BASES:

3.4 STANDBY LIQUID CONTROL SYSTEM

A. The conditions under which the Standby Liquid Control System must provide shutdown capability are identified via the Station Nuclear Safety Operational Analysis (Appendix G). The requirements of this specification are taken from the Operational Nuclear Safety Requirements of subsection 3.8.6 of the Final Safety Analysis Report. If no more than one operable control rod is withdrawn, the basic shutdown reactivity requirement for the core is satisfied and the Standby Liquid Control system is not required. Thus, the basic reactivity requirement for the core is the primary determinant of when the liquid control system is required.

The purpose of the liquid control system is to provide the capability of bringing the reactor from full power to a cold, xenon-free shutdown condition assuming that none of the withdrawn control rods can be inserted. To meet this objective, the liquid control system is designed to inject a quantity of boron that produces a concentration of 700 ppm of boron in the reactor core in less than 125 minutes. 5
The 700 ppm concentration in the reactor core is required to bring the reactor from full power to a three percent Δk subcritical condition, considering the hot to cold reactivity difference, xenon poisoning, etc. The time requirement for inserting the boron solution was selected to override the rate of reactivity insertion caused by cooldown of the reactor following the xenon poison peak.

Feb., 1976

The minimum limitation on the relief valve setting is intended to prevent the loss of liquid control solution via the lifting of a relief valve at too low a pressure. The upper limit on the relief valve settings provides system protection from overpressure.

B. Only one of the two standby liquid control pumping loops is needed for operating the system. One inoperable pumping circuit does not immediately threaten shutdown capability, and reactor operation can continue while the circuit is being repaired. Assurance that the

ATTACHMENT A

Responses to NRC Questions on Pilgrim I Reload 2
Licensing Submittal (NEDO-20855-01)

Question A1: Does BECo. plan to use an operating limit MCPR of 1.31 for 7 x 7 assemblies and 1.39 for 8 x 8 assemblies for the entire cycle?

Response: Yes

Question A2: Provide the cross sectional areas assumed for individual components in the DBA - ie, jet pumps, cleanup loop, etc.

Response: The component flow areas assumed are:

Suction line vessel nozzle area:	3.56 ft^2
Cleanup line area	.08 "
Jet pump (10) nozzle area	.71 "
TOTAL	4.35 ft^2

Question A3: Does a reactor scram occur as the result of a feedwater transient?

Response: In Paragraph 7.3.3.1.6.1 (Page 7-18) of NEDO-20855-01, the peak neutron flux was incorrectly stated as 120% of initial. The corrected statement should be: "Neutron flux increases to a value of 119.8% of initial at 109 seconds." Since the indicated neutron flux does not exceed the scram setpoint of 120%, scram does not occur. A time plot of the transient is shown in Figure 3-1 (attached).

Question A4: Provide a power-flow map for Reload 2 showing a 92% power limit.

Response: The Pilgrim Cycle 3 power/flow map with the nominal 92% flow control line is shown in Figure 5-1, attached. Refer to response to Question A10 for a description of how Pilgrim 1 will operate on the power/flow map to achieve the 92% power, 100% flow endpoint at EOC-3.

Question A5: For the over pressure transient with one relief valve out of service, what steam flow and power level were assumed? Are all other assumptions the same as those assumed in the previous analysis with all valves operable?

Response: The one relief valve out of service analysis was performed at 92% power and steam flow and 100% core flow and all other assumptions are the same as for the analysis with all valves operable.

Question A6: The Rod Withdrawal error transient doesn't appear to follow the core loading maps provided in NEDO20855-01. Clarify the inconsistencies that relate to bundle identification and location on the various core maps and figures provided in support of the RWE transient.

Response: The coordinates of Figure 2-1 of NEDO-20855-01 identify the locations of the fuel bundles and those of Figure 7-12 identify the location of control rods. Location of the control rods in Figure 2-1 may be determined by interpolation.

Erroneous bundle identifications are used in Figures 7-13 through 7-16. Corrections on these figures as well as for Figure 7-12 are given below.

Figure No.	As Shown	Should Be
7-12	"end rod is 35-18"	"Error rod is 18-35"
7-13	11, 11	21, 32
	11, 10	21, 34
	09, 09	17, 36
7-14	12, 12	23, 30
	10, 10	19, 34
7-15	11, 11	21, 32
	9, 9	17, 36
7-16	12, 8	23, 38
	8, 10	15, 34
	10, 10	19, 34

Question A7: Provide an analysis that establishes that a loading error accident does not significantly affect adjacent fuel assemblies.

Response: The fuel loading error analysis has been performed for Pilgrim Reload 2 with bypass flow holes plugged. Subsection 7.3.2.5.2 of NEDO-20855-01 is hereby revised as shown below.

"7.3.2.5.2 Results and Consequences

The analysis of the loading error accident is based on operating MPCR's at the limiting point in the cycle where the "B" scram reactivity curve is still applicable. This results in a peak linear heat generation rate (LHGR) of 16.6 KW/ft and a minimum critical power ratio (MCPR) of 0.96 in the misplaced bundle. This linear heat generation rate is below the value at which 1% plastic strain of the cladding occurs. Fuel damage is not expected to occur with a LHGR lower than that needed to cause a 1% plastic strain in the cladding (see Section 3.2.1 of Reference 1). Therefore, fuel failure is not expected for this event.

Fuel bundles adjacent to the misplaced bundle are insignificantly affected by the presence of the misplaced bundle."

In the above analysis, the Reload 2 8D262 fuel is the limiting bundle. Seven pins are expected to experience boiling transition. Bundles adjacent to the misloaded bundle are isolated by the water gap so that the thermal neutron flux, hence power, is not significantly increased; therefore, the effect on these bundles is considerably less than that for the misplaced bundle.

The operating MCPR over the range of "B" scram curve applicability (1.26 for 7 x 7 fuel and 1.33 for 8 x 8) on which this analysis is based are significantly lower than the ones to be administered throughout Cycle 3 (1.31 for 7 x 7 fuel and 1.39 for 8 x 8; see response to Question A1). The difference in CPR between the operating MCPR and the MPCR of the misplaced bundle is relatively insensitive to the initial value of operating MCPR. Therefore, the MCPR for the loading error identified above is conservative by about 5%; i.e., a MCPR of about 1.01 for the misplaced bundle would be experienced, based on the actual MCPR limits to be administered.

Question A8: Describe the extent, if any, of shuffling of the fuel from the initial core loading and Reload 1 locations. If fuel shuffles are to be made, discuss the applicability of the transient and accident analyses presented for Reload No. 2.

Response: Fuel shuffling assumptions used to design the reference loading pattern for the Pilgrim Reload 2 licensing analysis were as follows:

1. The lowest reactivity bundles were assumed to be discharged. If in actuality others were discharged, the final core configuration will be lower in reactivity than the design reference loading pattern since higher reactivity bundles were discharged.

2. The design of Reload 2 reference loading was based on the lowest projected Cycle 2 shutdown exposure. Hence, extension of Cycle 2 operation would produce a core with a lower reactivity than that presented in the license submittal.

