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Generation Group

March 31, 2006

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit No. 2; Docket No. 50-318
Response to Preliminary Accident Sequence Precursor (ASP) Analysis for the Unit 2 January 2004 Operational Event

REFERENCE: (a) Letter from Mr. P. D. Milano (NRC) to Mr. J. A. Spina, dated February 17, 2006, Preliminary Accident Sequence Precursor Analysis of January 2004 Operational Event

Reference (a) provided a copy of the preliminary accident sequence precursor (ASP) analysis performed by the Nuclear Regulatory Commission staff for an operational event at Calvert Cliffs Unit 2 in January 2004. This ASP analysis reviews the significance of the January 23, 2004 trip on Unit 2 at Calvert Cliffs. During this trip, the quick open signal for the turbine bypass valves and the atmospheric dump valves failed to clear as designed and an excess steam demand occurred. The steam generator isolation signals and safety injection actuation signals were actuated within approximately one minute. All safety injection actuation signal and steam generator isolation signal functions operated successfully.

We have performed a peer review of the ASP analysis as requested. One sequence in particular is believed to be overly conservative, based on simulator runs which evaluated plant response and operator actions. The affected sequence is significant in the sensitivity cases run in the ASP as well. Additional detail and other comments can be found in Attachment (1). We request that you consider these comments as you finalize the ASP analysis report.

Should you have questions regarding this matter, please contact Mr. L. S. Larragoite at (410) 495-4922.

Very truly yours,

JAS/PSF/bjd

Attachment: (1) Preliminary Accident Sequence Precursor Analysis Comments

cc: P. D. Milano, NRC
S. J. Collins, NRC
Resident Inspector, NRC
R. I. McLean, DNR

A001

ATTACHMENT (1)

PRELIMINARY ACCIDENT SEQUENCE PRECURSOR ANALYSIS

COMMENTS

Calvert Cliffs Nuclear Power Plant, Inc.
March 31, 2006

ATTACHMENT (1)

PRELIMINARY ACCIDENT SEQUENCE PRECURSOR ANALYSIS COMMENTS

This accident sequence precursor (ASP) analysis reviews the significance of the January 23, 2004 trip on Unit 2 at Calvert Cliffs. During this trip, the quick open signal for the turbine bypass valves (TBVs) and the atmospheric dump valves (ADVs) failed to clear as designed and an excess steam demand occurred. The steam generator isolation signals (SGIS) and safety injection actuation signals (SIAS) were actuated within approximately one minute. All SIAS and SGIS functions operated successfully.

The conditional core damage probability (CCDP) calculated by the Nuclear Regulatory Commission in this analysis was 1.2E-05. We believe this is overly conservative as described below. Approximately 80% (9.7E-06) of the risk calculated by the Nuclear Regulatory Commission is due to Sequence 47 which assumes core damage upon failure of both main steam isolation valves (MSIVs) to close and failure of the once through core cooling (OTCC) human action. It should be noted that failure of the MSIVs will not prevent use of the auxiliary feedwater (AFW) system. Additionally, the overcooling caused by the event and high pressure safety injection (HPSI) injection increases the likelihood of success for OTCC.

To illustrate the recovery possibilities available, we performed a simulator run with the quick open signal failing to clear <u>AND</u> with the MSIVs failing to close on an SGIS. Probabilistic risk assessment personnel walked through the Emergency Operating Procedures (EOPs) and discussed the operator actions expected in this scenario with Operations training personnel. The relevant graphs are attached. This includes the following parameters:

- Pressurizer Pressure
- Pressurizer Level
- T Cold [Reactor Coolant System (RCS)]
- Steam Generator Level and Pressure
- AFW Flow (Motor- and Steam-Driven)
- Reactor Vessel Level Monitoring System – Vessel Level

The following was determined from this simulator evaluation regarding operator actions:

1. We did not find any direction to secure AFW and did not interpret any procedure to require securing it.
2. We would normally initiate OTCC once level dropped to -350" in the steam generators. Since this condition is reached early in the scenario, OTCC would be readily achieved. To illustrate that OTCC is not required, we did not initiate OTCC for this simulation.
3. Between 5 and 10 minutes into the scenario Operations training personnel discussed manually isolating ADVs and TBVs. The operators did isolate the ADVs during the actual event. There is procedural guidance on how to take local/manual control of the TBVs in plant operating procedures. For simulation purposes these actions were not taken.

