Entergy

Entergy Nuclear Operations, Inc.
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, MI 49043

December 20, 2007

10 CFR 50.90

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

Response to Request for Additional Information on Realistic Large Break Loss-of-Coolant Accident License Amendment Request (TAC No. MD3492)

Dear Sir or Madam:

By letter dated November 6, 2006, Nuclear Management Company, LLC (NMC), the former licensee for the Palisades Nuclear Plant (PNP), requested Nuclear Regulatory Commission (NRC) review and approval of a proposed license amendment for the PNP. The proposed license amendment would add EMF-2103(P)(A), "Realistic Large Break [loss-of-coolant accident] LOCA [RLBLOCA] Methodology for Pressurized Water Reactors," as a reference to Technical Specification 5.6.5, "Core Operating Limits Report." EMF-2103(P)(A) is the NRC-approved AREVA NP (AREVA) RLBLOCA methodology. A summary report of the RLBLOCA analysis was submitted with the license amendment request (LAR).

In May 2007, AREVA notified Entergy Nuclear Operations, Inc. (ENO) that a discrepancy existed in the RLBLOCA analysis. ENO determined that a supplement to the November 6, 2006, LAR was required, and submitted a supplement letter on August 10, 2007. The letter enclosed proprietary and non-proprietary versions of an AREVA-issued revision 2 to summary report BAW-2501, "Palisades Nuclear Plant Realistic Large Break LOCA Summary Report," to replace those submitted in the November 6, 2006, LAR.

On October, 22, 2007, the NRC electronically sent a request for additional information (RAI) on the LAR. In a telephone call on November 19, 2007, ENO, with AREVA, provided verbal responses to the eight items in the RAI. ENO agreed to provide the responses in writing. Responses are provided in the enclosure to this letter.

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

I declare under penalty of perjury that the foregoing is true and correct. Executed on December 20, 2007.

Christopher J. Schwarz
Site Vice President
Palisades Nuclear Plant

Enclosure

CC Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

On August 10, 2007, Entergy Nuclear Operations Inc. (ENO), submitted "Supplement to License Amendment Request [LAR]: Realistic Large Break Loss-of-Coolant Accident [LOCA]". The LAR supplement contained technical report BAW-2501(P), "Palisades Nuclear Plant Realistic Large Break LOCA Summary Report," Revision 2. The report described the application of the Nuclear Regulatory Commission (NRC) approved AREVA best estimate (BE) large break loss-of-coolant accident methodology described in EMF-2103(P)(A), "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," Revision 0, to the Palisades Nuclear Plant (PNP).

By electronic mail on October 22, 2007, the NRC requested clarification of the PNP large break LOCA analyses as presented in BAW-2501(P), Revision 2. ENO's responses to the requested information are provided below.

NRC Request

1. *Core Power Operation (%) - Table 3.3* [BAW-2501(P), Revision 2, page 3-12]. *indicates that core power is ranged between 99.5% and 100.5%. The use of reactor power assumption other than 102%, regardless of BE or Appendix K methodology, is permitted by 10 CFR 50, Appendix K.I.A, "Required And Acceptable Features Of The Evaluation Models," "Sources of heat during the LOCA."*

   However, the paragraph also states: "...An assumed power level lower than the level specified in this paragraph [1.02 times the licensed power level], (but not less that the licensed power level) may be used provided . . .

   What is the basis for deviating from 10 CFR 50, Appendix K.I.A?