3. It was assumed that any bundle could be shuffled provided the resulting pattern met licensing criteria (e.g., MCPRs. shutdown margin) and fuel cycle criteria (e.g., energy requirement).

4. Quarter core mirror symmetry was maintained as in Cycle 2.

5. The design reference loading was based on the maximum number of Reload 2 bundles which could be loaded at the assumed EOC-2 exposure. Thus, any reduction in the number in the Reload 2 bundles loaded will result in a lower reactivity core than presented in the license submittal.

The criteria to be used in establishing the final loading pattern for Cycle 3 are given as follows:

1. The design reference locations of all Reload 1 and Reload 2 bundles remain unchanged.

2. If the leaker bundle is not one of those bundles originally scheduled for discharge per design reference loading pattern, it shall be replaced by a sound bundle with higher exposure; i.e., lower in reactivity.

3. Maintain greater than 1% shutdown margin (design).

4. Minimum cycle energy requirement shall be satisfied.

Application of the above criteria for establishing the final loading pattern assures that both the reactivity of the four-bundle cell which contains the replaced bundle and the worth of the control rod in that cell will be less than those of the design reference loading pattern. In addition, the extended Cycle 2 operation has made the core average exposure of the final loading pattern higher than that of the design reference loading pattern. The combination of these two factors will make the final laoding pattern more conservative than the design reference loading pattern as far as shutdown margin, rod withdrawal error, and other safety related analyses are concerned. Thus, the transient and accident analyses presented for Reload 2 are applicable.

Question A9: What power level is assumed in Table 5-4? Provide a discussion that this assumption results in the limiting case.

Response: Table 5.4 in NEDO-20855-01 was derived from Pilgrim's rated conditions. The parameters listed therein were used as initial conditions on both the 100% and 92% power level transient analysis listed in Table 5.3. The GETAB evaluations for these transients are not significantly affected by total core power level. The same initial MCPR for different total core power levels can be obtained by adjusting the radial power peaking factor. The transient ΔCPR is evaluated using the relative change in core conditions and is not very sensitive to initial factors such as the value of the radial power peaking factor. Thus a 10% increase in core power, for example, causes the same change in CPR in a bundle at a particular MCPR whether the core power is 90% or 100% of rated. Therefore, the initial conditions in Table 5-4 are applicable for GETAB transient analyses at both 100% and 92% power levels.

Question A10: Are the analyses at the endpoints of 100% power with "B" scram curve and 92% power with "EOC-3" scram curve bounding for all MCPR and pressure transients for all power and burnup combinations shown on Figure 7-11. Provide a description of how Pilgrim I will operate on the power/flow map to achieve the 92% power, 100% flow endpoint of EOC-3.

Response: Figure 7-11 of NEDO-20855-01 shows the resultant maximum power level profile as a function of cycle exposure. The derate schedule is shown as a linear function of fuel exposure connecting the specified calculational operating power limit points. The use of the linear relationship to connect the two calculational points in Figure 7-11 is conservative because the scram reactivity degrades gradually and would thus be a smooth function of core exposure. Thus, for the pressure transients connecting the actual calculational points with a straight line will conservatively maintain a minimum pressure margin of 25 psi since the actual allowable power level would be expected to lie somewhere above this operating limit line. Conservatism is incorporated into the operating MCPR's by imposing the limiting operating MCPRs of 1.31 for 7 x 7 fuel and 1.39 for the 8 x 8 fuel, calculated for the worst degraded condition (end-of-cycle), over the entire cycle. Thus, the analyses at the endpoints of 100% power with "B" scram curve, and 92% power with the EOC-3 scram curve, are bounding for all MPCR and pressure transients for all power and burnup combinations shown on Figure 7-11.

Operation at 100% power level is permissable over the range of "B" scram curve applicability. Beyond that point, 2600 MWD/T into the cycle, the power will be reduced from 100% power to 92% power at EOC-3, limited by the maximum power profile shown on Figure 7-11. This limit will be administered by imposing small step derates, each of which is valid for some incremental exposure. For each derate there will be administered a corresponding nominal power-flow line, interpolated between the nominal 100% flow control line and the nominal 92% flow control line shown on Figure 5-1.

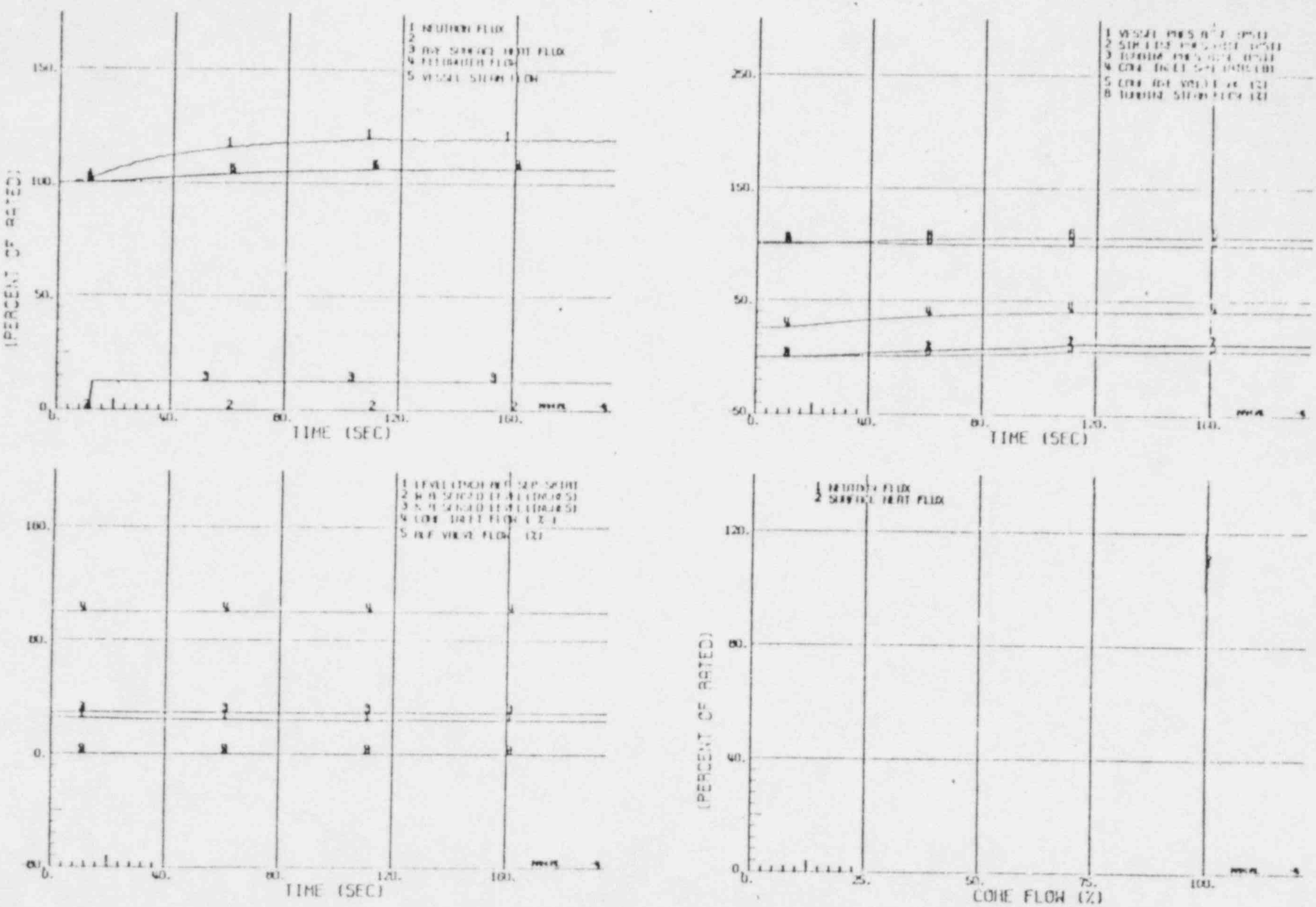

Figure 3-1 HK1 WD03HM001 PILGRIM 1998MWT/FULL CORE FLOW. LOSS OF 100 DEGREE F FW HEATER.

