RC(2)

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

December 5, 1973

Docket No. 50-219

Jersey Central Power & Light Company
ATTN: Mr. I. R. Finfrock, Jr.
Vice President - Generation
Madison Avenue at Punch Bowl Road
Morristown, New Jersey 07960

Gentlemen:

As you are aware the General Electric Company (GE) report NEDO-20181, "GEGAP-III A Model for the Prediction of Pellet-Clad Thermal Conductance in BWR Fuel Rods," November 1973, has been submitted to provide a basis for further review of the effects of BWR fuel densification. The related proprietary information is provided in NEDC-20181 Supplement 1 (Proprietary) November 1973.

The Regulatory staff considers that modifications to the "GE Model for Fuel Densification" transmitted to you in our letter of July 16, 1973, are appropriate. The enclosure represents the staff's current conclusions on BWR fuel densification.

We have requested, by separate letter, that GE supplement NEDO-20181 with calculations to determine the consequences of fuel densification, using the guidance provided in the enclosure. GE has indicated that they expect to complete these calculations by December 10, 1973. It is requested that you provide the necessary analyses and other relevant data for determining the effects of fuel densification on normal operation, anticipated transients, and accidents, including the postulated loss-of-coolant accident, using the guidance in the enclosure. If the analyses indicate that changes in operating conditions are warranted, you should submit proposed changes to your Technical Specifications with the analyses.

B/61

To meet our current schedule for completing our review of the GE fuel in the Oyster Creek Cycle 3 core and to allow possible early action for your facility, it is requested that you provide your response by December 13, 1973.

We are nearing completion of our review of an Exxon fuel densification model and will inform you of the results upon completion.

Sincerely,

Donald J. Skovholt
Assistant Director for
Operating Reactors
Directorate of Licensing

Enclosure:
Modified GE Model for Fuel
Densification (12/4/73)

cc w/enclosure:
G. F. Trowbridge, Esquire
Shaw, Pittman, Potts, Trowbridge
and Madden
910 - 17th Street, N. W.
Washington, D. C. 20006

GPU Service Corporation
ATTN: Mr. Thomas M. Crimmins
Safety & Licensing Manager
260 Cherry Hill Road
Parsippany, New Jersey 07054

Mr. Kenneth B. Walton
Brigantine Tutoring
309 - 21st Street, S.
Brigantine, New Jersey 08203

Daniel Rappoport, Esquire
2323 S. Broad Street
Trenton, New Jersey 08610

Anthony Z. Roisman, Esquire
Berlin, Roisman and Kessler
1712 N Street, N. W.
Washington, D. C. 20036

Miss Dorothy R. Horner
Township Clerk
Township of Ocean
Waretown, New Jersey 08753

Ocean County Library
15 Hooper Avenue
Toms River, New Jersey 08753

ENCLOSURE

MODIFIED GE MODEL FOR FUEL DENSIFICATION

The General Electric fuel densification model is described in NEDC-20181, NEDM-10735 and Supplements 1, 2, 3, 4, and 5 to NEDM-10735 (see references 1 through 6). Non-proprietary information regarding this matter is provided by NEDO-20181 (reference 9). The GE model when modified as described below is considered to be suitably conservative for the evaluation of densification effects in BWR fuel.

Possible effects of fuel densification are: (1) power spikes due to axial gap formation; (2) increase in LHGR because of pellet length shortening; (3) creep collapse of the cladding due to axial gap formation; and (4) changes in stored energy due to increased radial gap size. Similarly, the GE model for fuel densification consists of four parts: power spike model, linear heat generation model, clad creep collapse model, and stored energy model. The required modifications to each of these models are listed below.

Power Spike Model

The GE power spike model is acceptable as it is described in NEDM-10735 and Supplement 1 to NEDM-10735 and modified in Supplement 5 of NEDM-10735 as long as it is used in conjunction with a maximum axial gap size given by the following equation:

$$\Delta L = \left(\frac{0.965 - pi}{2} + 0.0025\right)L$$

where ΔL = maximum axial gap length

L = fuel column length

pi = mean value of measured initial pellet density (geometric)

0.0025 = allowance for irradiation induced cladding growth and axial strain caused by fuel-clad mechabical interaction

Linear Heat Generation Model

The following expression should be used to calculate the decrease in fuel column length in determinations of the linear heat generation rate:

$$\Delta L = \frac{0.965 - \rho i}{2} L$$

where: ΔL = decrease in fuel column length

L = fuel column length

ρi = mean value of measured initial pellet density (geometric)

Credit can be taken for fuel column length increase due to thermal expansion, and for the actual measured length of the fuel column.

