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MFN 08-332

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Subject: Response to Portion of NRC Request for Additional Information Letter No. 110 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-140 S01

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the subject NRC RAI originally transmitted via the Reference 1 letter and supplemented by an NRC request for clarification in Reference 2. A commitment is included in Enclosure 1 to provided DCD Tier 2 markups to reflect the response to RAI 6.2-140 S01 by May 22, 2008.

If you have any questions or require additional information, please contact me.

Sincerely,

James C. Kinsey

James C. Kinsey
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 06-419, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, *Request for Additional Information Letter No. 80 Related to ESBWR Design Certification Application*, November 2, 2006
2. MFN 07-510, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 110 Related to ESBWR Design Certification Application*, September 19, 2007

Enclosure:

1. MFN 08-332 - Response to Portion of NRC Request for Additional Information Letter No. 110 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-140 S01

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	eDRF	0000-0083-5492

Enclosure 1

MFN 08-332

Response to Portion of NRC Request for Additional Information Letter No. 110 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-140 S01

NRC RAI 6.2-140 S01:

In response to RAI 6.2-140, GEH provided results of containment pressure following a loss of coolant accident that were predicted using TRACG analysis extending up to 7 days. The containment pressure predicted was below the design value for 7 days under the assumptions that the isolation condenser (IC)/passive containment cooling (PCC) pool refill occurred at 3 days and the radiolytic gas production ceased after 3 days. However, the containment pressure appeared to be continuing to rise and could exceed design pressure after 7 days. Further, staff confirmatory analyses also show containment pressure continues to rise and could exceed design pressure before 7 days depending on the bypass leakage that is assumed.

10 CFR 50 Appendix A, General Design Criterion 50 requires that the containment shall be designed to accommodate, without exceeding the design leakage rate with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident.

Describe how the ESBWR design meets General Design Criterion 50. Show that resulting containment pressure and temperature following a LOCA can be mitigated sufficiently to reduce and control pressure for the long term. In addition, discuss appropriate treatment of all non-safety systems credited to provide this function after 72 hours, consistent with SECY 94-084.

GEH Response:

The ESBWR containment is designed to accommodate, without exceeding the design leakage rate with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident (LOCA), as required by 10 CFR 50 Appendix A, General Design Criterion (GDC) 50. GDC 50 is met by the ESBWR containment structure, which is designed to accommodate the pressure and temperature of loss-of-coolant accident (LOCA) conditions as calculated and described in DCD Tier 2, Section 6.2. The containment pressure and temperature responses are shown in the attached Figure 6.2-140 S01-1 and Figure 6.2-140 S01-2.

Sufficient margin is provided in the containment pressure and temperature response calculations based on the following:

1. The effects of energy sources, including the vessel structural and piping energy, have been included in the determination of peak conditions. The design complies with 10 CFR 50.44 as discussed in DCD Tier 2, Subsection 6.2.5.
2. Specific experiments were conducted for the ESBWR containment to verify containment cooling performance using the Passive Containment Cooling System (PCCS). These experiments, including test methods and results, are described in NEDC-32725P, Revision 1, TRACG Qualification for SBWR, (MFN 02-053, dated August 30, 2002) and NEDC-33079P, ESBWR Test and Analysis Program Description, March 2005 (MFN 05-020, dated April 13, 2005).
3. The calculational model and input are conservative as discussed in NEDC-33083-PA, TRACG Application for ESBWR, March 2005, with supplemental

discussion of conservative treatment of the NRC Safety Evaluation Report (SER) confirmatory items and design improvement provided in DCD Tier 2, Table 6.2-6a, Appendix 6A, and Appendix 6B.

For the time period of 0 to 72 hours following a LOCA, containment pressure and temperature control is passively accomplished by the safety-related containment structure and associated safety-related systems, including the PCCS.

For the time period of 72 hours to 7 days following a LOCA, containment pressure and temperature control is passively accomplished by the safety-related containment structure and associated safety-related systems, including the PCCS, and the following additional RTNSS Systems, Structures, and Components (SSCs):

- SSCs required for Isolation Condenser (IC)/Passive Containment Cooling (PCC) pool refill, including power supplies.
- Passive Autocatylitic Recombiners (PARs), which are conservatively assumed to not function until 72 hours, and then are assumed to only function to recombine hydrogen from radiolysis from 72 hours on (i.e., hydrogen content at 72 hours is assumed to remain constant for the duration of the LOCA recovery period).
- PCCS Vent Fans, including power supplies.