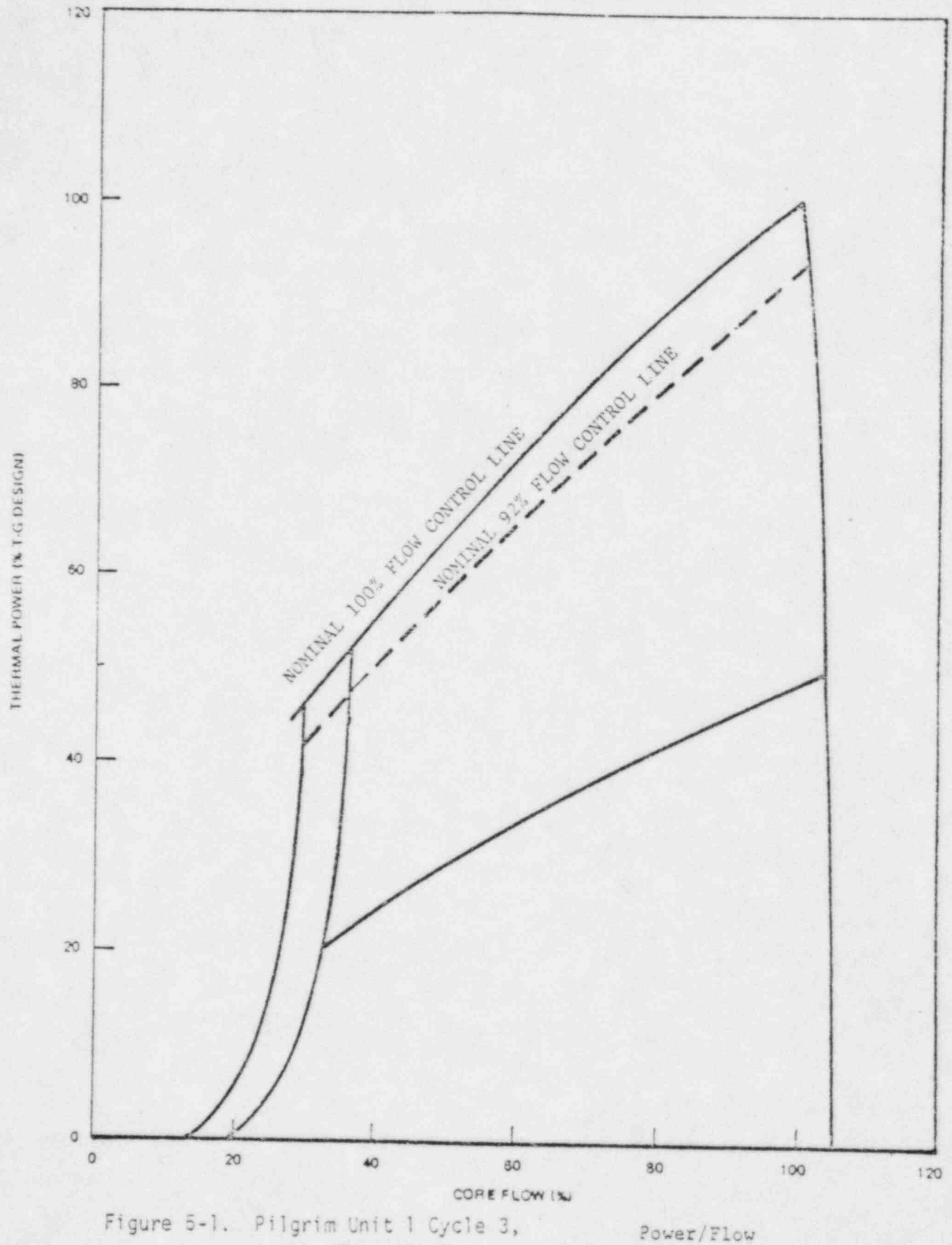

Figure 5-1. Pilgrim Unit 1 Cycle 3, Power/Flow Map with Derated Boundaries

ATTACHMENT B

Responses to NRC Questions on Pilgrim Single Loop Operation (NEDO-20999)

Question B1: Provide the details of the calculations which are used in the evaluation and comparisons of one and two pump operation for BWR/3 and BWR/4 type plants. The information required includes the input MAPLHGRS for one and two pump operation and the ECCS type information such as transient core flow, core pressure, lower plenum enthalpy, MCPR, convective heat transfer coefficient, water level, vessel pressure, peak cladding temperature, and break spectrum curve.

Response: The requested details of the calculations for one and two pump operation are compared in Table 1-1. It is noted that the calculation of the two pump MAPLHGR and peak cladding temperature (PCT) values presented in NEDO-20999 are entirely consistent with the procedures specified in NEDE-20566. The evaluation of MAPLHGR and PCT values for one-pump operation are also consistent with NEDE-20566 with the exception that boiling transition is assumed at 0.1 seconds after the LOCA. The time to boiling transition is provided as input to the one-pump analysis and is not calculated as part of the analysis as is the case in the two-pump analysis.

For two-pump operation, the transient core flow, core pressure, lower plenum enthalpy, and MCPR are calculated, as always, using the LAMB and SCAT computer codes. From these evaluations the duration of nucleate boiling after the LOCA is calculated. For single-loop operation, the transition from nucleate boiling is conservatively assumed at 0.1 seconds. Therefore, the LAMB and SCAT computer codes are not required and are not used in the evaluations for one pump MAPLHGR's and PCT's. With this exception, the heat transfer coefficients used for the evaluation of one-pump and two-pump MAPLHGR's and PCT's are identical. Water level and vessel pressure are calculated by the SAFE/REFLOOD Code for both one-pump and two-pump operation. PCT and break spectrum curves are calculated by the CHASTE (with SAFE/REFLOOD) computer code for both one-pump and two-pump operation.

Question B1A: In particular how are differences in reflood time, spray time and uncovery time used to predict a change in MAPLHGR. For example, a one second reflood delay is equivalent to a one-half percent reduction in MAPLHGR for late reflooders; while changes in the above parameters is equivalent to a one percent reduction in MAPLGHR for early reflooders.

