Supplement 5 to ANF-88-191

Dresden Units 2 and 3 LOCA-ECCS Analysis MAPLHGR Results for ANF 9x9 Fuel

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1.0 Introduction

Reference 1 documents results of LOCA analyses to determine MAPLHGR limits for ANF 9x9-2 fuel in Dresden Units 2 and 3. This letter supplement documents an analysis which extends the Reference 1 LOCA analyses to address the following issue:

- **LPCS runout flow.** The LPCS runout flow was reduced from 5650 gpm to 5276 gpm per pump. A ComEd evaluation of the single failure loop select logic (SF-LSL) event indicated that the LPCS runout flow will be degraded. In the SF-LSL event, it is postulated that the LSL failed to select the intact loop. With four LPCI pumps and two LPCS pumps running, the available net positive suction head (NPSH) for each pump is reduced. Thus, there is a potential that the pumps may cavitate. ComEd calculated that the reduced LPCS runout flow due to pump cavitation is at least 5300 gpm. (This analysis conservatively assumes the LPCS runout flow to be 5276 gpm.) Section 1.1 describes the SF-LSL scenario and provides a basis that the scenario is bounded by SF-LPCI with reduced LPCS runout flow. Therefore, the Reference 1 analysis is reanalyzed with reduced LPCS runout flow.

The following issues which were addressed in Supplements 1 through 4 of Reference 1 are still valid and are included in this analysis:

- **Revised reflood time based on a full core of 9x9-2 fuel and a later version of the FLEX computer code.** The peak clad temperature (PCT) results reported in Reference 1 were based on a reflood time determined for a full-8x8-1 core. The 8x8-1 reflood time is longer than that for a full-9x9-2 core and was used in Reference 1 to provide conservative results for transition cores. Starting with Cycle 14 for both units, the core was composed entirely of 9x9-2 fuel assemblies and a 9x9-2 reflood time is appropriate for use. In addition, revisions to the FLEX code subsequent to Reference 1 result in a reduced reflood time relative to that reported in Reference 1. The version of FLEX (uoct95) developed as part of the revised BWR EXEM LOCA evaluation methodology (Reference 5) was used.

- **Access hole cover leakage.** A previous evaluation (References 2 and 3) determined that the PCT increase for the Dresden LOCA analysis was less than 10°F due to 78 gpm of leakage around the access hole covers. The analysis documented in this supplement explicitly accounts for the access hole cover leakage in the FLEX reflood analysis. The leakage is modeled in FLEX by reducing the LPCS mass flow rate by the leakage mass flow rate. The leakage mass flow rate is based on the water density at the location of the leakage for LOCA conditions. The 78 gpm leakage is equivalent to a 35.7 gpm LPCS line leakage with a LPCS water temperature of 95°F, which is conservative relative to a LPCS water temperature of 170°F.

- **Bottom head drain line leakage.** A previous evaluation (Reference 4) determined that the PCT increase for the Dresden LOCA analysis was 35°F due to leakage through the bottom head drain line (conservatively estimated to be 286 gpm) and leakage through the access hole covers. The analysis documented in this supplement explicitly accounts for the bottom head drain line leakage in the FLEX reflood analysis. The leakage is modeled in FLEX by reducing the LPCS mass flow rate by the leakage mass flow rate. The leakage mass flow rate is based on the water density at the location of the leakage for LOCA conditions. The 286 gpm leakage is equivalent to a 130.9 gpm LPCS line leakage with a LPCS water temperature of 95°F, which is conservative relative to a LPCS water temperature of 170°F.

- **Limiting 9x9-2 fuel neutronic design.** The results presented in this supplement are performed for the nuclear lattice type (335-9G4.5) which was added to the core after the Reference 1 analyses that results in the highest PCT.

