NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

General Offices • Selden Street, Berlin, Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06141-0270
(203) 665-5000

January 11, 1991

Docket No. 50-213
B13710

Re: Zircaloy Clad
Conversion
ISAP Topic 2.17

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Gentlemen:

Haddam Neck Plant
Additional Information
Small-Break Loss of Coolant Accident Analysis--
Zircaloy Clad Fuel

On February 1, 1990, the NRC Staff informally requested that Connecticut Yankee Atomic Power Company (CYAPCO) provide additional information regarding Topical Report NUSCO-163, "Haddam Neck Plant Small-Break Loss of Coolant Accident (LOCA) Analysis--Zircaloy Clad Fuel," submitted to the Staff in a letter dated December 30, 1988.[1]

In accordance with the NRC Staff request, CYAPCO is hereby providing the attached additional information in response to the NRC Staff's 4 questions. Please contact us if you have any additional questions.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

FOR: E. J. Mroczka
Senior Vice President

BY: C. F. Sears
C. F. Sears
Vice President

Attachment
cc: T. T. Martin, Region I Administrator
A. B. Wang, NRC Project Manager, Haddam Neck Plant
J. T. Shedlosky, Senior Resident Inspector, Haddam Neck Plant

---

(1) E. J. Mroczka letter to the U.S. Nuclear Regulatory Commission, "Haddam Neck Plant, Small Break LOCA Analysis," dated December 30, 1988.

A001

Docket No. 50-213
B13710

Attachment

Haddam Neck Plant

Additional Information

Zircaloy Clad Fuel Small Break LOCA ECCS Analyses

January 1991

Question 1

Northeast Utilities' response to question 1 compared rupture temperatures based on NUREG-0630 and NULAP5 calculated clad temperatures. This comparison showed that no rupture was calculated. However, the figures provided do not compare the NULAP5 and NUREG-0630 rupture temperatures to show which is more conservative. Provide this comparison. Also the statement is made that the NULAP5 models are more conservative than the NUREG-0630 models because the NULAP5 models can account for prerupture cladding swell while the NUREG-0630 models do not. However, given the way the NULAP5 models are formulated in the code, the input needed to describe zircaloy clad deformation are tables of percent elongation and ultimate tensile strength versus temperature. This data is available in NUREG-0630 (see Figures 3, 6 and 7 and Appendix B) and could be used as input to the NULAP5 models just as the data from the report by Lowe was input to the NULAP5 models. Therefore, compare NULAP5 results where NUREG-0630 data and data from the Lowe report are used as code input to justify the conservatism of the NULAP5 models using the Lowe data.

Response

Figure 1 shows a comparison of NULAP5 and NUREG-0630 rupture temperatures. The rupture temperatures are given as a function of pressure difference (internal minus external pin pressure) over the applicable range for LOCAs. Since 0630 rupture temperature is a function of "H" -- the ratio of heating rate (deg-C/sec) to 28 deg-C/sec -- and hoop stress, five 0630 curves were generated to show this comparison over the possible range of H from 0.0 to 1.0. The figure shows that the NULAP5 rupture temperature calculation is conservative except for lowest pressure differentials.

Figure 2 shows calculat d rupture temperatures for the NULAP5 0.4 ft2 break case. This c se was the maximum cladding temperature case and the only case ıor which any swelling was calculated. This case was rerun with a coding change that output the NULAP5 calculated required temperature for rupture throughout the transient. This case was rerun again with a coding change that calculated and output the 0630 method for required temperature for rupture. The 0630 method included an ongoing H calculation driven by the transient conditions. A comparison of the calculated rupture temperatures for the two cases is given in Figure 2. This shows good agreement by the two methods and both show no rupture occurs.