Response: Sensitivity studies with Appendix K ECCS evaluation models provide the basis for estimating the effect of small changes in reflooding time (TFLOOD), uncovery time (TUNC), and core spray cooling initiation time on the MAPLHGR and PCT for early and late reflooders. For example, an increase of 1 second in reflooding time increases the PCT by about 3°F for a late reflooder and by about 5°F for an early reflooder. The one second increase in reflooding time decreases the MAPLHGR by about 0.10% for a late reflooder and by about 0.25% for an early reflooder.

TABLE 1-1

COMPARISON OF MAPLHGR AND PCT CALCULATION DETAILS FOR ONE-PUMP VERSUS TWO-PUMP OPERATION

	TWO-PUMP OPERATION	ONE-PUMP OPERATION
MAPLHGR For Table 2-3 of NEDO-20999	16.1 kw/ft	12.Z kw/ft
Core Pressure Calculation	LAMB	Not Applicable*
Transient Core Flow Calculation	LAMB	Not Applicable*
Lower Plenum Enthalpy Calculation	LAMB	Not Applicable*
MCPR	SCAT	Not Applicable*
Convective Heat Transfer Coefficient	NEDE-20566	NEDE-20566**
Water Level Calculation	SAFE/REFLOOD	SAFE/REFLOOD
Vessel Pressure Calculation	SAFE/REFLOOD	SAFE/REFLOOD
Peak Cladding Temperature Calculation	CHASTE	CHASTE
Break Spectrum Calculations	CHASTE plus SAFE/REFLOOD	CHASTE plus SAFE/REFLOOD

*Boiling transition for LOCA from one-loop operation is assumed at 0.1 seconds; therefore, LAMB and SCAT calculations not required.

**For one-pump operation, loss of nucleate boiling assumed at 0.1 seconds after the LOCA.

Question B1B: For the two-pump MAPLHGR is a constant heat transfer coefficient (HTC = 30) used until lower plenum flashing as in previous submittals or was the calculation done as described in NEDE-20566, (Dougall-Rohsenow with Ellion used to calculate steam generation)?

Response: The calculation was done as described in NEDE-20566 (Dougall-Rohsenow with Ellion).

Question B1C: Are hot node uncovery and core uncovery as used on Page 2-5 and 2-7 synomonous?

Response: Yes.

Question B2: Provide the data that shows that boiling transition occurs earlier for discharge than for suction breaks of the recirculation line, as discussed in Section 2.2.4 on Page 2-7 (NEDO-20999).

Response: This is a mistake in the text. The second sentence in the first paragraph of Section 2.2.4 should read: "Curves for both suction and discharge breaks are presented because the onset of boiling transition occurs significantly later for discharge breaks" (corrected in Supplement 1, attached). Examples of boiling transition times for suction break versus discharge break for several plants are listed below. Note that the onset of boiling transition occurs much later for discharge breaks.

ONSET OF BOILING TRANSITION (sec)

	Suction Break	Discharge Break
PLANT A	8.3	15.9
PLANT B	6.0	12.4
PLANT C	4.4	8.8

Question B3: Provide a discussion on the effect of core plugging on MAPLHGR reduction for one pump operation.

Response: Plugging the core plate holes, which substantially reduces reflooding capability after a LOCA, results in longer calculated reflooding times. The MAPLHGR reduction factor (a multiplication factor on the two pump MAPLHGR) which is a function of reflooding time, increases as the reflooding time increases (i.e., for plugged cores) as shown in Figure 1 of NEDO-20999. Therefore, the effect of core plugging is to increase the reflooding time and thereby increase the MAPLHGR reduction factor. Although the MAPLHGR Reduction Factor increases for plugged core, the resultant MAPLHGR for single loop operation is less for a plugged core than for the unplugged core. The assumed time to boiling transition is independent of whether or not the core is plugged.

Question B4: Provide a curve of transient PCT of the lowest axial plain to experience CPR = 1.0 prior to jet pump uncovery versus time with one pump operation.

Response: The cladding heatup analysis of the LOCA from one pump operation assumes that boiling transition occurs over the entire length of the fuel bundle at 0.1 seconds after the LOCA. In other words, all axial planes are assumed to experience CPR = 1.0 prior to jet pump uncovery. Therefore, the high-power axial plane experiences the most severe cladding heatup. Plots of calculated peak cladding temperature versus time for the high-power axial plane are provided in Figures 4-1 and 4-2 for early and late reflooding BWR/4 plants.

Question B5: Provide a discussion on the one pump vessel blowdown and reflooding calculations relating to the assumption of 102% of rated power and flow as being conservative when compared to operating at a reduced power level.

Response: The Appendix K ECCS blowdown-reflooding calculations (SAFE/REFLOOD computer codes) are performed assuming that the reactor is operating at 102% rated power with corresponding core flow, steam flow, etc. at the time of the postulated LOCA. For single loop operation, the reactor will be operating at considerably less than 100% rated power. The parameters input to the cladding heatup analysis are somewhat sensitive to the reactor operating conditions (core power, core flow, etc.) assumed in the blowdown-reflooding calculations.

Table 5-1 (attached) presents a comparison of calculations for the high-power axial plane uncovery time (TUNC), the core spray cooling initiation time (TSPRAY), and the high-power axial plane reflooding time (TFLOOD) for the following two cases:

CASE 1: LOCA from two-loop operation assuming the reactor is operating at 102% rated power with corresponding core flow, steam flow, etc.

CASE 2: LOCA assuming the reactor is operating at the approximate reduced power level for single loop operation (approximately 75% rated power) with corresponding core flow, steam flow, etc.

The comparisons are made for the DBA, 80% DBA, and 60% DBA break sizes for the example plant. Table 5-1 indicates longer uncovery time, longer time for the single-loop LOCA (reduced power and flow). The longer uncovery time and shorter reflooding time decrease the calculated peak cladding temperature (PCT) for the full power case, while the longer time for the initiation of spray cooling tends to increase the PCT by a small amount. The net effect of using the parameter values for the full power case rather than for the reduced power case is to increase calculated PCT for the DBA by approximately 10°F. Thus, since the PCT is slightly increased by this assumption, it is convenient and conservative to use the parameter values corresponding to the two-pump LOCA from full power for the cladding heatup calculations for the single-loop LOCA.

