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MIDDLE SOUTH UTILITIES SYSTEM

April 8, 1983

L. V. MAURIN
*Vice President Nuclear Operations*

W3P83-1117
3-A1.01.05

Director of Nuclear Reactor Regulation
Attention: Mr. G. Knighton, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: Waterford SES Unit 3
Docket No. 50-382
Fuel Shoulder Gap Spacing

REFERENCE: Letter dated February 15, 1983 from
Novak to Maurin

Dear Sir:

Your referenced letter asked that LP&L amend the Waterford 3 FSAR to reflect fuel assembly modification necessary to increase the shoulder gap spacing. In addition you asked that information be included as to the basis for choosing the additional dimensional clearance.

Enclosed please find the requested additions to the FSAR. This information will appear in the next scheduled amendment (No. 32) to the Waterford FSAR.

The adequacy of the gap spacing on Combustion Engineering 16x16 fuel will be confirmed generically by measurements taken on Arkansas Nuclear One, Unit 2 fuel at their next refueling outage. LP&L will provide this information to the Staff as it becomes available. Given the present schedule of ANO-2 there is every indication that this issue may be resolved prior to the second cycle of operation at Waterford 3.

Should you have any questions or comments on this matter, please contact me or Mike Meisner at (504) 363-8938.

Yours very truly,

LV Maurin

L. V. Maurin

LVM/MJM/cb

cc: W. M. Stevenson, E. L. Blake, J. Wilson

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distribution, fuel assembly component tolerances, crud buildup, drag coefficient, and bypass flow. The springs are sized and the spring preload selected such that a net downward force will be maintained for all normal and anticipated transient flow and temperature conditions. The design criteria limit the maximum stress under the most adverse tolerance conditions to below yield strength of the spring material. The maximum stress occurs during cold conditions and decreases as the reactor heats up. The reduction in stress is due to a decrease in spring deflection resulting from differential thermal expansion between the Zircaloy fuel bundles and the stainless steel internals.

During normal operation, a spring will never be compressed to its solid height. However, if the fuel assembly were loaded in an abnormal manner such that a spring were compressed to its solid height, the spring would continue to serve its function when the loading condition returned to normal.

The lower end fitting is a single piece stainless steel casting consisting of a plate with flow holes and four support legs which also serve as alignment posts. Precision drilled holes in the support legs mate with four core support plate alignment pins, thereby properly locating the lower end of the fuel assembly.

The four outer guide tubes have a widened region at the upper end which contains an internal thread. Connection with the upper end fitting is made by passing the male threaded end of the guide posts through holes in the lower cast flow plate and into the guide tubes. When assembled, the flow plate is secured between flanges on the guide tubes and on the guide posts. INSERT A The connection with the upper end fitting is locked with a mechanical crimp. Each outer guide tube has, at its lower end, a welded Zircaloy-4 fitting. This fitting has a threaded portion which passes through a hole in the fuel assembly lower end fitting and is secured by a Zircaloy-4 nut. This joint is secured with a stainless steel locking ring tack welded to the lower end fitting in four places.

The central guide tube inserts into sockets in the upper and lower end fittings and is thus retained laterally by the relatively small clearance at these locations. The upper end fitting socket is created by the center guide tube post which is threaded into the lower cast flow plate and tack welded in two places. The lower end fitting socket is machined out of the lower end fitting casting. There is no positive axial connection between the central guide tube and the end fittings

The five guide tubes have the effect of ensuring that bowing or excessive swelling of the adjacent fuel rods cannot result in obstruction of the control element pathway This is so because:

a) There is sufficient clearance between the fuel rods and the guide tube surface to allow an adjacent fuel rod to reach rupture strain without contacting the guide tube surface

b) The guide tube, having considerably greater diameter and wall thickness (and also, being at a lower temperature) than the fuel rod, is considerably stiffer than the fuel rods and would, therefore,

The Zircaloy-4 spacer grid material is of the same composition as the fuel rods and guide tubes with which it is in contact, thereby obviating any problem of chemical incompatibility with those components. For the same reason, adequate resistance to corrosion from the coolant is assured (see Subsection 4.2.3.2.3, for additional information relative to the corrosion resistance of Zircaloy-4 in the primary coolant environment).

The Inconel-625 material used for the lowest spacer grid is in contact with the coolant, the 304 stainless steel lower end fitting (to which it is welded), the Zircaloy-4 fuel rods, the poison rods, and the Zircaloy-4 guide tubes. The mutual chemical compatibility of these materials in a reactor environment has been demonstrated by C-E's use of these materials in fuel assemblies that have been operated in other C-E reactors and for which post irradiation examination has yielded no evidence of chemical reaction between these components. In addition, experiments have also been performed at C-E on Inconel type alloys and Zircaloy-4 which showed the eutectic reactions did not occur below 2200 F, a temperature far in excess of that anticipated at the lower grid location in the event of a LOCA.