FIGURE 1

RUPTURE TEMPS VS. CLAD PSID
FOR NULAP5 AND NUREG-0630

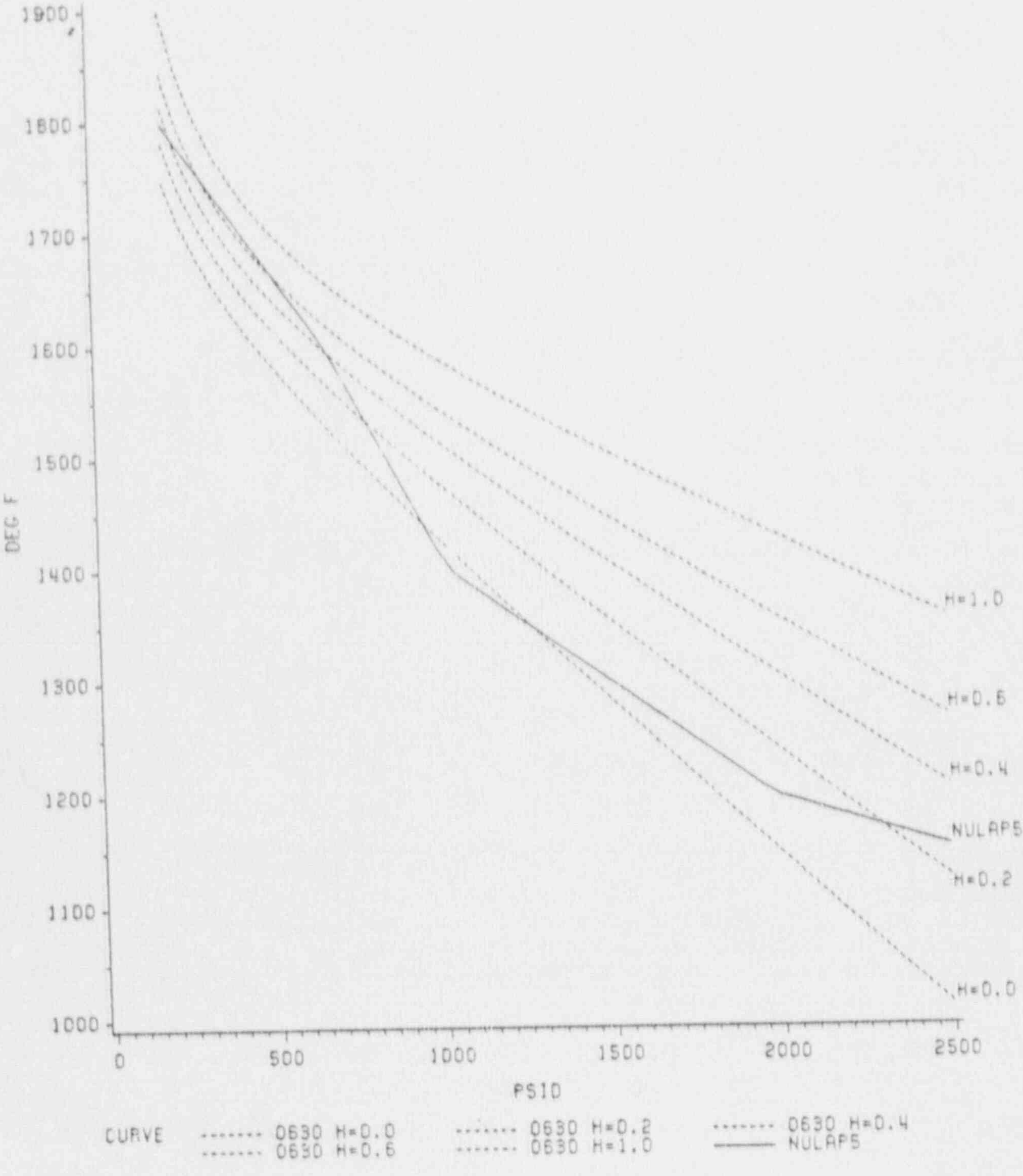
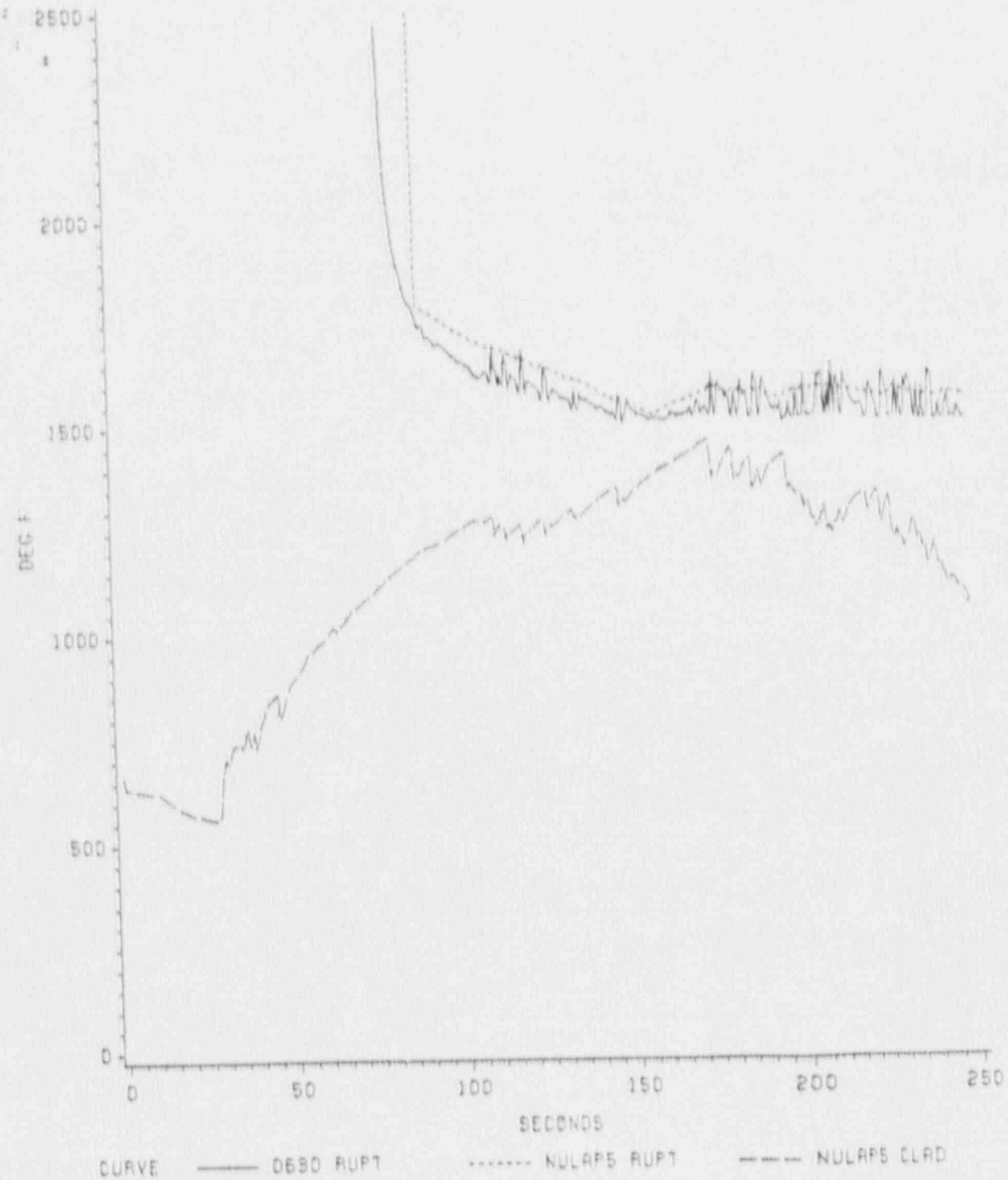


