DOCKET FILES

MAY 16 1978

Docket No. 50-305

Wisconsin Public Service Corporation
ATTN: Mr. E. W. James
Senior Vice President
Post Office Box 1200
Green Bay, Wisconsin 54305

Gentlemen:

Our letter dated December 16, 1977, provided our safety evaluation report on the emergency core cooling system (ECCS) evaluation model for Westinghouse two-loop plants. On the basis of that report you were requested to provide within 30 days appropriate bases, including any necessary operating limitations, to justify continued operation of the Kewaunee Nuclear Power Plant beyond this 30 day period. Your letter dated January 16, 1978, provided a response to this request. By letter dated February 10, 1978, we requested additional information. You responded to this request by letter dated February 20, 1978.

Our attached safety evaluation concludes that the calculations provided by your letter of February 20, 1978, provided an acceptable basis for continued operation of the Kewaunee Nuclear Power Plant while long-term efforts continue to develop an ECCS evaluation which specifically treats upper plenum injection. This evaluation demonstrates that, for Kewaunee, specific consideration of upper plenum injection water interaction with core generated steam, using acceptable modifications of the model described in our November 1977 SER, results in a decrease in calculated peak clad temperature of only 10°F (for the 120% ANS decay heat case) over the temperature resulting from prior calculations based on the Westinghouse model.

We acknowledge receipt of your most recent submittal dated March 16, 1978, which responds to that portion of our letter of December 16, 1977, which requested that you provide within 90 days a permanent resolution (and a schedule for its implementation) to our concerns about upper plenum injection of ECCS water. Your proposal is consistent with the recommendations contained in our March 1978 SER a copy of which is enclosed.

ECCS

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We look forward to working with you on the long-range effort to develop an acceptable ECCS model which specifically treats upper plenum injection.

Sincerely,

**Original signed by**

A. Schwencer, Chief
Operating Reactors Branch #1
Division of Operating Reactors

Enclosure:
March 1978 SER

cc w/encl:
See next page

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ANALYSIS BRANCH

DIVISION OF SYSTEMS SAFETY

OFFICE OF NUCLEAR REACTOR REGULATION

# SAFETY EVALUATION REPORT

# ON

# INTERIM ECCS EVALUATION MODEL

# FOR

# WESTINGHOUSE TWO-LOOP PLANTS

March 1978

## Introduction

On December 16, 1977 the licensees of Westinghouse designed two-loop plants were sent letters from Mr. Case, which required them to provide an interim basis for continued safe operation in light of staff concerns relative to the effectiveness of the two-loop plant ECCS. On January 16, 1978 each licensee provided essentially the same letter as the interim basis for continued safe operation. The purpose of this memorandum is to provide a safety evaluation of the proposed upper plenum injection analysis as presented in those letters.

## Summary of Review

The January 16 licensee letters provided their evaluation of the effectiveness of the ECCS Upper Plenum Injection (UPI) during a postulated LOCA. Use was made of a staff model described in the "Safety Evaluation, ECCS Evaluation Model for Westinghouse Two-Loops Plants," December, 1977. However there were six changes made to the staff model by Westinghouse. The staff SER model accounts for the effects of Upper Plenum Injection by estimating the effects of: steam generation; steam condensation; and liquid entrainment on the core reflood rate and the associated change in calculated peak clad temperature. When the staff model was generated, it was intended to be suitably conservative for evaluating Upper Plenum Injection performance during a postulated LOCA or if necessary, for establishing an interim basis for operation of the two-loop plants. The staff model, a simplified model which started out as a hand calculation, was an attempt to approximate a fix for an interim period. It was not (and still is not) an ECCS Evaluation Model which fully complied with 10 CFR 50 Appendix K. The staff model, or the staff model with approved changes, could possibly be used as a basis for establishing interim operating conditions. However, neither model is acceptable for long term use. For example, the use of a decay heat model of 1.0 x ANS decay heat might be acceptable on an interim basis (i.e., to determine if there is a safety problem) but is not suitable for a long term evaluation model. Part 50.46 requires that, "ECCS cooling performance be calculated with an acceptable evaluation model...". Appendix K sets forth certain required features of an acceptable evaluation model including the requirement that, "the refilling of the reactor vessel and the time and rate of flooding of the core shall be calculated by an acceptable model that takes into consideration the thermal and hydraulic characteristics of the core and of the reactor system". Neither the Staff model nor the proposed Westinghouse variation is an integral model for the evaluation of a postulated LOCA. Instead, each provides a possible adjustment to be used together with the "incorrect" old LOCA calculation. The documentation and sensitivity studies required of an evaluation model are also absent. Most important is the lack of rigor in the staff approximate method; it was not subjected to the same scrutiny that we demand for long-term generic use.

