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SUBJECT: Forwards response to requests for addl info re Cycle 6 reload.Performance of CE fuel examined & Tech Spec change to remove augmentation factors supported.

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FLORIDA POWER & LIGHT COMPANY

May 13, 1983
L-83-290

Office of Nuclear Reactor Regulations
Attention: Mr. Darrell G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Eisenhut:

Re: St. Lucie Unit No. 1
Docket No. 50-335
Cycle 6 Reload

During review of the St. Lucie Unit No. 1 applications for license amendments, concerning Cycle 6 reload (L-83-27 dated January 20, 1983, and L-83-57 dated February 8, 1983), NRC on several occasions, requested additional information. The purpose of this letter is to formally submit Florida Power & Light Company's responses to the requests for additional information, which were previously provided to NRC to support timely review of the applications.

Very truly yours,

Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/RJS/cab

Attachments

A001

ATTACHMENT 1

Assessment of St. Lucie Unit 1 Cycle 6 Reload

Transient Analysis with PTSPWR2 Code

FPL has reviewed Exxon Nuclear Company's (ENC) calculations for the proposed Cycle 6 reload as contained in Reference (1) and has concluded that the reference adequately supports a conclusion that Cycle 6 operation at licensed operating power is safe, and will not endanger the health and safety of the general public.

This conclusion has been reached upon consideration that:

1) The physical differences between the new Exxon fuel assemblies and coresident once and twice burned Combustion Engineering (CE) fuel assemblies are slight and would cause no significant differences to the calculated consequences of the Design Basis Events (DBE's).

2). The fuel management scheme and neutronic characteristics of the mixed CE/ENC core for Cycle 6 are similar to those of Cycle 5 and similar to what FPL would have expected from a CE designed reload.

3) With the exception of shutdown margin and moderator temperature coefficient, no changes have been made to Technical Specifications (TS), operating limits and setpoints for Reactor Protective System (RPS) and other plant operating systems even though calculations with Exxon methodologies demonstrate, in many cases, greater safety margins.

4) In both instances where Technical Specifications changes have been requested, the changes are based on justifiable differences between Exxon and Combustion Engineering methodologies.

It is concluded that the analyses performed with the PTSPWR2 code adequately support FPL's application for reload licensing amendment.

Physical Differences:

Except for the following differences the Exxon fuel assemblies are similar in design, material and construction to Combustion Engineering assemblies.

1) Spacer grid design is the Exxon standard design providing more rigidity.

2) Cladding is thicker [.031"(ENC) vs .028"(CE)].

3) The four corner guideposts are 1/2" shorter

4) Spacer grids are not pure Zircalloy -4

ENC Mechanical and material properties have been proven to be compatible with CE fuel since a virtually identical 14X14 Exxon design has been used in the Maine Yankee reactor. The shorter corner guideposts will create no problem since the CEA's rest on the center post, which is equivalent in height for both CE and ENC assemblies.

The Exxon spacer grid design has a higher loss coefficient (and therefore larger pressure drop) than a CE grid. This has been accounted for in detail by a flow redistribution analysis provided in Reference (3). The penalty for redistribution will lessen in future cycles as transition to an all ENC core progresses.

It is concluded that none of the physical changes have a significant effect on the thermal-hydraulic behavior of the fuel.

Physics, Neutronics and Fuel Management

The fuel management strategy for Cycle 6 remains the same as that for Cycle 5, i.e. in-in-out. Calculated available rod scram worth at both BOC and EOC are comparable to values calculated by CE for Cycle 5 as follows:

Calculated Available Rod Worth		CE (Cycle 5)	ENC (Cycle 6)
(W/Calculational Uncertainties)	BOC $\Delta k/k$	4.8	4.8
	EOC $\Delta k/k$	5.2	5.1

The scram reactivity insertion calculated by Exxon is more realistic than the one used in previous cycles. As noted in Reference (1), three different scram reactivity insertion curves corresponding to limiting bottom peaked, mid-peaked, and top peaked power shapes were generated.

For a specific transient, the most limiting power shape is chosen and the consistent reactivity insertion curve is also applied on scram. Combustion Engineering uses one highly conservative reactivity insertion curve regardless of the power shape chosen.

This more advantageous selection of scram insertion has benefits to many of the transients.

The post-rod drop radial peaking factor for the Exxon rod drop event is significantly lower than CE's and is based on standard Exxon neutronics methods.

	CE (Cycle 5)	Exxon (Cycle 6)
Post Drop Radial Peak (%) Increase	116	110

The 6% decrease in radial peaking has significant beneficial effects for the CEA drop discussed later.

TRANSIENTS

The two most DNB limited transients are the Loss of Flow and the Dropped CEA events. The most significant transient from the standpoint of overpressurization is the Loss of Load event. FPL review of these transients has determined that differences in the results for these events arise mainly from use of the XNB instead of the CE-1 correlation, a scram reactivity insertion curve chosen to be consistent with the power shape selected, and a more realistic but still conservative selection of input parameters.

