Consumers Power Company

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August 31, 1977

Regulatory File Cy

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Director of Nuclear Reactor Regulation
Att: Mr Don K Davis, Acting Branch Chief
Operating Reactor Branch No 2
US Nuclear Regulatory Commission
Washington, DC 20555

DOCKET 50-155 - LICENSE DPR-6 -
BIG ROCK POINT PLANT -
CHANGE IN MCHFR LIMITS

Enclosed is an Exxon Nuclear Corporation study which provides a synthesized Hench-Levy Minimum Critical Heat Flux Ratio (MCHFR) limit which ensures that a Minimum Critical Power Ratio (MCPR) limit of 1.32, as derived by the XN-2 Critical Power Correlation, will not be violated at Big Rock Point. This study is forwarded in response to your letter of August 3, 1977.

WB Slubitsky for
David A Bixel
Nuclear Licensing Administrator

CC: JGKeppler, USNRC

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HENCH-LEVY MCHFR LIMIT FOR THE BIG ROCK POINT REACTOR

SUMMARY

A minimum critical heat flux ratio (MCHFR) limit of 2.15 as determined by the ENC synthesized Hench-Levy critical heat flux correlation has been shown to be conservative in the assessment of thermal margins for the Big Rock Point Reactor. The 2.15 MCHFR limit was determined to conservatively provide nonpenetration of the 1.32 minimum critical power ratio (MCPR) as determined by the XN-2 critical power correlation.(1) The analysis, performed with the XCOBRA computer code,(2) considered the effects of variations in power/flow, assembly local peaking, axial power distribution and nominal expected conditions. The 2.15 MCHFR limit was determined to be applicable for the limiting assembly and envelopes the anticipated operating range of axial power distribution, inlet enthalpy, local peaking, and mass velocity for Cycle 15 and future cycles.

The 2.15 MCHFR limit was shown to be applicable for conditions of reduced reactor flow as long as the nominal power-to-flow relationship is maintained; that is the MCPR was determined to be greater for the partial power/partial flow cases than the full power/full flow case. The analysis assumes that the reactor is operated such that a reduction of reactor flow is accompanied by a proportionate reduction in reactor power.

THERMAL HYDRAULIC ANALYSIS

The analysis presented here is necessitated by the desire to relate the MCHFR as determined by the ENC synthesized Hench-Levy critical heat flux correlation with the MCPR as determined by the NRC approved XN-2 critical power correlation. The analysis consists of several sensitivity studies which establish an MCHFR limit that conservatively provides nonpenetration of the 1.32 XN-2 MCPR limit.

A power-flow sensitivity was performed to determine the most limiting conditions for Cycle 15 and subsequent cycles in terms of full power/full flow or partial power/partial flow at the reactor operating design conditions shown in Table 1. As shown in Table 2, the most limiting condition was determined to be full power/full flow. The additional sensitivity studies were then performed at conditions equivalent to those given in Table 1 to establish the required Hench-Levy MCHFR limit value which envelopes anticipated operating conditions for Cycle 15 and subsequent cycles.

An assembly local peaking sensitivity study was performed assuming the most adverse anticipated conditions of assembly local peaking and assembly axial power distribution as well as ± 50% variation in inlet subcooling enthalpy. For each value of inlet enthalpy and mass velocity, those fuel assembly powers which resulted in an XN-2 MCPR of 1.32 were determined. The Hench-Levy MCHFR for each case was then calculated using the conditions obtained above. As is shown in Table 3, the maximum Hench-Levy MCHFR so obtained was 2.11. Thus, for additional conservatism a Hench-Levy MCHFR limit value of 2.15 is proposed.

The sensitivity of the Hench-Levy MCHFR limit to axial power distribution was determined in this study. This sensitivity is shown by comparison of the local peaking sensitivity results (Table 3) with the results of a similar set of calculations which assumed an axial peaking of 1.5 at X/L = 0.5. All other assembly conditions were identical to those used in the local peaking sensitivity study. The determination of the MCPR limiting assembly power and corresponding Hench-Levy MCHFR values was identical to the procedure used in the local peaking study.

As shown in Table 4, the highest Hench-Levy so obtained was 2.06 and further illustrates that the proposed value of 2.15 conservatively envelopes anticipated Cycle 15 and subsequent cycle conditions.

