C. Minimum Critical Power Ratio (MCPR)

1. During power operation MCPR shall be ≥ the MCPR operating limit specified in 3.11.C.2. If at any time during operation it is determined by normal surveillance that the limiting value for MCPR is being exceeded, action shall be initiated within 15 minutes to restore operation to within the prescribed limits. If the steady state MCPR is not returned to within the prescribed limits within two (2) hours, the reactor shall be brought to the Cold Shutdown condition within 36 hours. Surveillance and corresponding action shall continue until reactor operation is within the prescribed limits.

For core flows other than rated the MCPR limits shall be the limits identified above times K_f where K_f is as shown in Figure 3.11-8

As an alternative method providing equivalent thermal-hydraulic protection at core flows other than rated, the calculated MCPR may be divided by Kf, where Kf is as shown in Figure 3.11-8.

2. The operating limit MCPR values as a function of τ are given in Table 3.11-1 where τ is given by specification 4.11.C.2.

C. Minimum Critical Power Ratio (MCPR)

1. MCPR shall be determined daily during reactor power operation at > 25% rated thermal power and following any change in power level or distribution that would cause operation with a limiting control rod pattern as described in the bases for Specification 3.3.B.5.

2. The value of τ in Specification 3.11.C.2, shall be equal to 1.0 unless determined from the result of surveillance testing of Specification 4.3.C as follows:

a) τ' is defined as

$$\tau = \frac{\tau_{ave} - \tau_B}{1.275 - \tau_B}$$

b) The average scram time to the 30% insertion position is determined as follows:

$$\tau_{ave} = \frac{\sum_{i=1}^{n} N_i \tau_i}{\sum_{i=1}^{n} N_i}$$

where: n = number of surveillance tests performed to date in the cycle.

N_i = number of active control rods measured in the ith surveillance test.

τ_i = average scram time to the 30% insertion position of all rods measured in the ith surveillance test.

c.) The adjusted analysis mean scram time (τ_B) is calculated as follows:

$$\tau_B = \mu + 1.65 \left(\frac{N_i}{\sum_{i=1}^{n} N_i} \right)^{\frac{1}{2}} \sigma$$

Where:

μ = mean of the distribution for average scram insertion time to the 30% position 0.945 sec

N_i = total number of active control rod measured in specification 4.3.C

σ = standard deviation of the distribution for average scram insertion time to the 30% position, 0.064 sec.

TABLE 3.11-1

OPERATING LIMIT MCPR VALUES

MCPR Operating Limit

τ	8x8	P8x8R
≤ 0	1.32	1.35
0 to .1	1.32	1.36
.1 to .2	1.33	1.36
.2 to .3	1.33	1.36
.3 to .4	1.34	1.37
.4 to .5	1.34	1.37
.5 to .6	1.35	1.38
.6 to .7	1.35	1.38
.7 to .8	1.36	1.39
.8 to .9	1.36	1.39
.9 to 1.0	1.37	1.40

BASES

3.11A Average Planar Linear Heat Generation Rate (APLHGR)

This specifications assures that the peak cladding temperature following the postulated design basis loss-of-coolant accident will not exceed the limit specified in the 10 CFR 50, Appendix K.

The peak cladding temperature (PCT) following a postulated loss-of-coolant accident is primarily a function of the average heat generation rate of all the rods of a fuel assembly at any axial location and is only dependent, secondarily on the rod to rod power distribution within an assembly. The peak clad temperature is calculated assuming a LHGR for the highest powered rod which is equal to or less than the design LHGR. This LHGR times 1.02 is used in the heat-up code along with the exposure dependent steady state gap conductance and rod-to-rod local peaking factors. The limiting value for APLHGR is this LHGR of the highest powered rod divided by its local peaking factor.

The calculational procedure used to establish the APLHGR limit for each fuel type is based on a loss-of-coolant accident analysis. The emergency core cooling system (ECCS) evaluation models which are employed to determine the effects of the loss of coolant accident (LOCA) in accordance with 10CFR50 and Appendix K are discussed in Reference 1. The models are identified as LAMB, SCAT, SAFE, REFLOOD, and CHASTE. The LAMB Code calculates the short term blowdown response and core flow, which are input into the SCAT code to calculate blowdown heat transfer coefficients. The SAFE code is used to determine longer term system response and flows from the various ECC systems. Where appropriate, the output of SAFE is used in the REFLOOD code to calculate liquid levels. The results of these codes are used in the CHASTE code to calculate fuel clad temperatures and maximum average planar linear heat generation rates (MAPLHGR) for each fuel type.

