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DESCRIPTION: Ltr notarized 11-24-75 furn addl info on control rod drop transient & minimum departure from nucleate boiling ratio calculations & atrans the following:

ENCLOSURES: Enc. A provides responses to five questions from our staff on MDNBR calculations....

Enc. B entitled "Dropped Rod Transient Assuming No. Turbine Runback & No Rod Blodk"

(40 cys ea encl rec'd) ACKNOWLEDGED

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PLANT NAME: H.B. Robinson Unit 2

FOR ACTION/INFORMATION

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Regulatory Docket File

November 24, 1975

FILE: NG-3514(R) SERIAL: NG-75-2095

Mr. Benard C. Rusche, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

RE: H. B. ROBINSON UNIT NO. 2
DOCKET NO. 50-261
FACILITY OPERATING LICENSE NO. DPR-23

RECEIVED DEC 1 1975 U.S. NUCLEAR REGULATORY COMMISSION

Dear Mr. Rusche:

Your staff has requested additional information regarding the control rod drop transient and minimum departure from nucleate boiling ratio (MDNBR) calculations in support of our Cycle 4 reload application. This information has been previously provided to your staff during informal discussions. This letter and enclosures formally document this additional information.

Enclosure A provides the responses to five questions from your staff on MDNBR calculations. Enclosure B contains additional information regarding the dropped rod transient assuming no turbine runback and no rod block.

We hope this information is sufficient for your staff to complete their review of the Cycle 4 reload application.

Yours very truly,

E. E. Utley
Vice President
Bulk Power Supply

DOCKETED USNRC DEC 1 1975 MAIL SECTION DOCKET CLERK DL

RLMjr/nja
Enclosures

Sworn to and subscribed before me this 24th day of November, 1975.

Marilyn V. Pease
Notary Public

My Commission Expires: October 19, 1980

13530

336 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

~~13485~~

ENCLOSURE A

Question 1

Provide and justify the values used for the following hot channel factors:

a) Fraction of heat generated in fuel.
b) Engineering factor on enthalpy rise.
c) Engineering factor on local heat flux.
d) Pitch and bowing factor.
e) Plenum maldistribution factor.
f) Nuclear enthalpy rise factor.

Response

a) The value used for the fraction of heat generated in the fuel in calculating the H. B. Robinson MDNBR was 0.974. This value is justified by methods outlined in XN-75-43, page 18.

b) The engineering factor on enthalpy rise (1.02) was calculated by comparing two separate XCOBRA-IIIC computer runs. One computer run modeled an ENC assembly with nominal dimensions for fuel rod pitch, diameters, etc., while the other run contained reduced rod pitch and diameter as shown in XN-75-42 on page 5. Since the calculation of MDNBR was performed with a model including the engineering uncertainties, the engineering enthalpy rise factor is implicit in the calculation of MDNBR.

c) The engineering factor on local heat flux (1.02) was calculated on the basis of manufacturing tolerances on pellet density, pellet enrichment, pellet diameter, and clad diameter. A variation of maximum tolerance is assumed for each of these characteristics and the resulting increases are statistically summed to obtain the total engineering heat flux factor. The maximum tolerance is that permitted in the product specification and drawings and is greater than two standard deviations. In the case of pellet density the maximum tolerance is greater than three standard deviations as indicated by post-manufacturing measurements.

d) The pitch and bowing factor (1.03) is calculated in a manner similar to the engineering enthalpy rise factor. The reduction in pitch modeled in the high enthalpy rise subchannel in calculating the MDNBR corresponds to the minimum spacing permitted by the product specification (130 mills in the case of H. B. Robinson). This corresponds to a 6 mill bow along the diagonal of each rod in the high enthalpy rise subchannel. The model used is shown on page 5 of XN-75-42.

e) The plenum maldistribution factor was determined by comparing the enthalpy rise in the hot assembly with and without a $\pm 5\%$ maldistribution of flow at the core inlet. The flow starved region chosen surrounded the hot assembly and was large enough to assure conservatism in the results. The $\pm 5\%$ magnitude of possible flow maldistribution is a pressure vessel characteristic described in the H. B. Robinson FSAR. The results of this calculation indicated that the

enthalpy rise in the hot assembly to the MDNBR location was not affected by the flow maldistribution at the inlet and therefore no penalty was assumed; that is, the factor was reported as being equal to 1.0.

