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JUN 1 2 1973

Docket No. 50-10

Commonwealth Edison Company
ATTN: Mr. L. D. Butterfield, Jr.
Nuclear Licensing Administrator
Post Office Box 767
Chicago, Illinois 60690

Gentlemen:

In connection with our ongoing review of Report No. GU-5293, "Evaluation of Densification in Dresden Unit 1 Fuel Supplied by Gulf United," dated February 23, 1973, we find that the additional information identified in the enclosed pages is needed to complete our review. We request that you submit this information before June 22, 1973, with one original and 39 additional copies.

Sincerely,

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

Enclosure:
Request for Information

cc w/enclosure:
John W. Rowe, Esquire
Isham, Lincoln & Beale
Counselors at Law
One First National Plaza
Chicago, Illinois 60670

bcc:
D. Davis VRooney
D. Ross RWReid
V. Stello

OFFICE	L:OR #2	L:OR #2	L:OR #2	L:OR #2	L:OR
SURNAME	RDSilver:rwg	RWReid	RMDiggs	DLZiemann	DJSkovholt
DATE	6/ /73	6/ /73	6/ /73	6/ /73	6/ /73

Form AEC-318 (Rev. 9-53) AECM 0240

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COMMONWEALTH EDISON COMPANY

DRESDEN UNIT I

DOCKET NO. 50-10

REQUEST FOR ADDITIONAL INFORMATION ON FUEL DENSIFICATION

1. Powder Preparation - provide the chemical process for powder preparation. Describe in detail any heat treatment or comminution treatment of the powder.

2. Powder Properties - provide the nominal mean particle diameter, particle size distribution, specific surface of the powder, and variation of these properties from batch to batch. Provide chemical analyses including oxygen/metal ratios, absorbed gases, metallic and nonmetallic impurities.

3. Pressing Parameters - provide the pressures used, type of dies and presses used, green pellet densities (mean values and standard deviations), binders and additives used and in what quantities, and how the additions were made.

4. Sintering Parameters - provide a complete description of the sintering cycle including heating rates, soak times, and cooling rates. Include the atmosphere and approximate concentration of impurities in the furnace.

5. Surface Finishing - provide the methods used to finish the pellets and the specifications for the finish.

6. Resintering Parameters - describe the pellet reheating procedure including the heating cycle. Cite reasons for choice of particular temperatures, times, and atmospheres.

7. Pellet Density - provide the mean immersion and geometric densities including standard deviations, sampling procedures, and minimum densities. If available, provide this information for irradiated fuel.

8. Pellet Chemical Properties - provide the O/M ratios, impurities (metallic and non-metallic) and specifications for the sintered pellets.

9. Pellet Microstructure - provide the average grain sizes and grain size distributions, pore morphology and location, axial and radial distributions of grain size and porosity in the fuel pellets (if not uniform). Provide sample photo-micrographs of typical (or atypical) pellets, both before and after irradiation. Show both etched and as-published microstructures.

10. Pellet Dimensions - provide statistical distributions, sampling procedures, and minimum dimensions.

11. Provide the methods of fabrication used to produce the cladding and to what specifications (e.g., chemistry, tensile test, burst, etc.). How are the rods inspected for leaks, hydriding, etc.?

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12. Describe the types of spacers and holddown springs used.

13. Provide any data showing fuel column lengths vs burnup and linear heat rating.

14. Provide input data needed by BUCKLE (staff code) for cladding collapse calculations:

    a. Cladding temperature.
    b. Fast Neutron Flux on Cladding.
    c. Yield Strength, Poisons ratio, and Young's modulus for conditions a & b above.
    d. External pressure.
    e. Internal pressure (cold, hot before densification, cold, hot after densification).
    f. The measured data for cladding OD, thickness and initial ovality including the mean, standard deviation, maximum and minimum values, the sample size and sampling procedure.

15. Define the critical collapse ovality. Provide technical justification for using this parameter.

16. Provide detailed calculational method and assumptions made for:

    a. hot internal pressure,
    b. clad wall temperature, and
    c. fast flux in the cladding.

17. Describe the creep law used in CREBUCK together with constants used. Provide comparisons with published and other experimental data.

18. Provide CREBUCK verification with controlled experiment results.

19. What is the margin of safety for the predicted collapse time?

20. A UO_2 production lot size is composed of virgin oxide, intermediate product, and reprocessed UO_2. Presumably the sintering parameters are adjusted to allow for differences in amounts of these materials. In general terms, describe how different amounts of these materials might be expected to influence densification of the sintered pellets. Describe any plans to follow the densification behavior of pellets as a function of batch composition (i.e., % virgin oxide, % reprocessed, etc.).