The Hot Zero Power Main Steam Line Break event has been reanalyzed by ENC. Two Technical Specification changes have been proposed based on this analysis which are discussed later in detail.

LOSS OF FLOW

For the Loss of Flow event a comparison of the applicable CE analysis of Reference (2) and the Cycle 6 ENC analysis of Reference (1) shows the following similarities:

1) The 4 pump flow coastdown curves are essentially equivalent (Figure 1).

2) Both analyses have comparable times for generation of the low flow trip signal and identical scram delay times.

3) Both analyses show minimum DNBR occurs at comparable times

   CE = 2.5 sec
   ENC = 2.25 sec

4) Changes in pressure from the initial value are minimal in the interval before minimum DNBR occurs.

A difference has been noted in the methods used by the two vendors, i.e., CE uses a "static" approach in which the time, flow and other parameters associated with the point of minimum DNBR is calculated with a system code. A detailed subchannel analysis is then completed to establish a value for MDNBR using the highly conservative assumption of fixing the heat flux at the full power value.

ENC uses a "dynamic" approach in which the MDNBR is based on the actual calculated conditions during the transient.

Other differences for the Loss of Flow include the use of the XNB versus the CE-1 correlation, and the previously discussed use of ASI dependent scram reactivity insertion.

CE MDNBR (based on CE-1) Cycle 5: 1.23

ENC MDNBR (based on XNB) Cycle 6: 1.346

CEA DROP

For the CEA drop event, a comparison of the applicable CE analysis of Reference (2) and the Cycle 6 ENC analysis of Reference (1) shows the following:

1) The temperature responses are similar for both analyses and relatively flat for the period of interest.

2) Both analyses show a comparable drop in power in similar timeframes and subsequent return to ~100% power level later in the transient.

Minimum power:	CE	91.7% @ 1.22 sec
	ENC	88.00% @ ~1.5 sec

3) The minimum system pressures reached are nearly equivalent.

Minimum Pressure:	CE	~2205 psia
	ENC	~2215 psia

4) Minimum pressures occur at comparable power levels.

5) Primary system flows stay constant for both analyses.

Since DNBR is largely a function of power versus temperature, pressure and flow, it is concluded that the higher DNB ratio reported by ENC is due largely to the more favorable post-drop peaking factors calculated by Exxon and the different DNB correlations used.

Exxon has estimated that the flow redistribution due to spacer grid design differences mentioned earlier creates a maximum 6% reduction in DNBR.

CE results from Reference (2) demonstrate a greater than 6% margin to DNBR using the CE-1 correlation. The introduction of ENC fuel would therefore not be expected to challenge the DNB limit for the CEA event if CE calculational methods were used.

Figures (2) and (3) show DNBR and power versus time for both vendors.

CE MDNBR	1.29
ENC MDNBR	1.485

LOSS OF LOAD

The Loss of load is the limiting event for determination of possible overpressure conditions.

For this transient,

1) The temperature profiles are nearly equivalent.

2) The differential increase in pressure over the starting values are nearly the same:

   For CE : 372 psid
   ENC: 407 psid

3) The rate at which the pressure increases is somewhat greater for the Exxon results.

   For ENC + 54.8 psid/sec
   CE + 33.8 psid/sec

Despite initiation of the ENC transient from the nominal operating pressure (50 psid higher than the CE starting point), the ENC results show that the upset limit of 2750 psia was not challenged. Hence the reload is concluded to be safe for overpressure events. The differences in calculated results demonstrates that PTSPWR2 is conservative for the loss of load event.

Figure (4). shows differential pressure versus time for both vendors.

Steam Line Break

The zero power Main Steam Line Break event determines the shutdown margin requirements for the cycle. The ENC analysis shows a 3.6% $\Delta k/k$ requirement to be adequate for Cycle 6. A change to Technical Specifications has been submitted based on the ENC analysis to reduce the shutdown margin requirement from 5.0% to 3.6% $\Delta k/k$.

FPL review, which included a detailed inhouse computer study, indicated two major differences between the CE Cycle 5 and the ENC Cycle 6 analyses:

1) MTC Value - For MSLB analysis ENC used the new proposed Technical Specification maximum MTC of -28 pcm/°F, which is more conservative than the -22 pcm/°F value used by CE since it maximizes the positive reactivity insertion per degree of primary system cooldown.

2) Boron Reactivity Insertion - The CE analysis, Reference (4), assumed that injected boron instantaneously mixes with the entire RCS volume. The Exxon model mixed the injected boron with cold leg water based on natural circulation flow ratios and then propagated the mixture to the core. The ENC model provides higher concentrations of boron into the core earlier in the transient.

Both vendor's results have been adequately matched by FPL computer models of the MSLB with the only significant differences between the two cases being the MTC and boron reactivity values. FPL is therefore convinced that the model for boron dilution is the major contributor to the less restrictive shutdown margin requirements presented by ENC.

