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December 14, 2005

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Document Control Desk

Subject: Oconee Nuclear Station
Docket Numbers 50-269, 270, and 287
Supplemental Response to Request for Additional Information Pertaining to Defense in Depth and Diversity Assessment Associated with the Digital Upgrade of Oconee's Reactor Protective System and Engineered Safeguards Protective System

Duke Energy Corporation (Duke) submitted the defense-in-depth and diversity (D-in-D&D) assessment on March 20, 2003. The associated License Amendment Request (LAR) for the reactor protective system (RPS) and the engineered safeguards protective system (ESPS) digital upgrade was submitted on February 14, 2005. On October 26, 2005, Duke responded to a Request for Additional Information (RAI) associated with the D-in-D&D assessment performed for the digital upgrade.

In the response to RAI 7, Duke committed to provide the results of sensitivity analyses by December 15, 2005. The sensitivity analyses demonstrate that additional time is available for operator action beyond what was assumed in the D-in-D&D assessment. The Attachment provides the results of the sensitivity analyses.

A001

If there are any additional questions, please contact Boyd Shingleton at (864) 885-4716.

Very truly yours,

R. A. Jones, Vice President
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R. A. Jones, being duly sworn, states that he is Vice President, Oconee Nuclear Site, Duke Energy Corporation, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this revision to the Renewed Facility Operating License Nos. DPR-38, DPR-47, DPR-55; and that all the statements and matters set forth herein are true and correct to the best of his knowledge.

R. A. Jones, Vice President
Oconee Nuclear Site

Subscribed and sworn to before me this 14th day of December, 2005

Notary Public

My Commission Expires:

9/20/2009

Attachment

NRC Request for Additional Information (RAI)
Associated with the Digital Upgrade of Oconee's Reactor Protective System and Engineered Safeguards Protective System

RAI 7

How much time *is available for operators* to take the actions such that accident acceptance criteria are met (reactor coolant system overpressure, radiological, reactor building pressure, coolable geometry)?

(It is clear from the licensee's submittal what operator action times were *assumed* - what is not clear is how much time do operators *have*.)

This question is posed for the following credited operator actions:

Control Rod Ejection
- **Manual HPI actuation at 5 minutes**
- **Manual reactor building cooling system (RBCS) and reactor building spray (RBS) actuation at 8 minutes**

Small Break LOCA
- **Manual reactor trip at 2 minutes**
- **Manual HPI actuation at 5 minutes**
- **Manual reactor building cooling system (RBCS) and reactor building spray (RBS) actuation at 8 minutes**

Response to RAI 7

In the October 26, 2005, RAI response, Duke indicated that sensitivity analyses were being performed to demonstrate that additional time is available for operator actions necessary to mitigate the Rod Ejection (REA) and Small Break Loss of Coolant Accident SBLOCA) transients. The simulator validations described in the October 26, 2005, response clearly demonstrate that adequate time is available for operators to take the manual operator actions assumed in the D-in-D&D assessment. In addition, the sensitivity analyses performed by Duke demonstrate that additional time is available for operator actions beyond what was assumed in the D-in-D&D assessment. Duke did not attempt to determine the maximum time available for operators to take the actions such that accident acceptance criteria are met.

A summary of the results of the sensitivity analyses is provided below. The acceptance criteria described in the March 20, 2003, submittal (Reference 1) for both the REA and SBLOCA transients is evaluated. The SBLOCA described in Reference 1 is a core flood line break, (CFLB) as this break location represents the biggest core cooling challenge. The acceptance criteria described in Reference 1 are: Reactor Coolant System overpressure, radiological limits, Reactor Building (RB) pressure, and core coolable geometry.

The sensitivity analyses demonstrate that there is significant margin to the RB overpressure criterion for SBLOCA events, such that substantial operator action time is available. The sensitivity analyses confirmed that for SBLOCA events, there is at least an hour for the operator to initiate RBS and RBCS prior to exceeding the acceptance criteria for the D-in-D&D assessment (compared to the 8 minutes assumed in the analyses). The analyses also confirmed that there is at least three additional minutes for operators to initiate High Pressure Injection (HPI) and Low Pressure Injection (LPI) (5 minutes assumed, 8 minutes available).

The operator action to trip the reactor is discussed initially, followed by the operator actions to initiate HPI, RBCS and RBS versus each acceptance criterion.

SBLOCA Manual Reactor Trip

The manual reactor trip operator action time was selected based upon the current licensing basis requirement to trip the reactor coolant pumps (RCP) within 2 minutes of a loss of subcooled margin (LOSCM). There is a high degree of confidence that this operator action time would be satisfied. The time between break initiation and a LOSCM is sufficiently short enough to be included in the operator response time. The anticipated procedural response is to trip both the reactor and the turbine before tripping the RCPs.

For a CFLB transient, there is sufficient reactivity feedback due to moderator voiding in the core to reduce the core power level to approximately 5% by the time operator action to trip the reactor is assumed. A delay in this action would not impact the RB overpressure criterion but might affect the core coolable geometry criterion. The reasoning for this conclusion is explained further below, but a brief explanation follows.

There is significant margin to the RB overpressure criterion such that continued low power operation prior to a manual reactor trip is not a concern. However, the primary consideration for maintaining a coolable geometry is the amount of primary coolant remaining in the Reactor Coolant System (RCS). A delay in tripping the reactor would result in an additional delay in tripping the operating RCPs, since procedural guidance would require the operator to trip the reactor before stopping the RCPs. Continued RCP operation would increase the mass depletion from the RCS, adversely impacting the coolable geometry criterion. The amount of time available to take operator action is not significantly different than the additional time available to actuate HPI and LPI, which is determined below. However, diverse LPI actuation will extend the available time by providing core cooling and negative reactivity due to boron addition.

Reactor Coolant System Overpressure

The RCS overpressure acceptance criterion is not affected by variations in the operator actions described for the REA and CFLB transients.