The following was determined from this simulator evaluation regarding plant response:

1. An AFW Block was not initiated as both steam generators decreased in pressure at the same rate. [Note that an Auxiliary Feedwater Actuation System (AFAS) Block did not occur during the actual event. Even if one had occurred there are relatively simple recoveries to restore AFW after a block signal.]
2. The turbine-driven AFW pumps functioned until steam pressure dropped to approximately 50 psia in the steam generators and they were secured at this point.

3. Significant HPSI flow occurred into the RCS. This is evidenced by pressurizer level increasing at the lower temperatures and by observation of HPSI flow in the simulator. High pressure safety injection flow was not recorded in this simulator run.
4. The reactor core was not uncovered. There was indication of lowering reactor coolant level as observed on the Reactor Vessel Level Monitoring System from the 5 minute to the 12 minute time frame. At the lowest point, there was approximately 7 feet of water above the active fuel.
5. The RCS temperature leveled out above 350 degrees Fahrenheit.
6. Pressure in the RCS leveled out at approximately 1000 psia. Pressure was controlled using operator actions to secure HPSI flow, charging flow, and pressurizer heaters. Auxiliary spray was also used to maintain pressure.
7. Auxiliary feedwater flow, using the motor-driven AFW pump, was maintained during the entire transient after AFAS actuation.
8. Condenser vacuum was lost approximately 12 to 15 minutes into the transient. This is based on an assumed time for the condenser air removal units to fail on loss of Service Water (due to SIAS actuation). Note that for purposes of simulation the TBVs remained open.

Simulator Conclusions

1. Auxiliary Feedwater would successfully prevent core uncovery without OTCC and the operators will not secure the motor-driven pumps.
2. Operators understood the need to isolate the TBVs and ADVs and have procedural direction on how to manually take control.
3. Large amounts of cool water will enter the RCS from HPSI system. This will dramatically increase the success likelihood of OTCC.

Given the above conclusions Calvert Cliffs Nuclear Power Plant postulates the following recoveries and deltas from Sequence 47.

- Motor-driven AFW can successfully prevent core damage as noted in #1 above. The failure probability of this hardware is less than 1%. This is based on the failure probability of the motor-driven pump and its associated flow control hardware. There is assumed to be some small probability the operators would secure AFW due to uncertainty, but this is recoverable.
- Even if the operators secure AFW once the steam generators go dry, there is significant core cooling done during the first 5 minutes of AFW flow, plus the large quantities of cool water injected by the HPSI and charging systems. This cooling will allow significantly more time to initiate OTCC. Thus the 20% failure probability is felt to be very conservative.
- The need to isolate TBVs is recognized and procedural direction exists to accomplish this task (via manipulating local manual instrument air valves). The operators will have greater than 45 minutes to recognize this need and perform the action, as well as reinitiate AFW flow using the motor-driven pump. This is only needed in the case where operators do secure AFW flow <u>AND</u> loss of condenser vacuum does not occur within this time frame.
- Service Water is lost to the Turbine Building due to SIAS actuation. Therefore, the condenser air removal units will fail, probably within the first half hour. The TBVs are closed (even with Quick Open stuck on) on a loss of condenser vacuum. Thus, the operators could use AFW to feed the steam generators before core damage could occur, and use the manually controlled ADVs as in the actual event.

Once Through Core Cooling Evaluation

The key drivers for establishing OTCC are that the steam generator levels reaches -350" (decreasing), or T_{cold} rises uncontrollably 5 degrees or greater. During a worst case total loss of feedwater, the reactor trips at a steam generator water level of -50" and the steam generator inventory is boiled off, maintaining the RCS temperature at approximately 535°F (ADV program control). This scenario provides the least time available to initiate OTCC prior to core damage. With a high RCS pressure, it is difficult to reduce RCS pressure down to the injection point of the HPSI pumps. Because of this, the EOPs direct operators to aggressively cool down per Technical Specification limits following a total loss of feedwater. The lower the RCS pressure when OTCC is initiated the more readily OTCC can be achieved.