The nominal expected conditions study was performed to assess the conservatism of a 2.15 ENC synthesized Hench-Levy MCHFR limit at the conditions indicated in Table 1. An ENC synthesized Hench-Levy MCHFR limit of 1.60 was found to be adequate, further demonstrating the acceptability of the proposed 2.15 limit. The results of this sensitivity study are shown in Table 5.

TABLE 1

ASSUMED OPERATING CONDITIONS

Reactor Power @ 122% Overpower, MW_{th}	292.8
Effective Reactor Flow Rate, 10^6 lb/hr	9.9
Inlet Subcooling, Btu/lb	22.8
Operating Pressure, psia	1350
Hot Assembly Operating Conditions*	
Hot Assembly Flow Rate, lb/hr	123,100
Radial Peaking	1.45
Local Peaking	1.20
Assembly Power @ 122% Overpower, MW_{th}	5.05

TABLE 2

SENSITIVITY OF THERMAL MARGINS
TO PARTIAL POWER/FLOW OPERATION

Percent of Rated Power/Flow	Reactor Power (MW_{th})	Effective Reactor Flow (lb/hr)	Hot Assembly Thermal Margin: ENC-Hench-Levy MCHFR	Hot Assembly Thermal Margin: XN-2 MCPR
122/100	292.8	9.9×10^6	1.86	1.52
100/100	240	9.9×10^6	2.63	1.87
75/75	180	7.4×10^6	3.55	2.25
50/50	120	5.0×10^6	5.40	2.80

TABLE 3

SENSITIVITY OF THERMAL MARGINS
TO ASSEMBLY LOCAL POWER CONDITIONS

Assembly Mass Velocity (lb/hr-ft²)	Assembly Flow (lb/hr)	Inlet Enthalpy (Btu/lb)	Assembly Power (MW)	Hench-Levy MCHFR	XN-2 MCPR
0.79×10^6	127,900	560	3.66	2.00	1.32
0.91×10^6	148,600	570	3.57	2.03	1.32
1.12×10^6	182,800	580	3.40	2.11	1.32

1.70 axial peak @ 0.7 of core height.

1.60 local peaking factor.

TABLE 4

SENSITIVITY OF THERMAL MARGINS TO ASSEMBLY AXIAL PEAKING CONDITIONS

Assembly Mass Velocity (lb/hr-ft2)	Assembly Flow (lb/hr)	Inlet Enthalpy (Btu/lb)	Assembly Power (MW)	Hench-Levy MCHFR	XN-2 MCPR
0.79×10^6	127,900	560	4.22	1.94	1.32
0.91×10^6	148,600	570	4.10	1.97	1.32
1.12×10^6	182,800	580	3.88	2.06	1.32

1.51 axial peaking @ 0.5 of core height.

1.60 local peaking factor.

TABLE 5

SENSITIVITY OF THERMAL MARGINS AT NOMINAL ASSEMBLY CONDITIONS

Assembly Mass Velocity ($lb/hr\text{-}ft^2$)	Peak Assembly Flow (lb/hr)	Inlet Enthalpy (Btu/lb)	Hench-Levy MCHFR*	XN-2 MCPR*
0.65×10^6	106,200	560	1.60	1.45
0.70×10^6	114,400	570	1.60	1.47
0.77×10^6	124,700	580	1.60	1.48

*Corresponding to reactor operation at 122% overpower as shown in Table 1.

1.51 axial peaking at .5 of core height.

1.20 local peaking factor.

REFERENCES

1. XN-75-34, "The XN-2 Critical Power Correlation," Revision 1 (1975).

2. XN-NF-77-43, "XCOBRA Code Operating Manual" (1977).

RC FORM 195
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U.S. NUCLEAR REGULATORY COMMISSION

DOCKET NUMBER 50-155

FILE NUMBER

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TO: Mr. Don K. Davis

FROM: Consumers Power Co.
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David A. Bixel

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ENCLOSURE
Consists of Exxon Nuc. Corp. study providing synthesized Hench-Levy Minimum Critical Heat Flux Ratio limit.

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1 CY Encl Rec'd

PLANT NAME: BIG ROCK POINT

jcm 09/06/77

FOR ACTION/INFORMATION

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