The REA transient is prevented from reaching the RCS system overpressure acceptance criteria by a Diverse Scram System (DSS) actuation. The DSS actuation shuts the reactor down, and subsequently allows the associated primary coolant break to reduce the RCS pressure. Since the DSS actuation is not associated with an operator action, this acceptance criterion is also not affected by variation in operator action times.

The SBLOCA transient is characterized by a decrease in RCS pressure, and therefore does not challenge this acceptance criterion. Thus, variations in the assumed operator action times will also not affect this acceptance criterion.

Radiological Limits
The radiological limits acceptance criterion is not affected by variations in the operator actions described for the REA and CFLB transients.

The radiological source term for both the REA and CFLB transients could be adversely impacted by a transient response that progressed to the point where additional core damage results. The radiological consequences for these transients are bounded by those determined for the Maximum Hypothetical Accident (MHA). Since the MHA analysis includes a core melt source term, and meets the 10 CFR 100 criterion, the ability to satisfy this acceptance criterion would not appear to be contingent upon ensuring adequate core cooling. However, as shown below, the core cooling criterion is satisfied for both transients. Therefore, this acceptance criterion is unaffected.

Reactor Building Pressure
The RB pressure acceptance criteria identified in Reference 1 is 125 psig. This value corresponds to the ultimate failure pressure of the Reactor Building and not the design pressure limit (59 psig). This acceptance criterion will not be affected by reasonable variations in the operator action times to actuate HPI, RBCS and RBS.

The current Oconee design basis peak containment pressure analysis does not model the engineered safeguards such as RBCS and RBS. The short-term containment pressure response is defined by the mass and energy release and the inherent ability of the Reactor Building to mitigate that response. The concrete and steel structures in the Reactor Building are sufficient heat sinks to adequately mitigate the containment pressure response for a design basis double-ended large break LOCA. Note that the Oconee design basis long-term containment response analysis does model the engineered safeguards (ES) actuations for RBCS and RBS.

In order to reach the acceptance criterion for a relatively slow moving transient, such as a SBLOCA, it is reasonable to conclude that the containment passive heat structures would need to be heated to a temperature approximately equivalent to the saturation conditions at the pressure acceptance criterion. For an acceptance criterion of 125 psig, the containment passive heat structures would need to be heated to a temperature of approximately 350°F. Given that the bounding high initial containment temperature is approximately 140°F, a significant amount of heat and a corresponding delay in actuating RBCS and RBS would be required to approach this criterion. In reality, the transfer to sump recirculation would complicate this since the LPI heat exchangers would begin to remove heat from the building at this point in the event.

To demonstrate this effect, a design basis large break LOCA case was reanalyzed without actuation of either the RBCS or RBS. The containment pressure response is presented in Figure A-1 for the initial 2 hours of the case. As illustrated in Figure A-1, the initial pressure peak is not exceeded for the initial hour of the event, as pressure continues to decrease. RB pressure does begin to increase, but only after 1.5 hours has elapsed. This case assumes prompt ECCS injection to the RCS. In order to provide a continuous mass and energy release, it is necessary to assume that either prompt operator action is taken to initiate HPI and LPI, or that the ES actuation for these functions is not affected by an Reactor Protective System (RPS)/Engineered Safeguards Protective System (ESPS) software common mode failure. Thus it may be concluded that variations in the operator action time to initiate HPI and LPI are not critical for this acceptance criterion.

The containment pressure response for a REA will be bounded by that of the SBLOCA identified in Reference 1. The containment pressure response for both of these break sizes is bounded by that of the large break LOCA presented in Figure A-1. For comparison, the containment pressure response for a CFLB with assumptions obtained from Reference 1 is presented in Figure A-2. Thus, it is reasonable to conclude that the RB pressure acceptance criterion will not be affected by reasonable variations in the operator action times to actuate HPI, RBCS and RBS.

<u>Coolable Geometry</u>
The core cooling acceptance criteria identified in Reference 1 is coolable geometry. This criterion is the same as the fourth criterion listed in 10CFR 50.46. The SBLOCA analysis described in Reference 1 was performed by Framatome-ANP using the Nuclear Regulatory Commission (NRC)-approved Appendix K RELAP5 SBLOCA Evaluation Model. The break selected to be evaluated is a CFLB, as this break location represents the biggest core cooling challenge. The CFLB bounds the small break associated with a REA event with respect to core cooling.

The Framatome-ANP CFLB analysis presented in Reference 1 demonstrates that at least 5 minutes is available for operator action to initiate LPI and HPI flow. Subsequent to the submittal of Reference 1, a decision was made to implement a diverse LPI actuation. The injection flow due to a diverse LPI actuation is not credited in the Framatome-ANP CFLB analysis.

The evaluation to determine additional operator action time available to actuate HPI and LPI was performed using the Duke RELAP5 mass and energy release model described in DPC-NE-3003-PA (Reference 3). The Duke RELAP5 model represents the core using an average core channel and does not contain the level of fidelity required by 10CFR50 Appendix K for determining peak clad temperatures. The Framatome-ANP RELAP5 SBLOCA Evaluation Model does meet the Appendix K requirements, and as such was used for the analyses presented in Reference 1. The Duke RELAP5 model provides a general indication relative to core cooling, and is therefore appropriate for this purpose.

Three sensitivity cases were performed using the Duke RELAP5 model to assess the operator time available to initiate HPI and LPI flow. The first case is a simulation using the operator action times identified in this RAI (and assumed in Reference 1). The second case assumes no operator action to actuate Emergency Core Cooling System (ECCS) injection. The third case evaluates the impact of a diverse LPI actuation. Each of these cases is described below. For the purposes of this discussion, the analysis presented in Reference 1 will be referred to as the Framatome-ANP RELAP5 analysis.

The first case is a simulation using the operator action times identified in this RAI. This case makes similar assumptions relative to the timing of ECCS injection and reactor trip as the Framatome-ANP RELAP5 analysis. The resulting collapsed core liquid level and clad surface temperatures indicate that adequate heat transfer is maintained. This result is consistent with the results of the Framatome-ANP RELAP5 analysis. The collapsed core liquid level for this case is provided on Figure A-3. The clad surface temperatures for the upper half of the core are provided on Figure A-4.

