Florida Power
CORPORATION

October 16, 1984
3F1084-13

Director of Nuclear Reactor Regulation
Attention: Mr. John F. Stolz, Chief
Operating Reactors Branch #4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Crystal River Unit 3
Docket No. 50-302
Operating License No. DPR-72
Storage of Neutron Sources in Spent Fuel Pools

Reference:
1) FPC letter from W. P. Stewart to R. W. Reid, dated March 16, 1979
2) NRC letter from R. W. Reid to J. A. Hancock, dated November 17, 1980

Dear Sir:

During the review of Florida Power Corporation's (FPC's) request to increase capacity of the spent fuel pools, the NRC requested information in order to evaluate the high density spent fuel rack vendor's qualification program. In the response to question A.1 of enclosure 2 of reference 1, FPC indicated we would not store sources of neutrons other than spent fuel assemblies in the spent fuel pools. Accordingly, the remainder of enclosure 2 was based on the assumption that neutron sources would contribute negligible irradiation to the total dose expected to be received by the new rack material.

During the investigation of the core barrel bolt problem, FPC found it necessary to completely unload the core and temporarily store two neutron sources (maximum source strength: 4.8×10^9 neutrons/sec. each) in spent fuel pool A. This violation of our analysis assumption was discovered and evaluated. B&W was asked to evaluate the impact these additional sources would have on neutron production and spent fuel pool criticality safety. The attached evaluation indicates no hazard to neutron production level or criticality safety. FPC has verified that the contribution from the temporary storage of neutron sources to the total dose received by the rack material remains negligible. FPC also evaluated the dose to personnel associated with the storage of neutron sources in the spent fuel pool and found the neutron and gamma dose rates to be negligible. Therefore, the assumptions in reference 1 and the safety evaluation attached to reference 2 are still valid.

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Since the capability to completely unload the core at any time is a requirement, the analysis assumption in reference 1 is not appropriate as an operating commitment. Therefore, the purpose of this letter is to: 1) document that the analysis assumption that . . . "the contribution of neutron irradiation to the total dose received by the (rack) material is negligible" . . . is still valid, and 2) revise the analysis assumption that, "No sources of neutrons other than spent fuel assemblies will be stored in the Crystal River spent fuel pools.", to allow storage of neutron sources (e.g., regenerative or primary neutron sources up to 9.6×10^9 neutrons/sec. total) and new fuel assemblies in the spent fuel pools .

FPC has determined an application fee for this submittal is not required since NRC review began with the original request to increase the capacity of the spent fuel pools on January 9, 1978.

Sincerely,

G. R. Westafer
Manager, Nuclear Operations
Licensing and Fuel Management

DLT/feb

Attachment

cc: Mr. J. P. O'Reilly
Regional Administrator, Region II
U.S. Nuclear Regulatory Commission
101 Marietta Street N.W., Suite 2900
Atlanta, GA 30323

BABCOCK & WILCOX - UPGD
ENGINEERING INFORMATION RECORD

RPT-84-09

Safety Related: YES [X] NO [ ]

DOCUMENT IDENTFIER 51 -1150217-00

TITLE Storage of Sb-Be Neutron Sources at FPC

PREPARED BY J.R. Worsham III DATE 3/14/84

REVIEWED BY W.G. Pettus DATE 3-14-84

REMARKS

References:

1) B&W Memo, "Storage of Neutron Sources in Spent Fuel Pool," C.E. Barksdale, March 1, 1984. (Information Only)

2) B&W #58-0298-00, "Design Report Sb-Be Neutron Source," Monsanto Research," August, 1974.

3) B&W #81-0059-02, "Final Design Report Mark B Secondary Neutron Sources," General Electric Company, March, 1978.

4) LA-5651-M, "Fundamentals of Passive Nondestructive Assay of Fissionable Material," R.H. Augustson and T.D. Reilly, June, 1974. (Information Only)

5) B&W #32-1138062-00, "CR-3 460D CY5 FFCD," J.W. Harwell, September, 1983.

6) B&W #32-3040-00, "UO_2 Irradiation...," C.L. Whitmarsh, August, 1978.

7) Introduction to Nuclear Engineering, R.L. Murray, Prentice-Hall Inc., 1954 (page 140).