Each of the six changes proposed by the licensees to the model has been evaluated to determine the acceptability of the Westinghouse calculations. The following description of the first change is taken from the Attachments to the owner's letters.

1. "The clad temperature rise versus flooding rate curve, Figure 24 in the SER, was replaced by a more realistic curve. The new curve was based on the Westinghouse design FLECHT correlation with input more specific to the Westinghouse two-loop plants".

Evaluation:

The SER curve is based on the most conservative data from the reflood rate sensitivity studies presented in the PWR FLECHT Final Report Supplement, WCAP-7931. The Westinghouse calculation takes credit for the calculated pressure, subcooling and linear heat rate in establishing the relationship between peak clad temperature and reflood rate. Based on our review of the actual input values used and the method of implementation, this change is acceptable. The second change is described as follows:

2. "The input was changed to allow transient input for pressure, injection rates, flooding rates and decay heat".

Evaluation:

The most important portion of the reflood transient occurs between 60 seconds and 100 seconds. The time dependent input for decay heat allows approximately a 10% reduction over this time span. The SER model is based on a constant decay heat, with the value determined at the beginning of a reflood. Since this change only involves more detailed input, it is acceptable to the staff. The third change is described as follows:

3. "The carryover fraction, CRF, discussed on page 40 of the SER was changed from 0.8 in the staff model to 0.7 in the Westinghouse

model. Carryover fractions of 0.7 are more typical of the two-loop plants".

Staff calculation of the carryover fraction, CRF, during reflood for a two-loop plant with upper plenum injection range in value from 0.6 to 0.8 as a function of time.

The carryover rate fraction, CRF, appears in two different forms in the staff model. It appears in the quench front progression equation as (1-CRF) where the value of (1-CRF) is .3. This agrees with the suggested value of CRF = .7 from Westinghouse. The carryover rate fraction is also included as one of the components of the constant which is used to characterize the relationship between changes in bottom quench front steam and water flows, and the flooding rate. In the staff evaluation model the system resistance to flow establishes the total steaming rate out the break during reflood. This steaming rate determines the reflood rate (Vin) according to the following equation:

$$\text{Vin} \times \text{CRF} \times \text{Area} \times \text{Liquid Density} = W_{TOTAL}$$

Changes in the total bottom quench front steam and water flow ($W_{TOTAL}$), and the reflood rate are therefore related by the following perturbation equation:

$$\Delta\text{Vin} = \Delta W_{TOTAL} /(\text{CRF} \times \text{Area} \times \text{Density})$$

The staff model includes a value of CRF of .8 in this estimate of the system flow resistance.

The use of a constant CRF of 0.7 appears to be consistant with the CRF value for the two-loop plant evaluation model calculations and therefore the use of a 0.7 value is appropriate. The fourth change is described as follows:

4. "The bottom quench front in the staff model was initialized at 0.0 feet. Since this calculation starts some 20 seconds into reflood, the Westinghouse model initiates the bottom quench front at 1.5 feet which is a lower bound value from the Westinghouse ECCS Evaluation Model results".

The SER model was initiated at 60 seconds because this is the time at which the reflood rate calculated with the present evaluation model for the worst break becomes a well behaved and smoothly varying function of time. Prior to 60 seconds the calculated reflood rate varies dramatically as the bottom reflood water first rushes into the core relatively unimpeded and then generates a large amount of steam which causes the reflood rate to drop sharply. The presence of Upper Plenum Injection would significantly alter this initial phase of reflood in a way that the staff's relatively simple, perturbation technique could not accurately represent. Since the upper plenum injection begins at 26 seconds in the evaluation model calculation, for the worst break, significant steam generation from this water would be occuring when the bottom reflood water reached the core. The upper plenum steam generation would lessen the initial rush of water into the core because of the increased steam binding effects.