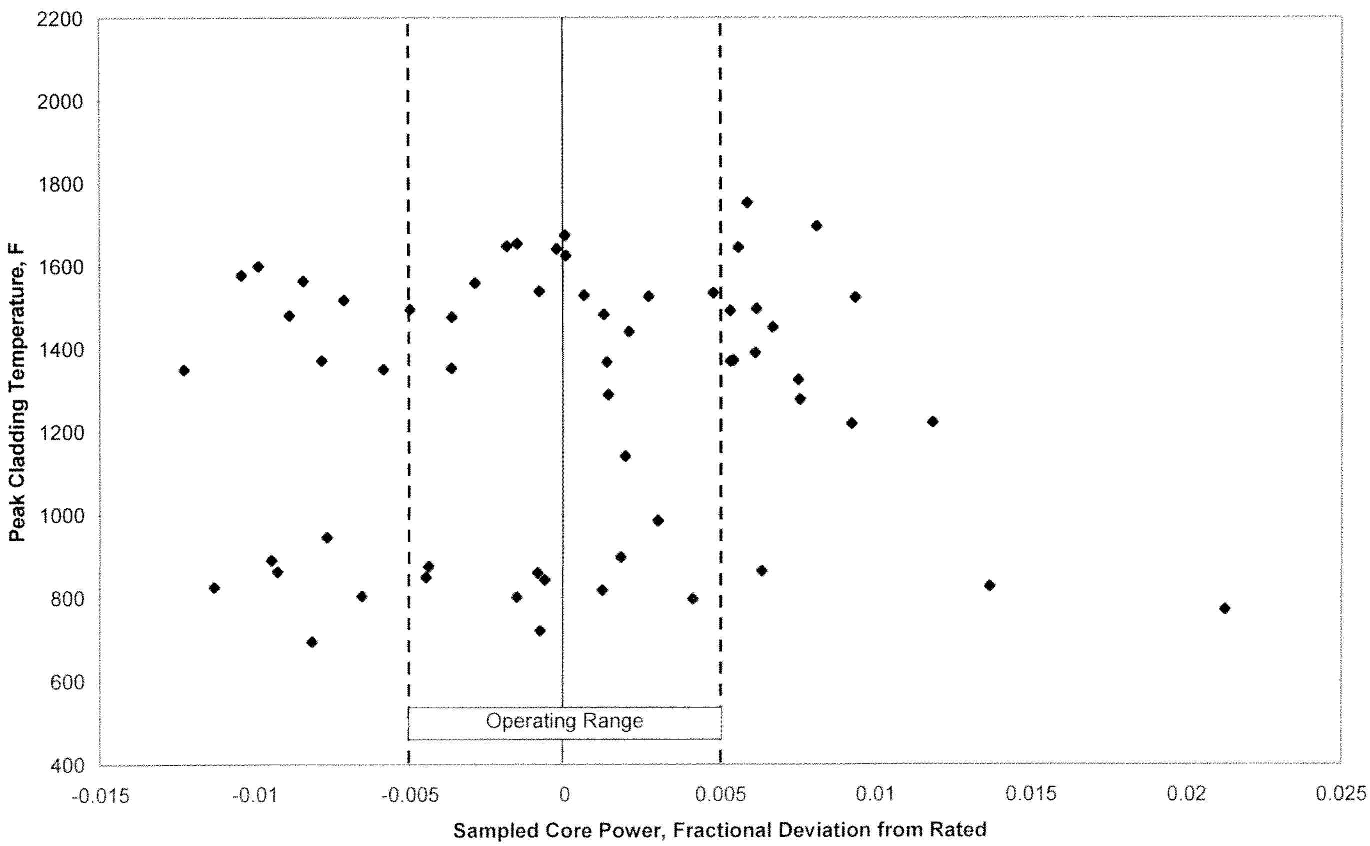
   What is the basis for power ranging? (That causes a conflict between two independent uncertainty profiles.)

ENO Response

1. The suggested requirement establishing the basis for the core power to be used in the analysis of PNP is Appendix K to 10 CFR 50.46. The LOCA analysis submitted is a statistically based evaluation for which the requirements of 10 CFR 50.46, Appendix K, Part I, do not apply. The method of establishing the core initial power for PNP was as specified in EMF-2103(P)(A), Revision 0, in accordance with the NRC approval of that methodology. Core power is sampled over the power operating range convolved with the core power measurement uncertainty.

The NRC issued Amendment 216 to the PNP operating license on June 23, 2004 (ML040970622), which approved a measurement uncertainty recapture power uprate. The PNP operating range is ± 0.5% of rated power. Therefore, in the report, power is first sampled between 99.5% and 100.5% using a uniform distribution. The model power is then obtained by adjusting the nominal power by the PNP reduced measurement uncertainty, approximately 0.6%, based on a Gaussian distribution. Figure 1-1, provides a scatter plot of peak cladding temperature (PCT) as a function of fractional deviation from rated power. As can be observed, approximately half of the case set has a power below 100% and the other half above. However, because the Gaussian distribution for instrument uncertainty both increases and decreases the core power as sampled from the operating range, 76% of the assigned powers lie above the 99.5% lower boundary of the operating range. Two-thirds of the cases of the set have sampled core powers at or above 99.8% of rated power. Furthermore, the highest PCT occurs for a case with a core power of 100.6%.