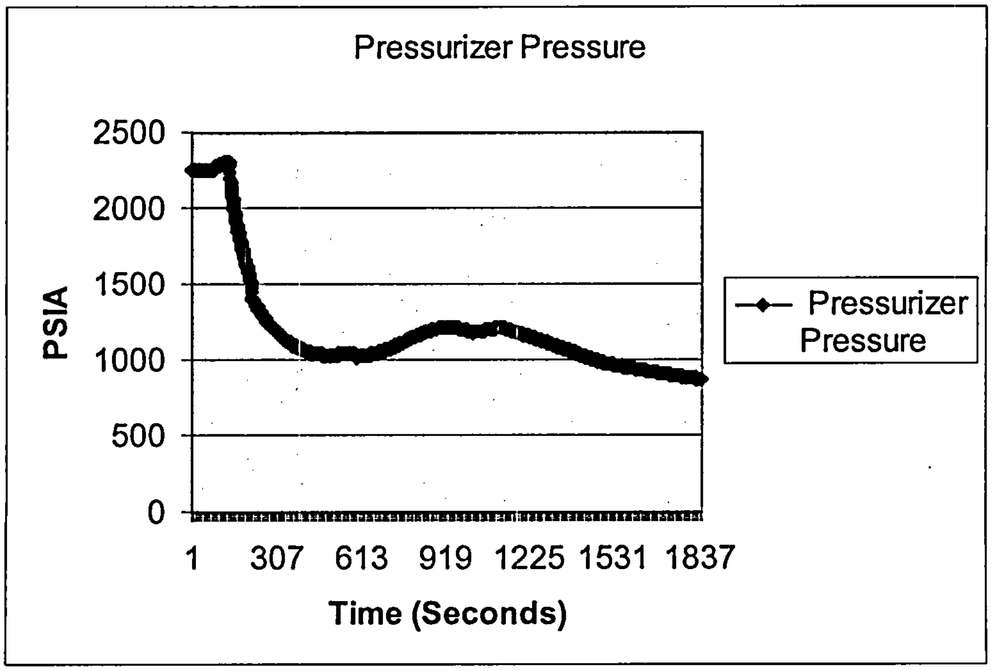
Since OTCC is initiated at -350" steam generator water level, an excessive steam demand event provides the largest response time available. Additionally, two specific scenarios have additional benefits related to OTCC; cases where AFW is initially available, and cases where the MSIVs fail and the RCS pressure drops below the HPSI discharge pressure. When AFW is initially available, the availability of the turbine-driven AFW pumps (until the steam generator pressure drops below the point of effectively driving the pumps) prolongs the time of steam generator depletion. This delay means the decay heat is lower when OTCC is initiated. For cases where the MSIVs fail, the RCS pressure drops below the HPSI discharge pressure. Therefore, the cool HPSI pump water provides further RCS cooling. This also acts to extend the time of steam generator depletion. This makes OTCC more readily achievable.

Given this, it is likely that the failure of both MSIVs to close would produce the largest time available to achieve OTCC. Conversely, if both MSIVs closed, this would provide the least time available to achieve OTCC. To determine the time available, the difference between the steam generators reaching -350" and core exit thermocouple (CET) reaching 560°F would have to be determined. The EOP bases state "...Core cooling must be initiated prior to CET temperatures reaching 560°F. This is because the RCS will reach saturated conditions during Once-Through-Cooling at about the temperature it was initiated. Saturation pressure for 560°F is approximately 1133 PSIA. Above this pressure, HPSI flow may not be sufficient for core cooling requirements..."

The RCS pressure prior to OTCC should not be used as the timing basis for OTCC. As can be seen from the EOP basis document, the RCS temperature should be used instead. In general, the lower the RCS pressure is prior to initiation of OTCC, the greater the likelihood that OTCC can be achieved.

Overall Conclusion:

Sequence 47 is overly conservative by at least two orders of magnitude. This sequence should include failure of motor-driven AFW, an operator action to manually close the TBVs, as well as a less conservative OTCC human action. Thus, the calculated CCDP per the ASP analysis should be significantly reduced. It is also worth mentioning that Operations can mitigate mechanical rod failures (Sequence 49) as long as the anticipated transient without scram does not occur at the beginning of the fuel cycle. These issues will also impact the sensitivity analyses performed as it is assumed that these sequences are significant contributors.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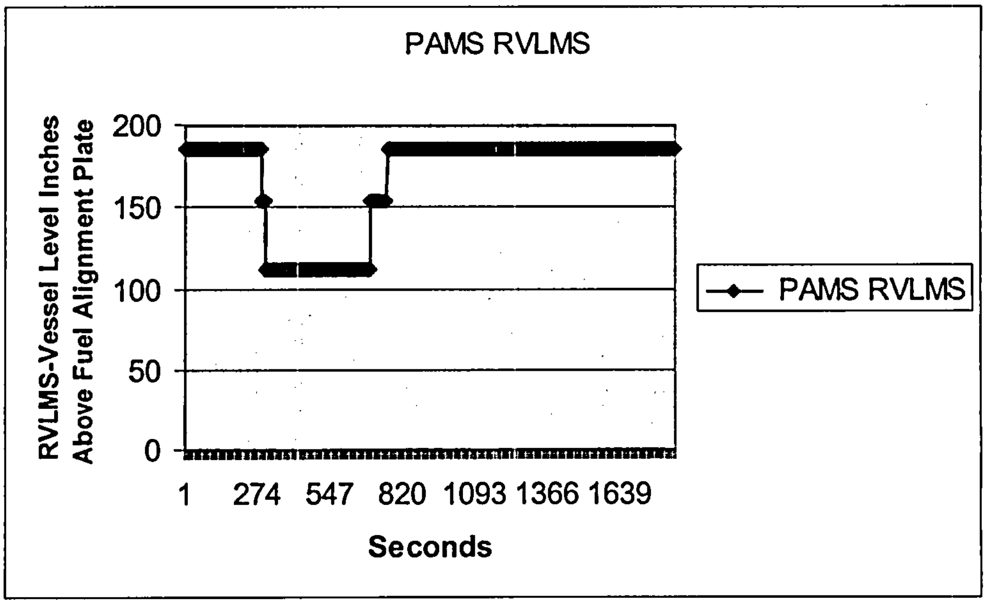
Time (Seconds)
Pressurizer Pressure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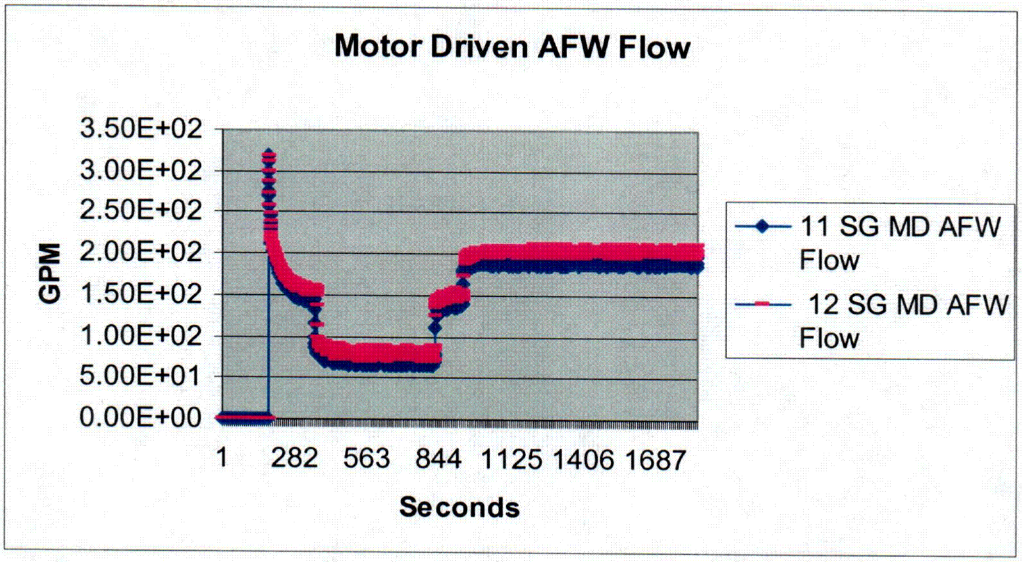
Seconds
PAMS RVLMS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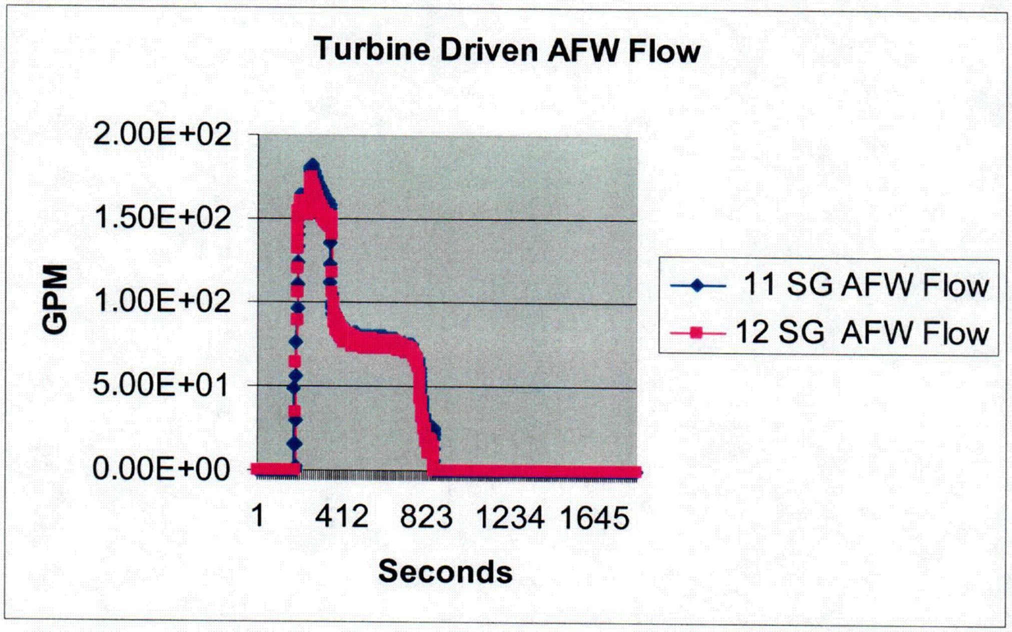
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Seconds
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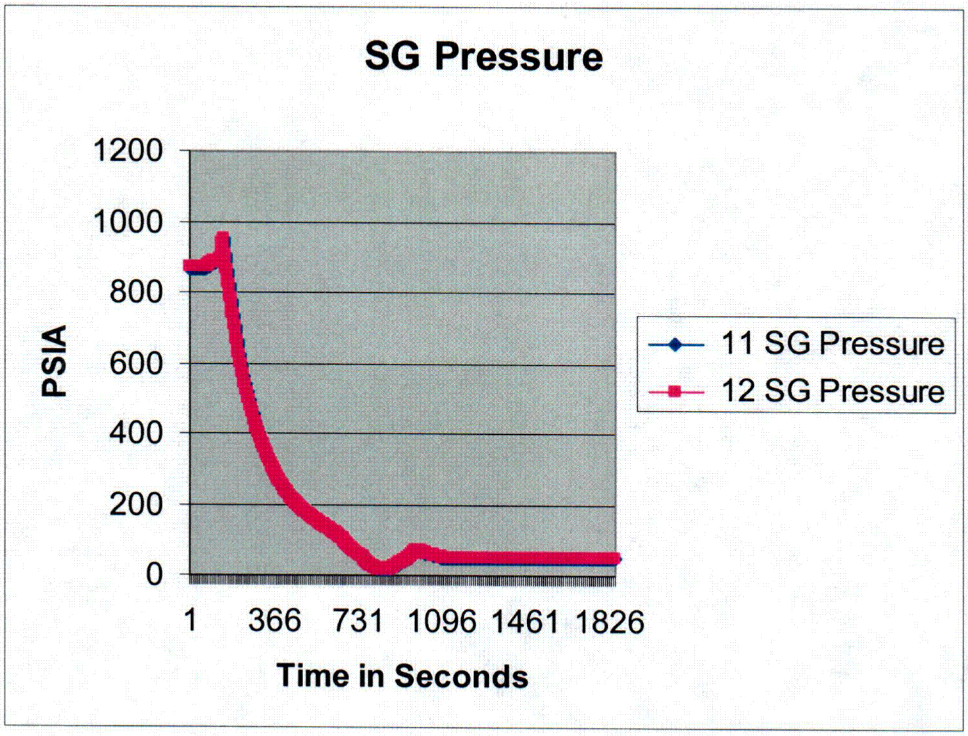
12 SG AFW Flow

