(15)

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

50-244

MAR 1 1 1980

MEMORANDUM FOR: Dennis L. Ziemann, Chief, Operating Reactors Branch #2, Division of Operating Reactors

FROM: Paul S. Check, Chief, Reactor Safety Branch, Division of Operating Reactors

SUBJECT: EVALUATION OF THE OPERATION OF R. E. GINNA REACTOR FOR CYCLE 10 WITH FOUR MIXED OXIDE FUEL BUNDLES

PLANT NAME: R. E. Ginna Nuclear Power Plant
LICENSING STAGE: Operating
RESPONSIBLE BRANCH AND PROJECT MANAGER: SEP, J. Shea
REVIEW STATUS: Complete

Enclosed is our evaluation of the use of four mixed oxide fuel assemblies for Cycle 10 in the R. E. Ginna reactor. We find the use of these assemblies acceptable for Cycle 10 with no changes. For future cycles, we will require an increase in the nuclear uncertainty associated with the total peaking factor.

for Vincent W. Panciera
Paul S. Check, Chief
Reactor Safety Branch
Division of Operating Reactors

Enclosure:
As stated

cc: D. Eisenhut
R. Tedesco
G. Lainas
V. Panciera
F. Coffman
S. Weiss
J. Shea
K. Kniel
R. Meyer
R. Lobel

XA 8003310179

Take out w/o encl page ct.

Contact: R. Lobel, RS/DOR Rdg
X27463

A5

## Introduction

By application (Reference 2) dated December 14, 1979 (transmitted by letter dated December 20, 1979), Rochester Gas and Electric Corporation (RG&E) requested an amendment to License No. DPR-18 for the R. E. Ginna Nuclear Power Plant to allow plant operation with four plutonium Mixed Oxide (MOX) fuel assemblies. By letter (Reference 6) dated February 20, 1980, RG&E provided additional information responsive to our questions.

The staff has previously evaluated generically the ability of nuclear reactors to operate with mixed oxide fuel in excess of the four bundles now being considered for Ginna. After discussions with and reviewing submittals from the domestic nuclear fuel manufacturers, the staff put its findings in Chapter IV, Section C-3 of WASH 1327 (Reference 1). This section adequately discusses the differences in nuclear and material properties of mixed oxide and $UO_2$ fuel and the impact of these differences on reactor safety. These differences will not be included in this safety evaluation for Ginna Cycle 10 operation with four MOX fuel assemblies.

Mixed oxide fuel has been irradiated in other U. S. light water reactors. This experience up to 1975 is discussed in Reference 1. The experience of Exxon and Westinghouse with mixed oxide fuel is given in Tables 1 and 2.

Our evaluation concerns the specific effects on reactor safety of loading four mixed oxide assemblies and 32 new $UO_2$ assemblies in Ginna core beginning with Cycle 10 operation.

## Fuel Design

A description of the fuel to be irradiated during Cycle 10 in Ginna is given in Table 3.1 of Reference 2. The mechanical design of the fuel assemblies containing the mixed oxide fuel is similar to fuel already irradiated at Ginna (designated Region 7). No problems have occurred with this fuel batch except for excessive fuel rod bowing. Westinghouse, in discussions with the staff, claimed that this was traced back to the cladding material used for the Region 7. The licensee has stated that none of this material was used for the mixed oxide fuel rod cladding.

Based on previous operating experience of Westinghouse 14x14 fuel, and specifically with the Region 7 fuel irradiated in Ginna, we anticipate no problems with the four mixed oxide fuel assemblies.

TABLE I

# EXXON NUCLEAR COMPANY MIXED OXIDE FUEL PERFORMANCE

| REACTOR | NUMBER OF ASSEMBLIES | MATRIX | EXPOSURE (MWD/MT) AVERAGE | EXPOSURE (MWD/MT) MAXIMUM |
|---|---|---|---|---|
| BIG ROCK POINT | 2* | 11x11 | 30,400 | 30,400 |
| | 6* | 11x11 | 25,000 | 25,400 |
| | 12 | 11x11 | 24,300 | 30,800 |
| | 8* | 11x11 | 17,100 | 17,800 |
| | 14 | 11x11 | 15,700 | 17,900 |
| KAHL | 18 | 6x6 | 11,600 | 12,200 |

* DISCHARGED

TABLE 2

## WESTINGHOUSE MIXED OXIDE IRRADIATION EXPERIENCE IN PWRs

| Reactor | Core/Cycle | Number of Rods | Power (kw/ft) | Burnup (MWD/MTU) | Dates Of Operation |
|---|---|---|---|---|---|
| Saxton | Core II | 638 | 18.7(1,3) | 28,000(2) | Dec. 1965 to Oct. 1968 |
| Saxton | Core III | 250 | 21.2(1) | 51,000(2) | Dec. 1969 to May 1972 |
| San Onofre | Cycle 2 | 720 | 6.9(1) | 12,600(2) | Nov. 1970 to Dec. 1971 |
| San Onofre | Cycle 3 | 716 | 7.3(1) | 25,200(2) | March 1972 to June 1973 |
| Beznau | Cycle 8 | 716 | 6.1(4) | 11,200(5) | June 1978-June 1979 |
|  | Cycle 9 | 716 | 5.9(4) | 20,900(5) at EOC 9 | Presently operating |

(1) Peak pellet power achieved during the cycle.

