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PLANT TRANSIENT ANALYSIS FOR H.B. ROBINSON UNIT 2 AT 2300 MWt WITH INCREASED $F^N_{\Delta H}$: SUPPLEMENT 4

Inadvertent Loading and Operation of a Fuel Assembly in an Improper Position

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PLANT TRANSIENT ANALYSIS FOR H. B. ROBINSON UNIT 2 at 2,300 MWt WITH INCREASED $F^N_{\Delta H}$:

Supplement 4

Inadvertent Loading and Operation of a Fuel Assembly In An Improper Position

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1.0 INTRODUCTION

This report presents the results of the analysis of the Inadvertent Loading and Operation of a Fuel Assembly in an Improper Position for Cycle 10 in H.B. Robinson Unit 2. These specific calculational results are being provided in addition to the administrative procedures previously outlined in Reference 1.

The analysis of the inadvertant loading of a fuel assembly has considered a spectrum of fuel assembly misloadings which also include the effects of gadolinia depletion and the misloading of a Part Length Shielding Assembly (PLSAs). The analysis assumes that hot full power is equal to 2,300 MWt.

2.0 SUMMARY

Fuel assembly loading errors are prevented by administrative procedures implemented during core loading. These administrative procedures make it extremely unlikely that an assembly will be misloaded.

For the unlikely event that a fuel loading error would occur, the analysis to determine the effect on power peaking considers two (2) categories of misloadings; detectable and undetectable. To determine whether or not a particular misloading is detectable, the deviation from incore detector readings for the correctely loaded core is calculated. Misloading events that result in deviations of 20% or more from the incore detector readings for the correctly loaded core are assumed to be detectable. Loading errors in the detectable category will be found prior to exceeding 30% of rated power. Analysis shows that the Cycle 10 power peaking associated with detectable misloadings can be tolerated at 30% of rated core power, without penetrating the DNB SAFDL.

For those cases which are assumed to be undetectable, the maximum calculated value of $F_{\Delta H}$ is 1.81 at full power. As was demonstrated in the analysis of the Static Misalignment of a Single Full Length RCCA (Event 15.4.3)[2], an $F_{\Delta H}$ of 1.94 can be tolerated during full power steady-state operation without penetration of the DNBR SAFDL. The misloading event for Cycle 10 will not, by itself, result in penetration of the DNBR SAFDL.

Should an independent Condition II event occur with the core in a misloaded configuration, some fuel may experience boiling transition. The extent of fuel failure and potential for radiological release would be conservatively bounded by the result reported in Reference 2 for the Single Control Rod Withdrawal event, which considered an $F_{\Delta H}$ of 2.096. Thus, the misloaded assembly event will not result in a violation of any radiological criteria.

3.0 GENERAL DESCRIPTION

A general description of the H.B. Robinson Unit 2 core for Cycle 10 can be found in Reference 3.

4.0 ANALYTICAL METHODOLOGY

The neutronics analytical methods used in this analysis are discussed in Reference 3.

5.0 INADVERTENT FUEL ASSEMBLY LOADING

15.4.7 INADVERTENT LOADING AND OPERATION OF A FUEL ASSEMBLY IN AN IMPROPER POSITION

15.4.7.1 Identification of Causes and Event Description

Core loading errors arise from the loading of one or more fuel assemblies into improper core locations. This can result in changes in the power distribution and increases in local power density which may go undetectable by incore instrumentation.

Reactor protection for the misloaded fuel assembly event depends on administrative plant procedures. To reduce the probability of core loading errors, each fuel assembly is marked with an identification number and loaded in accordance with a fuel loading or shuffle procedure to achieve the design core loading plan, Reference 1. The location of each assembly is verified prior to replacing the upper internals.

Incore instrumentation is used to determine the core power distribution and can also be used to monitor for possible misloaded assemblies. The instrumentation includes 48 incore thimble tubes to accommodate incore neutron flux probes. Incore flux maps are taken at cycle startup and during initial power ascension at power levels of 30%, 70%, 90%, and 100% of rated thermal power, and at monthly surveillance intervals thereafter.

In the unlikely event that a loading error occurs, the power distribution will be changed by an amount proportional to the change in reactivity of the misloaded assembly. Large changes in the measured power distribution relative to the projected power distribution will be readily detectable by the incore instrumentation system at startup and during initial power ascension. However, small changes in the measured power distribution may

go undetected by startup power ascension flux maps and continued operation at rated power can result in an increase in the radial peaking factor primarily for the case where the misloaded assemblies are the fresh gadolinia-bearing assemblies. If power operation persists with radial peaking factors in excess of Technical Specification limits due to an undetected misloading event, the DNBR SAFDL may be penetrated.

