SOUTHERN CALIFORNIA EDISON, SAN ONOFRE
NUCLEAR GENERATING STATION 2 AND 3 (SONGS 2 & 3)

DOCKETS 50-361 AND 50-362

ADDENDUM TO CEN-291(S)-NP

RESPONSE TO NRC QUESTIONS ON SONGS-2 CYCLE 2

JANUARY, 1985

COMBUSTION ENGINEERING, INC.
NUCLEAR POWER SYSTEMS
POWER SYSTEMS GROUP
WINDSOR, CONNECTICUT

SONGS 2 CYCLE 2

NRC QUESTIONS AND ANSWERS

ROUND #4

Question 1

Verify that the 1.5% fuel pin failure resulting from the increased main steam flow event with a concurrent single failure is based on the assumption that all rods reaching a DNBR less than 1.31 fail.

Response

The 1.5% fuel pin failure resulting from the Increased Main Steam Flow Event with a concurrent single failure is not based on the assumption that all rods reaching a DNBR less than 1.31 fail. The method that was used to calculate the pin failure is consistent with the DNB convolution method used on previous C-E FSARs and Reload Analysis Reports. The DNB convolution method accounts for the probability of DNB occurring as a function of the DNBR value. The total number of rods which are predicted to experience DNB is a summation over the reactor core of the number of rods with a specific DNBR (using the CE-1 correlation) times the probability of DNB at that DNBR. This method is described in the C-E Loss of Flow topical report (Reference 1) and, under the conservative assumptions employed in the safety analysis, yields the percentage of fuel failure which will not be exceeded at a 95% probability/95% confidence level.

C-E believes that this method is applicable to all C-E fueled plants and to all Design Basis Events that result in calculated fuel pin failures (Reference 2). NRC approval of the DNB convolution technique for calculating fuel failure for the CEA Ejection and Seized Rotor Events is summarized in the Safety Evaluation Reports for St. Lucie 2 and System 80 (References 3 through 6). NRC also provided generic approval of the DNB convolution method for the Seized Rotor Event in the Loss of Flow topical report (References 1 and 7).

For the CEA Ejection analyses, which are characterized by core power increases, NRC reviewed in detail the applicability of the DNB convolution method to both the St. Lucie 2 and CESSAR System 80 plants (References 3 and 5). That review showed that, for both plant designs, the DNB convolution method yielded substantially higher fuel failure predictions than would an NRC-preferred method based on fuel rod energy deposition (Reference 8). Since the NRC review covered two different plant designs and showed the conservatism of the DNB convolution method for both designs, C-E believes that the NRC has confirmed the validity of the DNB convolution methodology in the CEA Ejection analysis for C-E fueled plants.

C-E also believes that the DNB convolution methodology is applicable to other events whose characteristic core power increases and coolant flow decreases fall within the bounds of those for the CEA Ejection and Seized Rotor events, specifically reviewed by NRC as described above. This belief was confirmed, in C-E's opinion, when NRC reviewed and accepted the fuel failure predictions for the Steam Line Break analysis in the St. Lucie 2 FSAR (page 15-25 of Reference 3). That event was characterized by a moderate (~35%) power increase followed by a loss of core flow. The DNB convolution method was used to predict the extent of fuel failures for that analysis. The Increased Main Steam Flow (Excess Load) Event with a concurrent single failure (loss of core flow), referred to in this NRC Question 1, has a core power increase (~26%) and a loss of core flow which are within the bounds of the CEA Ejection and Seized Rotor events reviewed by NRC, as described above. Therefore, C-E believes that the DNB convolution methodology is clearly applicable to the Increased Main Steam Flow event. This methodology results in a prediction of 1.5% fuel failures, which corresponds to 4.0% fuel with a DNBR less than 1.31.

References

1. "Loss of Flow C-E Methods for Loss of Flow Analysis," Combustion Engineering, Inc. CENPD-183-A, June 1984.

2. Letter, A. E. Scherer to R. L. Tedesco (NRC), Combustion Engineering, Inc. LD-81-047, August 20, 1981.

3. Safety Evaluation Report, St. Lucie Unit 2 - Docket No. 50-389, NUREG-0843, October 1981 (page 15-11).

4. Safety Evaluation Report, St. Lucie Unit 2 - Docket No. 50-389, NUREG-0843, Supplement 2, September 1982 (page 15-1).

5. Safety Evaluation Report, CESSAR System 80, Docket STN 50-470, NUREG-0852, November 1981 (page 15-12).

6. Safety Evaluation Report, CESSAR System 80 Docket STN 50-470, NUREG-0852, Supplement 2, September 1983 (page 15-15).

7. NRC Letter, Harold Bernard to A. E. Scherer (C-E), May 12, 1982.

8. NRC Letter, Dennis M. Crutchfield to W. G. Counsil (Connecticut Yankee Power Company), March 23, 1982.

Question 2

Why has environmental degradation of sensor input to the CPCs and pressure measurement systems been assumed for the steam line break event inside containment with a loss of AC power whereas for the previous cycle, the event was followed by a low DNBR trip initiated by the CPCs?