The second case assumes no operator action to actuate ECCS injection. This case is identical to the first case, with the exception that ECCS is not actuated. The collapsed core liquid level for this case is provided on Figure A-5. The clad surface temperatures for the upper half of the core are provided on Figure A-6. As illustrated on Figure A-6, the cladding surface temperature for the uppermost core node begins to depart from the fluid saturation temperature of about 330°F at approximately 320 seconds. The amount of time available is estimated using the Framatome-ANP RELAP5 case result of a maximum clad temperature in the average channel of about 1000°F, and a maximum allowable clad temperature of 1800°F. Since the metal-water reaction is expected to become significant at 1800°F, no additional time beyond this point is considered. A cladding surface temperature increase of 800°F is used to estimate the available time for operator action. The highest node clad temperature reaches 1130°F at about 500 seconds. The time difference between the beginning of the temperature increase and the time when the cladding surface temperature increases by 800°F defines the additional available operator action time. This would indicate that approximately 180 seconds of additional time is available for operator action.

The third case evaluates the impact of a diverse LPI actuation for a double-ended CFLB. This case is identical to the first case, with the exception that LPI is actuated at 120 seconds. The time selected is expected to bound the timing of the proposed diverse LPI actuation. The normal 3 pump HPI flow rate exceeds the LPI injected flow rate for a CFLB. The collapsed core liquid level for this case is provided on Figure A-7. The clad surface temperatures for the upper half of the core are provided on Figure A-8. The results of this case indicate that once LPI is actuated, the collapsed core liquid level continuously increases, and clad surface temperatures indicate that adequate heat transfer is maintained. Thus, it may be concluded that for a CFLB with a diverse LPI actuation, the operator action time to initiate HPI flow is not critical.

For SBLOCAs other than the CFLB, additional operator action time, beyond that determined above, is available to initiate HPI flow. For these break locations, two Core Flood Tanks (CFTs) are available for injection. If the break flow area was small enough to keep RCS pressure above the LPI pump shutoff pressure, then the RCS mass depletion rate would also be reduced, providing additional time.

There are two conclusions with respect to adequate core cooling that may be drawn from these cases. First, if a diverse LPI actuation is not considered, the results indicate that approximately 180 seconds of additional time is available for the operator to initiate HPI and LPI. Second, when diverse LPI actuation is considered, the results indicate that for a CFLB, HPI does not need to be actuated.

<u>Conclusion</u>

There is significant margin to the RB overpressure criterion for SBLOCA events, such that substantial operator action time is available. The sensitivity analyses confirmed that for SBLOCA events, there is at least an hour for the operator to initiate RBS and RBCS prior to exceeding the acceptance criteria for the D-in-D&D assessment (compared to the 8 minutes assumed in the analyses). The analyses also confirmed that there is at least three additional minutes for the operator to initiate HPI and LPI (5 minutes assumed, 8 minutes available).

The simulator validations, provided in Reference 2, demonstrated that operators can initiate a reactor trip in 35 seconds, HPI in 1 minute and 44 seconds, RBC in 3 minutes and 22 seconds, and RBS in 9 minutes and 47 seconds (the maximum times of the three simulator validations).

As such, the sensitivity studies coupled with the simulator validation results demonstrate that adequate time is available for operator action.

References

1. March 20, 2003 letter from R. A. Jones (Duke) to USNRC Document Control Desk, Subject: Oconee Nuclear Station, Defense in Depth and Diversity Assessment Associated with the Digital Upgrade of Oconee's Reactor Protective System and Engineered Safeguards Protective System.

2. October 26, 2005 letter from R. A. Jones (Duke) to USNRC Document Control Desk, Subject: Response to Request for Additional Information Pertaining to Defense in Depth and Diversity Assessment Associated with the Digital Upgrade of Oconee's Reactor Protective System and Engineered Safeguards Protective System.

3. DPC-NE-3003-PA, Mass and Energy Release and Containment Response Methodology, Oconee Nuclear Station, Revision 1, September 2004, Duke Power Company.