The significant plant input parameters and the MAPLHGR's for the present fuel types calculated by the above procedure are included in Reference 2. The curves in Figures 3.11-1 through 3.11-6 were developed assuming no core spray heat transfer credit in the LOCA analysis.

REFERENCES

1. General Electric BWR Generic Reload Fuel Application, NEDE-2401'-P.

2. Loss of Coolant Accident Analysis Report for Pilgrim Nuclear Power Station, NEDO-21696, August 1977 as amended.

BASES:

3.11C MINIMUM CRITICAL POWER RATIO (MCPR)

Operating Limit MCPR

For any abnormal operating transient analysis evaluation with the initial condition of the reactor being at the steady state operating limit, it is required that the resulting MCPR does not decrease below the Safety Limit MCPR at any time during the transient assuming instrument trip setting given in Specification

The difference between the specified Operating Limit MCPR in Specification 3.11C and the Safety Limit MCPR in Specification 1.1A defines the largest reduction in critical power ratio (CPR) permitted during any anticipated abnormal operating transient. To ensure that this reduction is not exceeded, the most limiting transients are analized for each reload and fuel type (8x8 and P8x8R) to determine that transient which yields the largest value of Δ CPR. This value, when added to the Safety Limit MCPR must be less than the minimum operating limit MCPR's of Specification 3.11.C. The result of this evaluation is documented in the "Supplemental Reload Licensing Submittal" for the current reload.

The evaluation of a given transient begins with the system input parameters shown in Tables 5-4, 5-6 and 5-8 of NEDE-24011-P[1], Supplemented by reload unique inputs given in the current Supplemental Reload Licensing Submittal. These values are input to a GE core dynamic behavior transient computer program described in NEDO-10802[2]. The transient code used for all pressurization events is described in NEDE-24154-P (Reference 5). The MCPR analysis for pressurization events is done in accordance with the procedures given in Reference 6.