ENC has indicated their method of treating boron dilution through flow ratios has been used for analysis on other plants. Additionally, ENC has benchmarked the natural circulation flows calculated by PTSPWR2 against SL1 natural circulation tests. FPL considers that a less restrictive model for dilution of injected boron is reasonable.

The MDNBR value of 1.27 generated by CE for the MSLB transient Reference (4) represented the result of a HFP initial condition. The MDNBR value of 4.5 listed in Reference (1) for Cycle 6 represented a HZP initial condition. No MDNBR value for the CE HZP case was quoted. The HZP initial condition case was the only MSLB transient analyzed for Cycle 6 since this initial conditions has been previously demonstrated to produce the most limiting results with regard to return to power. The HFP transient is bounded in terms of return to power by the HZP MSLB.

Neither the CE nor ENC results show significant return to power, thus preventing any core damage. This approach, itself, is conservative since NRC SRP 15.1.5 does allow some level of fuel damage.

References:

(1) XN-NF-82-99, Plant Transient Analysis for St. Lucie Unit 1, January 1983 submitted via letter R. E. Uhrig to D. G. Eisehut, L-83-27 dtd January 20, 1983.

(2) SL1 Cycle 4 Stretch Uprating Submittal submitted via letter R. E. Uhrig to D. G. Eisenhut, L-80-381 dtd November 14, 1980.

(3) XN-NF-82-81, Rev. 1 St. Lucie Unit 1 Cycle 6 Safety Analysis Report submitted via letter R. E. Uhrig to D. G. Eisenhut, L-83-27 dtd January 20, 1983.

(4) Amendment to Cycle 4 Stretch Uprating Containing post-TMI MSLB analysis and answers to NRC questions submitted via letter R. E. Uhrig to R. A. Clark, L-81-388 dtd September 4, 1981.