Treatment consistent with SECY 94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" for the SSCs required for IC/PCC pool refill, including power supplies, credited for reducing containment pressure and temperature from 72 hours to 7 days following a LOCA is discussed in DCD Tier 2, Chapter 19. At or before 7 days, the Emergency Core Cooling Systems (ECCS) performance analysis described in DCD Tier 2, Section 6.3, and containment pressure and temperature response calculations described in DCD Tier 2, Section 6.2, demonstrate that a reactor stable shutdown condition is achieved, and containment pressure and temperature remain stable with sufficient margin to ensure that the containment design leakage rate is not exceeded, respectively. Stable shutdown was defined by the Electric Power Research Institute (EPRI) as reactor temperatures less than or equal to 215.6°C (420°F), and has been determined to be an acceptable safe shutdown condition by the NRC staff as described in SECY 94-084. Therefore, the SSCs described above that provide the capability to achieve and maintain acceptable containment pressure and temperature conditions associated with a reactor stable shutdown condition are included in RTNSS. With the safety-related ECCS and safety-related containment structure and associated safety-related systems, including the PCCS, and the additional RTNSS SSCs described above, reactor stable shutdown and acceptable containment pressure and temperature conditions can be maintained for a significant period of time beyond 7 days. The response to RAI 6.2-139 will provide the most current containment pressure and temperature response curves for the time period of 0 to 7 days following a LOCA.

Beyond 7 days following a LOCA, continued reactor cooldown from stable shutdown temperatures less than or equal to 215.6°C (420°F) to cold shutdown temperatures less than or equal to 93.3°C (200°F) is performed as a controlled evolution when the prerequisites are met, the appropriate additional non-safety related, non-RTNSS equipment is available, and the operators are sufficiently prepared.

The ESBWR PCCS passively prevents exceeding containment design pressure and temperature following a LOCA. The operational characteristics of the PCCS depend on and are driven by the presence of steam in the containment drywell, with PCCS operation assured after 72 hours by refill of the IC/PCC pool and the operation of the PCCS Vent Fans. The design for the accident recovery phase for the time period beyond 7 days following a LOCA is to use the Fuel and Auxiliary Pools Cooling System (FAPCS) to reduce containment pressure and temperature beyond the point where little or no steam remains present in the containment using a combination of Suppression Pool Cooling and Low Pressure Coolant Injection modes. The major components in the FAPCS system are located in the Fuel Building, so this is an acceptable mitigation plan when there is no fuel damage, which is the expected condition calculated in the DCD Tier 2, Section 6.2 and Section 6.3 containment and ECCS LOCA analyses. The radiological dose analyses must also show acceptable mitigation even if non-mechanistic fuel failures are assumed at a level defined in Regulatory Guide 1.183, Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors. In order to meet this objective, it is desirable to maintain a coolant flow path within the confines of the Reactor Building that may be used to reduce containment pressure and temperature beyond the point where little or no steam remains present in the containment.

Therefore, to provide an alternate long-term accident recovery method for containment pressure and temperature control, assuming non-mechanistic fuel failure conditions, a feature is designed into the ESBWR to allow the operator, under procedural control, to crosstie the Reactor Water Cleanup (RWCU)/Shutdown Cooling (SDC) system suction to the FAPCS suppression pool suction, and the RWCU/SDC discharge to the FAPCS containment cooling discharge line. This provides the capability to use the RWCU/SDC system to cool the containment while confining potential leakage of contaminated water to the Reactor Building (RB). The crosstie can be used at any time following a LOCA. However, it is not credited until after 7 days following a LOCA. This accident recovery mode does not cause Control Room or offsite radiological doses to increase because the crosstie is not placed in service until the RB Purge Exhaust/Recirculation Filter Units are operating to maintain the RB at a negative pressure and to filter the potential airborne contamination in the RB before release to the environment. There are specific efficiency requirements for the RB Purge Exhaust/Recirculation Filter Units to ensure adequate filtration before release of RB atmosphere to the environment. In the unlikely event of a seismic event, sufficient time exists to ensure that the equipment necessary for the crosstie operation is available or can be repaired to support bringing the reactor to cold shutdown, including reducing containment pressure and temperature.

The FAPCS and the RWCU/SDC crosstie options provide the ability to bring the reactor to cold shutdown, including reducing containment pressure and temperature, effectively terminating the LOCA. The crosstie option also confines potential leakage of contaminated water to the RB, where the RB Purge Exhaust/Recirculation Filter Units are used to provide cleanup and maintain acceptable Control Room and offsite dose levels in accordance with Regulatory Guide 1.183, Appendix A.