The only dissimilarity, between the fuel for which post-irradiation examination data are presently available and the Waterford-3 design (other than dimensional variations), is that the Inconel-625 is used as a spacer grid for Waterford-3 and was used originally as a retention grid. However, the effect that such a change might have on fretting behavior has been evaluated in out-of-pile flow test programs (see Subsection 4.2.3.2.4.2).

4.2.3.1.4 Dimensional Stability of Zircaloy

Zircaloy components are designed to allow for dimensional changes resulting from irradiation-induced growth. Extensive analyses of in-pile growth data have been performed to formulate a comprehensive model of in-pile growth.[3] The in-pile growth equations are used to determine the minimum axial differential growth allowance which must be included in the axial gap between the fuel rods and the upper end fitting. For determining the necessary fuel rod growth allowance, the growth correlations for fuel rod and guide tube growth are combined statistically such that the minimum initial gap is adequate to accommodate the upper 95 percent confidence level of differential growth between fuel rods and guide tubes in the peak burnup fuel assembly. For the purpose of predicting axial and lateral growth of the fuel assembly structure (thereby establishing the minimum initial clearance with interfacing components), the equations are used in a conservative manner to ensure adequate margins to interference are maintained.

INSERT B

4.2.3.1.5 Fuel Handling and Shipping Design Loads

Three specific design bases have been established for shipping and handling loads. These are as follows:

a) The fuel assembly, when supported in the new fuel shipping container, shall be capable of sustaining the effects of five g axial, lateral or vertical acceleration without sustaining stress levels in excess of those allowed for normal operation. The five g criterion was originally established experimentally, and its adequacy

of cycles at a given effective strain range to the permitted number at that range as taken from the fatigue curve presented in Figure 4.2-2.

4.2.3.2.6 Fuel Rod Bowing

Analysis of bowing data has shown that the bowing expected in the 16 x 16 design will have no effect on the margin to DNB beyond the allowance provided by the pitch, bowing and clad diameter enthalpy rise factor given in Table 4.4-1 and discussed in Section 4.4. A more complete discussion of the cause and effects of rod bowing is presented in References 53 and 75. 6

4.2.3.2.7 Irradiation Stability of Fuel Rod Cladding

The combined effects of fast flux and cladding temperature are considered in three ways as discussed below:

a) Cladding Creep Rate

The in-pile creep performance of Zircaloy-4 is dependent upon both the local material temperature and the local fast neutron flux. The functional form of the dependencies is presented in Reference 14 for gap conductance calculations, and in Reference 22 for cladding collapse time predictions.

b) Cladding Mechanical Properties

The yield strength, ultimate strength, and ductility of Zircaloy-4 are dependent upon temperature and accumulated fast neutron fluence. The temperature and fluence dependence is discussed in Subsection 4.2.1.2.2.1. Unirradiated or irradiated properties were used depending upon which is more restrictive for the phenomenon being evaluated.

c) Irradiation Induced Dimensional Changes

Zircaloy-4 has been shown to sustain dimensional changes (in the unstressed condition) as a function of the accumulated fast fluence. These changes are considered in the appropriate clearances between the various core components. The irradiation induced growth correlation method is discussed in Reference 3 (SEE SECTION 4.2.3.1.4).

Zircaloy-4 fuel cladding has been utilized in pressurized water reactors at temperatures and burnups anticipated in current designs with no failures attributable to radiation damage. Mechanical property tests on Zircaloy-4 cladding exposed to neutron irradiation of $4.7 \times 10^{21}$ nvt (estimated) have revealed that the cladding retains a significant amount of ductility (in excess of four percent elongation). Typical results are shown in Table 4.2-2. It is believed that the fluence of $4.7 \times 10^{21}$ nvt is at saturation so that continued exposure to irradiation will not change these properties.[(54)]

4.2.3.2.8 Cladding Collapse Analysis

A cladding collapse analysis is performed to ensure that no fuel rod in the core will collapse during its design lifetime. The clad collapse calcula-

INSERT A

On those assemblies scheduled for three cycles of operation (some Batch B and all Batch C fuel assemblies), stainless steel spacer shims are located between the guide tube flanges and the flow plate to provide additional clearance between the fuel rods and the upper end fitting.

INSERT B

Inspection of fuel assemblies after two cycles of operation at the Arkansas Nuclear One, Unit 2 reactor has shown higher rates of gap closure than predicted by the method described in Reference (3). It is expected that the closure rates predicted by Reference (3) will remain valid for the Waterford 3 fuel assemblies because of the differences in the Waterford and Arkansas designs. Nonetheless, additional shoulder gap has been provided in those fuel assemblies scheduled for three cycles of operation.

The additional gap was selected to provide the maximum shoulder gap without violating other design criteria. Based on the shoulder gap reduction observed at ANO-2 at EOC2, the additional shoulder gap is expected to provide three cycle operation capability.