FIGURE 4-1

PEAK CLADDING TEMPERATURE FOLLOWING A DBA FROM SINGLE LOOP OPERATION FOR EXAMPLE PLANT

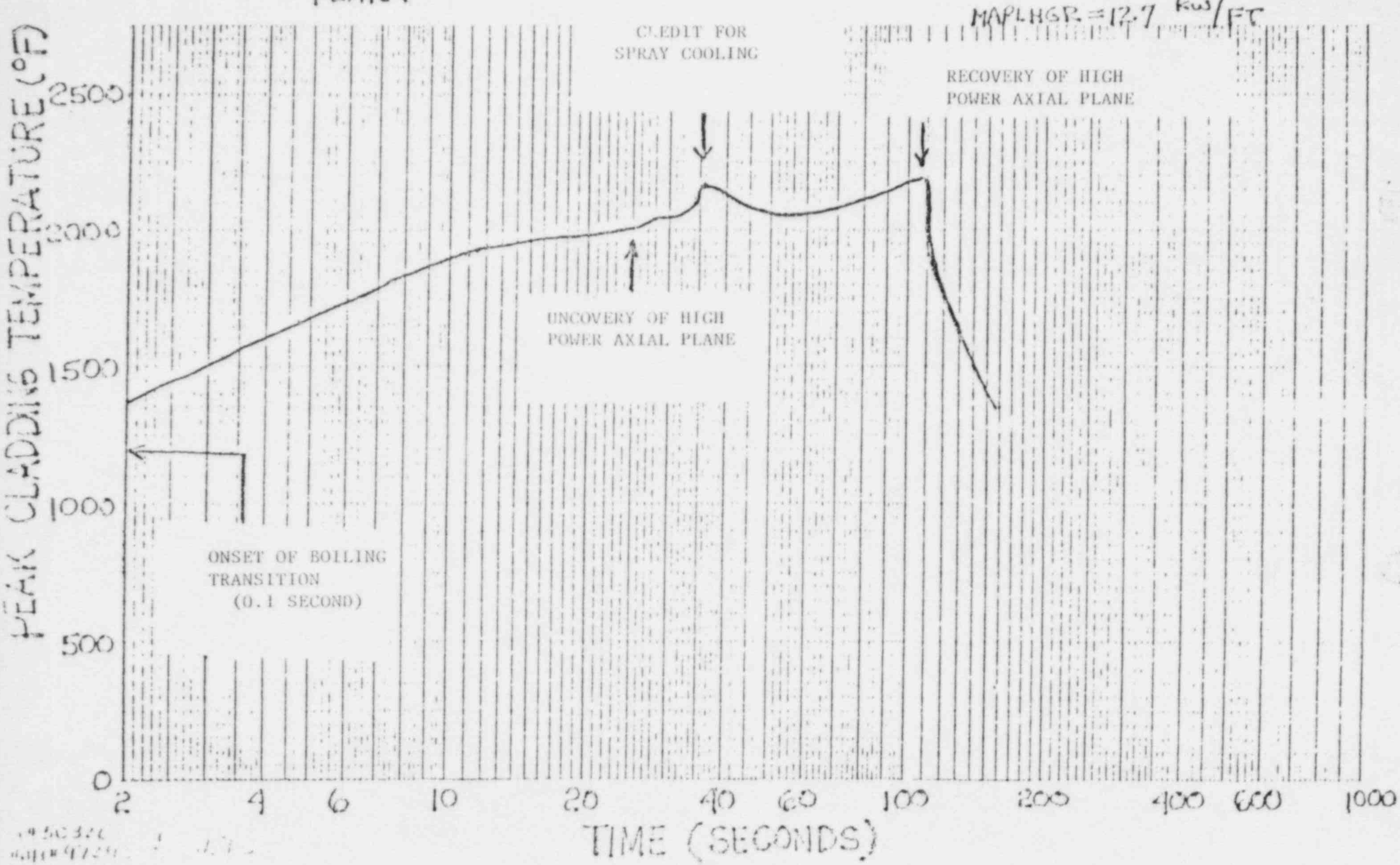

FIGURE 1

PEAK CLADDING TEMPERATURE FOLLOWING A DBA FROM SINGLE LOOP OPERATION FOR EXAMPLE PLANT

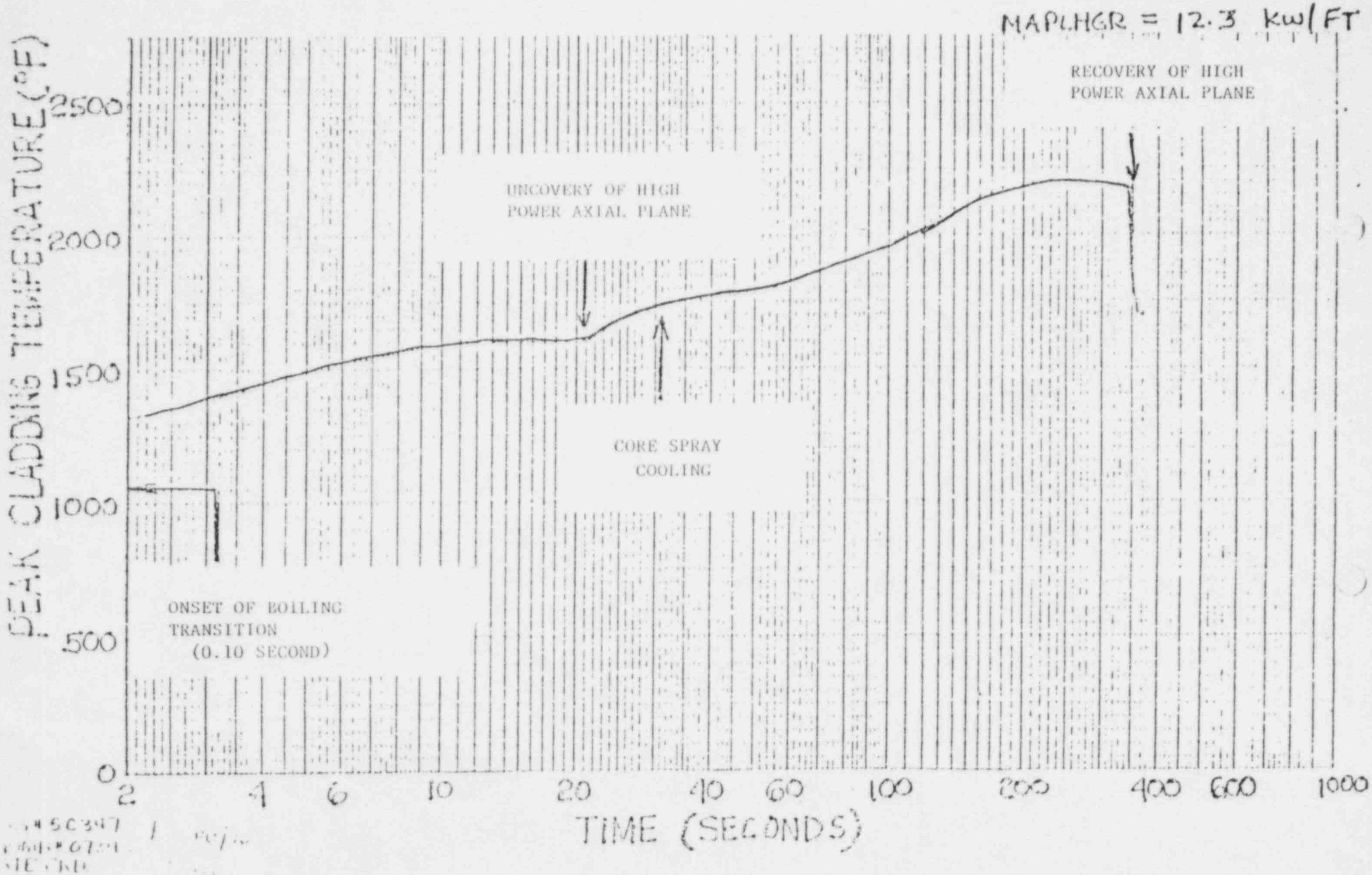

TABLE 5-1

<u>COMPARISON OF BLOWDOWN-REFLOODING PARAMETERS FOR FULL POWER (TWO-LOOP OPERATION) CASE VERSUS REDUCED POWER CASE (SINGLE-LOOP OPERATION)</u>

BREAK SIZE		CASE 1*	CASE 2**
DBA	TUNC[a]	25.4	26.1
	TSPRAY[b]	33.5	34.5
	TFLOOD[c]	106.3	104.7
80% DBA	TUNC	28.1	29.2
	TSPRAY	39.6	40.9
	TFLOOD	103.6	99.4
60% DBA	TUNC	33.0	37.6
	TSPRAY	51.7	53.5
	TFLOOD	105.4	104.3

[a]TUNC = Hot node uncovery time (sec)

[b]TSPRAY = time at which credit is assumed for core spray heat transfer (sec)

[c]TFLOOD = Reflooding time for hot node (sec)

*CASE 1: LOCA from two-loop operation assuming the reactor is operating at 102% rated power with corresponding core flow, steam flow, etc.