(2) Peak pellet burnup at the end of life.

(3) Two mixed oxide fuel rods achieved 18.7 kw/ft during a special overpower test. However, the peak power for the remainder of rods was 13.7 kw/ft.

(4) Assembly average power.

(5) Assembly average burnup.

The licensee, in Reference 2, notes that the densification of Westinghouse mixed oxide fuel is less than or equal to that of $UO_2$. An Electric Power Research Institute (EPRI) Study (Reference 3) showed that, in general, the behavior of mixed-oxide fuel is comparable with that of $UO_2$ fuel, i.e., $PuO_2$ additions to $UO_2$ typical of plutonium recycle fuels do not create any limitations on performance in terms of densification.

Also, like $UO_2$ fuels, it was demonstrated in this EPRI Study that stability towards densification of the mixed-oxide fuel types studied is related to microstructural characteristics, i.e., grain size, pore size, and volume percent of submicron porosity.

The licensee has presented data (Reference 6) which show that mixed oxide fuel manufactured by Westinghouse does not densify any differently than $UO_2$ fuel manufactured by Westinghouse. This conclusion is important in justifying the use of the standard Westinghouse densification model for LOCA analyses and other postulated accident analyses.

Data from mixed oxide fuel irradiated in San Onofre, Saxton and Beznau were compared with the data base for $UO_2$ fuel given in WCAP 8218 (Reference 4) to show that no difference in densification would be expected.

## Nuclear Design and Safety Analysis

Because only four mixed oxide fuel bundles are to be included in the Cycle 10 reloading, and these four assemblies will be located symmetrically at the core periphery, the effect on the core properties will be minimal. The values of the kinetics parameters for Cycle 10 and a calculation of shutdown margin are reported in Reference 2.

Cycle 10 with mixed oxide fuel has slightly lower control rod worths and shutdown margin than without mixed oxide. The differences, as reported by the licensee in a telephone conversation with the staff, are less than approximately 0.5%.

According to Reference 1, the uncertainty associated with the calculation of local power peaking in mixed oxide fuel may be greater than that currently used for $UO_2$ fuel. This effect was not considered by the licensee since the mixed oxide fuel bundles will be in the periphery of the core at a power level below the core average. We understand that the current plan for the next cycle is to continue to keep these bundles below the core average power. However, for future cycles, we will require that the licensee determine an appropriate uncertainty for mixed oxide fuel to be applied to $F_Q$.

Exxon Nuclear Company performed the physics calculations for Cycle 10. Comparisons of Exxon calculational methods for mixed oxide fuel with data are given in Reference 5. In particular, Tables 4.2-1 and 4.2-2, 4.2-3 and 4.2-4 give comparisons with critical experiments which contained $UO_2$ rods and $PuO_2$ rods. These comparisons are an indication of the ability of Exxon's physics methods to calculate power distributions and related quantities such as neutron multiplication factors and buckling. In general, the comparison is good.

For Cycle 10, because of the addition of the four mixed oxide assemblies, the reactivity worth of the boric acid will decrease and the BOC delayed neutron fraction will decrease so that the values assumed for safety analyses are no longer valid. Because of this, the postulated accidents listed below in Table 3 were reevaluated. These accidents are the most limiting with respect to the above two parameters. According to the licensee, the results of the analyses show that the applicable safety criteria for each event were met. The reference analyses for Cycle 10 are given in References 8 and 9.

TABLE 3

Steam Line Break (Large and Small)

Fast Rod Withdrawal

Rod Ejection

Although boron worth decreases, the safety criterion for the steam line break will still be met since the minimum Departure from Nucleate Boiling Ratio (DNBR) of the reference analysis is above the safety limit of 1.3 and the change in the delayed neutron fraction ($\beta$) from the reference analysis would result in only a slight increase in fuel rod power and a negligible change in DNBR.

A recalculation of the Rod Ejection Accident showed that the maximum total peaking factor ($F_Q$) after ejection was less than for the reference cycle.