REFERENCES

1. General Electric BWR Generic Reload Fuel Application, NEDE-24011-P.

2. R. B. Linford, Analytical Methods of Plant Transient Evaluations for the GE BWR, February 1973 (NEDO-10802).

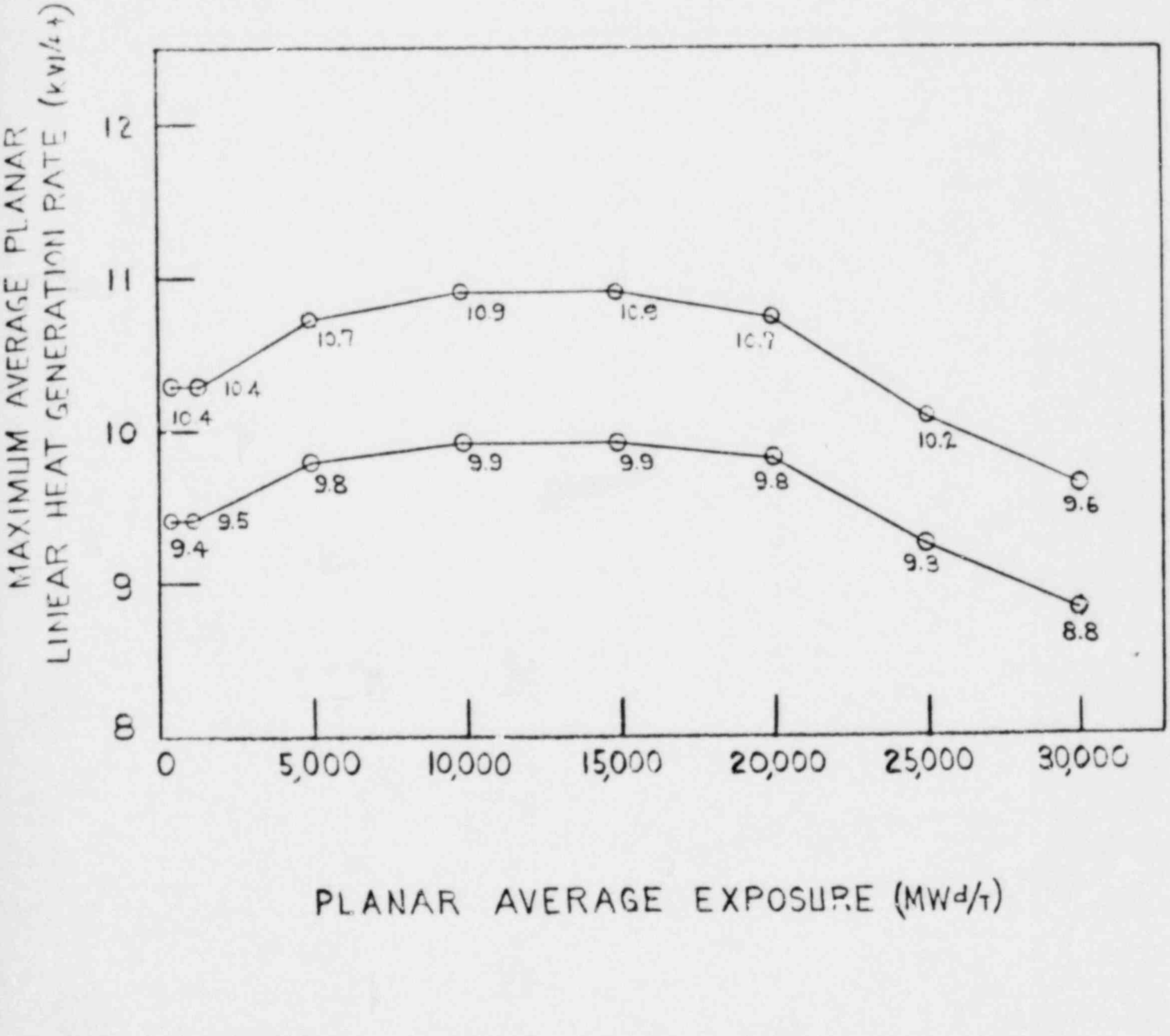
3. General Electric Company Analytical Model for Loss-of-Coolant Analysis in Accordance with 10 CFR 50, Appendix K, NEDE-20566 (Draft), August 1974.

4. Letter from J. E. Howard, Boston Edison Company to D. L. Ziemann USNRC, dated October 31, 1975.

5. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors, October 1978 (NEDE-24154-P).

6. Letter, R. P. Denise (NRC) to G. G. Sherwood (GE), January 23, 1980.

FIGURE 3.11-6
MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE
VERSUS
PLANAR AVERAGE EXPOSURE
FUEL TYPE P8DRB 265H



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TITLE LOSS-OF-COOLANT ACCIDENT ANALYSIS REPORT FOR PILGRIM NUCLEAR POWER STATION

ISSUE DATE AUGUST 1977

ERRATA And ADDENDA SHEET

NO. 1

DATE August 1981

NOTE: Correct all copies of the applicable publication as specified below.

ITEM	REFERENCES (SECTION, PAGE PARAGRAPH, LINE)	INSTRUCTIONS (CORRECTIONS AND ADDITIONS)
1	Pages iii and iv	Replace with new pages iii and iv
2	Page 3-1	Replace with new page 3-1
3	Page 4-3	Replace with new page 4-3
4	Pages 4-7 to 4-9	Replace with new pages 4-7 to 4-9
5	Pages 4-10 to 4-12	Add new pages 4-10 to 4-12
6	Appendix A	Add new Appendix A (pages A-1 to A-7)
		Changes are indicated by vertical bar in the right-hand margin.

TABLE OF CONTENTS

LIST OF TABLES

3. INPUT TO ANALYSIS

A list of the significant plant input parameters to the LOCA analysis is presented in Table 1.