Containment pressure and temperature responses using an example accident recovery evolution using the RWCU/SDC crosstie option are shown in the attached Figure 6.2-140 S01-1 and Figure 6.2-140 S01-2. These response curves credit the RWCU/SDC non-regenerative heat exchanger (NRHX) operating in suppression pool cooling mode for 24 hours beginning at 7 days following a LOCA, followed by vessel injection via the SDC system with suction from the suppression pool. This TRACG calculation starts with decay heat and other containment conditions at 7 days. However, there is no requirement to start these accident recovery options at 7 days since the reactor is in a safe stable shutdown condition, and containment pressure and temperature continue to be maintained with sufficient margin to containment design limits for a sufficient time period to allow for use of other non-safety related, non-RTNSS SSCs to be placed in service to achieve cold shutdown.

The analysis shows that after being in suppression pool cooling for 24 hours, and then injecting into the reactor vessel for approximately 10 hours, the suppression pool temperature reaches equilibrium with the reactor bulk water temperature at 70°C (158°F). Therefore, with the suppression pool temperature being less than 93.3°C (200°F) and in equilibrium with reactor bulk water temperature, the average reactor coolant temperature is less than 93.3°C (200°F) and the reactor is in cold shutdown, which is considered the end of the accident recovery phase. Table 6.2-140 S01-1 lists the RWCU/SDC NRHX data used in the analysis.

Table 6.2-140 S01-1: RWCU/SDC NRHX Data

RWCU/SDC NRHX Characteristic	Value
Shell Side Flow Rate	1590 m^3/hr (7000 gpm)
Tube Side Flow Rate (Suppression Pool Cooling mode)	605 m^3/hr (2665 gpm)
Tube Side Flow Rate (Reactor Pressure Vessel Injection mode)	605 m^3/hr (2665 gpm)
Shell Side Inlet Temperature	38.3°C (101°F)
Heat Exchanger K Value	4.6E+05 J/sec-°C (8.7E+05 Btu/hr-°F)

The SSCs that are applied to the RWCU/SDC crosstie to FAPCS long-term cooling beginning at or beyond 7 days following a LOCA include:

- FAPCS (suppression pool suction and containment cooling supply lines in the RB);
- RWCU/SDC (portions thereof);
- Reactor Component Cooling Water System (RCCWS) (portions thereof);
- Reactor Building Contaminated Area HVAC Subsystem (CONAVS); and
- Those support systems required to operate the above systems.

The additional SSCs necessary to satisfy long-term safety RTNSS requirements (RTNSS B) are those necessary to keep the reactor at safe stable shutdown conditions, to rapidly reduce containment pressure and temperature to levels where there is acceptable margin, and then to maintain those conditions for a sufficient time period to allow for use of other non-safety related, non-RTNSS SSCs to be placed in service to achieve cold shutdown. These SSCs classified as RTNSS B include:

- IC/PCC pool refill;
- PCCS Vent Fans; and
- PARS.

The only support required for the above SSCs are the power supplies to the PCCS Vent Fans and the power to the IC/PCC pool refill pumps. These supporting SSCs are also classified as RTNSS B.

The ESBWR SSCs designed to bring the reactor to cold shutdown conditions and further reduce containment pressure and temperature are also considered for RTNSS under the probabilistic categories. None of these SSCs meet the threshold in the baseline focused Probabilistic Risk Assessment (PRA) as defined in SECY 93-087. However, the FAPCS option for bringing the reactor to cold shutdown conditions may meet the risk significance threshold for RTNSS C when uncertainties are considered. DCD Tier 2, Chapter 19A, Revision 4, already defines these SSCs as requiring RTNSS. The RWCU/SDC crosstie to FAPCS option does not meet any of the probabilistic thresholds.

Any of the long-term cooling systems, including support systems, that do not meet other RTNSS thresholds, are also evaluated for the potential to introduce adverse system interactions (RTNSS E). This evaluation is on-going, and at this preliminary stage it is expected that the only SSCs that will meet this RTNSS criterion are the charcoal filters for the CONAVS. The completed evaluation will be included in DCD Tier 2, Chapter 19A, in Revision 5.