C01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Time in Seconds
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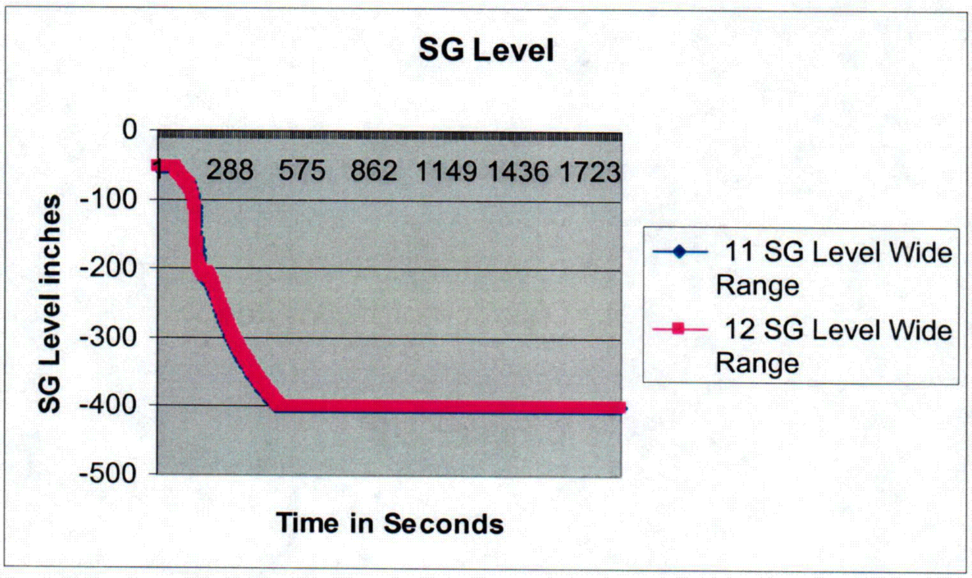
12 SG Pressure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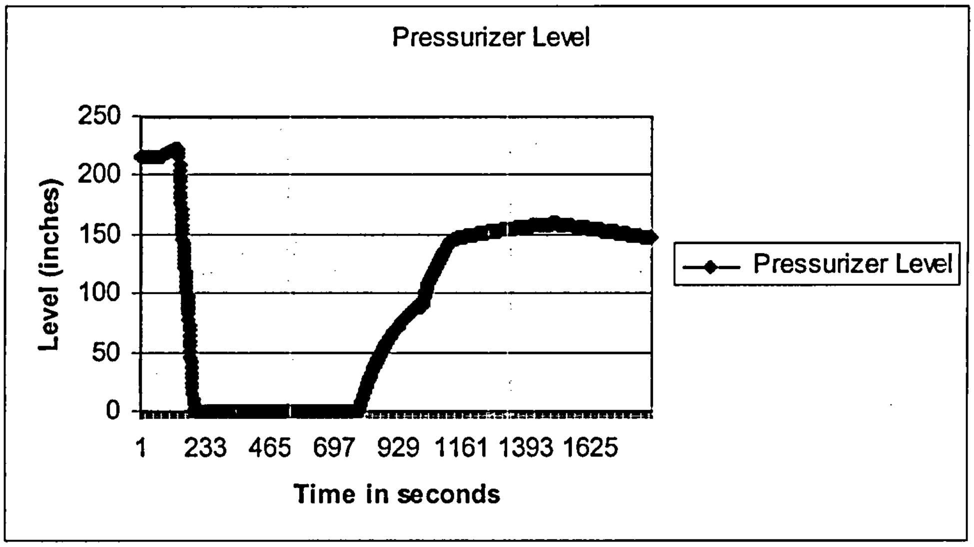
C02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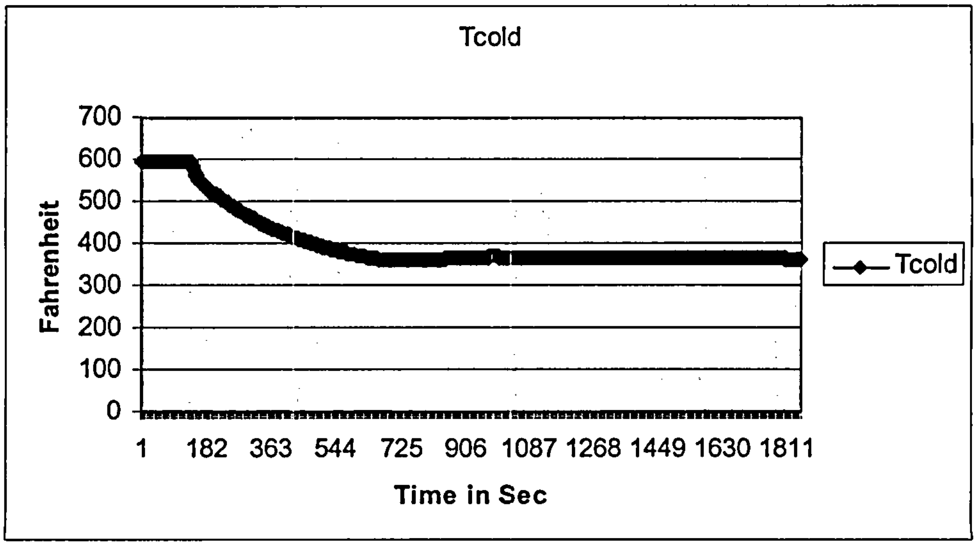
Time in seconds
Pressurizer Level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Time in Sec
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