Table 1

SIGNIFICANT INPUT PARAMETERS TO THE LOSS-OF-COCLANT ACCIDENT ANALYSIS

Plant Parameters:

Core Thermal Power	2037 MWt, which corresponds to 102% of rated core power
Vessel Steam Output	8.14×10^6 lbm/h, which corresponds to 102% of rated core power
Vessel Steam Dome Pressure	1050 psia
Recirculation Line Break Area for Large Breaks - Suction	4.34 ft^2 (DBA)
Number of Drilled Bundles	428

Fuel Parameters:

	Fuel Type	Fuel Bundle Geometry	Peak Technical Specification Linear Heat Generation Rate (kW/ft)	Design Axial Peaking Factor	Initial Minimum Critical Power Ratio*
A.	8DB219L	8 x 8	13.4	1.5	1.24
B.	8DB219H	8 x 8	13.4	1.5	1.24
C.	8DB262	8 x 8	13.4	1.5	1.24
D.	P8DRB265L	8 x 8	13.4	1.5	1.24
E.	P8DRB282	8 x 8	13.4	1.5	1.24
F.	P8DRB265H	8 x 8	13.4	1.5	1.24

*To account for the 2% uncertainty in bundle power required by Appendix K, the SCAT calculation is performed with an MCPR of 1.22 (i.e., 1.24 divided by 1.02) for a bundle with an initial MCPR of 1.24.

4.5 RESULTS OF THE CHASTE ANALYSIS

This code is used, with suitable inputs from the other codes, to calculate the fuel cladding heatup rate, peak cladding temperature, peak local cladding oxidation, and core-wide metal-water reaction for large breaks. The detailed fuel model in CHASTE considers transient gap conductance, clad swelling and rupture, and metal-water reaction. The empirical core spray heat transfer and channel wetting correlations are built into CHASTE, which solves the transient heat transfer equations for the entire LOCA transient at a single axial plane in a single fuel assembly. Iterative applications of CHASTE determine the maximum permissible planar power where required to satisfy the requirements of 10CFR50.46 acceptance criteria.

The CHASTE results presented are:

- Peak Cladding Temperature versus time
- Peak Cladding Temperature versus Break Area
- Peak Cladding Temperature and Peak Local Oxidation versus Planar Average Exposure for the most limiting break size
- Maximum Average Planar Heat Generation Rate (MAPLHGR) versus Planar Average Exposure for the most limiting break size

A summary of the analytical results is given in Table 2. Table 3 lists the figures provided for this analysis. The MAPLHGR values for each fuel type in the Pilgrim core are presented in Tables 4A through 4F.

Table 4A

MAPLHGR VERSUS AVERAGE PLANAR EXPOSURE

Plant: Pilgrim

Fuel Type: 8DB219L

Average Planar Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Oxidation Fraction
200.0	11.4	2039.	0.018
1,000.0	11.5	2039.	0.017
5,000.0	11.9	2064.	0.017
10,000.0	12.1	2098.	0.019
15,000.0	12.3	2126.	0.021
20,000.0	12.1	2126.	0.021
25,000.0	11.3	2013.	0.014
30,000.0	10.2	1866.	0.008
35,000.0	9.6	1787.	0.006
40,000.0	9.0	1707.	0.004

Table 4B

MAPLHGR VERSUS AVERAGE PLANAR EXPOSURE

Plant: Pilgrim

Fuel Type: 8DB219H

Average Planar Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Oxidation Fraction
200.0	11.2	2038.	0.018
1,000.0	11.3	2032.	0.017
5,000.0	11.8	2056.	0.017
10,000.0	12.2	2102.	0.019
15,000.0	12.3	2131.	0.021
20,000.0	12.1	2128.	0.021
25,000.0	11.3	2015.	0.015
30,000.0	10.2	1866.	0.008
35,000.0	9.6	1787.	0.006
40,000.0	9.0	1706.	0.004

Table 4C

MAPLHGR VERSUS AVERAGE PLANAR EXPOSURE

Plant: Pilgrim

Fuel Type: 8DB262

Average Planar Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Oxidation Fraction
200.0	11.1	2032.	0.016
1,000.0	11.3	2028.	0.015
5,000.0	11.9	2071.	0.017
10,000.0	12.1	2061.	0.016
15,000.0	12.2	2091.	0.018
20,000.0	12.1	2104.	0.019
25,000.0	11.6	2049.	0.016
30,000.0	10.7	1928.	0.010
35,000.0	9.8	1803.	0.006
40,000.0	9.2	1719.	0.005