- **Core shroud leakage.** A previous evaluation (Reference 8) determined the PCT with the added leakage of the core shroud (184 gpm). The analysis described in this supplement also explicitly accounts for the core shroud leakage (184 gpm) in the FLEX reflood analysis. The leakage rate was provided in Reference 6. The core shroud leakage is modeled in FLEX by reducing the LPCS mass flow rate by the leakage mass flow rate. The leakage mass flow rate is based on the water density at the location of the leakage for LOCA conditions. The 184 gpm leakage is equivalent to a 136.9 gpm LPCS line leakage with a LPCS water temperature of 95°F, which is conservative relative to a LPCS water temperature of 170°F.

- **LPCS line leakage.** A previous evaluation (Reference 8) determined the PCT with the added leakage of the LPCS line (83 gpm). The analysis described in this supplement assumes 400 gpm for the LPCS line leakage. The leakage rate was provided in Reference 9. The analysis described in this supplement explicitly accounts for the LPCS line leakage by reducing the LPCS flow rate by the LPCS leakage rate.

- **LPCS water temperature.** The LPCS water temperature was increased from 95°F to 170°F.

The analysis documented in this supplement was performed in response to Reference 10.

The leakages used in the analysis bound the actual leakages at Dresden Units 2 and 3 based on the information provided in Reference 9. Specifically, Unit 2 has a LPCS line leakage of 398 gpm, a core shroud weld leakage of 184 gpm, an access hole core leakage of 78 gpm and a bottom head drain line leakage of 225 gpm. Unit 3 has a LPCS line leakage of 266 gpm, a core shroud weld leakage of 0 gpm, an access hole cover leakage of 0 gpm, and a bottom head drain line leakage of 225 gpm. The analysis used a LPCS line leakage of 400 gpm, a core shroud weld leakage of 184 gpm, an access hole cover leakage of 78 gpm, and a bottom head drain line leakage of 286 gpm.

1.1 *Method of Analysis*

If the recirculation line break is in the pump suction side (PS), the ECCS equipment available with SF-LSL is four LPCI pumps and two LPCS pumps. This event is non-limiting because the limiting large break LOCA is SF-LPCI which results in no LPCI pumps and two LPCS pumps.

If the recirculation line break is in the pump discharge side (PD), downstream of the LPCI injection point, the LPCI flow is degraded, but two LPCS pumps are still available; therefore, this event is bounded by SF-LPCI PD. If the break is upstream of the LPCI injection point, then all the LPCI flow is lost through the break. This is similar to the case of SF-LPCI PD with reduced LPCS runout flow. The limiting large break LOCA is 1.0 DEG/PS, SF-LPCI. With degraded LPCS runout flow, 1.0 DEG/PS will still bound 1.0 DEG/PD for SF-LPCI. Therefore, if the 1.0 DEG/PS, SF-LPCI event is analyzed with reduced LPCS runout flow, the resulting PCT will bound the PCT for 1.0 DEG/PD, SF-LPCI, which is similar to 1.0 DEG/PD, SF-LSL.

Only tables and figures that are different from Reference 1 are provided in this supplement; results in all other tables and figures are unchanged from Reference 1. Section, table, and figure numbers used in this supplement correspond to those used in Reference 1.

3.0 Results

No additional RELAX blowdown analyses were performed for the analysis described in this supplement; boundary conditions for the reflood and heatup analysis were obtained from Reference 1.

The version of FLEX (uoct95) developed as part of the revised BWR EXEM LOCA evaluation methodology (Reference 5) was used to determine the reflood time for a full core of 9x9 fuel. The FLEX analysis explicitly accounted for the leakage through the access hole covers, the bottom head drain line, the core shroud, and the LPCS line. Results from the FLEX analysis are provided in Figures 3.20–3.22a. Figure 3.22a provides a plot of entrained liquid flow versus time. In the revised BWR EXEM methodology, entrained liquid flow is the parameter used to define the time of core reflood. The reflood time obtained from the FLEX analysis was 173.8 seconds as shown in Table 3.3.

