GE Nuclear Energy

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Document Control Desk
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Theodore S. Michaels

References: 1) License R-33, Docket 50-73.
2) Letter, T. S. Michaels to G. E. Cunningham; January 9, 1990.

Dear Mr. Michaels:

This letter is in response to your request (Ref. 2) for additional information concerning the radiation levels of NTR fuel. Attached is a copy of a report summarizing the radiation levels associated with the NTR fuel and demonstrating that the fuel is self-protecting.

Sincerely,

G. E. Cunningham
Senior Licensing Engineer
(415) 862-4330

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Attachment

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February. 14, 1990

cc: J. H. Cherb
G. E. Cunningham
E. J. Strain

To: D. R. Smith

From: B. M. Murray

Subject: Calculated Dose Rate at 3 Feet From an NTR Fuel Element

Calculations were made using computer codes RIBD[1], which calculates the fission product inventory following periods of fuel irradiation and decay, and ISOSHLD[2], which calculates dose rates at given distances from a described source geometry, to determine the unshielded dose rate at a distance of three feet from the side and the end of an irradiated NTR fuel element. The purpose of these calculations is to demonstrate that the fuel elements in the NTR core are self protected, i.e., that the dose rate at three feet is at least 100 Rem per hour.

The results of the calculations are shown on the attached tables and graphs. They show that the dose rate at three feet from an unshielded NTR fuel element can be expected to exceed 100 R/h for at least 80 days following shutdown. The dose rate calculations do not take any credit for activated hardware or impurities in the fuel element, only the gamma and bremsstrahlung photons from the 450 fission product isotopes calculated by RIBD.

The description and values used in the calculational model are given below:

Geometry:

A single fuel element was modeled as a homogenized cylinder of uranium and aluminum, surrounded by a layer of aluminum. The fuel cylinder dimensions are 2.68 inches diameter by 15.16 inches long. The surrounding side layer of aluminum is 0.07 inches thick and the end layer is 0.027 inches thick. The dose rate measurement points are 36 inches from the outer surfaces of the surrounding shell, at the midplane of the cylinder and on the centerline of the cylinder. The source volume was divided into 30 angular, 60 axial and 30 radial elements for the side case integration, and 30 radial and 401 axial elements for the end case integration.

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[1] RADIOACTIVE ISOTOPE BUILDUP AND DECAY, RIBD-1, GE-APED version of the RSIC distributed code RIBD, ccc-137, memorandum SCER-132, Dec. 1968.

[2] ISHLD01, the GE-NE version of the RSIC distributed code ISOSHLD, Kernel Integration Code - General Purpose Isotope Shielding Analysis, CCC-79.

Densities:

The density of the uranium in the source cylinder is 0.19 grams per cubic centimeter. The density of the aluminum in the source cylinder is 0.904 grams per cubic centimeter. The density of the aluminum skin is 2.7 grams per cubic centimeter.

Fuel Irradiation:

The burnup and operating power for a single fuel element was calculated as one sixteenth of the burnup and nominal operating power of the total core, 111 MWd and 100 kW. The power history used for the RIBD fission product inventory calculation was 0.00625 MW for 1108 days followed by 20 more shutdown and power operation steps. The second step was a long weekend shutdown of 3.8 days followed by a 0.2 day power step of 0.000625 MW. The following 18 steps were weekly cycles with the same power for 0.2 days (4.8 hours) and overnight or weekend shutdowns, for a total power operation time of 1110 days (9.59E7 seconds), and a total elapsed time of 1125 days (3.08 years).

Twenty decay times following shutdown were chosen: 1, 5, 10, 20, 30, 40, 50, 60, 70, 80 90, 100, 120, 140, 160, 180, 200, 250, 300, and 365 days.

The other fuel parameters used were:

Average thermal neutron flux = 5.23E11 $n/cm^2/sec$.

U-235 absorption cross section = 683 barns.

Initial mass of U-235 (93.17%) in core = 3992 grams (249.5 grams per element).

U-239 production rate = 3.6E-4 grams per MWd.