DCD Impact:

DCD Tier 2 markups to incorporate the necessary information addressed in the above response will be submitted to the NRC by May 22, 2008. These DCD Tier 2 changes will include the following:

- Changes related to the addition of the PCCS Vent Fans to DCD Tier 2 will be provided in the response to RAI 6.2-139.
- Changes to DCD Tier 2, Chapter 6 to document the RWCU/SDC NRHX performance characteristics as shown in Table 6.2-140 S01-1.
- Changes to DCD Tier 2, Subsection 5.4.8 to document the crosstie capabilities of the RWCU/SDC system. This will include flow diagram changes.
- Changes to DCD Tier 2, Subsection 9.1.3 to document the crosstie capabilities of the FAPCS. This will include flow diagram changes.
- Changes to DCD Tier 2, Subsection 7.6.1.1 to document the high pressure/low pressure system interlocks required for the RWCU/SDC crosstie to FAPCS design.

- Changes to DCD Tier 2, Section 9.4 to document changes to the CONAVS for supporting the RWCU/SDC crosstie to FAPCS design.
- Changes to DCD Tier 2, Chapter 19A to document the RTNSS classification of the charcoal filters for the CONAVS.

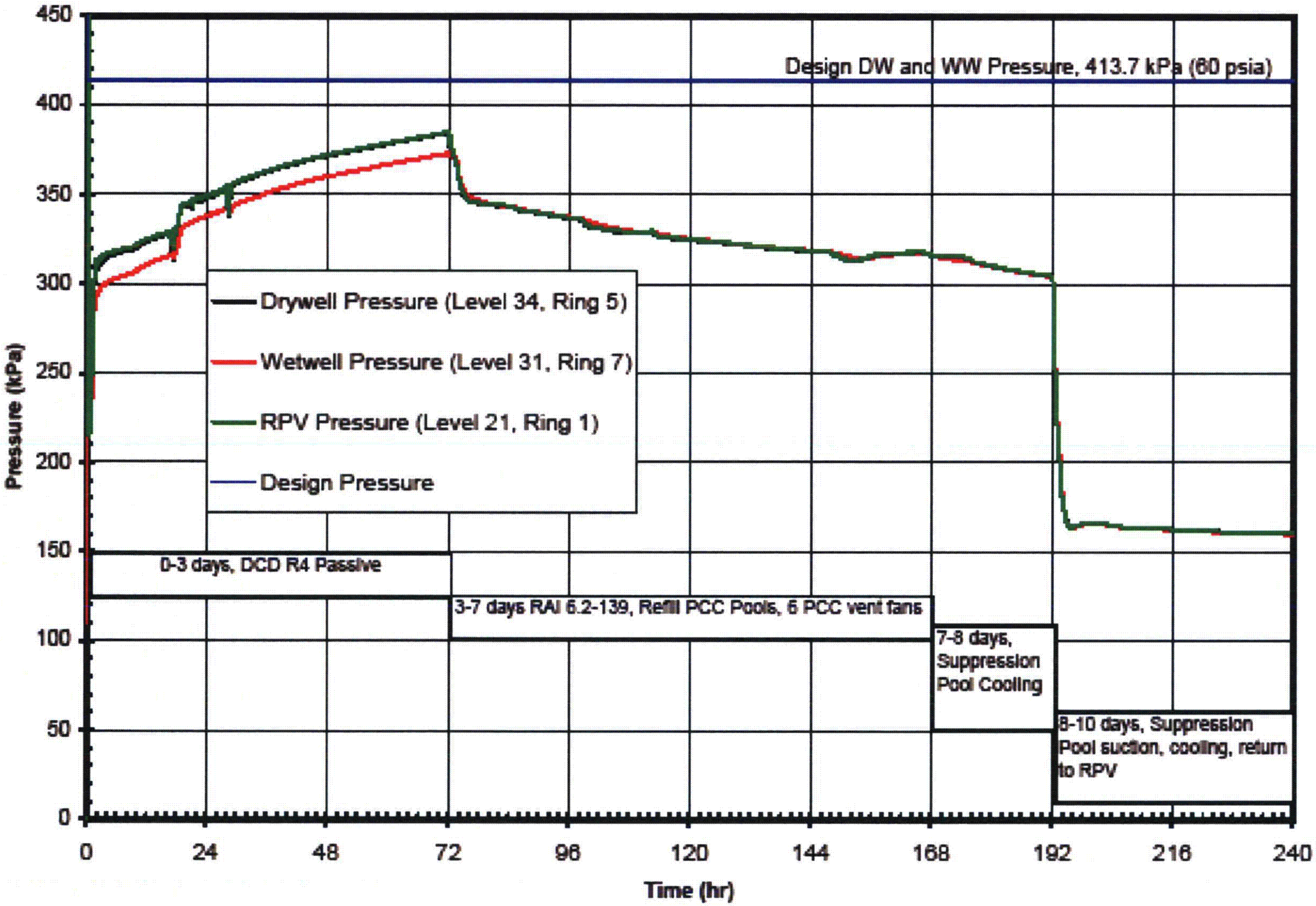

Figure 6.2-140S01-1: Containment Pressure Response, 0-10 Days

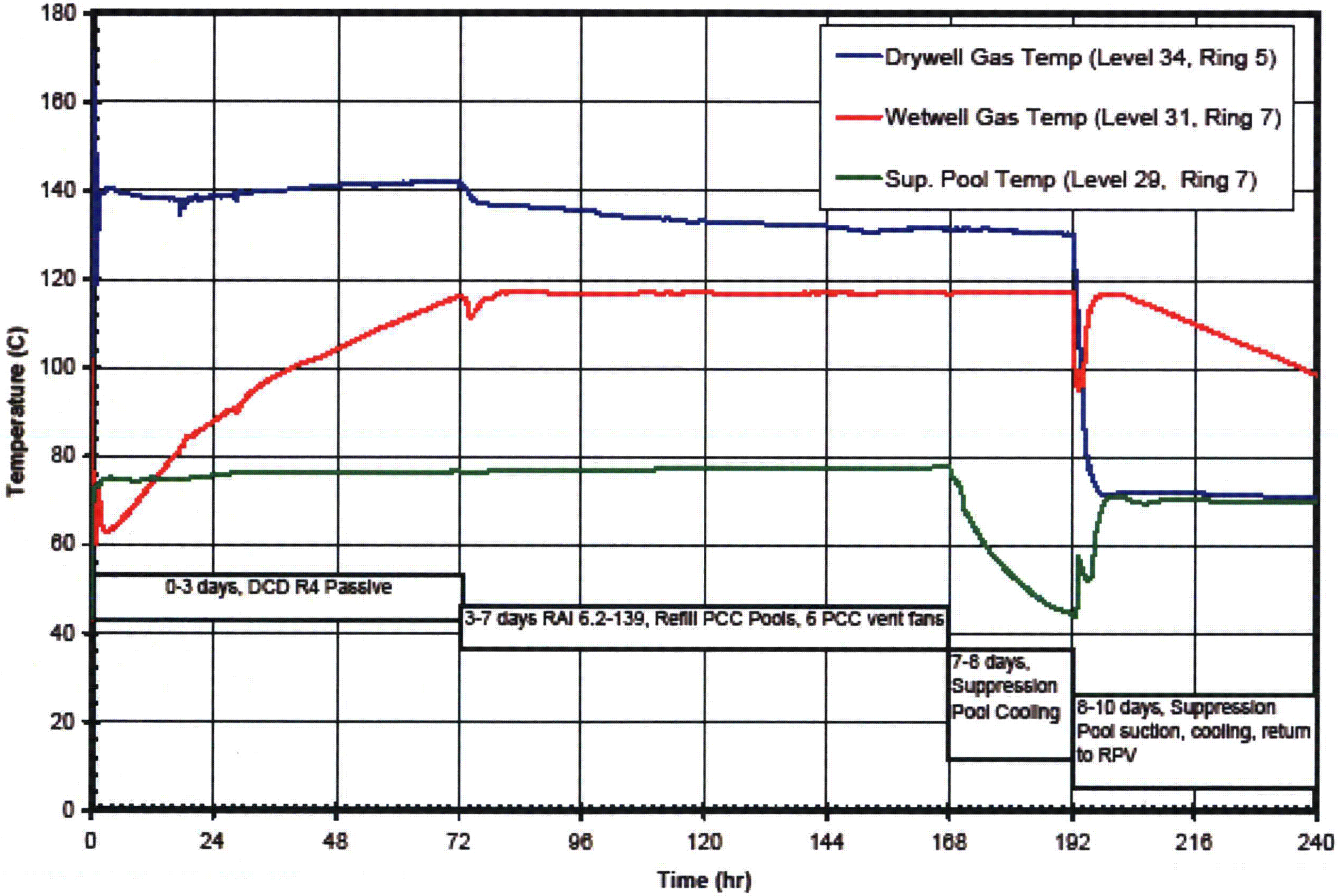

Figure 6.2-140S01-2: Containment Temperature Response, 0-10 Days