Response

We believe that the CPCs will function during a Steam Line Break (SLB) event and that an earlier trip will consequently occur resulting in less severe consequences than shown in the current licensing analysis. The SLB events for which a CPC trip would be advantageous are relatively small line breaks for which only minimal environmental degradation of sensor impact would be expected. However, for plants more recently licensed (Palo Verde), questions on the effect of the steam environment on the uncertainties of the various sensors that input into the CPC have been raised. Because of the difficulty of demonstrating that there would be no significant degradation of the sensor performance in this steam environment, at this time it has been conservatively assumed that the CPCs are not the primary trip.

Question 3

With regard to the CPC software change where a CPC trip is initiated when the pump speed falls below 95% for a loss of flow event, provide the following:

(a) A comparison between the CPC and the CESEC (Safety Analysis) Calculations on the time to reach 95% pump speed and flow rate.

(b) A comparison of the time-to-trips between the old method of DNBR trip and the new pump speed trip.

Response

(a) The Cycle 2 time to reach 95% flow rate was 0.80 seconds for the CESEC (Safety Analysis) Calculation, whereas, the time to reach the 95% pump speed is 0.65 seconds for the CPC Calculation. Thus, a CPC trip would occur before the time assumed in the safety analysis.

(b) The Safety Analysis time to trip for the most adverse (fastest) flow coastdown is 0.60 seconds for the old method of the DNBR trip and 0.80 seconds for the new pump speed trip. The Cycle 2 CPC time to trip for the most adverse flow coastdown is 0.65 seconds for the new pump speed trip. This time to trip is independent of the pre-event CPC thermal margin. The time to trip for the old method (flow projection) of DNBR trip is dependent on the initial CPC thermal margin. At a power operating limit (POL) the most adverse flow coastdown would result in a trip in $\leq$0.15 seconds. Under conditions of higher initial CPC thermal margin, the old method of DNBR trip could be delayed by as much as several seconds.

Question 4

The underflow fraction (UFF) from the loss of flow event is used in COLSS for the calculation of overpower margin. This overpower margin is credited to compensate for some margin required of other events such as rod drop event. Therefore, the use of UFF in the COLSS OPM calculation and the values of UFF as a function of axial shape index should be clarified in the Technical Specification Bases.

Response

A modified version of Technical Specification Bases 3/4.2.4 is attached. The suggested changes clarify the use of the Underflow Fraction (UFF) in COLSS and provide a definition of the UFF.

AZIMUTHAL POWER TILT - T_q (Continued)

T_q is the peak fractional tilt amplitude at the core periphery

g is the radial normalizing factor

θ is the azimuthal core location

θ_o is the azimuthal core location of maximum tilt

P_{tilt}/P_{untilt} is the ratio of the power at a core location in the presence of a tilt to the power at that location with no tilt.

3/4.2.4 DNBR MARGIN

delete

The limitation on DNBR as a function of AXIAL SHAPE INDEX represents a conservative envelope of operating conditions consistent with the safety analysis assumptions and which have been analytically demonstrated adequate to maintain an acceptable minimum DNBR throughout all anticipated operational occurrences, of which the loss of flow transient is the most limiting. Operation of the core with a DNBR at or above this limit provides assurance that an acceptable minimum DNBR will be maintained in the event of a loss of flow transient.

any Anticipated Operational Occurrence (AOO)

delete

Either of the two core power distribution monitoring systems, the Core Operating Limit Supervisory System (COLSS) and the DNBR channels in the Core Protection Calculators (CPCs), provide adequate monitoring of the core power distribution and are capable of verifying that the DNBR does not violate its limits. The COLSS performs this function by continuously monitoring the core power distribution and calculating a core operating limit corresponding to the allowable minimum DNBR. Reactor operation at or below this calculated power level assures that the limits of Figure 3.2-1 are not violated. The COLSS calculation of core power operating limit based on the minimum DNBR limit includes appropriate penalty factors which provide, with a 95/95 probability/confidence level, that the core power limit calculated by COLSS (based on the minumum DNBR limit) is conservative with respect to the actual core power limit. These penalty factors are determined from the uncertainties associated with planar radial peaking measurement, engineering design factors, state parameter measurement, software algorithm modelling, computer processing, rod bow and core power measurement.