**CASE 2: LOCA from single-loop operation assuming the reactor is operating at reduced power with corresponding core flow, steam flow, etc.

Question B6: Discuss the significance of the PCT term in the MAPLHGR Reduction Factor (F) equation and its tendency to lower the "F" factor when the 2 pumps PCT is below 2200°F. Clarify the statement in Paragraph 3 of Page 2-9 (NEDO-20999) that no credit for PCT margin is taken to calculate the one pump MPALHGR.

Response: This question is not relevant to Pilgrim operation in Cycle 3 because MAPLHGR limits are derived from the 2200°F Appendix K limits throughout the cycle. However, in the interest of forwarding information to the NRC, the following information is forwarded from G.E. Since this information is generic in nature and is not applicable to Pilgrim, it is expected that it will be used for information purposes and will not effect the NRC review of the Pilgrim single loop submittal.

The equation:

$$F = 1 - \left[\frac{\text{MAPLHGR (2 Pump) - MAPLHGR (1 Pump)}}{\text{MAPLHGR (2 Pump)}}\right] - \left[\frac{2200^{\circ}\text{F - PCT (2 Pump)}}{20^{\circ}\text{F}}\right] \times 0.01$$

is used to calculate the generic MAPLHGR Reduction Factor (F) curve in Figure 1 of NEDO-20999. The standard procedure followed in calculating the data points in Figure 1 is as follows:

(1) One-pump MAPLHGR and PCT values for selected BWR/3-BWR/4 plants are conservatively calculated according to the assumptions of Section 2.2.3 (two-pump MAPLHGR and PCT values are already available for previous Appendix K ECCS analysis submittals);

(2) These MAPLHGR and PCT values for one and two pump operation are then used in the above equation to calculate F. If the two-pump PCT is equal to 2200°F, then the PCT term in the above equation is zero and the equation to calculate the MAPLHGR Reduction Factor is simply:

$$F = 1 - \left[\frac{\text{MAPLHGR (2 pump) - MAPLGHR (1 Pump)}}{\text{MAPLHGR (2 Pump)}}\right]$$

If the two pump PCT is less than 2200°F then the PCT term is employed to ensure that a conservatively low MAPLHGR Reduction Factor for the generic curve in Figure 1 is calculated. For example, suppose that results of specific heatup calculations for a particular BWR/3-BWR/4 are as follows:

MAPLHGR (2 Pump) = 15.00 kw/ft; PCT (2 Pump) = 2000°F.

MAPLHGR (1 Pump) = 14.25 kw/ft; PCT (1 Pump) = 2200°F.

These results show that the one-pump MAPLHGR is reduced to 14.25/15.00 = .95 of the two-pump MAPLHGR. It is noted for this example that the MAPLHGR for single-loop operation is reduced by a comparatively small amount (5%) because there is 200°F (2200°F - 2000°F) of margin in the two-pump PCT before the MAPLHGR is limited by the 2200°F Appendix K limit.

The results cited in this example are now used to calculate a generic data point for Figure 1. Using the above equation, the calculated MAPLHGR Reduction Factor for Figure 1 is

$$F = 1 - \left[\frac{15.00 - 14.25}{15.00}\right] - \left[\frac{2200 - 2000}{20}\right] \times .01 =$$

$$1.0 - 0.05 - 0.10 \quad = \quad .85$$

Therefore, for this example plant, the effect of the PCT term in the equation for F is to reduce the calculated generic MAPLHGR Reduction factor for Figure 1 by 0.10 (from 0.95 to 0.85). Therefore, 0.85 is a conservatively low MAPLHGR Reduction Factor that may be applied to a different plant with an equal reflooding time and with a two-pump PCT equal to 2200°F.

To answer the second part of this question, consider the following example. A single-loop operation MAPLHGR is required for a plant with the same reflooding time as the plant in the above example, but the two pump PCT is 2100°F. The generic MAPLHGR Reduction Factor (F) from Figure 1 is 0.85, and therefore the single-loop MAPLHGR is:

$$\text{MAPLHGR (1 Pump)} = F \times \text{MAPLHGR (2 Pump)}$$

$$= 0.85 \times \text{MAPLHGR (2 Pump)}$$

It is noted in this example that credit for the 100°F margin (2200°F - 2100°F) in the two pump PCT is conservatively ignored in the calculation of the single-loop MAPLHGR from Figure 1. Taking credit for this margin would increase the MAPLHGR reduction factor to 0.90 (instead of 0.85) and thereby increase the one-pump operation MAPLHGR by approximately 5%.

In summary, it is conservative to account for the two pump PCT margin in the calculation of the generic MAPLHGR Reduction Factor Curve (Figure 1) because this results in conservatively low values of F to be applied generically to all BWR/3-BWR/4 plants with comparable reflooding times. On the other hand, it is conservative to ignore the two pump PCT margin when using the generic MAPLGHR Reduction Factor (Figure 1) curve to calculate the one pump operation MAPLGHR because, by so doing, conservatively low MAPLHGR's are obtained.

Question B7: Provide assurance that all BWR/3 and BWR/4 plants without the LPCI modification will be limited by the suction line break. For example, BSEP #2 with a LPCI modification is limited by the discharge line break, it is not obvious that without the LPCI modification that the limiting break will rivert to the suction line. Plugging of the bypass flow holes in the core support plate may also have an effect on the limiting break location.

Response: In the heatup analysis for single loop operation, boiling transition is assumed at 0.1 seconds for both suction and discharge line breaks. Therefore, the reflooding time is the primary parameter determining the peak cladding temperature. For BWR/3-BWR/4 plants without the LPCI modification, the reflooding time for the suction line break is always longer than for the discharge break. This results because inventory losses during vessel blowdown are always less for the discharge line break due to smaller break area (restricted by the limiting flow area through the recirculation pump). Since the suction break has a longer reflooding time, it will always be more limiting on MAPLHGR than the discharge line break for BWR/3-BWR/4 plants without the LPCI modification.

Plugging the bypass leakage holes significantly retards core reflooding for either suction break or discharge break. The suction break reflooding time is longer for plugged bypass holes (for the same reasons cited above) and therefore limits the MAPLHGR in this case also.

