UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO EVALUATION OF RESPONSE TO NRC BULLETIN NO. 90-02

NORTHERN STATES POWER COMPANY

MONTICELLO NUCLEAR GENERATING PLANT

DOCKET NO. 50-263

1.0 INTRODUCTION

The licensee responded to NRC Bulletin 90-02, "Loss of Thermal Margin Caused by Channel Box Bow," in a letter dated April 26, 1990, and indicated that 217 of the channel boxes in the Monticello reactor core (Cycle 14) are being used for a second fuel bundle lifetime (Ref. 1). The response described the number and disposition of these channel boxes in the core, and described the actions taken to assure compliance with the technical specification thermal limits. The staff review of the April 26 submittal identified the need for additional information. Specifically, the staff requested that the licensee provide the data base on channel box bow versus exposure associated with the methods used to account for the effects of channel box bow on thermal margin during the second bundle lifetime. The licensee responded in a letter dated August 15, 1990 (Ref. 2).

This safety evaluation covers the staff review of the Northern States Power Company strategy for reuse of channel boxes for the existing cycle (Cycle 14) only.

2.0 EVALUATION

Channel Boxes Disposition In The Core

There are 217 bundles channeled with reused channels, i.e., Second Bundle Lifetime Channel Boxes. There are four types of fuel in the current Monticello core: P8X8R, PB8x8R, GE8X8EB, and GE8X8NB fuel designs. These fuel designs were installed in Cycles 11 thru 14 respectively. The PB8X8R and GE8X8EB fuel batches utilize reused channels. The P8X8R and GE8X8NB fuel batches utilize new channels. In the next cycle (Cycle 15), new advanced-design channels will be utilized with the GE8X8NB-3 fuel that will be loaded as fresh fuel. Figure 1, Ref. 1, graphically illustrates the disposition of reused channels in the Monticello core for the current cycle.

GE Methodology and Associated Data Base

After startup of Cycle 14, General Electric performed a Cycle 14 specific calculation of the impact of channel box bow on the CPR. This analysis analyzed 8 symmetric potentially limiting (for MCPR) 4-bundle cells in the core. Each of these cells had 2 fresh bundles with new channel boxes, 1 once-burned bundle with a reused channel, and 1 twice-burned bundle with a reused channel. Projected channel box bows for the end of Cycle 14 for each of the 16 reused

channel boxes and for the 16 new channel boxes were calculated using the General Electric methodology. These calculations used detailed operating histories (cycle-by-cycle core locations and exposure accumulations) to account for historic flux gradients for each channel box. Every reused channel box in the Monticello core was measured prior to its reuse in the core. The individual calculated channel box bow values were used to calculate MCPR impacts.

At the request of the NRC staff, the licensee provided plots of channel box bow versus cumulative exposure for the bounding reused channels. This data was comprised of measured and predicted (to end of present cycle) data. Three channel boxes were singled out as being representative of minimum and maximum bow/exposure data (Ref. 2).

The channel box bow history for each of the three channel boxes was represented by three or four connected data points. The lowest exposure data is the measured value of channel box bow at the end of the first bundle lifetime. GE's channel box bow methodology was then applied to each channel box using each channel's actual operating history to predict the channel box bow at the end of the first bundle lifetime. The prediction was then normalized to the measured channel box bow at the end of the first bundle lifetime, and the prediction was then extended to the subsequent cycles, concluding with the end of Cycle 14. The remaining reused channels present in Monticello Cycle 14, fall between the maximum and the minimum values.

To aid the NRC staff in evaluating this data, the staff correlated all of the channel box bow data available to it from fuel vendors and licensees. This bow data was usually in the form of scatter plots of channel bow as a function of burnup. The staff developed limiting curves for each data source. The data from all of the sources were plotted as limiting curves. This provided the NRC staff with a visual representation of all the limiting bow data as a function of exposure. The plots indicate that there is very good agreement among all the data especially within the constraint of the single bundle lifetime, which is taken to be approximately 38-40 GWD/MTu. That is, all of the data were consistent in magnitude and trends.

The data indicate that channel box bowing is approximately linear from 0 to approximately 40 GWD/MTu. Beyond 40 GWD/MTu, data from all sources is sparse and consequently, viable data comparison is very difficult. As a result, based on the small number of data points available, one can only point to a trend. However, the rate of bowing with exposure appears to increase sharply.

Conformance With CPR Technical Specifications

In Cycle 14, Monticello has applied a conservative delta-CPR adder to account for potential bow of reused channel boxes. An administrative limit on MFLCPR (Maximum Fraction of Limiting CPR) of 0.87 has also been applied since the beginning of Cycle 14. This is equivalent to a delta-CPR adder of 0.194 for a CPR operating limit of 1.30. This initial delta-CPR adder was selected on the basis of analysis of the Oskarshamn event (Information Notice 89-69).

The results of Cycle 14 channel box bow predictions calculation were used to calculate MCPR impacts. A key assumption in the MCPR thermal impact assessment was the use of core average cell average bow. As discussed in Reference 3,

detailed lattice physics calculations have demonstrated that the power level in the fuel rods in the corner and bundle periphery near the control blade can be reliably correlated to the average bow of the eight channel faces adjacent to the control blade (cell average bow), for the bundles that do not experience the cell maximum bow. The bundle in the cell with the maximum channel box bow will experience a greater relative power increase than its neighboring bundles. For the case of single bundle lifetime channels, the bundle with the maximum channel box bow will most likely be the highest exposure bundle. This highest exposure bundle will be substantially reduced in power relative to the fresh bundles, due to fuel enrichment depletion effects, and therefore will have substantially greater margin to boiling transition. However, for the case of reused channels, the bundle in the cell with the maximum bow may be a high power bundle. Therefore, the individual channel box bow and MCPR impact of that channel box bow was evaluated for each bundle in cells containing reused channels. This ensures that an appropriate assessment of the MCPR thermal impact is obtained.

The licensee stated in their April 26,1990 response letter that in Cycle 15, core-monitoring software will include R-Factor calculated with channel box bow effects included, which will insure that calculated MCPR values will compensate for channel box bow. At that time the administrative limit on MFCPR will be removed.

3.0 CONCLUSIONS

Based on the above evaluation, the NRC staff concludes that the licensee's utilization of reused channel boxes for the existing cycle (Cycle 14) is acceptable. However, the application of this data and methodology to any future reuse of channel boxes must be evaluated on a cycle specific basis. While the current methodology appears to compensate adequately for severely bowed channels, further study by the licensee is needed with respect to its impact on core wide analyses at advanced exposures. For example, core inlet flow distribution, fuel shuffling scheme, MCPR Safety Limit, LHGR, MAPLHGR, limitation on exposure, and continued demonstration that the bow model is adequate for advanced exposures are important and would require further analysis.

4.0 REFERENCES

1. Letter from Thomas M. Parker, Northern States Power Company, to NRC, Response to NRC Bulletin 90-02, "Loss of Thermal Margin Caused by Channel Box Bow," dated April 26, 1990.

2. Letter from Thomas M. Parker, Northern States Power Company, to NRC, Response to NRC Request for Additional Information on Response to NRC Bulletin 90-02, "Loss of Thermal Margin Caused by Channel Box Bow," dated August 15, 1990.

3. J.S. Charnley (GE), letter to R.C. Jones (NRC), "Fuel Channel Bow Assessment," MFN086-89, November 15, 1989.

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