14-Feb-90

DOSE RATE 3' FROM SIDE OF NTR FUEL ELEMENT VERSUS DECAY TIME

INITIAL U-235 WEIGHT - 249.5 GRAMS
OPERATING POWER - 0.00625 MW
OPERATING TIME - 1125 DAYS

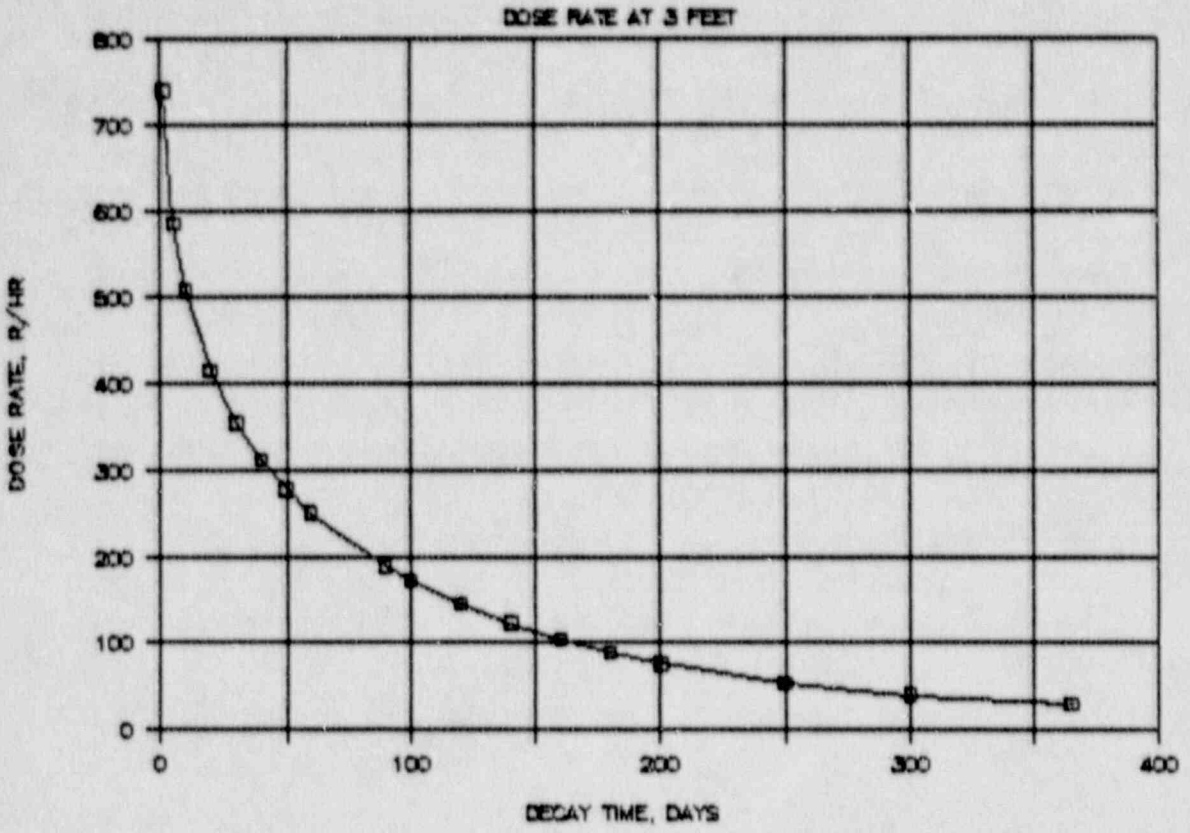
DECAY TIME, DAYS	CALCULATED DOSE RATE, R/h
0	8429000
1	740.7
5	584.6
10	508.5
20	414.4
30	353.9
40	310.3
50	276.7
60	249.4
90	188.7
100	172.7
120	145.6
140	123.1
160	104.7
180	89.34
200	76.73
250	54.23
300	40.54
365	30.41

DOSE RATE 3' FROM END OF NTR FUEL ELEMENT VERSUS DECAY TIME

INITIAL U-235 WEIGHT - 249.5 GRAMS
OPERATING POWER - 0.00625 MW
OPERATING TIME - 1125 DAYS

DECAY TIME, DAYS	CALCULATED DOSE RATE, R/h
0	4479
10	258.9
20	210.9
30	180.0
40	157.8
50	140.7
60	126.9
70	115.2
80	105.1
90	96.09

SIDE OF NTR FUEL ELEMENT



END OF NTR FUEL ELEMENT