Question B8: Section 2.2.5 needs clarification on the following items.

B8A: The last paragraph on Page 2-10 needs clarification with regard to boiling transition for large breaks being maximum relative to the DBA. Will a smaller break relative to the DBA have a longer time to B.T. and therefore a greater MAPLHGR reduction for one pump operation.

Response: In Section 2.2.5 it is stated that for the plant selected for the calculations in Table 2-3, "the time to boiling transition is maximum relative to the DBA". To understand the meaning of this, consider Table 8-1. The last column shows the boiling transition times for large breaks (80% DBA, 60% DBA, and 1 ft^2) minus the DBA boiling transition time for two plants. Relative to Plant B, it is seen for Plant A that the duration of nucleate boiling for the large breaks is longer relative to the DBA boiling transition time. Therefore, the assumption of early boiling transition for one-pump operation increases the large break PCT's relative to the DBA PCT to a larger extent for Plant A than for Plant B. Thus, Plant A was selected for the calculations shown in Table 2-3 to illustrate that the PCT for the large break portion of the break spectrum decreases with decreasing break area.

With regard to the second part of question #8A, it is true that the boiling transition times increase with decreasing break areas. It is not true, however, that a break smaller than the DBA will limit the one-pump MAPLHGR for a BWR/3-BWR/4 plant. In Section 2.2.5, the evaluations presented in Table 2-3 are applied generically to all BWR/3-BWR/4 "lead plant" analyses. This conclusively demonstrates that the large break PCT's for all "lead plants" (and thus for all BWR/3-BWR/4 plants) are always less than the DBA PCT for one-pump operation.

For smaller breaks (i.e., break area <1.0 ft^2) Section 2.2.5 presents a comparison (for break area = 0.07 ft^2) of the effect of single-loop operation on the PCT. For this one case, the PCT increased from 1725°F to 1760°F in going from two-pump to one-pump operation.* The slight increase in PCT for this example is explained in the second paragraph of page 2-12. The last paragraph on this page summarizes the arguments that the small break PCTs remain well below DBA PCT.

There is a tendency to draw an analogy between single-loop operation in jet pump BWR plants and non-jet pump BWR plants because the duration of nucleate boiling for both cases is quite short (less than 1-2 seconds). Since the MAPLHGR's for non-jet pump BWR plants are currently limited by breaks smaller than the DBA, it has been suggested by the NRC staff that this may be the case for single loop operation in jet pump BWR's. However, such is not the case because for jet pump BWR's the PCT transient is terminated by reflooding, whereas the non-jet pump BWR's rely on PCT turnover by core spray cooling to terminate the heatup transient. The reflooding phenomenon occurs much earlier, particularly for smaller breaks, than does PCT turnover as illustrated in Table 8-2, which compares the reflooding time for a late reflooding BWR versus PCT turnover time for a non-jet pump BWR.

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)

38B: Are the two pump PCT's in Table 2-3 calculated using the original MAPLHGR and the one pump PCT's calculated with a two pump MAPLHGR reduced by the reduction factor with no credit for "2200°F - PCT" margin?

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*It is noted that these small break PCT's were calculated with the CHASTE computer code. For two-pump operation (PCT = 1725°F) the small break assumptions are employed (i.e., nucleate boiling until uncovery). For one-pump operation (PCT = 1760°F) Ellion pool boiling (htc = 20 Btu/hr-ft^2-°F) is assumed until uncovery. The MAPLHGR used in the one-pump PCT calculation is reduced by 15% from the two-pump MAPLHGR.

TABLE 8-1

COMPARISON OF BOILING TRANSITION TIMES FOR LARGE BREAKS*

	BREAK SIZE	BOILING TRANSITION TIME (sec)	BOILING TRANSITION TIME MINUS DBA BOILING TRANSITION TIME (sec)
PLANT A**	DBA	8.3	--
	80% DBA	10.0	1.7
	60% DBA	12.6	4.3
	1.0 ft^2	27.0	18.7
PLANT B	DBA	5.8	--
	80% DBA	7.0	1.2
	60% DBA	9.0	3.2
	1.0 ft^2	20.1	14.3

*All boiling transition times are for a LOCA from two-pump operation.

**PLANT A is the plant used for the calculations for Table 2-3.

TABLE 8-2

COMPARISON OF REFLOODING TIME FOR A LATE REFLOODING JET PUMP BWR VERSUS PCT TURNOVER TIME FOR A NON-JET PUMP BWR

BREAK SIZE	LATE REFLOODING JET PUMP BWR	NON-JET PUMP BWR
	REFLOODING TIME (sec)	PCT TURNOVER TIME (sec)
DBA	280	300
1.0 ft^2	220	340
0.1 ft^2	360	550
0.07 ft^2	480	650

Response: The calculations presented in Table 2-3 were performed for the BWR/3-BWR/4 with the earliest reflooding time (106 seconds) as explained in Section 2.2.5. The MAPLHGR's used for the PCT calculations are 16.1 kw/ft (the original MAPLHGR) and 12.7 kw/ft for two-pump and one-pump operation, respectively. From Figure 1 of NEDO-20999 the MAPLHGR Reduction Factor is 0.74 for this plant. Therefore, the one-pump MAPLHGR for this plant would be 0.74 x 16.1 = 11.9 kw/ft if no credit is assumed for the "2200°F - PCT" margin. However, taking credit for this margin increases the single loop MAPLHGR to 12.7 kw/ft. Although the value of 11.9 kw/ft is the recommended MAPLHGR for single loop operation, the 12.7 kw/ft value is used for the one-pump PCT break spectrum calculations in Table 2-3 because this results in higher calculated PCT's for the breaks smaller than the DBA, and therefore is conservative.

It is further noted for clarification that the PCT comparison in Section 2.2.5 for the 0.07 ft^2 break was calculated for a different plant for which the MAPLHGR Reduction Factor for single-loop operation is 0.85 (i.e., a 15% reduction from the two pump MAPLHGR).

B8C: Describe how the MAPLHGR's for one and two pump operation are derived in Table 2-3. If Figure 1 is used for the shortest reflood time plant, the reduction factor is 0.74, and the one pump MAPLHGR would be 16.1 x .74 or 11.9. The MAPLHGR reduction factor derived from the MAPLHGR's shown in Table 2-3 are $F = 1 - \left[\frac{16.1 - 12.7}{16.1}\right] = .79$.

Response: The answer to this part of Question #8 is included in Part B immediately above.

Question B9: For the discussion of small break PCT's in Section 2.2.5 the following needs to be clarified.

B9A: Are the two pump MAPLHGR's calculated using the SAFE code with the small break assumptions (i.e., nucleate boiling till core uncovery zero heat transfer till core spray, and core spray heat transfer until reflood)?

Response: This question refers to the two pump PCT's, rather than MAPLHGR's, for small breaks. For single-loop operation, the small break PCT's are calculated with the CHASTE Code assuming loss of nucleate boiling at 0.1 seconds, followed by Ellion pool boiling until core uncovery, zero heat transfer until core spray, and core spray heat transfer until reflooding. This method is identical to that for the large break PCT calculations for single loop operation. For two-loop operation, the small break PCT is calculated with the CHASTE code with the small break assumptions, i.e., nucleate boiling until core uncovery, zero heat transfer until core spray, and core spray heat transfer until reflooding.