A heatup analysis was performed for the limiting break (1.0 DEG/PS, SF-LPCI), limiting state point (100/87), and limiting exposure (5 GWd/MTU) identified in Reference 1 with HUXY (unov94). Results from the heatup analysis are provided in Tables 3.1 and 3.2. PCT versus time is provided in Figure 3.26. Key event times for the analysis are provided in Table 3.3 (note, only the last four event times in Table 3.3 are different from Reference 1). The reduction in LPCS runout flow caused a PCT increase of 133°F as compared to the Reference 11 results. The PCT will be 2163°F at 173.8 seconds with the reduced runout flow of 10,552 gpm for two LPCS pumps.

The results from the LOCA analysis are in conformance to 10 CFR 50.46 ECCS criteria. The MAPLHGR limits provided in Table 1.2 and Figure 1.1 of Reference 1 remain unchanged.

5.0 References

1. *Dresden Units 2 and 3 LOCA-ECCS Analysis MAPLHGR Results for ANF 9x9 Fuel*, ANF-88-191, Advanced Nuclear Fuels Corporation, December 1988.

2. Letter, Udell Fresk to R. J. Chin, "Impact of Replaced Access Hole Covers on Dresden LOCA Analysis," YUF:025:93, January 19, 1993.

3. Letter, Udell Fresk to D. R. Zahakaylo, "Impact of Replaced Access Hole Covers on Dresden LOCA Analysis," YUF:042:93, February 3, 1993.

4. Letter, Udell Fresk to R. J. Chin, "Impact of Reactor Vessel Bottom Head Drain Line on Dresden Units 2 and 3 LOCA Analyses," YUF:098:95, SPCCWE:055:95, March 14, 1995.

5. *Advanced Nuclear Fuels Corporation Methodology for Boiling Water Reactors EXEM BWR Evaluation Model*, Advanced Nuclear Fuels Corporation, ANF-91-048(P)(A), January 1993.

6. Letter, R. W. Tsai (ComEd) to J. H. Riddle (SPC), "Dresden Core Shroud and Core Spray Line Leakages During LOCA Conditions," NFS:BSA:95-080, October 23, 1995.

7. Deleted.

8. Supplement 3 to ANF-88-191 transmitted via letter, J. H. Riddle (SPC) to R. J. Chin (ComEd), "Dresden LOCA PCT Documentation for Core Shroud and Core Spray Line Leakages," JHR:151:95, November 30, 1995.

9. Letter, R. W. Tsai (ComEd) to J. H. Riddle (SPC), "Request for an Additional Supplement to ANF-88-191," NFS:BSA:96-123, October 24, 1996.

10. Letter, R. W. Tsai (ComEd) to J. H. Riddle (SPC), "Request for an Additional Supplement to ANF-88-191, NFS:BSA-97-003, January 9, 1997.

11. Letter, J. H. Riddle (SPC) to R. J. Chin (ComEd), "Dresden LOCA PCT Documentation for Core Spray Line Leakage of 400 GPM - Supplement 4 to ANF-88-191," JHR:96:438, November 2, 1996.

Table 3.1

Dresden Operating Conditions Comparison

	100% Flow	87% Flow
Peak Cladding Temperature, F	---	2163
Local Zr/H20 Reaction (maximum), %	---	3.67

Table 3.2

Dresden LOCA Analysis Results for ANF 9x9 Reload Fuel

Assembly Average Burnup (GWd/MTU)	MAPLHGR (kW/ft)	Local MWR (%)	PCT (°F)
0	11.40	---	---
5	11.75	3.67	2163
10	11.40	---	---
15	10.55	---	---
20	9.70	---	---
25	8.85	---	---
30	8.00	---	---
35	7.15	---	---
40	6.30	---	---

Core average metal-water reaction is < 1%.

