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April 12, 1976

BECo. Ltr. #76-31

Director of Nuclear Reactor Regulation
ATTN: D. L. Ziemann, Chief
Operating Reactors Branch #2
Division of Reactor Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Docket No. 50-293
License No. DPR-35

Additional Information Regarding
Single Loop Operation Submittal

Dear Sir:

In a letter dated March 29, 1976, you requested additional information concerning the request for approval for single loop operation as submitted by Boston Edison on November 17, 1975. This information has been provided by General Electric Company and is hereby submitted. The questions and responses are numbered as were the questions in Enclosure A to your March 29, 1976, letter.

Question 1. The additional information on the stability analysis presented in Supplement 1 to NEDO-20999 is not clear. Provide a curve of Decay Ratio versus Power similar to NEDO-20855-01 Figure 7-19 for single loop operation.

Response 1. A rewrite of Section 5 is given below.

5. STABILITY ANALYSIS

The least stable power/flow condition attainable under normal conditions occurs at natural circulation with the control rods set for rated power and flow. This condition may be reached following the trip of both recirculation pumps. Operation along the minimun forced recirculation line with one pump running at minimum speed is more stable than operating with natural circulation flow only, but is less stable than operating with both pumps operating at minimum speed. The core stability along the forced circulation, rated rod pattern line for single loop operation is the same as that for both loops operable except that rated power is not attainable. Hence, the core is limited to maximum power for single pump operation and only manual flow control should be used. This is illustrated in Figure 5-1.