Background

Florida Power Corporation contacted the Fuel Marketing & Project Management Section requesting information relating to the storage of the Sb-Be regenerative neutron sources in their spent fuel pool.[1] As indicated in Reference 1, there are two related questions to be addressed. The first is directly from the NRC and asks, what will the level of neutron production be if neutron sources are stored in the spent fuel pool. The second question is inferred from the first question and concerns the criticality safety associated with inserting sources into the pool.

Discussion

The answers to the questions concerning, (1) the neutron production level in the spent fuel pool and, (2) the criticality safety of the pool with neutron sources are discussed in the following two sections. The discussion of criticality safety is first because any changes in the effective neutron multiplication factor will change the neutron production level.

Spent Fuel Pool Criticality Safety

In a highly subcritical array of fuel assemblies, the location of neutron sources will influence the neutron flux distribution. However, the effective neutron multiplication factor will only be affected if each of the fuel assemblies has a different infinite neutron multiplication factor. Such a situation would occur with assemblies of different fissile loadings or different burnups. However, the criticality safety analysis of the Crystal River spent fuel pool assumed a uniform array with an upper bound of fissile loading and no burnup for each assembly. Therefore, the maximum K_{eff} with unborated water is still bounded by the previous results ($K_{eff} \leq .95$), and will not be increased by the addition of source rods anywhere in the spent fuel pool.

Neutron Production Level

The neutron production level in the spent fuel pool is considered to be the result of three factors, (1) the production from the radioactive source material, (2) the spontaneous fission and alpha sources in the fuel, and, (3) the production of fission neutrons as a consequence of source neutrons being absorbed in fissile material. The maximum source strength for the

Sb-Be sources[2,3] is 6.0×10^8 neutrons per second per source rod. Each source assembly contains eight rods and there are two source assemblies, or clusters. Thus the maximum Sb-Be source strength is 9.6×10^9 neutrons per second. The maximum source strength of the fresh fuel is less than 1.0×10^6 neutrons per second[4] which when added to the Sb-Be source continues to give a maximum strength of 9.6×10^9 neutrons per second.

The maximum Sb-Be source strength is independent of whether the manufacturer of the sources is Monsanto[2] or General Electric.[3] In addition, uncertainties in material loading, source material depletion, neutron irradiation levels and activation periods have all been considered when determining the maximum strength. Finally, the maximum strength does not include any decay period following the activation period.

The maximum neutron production level in the spent fuel pool is 20 times the maximum source strength, assuming the minimum degree of subcriticality for fresh fuel, $K_{eff} = .95$. Thus the maximum neutron production level in the spent fuel pool with fresh fuel is;

Maximum Neutron Production = Source Strength x Subcritical Multiplication Factor

Subcritical Multiplication Factor[7] $= \frac{1}{1-K_{eff}}$

Maximum Neutron Production $= 9.6 \times 10^9 \times \frac{1}{1-.95}$

$= 1.92 \times 10^{11}$ neutrons per second

Note: The burned fuel in Cycle 5 of Crystal River was also considered in the evaluation of the maximum neutron production level. At the beginning of the cycle the maximum source strength in all fuel assemblies will be less than 1.7×10^8 neutrons per second, and at the end of the cycle (460 EFPD) the maximum source in the fuel will be less than 5.0×10^8 neutrons per second.[4,5,6] The effective multiplication factor for the burned fuel is approximately 10% less reactive at BOC and 20% less reactive at EOC than completely unburned fuel. Thus, conservative estimates of the maximum neutron production level for BOC-5 and EOC-5 are 1.0×10^{11} and 7.0×10^{10} neutrons per second, respectively. Because the transuranic isotopic production rate is an exponential function, burned fuel neutron sources were checked at 100 EFPD and at extended burnups beyond 460 EFPD to determine if the BOC production level was a maximum. At 100 EFPD the neutron source strength in the fuel is 2.3×10^8 neutrons per second. Since reactivity decreases approximately linearly with burnup and the source at 100 EFPD is lower than a linear interpolation of the BOC and EOC sources, then the BOC production level is the maximum for the burnup fuel. Beyond 460 EFPD the source in the fuel was found to have saturated giving no appreciable increase while reactivity is still linearly decreasing. Thus, the BOC production level is again the maximum value in burned fuel.