ONS RPS D3 Analyses

Large Cold Leg Break w/o RBCS/RBS

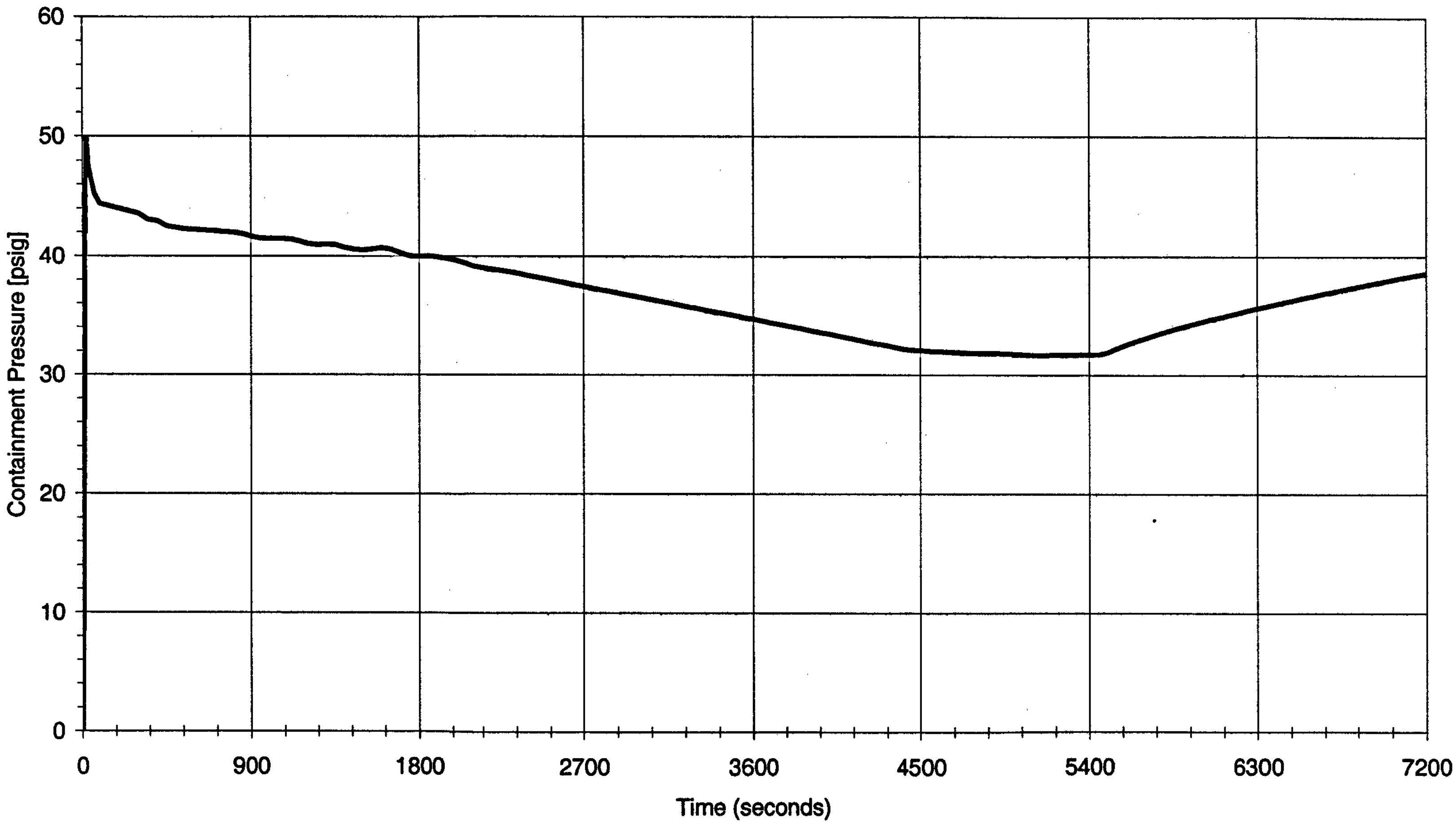

Figure A-1

ONS RPS D3 Analyses

Core Flood Line Break without RBCU/RBS
HPI/LPI actuated at 300 sec

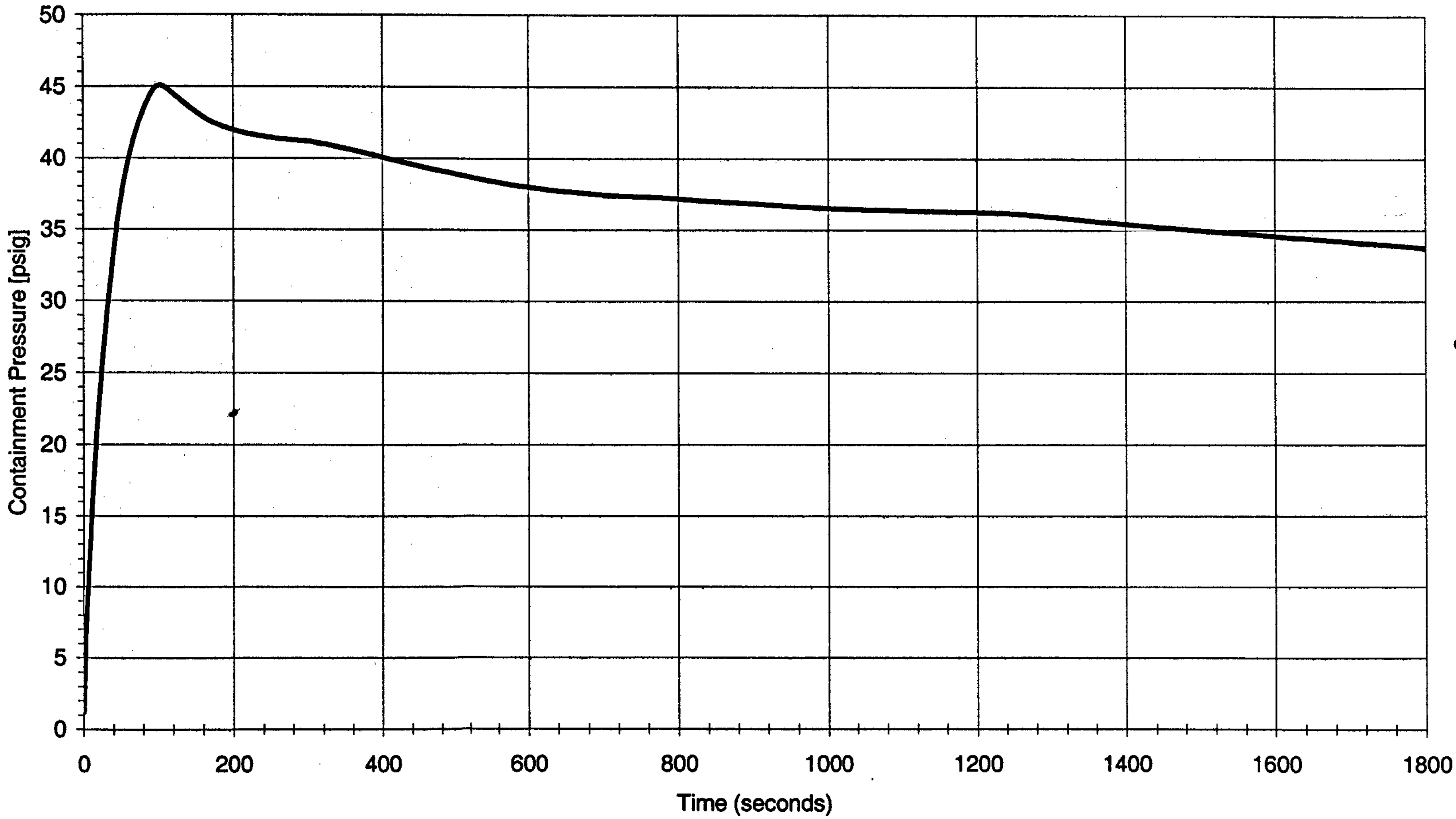

