ATTACHMENT A

Assessment of the Effect of Increased Fuel Rod Fill Gas Pressure

on

Core XIV ECCS Performance Analysis

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1.0 Introduction

During recent work performed by our fuel supplier, it was discovered that the initial fill gas pressure of the fresh fuel loaded into Core XIV was higher than the design specification of 125±5 psia. The maximum increase in the fill gas pressure was determined to be 18 psi with the mean increase being 13.4 psi.

Since the nominal initial fuel rod fill gas pressure is input to the ECCS Performance Analysis, an assessment of the effect which the higher pre-pressurization level has on large and small break LOCA analysis has been made. Only the fresh fuel loaded into Core XIV is affected.

2.0 Effect of Increased Fuel Rod Fill Gas Pressure on Small Break Loss of Coolant Accident Analysis

References 1 and 2 provided a complete small break LOCA analysis for Yankee Rowe Core XIII, the reference cycle. The small break results are characterized by relatively low peak clad temperature with respect to Appendix K limits and relatively high system pressure with respect to large break LOCA. The most limiting small break was the 4.0 inch ID cold leg break which had a PCT of 1793.4 °F. The effect of the increased fuel rod fill gas pressure on the small break LOCA results would be to reduce the predicted PCT's due to the better gap conductance caused by the higher heluim content.

Fuel rod balloning and rupture would not occur with the higher fill gas pressure since the temperatures predicted are low while the system pressures are high. Thus, the small break results presented in References 1 and 2 remain valid.

3.0 Effect of Increased Fuel Rod Fill Gas Pressure in Large Break LOCA

3.1 General

References 1 through 9 provided a complete Loss of Coolant Accident Analysis for Yankee Rowe Core XIII operation and serves as the reference analysis for the current cycle (Core XIV). Section 7.12.3 of Reference 10 provides the results of a burnup sensitivity study for Core XIV utilizing the same analytical techniques employed in the Core XIII reference analysis. The following discussion briefly describes our large break LOCA analysis and burnup sensitivty study methodology and then details the effect the increased fuel rod fill pressure has on the large break LOCA results submitted for the current cycle (Reference 10).

3.2 Break Spectrum Analysis

In accordance with 10CFR50.46 Appendix K, a large break spectrum analysis has been performed and submitted as previously mentioned for Yankee Rowe Core XIII utilizing Yankee Atomic's WREM-Based Generic PWR ECC Evaluation Model. This model is basically comprised of the RELAP4/MOD3 blowdown, hot channel and reflood models, the TOODEE-2EM fuel

rod heatup code and the GAPEX fuel rod performance code. Peak clad temperatures are calculated for guillotine and slot type break sizes with discharge coefficient ranging from 1.0 to 0.6 (or 0.4).
Beginning-of-life core conditions are assumed since the maximum fuel rod stored energy as predicted by the GAPEX code occurs at this time due to the significant pellet to clad gap.

The break spectrum analysis is performed with the hot rod power level consistent with meeting Appendix K limits. Thus, a peak linear heat generation rate (LHGR) for fresh fuel of 9.70 kw/ft was obtained for the reference cycle with the 1.0 DECLG break size and type being most limiting.

3.3 Burnup Sensitivity Analysis

At beginning-of-cycle, the fresh fuel is limiting due to the significant pellet to clad gap and resultant high stored energy. During the first few days of exposure, the fresh fuel pellet to clad gap decreases with a corresponding decrease in stored energy. Thus, it is possible to increase the peak LHGR such that the criteria set forth in Appendix K are still met along with achieving an LHGR that permits full power plant operation.

However, as the cycle progresses, the fuel rod pellet to clad gap no longer changes as it did in the first few days and fission gas continues to be released, degrading the gap heat transfer coefficient and increasing the fuel rod pressure. Due to the relatively long refill period and low fuel rod fill gas pressure, rod rupture cannot analytically be tolerated since it would occur at an elevated temperature when the $Zr-O_2$ reaction is highly exothermic. Thus, the effect of the above mentioned fuel rod burnup dependent changes on peak LHGR are addressed at various cycle average burnup conditions (BOC, 337 MWD/MTU, 840 MWD/MTU, 6000 MWD/MTU and 16000 MWD/MTU). Utilizing the blowdown results of the most limiting break size (1.0 DECLG) fuel rod heatup calculations are performed at the above burnup points. A curve of allowable peak rod LHGR versus cycle burnup is then generated for incorporation into plant technical specifications.