LOF - CORE FLOW vs TIME

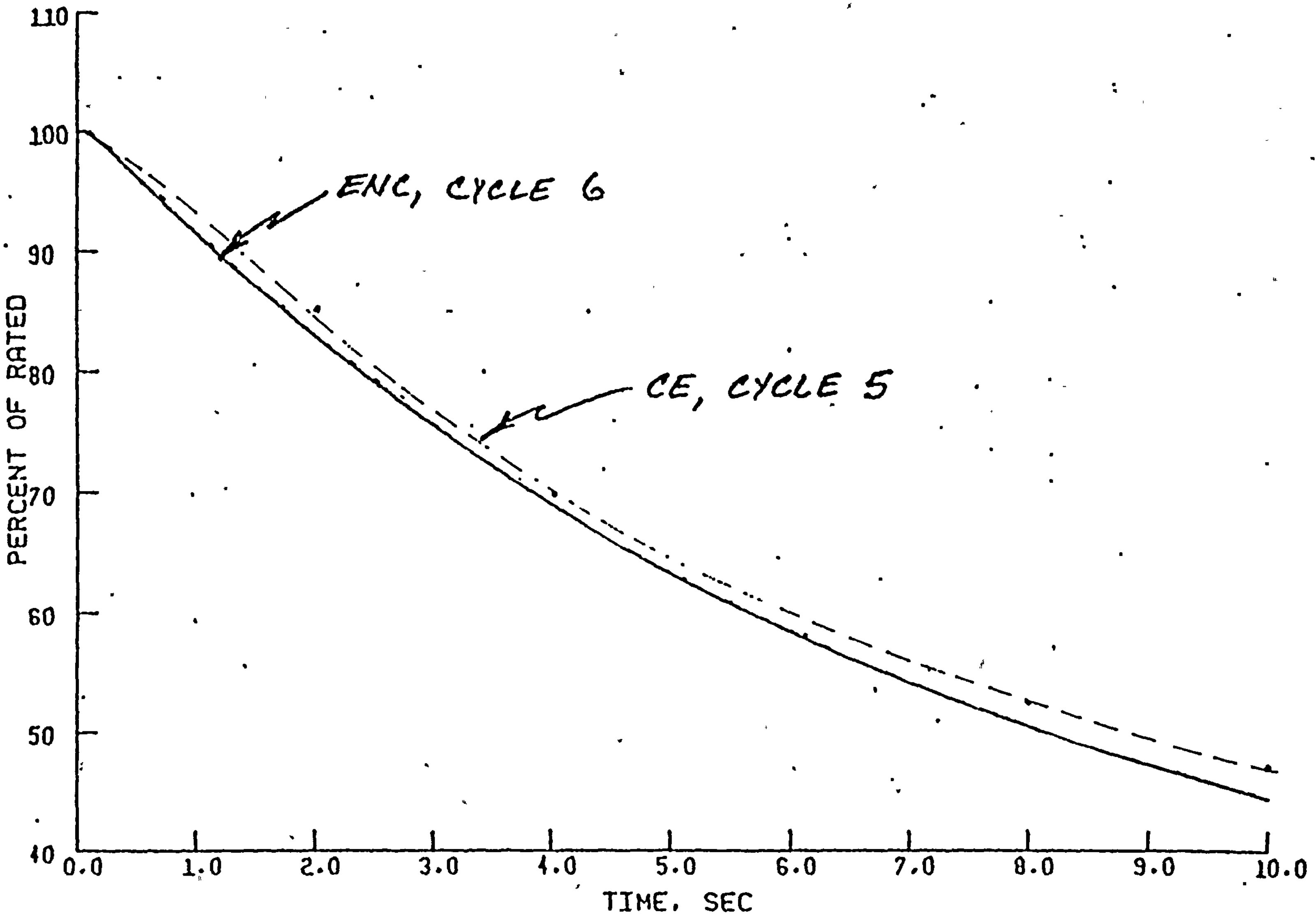

FIGURE (1)

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CEA DROP – DNBR vs TIME

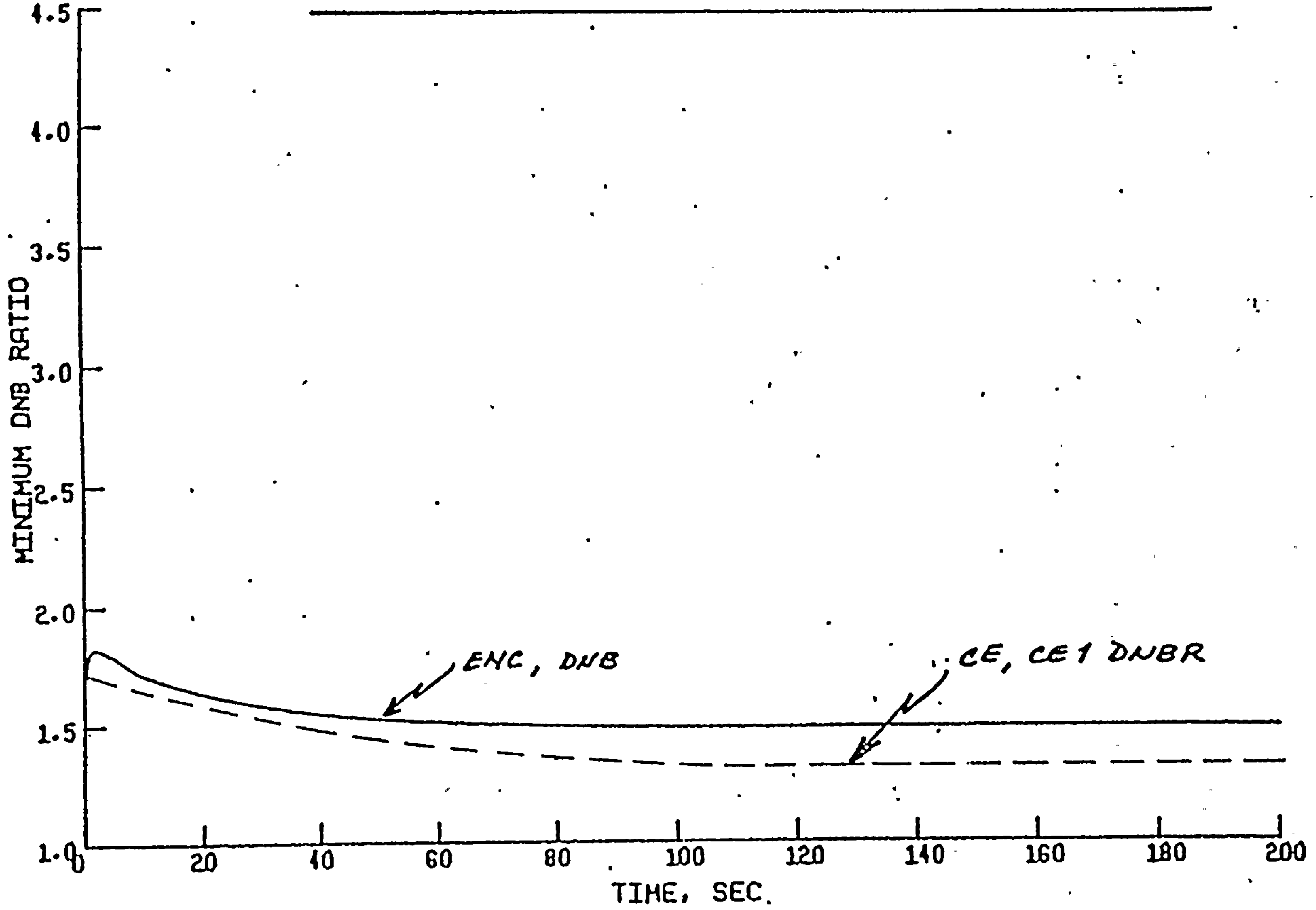

FIGURE (2)