Figure A-2

ONS RPS D3 Analyses

Core Flood Line Break without RPS/ES actuation
HPI/LPI actuated at 300 sec

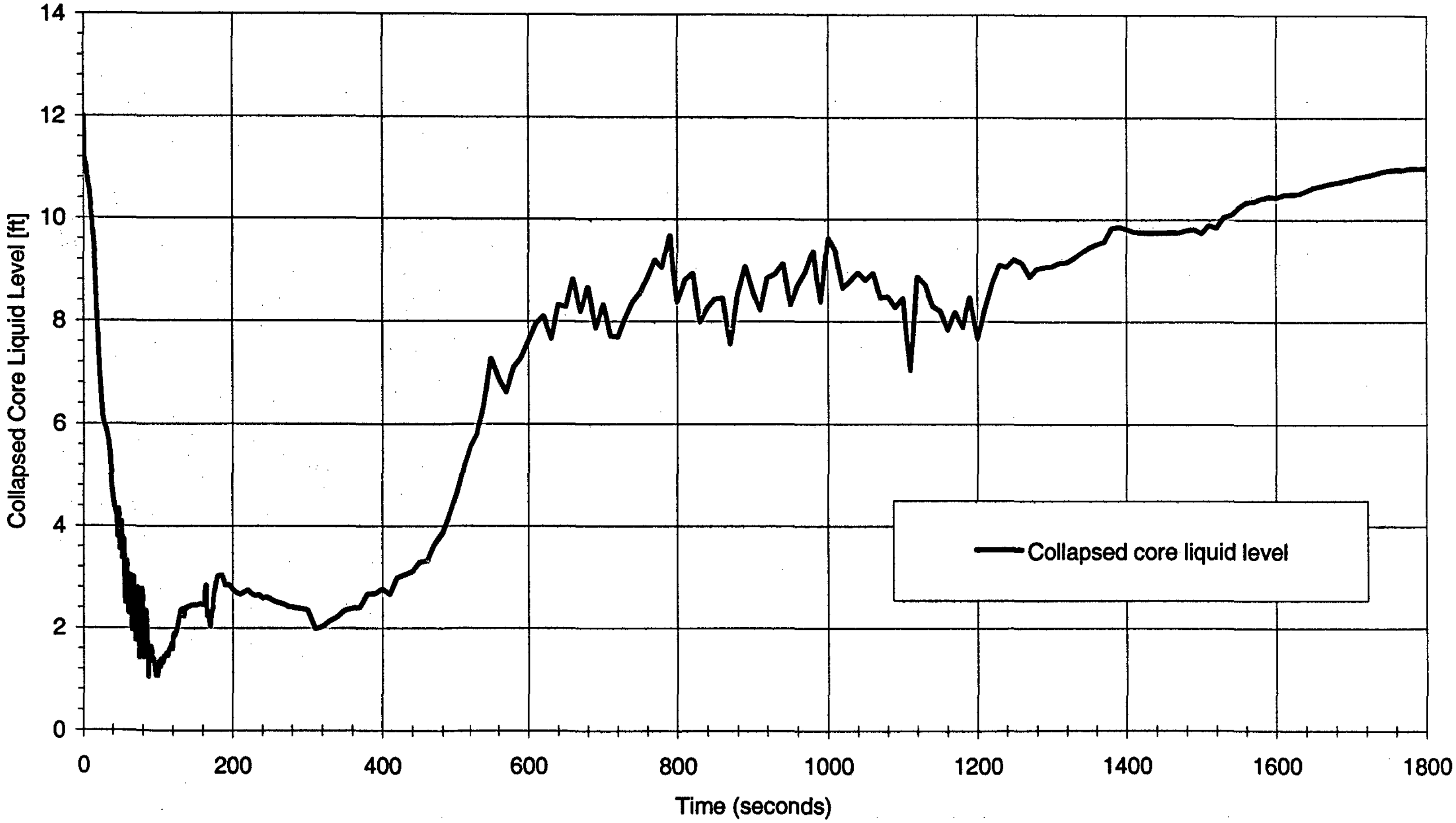

Figure A-3

ONS RPS D3 Analyses

Core Flood Line Break without RPS/ES actuation