3.4 Effect of Increased Initial Fuel Rod Fill Gas Pressure on Large Break ECCS Performance Calculation

The increased initial fuel rod fill gas pressure results in two competing effects on ECCS performance analysis calculations which diminish with increasing fuel rod exposure. At beginning of cycle the peak fresh fuel rod has more helium in it than the design situation which results in a slightly better pellet-clad gap heat transfer coefficient (h_{gap}) and a somewhat lower stored energy. This improved h_{gap} also allows more energy to be removed in the heatup calculations than in the design case and hence would result in a slightly lower PCT. However, due to the restriction that preclusion of rod rupture presents for Yankee Rowe fuel in ECCS licensing calculations, the higher fuel rod fill pressure may result in clad ballooning and rupture at a temperature where zirconium water reaction rates are highly exothermic. As the fuel rod exposure increases, the effect of the increased fill pressure diminishes since the fission gas released into the gap and plenum becomes dominating.

In order to determine the sensitivity associated with the increased fuel rod fill gas pressure, the hot rod calculations supporting the fresh fuel allowable rod LHGR versus Core XIV burnup curve (Tech. Spec. Figure 3.2.1) were reanalyzed with an initial fill gas pressure of 143 psig. This pressure reflects the highest observed fill pressure increase. Table 1 compares the result of the re-analysis at the previously mentioned burnup points for Core XIV.

The predicted clad temperatures for Core XIV at BOC, 6000 MWD/MTU and 16000 MWD/MTU given in Table 1 for the case of increased fuel rod fill pressure are slightly lower than the respective design cases. With the increased fill gas pressure, only at the 337 MWD/MTU and 840 MWD/MTU burnup points did rupture occur with the original peak LHGR's of 11.5 kw/ft and 12.0 kw/ft. In order to achieve acceptable results, the peak LHGR's at these points were reduced in power by 2.5%.

4.0 Summary and Conclusions

The peak rod LHGR's reported previously in Technical Specification Figure 3.2.1 for YR Core XIV for 0 MWD/MTU, 6000 MWD/MTU and 16000 MWD/MTU burnup remain valid with the increased fuel rod fill pressure. Only the points at 337 MWD/MTU and 840 MWD/MTU burnup had to be slightly reduced in power to account for the effect of increased fuel rod fill pressure.

Since the 337 MWD/MTU and 840 MWD/MTU burnup points had to be reduced in power to meet licensing criteria with increased fill gas pressure, the operating history of Core XIV has been reviewed to determine if measured fresh fuel peak rod LHGR's had exceeded the revised fresh fuel allowable peak rod LHGR's given in Figure 1. Curve 1 on Figure 1 presents the original fresh fuel allowable peak rod LHGR versus burnup submitted for Core XIV. Curve 2 on Figure 1 represents the revised curve while Curve 4 shows the actual measured peak rod LHGR's for Core XIV to date. Curve 3 on Figure 1 represents the peak rod LHGR required for full power. By comparing Curve 4 to Curves 1 and 2, it is seen that at no time during the current cycle had the LOCA limits been exceeded even though the fresh fuel allowable rod LHGR's in Curve 1 had to be reduced to Curve 2 to account for the effect of increased fuel rod fill gas pressure. Thus, Core XIV operation to date has been conducted within the limits put forth in 10CFR50.46 Appendix K.

REFERENCES

1. Proposed Change No. 145, Supplement No. 5, Yankee Rowe Core XIII ECCS Performance Evaluation, August 1, 1977.
2. Proposed Change No. 145, Supplement No. 7, WYR77-90, Additional Yankee Rowe Core XIII Small Break LOCA Analysis, September 21, 1977.
3. Proposed Change No. 145, Supplement No. 5 Errata, Yankee Rowe ECCS Modifications, August 5, 1977.
4. Yankee Rowe Core XIII LOCA Analysis, WYR77-81, August 9, 1977.
5. Yankee Rowe ECCS Modification, WYR77-81, August 22, 1977.
6. Proposed Change No. 145 Supplement No. 6, WYR77-85, Yankee Rowe Core 13 Technical Specifiction/ECCS Accumulator, September 8, 1977.
7. W. P. Johnson to USNRC, Yankee Rowe Core XIII LOCA Core Inlet Temperature and Accumulator Delay Sensitivity Analysis, October 7, 1977.
8. R. H. Groce to USNRC, Yankee Rowe Core XIII LOCA Core Inlet Temperature and Accumulator Delay Sensitivity Analysis Errata.
9. Proposed Change No. 145 Supplement No. 8, WYR77-100, Yankee Rowe Core XIII LOCA Burnup Sensitivity Analysis Results, October 27, 1977.
10. YAEC-1162 Yankee Nuclear Power Station Core XIV Performance Analysis, September 1978.