Table 3.3

Dresden 9x9 Limiting Break Event Times

Event	Time (sec)
Start	0.0
Initiate Break	0.05
Feedwater Flow Stops	0.55
Steam Flow Stops	5.05
Low Low Mixture Level	4.5
Jet-Pumps Uncover	7.6
Recirculation Pipe Uncovers	10.8
Lower Plenum Flashes	12.0
HPCI Flow Starts	14.5
LPCS Starts	37.3
Rated Spray Calculated	59.7
Depressurization Ends	145.7
Start of Reflood	163.9
Time of Hot Node Reflood (full-9x9 core based on 0.4 kg/sec entrained flow criteria)	173.8
Peak Clad Temperature Reached	173.8

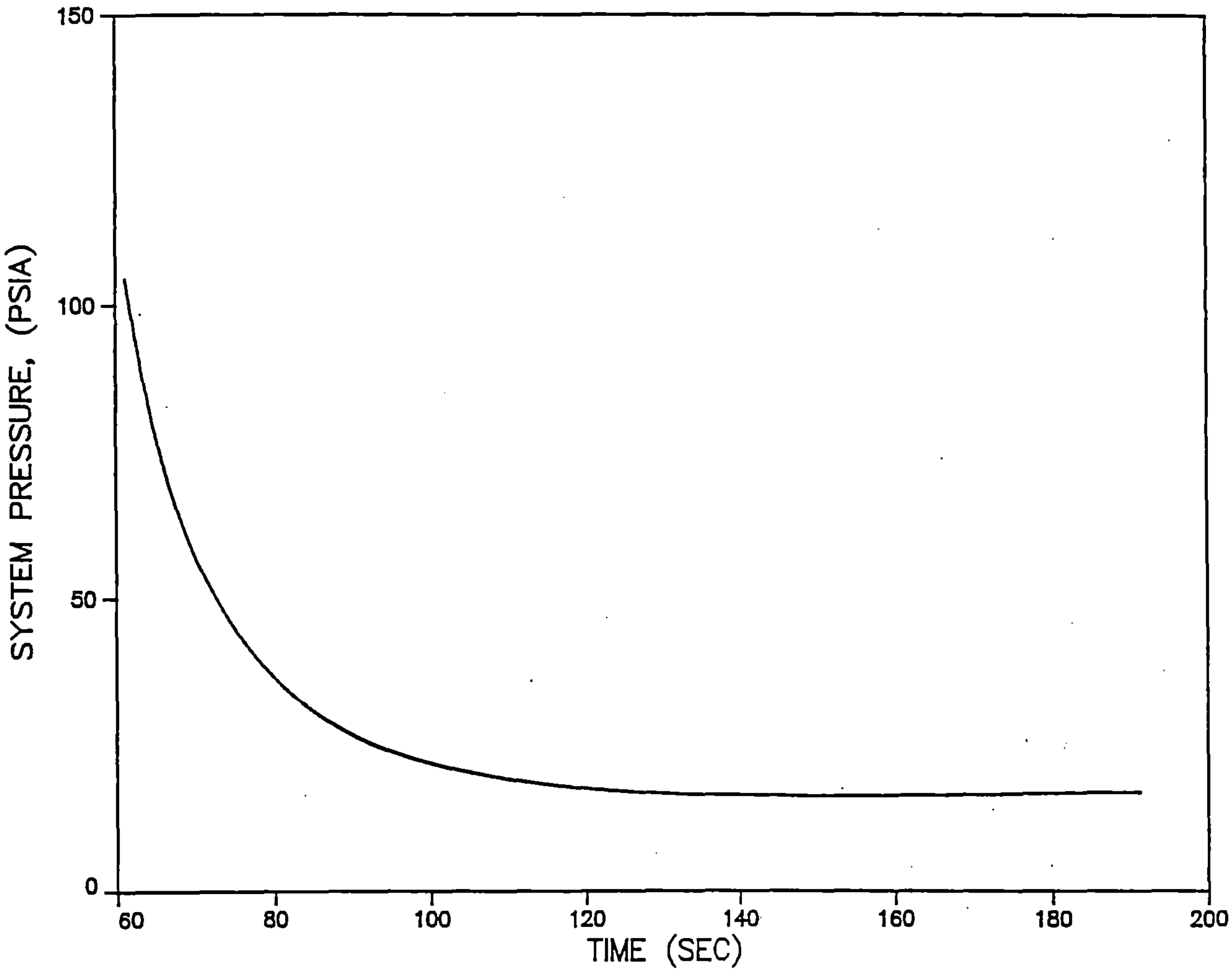

Figure 3.20

Refill / Reflood System Pressure

