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Westinghouse
Electric Corporation

Water Reactor
Divisions

Nuclear Technology Division

Box 355
Pittsburgh Pennsylvania 15230

NS-TMA-2291

August 15, 1980

[redacted] and Special Projects
Branch Division of Licensing
U.S. Nuclear Regulatory Commission
1717 H Street
Washington D. C. 20555

Dear Mr. Miller:

Subject: Response to NRC Request for Additional Information (7/28/80) on WCAP-9528

The attached question was received regarding the Westinghouse Electric Corporation report WCAP-9528 - "ECCS Evaluation Model for Westinghouse Fuel Reloads of Combustion Engineering NSSS." The following is our response to that question:

As is the case with Westinghouse nuclear steam supply systems, we are assessing the concerns associated with NUREG-0630 on a plant-by-plant specific basis. Potential penalties due to fuel rod models proposed by the NRC in NUREG-0630 have been considered and applied in our evaluation of the Westinghouse fuel reload of the Northeast Utilities' Millstone Unit 2 plant. Our assessment demonstrates that a conservative consideration of those penalties is compensated for by available credits as described in the attachment. The attached burst-blockage assessment for Millstone 2 is also being formally submitted to the staff by NUSCO in response to question 10 (BSR question set 3) asked of the utility related to cycle 4 licensing of Millstone Unit 2. (Copy of assessment enclosed, attachment #2).

We realize the generic burst-blockage consideration raised by the staff could eventually involve additional assessments or analyses. However, such supplemental efforts can be efficiently and appropriately defined only after a final resolution to the NUREG-0630 issues is established. Westinghouse has provided its position to assist in the resolution of differences in fuel rod materials models, as documented in NS-TMA-2175. As stated in that letter, Westinghouse believes the current Westinghouse models to be conservative and in compliance with Appendix K.

Very truly yours,

T. M. Anderson, Manager
Nuclear Safety Department

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Attachment

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ENCLOSURE

QUESTION ON WCAP-9528 TOPICAL REPORT

The NRC staff has been generically evaluating three materials models that are used in ECCS evaluation models. Those models are cladding rupture temperature, cladding burst strain, and fuel assembly flow blockage. Subsequent to the submittals of WCAP-9528 and its addendum, we have (a) met and discussed our review with Westinghouse and other industry representatives (Reference 1), (b) published NUREG-0630, "Cladding Swelling and Rupture Models for LOCA Analysis" (Reference 2), and (c) required fuel vendors and licensees of Zircaloy clad LWRs to confirm that their plants would continue to be in conformance with the ECCS criteria of 10 CFR 50.46 if the materials models of NUREG-0630 were substituted for those models of their ECCS evaluation models (References 3 and 4).

The Westinghouse materials models that are described in WCAP-9528 are virtually the same as those used in prior Westinghouse ECCS evaluation models, and they were evaluated in NUREG-0630. Small differences are attributable to modifications that were made to reflect the geometrical differences in fuel designs for the Millstone 2 plant. Therefore, until we have completed our materials model review, we will require plant analyses performed with the ECCS evaluation model as described in WCAP-9528 to be accompanied by supplemental analyses to be performed with the materials models of NUREG-0630.

Should Westinghouse elect not to explicitly model cladding temperature ramp rates, the materials models of NUREG-0630 to be used in the supplemental calculations are attached in Table 1.

We request that Westinghouse provide an example calculation with the NUREG-0630 model. This calculation should be the worst break calculated in WCAP-9528 for the CE NSSS. The reanalysis need only include those computer calculations for which a substantive change in results is expected.

References

1. Memorandum from R. P. Denise, NRC, to R. J. Mattson, "Summary Minutes of Meeting on Cladding Rupture Temperature, Cladding Strain, and Assembly Flow Blockage," November 20, 1979. Available in NRC PDR for inspection and copying for a fee.

2. D. A. Powers and R. O. Meyer, "Cladding Swelling and Rupture Models for LOCA Analysis," NRC Report NUREG-0630, April 1980. Available from the NRC Division of Technical Information and Docket Control.

3. Letter from D. G. Eisenhut, NRC, to all Operating Light Water Reactors, dated November 9, 1979. Available in NRC PDR for inspection and copying for a fee.

4. Memorandum from H. R. Denton, NRC, to Commissioners, "Potential Deficiencies in ECCS Evaluation Models," November 26, 1979. Available in NRC PDR for inspection and copying for a fee.