HPI/LPI actuated at 300 sec

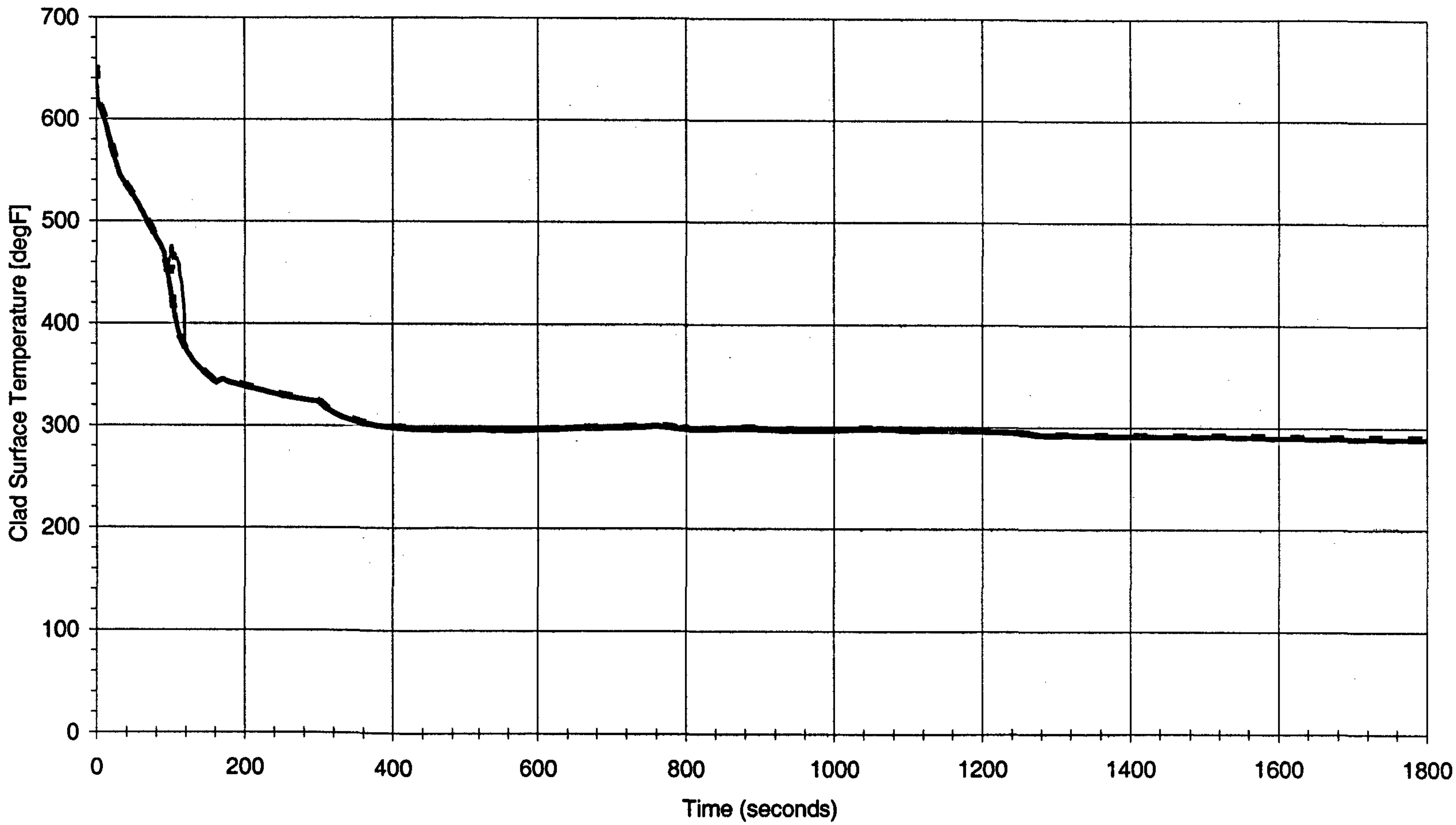

Figure A-4

ONS RPS D3 Analyses

Core Flood Line Break without RPS/ES actuation
HPI/LPI do not actuate

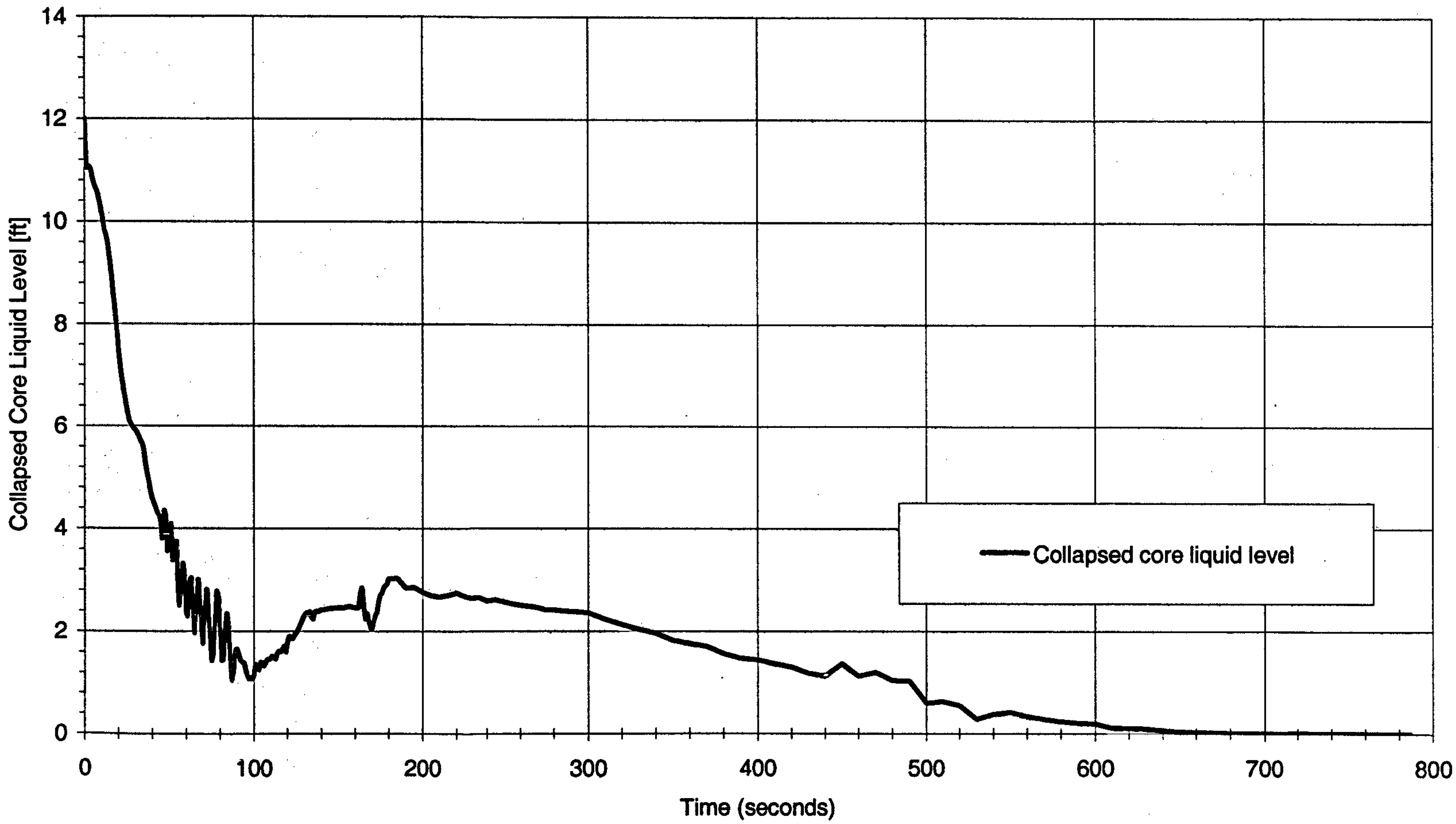