Table 4D

MAPLHGR VERSUS AVERAGE PLANAR EXPOSURE

Plant: Pilgrim Fuel Type: P8DRB265L

Average Planar Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Oxidation Fraction
200.0	11.6	2125.	0.023
1,000.0	11.6	2127.	0.023
5,000.0	12.1	2136.	0.022
10,000.0	12.1	2102.	0.020
15,000.0	12.1	2108.	0.020
20,000.0	11.9	2091.	0.019
25,000.0	11.3	2012.	0.015
30,000.0	10.7	1919.	0.010
35,000.0	10.2	1832.	0.008
40,000.0	9.6	1746.	0.006

Table 4E

MAPLHGR VERSUS AVERAGE PLANAR EXPOSURE

Plant: Pilgrim Fuel Type: P8DRB282

Average Planar Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Oxidation Fraction
200.0	11.2	2087.	0.020
1,000.0	11.2	2083.	0.020
5,000.0	11.8	2110.	0.021
10,000.0	12.0	2097.	0.020
15,000.0	12.1	2108.	0.020
20,000.0	11.8	2088.	0.019
25,000.0	11.3	2011.	0.015
30,000.0	11.1	1961.	0.012
35,000.0	10.4	1860.	0.008
40,000.0	9.8	1783.	0.006

Table 4F

MAPLHGR VERSUS AVERAGE PLANAR EXPOSURE

Plant: Pilgrim   Fuel Type: P8DRB265H

Average Planar Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Oxidation Fraction
200.0	11.5	2118.	0.022
1,000.0	11.6	2121.	0.022
5,000.0	11.9	2115.	0.021
10,000.0	12.1	2105.	0.020
15,000.0	12.1	2113.	0.020
20,000.0	11.9	2096.	0.019
25,000.0	11.3	2015.	0.015
30,000.0	10.7	1920.	0.011
35,000.0	10.2	1834.	0.008
40,000.0	9.6	1747.	0.006

APPENDIX A
LOSS-OF-COOLANT ACCIDENT ANALYSIS WITH NO CORE SPRAY HEAT TRANSFER CREDIT

A.1 Introduction

This Appendix describes the methods by which conservative MAPLHGR multipliers were determined for application to the MAPLHGR values reported in Section 4 of this report, assuming that no credit is taken for core spray heat transfer. The input changes to the approved 10CFR50 Appendix K computer codes are described in Section A.2, the depressurization rate sensitivity is discussed in Section A.3, the results of the analysis are given in Section A.4, and the conclusions are presented in Section A.5.

A.2 Input Changes to the LOCA Analysis

The approved versions of the SAFE, REFLOOD, and CHASTE codes were applied to the Pilgrim Plant as described in Section 4 of this report, with the input changes described below. No changes were made to the approved computer codes.

The postulated effect of cracks in the core spray spargers is to deprive the hot assembly of adequate spray flow during a LOCA. This effect is represented by setting the spray heat transfer coefficients in the CHASTE heatup code to zero, from their Appendix K values of 3.0, 3.5, and 1.5 BTU/(hr-ft^2-^{o}F) for the corner, other outside, and inside rods, respectively.

In the standard Appendix K analysis, the non-zero spray heat transfer coefficients are applied from the time rated core spray flow is achieved until the time that the hot node in the hot assembly is reflooded. After the reflooding time, a heat transfer coefficient of 25 BTU/hr ft^2 ^{o}F) is applied to all fuel rods, which is sufficient to cause the peak cladding temperature to decrease.

In the present analysis, credit was taken for a heat transfer coefficient of 25 BTU/(hr °F ft^2) applied to the outside of the channel starting at the time when the water level in the bypass (space between the channels) fills to the elevation of the hot node. Normally this outside channel cooling credit is not taken because it is not needed when core spray cooling is present. In the present analysis, credit for outside channel cooling is appropriate because the cool channel will act as a sink for the heat radiating from the uncooled rods to the channel.

The two input changes described above were made to the CHASTE heatup code, and no changes were made to the SAFE blowdown code, or the REFLOOD refill code.

A.3 Depressurization Rate Sensitivity

The sensitivity of the depressurization rate (which is calculated by the SAFE code) to the global core spray heat transfer coefficient was investigated. If it is postulated that, in the worst case, all assemblies are deprived of spray flow, then it is appropriate to set the SAFE spray heat transfer coefficient to zero. This was done in a comparison case for the Design Base Accident (DBA), which is later shown to still be the limiting break. The change in the calculated uncovery time of the hot node, and in the curve of pressure versus time, was found to be negligible. It was therefore concluded that no input changes in the SAFE code were appropriate for the present analysis.