Figure 1-1 Sampled Core Power versus Peak Cladding Temperature



NRC Request

2. *The BAW-2501 treatment ranges the availability of offsite power.*

   10 CFR 50, Appendix A, GDC [General Design Criterion] *35* [Emergency core cooling] *states that, "Suitable redundancy in components and features and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite electric power is not available) and for offsite electric power operation (assuming onsite power is not available) the system function can be accomplished, assuming a single failure."*

   The Staff interpretation is that two cases (loss of offsite power with onsite power available, and loss of onsite power with offsite power available) must be run independently to satisfy GDC 35.

   Each of these cases is separate from the other in that each case is represented by a different statistical response spectrum. To accomplish the task of identifying the worst case would require more runs. However, for LBLOCA analyses (only), the high likelihood of loss of onsite power being the most limiting is so small that only loss of offsite power cases need be run. (This is unless a particular plant design, e.g., CE [Combustion Engineering] *plant design, is also vulnerable to a loss of onsite power, in which situation the NRC may require that both cases be analyzed separately. This would require more case runs to satisfy the statistical requirement than for just loss of offsite power.)*

   What is your basis for assuming a 50% probability of loss of offsite power? Your statistical runs need to assume that offsite power is lost (in an independent set of runs). If, as stated above, it has been determined that Palisades, being of CE design, is also vulnerable to a loss of onsite power, this also should be addressed (with an independent set of runs).

ENO Response:

2. The basis for sampling offsite power at a 50% probability was established in EMF-2103(P)(A), Revision 0. As represented in the question, it is likely that the loss of offsite power (LOOP) is the more severe condition for the evaluation of most LOCA scenarios that comprise a sampling set under the AREVA realistic LOCA methodology. It can also be recognized that the probability of losing offsite power coincident with a LOCA is much less than 50%. Therefore, the assumption employed in the EMF-2103(P)(A), Revision 0, methodology provides a conservative assessment of the probable result of a LOCA at PNP. Further, offsite power availability, within this methodology, affects only the primary coolant pump status, powered or unpowered, and the delay times for pumped emergency core cooling

system (ECCS) injection. The single failure for ECCS availability is conservatively selected independent of the availability of offsite power. This combination of assumptions is considered sufficient to meet the requirements imposed by GDC-35.

Nonetheless, the case set for the PNP realistic large break LOCA has been examined and the eight cases with the highest PCT were sampled at the LOOP condition. Only the ninth case was sampled at the offsite power available condition. This case reports a PCT 152°F below the most limiting PCT of the case set. This makes it further evident that the PNP submittal assures the redundancy required by GDC-35.

NRC Request

3. *Does the version of SRELAP used to perform the computer runs assure that the void fraction is less than 95% and the fuel cladding temperature is less than 900°F before it allows rod quench?*

ENO Response

3. No. The version of S-RELAP employed for the PNP LAR only restricts quenching to cladding temperatures below T_{min}. There is no restriction on local void fraction. PCTs and significant cladding oxidation occur at void fractions above 98%. Cladding quench occurs after a substantial cladding cooldown accompanied by significant decreases in local void fractions. Because of the timing and prototypical void fractions at which quench occurs during a reflooding or refilling condition, it was not considered necessary to limit the quench process by local void fraction. By way of demonstration, Table 3-1 provides the T_{min} for each of the ten highest PCT cases from the PNP realistic large break LOCA case set along with an upper bound of the local void fraction at the time of quench for the PCT location.

Table 3-1 T_{min} and Quench Void Fraction for Upper Ten PCT Cases

PCT Ranking	Case Set Number	T_{min} °F	Upper Bound of Void Fraction at Quench
1	13	711	0.80
2	52	630	0.80
3	17	689	0.55
4	48	671	0.75
5	46	784	0.85
6	29	550	0.55
7	16	679	0.80
8	42	775	0.85
9	37	789	0.60
10	55	589	0.70

NRC Request

4. The licensee must provide justification that the SRELAP rod-to-rod thermal radiation model applies to the Palisades core.