The LOCA analysis was not redone for Cycle 10. The licensee has stated that the mixed oxide assemblies will be bounded by the $UO_2$ fuel assemblies with respect to Cycle 10 LOCA consequences. The licensee stated (Reference 6) that the volumetric average temperature (stored energy) for the mixed oxide fuel (at the same power and burnup) will be lower than for $UO_2$ fuel. The staff has performed an independent calculation to verify this result. Our calculations show only a slight difference between the volumetric average temperature calculated with mixed oxide fuel at 3.1% $PuO_2$ and $UO_2$ fuel with U235 enrichment of 3.45% (the enrichment of the Region 12 fuel). The calculated $UO_2$ volumetric average temperature is slightly higher. These calculations utilized the NRC code GAPCON THERMAL-2. Densification and fuel relocation were both considered. The confirmatory NRC calculations were done for a peak power fuel rod and a fuel rod at slightly above the average core power to a burnup of 5000 MWd/MTU to account for densification effects. The flux depression for the mixed oxide fuel was based on calculations done for the EPRI densification study (Reference 3). It is noted that although the mixed oxide fuel has a lower thermal conductivity than the $UO_2$, more of the heat is generated in the outside area of the fuel pellet and less at the center due to the neutron flux depression in the mixed oxide fuel rod interior.

As part of the calculation of $F_Q$, the licensee must include the effects of fuel rod bowing. As a fuel rod bows, the local moderation will increase and may result in power peaking. In Reference 7, Westinghouse presents calculations which show that this effect can be adequately accounted for within the existing uncertainty allowance. However, this calculation was for $UO_2$ fuel only. The mixed oxide fuel bundles, like all the Westinghouse fuel used in Ginna, is HIPAR, meaning that the guide tubes are stainless steel. Westinghouse has previously presented data to the staff to show that the amount of fuel rod bowing in HIPAR fuel is negligible. Therefore, the effect of any power peaking due to fuel rod bowing in the MOX fuel assemblies will be negligible.

## Summary

The addition of four mixed oxide fuel assemblies results in negligible changes to the Ginna Cycle 10 core. The licensee has taken the differences in fuel material properties into account in evaluating Cycle 10 performance. The fuel bundles are identical in design to Westinghouse fuel bundles previously irradiated satisfactorily at Ginna. Two parameters, the boron worth and the delayed neutron fraction are outside of the range of values used for previous accident analyses. The licensee reevaluated the most limiting postulated accidents for which these parameters have a significant effect and concluded that the applicable safety criteria are still met.

Based on the above, we have concluded that the Ginna reactor can be operated safely during Cycle 10 operation with four mixed oxide fuel assemblies. However, the licensee must determine the nuclear uncertainty on power peaking for the mixed oxide fuel rods before operation for future cycles. This uncertainty, after review and approval by the staff, should be applied to the mixed oxide fuel assembly irradiation beyond Cycle 10.

References

1. Fuel Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors: Health, Safety and Environment, WASH-1327, NUREG-0002, Vol. 3, Chapter IV, Section C-3, August 1976.

2. Letter to H. Denton, USNRC, from the Boigt LoBoeuf, Lamb, Leiby and Mac Rae, December 20, 1979 which contains as addenda the following documents:

   Westinghouse Fuel and LOCA Evaluation of R. E. Ginna Mixed Oxide Fuel Assemblies

   Plant Transient Analysis for the R. E. Ginna Unit 1 Nuclear Power Plant

   Addendum to the Criticality Analysis for the Ginna Nuclear Plant Fuel Storage Racks to Address the Storage of Mixed Oxide Fuel Assemblies

   Radiological Impact of Mixed Oxide Fuel Assemblies

   R. E. Ginna Nuclear Plant Cycle 10 Safety Analysis Report with Mixed Oxide Assemblies

3. Plutonia Fuel Study, Electric Power Research Institute (EPRI), January 1978.

4. Helluan, J. M., et. al., "Fuel Densification Experimental Results and Model for Reactor Applications," Westinghouse Electric Corporation, WCAP 8218, October 1973.

5. Skogen, F. K., "Exxon Nuclear Neutronic Design Methods for Pressurized Water Reactors," Exxon Nuclear Company, Inc., XN-75-27 June 1975.

6. Letter to Director of Nuclear Reactor Regulation, USNRC, from L. D. White, Rochester Gas and Electric Corporation, February 20, 1980.

7. Reavis, J. R., et. al., "Fuel Rod Bowing," Westinghouse Electric Corporation, WCAP 8691, December 1975.

8. Markowski, F. J., et. al., "Plant Transient Analysis for the R. E. Ginna Unit 1 Nuclear Power Plant," Exxon Nuclear Company, Inc., XN-NF-77-40.

9. Markowski, F. J., et. al., "Plant Transient Analysis for the R. E. Ginna Unit 1 Nuclear Power Plant," Exxon Nuclear Company, Inc., XN-NF-77-40, Rev. 1 July 3, 1979.