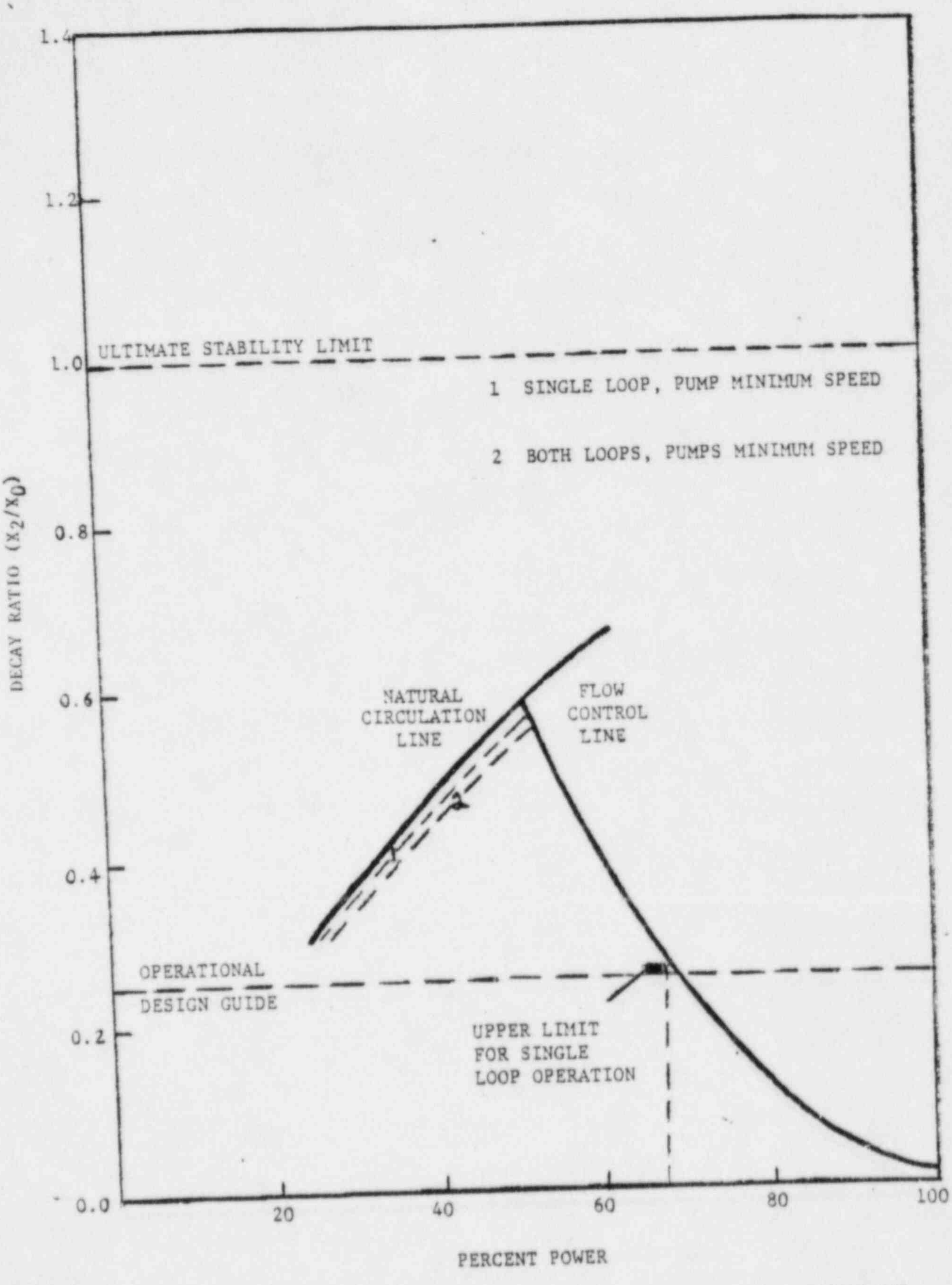

FIGURE 5-1 DECAY RATIO VERSUS POWER CURVE FOR TWO-LOOP AND SINGLE-LOOP OPERATION.

Question 2. At the NRC, GE, BECo. meeting on January 24, 1976, it was requested that more justification be provided to show that a small break could not be limiting one pump operation as in a non-jet pump plant. This has not been done. Please provide a discussion showing that reflood will take place before the crossover period.

Response 2. Add the following after the fourth paragraph of Response to Question B8A of the BECo. Letter dated March 19, 1976:

"...which compares the reflooding time for a late reflooding BWR versus PCT turnover time for a non-jet pump BWR"

Since reflooding for smaller breaks occurs much earlier than PCT turnover, the PCT for smaller breaks will be substantially less (at least 200-300°F less) for single-loop operation in jet pump plants than for a comparable break in a non-jet pump plant. Thus, the MAPLHGR for single-loop operation in jet pump BWR's will be limited by the maximum size break, and not by a smaller break as is currently the case for non-jet pump plants.

For single loop operation, immediate (0.1 sec.) loss of nucleate boiling is assumed independent of break size. Thus, the initial temperature response is identical for breaks of different sizes. The larger break uncovers earlier and therefore it has a higher temperature after the time of uncovery for the large break. Very late in the transient, the later spray initiation for the case of the smaller break causes the temperature difference between the large and small to be reduced. However, reflooding occurs at early enough times such that the larger break has the higher temperature. Specific detailed calculations have shown this to be the case (see NEDO-20999, Section 2.2.5).

Attached are plots (Table 2-1 and Figure 2-1) of peak cladding temperature versus time that are calculated with the single loop ECCS analysis for various sized breaks.

Question 3. The response to question B16 is incomplete. Provide a basis for increasing the core flow uncertainty to 6.0% for one loop operation. If the method of establishing the core flow uncertainty differs from that used in NEDO-20340, provide an equivalent analysis for single loop operation.

Response 3. The uncertainty analysis procedure used to establish the core flow uncertainty for one pump operation is basically the same as for two pump operation, except for some extensions. The core flow uncertainty analysis is described in References 1 and 2. The analysis of one pump core flow uncertainty can be summarized as follows:

PEAK CLADDING TEMPERATURE
VERSUS TIME
FOR VARIOUS SIZE BREAKS
FOR SINGLE LOOP OPERATION

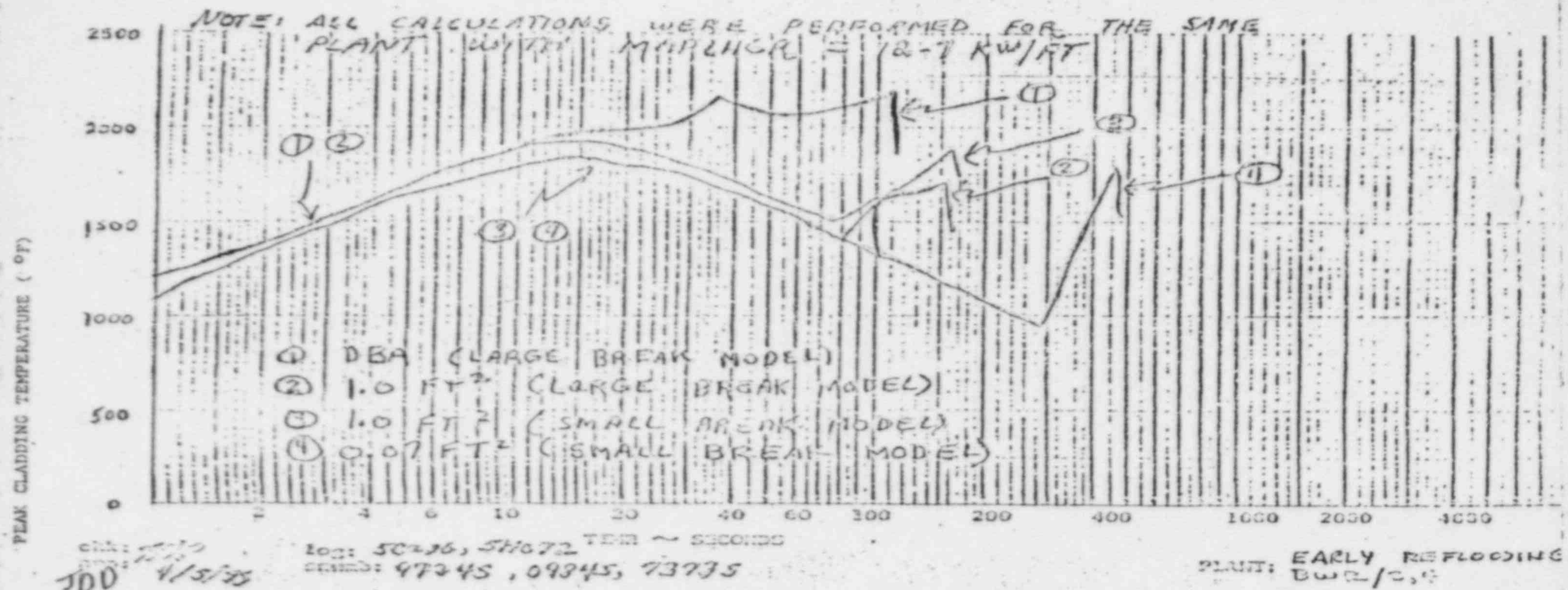

FIGURE 2-1

TABLE 2.1

COMPARISON OF KEY

PARAMETERS FOR VARIOUS BREAK

SIZES FOR SINGLE-LOOP ECCS ANALYSIS*

PARAMETER	DBA (LARGE BREAK MODEL)	1.0 FT^2 (LARGE BREAK MODEL	1.0 FT^2 (SMALL BREAK MODEL)	.07 FT^2 (SMALL BREAK MODEL)
Boiling Transition Time (sec)	0.10	0.10	0.10	0.10
Uncovery Time (sec)	25	85	85	290
Core Spray Cooling Time (sec)	34	95	95	--
Reflooding Time (sec)	107	154	160	457
Peak Cladding Temperature (°F)	2200	1925	1900	1830

* All calculations performed for the same plant with MAPLHGR = 12.7 $\frac{kw}{ft}$

a. During one pump operation, the core flow is measured by the following formula:

$$\begin{pmatrix}\text{Total}\\ \text{Core}\\ \text{Flow}\end{pmatrix} = \begin{pmatrix}\text{Active Loop}\\ \text{Indicated Flow}\end{pmatrix} - C \begin{pmatrix}\text{Inactive Loop}\\ \text{Indicated Flow}\end{pmatrix}$$

$$= \left(\frac{\Delta P}{K_{forward}}\right)^{\frac{1}{2}} - \left(\frac{K_{forward}}{K_{reverse}}\right)^{\frac{1}{2}} \left(\frac{\Delta P}{K_{forward}}\right)^{\frac{1}{2}}$$