TABLE 1

SUMMARY OF RESULTS
EFFECT OF INCREASED FILL GAS PRESSURE ON YR CORE XIV LOCA-BURNUP ANALYSIS

Core XIV Burnup (MWD/MTU)	0.0		337.0		840.0		6000.0		16000.0	
Peak Rod LHGR (kw/ft)	9.44		11.19	10.91	11.68	11.38	11.0		9.73	
Initial Fuel Rod Fill Gas Pressure (psig)	125	143	125	143	125	143	125	143	125	143
Fuel Pin Gas Inventory (Gram-Moles x 10^3)	3.59	4.04	3.61	4.06	3.65	4.10	4.0	4.46	4.59	5.04
Peak Clad Temperture (^oF)	1895	1886	2123	2074	2198	2126	2037	2011	1840	1823
Time of PCT (sec)	144	140	153	151	182	172	196	182	188	188
Rupture	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

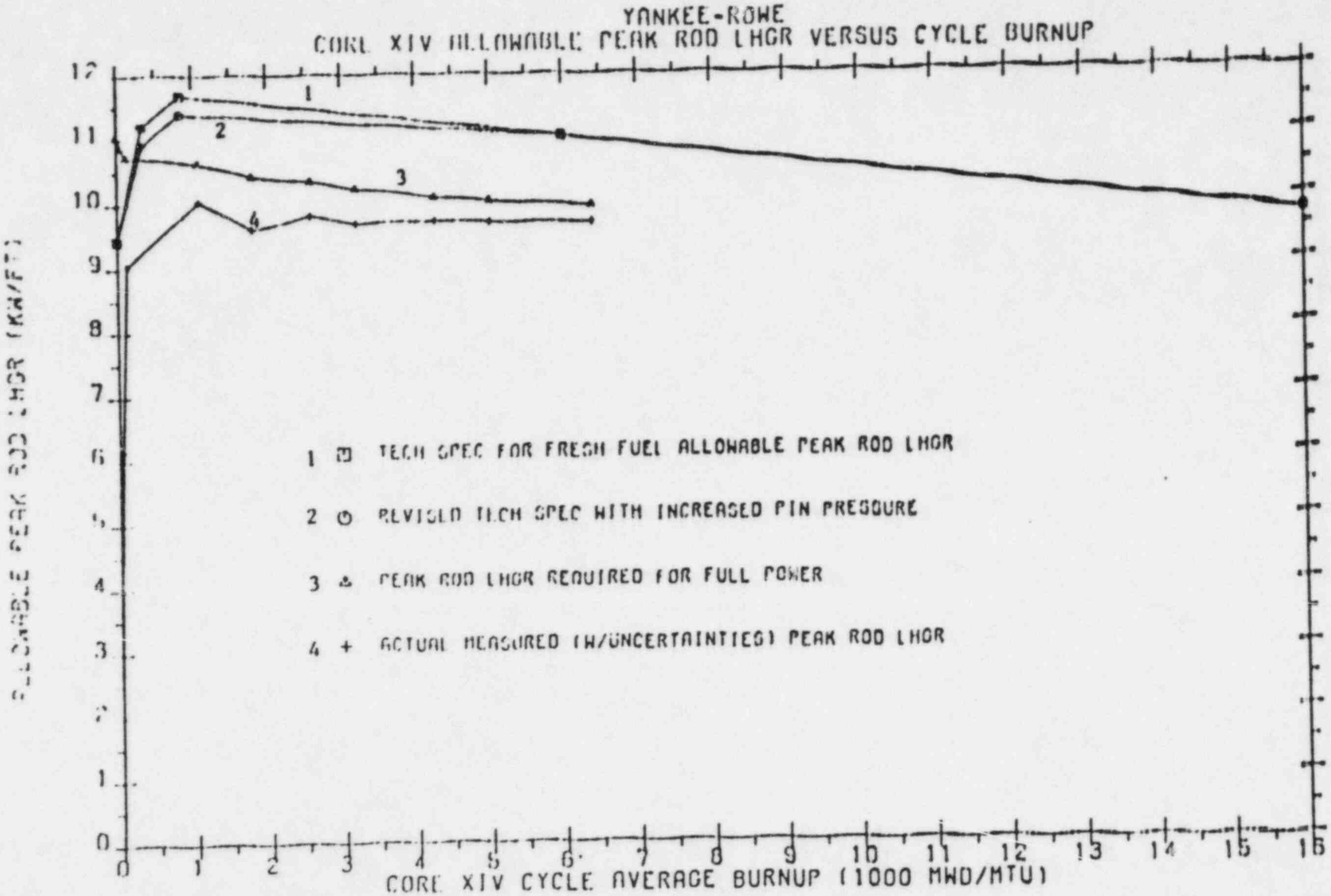

Figure 1

Comparison Fresh Fuel Allowable Peak Rod LHGR's to Actual Measured Peak Rod LHGR's