21. One lot of powder apparently had a bulk density which was somewhat different than the densities of other lots. Explain what accounts for this difference. Provide subsequent information on the relative sintered density of pellets prepared from these lots.

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22. Present a detailed description of your gap conductance and fuel temperature calculation technique. Include a description of all models used such as thermal expansion, fission gas release, fuel/gas thermal conductivity, fuel swelling, clad creepdown, restructuring, sorbed gas, and interfacial pressure. Give references for all models used.

23. Using the model described in Request No. 1, compare calculated gap conductances and/or fuel temperatures with experimental data in the same range of parameters as the fuel of interest. In particular, provide results for the specific experimental data given in Attachment 1 (enclosed).

24. Present calculations of gap conductance and fuel temperatures as a function of time and burnup. Resolve the gap conductance into components for contributions through the gas, solid-solid contact and radiation.

    Also present hot gap size, fuel pellet diameter, conductivity of gas mixture, and temperature jump distances (if used) as a function of time.

25. Provide input data needed by GAPCON for gap conductance calculation.

    a. diameter of pellet
    b. ID and OD of clad
    c. enrichment of fuel
    d. density of fuel (% theoretical)
    e. plenum volume
    f. active fuel column length
    g. sorbed gas content (cc/gram fuel)
    h. surface roughnesses of clad and fuel
    i. coolant temperature and pressure
    j. film coefficient between cladding and coolant
    k. initial fill gas pressure and composition

26. If any credit is taken for partial contact of fuel and cladding before complete gap closure, justify this assumption and the particular model used.

27. Provide the missing Figure 2.2 of report GU-5293 showing the beveled end surface configuration.

28. The axial thermal expansion of a fuel column with a peak power of 15.5 kw/ft is given as 1.044 inches. Show how this number is obtained.

29. GUNFC interprets its autoclave test results to mean that pellet to-clad interactions are reduced by beveling the pellets. Were the beveled and non-beveled pellets exactly alike in fabrication history, density, microstructure, etc.? If available, provide examples of the microstructures.

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30. Of the zircaloy clad rods that were cycled from room temperature to 750°F in an autoclave, how many rods were measured for length changes?

31. On page 2-2 of report GU-5293, it was reported that diameter measurements disclosed no measurable clad creepdown or clad ovalization. Describe the measurements made; include the number of rods, the positions along the rods and type of rod (interior or exterior rods). Provide the mean values, standard deviations, and minimum/maximum values.

32. Provide a calculation of the maximum axial compressive stresses in a fuel pellet column during full power operation. Include in this calculation the pellet-to-pellet contact areas and the compressive loads (spring and pellet weights) assumed.

33. In section 2.2 of report GU-5293, results of Yankee Rowe surveillance are described. In this respect provide the following:

    a. For the Yankee Rowe and Connecticut Yankee qualification assemblies, provide the numerical results of the diameter measurements versus length. Compare these measurements with your calculation methods.
    b. Describe any differences in the design and fabrication of the 95 "special surveillance" fuel rods which were inserted in Yankee Rowe in April 1972 from "normal" fuel rods; e.g., the Batch 6 or 7 rods (other than the beveled surfaces on the pellets).
    c. Provide the linear heat ratings and burnups of the rods removed for inspection from Yankee Rowe in September, 1972 and February, 1973.

34. Since there is some uncertainty that out-of-pile measurements on axial gap size and gap distribution are representative of inpile conditions; please perform sensitivity calculations including the case where the maximum theoretical axial gap size is calculated from the nominal initial density and an assumed final density of 96.5% of theoretical using the assumptions of the AEC model. An appropriate increase in the maximum gap size must be made to account for irradiation induced growth of the fuel rod cladding.

35. GU-5293 indicates that a pellet with an initially low density (two sigma) will produce 1% less power. Justify this assumption.

36. How is the void volume due to pellet dishing included in HOTROD calculations?

37. For comparison of HOTROD with experimental data, give the identification numbers of the rods for which the comparisons were made.

38. Explain the method used by HOTROD to model flux distribution axially along a fuel rod.

39. If gas released from the fuel in HOTROD, what is the assumed composition (both sorbed gas and fission gas)?

40. Explain the restructuring model used by HOTROD.

41. Explain the cladding creepdown model used by HOTROD.

42. Provide a comparison of the gas mixture thermal conductivity model with experimental data (or a reference which contains this comparison).