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CEA DROP - CORE POWER vs TIME

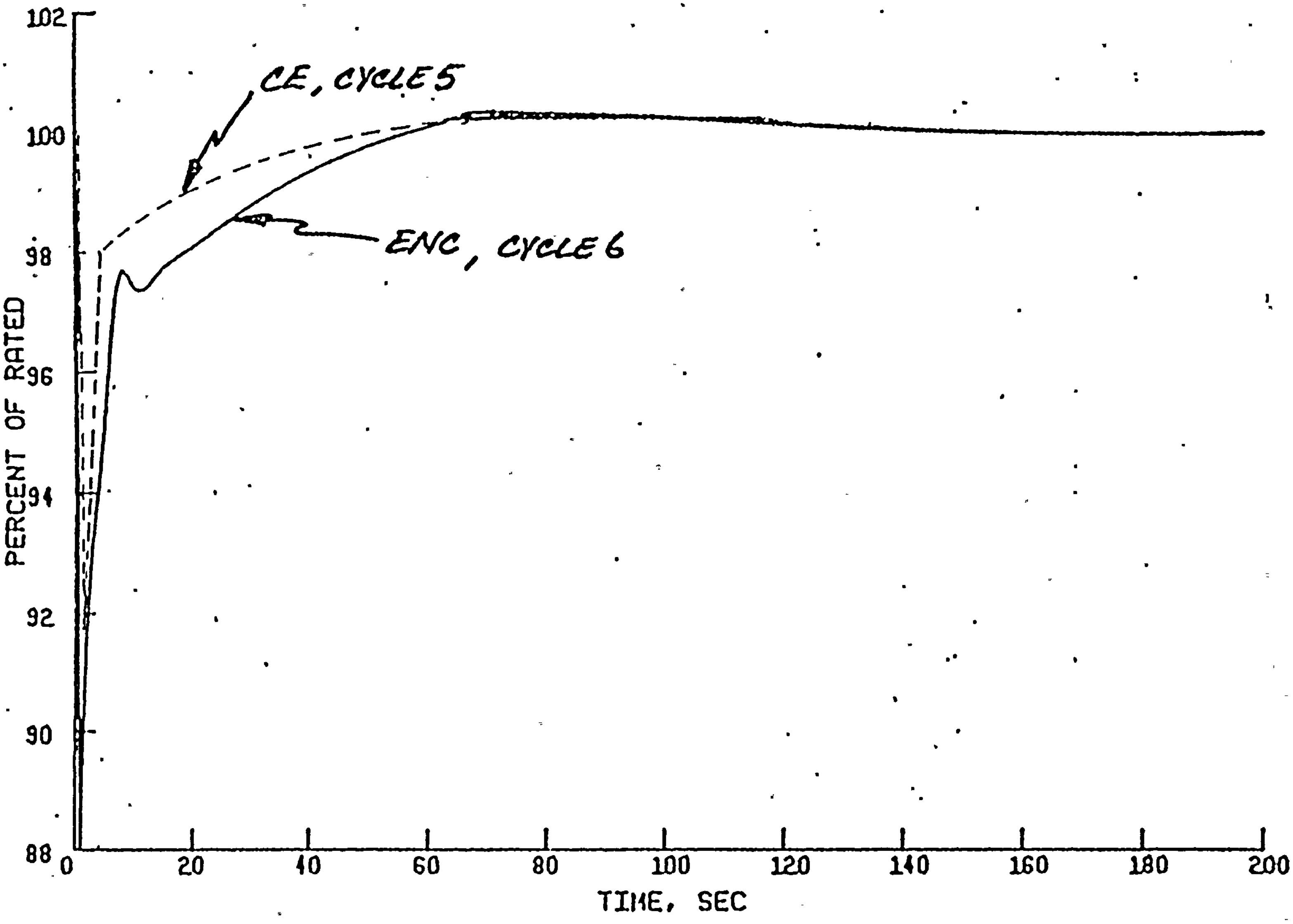

FIGURE (3)