Clad Creep Collapse Model

Examination of exposed BWR fuel rods (Ref. 5) and Regulatory staff calculations show that clad collapse will not occur in typical BWR fuel during the first cycle of operation. Consequently, no additional creep collapse calculations are required for the first cycle of typical BWR fuel.

For reactors in subsequent cycles of operation the GE creep collapse model described in NEDO-10735 should be used with the following modifications:

1. The equation used to calculate the change in ovality due to the increasing creep strain should account for the ovality change due to change in curvature as well as for the ovality change due to change in rod circumference.
2. A conservative value should be used for the clad temperature. Axial temperature variations in the vicinity of a fuel gap as affected by thermal radiation from the ends of the pellets and by axial heat conduction should be taken into account. Effects

from any buildup of oxide and crud on the clad surfaces should also be considered.

3. The calculations should be made for the fuel rod having the worst combination of fast neutron flux and clad temperature.
4. No credit should be taken for fission gas pressure buildup.
5. No credit should be taken for end effects. An infinitely long, unsupported length of cladding should be assumed.
6. Conservative values for clad wall thickness and initial ovality should be used. An acceptable approach is to use the two standard deviation limit of as-fabricated dimensions.

(1) Densification

The densification-kinetics expression as described in NEDC-20181 is acceptable subject to the restriction that the rate constants (M,A and D^{o}_{irr}) are adjusted such that a specified density increase occurs at a burnup no greater than 4,000 MWd/tU. The specified density increase will correspond to the density increase experienced by like fuel during an out-of-reactor resintering anneal at 1700°C for 24 hours. This density increase may be considered to give the maximum density in the model, and no further density increase need be predicted.

Resintering tests already performed by G.E. and reported in NEDC-20181 on archive and current production pellets may be used as a basis for obtaining the 24 hour resintering data. A linear interpolation to 24 hours will be acceptable on a plot of density increase vs log (time) between the measured points at 4 hours and 100 hours. The 4 hour and 100 hour points to correspond to a 95% tolerance on the measured density-increase distributions for the resintered pellets at each time period.

(2) For purposes of calculating the densification effect on gap conductance and stored energy the change in fuel pellet radius should be calculated from density change in (1) above and from the assumption that shrinkage is isotropic. i.e.

$$\frac{\Delta r}{r} = 1/3 \ \frac{\Delta \rho}{\rho} \text{ where}$$

$\Delta\rho$ = change in density from densification-kinetics expression described in NEDC-20181

r = radius

(3) <u>Creep</u>

Clad creepdown as it effects gap conductance may be calculated with the CREEP-1 code, as described in NEDC-20181, provided that the resultant creep strains are multiplied by 0.31.

(4) Since the assembly average stored energy is one of the most important inputs to BWR LOCA evaluation, a Technical Specification limit should be imposed on maximum permitted assembly power.

REFERENCES

1. "GEGAP-3 A Model for the Prediction of Pellet-Clad Thermal Conductance in BWR Fuel Rods," Supplement 1 (Proprietary), NEDC-20181 (Proprietary) November 1973.

2. D. C. Ditmore and R. B. Elkins: "Densification Considerations in BWR Fuel Design and Performance" NEDM-10735, December 1972.

3. "Responses to AEC Questions - NEDM-10735," NEDM-10735 Supplement 1, April 1973.

4. "Responses to AEC Questions NEDM-10735 Supplement 1," NEDM-10735 Supplement 2, May 1973.

5. "Responses to AEC Questions NEDM-10735 Supplement 1," NEDM-10735 Supplement 3, June 1973.

6. "Responses to AEC Question NEDM-10735," NEDM-10735 Supplement 4, July 1973.

7. "Densification Considerations in BWR Fuel," NEDM-10735 Supplement 5, July 1973.

8. B. C. Slifer and J. E. Hench, "Loss-of-Coolant Accident & Emergency Core Cooling Models for General Electric Boiling Water Reactors," NEDO-10329, April 1971.

9. NEDO-201[illegible], "GEGAP-III A Model for the Prediction of Pellet-Clad Thermal Conductance in BWR Fuel Rods," November 1973.

Information to be in
Supplement 1 to NEDO-20181

For additional confirmation of the performance of the GEGAP-III Computer code, the following sets of experimental data should be used for comparison to GEGAP-III calculations,

(1) all experimental data used for comparison in GEGAP-III document which describes original model.

(2)	WCAP-2923	Capsule 1
	CEA-R-3358	Rod 4111-AE-1 Rod 4113-AE1
	AECL-2588	Rod FAO