FIGURE 2
HADDAM NECK ZIRCALOY D.W FT2 SBLOCA
NUREG-0630 AND NULAPS RUPTURE TEMP VS. CLAD TEMP



Question 2

Question 5 asked for additional information to justify why the analysis for the 0.01 ft^2 break was terminated even though the clad surface temperature was increasing at the end of the calculation. The response stated that calculation was terminated because the core levels were stable or increasing and the total RCS inventory was increasing because the HPSI flow exceeded the core boiloff. As noted, the level in the hot assembly was stable at the end of the calculation (see Figure 8-1), but it appears that the hot channel mass is not increasing even though the system mass increased by approximately 30,000 lbm during the same time period. Therefore, clarify why the hot channel is not getting water into it over the last 500 s.

Response

The reason that the total RCS mass is increasing while it appears that the hot channel mass is not increasing is that the excess mass entering the system from HPSI flow is refilling both the pressurizer and reactor vessel upper head. The 0.01 $ft.^2$ break is small enough that the RCS coolant essentially remains in a subcooled natural circulation mode. No loop seal clearing phenomena occurs for this break size. The only regions that show any significant voiding are the pressurizer, reactor vessel upper head, and hot channel. The natural circulation flow in each of the RCS loops is subcooled and flowing in the normal flow direction. As the flow enters the annulus and lower plenum it rises up through the active core and upper plenum region into the hot legs via the path of least flow resistance. For this case the path of least resistance is up through the cooler outer assembly region (volume 340), into the outer upper plenum region (Volume 355) and into the hot legs. Flow entering the hot channel region (volume 343) would have to rise through both upper plenum volumes 358 and 362, across to upper plenum volume 360, down into volume 355 and then into the hot legs. This flow path has a higher resistance primarily due to the additional height and flow path length that the flow must traverse to get to the hot legs. Since the dominant flow path is up through the outer assemblies, only a small amount of flow will enter and leave the hot channel. This flow will be sufficient to maintain level in the hot channel. Since the flow in the hot channel is significantly less than that in the cooler outer channel, the coolant remains saturated and the hot channel rods are cooled by boiling. As the pressurizer and upper head slowly refill and any voids in the upper plenum volumes collapse, subcooled natural circulation flow will eventually be established in the hot channel.