¶

Add Insert

Parameters required to maintain the margin to DNB and total core power are also monitored by the CPCs. Therefore, in the event that the COLSS is not being used, operation within the limits of Figure 3.2-2 can be maintained by utilizing a predetermined DNBR as a function of AXIAL SHAPE INDEX and by monitoring the CPC trip channels. The above listed uncertainty penalty factors plus those associated with startup test acceptance criteria are also included in the CPC's which assume a minimum core power of 20% of RATED THERMAL POWER. The 20% Rated Thermal Power threshold is due to the neutron flux detector system being inaccurate below 20% core power. Core noise level at low power is too large to obtain usable detector readings.

INSERT TO BASES 3/4.2.4 DNBR MARGIN

"... includes allowances for the margin required to assure that the minimum DNBR will be maintained above the DNBR limit in the event of any AOO. This allowance is provided by a combination of the Underflow Fraction and the Power Operating Limit Bias. The Underflow Fraction (UFF) is a precalculated reduction factor applied to the COLSS measured core flow rate as a function of axial shape index. When the Loss of Flow event is the limiting AOO, the UFF is the fraction of flow at the time of minimum DNBR. Should another AOO be more limiting at a given axial shape index, then the UFF could be reduced appropriately to reserve additional margin to the DNBR SAFDL. The alternative is to adjust the Power Operating Limit Bias to allow for the additional thermal margin which is required. The Power Operating Limit (POL) Bias is a direct penalty on the COLSS POL calculation applied as a function of measured core power. The POL Bias term could be used to reserve thermal margin above that set aside by the UFF. Use of the POL Bias is especially convenient for events such as single CEA drops, where the margin requirements are core power level dependent. In addition, the COLLS calculation of the core POL ..."

Question 5

The value of the addressable constants BERR0, BERR1, ------ to BERR4 in the SONGS-2 CPC data base listing (CEN-266(s)-P, Rev. 01) are inconsistent with the values calculated in the SCU report (CEN-283(s)-P, Part 2). It is understood that the correct values from Part 2 of CEN-283 will be used during plant operation.

(a) What is the effect of using the incorrect BERRs values in the CPC functional test?

(b) Do the CPC trip times used in the safety analyses bound the true time of trip initiated by the CPC using the correct BERRs values?

(c) Provide a comparison between the CPC trip times using the correct BERRs values and the trip times assumed in the safety analyses for those events where a credit of CPC trip is taken.

Response

(a) The choice of BERR values does not affect the conclusion of the Phase I and II testing. The final testing compares the on-line single channel CPC with the CPC FORTRAN Simulator to verify the correct implementation of the new software. The only constraint on the BERRi values is that they are consistent.

(b) The trip times assumed in the safety analyses would bound the trip times calculated using the CPC FORTRAN Simulator and the BERRi values taken from CEN-283(S)-P. The procedure used to determine the CPC trip in the safety analysis guarantees that this is true. The BERRi terms are allowances for measurement and CPC system uncertainties. When incorporated into CPC, the BERRi terms reduce the CPC calculated margin, and hence result in an earlier trip than if these terms were absent. The safety analysis is performed with the BERRi terms absent. This consequently results in a delayed trip in the safety analysis and ensures that the safety analysis bounds the trip times which would be calculated using the CPC FORTRAN Simulator and the Cycle 2 BERRi values.

(c) As discussed in response to Question 5(b), the safety analysis is performed without incorporating the BERRi allowances into the CPC simulator; this results in a later trip in the safety analysis since the incorporation of BERRi terms would increase the conservatism of the CPC's and hence result in an earlier trip. Since a CPC trip must occur at or prior to that assumed in the safety analysis when the actual values of the BERRi terms are incorporated (because their incorporation reduces CPC calculated margins compared to that in the safety analysis), calculations to determine the time trips with the actual BERRi terms are not normally performed. However, we have estimated the time to trip for the Increased Main Steam Flow with a concurrent single failure event using actual BERRi terms; nominally the CPC will trip at least 5 seconds earlier than that shown in the safety analysis.

Question 6

The CPC Phase II Test Report (CEN-269(s)-P, Rev. 02) indicates that two dynamic software verification test (DSVT) cases have test results outside of their acceptance criteria. In case 23-1 the local power density result is less than the minimum acceptable value by 0.02%, and in case 26 the LPD trip time exceeds the maximum acceptable value by 0.08%. Even though the deviations are so small that you do not consider them as indication of software implementation error, a thorough investigation is required to determine the causes of deviation and determine if there is indeed no implementation error.

Response

A thorough investigation of the results of test cases 23-1 and 26 were again performed. The results of this investigation are described in the following paragraphs.

COMBUSTION ENGINEERING, INC.

ENCLOSURE 2