A.4 Analysis Results

A.4.1 Large Break Analysis

The identification of the limiting break for this analysis follows the approach in the body of this report. Table A-1 shows the total uncovered time for several breaks, taken from computer runs used to generate Figure 6 of this report. These uncovered times are expected to be unchanged for this analysis, since the effect on

the depressurization rate was found to be negligible in the previous section. The results of CHASTE calculations show that the DBA remains the limiting break.

A.4.2 Small Break Analysis

Break sizes smaller than 1.0 ft^2 are not limiting as shown in the comparison of the uncovered times in Table A-2. All breaks in Table A-2 have an uncovered time which is equal to or less than the 154 second uncovered time for the DBA, except for the 0.100 ft^2 break. For all these breaks (except the 100 ft^2, which is described later) the Peak Cladding Temperature (PCT) will be less than the 2200 °F calculated for the DBA, because the time of hot node uncovery decreases with decreasing break size, and the decay heat decreases with increasing break size, and the decay heat decreases with increasing time. Thus the 0.900 ft^2 break will have a lower PCT than the DBA, even though both breaks have equal uncovered times, because the 0.900 ft^2 break has an uncovery time of 71 seconds, which is much later than the DBA uncovery time of 20.6 seconds. The decay heat at 71 seconds is less than at 20.6 seconds, so the heatup in the uncovered period for the 0.900 ft^2 break is less than the heat-up for the DBA.

For the 0.100 ft^2 break, which has an uncovered time only 3 seconds more than the DBA, the PCT is calculated by the small break model to be less than 1700°F.

A.5 Conclusions

Using the DBA as the limiting break, a bounding analysis was performed with the CHASTE code. The results of the calculations show that for each of the fuel types, a MAPLHGR multiplier which is independent of exposure must be applied to the MAPLHGR values given in Section 4 of this report. These MAPLHGR multipliers are given in Table A-3. The use of these multipliers conservatively determines the MAPLHGR required to keep the PCT below 2200°F for the DBA, with no credit assumed for core spray heat transfer.

The calculations described in this Appendix were performed at the request of the Boston Edison Company (BECO) in order to support BECO's proposal to return to service taking no credit for core spray heat transfer. The technical justification for such calculations has been presented in this Appendix. However, General Electric considers the assumption of no core spray heat transfer credit to be excessively conservative, based on the calculations which support the continued structural integrity of the core spray spargers (presented in Reference A-1) and the many recognized conservatisms in the current LOCA models.

A.6 References

A-1 Supplement 1 to Supplemental Reload Licensing Submittal for Pilgrim Nuclear Power Station Unit 1 Reload 4, NEDO-24224-1 Supplement 1, March 1980.

Table A-1

Pilgrim Large Break Results
LPCI Injection Valve Failure; 2LPCS + HPCI + ADS Available
No Core Spray Heat Transfer with Channel Cooling

Break Size (ft.^{2})	Uncovered Time (sec)	Chase PCT (°F)*
4.343 (DBA)	154	2200
3.474 (80% DBA)	145	2142**
2.606 (60% DBA)	133	2062**
1.000	149	2068**

*MAPLHGR = 11.55 kw/ft. for 8D262 fuel at 10,000 MWd/t

**Conservatively estimated by using temperature differences for a MAPLHGR of 11.08 kw/ft.

Table A-2

Pilgrim Small Break Uncovery Time

Break Size (ft^2)	Uncovered Time (sec)	Failure Assumed
0.900	154	LPCI Injection Valve
0.800	133	
0.700	131	
0.600	102	
0.500	95	
0.400	90	
0.300	75	
0.200	107	
0.150	109	HPCI Injection Valve
0.100	157	
0.080	151	
0.060	155	
0.040	132	

Table A-3

MAPLHGR Multipliers Assuming No
Core Spray Heat Transfer Credit

Fuel Type	Core Flow ≥ 90% Rated	Core Flow < 90% Rated
8DB219L	0.93	0.85
8DB219H	0.93	0.85
8DB262	0.94	0.86
P8DRB265L	0.91	0.84
P8DRB282	0.92	0.85
P8DRB265H	0.90	0.82