This NULAP5 predicted phenomenon is solely attributable to the nodalization scheme used to model the active core and upper plenum regions. As described in detail in Section 2.3.3 of the Reference, dual parallel channels are used in the nodalization of both the active core and upper plenum regions. This nodal scheme, however, does not use "cross-flow" junctions to provide communication between the parallel channels other than at the top of the upper plenum between volumes 362 and 360. With this nodal scheme, the only communication between the parallel channels is through the lower plenum volume 335 and between the upper plenum volumes 362 and 360. Junctions to simulate crossflow between the parallel core channels were specifically not used. This prevents water, draining back into outer assemblies from the steam generators, from communicating with the hotter center assemblies and artificially desuperheating steam and quenching rods should the core be uncovered. This type of nodalization was specifically used to address the loop seal clearing and steam generator tube water drainage phenomena associated with small RCP discharge leg breaks.

Reference: "Calculative Methods for the " . .ilities Small Break LOCA ECCS Evaluat.o. Model," Vol. I, July, 1984, Docket No. 50-213.

Question 3

The original NULAP5 submittal justified a 0.7 multiplier on the steam generator condensation heat transfer coefficient to account For heat transfer degradation based on the amount of noncondensibles that could be generated during a SBLOCA at Haddam Neck. Included in the analysis was 0.5% core wide oxidation of the stainless steel cladding. With the switch to Zircaloy clad fuel, Northeast Utilities must provide additional information to justify the multiplier is still applicable to the new fuel.

Response

Calculations show that the Zircaloy core will contain 32,800 lbs of Zircaloy cladding and end fittings plus 2,420 lbs of stainless steel in the guide and instrument tubes. For comparison, the stainless steel core contained 30,170 lbs of stainless steel in the cladding, end fittings, guide and instrument tubes. The effect of the increased mass of metal susceptible to metal-water reaction during a LOCA is mostly offset by a smaller volume of hydrogen released in a potential Zircaloy and steam interaction, as compared to hydrogen released in stainless steel and steam interaction (1 gram of Zircaloy will release 0.491 liters of hydrogen @ STP while 1 gram of stainless steel will release 0.535 liters of hydrogen). Assuming 0.5% core-wide oxidation, the Zircaloy cladding will generate 1395 ft^3 of hydrogen (@ STP) as compared to 1295 ft^3 (@ STP) for the existing stainless steel core.

The effect of additional 100 ft^3 (STP) of noncondensible hydrogen gas on the condensation heat transfer in the steam generators has been evaluated. The additional amount of hydrogen will slightly increase the degradation in heat transfer during condensation. The degradation multiplier will change from 0.7 to 0.69. The difference is negligible and will have no impact on the calculated parameters such as peak clad temperature. Therefore the original multiplier is still applicable to the new fuel.

Question 4

Will Zircaloy analysis be bounding when the core will have both stainless steel and Zircaloy fuel?

Response

For a mixed core, containing both stainless steel and Zircaloy fuel, the small break LOCA ECCS performance analysis will include two cases: the first one with all stainless steel core and the second one with all Zircaloy core. The analysis showing the highest calculated peak cladding temperature will be the bounding analysis. Both cases will, of course, assume the same peak linear heat generation rate. Currently for the stainless steel case, a PLHGR of 17.0 kw/ft has been assumed.

By design, there are very few hydraulic differences between the Zircaloy and stainless assemblies. The major difference is that the bottom nozzles for the Zircaloy assemblies are about 0.45" shorter to accommodate additional irradiation growth. Because of the gap between the end of the fuel rod and the top nozzle at the beginning of life, it is estimated that the pressure drop for a Zircaloy assembly is about 1% higher than for a stainless assembly. This difference becomes smaller during burnup. It is important to note that this pressure drop difference is during normal operation when the majority of the pressure drop is due to friction and form loss. However, during a small break LOCA the majority of the core pressure drop is due to the density head of the relatively slow moving water and two-phase mixture. The impact of different assembly designs on the density head is negligible. As a result, there is no need to model separate regions for Zircaloy and stainless assemblies in small break LOCA analyses.