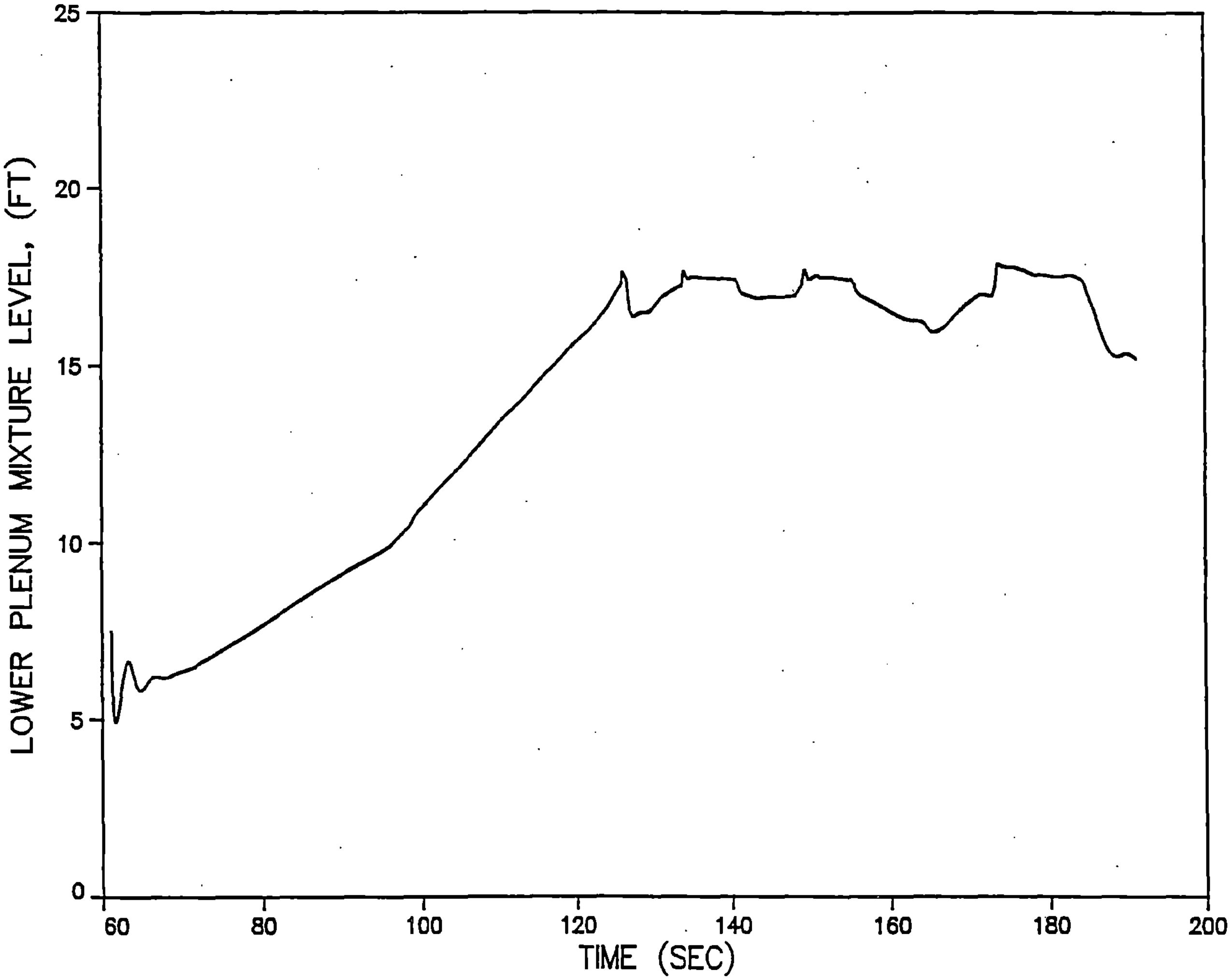

Figure 3.21

Refill / Reflood Lower Plenum Mixture Level

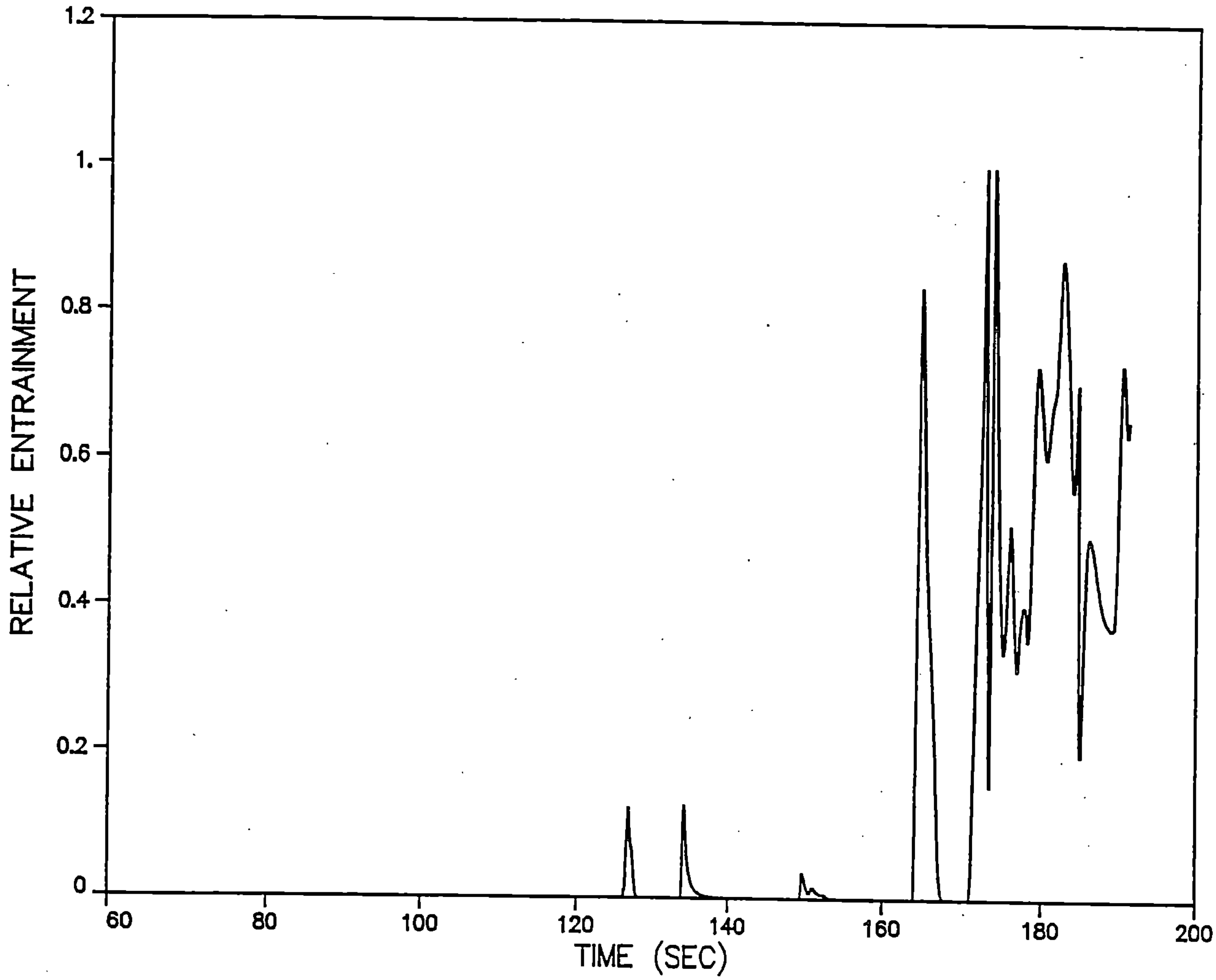

Figure 3.22

Refill / Reflood Relative Core Midplane Entrainment