In addition to investigating the effects of a core wide flow maldistribution, the calculation of MDNBR was performed with a subchannel model of two adjacent assemblies. The flow to the higher powered assembly was reduced 5% while the flow to the lower powered assembly was increased 5%. The effect upon enthalpy rise to the point of MDNBR of this local flow maldistribution was also found to be negligible.

f) The nuclear enthalpy rise factor was assumed equal to 1.55 which provides operational margin. The highest radial power calculated for the neutronic design was 1.259 with a peak local within that assembly of 1.088. The calculated nuclear enthalpy rise factor was therefore conceivably as high as 1.370. With the inclusion of an 8% calculational uncertainty, this number becomes 1.479 which is less than the design $F_{\Delta H}$ of 1.55.

Question 2

Provide and justify the values used for reactor coolant pressure and inlet enthalpy in calculating MDNBR.

Response

The MDNBR calculation was performed at 2250 psia with a core temperature of 551.9°F. The 2250 psia is the nominal operating pressure of the reactor core while the 551.9°F inlet temperature represents a 5.8°F margin above the nominal inlet fluid temperature of 546.1°F. These operating conditions are consistent with previous MDNBR analysis for this core and provide a conservative design basis.

Question 3

Provide a description of the procedure used in determining the hot assembly. List any computer codes used. Describe the interassembly mixing assumed.

Response

The reactor power distribution is calculated with the PDQ7-HARMONY computer code. This calculation provides a maximum radial peaking as well as the maximum local peaking within that highest radially peaked assembly. The radial and local peaking in that assembly is then conservatively increased, to ensure that the thermal hydraulic evaluation is performed with all the licensed power peaking factors ($F_{\Delta H}$ = 1.55).

The interassembly mixing model employed in a core flow distribution calculation is the same as that used for a subchannel calculation and is described

in XN-74-42; however, a mixing model is not used to determine the hot assembly since that designation is made on the basis of nuclear peaking and not on local enthalpy rise. For the H. B. Robinson reactor, the increase in the radial power of the maximum radially peaked assembly is sufficient to ensure that the hot subchannel within the hot assembly is concurrently the high enthalpy rise subchannel in the core.

Question 4

Describe how the time dependent forcing functions for flow, inlet enthalpy, rod surface heat flux, and pressure are determined for use as inputs to the transient MDNBR code calculations.

Response

The forcing functions for flow, inlet enthalpy, rod heat flux, and pressure are calculated using the Exxon Nuclear PTS-PWR computer code described in XN-75-14. This code also contains a calculation of MDNBR by using the hot channel factors identified as a part of the steady-state hot channel analysis. The PTS values of flow, inlet enthalpy, rod heat flux and pressure may also be used as boundary conditions for the XCOBRA-IIIC code. The rod heat flux versus time used in XCOBRA-IIIC corresponds to the core average heat flux (PTS value) times the radial and local peaking factors or $F_{\Delta H}$. The axial power distribution is an input to both the PTS and XCOBRA-IIIC code. Because the PTS-PWR code has the ability to calculate MDNBR's, it is possible to identify the most limiting transient. The MDNBR values determined by the PTS for this limiting transient can then be corroborated by a transient XCOBRA-IIIC calculation as was done for the Three Pump Coastdown Transient presented in XN-75-42 (Section 3.0).

Question 5

Justify not applying an uncertainty to the non-uniform heat flux factor ("Tong-E" factor) for calculating DNB heat flux.

Response

The Exxon Nuclear methodology for calculating DNBR is presented in XN-75-48. The analysis described in this document establishes that an MDNBR of 1.20 secures with 95 percent confidence that 95 percent of the rods having such an MDNBR will not experience DNB. Although a 95/95 tolerance statement has been judged sufficient for such a criterion, a conservative criterion of 1.30 for MDNBR using the W-3 correlation plus correction factors for the effects of a nonuniform axial heat flux distribution, an unheated boundary, and mixing vane grid spacer DNB is used. Thus, a conservatism of 8 percent exists between the 1.20 (necessary) and the 1.30 (accepted) tolerance limits.

Furthermore, the description of the predicted DNB behavior of tests described in XN-75-48 includes a comparison for two separate non-uniform axial distributions, u sine u and cosine u. The Exxon Nuclear methodology resulted in less than a one percent difference in the average ratio of predicted burnout heat flux to measured burnout heat flux for the two axial distributions. The standard deviations of the ratios of predicted burnout heat flux to measured burnout heat flux of the two axial shapes were within three percent. Thus,

the eight percent conservatism between the 1.20 and 1.30 MDNBR values is judged sufficient to bound possible uncertainties in application of the non-uniform heat flux factor. The ability to predict the DNB effects of two separate axial heat flux distributions with no bias appearing by way of the standard deviation is a strong indication that the effects of nonuniform axial heat flux distribution have been accommodated in the Exxon Nuclear DNB predictive methods. It should be recognized that any bias that may exist in any part of the ENC predictive methods would be included in the experimental data prediction and would, therefore, be accounted for in the derived statistical MDNBR tolerance limits.