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LOSS OF LOAD

RCS PRESSURE DIFFERENTIAL VS. TIME

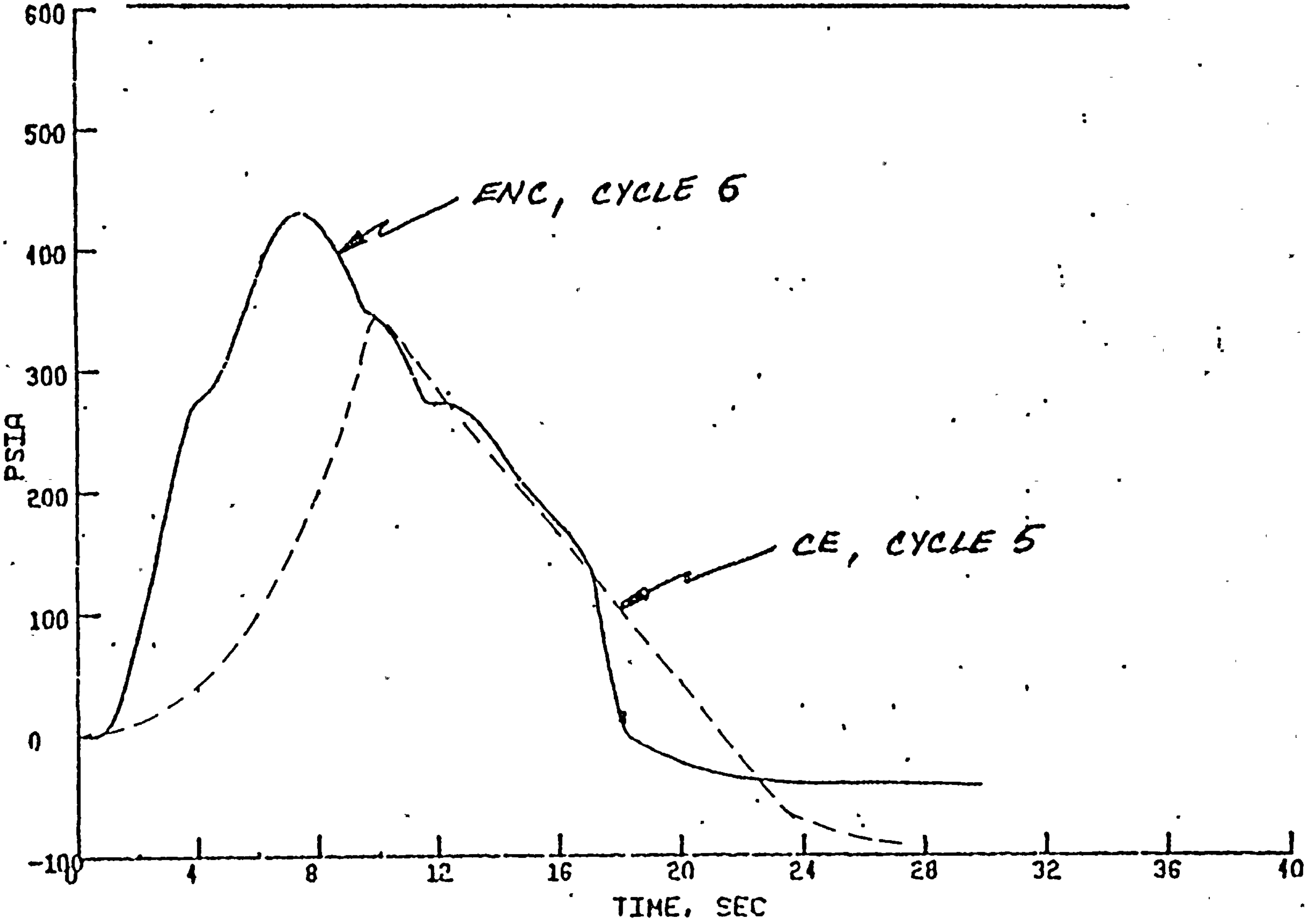

FIGURE (4)

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MSLB – BORON INJECTION vs. TIME