TABLE 1

CLADDING MODELS FOR USE IN SUPPLEMENTAL CALCULATIONS

Rupture Temperature

$$T_R = 3960 - 20.4\,\sigma - \frac{8{,}510{,}000\,\sigma}{100 + 2790\,\sigma}$$

Burst Strain and Flow Blockage

T_R	ε	F.B.
600	10	6.5
625	11	7.0
650	13	8.4
675	20	13.8
700	45	33.5
725	67	52.5
750	82	65.8
775	89	71.0
800	90	71.5
825	89	71.0
850	82	65.8
875	67	52.5
900	48	35.7
925	28	20.0
950	25	18.0
975	28	20.0
1000	35	25.7
1025	48	35.7
1050	77	61.6
1075	80	64.5
1100	77	61.6
1125	39	28.5

T_R	ε	F.B.
1150	26	18.3
1175	26	18.3
1200	36	26.2

Where,

T_R is rupture temperature (^{o}C)

σ is hoop stress (kpsi)

ε is circumferential strain (0/0)

F.B. is flow blockage (0/0)

ATTACHMENT 2

A. Evaluation of the potential impact of using fuel rod models presented in draft NUREG-0630 on the Loss of Coolant Accident (LOCA) analysis for Millstone 2 Reload, Cycle 4.

This evaluation is based on the limiting break LOCA analysis identified as follows:

BREAK TYPE - DOUBLE ENDED COLD LEG GUILLOTINE

BREAK DISCHARGE COEFFICIENT $C_D = 0.6$, pump suction

WESTINGHOUSE ECCS EVALUATION MODEL VERSION CE NSSS

CORE PEAKING FACTOR *2.464

HOT ROD MAXIMUM TEMPERATURE CALCULATED FOR THE BURST REGION OF THE CLAD - 1748 °F = PCT_B

ELEVATION - 5.70 Feet.

HOT ROD MAXIMUM TEMPERATURE CALCULATED FOR A NON-RUPTURED REGION OF THE CLAD - 2111 °F = PCT_N

ELEVATION - 7.5 Feet

- CLAD STRAIN DURING BLOWDOWN AT THIS ELEVATION 0.13 Percent
- MAXIMUM CLAD STRAIN AT THIS ELEVATION - 4.83 Percent

Maximum temperature for this non-burst node occurs when the core reflood rate is (GREATER) than 1.0 inch per second and reflood heat transfer is based on the (FLECHT) correlation.

AVERAGE HOT ASSEMBLY ROD BURST ELEVATION - NA Feet

HOT ASSEMBLY BLOCKAGE CALCULATED - NA Percent

1. BURST NODE

The maximum potential impact on the ruptured clad node is expressed in letter NS-TMA-2174 in terms of the change in the peaking factor limit (FQ) required to maintain a peak clad temperature (PCT) of 2200°F and in terms of a change in PCT at a constant FQ. Since the clad-water reaction rate increases significantly at temperatures above 2200.°F, individual effects (such as ΔPCT due to changes in several fuel rod models) indicated here may not accurately apply over large ranges,

*(Peak kw/ft ÷ Average kw/ft)

but a simultaneous change in FQ which causes the PCT to remain in the neighborhood of 2200.°F justifies use of this evaluation procedure.

From NS-TMA-2174:

For the Burst Node of the clad:

- 0.01 ΔFQ → ✓ 150°F BURST NODE ΔPCT

- Use of the NRC burst model and the revised Westinghouse burst model could require an FQ reduction of 0.027

- The maximum estimated impact of using the NRC strain model is a required FQ reduction of 0.03.

Therefore, the maximum penalty for the Hot Rod burst node is:

$$\Delta PCT_1 = (0.027 + .03)\ (150^{\circ}F/.01) = 855^{\circ}F$$

Margin to the 2200°F limit is:

$$\Delta PCT_2 = 2200.^{\circ}F - PCT_B = \underline{452}\ ^{\circ}F$$

The FQ reduction required to maintain the 2200°F clad temperature limit is:

$$\Delta FQ_B = (\Delta PCT_1 - \Delta PCT_2)\ \left(\frac{.01\ \Delta FQ}{150^{\circ}F}\right)$$

$$= (\underline{855} - \underline{452})\ \left(\frac{.01}{150}\right)$$

$$= \underline{.0269}$$ (but not less than zero).