The combination of the eight percent conservatism in the MDNBR limit of 1.30 and success in obtaining the same fit for two different axial profiles confirms that no further penalties need be applied.

DOCUMENTS REFERENCED IN RESPONSES TO QUESTIONS 1-5

1. XN-75-38, H. B. Robinson Unit 2 Cycle 4 Reload Fuel Licensing Data Submittal.
2. XN-75-42, PWR Thermal-Hydraulic Hot Channel Calculations.
3. XN-75-43, Core Physics Methods and Data Used as Input to LOCA Analysis.
4. XN-75-48, Definition and Justification of Exxon Nuclear Company DNB Correlation for PWRs.
5. XN-75-14, Plant Transient Analysis of the H. B. Robinson Unit 2 PWR for 2300 MWt.

ENCLOSURE B

DROPPED ROD TRANSIENT ASSUMING NO TURBINE RUNBACK AND NO ROD BLOCK

The dropped rod transient with no turbine runback and no rod block was analyzed using the Exxon Nuclear PWR-PTS model with the following assumptions:

(1) A conservative total power peaking factor of 2.65 as input to the MDNBR calculation.
(2) A reactor power of 2300 MWt.
(3) A negative reactivity insertion of -2.0×10^{-3} Δk due to the dropped rod.

The assumption that the turbine runback and rod block both do not occur, means that the core will return to power by adjusting the control bank insertion. The minimum value of MDNBR equal to 1.47 was calculated during the transient.

The conservatism with respect to the total peaking factor of 2.65 used in the DNB analysis is demonstrated by a full core diffusion theory calculation with the "worst" dropped rod inserted.

An unrodded power distribution having a peak F_{xy} of 1.422 was chosen as the reference condition. With the rod inserted, the peak F_{xy} increased to 1.785 and was located in the quadrant opposite the one with the dropped rod. The resulting total peaking factor is 2.39 which includes a factor of 1.08 on the F_{xy} value to get $F_{\Delta H}$ and an engineering factor of 1.03. The axial peaking factor was obtained from a 3-D XTG calculation and was equal to 1.204.

The calculated total peaking factor of 2.39 is well below the 2.65 value used in the MDNBR analysis.

The radial power distribution with the "dropped rod" inserted is shown on Figure 1. On a quadrant-to-quadrant basis, the calculation indicates a radial tilt of about 22% for the particular dropped rod analyzed. The calculated worth of the dropped rod was 1.13×10^{-3} $\Delta\rho$.

Figure 1

ASSEMBLY AVERAGE POWERS WITH A DROPPED ROD

Quadrant Average Power = 1.221

F_{xy} = 1.785

Quadrant Average Power = 0.976

						.647	1.060	.827						
				.842	1.174	1.487	1.434	1.435	1.084	.745				
			1.006	1.555	1.143	1.139	1.079	1.085	1.032	1.341	.835			
		1.015	1.513	1.546	1.466	1.350	1.329	1.272	1.298	1.295	1.205	.772		
	.662	1.582	1.562	1.090	.989	1.022	1.289	.953	.855	.875	1.182	1.147	.599	
	1.215	1.176	1.500	1.003	1.021	1.296	.934	1.179	.850	.760	1.065	.796	.786	
.891	1.559	1.189	1.402	1.055	1.320	1.253	.865	1.107	1.045	.743	.909	.730	.918	.508
1.123	1.519	1.143	1.404	1.357	.976	.891	.874	.765	.725	.864	.797	.618	.814	.601
.883	1.538	1.167	1.372	1.027	1.271	1.190	.805	.998	.895	.563	.594	.520	.736	.442
	1.180	1.133	1.434	.950	.952	1.182	.824	.991	.651	.440	* .322	.408	.499	
	.825	1.499	1.465	1.007	.894	.899	1.092	.763	.617	.520	.576	.580	.331	
		.949	1.394	1.400	1.299	1.161	1.099	.994	.932	.836	.701	.420		
			.913	1.388	.997	.964	.881	.845	.752	.909	.528			
				.741	1.010	1.243	1.165	1.127	.808	.525				
						.701	.861	.657						

Quadrant Average Power = 1.126

Quadrant Average Power = 0.671

Core Average Power = 0.999

Core Tilt = 1.221

* Assembly With Rod