B9B: It appears that the small break model (SBM) should yield a greater reduction in MAPLHGR because the core uncovers slowly (no B.T. occurs) and MAPLHGR reduction is greater for one loop operation at longer times to boiling transition (B.T.). Compare the 1.0 ft^2 using the LBM and SBM. Provide the MAPLHGR's PCT's for two pump and one pump operation.

Response: The first part of this question is answered in the response to question 8A. Table 9-1 presents the 1.0 ft^2 PCT for the Large Break Model (LBM) and Small Break Model (SBM) for both two-loop and single-loop operation. The MAPLHGR's used in the calculations are also specified in Table 9-1. It is noted that both the LBM and SBM PCT calculations for single loop operation were performed assuming the Ellion correlation until uncovery. Furthermore, if nucleate boiling (rather than Ellion) until uncovery is assumed for the single-loop operation SBM, the PCT decreases from 1900°F to 1480°F as shown in Table 9-1.

Question B10: Provide the delay to boiling transition based on the GE correlation if calculated. If the delayed boiling transition was not calculated give justification for not considering in one pump operation.

Response: For single-loop operation the delay to boiling transition for all BWR/3-BWR/4 plants is not calculated but rather conservatively assumed to be 0.1 seconds after the LOCA. For non-jet pump BWR/2 plants (not included in the scope of this report) the calculated delay to boiling transition is typically 1.0 - 1.5 seconds. The calculated delay time to boiling transition (using the non-jet pump plant boiling transition correlation) is essentially the same for BWR/2, 3, and 4 plants because the major determining parameter in the calculation is bundle power, which is approximately equal for these plants.* Therefore, the justification for using the assumed value (0.1 seconds) rather than a calculated value (approximately 1.0-1.5 seconds) is that this assumption results in conservatively high calculated peak cladding temperatures (because the longer duration of nucleate boiling is more effective in removing the stored energy from the fuel before the transition to film boiling, and therefore, if assumed, reduces the calculated PCT).

*Actually the time to boiling transition would be longer for BWR/3 and 4's because, even for a LOCA from single loop operation, there would be significant core coastdown flow induced by natural circulation through the jet pumps. This induced core flow would result in later boiling transition than that predicted by the correlation used for BWR/2 plants which assumes zero core coastdown flow.

TABLE 9-1

COMPARISON OF PCT FOR 1.0 FT^2 BREAK USING LARGE BREAK MODEL AND SMALL BREAK MODEL FOR TWO-LOOP AND SINGLE-LOOP OPERATION

	PEAK CLADDING TEMPERATURE (°F) FOR 1.0 FT^2 BREAK	
	TWO-LOOP OPERATION*	ONE-LOOP OPERATION**
Small Break Model[a]	1715	1900***
Large Break Model[b]	1730	1925

[a]Small Break Model: SAFE/REFLOOD

[b]Large Break Model: CHASTE

*MAPLHGR = 16.1 kw/ft for two-loop operation.

**MAPLHGR = 12.7 kw/ft for single-loop operation. For single-loop operation, the Ellion correlation is assumed until uncovery for both LBM and SBM.

***If nucleate boiling until uncovery is assumed for the SBM single-loop PCT, the result is PCT = 1480°F.

Question B11: Provide the MAPLHGR curves for one loop operation for the plugged, reload core.

Response: NEDO-20999 is applicable for the bypass flow holes plugged case only. This clarification is made in Supplement 1 (attached)..

Question B12: Provide assurance that the K_f factors that are derived from the cold water increase transient (recirculation pump speed up, both loops operating) will be bounding for one loop operation.

Response: The K_f factors are derived assuming that both recirculation loops increase speed to the maximum permitted by the M-G Set scoop tube position set screws. This condition produces the maximum possible power increase and hence maximum ΔMCPR for transients initiated from less than rated power and flow. When operating with only one recirculation loop the flow and power increase associated with the increased speed on only one M-G Set will be less than that associated with both pumps increasing speed, and, therefore, the K_f factors derived with the two pump assumption are conservative for single loop operation.

B12A: Also provide a discussion of the cold water increase (positive reactivity insertion) transients and how they are bounded by the two-loop full power analysis.

Response: The loss of feedwater heater event is generally the most severe cold water increase event with respect to increase in core power. This event is caused by positive reactivity insertion from core flow inlet subcooling (see Reference 5 of NEDO-20999); therefore, the event is independent of two-pump or one-pump operation. The severity of the event is primarily dependent on the initial power level. The higher the initial power level, the greater the CPR change during the transient. Since the initial power level during one-pump operation will be significantly lower, the one-pump cold water increase case is conservatively bounded by the full power (two-pump) analysis.

Question B13: Provide details on how the curves relating core flow to drive flow, as described in Section 4.2, are obtained.

Response: See revised pages to NEDO-20999 (attached).

Question B14: The derivation of the rod block equation appears to have an inconsistency. Should the first equation on Page 4-4 read, "$RB_{100} = m(100 + \Delta W) + RB_o'$", rather than, "$RB_{100} = m(100 + \Delta W) + RB$"?

Response: See revised pages to NEDO-20999 (attached).

Question B15: Provide the 100% point on the drive flow axis on Figure 4. There appears to be an inconsistency on the location of the 100% point. The point F_c = 100%, W = 100% should be the two pump curve, while the abscissa label indicates the one pump curve.

Response: See revised pages to NEDO-20999 (attached).

Question B16: Justify using the two loop uncertainty factors for calculating the Safety Limit MCPR for single loop operation. The reverse flow through the idle jet pumps may result in a higher flow uncertainty factor.

Response: Most of the uncertainties used in statistical analysis (Table 5-1 of NEDO-20855-1) are independent of whether flow is provided by two loops or a single loop. The only exception is the total coreflow which, for two pump operation, has a standard deviation (% of point) of 2.5. For single loop operation, this value would increase to about 6% of rated core flow. The 3.5% increase in core flow uncertainty corresponds to an increase in the safety limit of approximately 0.004 which can be neglected.

It should be noted that the steady state operating MCPR with single loop operation will be conservatively established by multiplying the rated flow MCPR limit by the K_f factor. This assures that the 99.9% statistical limit requirement is always satisfied.

Question B17: Provide a technical basis for the proposed changes in the intercept and slope for both the flow biased APRM flux scram and the rod block setting. Provide a quantitative assessment of margins to the MCPR safety limit at the lower permissible values of core flows for 100% control rod pattern. Include in the assessment such local power increase transients where thermal/hydraulic and sudden effects are in phase. Examples are rod withdrawal errors and xenon redistribution caused by normal operations.

Response: A more detailed justification for the proposed changes in the intercept and slope for the flow biased APRM scram and the rod block setting than has already been provided is not available at this time. General Electric has advised us that it will be several months before this information becomes available. We will continue to review the benefits of this proposed Technical Specification revision and will forward the information as appropriate as it becomes available and following completion of our review of this information.