ENO Response

4. The EMF-2103(P)(A) realistic large break LOCA methodology does not provide modeling of rod-to-rod radiation. The fuel rod surface heat transfer processes included in the solution at high temperatures are: film boiling, convection to steam, rod to liquid radiation, and rod to vapor radiation. This heat transfer package was benchmarked against various experimental data sets involving both moderate (1600°F – 2000°F) and high (2000°F to over 2200°F) PCTs and shown to be conservative when applied nominally. The normal distribution of the experimental data was then determined. During the execution of a realistic large break LOCA evaluation, the heat transferred from a fuel rod is determined by the application of a multiplier to the nominal heat transfer model. This multiplier is determined by a random sampling of the normal distribution of the experimental data benchmarked. Because the data benchmarked includes the effects of rod-to-rod radiation, and the nominal heat transfer modeling is conservative relative to the benchmarked data, it is reasonable to conclude that the modeling implicitly includes a conservative allocation for rod-to-rod effects.

   Notwithstanding any conservatism evidenced by experimental benchmarks, the application of the model to commercial nuclear power plants provides some additional margins due to limitations within the experiments. The benchmarked experiments, FLECHET SEASET and ORNL THTF, used to assess the S-RELAP heat transfer model incorporated constant rod powers across the experimental assembly. Temperature differences that occurred were the result of guide tube, shroud or local heat transfer effects. In the operation of a pressurized water reactor (PWR) and in the realistic large break LOCA evaluation, a radial local peaking factor is present, creating power differences that tend to enhance the temperature differences between rods. In turn, these temperature differences lead to increases in net radiation heat transfer from the hotter rods. The expected rod-to-rod radiation will likely exceed that embodied within the experimental results. Therefore, the implicit application of rod-to-rod radiation of the EMF-2103(P)(A) realistic large break LOCA methodology is more conservative.

In summary, the conservatism of the heat transfer modeling established by benchmark can be reasonably extended to plant applications, and the plant local peaking provides a physical reason why rod-to-rod radiation should be more substantial within a plant environment than in the test environment. As a further consideration, the limiting cladding temperature for PNP is 1751°F. Therefore, the lack of an explicit rod-to-rod radiation model, in the version of S-RELAP applied to PNP, does not invalidate the conclusion that the cladding temperature and local cladding oxidation have been demonstrated to meet the criteria of 10 CFR 50.46 with a high level of probability.

NRC Request

5. *Is the Forslund-Rohsenow model contribution to the heat transfer coefficient limited to less than or equal to 15% when the void fraction is greater than or equal to 0.9?*