15.4.7.2 Analysis Method

A spectrum of misloading events has been analyzed with the XTGPWR code for the Cycle 10 core loading plan in H. B. Robinson Unit 2. Initial calculations of the steady-state power distribution were all performed for beginning-of-life at 2,300 MWt (HFP) conditions using a full core 3-dimensional twenty-four (24) axial node model. Full core power distributions were calculated for the correctly loaded core and for a spectrum of misloading configurations. A misloading that resulted in a greater than or equal to 20% increase in the misloaded assembly power was considered to be detectable. The 30% power level map can be used as an early detection of a misloaded assembly since the power distribution changes only slightly during power escalation.

For undetectable misloading cases, the analysis focuses on core power peaking limits. If power peaking values for the misloaded core are calculated not to exceed Technical Specification limits (including uncertainties), no further evaluation is necessary as DNB will not be exceeded. If calculations indicate that Technical Specification peaking limits could be exceeded, additional analysis is necessary. The additional analysis includes a DNBR determination. If penetration of the XNB critical heat flux correlation safety limit has occurred, then a determination of the fraction of the fuel to experience boiling transition is made and the radiological consequences of such failures is assessed.

15.4.7.3 Definition of Events Analyzed and Bounding Input

A spectrum of misloading cases was analyzed. These cases represent the misloading of assemblies into core locations which are designated to be occupied by exposed or fresh fuel with different assembly reactivity characteristics.

For those cases which are found to be undetectable at begining-of-cycle, a cycle depletion calculation was performed to determine the power history as a function of cycle exposure. From the results of the depletion calculation, the peak $F_{\Delta H}$ can be assessed relative to the Technical Specification limit. Since plant procedures require that measured power distributions be taken at monthly intervals, some of the undetectable events at BOL will be prevented from exceeding the Technical Specification limit by this periodic assessment. For those misloading events that remain undetectable, a DNB analysis is performed to determine the potential impact on the core.

15.4.7.4 Analysis of Results

The fuel misloading analysis determined the maximum value of $F_{\Delta H}$ which can be expected to go undetected. The events analyzed can be categorized as the replacement of:

1) Exposed fuel with exposed fuel,

2) Exposed fuel with fresh fuel,

3) Fresh fuel with fresh gadolinia fuel; and

4) PLSAs with fuel.

Results of the calculations indicated that category (1) events are generally undetectable but never approached a power peaking configuration in the core that would cause penetration of the DNBR SAFDL.

The worst undetectable misloading case occurred in category (2). Here, a once-burnt assembly was interchanged with a fresh assembly containing 12 pins of gadolinia-bearing fuel pins. At the start of the cycle the $F_{\Delta H}$ is 1.63 and with cycle depletion, the radial peaking factor $F_{\Delta H}$ reaches a peak value of 1.81 at mid-cycle for the misloaded configuration.

The maximum $F_{\Delta H}$ calculated to result from an undetected misloading error at full power is less than the 1.94 $F_{\Delta H}$ considered in the MDNBR determination for the Static Misalignment of a Single Full Length RCCA reported in Reference 2. For that event, the calculated MDNBR is above the XNB critical heat flux correlation safety limit of 1.17. Therefore, the misloaded assembly event (undetected case) is tolerable at full power steady-state operation without fuel failures.

Should a limiting Condition II event occur with the core in a misloaded configuration, some fuel may experience boiling transition. In such an event, the number of fuel failures and the potential radiological release are bounded by that reported in Reference 2 for the single control rod withdrawal event. That event considered an $F_{\Delta H}$ of 2.096, well in excess of those calculated to occur for the misloaded assembly event. The radiological consequences of a limiting Condition II event occurring with the core in a misloaded configuration are acceptable.

6.0 REFERENCES

1. XN-NF-83-72, Revision 2, Supplement 1, "H. B. Robinson Unit 2, Cycle 10 Safety Analysis Report, Revision 2 Disposition of Chapter 15 Events, Exxon Nuclear Company, July 1984.

2. XN-NF-84-74, Supplement 1, Plant Transient Analsyis for H. B. Robinson Unit 2 at 2,300 MWt with Increased $F^N_{\Delta H}$, Supplement 1, "Analysis of Control Rod Misoperation Events (RCCA Misalignments)", Exxon Nuclear Company, July 1984.

3. XN-NF-83-72, Revision 2, H. B. Robinson Unit 2, Cycle 10 Safety Analysis Report, Exxon Nuclear Company, July 1984.

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