43. Provide the variation of internal pressure of Dresden-1, Cycle IX rods with time.

44. Discuss the model used in HOTROD for fuel melting if such a model exists, i.e., heat of fusion, volumetric expansion and melting temperature.

45. In those rods which contain Gd_2O_3, describe the effect of Gd_2O_3 addition on melting point, thermal conductivity, thermal expansion, sinterability, fuel densification behavior, cladding compatability, and microstructure.

46. Gd_2O_3 is reported to be hygroscopic. If water is used as a coolant during grinding, does the sintered product pick up significant H_2O? Has this been determined as a function of temperature? Specify method and temperatures used for H_2O determination.

47. Provide details of UO_2 - Gd_2O_3 fuel preparation including:

    a. Type of Gd_2O_3 power - particle size distribution, specific surface, impurity level, etc.
    b. Process for powder blending.
    c. Homogeneity - degree and how determined.
    d. Methods used to prevent Gd_2O_3 contamination throughout plant.

48. Does UO_2 - Gd_2O_3 have a different tendency to crack during reactor startup than UO_2?

49. Describe any tests or evaluations in or out-of-pile now in progress or contemplated for UO_2 - Gd_2O_3 fuel.

50. If different from the model for UO_2, provide specific values for swelling and gas release models for UO_2 - Gd_2O_3 as a function of burnup.

51. Lewis (Nuclear Applications, Vol. 2) is cited as a source of the experimental data points used as a comparison with the GUNFC fission gas release model. Explain what data from Lewis was used and how the calculations were done for the comparison. Give an example of the calculation for one data point.

52. Provide HOTROD fission gas release fractions for the experimental data provided in Attachment 2 (enclosed).

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ATTACHMENT 1

Enclosed is experimental data needed to perform gap conductance calculations. Please calculate gap conductance, maximum fuel temperature and volumetric average fuel temperature over the range of conditions specified.

PARAMETER	WCAP 2923 CAPSULE 1	WCAP 2923 CAPSULE 2	G.E. ROD AEG
Pellet ID (inch)	.068	.068	0.
Pellet OD (inch)	1.25	1.25	.4890
Clad ID (inch)	1.2745	1.2745	.5050
Clad OD (inch)	1.3245	1.3245	.5650
Pellet Enrichment (w/o)	.64	.82	2.50
Pellet Density (% TD)	95%	95%	95%
Sorbed Gas Content cc/gm (STP)	.01, .03, .05N_2	.01, .03, 05N_2	.01, .03, 05N_2
Clad Material	SS348	SS348	SS
Plenum Volume in^3	.5	.5	.5
Coolant Temp °F	270	270	590
Coolant Press (psi)	50	50	1050
Active Fuel Length (inch)	4.41	4.46	30.0
Surface Roughness, fuel	$70x10^{-6}$	$70x10^{-6}$	$39x10^{-6}$
clad (inch)	$70x10^{-6}$	$70x10^{-6}$	$20x10^{-6}$
Initial Fill Gas (psi)	14.7 He	14.7 He	14.7 He
Power Range (kw/ft)	16-23	2-25	10-22
Peak/Avg. Axial Flux Ratio	1.00	1.00	1.5

ATTACHMENT 2

CVTR RODS (Reference WCAP-3850-5)

INPUT DATA FOR FISSION GAS CALCULATION

PARAMETER	ROD 44.732	ROD W13.831	ROD 83.832	ROD 502-2-31
Enrichment (w/o U235)	4.7	3.8	3.8	2.
Density (% TD)	93	93	93	93
Fuel OD (inch)	.4317	.4329	.4475	.4300
Clad ID (inch)	.4395	.4395	.4535	.4300
Clad Wall (inch)	.024	.024	.017	.026
Cold Gap (mils)	7.8	6.6	6.0	6.0
Clad Material	Zr	Zr	Zr	Zr
Sorbed gas (cc/gm)	0.	0.	0.	0.
Initial Fill Gas	1 atm He	1 atm He	1 atm He	1 atm He
Active Length (in)	77.81	80.25	81.16	95.12
h_{film} (Btu/hr ft^2 °F)	8790	8790	8790	9910
Burnup (MWD/MTU)	7900	6410	7330	10800
Coolant	D_2O	D_2O	D_2O	D_2O
Coolant Press (psi)	1500 ± 50	1500 ± 50	1500 ± 50	1500 ± 50
Coolant Temp (Sat)(°F)	600 ± 10	600 ± 10	600 ± 10	600 ± 10
Fission Gas released (Xe + Kr) (%)	28.6	12.6	4.4	1%
kw/ft	21.8	15.9	17.6	9.3