposed reactivity control method against FSAR Design Criteria 27, "Redundancy of Reactivity Control". This evaluation should address the following:

- credible errors in the model's ability to predict K-effective noted in NRC Concern No. 1.
- credible errors in providing the correct boron loading to the defueling elements.
- action to be taken if defueling shutdown margins are not met after defueling a specific region.

PSC RESPONSE:

General Design Criterion (GDC) 27 of the FSV Updated FSAR states that *"at least two independent reactivity control systems, preferably of different principles, shall be provided."*

During normal reactor operation, primary reactivity control is provided by 37 pairs of control rods. A second system, the reserve shutdown system (RSS), provides independent reactivity control. The RSS consists of 37 hoppers of boronated graphite balls which can be released into 37 cylindrical holes, one per refueling region. Hence, the RSS provides an independent reactivity control system of a different principle from the normal control rod system.

Under the proposed procedure and sequence for defueling, for active regions containing fuel with control rods capable of being withdrawn, both the control rods and the RSS neutron absorber material will be capable of being inserted. Control rods fully inserted in active regions will normally be disabled to prevent inadvertent rod withdrawal, except for those control rods in regions involved in shutdown margin verification. Redundant reactivity control methods are only needed for the regions of the core which still contain fuel. The defueling sequence is identified in Figure 2-1 of the Defueling SAR.

Analysis indicates that the negative reactivity contribution of the lumped poison pins in the defueling elements is greater than the combined negative reactivity of both the fully inserted control rods and RSS of an active region containing fuel. Increasing the boron content in defueling elements would not result in a significant decrease in reactivity and would have an insignificant effect on core shutdown margin. For this reason, defueling elements have not been designed to be capable of accepting control rods or reserve shutdown material. Regions containing defueling elements are, in effect, comparable to regions for which both redundant reactivity control systems have been actuated, and no further significant decrease in reactivity is possible due to the presence of additional neutron absorbing material. Alternately, regions containing defueling elements may be considered to be equivalent to the boronated top, bottom and side reflector elements surrounding the active core, which do not have redundant means of reactivity control.

The lumped poison pins provide a passive method of ensuring reactivity control and there is no credible mechanism for loss of boron from the defueling elements. This method of reactivity control was not envisioned by GDC 27, which was developed for systems which actively control reactivity by enabling controlled reactivity increases for criticality and power production, and controlled reactivity decreases.

The boronation level in the defueling elements was intentionally chosen to saturate the reactivity effects so that shutdown margins would not be sensitive to credible errors in boron loading. Significant errors in boron loading would be detected by unexpected trends in the nuclear instrumentation Startup Channel count rate. If such a trend is observed during the defueling process, or if the required shutdown margin verification tests reveal problems, defueling operations will be halted until the reasons for these anomalies can be identified.

As explained in response to NRC Concern No. 1, model errors hypothesized by the NRC are a result of inappropriate extrapolation of limited data.