ENO Response

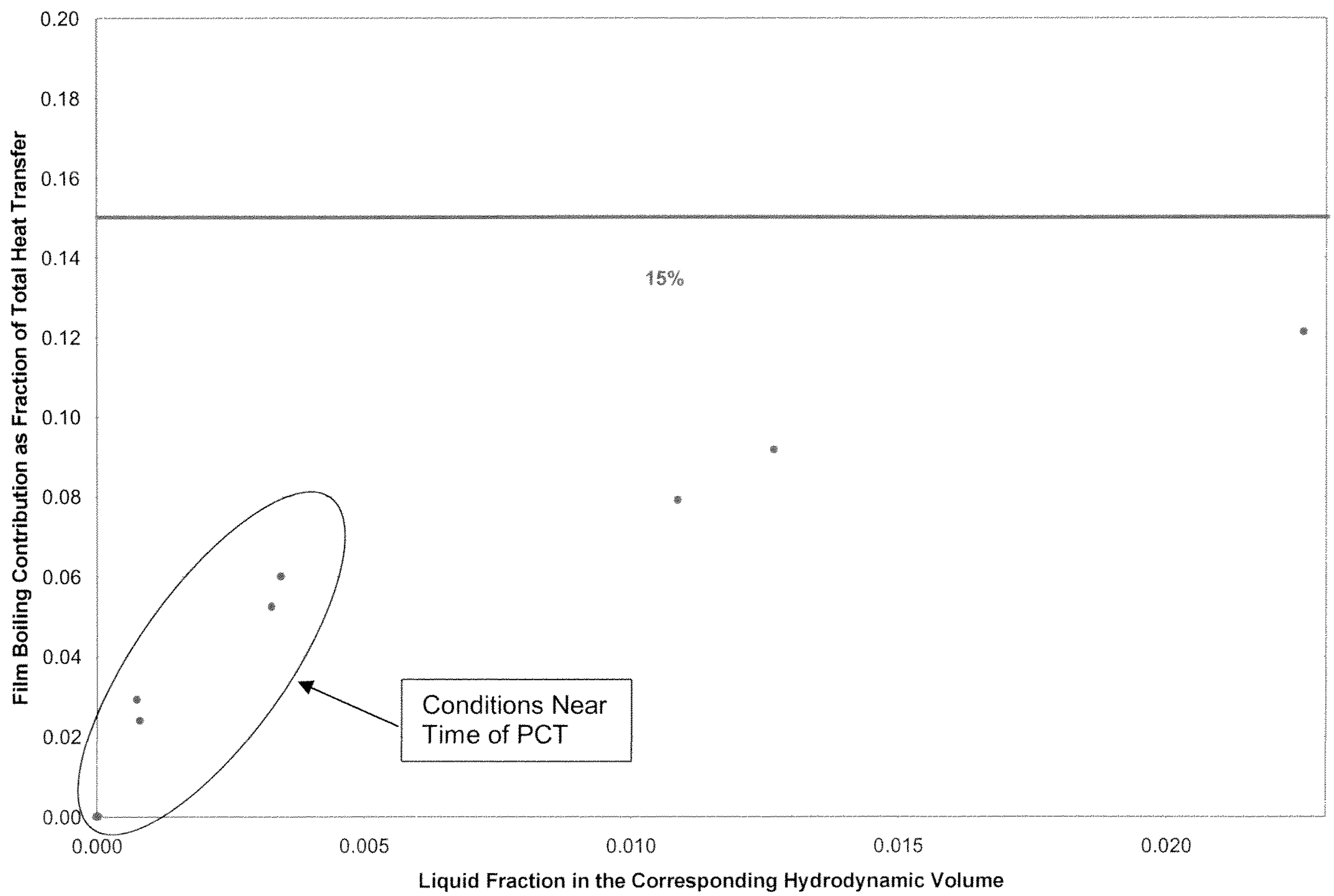
5. EMF-2103(P)(A), Revision 0, does not require a limitation on the Forslund-Rohsenow heat transfer correlation. However, as a practical matter, the contribution of Forslund-Rohsenow to the total heat transfer package decreases as the local void fraction increases and is less than 15% for void fractions above approximately 97%. Figure 5-1 provides a scatter plot, taken from the limiting PNP case, of a sampling of the percentage of the Forslund-Rohsenow contribution to heat transfer as a function of liquid fraction. The sampling includes several points near the time of PCT (circled area). As expected, the fluid cooling the hot spot at the time of PCT comprises steam in transition to low liquid fraction. The contribution of Forslund-Rohsenow to the total heat transfer in such a flow is limited, and well below 15%. Thus, it can be concluded that there would be no direct influence of a limitation on Forslund-Rohsenow on the resultant limiting PCT for PNP.

   An indirect effect on PCT may occur because such a limitation may reduce steam generation below the hot spot where the void fraction could reside between about 90% and 97%. Such an impact is expected to be small and, given that the limiting

PCT for PNP is 1751°F, well below the temperature (1800°F) at which local oxidation can become a complicating influence, does not pose a concern for the conclusions reached by the realistic large break LOCA evaluation.

In summary, there is no limitation of the contribution of Forslund-Rohsenow to the heat transfer for the PNP realistic large break LOCA analysis. However, the impact of such a limitation, if it were to be applied, would be minimal and would not lead to an alteration of the conclusions of the analysis that the cladding temperature and local cladding oxidation have been demonstrated to meet the criteria of 10 CFR 50.46 with a high level of probability.

Figure 5-1 Film Boiling Heat Transfer Contribution – Forslund-Rohsenow Limit Case 13, PCT Node 36, @ ~PCT Time (27s)



NRC Request

Note: In accordance with a telephone discussion with the NRC on November 19, 2007, this question has been reworded from the NRC e-mail to provide clarity.