Figure A-5

ONS RPS D3 Analyses

Core Flood Line Break without RPS/ES actuation
HPI/LPI do not actuate

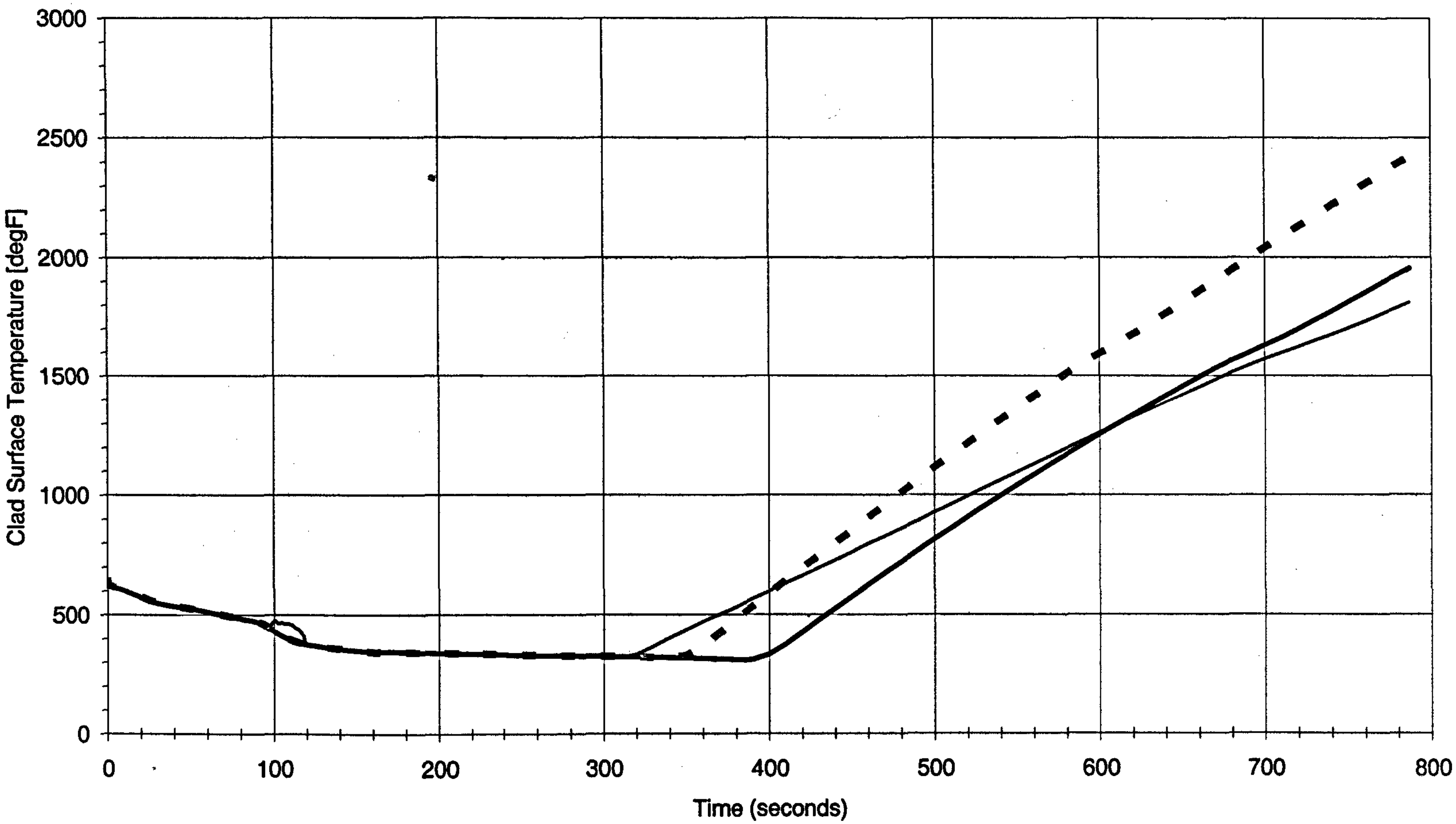

Figure A-6

ONS RPS D3 Analyses

Core Flood Line Break without RPS/ES actuation