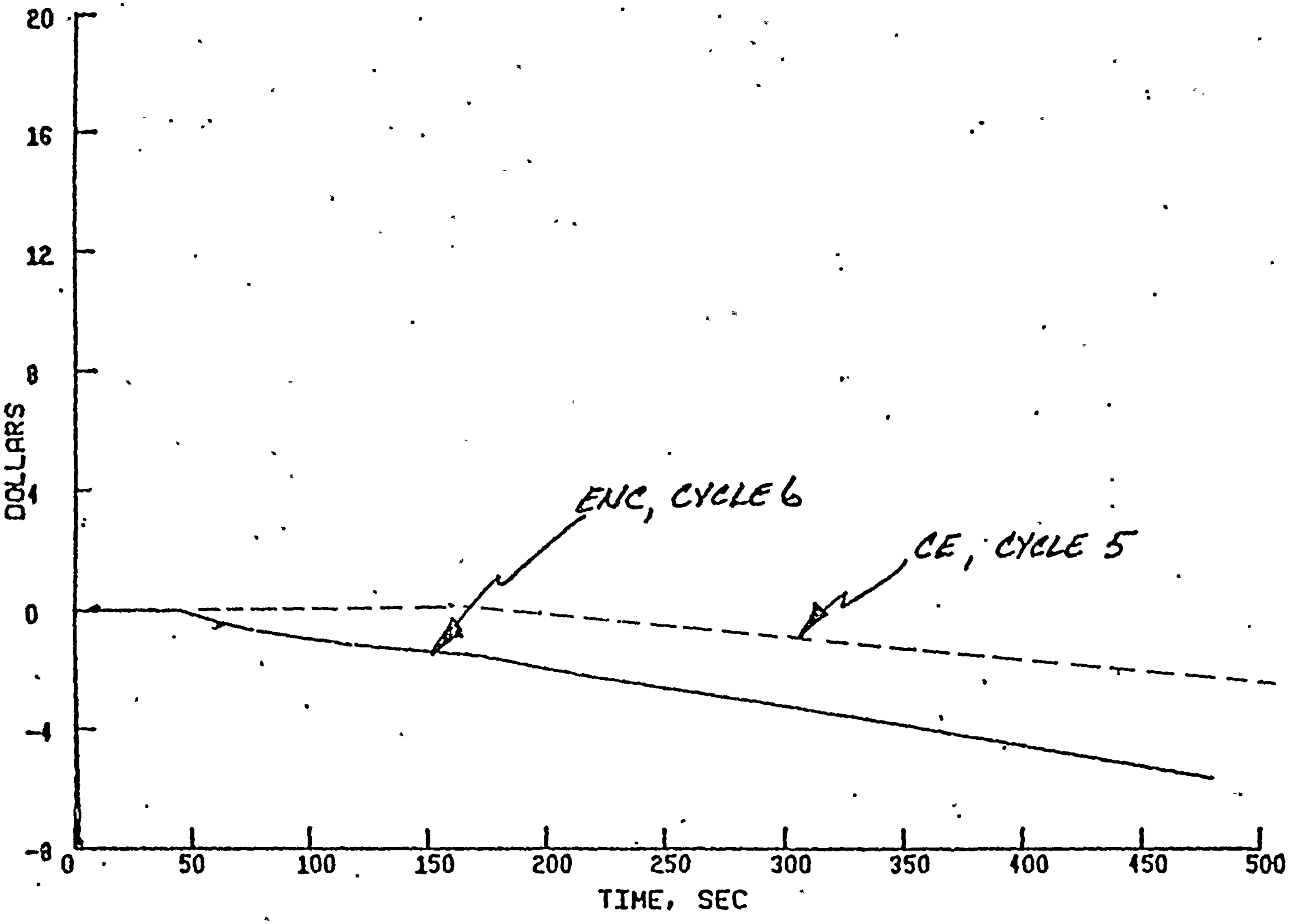

FIGURE (5)

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RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION ON CYCLE 6 RELOAD CONCERNING PERFORMANCE OF COMBUSTION ENGINEERING FUEL

EOL INTERNAL FUEL ROD PRESSURES FOR C.E. AND ENC FUELS

RODEX2/DOCT82 calculations were performed for St. Lucie Unit 1 to determine end-of-life internal fuel rod pressures for both C.E. and ENC fuel. The RODEX2 code is currently under NRC review, with final review expected in the summer of 1983. The analyses were performed in accordance with procedures described in XN-NF-81-58(P), Supplement 1, Revision 2. For peak rod burnups to 51,700 MWD/MTM for ENC fuel and to 50,600 MWD/MTM for C.E. fuel, the fuel rod internal pressure remains below the system operating pressure of 2250 psia.

ROD BOW PENALTY FOR C.E. FUEL AT HIGH BURNUP

The rod bow penalty for C.E. fuel was calculated for high burnup (44.5 GWD/MTM peak assembly) using NRC guidelines. The resulting incremental penalty to be applied to the XNB correlation was 1.35% greater for C.E. fuel than Exxon fuel. Had the Exxon methodology been used, neither fuel type would experience a DNB penalty due to rod bow.

In the St. Lucie Cycle 6 SAR (XN-NF-82-81), the Exxon fuel assembly was found to have a 6.0% lower MDNBR than the limiting C.E. bundle for Cycle 5 due to flow diversion from the Exxon bundles to C.E. bundles. The Cycle 6 MDNBR for C.E. fuel is 2% higher than for Cycle 5. Therefore, the application of 1.35% rod bow penalty to the C.E. fuel rod will not make it more limiting than ENC fuel analyzed for Cycle 6. The MDNBR analysis for Cycle 6 bounds operation of Exxon and C.E. fuels for future cycles.

ATTACHMENT 3
RESPONSE TO NRC REQUEST FOR POST IRRADIATION SURVEILLANCE DATA TO SUPPORT ST. LUCIE UNIT 6 TECHNICAL SPECIFICATION CHANGE TO REMOVE AUGMENTATION FACTORS

The exposure record of ENC fuel, taken together with fuel performance data obtained over a wide range of exposures, indicates that axial column gap formation and subsequent creep ovality are not an inherent problem with ENC designs. Supporting data is detailed below, drawn from profilometry measurements, eddy current tests, and visual examination.