2. NON-BURST NODE

The maximum temperature calculated for a non-burst section of clad typically occurs at an elevation above the core mid-plane during the core reflood phase of the LOCA transient. The potential impact on that maximum clad temperature of using the NRC fuel rod models can be estimated by examining two aspects of the analyses. The first aspect is the change in pellet-clad gap conductance resulting from a difference in clad strain at the non-burst maximum clad temperature node elevation. Note that clad strain all along the fuel rod stops after clad burst occurs and use of a different clad burst model can change the time at which burst is calculated. Three sets of LOCA analysis results were studied to establish an acceptable sensitivity to apply generically in this evaluation. The possible PCT increase resulting from a change in strain (in the Hot Rod) is +20.°F per percent decrease in strain at the maximum clad temperature locations. Since the clad strain calculated during the reactor coolant system blowdown phase of the accident is not changed by the use of NRC fuel rod models, the maximum decrease in clad strain that must be considered here is the difference between the "maximum clad strain" and the "clad strain at the end of RCS blowdown" indicated above.

Therefore:

$$\Delta PCT_3 = \left(\frac{20^{\circ}F}{.01 \text{ strain}}\right) (\text{MAX STRAIN - BLOWDOWN STRAIN})$$

$$= \left(\frac{20}{.01}\right) (\underline{.483} - \underline{.13}) \times 10^{-2}$$

$$= \underline{94^{\circ}F}$$

The second aspect of the analysis that can increase PCT is the flow blockage calculated. Since the greatest value of blockage indicated by the NRC blockage model is 75 percent, the maximum PCT increase can be estimated by assuming that the current level of blockage in the analysis (indicated above) is raised to 75 percent and then applying an appropriate sensitivity formula shown in NS-TMA-2174.

Therefore,

$$\Delta PCT_4 = 1.25^{\circ}F \text{ (50 - PERCENT CURRENT BLOCKAGE)} + 2.36^{\circ}F \text{ (75-50)}$$

$$= 1.25 \text{ (50 - \_\_\_\_)} + 2.36 \text{ (75-50)}$$

$$= \_\_\_\_ {}^{\circ}F$$

If PCT_N occurs when the core reflood rate is greater than 1.0 inch per second $\Delta PCT_4 = 0$. The total potential PCT increase for the non-burst node is than

$$\Delta PCT_5 = \Delta PCT_3 + \Delta PCT_4 = 94^{\circ}$$

Margin to the 2200°F limit is

$$\Delta PCT_6 = 2200^{\circ}F - PCT_N = 89^{\circ}$$

The FQ reduction required to maintain this 2200°F clad temperature limit is (from NS-TMA-2174)

$$\Delta FQ_N = \overset{94 - 89}{(\Delta PCT_5 - \Delta PCT_6)} \left(\frac{.01 \Delta FQ}{10^{\circ}F \ \Delta PCT}\right)$$

ΔFQ_N = $\underline{-.005}$ but not less than zero.

The peaking factor reduction required to maintain the 2200°F clad temperature limit is therefore the greater of ΔFQ_B and ΔFQ_N,

or; $\Delta\ FQ_{PENALTY} = 0.0269$

B. The effect on ECCS analysis results of using improved, more representative data has been assessed in relation to the ECCS analysis performed and submitted for the cycle 4 reload of the Millstone 2 plant. It has been determined that the margin involved in the conservatism of input parameters is more than adequate to offset potential burst-blockage model impacts. Specifically, design value fuel pellet temperatures were assumed for the Millstone 2 ECCS analysis involving Westinghouse fuel. Fuel parameters specific for cycle 4 confirm the existence of additional margin (33°F) compared to the values utilized in the analysis.

Previous licensing credits applied to the W evaluation model analysis have resulted in a minimum F_Q increment of 0.07 for each 85°F reduction in pellet temperature. Therefore, incorporating the cycle-4 specific fuel information would result in a cycle 4 margin of 0.0271 in F_Q for the 33°F margin in the pellet temperature parameter for the cycle 4 Millstone 2 fuel. Hence, consideration of pellet temperature-related input confirms that adequate margin exists in the ECCS analysis submittal to preclude any F_Q or peak kw/ft adjustments associated with burst-blockage considerations.

C. The peaking factor limit adjustment required to justify plant operation for this burst-blockage issue is determined as the appropriate ΔF_Q credit identified in section (B) above, minus the $\Delta FQ_{PENALTY}$ calculated in section (A) above (but not greater than zero):

F_Q ADJUSTMENT = 0.0271 - 0.0269 $\sim$0