Diverse LPI actuated at 120 sec

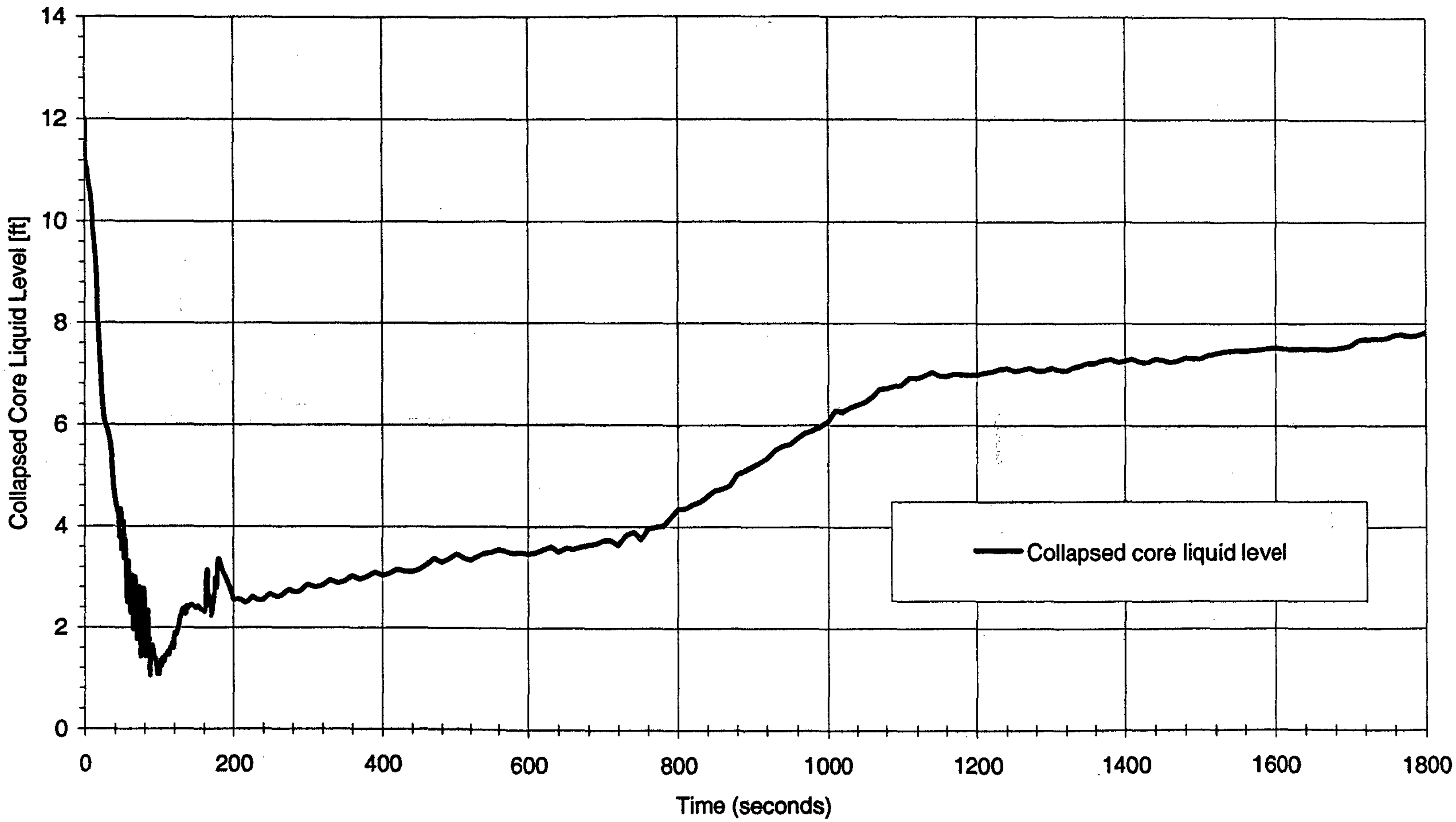

Figure A-7

ONS RPS D3 Analyses

Core Flood Line Break without RPS/ES actuation
Diverse LPI actuated at 120 sec

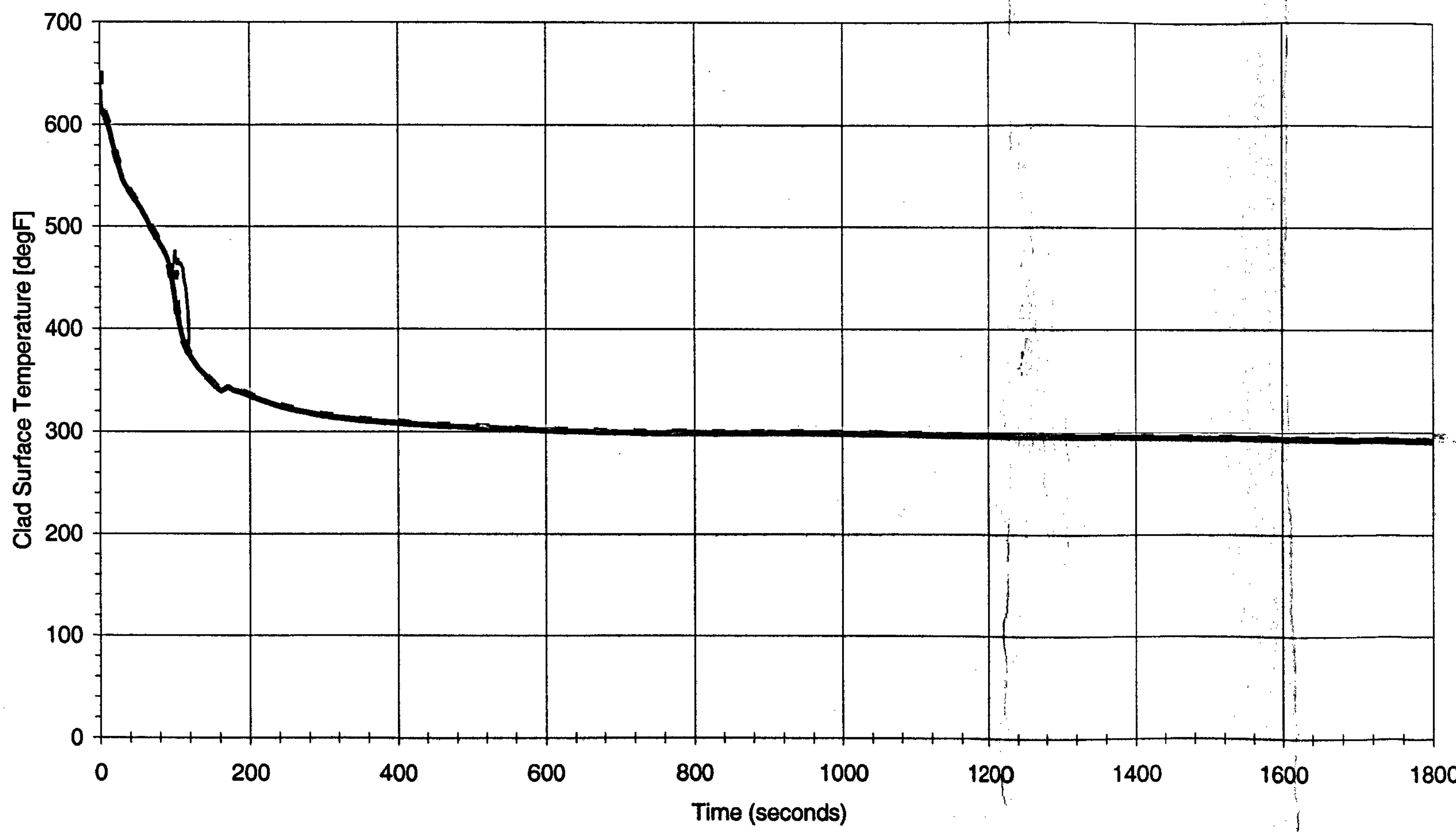

Figure A-8