Profilometry measurements have been obtained on 40 PWR rods measured repeatedly throughout their irradiation life. A group of 20 rods, 0.424 inch in diameter, from a single assembly at the HB Robinson reactor have been subjected to diameter measurements after being withdrawn from the assembly. These rods have shown continued creepdown to 0.67% (0.0028") after five cycles of exposure, at an assembly average burnup of 47,700 MWD/MTU. These rods averaged 0.64% and 0.56% creepdown at 40,200 and 32,600 MWD/MTU, respectively. Ovality calculations on the measurements taken at 47,700 MWD/MTU indicate a typical ovality of 0.00045 inches excluding spacer locations, or approximately 0.00180 inches including spacers.

An additional 20 rods in a single assembly at Biblis-A, also 0.424 inch in diameter, have been measured while in the assembly with a profilometer placed against the rods. These rods show a maximum creepdown of 0.97% (0.0041") at 39,600 MWD/MTU after four cycles, with only 0.80% the preceding cycle at 31,400 MWD/MTU.

None of the profilometry data obtained reveals significant cladding deformation which might precede collapse or indicate the presence of pellet column gaps. This is supported by rod growth data, which is consistent for both BWR and PWR fuel, and indicates no ratcheting or severe mechanical pellet-clad interactions suggesting the presence of pellet stack gaps into which cladding might subside. In excess of 3,000 irradiated rods have been withdrawn and tested with an eddy current coil during repair and inspection campaigns. Each rod is tested by being drawn through an encircling eddy current coil exceeding the rod diameter by 30 to 50 mils. No interference has been encountered between the coil and the fuel rod cladding, indicating the absence of large ovality of all the rods tested.

Visual examinations have been performed on approximately 130 irradiated PWR assemblies at burnups between 9,000 annd 48,000 MWD/MTU. In excess of 7,000 peripheral rods have been found to be free of visible defects. No cladding deformation has been observed on the unfailed rods examined.

The PWR fuel examination results, collected both from individual rod measurements and from assembly examinations, are included with the data catalog in Table 1. The data, taken together with the previously submitted BWR rod gamma scan and densification data and with the generic fuel rod evaluation, substantiates the conclusions that significant axial gaps and subsequent clad creep ovality do not occur in ENC fuel.

TABLE. 1. PWR FUEL EXAMINATION DATA

DATA TYPE	NO. OF RODS	NO. OF REACTORS	EXPOSURE GWD/MTU	RESULTS
PROFILOMETRY	20	1*	32.6-47.7	CONTINUED CREEPDOWN TO 0.67% AT FAST FLUENCE OF 7.7X10E21 N/CM2; OVALITY OF 0.45 MILS
	20	1**	31.4-39.6	CREEPDOWN TO 0.97% AT FAST FLUENCE OF 6.36M10E21 N/CM2
EDDY CUURRENT	>3,000	5	9.0-47.7	NO ABNORMAL CLADDING FEATURES DETECTED
VISUAL	>7,000	12	9.0-47.7	NO EVIDENCE OF CREEP COLLAPSE OR OF SIGNIFICANT DEFORMATION

---

* H. B. ROBINSON
**BIBLIS-A

CREEP COLLAPSE EVALUATION

A cladding creep collapse analysis was performed for the fuel rod design configuration described in the St. Lucie Unit 1 FSAR. The calculations were performed with the RODEX2 and COLAPX codes in accordance with the methods used for the previous ENC fuel rod cladding creep collapse analysis for St. Lucie.

The RODEX2 analysis was performed with the minimum fill gas pressure, maximum fuel densification, minimum statistical cladding wall thickness and nominal pellet dimensions. The reactor coolant, fuel rod internal temperature, and pressure histories generated by the RODEX2 analysis were input to the COLAPX code along with the maximum statistical initial cladding ovality and the fast flux history, corresponding to a peak assembly burnup of 45,000 MWD/MTU. The COLPAX code calculated by large deflection theory the ovality of the cladding as a function of time, while the uniform cladding creepdown was obtained from the RODEX2 analysis.

The ENC Design Criteria for cladding creep collapse requires that the ovality increase and creepdown be summed, and at a rod average burnup which is beyond the point of complete fuel densification, the total creepdown shall not exceed the initial minimum diametral fuel cladding gap. The analysis showed that at a rod average burnup of 8,500 MWD/MTU (which is greater than the 6,000 MWD/MTU criteria), the combined creepdown of .0038 inch is less than the initial minimum diametral fuel cladding gap of .0055 inch.

Visual examination and failure performance of the existing fuel assemblies in St. Lucie after three cycles of irradiation with exposures to 35,500 MWD/MTU show no evidence of cladding creep collapse. In addition, the burnups achieved are higher than the calculated exposures at which axial gaps could have caused creep collapse. This further supports the evaluation which predicts the axial gaps in the fuel were closed by the time fuel densification was complete.

Using the ENC calculational methods, the results showed that fuel of the existing St. Lucie configuration would comply with the ENC design criteria for creep collapse for peak assembly burnups up to 45,000 MWD/MTU.