The initial phase of bottom reflood would therefore be less dramatic in the variation in the reflood rate. The Staff model effectively assumes a smooth and well behaved reflood from the bottom of core recovery. The staff model includes a simple treatment of this initial phase of reflood with upper plenum injection. The proposed change by Westinghouse would not consider any effects of upper plenum injection prior to the reflood level reaching 1.5 feet. Although the staff SER model could be improved in this area, the Westinghouse change does not appear to increase the accuracy of the representation and is clearly in a non-conservative direction. This change is therefore unacceptable at the present time. The fifth change is described as follows:

5. "The heat transfer model, described on page 37 of the SER, was altered to account for the amount of heat transfer in the unquenched region which is going to the bottom generated steam rather than the top generated steam. This was done by reducing the heat transfer to the top generated steam by 25 percent. This is a conservative lower bound".

The staff SER model assumes two predominant sources of steam:

1. The bottom quench front progression; and,
2. The steam generation due to upper plenum injection water entering the core from above.

The bottom quench front steam was assumed to be carrying a significant amount of water so that the total steam and water from the bottom quench front equalled the carryover function times the reflood rate. Since each pound of steam from the bottom quench front was already carrying on the order of three pounds of water, this steam was not inlcuded in the upper plenum injection entrainment correlation. The steam generated from the top quench front and from heat transfer to the upper plenum injection water in the unquenched portion of the core was input into the entrainment correlation. The Westinghouse change suggests that three sources of steam provide a better representation of the reflood steam generation. One source of steam is at the bottom quench front; a second source is the top quench front and steam generated by the top injection water entering the core; and the third is the vaporization of water carried up from the bottom quench front. . The Westinghouse model therefore proposes to identify two separate sources of steam in the unquenched portion of the core. This is acceptable and in fact may be a more accurate representation. However, the proposed model change does not include the steam generation in the unquenched region from the bottom quench front water as input to the entrainment correlation. The basis for not including the bottom quench front steam in the entrainment is that this steam is already carrying a significant amount of water. No basis has been provided for not including the steam generation in the unquenched region of the core from the bottom quench front water in the entrainment correlation. This proposed change is therefore unacceptable as presented. A modified change which included all non-bottom quench front steam in the entrainment correlation could be acceptable. The sixth proposed change is stated as follows:

6. "The metal heat model was altered to take into account the finite amount of heat stored in the upper plenum metal. The heat capacity of the upper plenum metal is 5930 (BTU/°F). This metal energy is removed in a finite period of time after which no energy is added to the

fluid from the metal resulting in increased subcooling for the remainder of the transient".

The staff SER model uses a simple constant heat input model for the heating effect in the upper plenum. The concept of a finite stored energy model is acceptable. The basis for establishing the initial stored energy and the heat release rate has been reviewed and is sufficiently conservative for use in the interim calculations. This proposed change is therefore acceptable.

Since two of the Westinghouse proposed changes were found to be unacceptable, the staff letters, of February 10, 1978 to the Two-Loop Licensees, formally requesting additional information included a request for new calculations in which the unacceptable proposed changes were removed. Table I presents the results of these calculations for both 100% ANS decay heat and 120% ANS decay heat.

Staff Findings

The following conclusions are based on our review of the information presented by the two-loop plant owner-operators.

First, the calculations performed with the proposed changes 1, 2, 3 and 6 are acceptable as an interim basis for continued safe operations of the Westinghouse two-loop plants. Although some of the calculations result in increases in peak clad temperature, none results in a peak clad temperature greater than 2200°F.

Second, the long term effort to produce an acceptable ECCS evaluation model for treating Upper Plenum Injection should continue unless the two-loop plant owners propose to modify the ECCS hardware to eliminate Upper Plenum Injection.

Table I

Upper Plenum Injection Results

| PLANT | CURRENT WESTINGHOUSE EVALUATION MODEL ANALYSIS $F_q$ | PEAK CLAD TEMPERATURE | NEW U.P.I. ANALYSIS* $F_q$ | PEAK CLAD TEMPERATURE 1.0 ANS Decay Heat | 1.2 ANS Decay Heat |
|---|---|---|---|---|---|
| WEP/WIS | 2.32 | 1965 | 2.32 | 1945 (-20) | 2025 (+60) |
| RGE | 2.32 | 1957 | 2.32 | 1900 (-57) | 1972 (+15) |
| NSP/NRP | 2.32 | 2187 | 2.32 | 2110 (-77) | 2177 (-10) |
| WPS | 2.25 | 2172 | 2.25 | 2090 (-82) | 2162 (-10) |

*With Unacceptable Proposed Changes Deleted.