6. *If the PCT is greater than 1800°F or the containment pressure is less than 30 [pounds per square inch] psia, has the PNP downcomer model been rebenchmarked by performing sensitivity studies, assuming adequate downcomer noding in the water volume, vessel wall and other heat structures?*

ENO Response

6. The PCT for the PNP realistic large break LOCA submittal is 1751°F and the containment pressure is 46 psia at the time of PCT for the limiting case. The containment pressure remained above 30 psia through core quench. Therefore, since the PCT is less than 1800°F and the containment pressure is greater than 30 psia, there is no need for additional sensitivity studies.

NRC Request

7. *Were all the break sizes assumed to be greater than or equal to 1.0 ft^2?*

ENO Response

7. No. EMF-2103(P)(A), Revision 0, sets the minimum total break size at 0.1 times Apipe, 0.5 ft^2, for PNP. However, the PNP case set contains only one case with a total break area below 1.0 ft^2. The total break area for that case was 0.93 ft^2 and the PCT was 720°F.

   Note: According to EMF-2103(P)(A), Revision 0, methodology, the break area (guillotine or split type break) is referenced as one half of the total opening between the reactor coolant system and the containment. Thus, tables and figures within BAW-2501 that refer to break area will show several breaks at less than 1.0 ft^2 and one at less than 0.5 ft^2. These values represent half of the total break area. The one case at less than 0.5 ft^2 is the case referenced in the above response with a total break area of 0.93 ft^2.

NRC Request

8. *EMF-2103, Revision1 was withdrawn. Please identify the containment methodology that was used, and show that it is acceptable for use with EMF-2103, Revision 0.*

ENO Response

8. The containment methodology is specified in EMF-2103(P)(A), Revision 0. The primary goal of the methodology was to achieve a containment pressure prediction that was reasonably a best estimate when sampled parameters associated with the containment response are set at nominal values. The values for the sampled parameters were then distributed over a range that trended to pressures slightly less than best estimate.

   To accomplish this for PNP, the containment model employed for 10 CFR 50.46 Appendix K based deterministic LOCA evaluations was adopted with the following modification.

   > The condensing heat transfer model was adjusted from 4 x Tagami plus Uchida to an approximate best estimate. The best estimate is created by applying a multiplier to Uchida that approximates 1 x Tagami plus Uchida. This step is needed because Tagami depends on the timing of the blowdown and that timing varies during the case set with break size.

   Subsequent to the generation of the PNP realistic large break LOCA containment model, the containment heat structure descriptions were updated. The containment pressure result based on this revised data was benchmarked to the containment result produced by the original heat structure data for the limiting case and demonstrated comparable containment pressure and cladding temperature results. It was decided that the original heat structure data provided an adequate base for the realistic large break LOCA calculations and no reevaluation of the realistic large break LOCA was required.

   The sampling parameters that affect the containment response for a given case are the containment free volume and the initial containment atmospheric temperature. The containment free volume was sampled from a lower end value of 1.64 million ft^3 to a maximum value of 1.804 million ft^3 using a uniform distribution. The minimum value of 1.64 million ft^3 is the volume used in the containment design pressure calculation. The upper end value of 1.804 million ft^3 is the envelope available within the inner shell of the containment with all interior structures removed. The containment atmospheric temperature is ranged between the minimum and maximum values for containment temperature as set in the plant technical specifications. The initial building humidity is held constant across the case set at 100% in agreement with the NRC Standard Review Plan, Branch Technical Position 6-2, "Minimum Containment Pressure Model for PWR ECCS Performance Evaluation," Revision 3, for minimum containment pressure calculations.

The net effect is a set of containment pressure predictions that lie between a best estimate response and the full conservatism of a Branch Technical Position 6-2 model used for deterministic, Appendix K based LOCA evaluations. For PNP this is illustrated in the Figures 8-1 through 8-3. The first two are scatter plots of PCT versus the sampled containment volumes and initial atmospheric temperatures. Figure 8-3 is a plot of containment pressure versus time for the limiting case (13) which is also representative of large break cases with higher containment pressures, a case (17) representative of large break cases with lower containment pressures, and the containment pressure response for the reference Appendix K calculation.