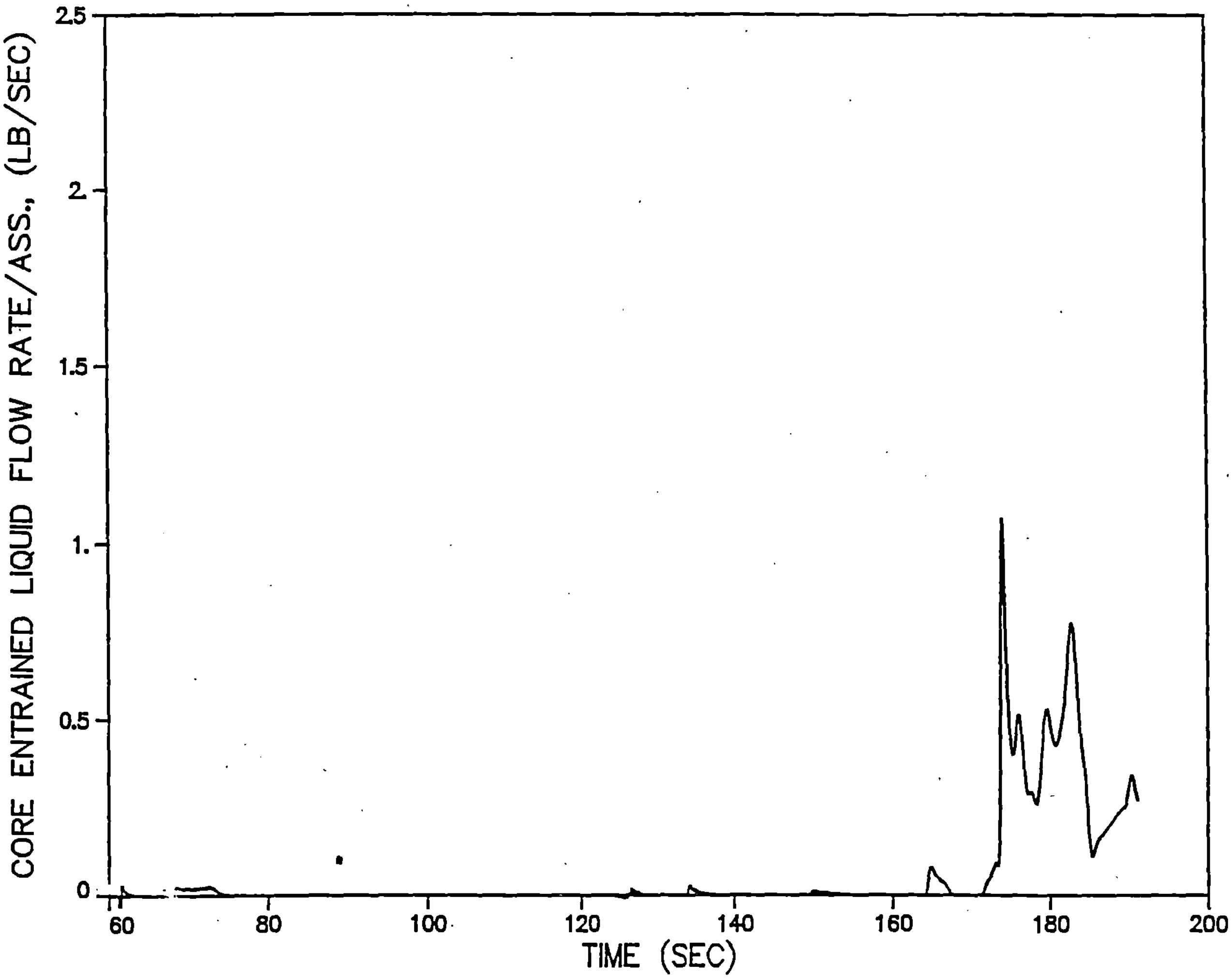

Figure 3.22a

Refill / Reflood Core Entrained Liquid Flow Rate

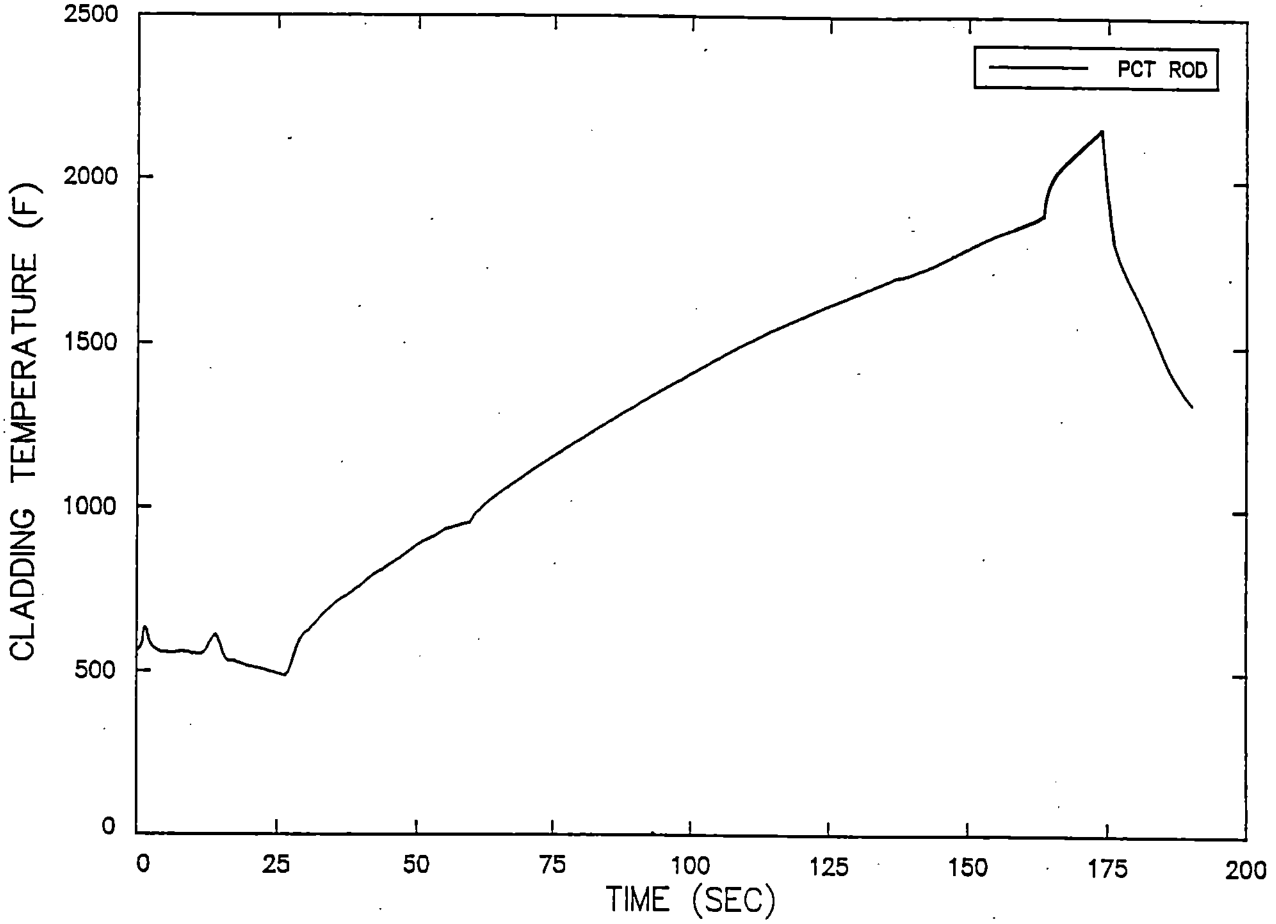

Figure 3.26

Hot Assembly Heatup Results
5 GWd/MTU