The constant "C" is required to modify the inactive loop flow indication since the jet pump diffuser flow coefficient is different for reverse flow compared with the forward flow coefficient used for the core flow instrumentation calibration.

b. The core flow uncertainty analysis must now account for the uncertainty in "C". The value of "C" has been determined analytically, using a conservative bounding analysis; therefore, the core flow input to the process computer during one pump operation has a conservative bias, since "C" was analyzed in a conservative manner. However, the following uncertainty analysis is based on the uncertainty in the true (or nominal) value of "C", not the uncertainty in the conservative value of "C" used in the reactor flow measurement.

"C" can be defined as:

$$C = \left(\frac{K_{forward}}{K_{reverse}}\right)^{\frac{1}{2}}$$

where:

$K_{forward}$ = The forward flow loss coefficient resulting from in-reactor calibration tests assumed for the analytical derivation of "C".

Note: $K \equiv (\text{flow})^2\ (\Delta P)$

$K_{reverse}$ = The loss coefficient calculated for reverse flow.

Combining the uncertainties in $K_{forward}$ and $K_{reverse}$, it can be shown that

$$\sigma_c \approx 3.42$$

c. Now the effect of this reverse flow coefficient uncertainty must be related to total core flow uncertainty. Assuming that 33%*of the flow in the active (forward flowing) jet pumps backflows through the inactive pumps, it can be shown that:

$$\sigma^2_{W_T} = \sigma^2_{W_A} + \left(\frac{0.33}{1-0.33}\right)^2 \sigma^2_c$$

where:

σ_{W_T} = the uncertainty in the total core flow.

σ_{W_A} = the uncertainty in the active loop flow.

To produce a conservative, bounding analysis, <u>assume</u> $\sigma_{W_A} = 4.0\%$. Then:

$$\sigma^2_{W_T} = (4.0\%)^2 + \left(\frac{0.33}{1-0.33}\right)^2 (3.42)^2 = (4.34\%)^2$$

When the effect of 4.1% core bypass flow uncertainty at 12% (bounding case) bypass flow fraction is added to the above total core flow uncertainty, the active coolant flow uncertainty is:

$$\sigma^2_{\substack{\text{active}\\\text{coolant}}} = (4.34\%)^2 + \left(\frac{0.12}{1-0.12}\right)^2 (4.1\%)^2 = (4.38\%)^2$$

This verifies the assumption of core flow uncertainties of 6%. Actually, the core flow accuracy is expected to be much better, as shown above.

In summary, core flow during one pump operation is measured in a conservative way, its uncertainty has been conservatively evaluated, and the net effect on MCPR is insignificant.

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*Note: This value can vary from about 20% to 30%, depending on plant type and operating conditions. 33% is a conservative bounding value.

REFERENCES:

1. Letter to Walter R. Butler (AEC/NRC), Subject: Response to the Third Set of AEC Questions on the General Electric Licensing Topical Reports NEDO-10958 and NEDE-10958, "General Electric BWR Thermal Analysis (GETAB): Data, Correlation and Design Application", July 11, 1974.

2. J. F. Carew, "Process Computer Performance Evaluation Accuracy", June 1974, (NEDO-20340)

In addition, your staff requested confirmation that the information contained in a July 24, 1974 letter from Mr. Hines of General Electric to Mr. Butler of the NRC was applicable to Pilgrim. General Electric Co. has confirmed that the appropriate portions of this letter are applicable to Pilgrim, and specifically that at an MCPR of 1.01 there are 1.8 fuel pins which are expected to experience boiling transition.

We believe that this information should be sufficient to allow issuance of your approval of single loop operation for Pilgrim I. However, if you do require additional information, please advise us.

Very truly yours,

G. Carl Andognini

G. Carl Andognini
Manager
Nuclear Operations