In summary, the containment pressure model used for PNP has been constructed to provide a range of reasonably expected responses. This is appropriate for a statistically based realistic LOCA evaluation model in reaching the conclusion that the cladding temperature and local cladding oxidation have been demonstrated to meet the criteria of 10 CFR 50.46 with a high level of probability.

Figure 8-1
PCT versus Containment Free Volume

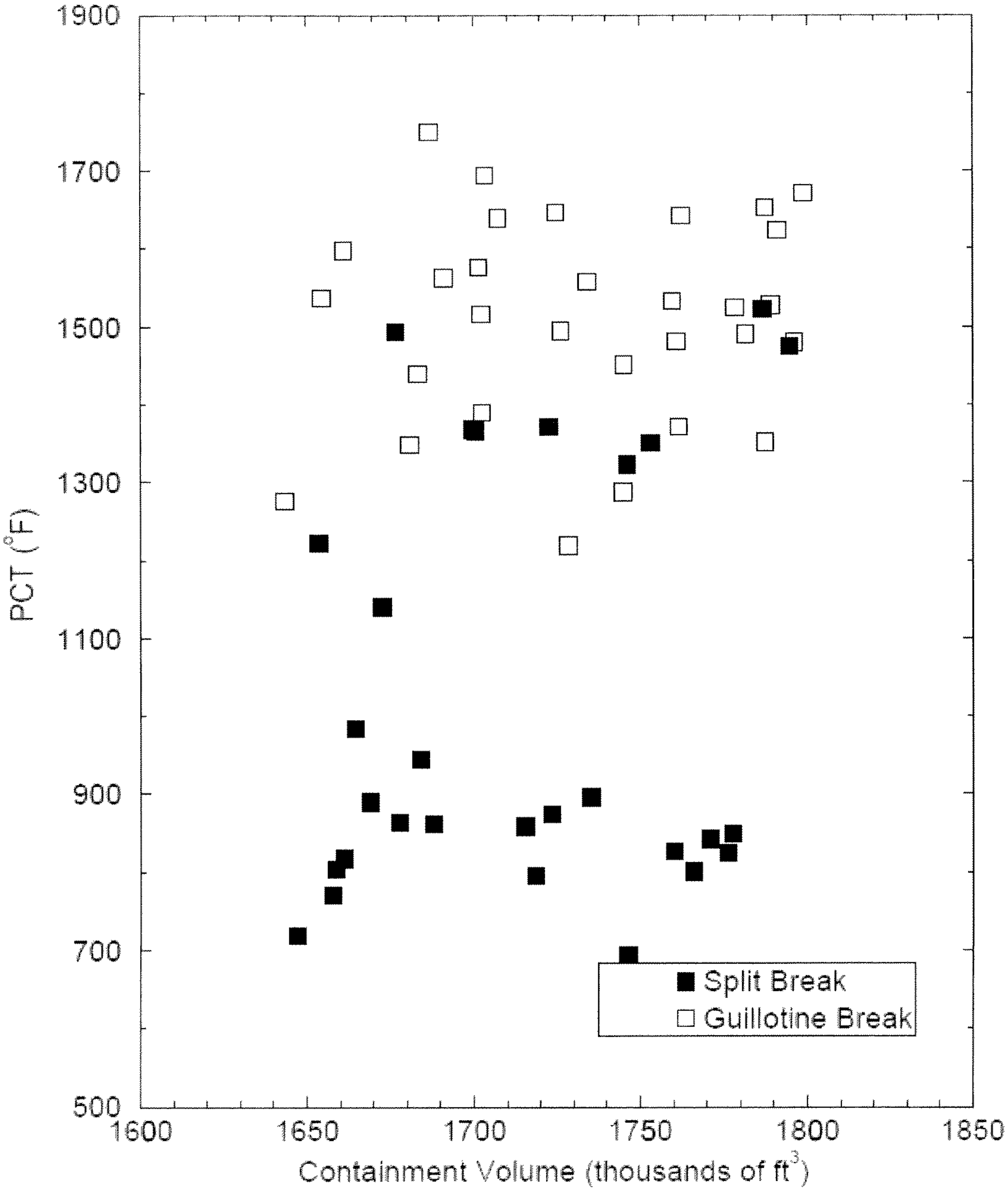


Figure 8-2
PCT versus Initial Containment
Atmospheric Temperature

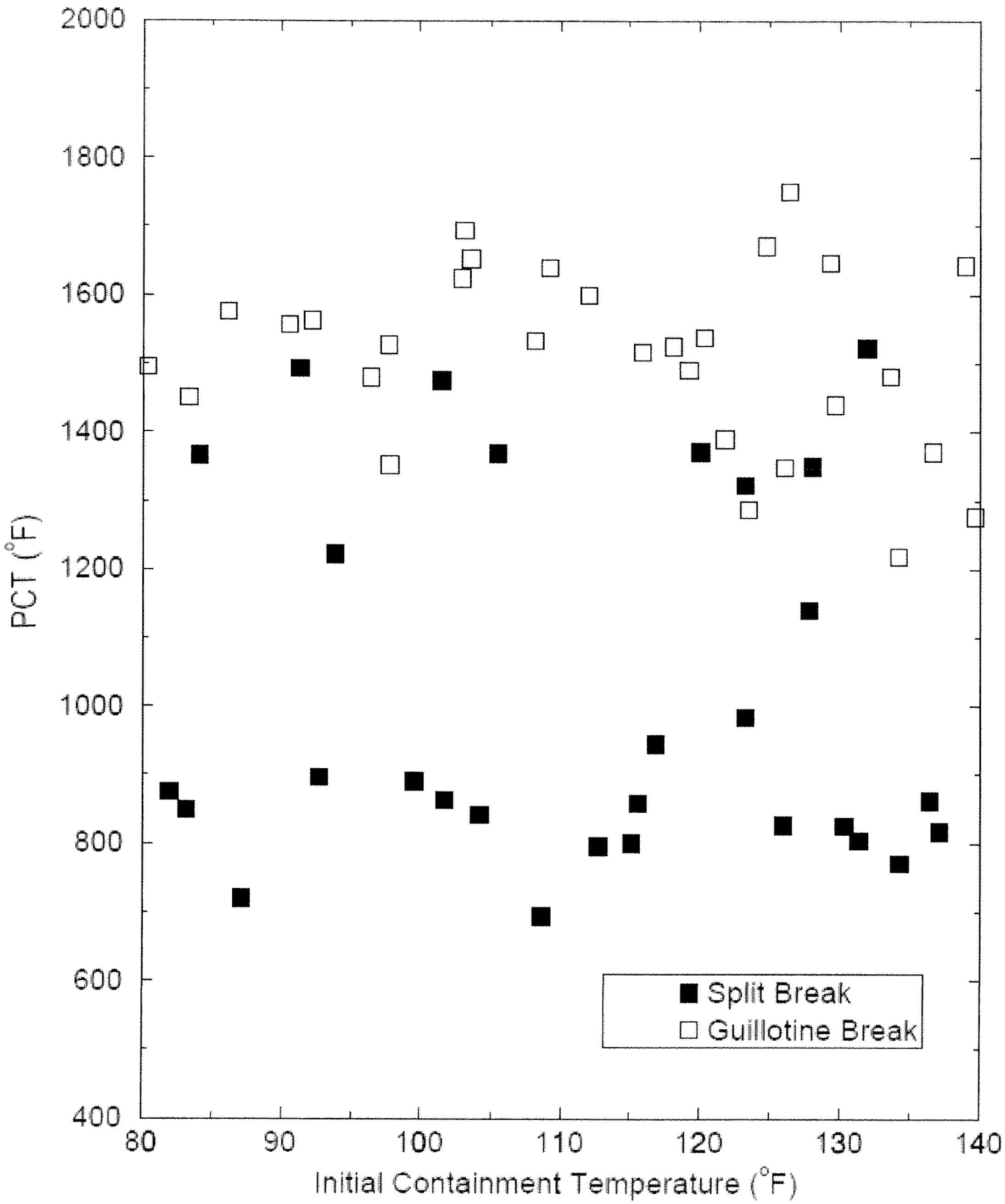


Figure 8-3
Containment Pressure Comparisons